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Global Action Plan for the Prevention of Runway Incursions

Part I - Recommendations

Part II - Guidance and Explanatory Material

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ORGANISATIONS THAT SUPPORTED THE INITIATIVE:

This document has been produced under the framework of the ICAO Global Aviation Safety Plan and Global Aviation Runway Safety Action Plan. It provides complimentary best practices.

COORDINATING ORGANISATIONS		SIGNATURE
Michele Merkle, Director, Air Navigation Bureau	ICAO	
Hassan Shahidi, President and CEO	FLIGHT SAFETY FOUNDATION	
Raúl Medina, Director General	EUROCONTROL	

VALIDATING ORGANISATION		SIGNATURE
Luis Felipe de Oliveira, Director General	ACI World	
Simon Hocquard, Director General	CANSO	
Nick Careen, Senior Vice President	IATA	

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Executive Summary

Runway incursions[1] are among the most persistent threats to aviation safety. The International Civil Aviation Organization (ICAO) places runway incursions among the five highest-risk categories of events that must be addressed to mitigate the risk of aviation fatalities. The potential consequences of a runway incursion are severe, especially if that incursion ends in a collision.

Despite repeated attempts over the decades to end incursions, they still occur, as evidenced by a spate of incidents at U.S. airports in 2023. These close calls heightened concerns about the potential for disaster. While the United States experienced nearly two dozen of these serious incidents in 2023, the risk of runway incursions is a global issue. As air traffic operations increase, the risk of runway incursions also is likely to increase unless new safety defenses are implemented. While general aviation aircraft are involved in as many as 70 percent of all incursions in some parts of the world, data show upward trends not only in the overall rate of high-risk runway incursions but also in airliner involvement in those incidents.

Overall, runway incursion risks include a complex combination of factors that can only be addressed through a collaborative approach involving aircraft operators, air navigation service providers (ANSPs), airports and regulators. All of these stakeholders have been involved in developing the Global Action Plan for the Prevention of Runway Incursions (GAPPRI), with more than 200 aviation experts from 80 organisations around the world working together to develop the initiative.

The findings and recommendations in Part I of the GAPPRI report are based on an analysis of multiple global and regional datasets, combined with insights from operational expertise. This inclusive strategy extended beyond the study of only hazardous events; the recommendations incorporate lessons from all operations, with both desirable and undesirable outcomes. The following are the high-level findings and conclusions:

- **Variability in human performance:** Runway incursions predominantly arise from scenarios involving human performance. Individuals at the forefront of the aviation system, including pilots, air traffic controllers and vehicle drivers on aerodrome manoeuvring areas, consistently adapt to varying pressures and workloads, balancing multiple goals within an increasingly complex operational environment. While this adaptability contributes to the safe functioning of the system, it can sometimes interact unfavourably with operational conditions, leading to issues such as distraction, miscommunication, misidentification, or misapplication of operational processes, which have resulted in serious incidents.
- **Lack of systemwide collision avoidance barriers:** Significantly disparate efficacy levels were observed between collision avoidance barriers for runway incursion incidents and en route separation incidents. Unlike the airborne collision avoidance system (ACAS/TCAS), which serves as the final technological barrier in the skies, there exists no universally implemented last line of defence against runway collisions. While ground-based technologies such as ASMGCS[2] and ASDE-X[3] at large airports have been effective as a last-resort barrier in preventing runway collisions, these systems are often cost-prohibitive and not scalable to deploy at thousands of airports. Effective layers of systemic barriers upstream and downstream in the chain of events potentially leading to runway collision are required to ensure safe growth in the future.
- **Degraded runway status awareness:** More than one-third of high-risk runway incursions could have been averted through better situational awareness technologies that assist air traffic controllers in detecting potential runway conflicts. Taxiway and runway stop-bars or similar functional barriers can significantly strengthen runway status awareness for pilots. Among the foremost risk scenarios for runway incursions are instances in which air traffic controllers clear pilots to land or depart on an occupied runway, pilots fail to hold short of a runway as instructed, or vehicles enter a runway without clearance. A systematic approach to addressing runway incursion scenarios and potential runway collision scenarios through risk and resilience management is likely to reduce or eliminate serious runway incursions.

1 Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take off of aircraft.

2 Advanced surface movement guidance and control (ASMGC) is a system providing routing, guidance and surveillance of aircraft and vehicles.

3 Aircraft Surface Detection Equipment, Model X (ASDE-X) is a surveillance system using radar, multilateration and satellite technology that allows air traffic controllers to track surface movement of aircraft and vehicles.

- **Miscommunication and coordination:** A prevalent theme across incidents is the apparent breakdown in communication and coordination between air traffic control and pilots. Instances include simultaneous clearances given to aircraft on the same runway, aircraft crossing paths due to misunderstood instructions, and inefficiencies in communication among manoeuvring area vehicle drivers because of language barriers or differing communication channels — conditions that can impede shared situational awareness.
- **Challenges in surface navigation:** Safe navigation for runway management poses a significant challenge, as evidenced by multiple incidents. Incorrect positioning of aircraft or manoeuvring area vehicles on runways due to inaccurate position awareness or navigation routing points to potential procedural lapses, inadequacies in navigation capabilities and guidance, or insufficiencies in aerodrome signage, markings and lighting.

To address these findings, GAPPRI provides a comprehensive, collaborative plan to enhance safety through synchronised, consensus-based recommendations encompassing best practices that exceed regulatory requirements. It empowers aviation stakeholders around the world to proactively mitigate the threat of runway incursions.

GAPPRI includes 127 recommendations across stakeholder groups, including airport operators, ANSPs, aircraft operators, manufacturers, national governments and regulators, and organisations involved in research and development.

The GAPPRI findings emphasise the need to fortify various operational barriers for operators, ANSPs and aerodromes. In addition, they highlight the pivotal role of regulators, policymakers and manufacturers in facilitating risk management and strengthening operational barriers. The key areas of broad recommendations include:

- **Empowering and equipping aviation personnel:** This entails fostering a culture that prioritises safe runway operations over commercial pressures, emphasising the importance of taking sufficient time for critical safety tasks, promoting mental readiness, raising awareness about fatigue, nurturing positive team dynamics, and encouraging informed decision-making. Of the 127 recommendations, several call for enhanced and recurrent training, specifically focusing on scenarios involving runway incursions. A specialized human performance training program tailored to runway safety is likely to be instrumental in understanding and managing external pressures and workload.
- **Integration of advanced technologies:** The deployment of cutting-edge technological systems capable of providing real-time awareness of aircraft and vehicle positions, navigation route assistance, detection of deviations, and timely alerts for potential runway incursions and collisions is strongly recommended. These systems should be equipped to offer multiple layers of systemic barriers and in-depth defenses. Immediate alerts for air traffic controllers, pilots and maneuvering area vehicle drivers in the event of a potential collision or unauthorized runway entry are vital components.
- **Enhanced procedures for runway operations:** Recommendations call for regular reviews and updates of procedures and policies for aerodrome operators, ASNPs and aircraft operators to ensure the protection of runway operations. These recommendations underscore the importance of maintaining vigilance during all ground operations, implementing threat-and-error-based briefings for the crew and emphasising the significance of effective monitoring. Moreover, there is a pressing need for flight crews and air traffic controllers to optimise teamwork and enhance their awareness of traffic and runway statuses during runway operations.
- **Enhanced communication protocols:** Implementation of standardised phraseology and enhanced communication procedures for runway operations is crucial to minimise misunderstandings between air traffic controllers, flight crews and maneuvering area vehicle drivers. Fostering a culture that prioritises immediate clarification of any communication uncertainties is recommended. Additional recommendations include the adoption of a sterile control room and cockpit concept; managing the specific threats

of conditional clearances, complex or early clearances, runway entry or take-off clearance omission; and planning for a common frequency and language for all movements in the maneuvering area.

- **Enhanced aerodrome visual aids:** Enhancements to runway and taxiway signs, markings and lights, particularly in adverse weather conditions, are essential for increased visibility and safe navigation. The installation of additional signage at critical intersections and the use of stop-bars or other lighting systems (e.g., autonomous runway incursion warning systems) are also recommended.
- **Risk mitigation through infrastructure design:** While aerodrome infrastructure is predominantly a permanent fixture, any additions or modifications should be made in a manner that minimises or eliminates the risk of runway collisions.
- **Enhanced safety management and support for runway safety teams:** Beyond regulatory compliance, the recommendations propose evaluation of the efficiency of safety management systems and aerodrome safety teams in reducing the risk of runway collision. Enhanced safety learning and sharing of information among all involved parties are crucial for raising awareness and comprehensive operational insights. Cooperative change management between aerodrome operators and ANSPs should occur in relation to ongoing aerodrome work and infrastructure development to reduce the likelihood of runway incursions.

GAPPRI is intended to serve as a roadmap for addressing risk and instilling resilience, enabling government and industry not only to cope with increases in traffic but also to be proactive in anticipating and addressing problems. Its recommendations include immediate and near-term actions to mitigate the serious incidents studied, but also future solutions involving introduction of new technologies that are in the development pipeline that could be deployed in the medium time horizon. GAPRRI also identifies research and development investments with potential high-risk mitigation benefits that would be mature for deployment in the longer-term time horizon.

GAPPRI's next steps include collaboration amongst stakeholders to review the plan's recommendations and assess their relevance, to identify the best practices for implementing the recommendations they have identified as relevant, to conduct an appropriate impact assessment when deciding how to implement the recommendations, to implement specific actions and monitor their effectiveness, and to share lessons learned with the industry.

GAPPRI acknowledges diversity in risk profiles and encourages the sharing of successful strategies with a goal of empowering aviation stakeholders worldwide to proactively mitigate the threat of runway incursions and build a safer, more resilient aviation ecosystem.

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- Jairo Guardia, DHL Panama
- Egemen Anayurt, DHMI
- Çağdaş Bahçekapılı, DHMI
- Cantug Kayalı, DHMI
- Tarkan Kidil, DHMI
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- Steven Debban, FAA
- Kelvin Ampofo, FAA Airports
- Birkley Rhodes, FAA Airports
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- Harro Ranter, FSF
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- The Global Action Plan for the Prevention of Runway Incursions initiative is coordinated by:

Tzvetomir Blajev, FSF Director Europe and Global Operational Safety, Operational Safety Coordinator EUROCONTROL, blajev@flightsafety.otg, tzvetomir.blajev@eurocontrol.int

2. Statement of Commitment

Runway incursions are one of the most serious types of aviation incidents. The International Civil Aviation Organisation (ICAO) identifies runway incursions as one of the five high-risk categories of occurrences to be addressed to mitigate the risk of fatalities in aviation. Runway incursion is the main precursor to be managed to prevent collision on the runway. The potential consequences of a runway collision are very serious if it involves fast, high energy jet planes moving on a relatively confined runway strip. Unlike having the airborne collision avoidance system (ACAS) as the last technological barrier in the skies, there is no similar universally implemented system to serve as last line of defence against runway collision.

Runway collision risk depends on the number of traffic interactions on and around runways. Runway traffic interactions more than double when traffic doubles. Runway collision risk will increase considerably if no additional safety defences are implemented, considering that traffic will double in 20 years. Runway incursion risk is made up of a complex combination of factors in different aviation segments. Addressing the risk can only be done in synchronisation and collaboration.

The jointly owned risk requires joint solutions. This is why the industry came together, in a dedicated working group, to discuss and agree on what are the most important actions to address the runway incursion risk. More than 200 professionals from more than 80 organisations worked in sub-working groups led by the International Air Transport Association (IATA), Airports Council International (ACI), the U.S. Federal Aviation Administration (FAA), CANSO, EUROCONTROL, the U.K. Civil Aviation Authority (CAA) and Flight Safety Foundation. The initiative was developed within, and complements the frameworks of, the ICAO Global Aviation Safety Plan and Global Runway Safety Action Plan.

The resulting Global Action Plan for the Prevention of Runway Incursions (GAPPRI) is a comprehensive, collaborative effort to enhance aviation safety. It offers synchronised, consensus-based recommendations encompassing best practices that go beyond regulatory compliance. This plan acknowledges diversity in risk profiles and resilience among stakeholders, encouraging the sharing of successful strategies. It provides a robust roadmap for various time horizons, ensuring adaptability to evolving aviation needs. By addressing risk and resilience holistically, this action plan empowers aviation stakeholders worldwide to proactively mitigate the threat of runway incursions, fostering a safer, more resilient global aviation ecosystem.

The organisations that contributed to this action plan are committed to enhancing the safety of runway operations by advocating the implementation of the recommendations that it contains.

The imperative to address this issue is clear. The goal is not merely to cope with the increased traffic but also to stay ahead of it, so that we can minimise the risks associated with higher runway traffic interactions and increased operational complexity. Ultimately, our commitment to safety in the face of growing air traffic is non-negotiable, and it demands our unwavering dedication and proactive action.

We are committed to a culture of continuous improvement. We encourage a culture of reporting runway safety concerns and incidents but also seek to develop resilient behaviours and best practices to prevent runway collisions.

We recognise the importance of effective communication and collaboration among all stakeholders in aviation, including air traffic control, pilots, ground personnel and regulatory authorities. We will work together to improve coordination and communication.

We will invest in training and education programs for our personnel to ensure they are well-prepared to prevent runway collisions. This includes awareness of procedures, technology and human factors.

We will explore and implement advanced technologies and systems that aid in runway collision prevention.
We commit to supporting runway collision prevention research efforts and sharing relevant data and insights to advance our collective understanding of the challenges and solutions.

We will establish clear lines of accountability within and across our organisations to ensure that runway collision prevention measures are consistently enforced and improved.
We will actively engage with the public to raise awareness about the importance of runway collision prevention and its role in aviation safety.

3. Introduction and Background

This document contains Part 1 and Part 2 of the Global Action Plan for the Prevention of Runway Incursions (GAPPRI).

Part I contains the agreed recommendations to the following civil aviation organisations: aerodrome operators, air navigation service providers, aircraft operators, manufacturers, and regulators. It also addressees research and development (R&D) recommendations to States, international organisations and the industry.

Part 2 provides explanatory and guidance material, and related best practices for the recommendations listed in this document. The guidance and explanatory material (GEM) are provided as appendices to this document.

The development of the GAPPRI recommendations is based on the following principles:

- Provide recommendations that **address actions beyond regulatory compliance.** The recommendations in this action plan are not exhaustive in managing runway incursion risk and resilience. It is fundamental that organisations shall comply with international, regional and national rules and regulations.
- Provide recommendations **to organisations and not to individuals. Specifically address runway collision risk and resilience, supporting the system at the front end to manage workload, external pressures, goal conflicts and constraints,** rather than addressing the safety management system in general.
- Recommendations should be **based on consensus**. A recommendation is included in the action plan only if there was a consensus for it during the drafting and the subsequent validation process.
- The approach followed by the working group is **knowledge-based and data-driven and uses Learning From All Operations**, an approach expanding from a focus on hazardous events to an analysis of routine operational data, to learn from all operations and events — not just from those that are unwanted.
- **Promote technology embedded in systemic solutions.** Promote technological solutions that are clearly integrated with the respective training, procedures, standardisation, certification and oversight.
- **Provide recommendations for three different time horizons.** The first time horizon is now — organisations addressed by the recommendations should start assessing their relevance and plan for implementation as soon as this action plan reaches them. The second time horizon is up to 10 years in the future and is mainly for recommendations that require development and global implementation of new technologies. Finally, the third time horizon of 15 years is for R&D recommendations that address issues with clear potential high-risk mitigation benefits but lack maturity for implementation within the 10 years horizon.
- **Provide functional recommendations.** Responsible organisations should decide specific details and implementation solutions after taking into account local conditions and specific context. When reviewing the recommendations, organisations should note that they are not prioritized in any specific order.
- The **verb "should"** is used to signify that, while a recommendation does not have the force of a mandatory provision, its content, if relevant, has to be appropriately transposed at the local level to ensure its implementation.

The organisations this action plan is addressed to should:

- Organise a review of the respective recommendations and assess their relevance against local conditions and specific context.
- Consult the best practices for implementing the selected recommendations and seek support, if needed, from the GAPPRI coordinating partners.
- Conduct an appropriate impact assessment (including safety risk assessment) when deciding on the specific action to implement the recommendations.
- Implement the specific action/change and monitor its effectiveness.
- Share the lessons learnt with the industry.

Global Action Plan for the Prevention of Runway Incursions

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RECOMMENDATIONS TO AERODROME OPERATORS

REF	Recommendation
	SAFETY MANAGEMENT AND SUPPORT TO RUNWAY SAFETY TEAMS
ADR1	Annually assess own contribution to the effectiveness of the aerodrome local runway safety teams (LRSTs), including the existence and implementation of runway safety action plans.
ADR2	Ensure harmonised awareness of runway incursion risk management procedures, practices and issues among front-line operators (pilots, air traffic controllers and manoeuvring area vehicle drivers).
ADR3	Annually evaluate the consistency of runway safety procedures for operations on the manoeuvring area of the aerodrome (pilots and manoeuvring area vehicle drivers) at LRST meetings.
ADR4	Ensure that information is provided to and requested from all participating parties in an incident, so that a complete picture of causal and contributory factors can be built, lessons learned and actions taken.
ADR5	Share at local, national and international levels the lessons learned and essential safety information from occurrence investigation reports and runway safety analyses.
ADR6	Coordinate changes to manoeuvring area procedures with stakeholders operating on the manoeuvring area of the aerodrome. Periodically assess the effectiveness of the arrangements and update as necessary.
ADR7	Ensure that new aerodrome infrastructure and changes to existing infrastructure are designed to reduce the likelihood of runway incursions.
ADR8	Assess all arrangements associated with aerodrome construction works in progress (WiP) and: a. The potential for runway incursion during runway closure or WiP should be risk-assessed in coordination with the air navigation service provider (ANSP) and resident aircraft operators and mitigated. b. Ensure that appropriate coordination between the aerodrome operator and ANSP is in place prior to notifying the regulator. c. Ensure that up-to-date information about temporary work areas and the consequential operational impact is adequately presented and disseminated. d. Ensure that existing signs on related area are covered, lights are switched off, and markings are removed when appropriate. e. Ensure that temporary signs and markings are clearly visible, adequate and unambiguous in all applicable conditions.
ADR9	In coordination with ANSPs and as part of the management of change procedures before works, assess the sight lines from the tower visual control room (VCR) and existing visibility restrictions which have a potential impact on the controllers' ability to see the runway. Avoid such visibility restrictions or develop and implement appropriate short-term mitigations and identify longer term improvement measures, whenever possible.
ADR10	Implement peer reviews to assess runway safety, the state of airside infrastructure and operational processes.
ADR11	Establish leading and lagging runway safety performance indicators.
	TRAINING AND COMPETENCE
ADR12	Annually assess, and update as necessary, how the runway incursion risks and mitigations are included within initial and refresher/recurrent training of operational staff.
ADR13	Define driver training program requirements. Periodically assess formal manoeuvring area driver permits, training and refresher programmes (including practical training and proficiency checks) against driver training requirements.

REF	Recommendation
ADR14	Consider implementing a three-level scheme for aerodrome driving permits: apron only, manoeuvring area (excluding runways) and runways. Periodically, in a phased manner, audit airside driving permits (e.g., check 'recency' of use), in particular those allowing access to the runways, which should be as few as possible. Adjust, if needed, the validity period of the permit.
RUNWAY INSPECTION	
ADR15	In collaboration with the ANSP, periodically review the procedures for runway inspections and other runway works. This should include: a. Carrying out routine runway inspections in the opposite direction of runway movements with vehicle lights on regardless of time of day. b. Ensuring that uni-directional lighting is inspected efficiently on the basis of risk and operational needs assessment. c. Implementing procedures to increase overall situational awareness when vehicles occupy a runway (to be decided locally, e.g., technology, 'vehicle operation normal' calls or other means). d. Implement standard routes and timings for routine runway inspections. e. Temporarily suspending operations to allow a full runway inspection to be performed without interruption on the basis of risk and operational needs assessment. f. Vehicles entering a runway should be equipped with a dashboard camera recording the outside view from the vehicle, to collect information about actual and potential risks of runway incursion. The information would be used exclusively for safety improvement.
AERODROME INFRASTRUCTURE SUPPORTING SAFE NAVIGATION	
ADR16	Periodically assess and ensure that signs, markings and lights on the movement area are clearly visible, adequate and unambiguous in all appropriate conditions, e.g., in all light conditions and when wet.
ADR17	Avoid designing closely spaced multiple parallel runway holding positions on the same taxiway. Where this cannot be done, the holding positions should be clearly segregated.
ADR18	In relation to aerodrome protected areas: a. In coordination with ANSPs, identify the protected area for each runway and produce a chart/map of aerodrome protected areas. b. Ensure that drivers of vehicles operating on the manoeuvring area are familiar with the protected area map.
ADR19	Implement enhanced taxiway centreline markings and mandatory instruction markings at all certified airports.
ENHANCED PROCEDURES FOR SAFE RUNWAY OPERATIONS	
ADR20	a. In cooperation with ANSPs, implement H24 stop bars or other lighting systems (e.g., autonomous runway incursion warning systems (ARIWS)) at all active runway holding positions, providing an equivalent level of safety commensurate with the level and complexity of operations and the potential risk of runway incursion. b. Assess the need for elevated stop bars to improve stop bar visibility. c. Consider use of LED technology and reduced spacing (e.g., spacing of 1,5 m) to improve stop bar clarity. d. In cooperation with ANSPs, implement procedures, in line with the applicable regulations, to be followed in case of stop bar unserviceability.
ADR21	Review procedures which require pilots to monitor or call secondary VHF frequencies (e.g., for ramp entry, gate location) while manoeuvring on airport taxiways to avoid high workload for the pilot handling the aircraft and air traffic control (ATC) communication (wherever relevant to aerodrome operator or apron management service provider).

REF	Recommendation
ADR22	Ensure all manoeuvring area vehicle drivers are briefed at the start of a shift, including providing awareness of safety-significant airport information. The safety-significant information should also be checked before the start of the mission.
ADR23	Ensure that vehicle driver procedures and guidance contain a requirement for explicit ATC clearances to enter or cross any runway, regardless of runway status (active/inactive).
SAFE RUNWAY OPERATIONS COMMUNICATIONS	
ADR24	To minimise call sign confusion at aerodromes, aerodrome operators should ensure the use of predefined and process-specific unique call signs for manoeuvring area vehicles.
ADR25	Develop and implement a phased plan for use of one frequency and English language for all communication associated with the operation of a runway. The phased plan should aim at improving the shared situational awareness of all front-line operators and should provide realistic and practicable measures that ensure an adequate level of safety for each of its phases.
ADR26	Periodically evaluate radio telephony practices, assessing elements such as use of ICAO-compliant phraseology.
ADR27	In cooperation with ANSPs, implement communication procedures for airside vehicles' drivers on what phraseology needs to be applied by both parties, including standard phrases for: a. Radio checks and readability scale. b. Radio communication failures (transmitting blind). c. When a driver becomes lost or uncertain of the vehicle's position in the manoeuvring area. d. Position reporting. e. Runway access and runway crossing requests.
AERONAUTICAL INFORMATION	
ADR28	In collaboration with ANSPs, ensure that significant and up-to-date aerodrome information which may affect operations on the runway is provided to manoeuvring area drivers and pilots (e.g., by NOTAMS, automatic terminal information service (ATIS), radiotelephony (R/T), maps, new digital technology or other means).
ADR29	Information on temporary changes to operating conditions at the aerodrome should be communicated in a way to increase situational awareness of the most critical changes. When needed, an Aeronautical Information Publication (AIP) supplement with graphics and charts should be published.
ENHANCED TECHNOLOGY FOR SAFE RUNWAY OPERATIONS	
ADR30	Commensurate with the level and complexity of operations and the potential risk of a runway incursion, consider providing airside vehicle drivers with a real-time functionality for awareness and alerting to the potential for a runway collision between an aircraft and an airside vehicle and with real-time alerts when crossing into the protected area, such that drivers will be alerted in the event of a runway incursion.
ADR31	Enable the tracking of vehicle movements in the manoeuvring area when possible. Facilitate situational awareness by adopting technologies that enable ATC and other parties to locate and identify traffic in the manoeuvring area.
ADR32	Assess technical feasibility and business sustainability of new procedures and technologies for runway inspection.
ADR33	Implement policies and means to support vehicle drivers with identification of hold limits in respect to the protected area of a crossing runway (e.g., marking, geofencing, airport moving map).

RECOMMENDATIONS TO AIR NAVIGATION SERVICE PROVIDERS

REF	Recommendation
	SAFETY MANAGEMENT AND SUPPORT FOR RUNWAY SAFETY TEAMS
ANSP1	Support the regulator to periodically assess the effectiveness of aerodrome local runway safety teams (LRSTs), including the existence and implementation of runway safety action plans. Annually assess own contribution to the effectiveness of the aerodrome LRSTs. Promote the creation and support the work of a national runway safety team.
ANSP2	Ensure harmonised awareness of runway incursion risk management procedures, practices and issues among the front-line operators (pilots, air traffic controllers and manoeuvring area vehicle drivers). Support aerodrome operators to develop aerodrome-specific educational materials to familiarise pilots and vehicle drivers with hot spots and other aerodrome-specific safety information in the aerodrome environment.
ANSP3	Annually assess, and update as necessary, how runway incursion risk management is included within initial and refresher/recurrent training of operational staff.
ANSP4	Ensure that information is provided to, and requested from, all participating parties in an incident, so that a complete picture of causal and contributory factors can be built, lessons learned and actions taken.
ANSP5	Share at local, national and international level the lessons learned and salient safety information from occurrence investigation reports and runway safety analyses.
ANSP6	Ensure that arrangements are in place to coordinate changes to manoeuvring area procedures, including work in progress, with stakeholders operating on the manoeuvring area of the aerodrome. Periodically assess the effectiveness of the arrangements and update as necessary.
ANSP7	Periodically (initially and upon change) review runway capacity–enhancing procedures when used either individually or in combination (intersection departures, multiple line-ups, conditional clearances etc.) to identify any potential hazards and, if necessary, develop appropriate mitigation strategies.
ANSP8	Annually assess the consistency of runway safety procedures for operation on the manoeuvring area of the aerodrome internally and at LRST meetings. The assessment should include coordination and communication procedures and practices between ATC work positions and between ATC and the other parties operating on the manoeuvring area.
ANSP9	In coordination with the aerodrome operators, periodically review the procedures for runway inspections and other runway works. This should include: a. Carrying out routine runway inspections in the opposite direction of runway movements with illuminated vehicle lights regardless of time of day. b. Informing flight crew of the runway inspection in progress in case of aircraft on final approach or approaching the runway holding position. c. Implementing procedures to increase overall situational awareness when vehicles occupy a runway (to be decided locally, e.g., technology, 'vehicle operation normal' calls or other means). d. Implement standard routes and timings for routine runway inspections. e. Wherever practicable, approval for a planned runway inspection should be given when there is sufficient time for the inspection to be carried out without any interruption. f. New procedures and technologies (e.g., unmanned aircraft systems) for runway inspection should be assessed for future implementation.
	SAFE RUNWAY OPERATIONS COMMUNICATIONS
ANSP10	Develop and implement a phased plan for use of one frequency and English language for all communication associated with the operation of a runway. The phased plan should aim at improving the shared situational awareness of all front-line operators and should include realistic and practicable measures that provide an adequate level of safety for each of its phases.

REF	Recommendation
ANSP11	Periodically evaluate radio telephony practices, assessing elements such as frequency loading and use of ICAO-compliant phraseology. Promote wherever practical ATC teamwork in crosschecking communication messages and read backs.
ANSP12	Ensure that ATC communication messages are not overly long or complex in order to assist pilots and vehicle drivers to maintain good situational awareness whilst taxiing or during critical stages of operations.
ANSP13	Ensure that, whenever practicable, en route clearances are passed prior to taxi, and, in order to avoid flight crew distractions during taxi, consider passing any revision to the en route clearance whilst the aircraft is stopped.
ANSP14	Ensure that air traffic controllers always use the phrase: "HOLD POSITION" when passing a revised clearance to an aircraft that is at a holding position or on the runway.
ANSP15	In cooperation with aerodrome operators, implement procedures for airside vehicle drivers, including standard phrases for: a. Radio checks and readability scale. b. Radio communication failures (transmitting blind). c. The use of predefined and process-specific discrete call signs for manoeuvring area vehicles. d. When a driver becomes lost or uncertain of a vehicle's position in the manoeuvring area. e. Position reporting. f. Runway access and runway crossing requests
ANSP16	In relation to conditional clearances: a. The procedures should eliminate or mitigate the risk of the operational use of conditional clearances. b. If conditional clearances are used, ensure a policy and procedures are developed and implemented in accordance with ICAO provisions. c. Ensure that air traffic control officers (ATCOs) are aware of potential threats and errors when using conditional clearances.
AERONAUTICAL INFORMATION	
ANSP17	In relation to aeronautical information: a. In coordination with aerodrome operators, implement procedures to ensure that significant and up-to-date aerodrome information which may affect operations on the runway is provided to manoeuvring area drivers and pilots (e.g., by notices to airmen (NOTAMS), ATIS, R/T, maps, new digital technology or other means). b. Information on temporary changes to operating conditions at the aerodrome should be optimised to increase the situational awareness of the most critical changes. When needed, an AIP supplement with graphics and charts should be published.
SUPPORTING PILOT WORKLOAD AND PRESSURES MANAGEMENT	
ANSP18	In relation to standard taxi routes: a. Assess the risk potential of taxiing traffic confusion on or near the runway and mitigate it by implementing, whenever practicable, the use of standard taxi routes. b. If standard taxi routes are implemented, they should be published with clear designators. c. To reduce complexity during taxi operations, the number of published standard taxi routes should be restricted to only the routes with potential risk of taxiing traffic confusion.
ANSP19	When planning a runway assignment change for departing or arriving traffic, consider the time the flight crew will need to prepare/rebrief. As far as practicable, changing the runway assignment for an aircraft taxiing for departure should be avoided.

REF	Recommendation
ANSP20	To prevent pilots from taking the wrong intersection, a line-up and/or take-off or crossing clearance should be issued only when the aircraft is at or approaching the runway holding position and there are no intersections on the taxiway ahead of the aircraft.
ANSP21	Line-up clearance should not be issued if: a. The pilot has reported the aircraft is not ready to depart. b. The aircraft is expected to wait on the runway for more than 90 seconds for the take-off clearance. If the aircraft holds on the runway for longer than 90 seconds, an updated instruction should be provided to the pilot.
ANSP22	If the take-off clearance is not issued together with the line-up clearance, the phrase "line-up and wait" should be used.
ANSP23	Ensure that when an aircraft is instructed to line up and wait due to a reason other than usual runway traffic spacing, the aerodrome controller provides the reasons for waiting (e.g., provides information about traffic to cross the runway).
ANSP24	Issuance of a premature or late landing clearance should be avoided. Criteria should be decided locally (e.g., not before the final approach fix/final approach point (FAF/FAP), not below 1,000 ft above ground level).
ANSP25	Assess the policy, procedures and practices related to the use of "immediate departure" to avoid, as far as practicable, its use or mitigate the associated runway incursion risks.
ANSP26	Assess the policy, procedures and practices related to the use of line-up clearance while runway inspection is in progress to avoid, as far as practicable, its use or mitigate the associated runway incursion risks.
ENHANCED PROCEDURES FOR SAFE RUNWAY OPERATIONS	
ANSP27	Assess the current procedures and practices regarding runway occupancy status and ensure the use of memory aids, considering also the availability of new/emerging technologies.
ANSP28	a. In cooperation with aerodrome operators, implement H24 stop bars or other lighting systems (e.g., ARIWS) at all active runway holding positions to provide a level of safety commensurate with the level and complexity of operations and the potential risk of runway incursion. b. Ensure that stop bars at runway holding positions are controlled by the controller in charge of the runway operations on that runway (aerodrome controller). c. In cooperation with aerodrome operators, implement procedures, in line with the applicable regulations to be followed in case of stop bar unserviceability.
ANSP29	Assess the sight lines from the tower visual control room (VCR) and existing visibility restrictions which have a potential impact on the controllers' ability to see the runway and: a. Implement appropriate short-term mitigations, and b. Identify longer-term improvement measures.
ANSP30	Review controllers' tasks, the operational environment and operating procedures to ensure optimal "heads-up" time for aerodrome controllers.
ANSP31	Ensure that operating procedures include monitoring of aircraft vacating runways, in particular where the exit taxiway may lead directly to another runway (crossing).
ENHANCED TECHNOLOGY FOR SAFE RUNWAY OPERATIONS	
ANSP32	Consider the implementation of runway safety nets and emerging technologies that can improve the situational awareness of front-line operators.
ANSP33	Improve situational awareness by adopting the use of technologies that enable location identification of traffic on the manoeuvring area (e.g., via GPS with transponder, Mode S squitter).

RECOMMENDATIONS TO AIRCRAFT OPERATORS

REF	Recommendation
	SAFETY MANAGEMENT AND TRAINING
AO1	Aircraft operators should, through their safety management systems, ensure that information is collected on all runway and taxiway incursion incidents and perform analysis and risk assessments to identify risks and contributing factors. Operators should develop and implement action plans to mitigate identified risks and monitor the implementation/effectiveness of those action plans.
AO2	Aircraft operators should actively participate in aerodrome local runway safety team (LRST) activities.
AO3	Aircraft operators should actively participate in safety information–sharing programs that would allow them to benchmark their safety performance (including runway incursions) with the industry and get a better awareness of existing and emerging safety risks.
AO4	Aircraft operators should provide training for pilots regarding aerodrome signage, markings and lighting. Operators should ensure pilot competence in this area is achieved both during initial and recurrent training.
AO5	Aircraft operators and training providers should include realistic, evidence- and competency-based scenarios in their training programmes, requiring threat and error management for runway incursion prevention and mitigation.
AO6	Aircraft operators should, through their initial and recurrent training programmes, ensure pilots use standard RT phraseology, in the English language, and are aware of the runway incursion risks of non-standard RT procedures. Flight crews should be trained to recognise and increase own vigilance when local ATC procedures are non-standard, when ATCOs speak too quickly or when frequencies are congested.
	GROUND OPERATIONS
AO7	Aircraft operators should implement policy and procedures that enable flight crews to plan ground operations effectively, by providing up-to-date airport charts, relevant NOTAMs, active runway configuration, latest weather/airfield conditions, and airport briefing sheets, in order to provide optimum situational awareness and reduce runway incursion–related risks.
AO8	Aircraft operators should consider implementing threat and error management–based briefings which focus on threats for the taxi phase and runway incursions.
AO9	Aircraft operators should implement policies or standard operating procedures (SOPs) for flight crews not to conduct a take-off or an approach following any runway change until the appropriate set-up, planning, performance calculations and re-briefings are completed. When a take-off runway change is received whilst taxiing, set-up, planning, performance calculations and re-briefings should be performed by the flight crew without rushing and when the aircraft is stationary.
AO10	Aircraft operators should implement policy and procedures that aerodrome charts must be displayed on the flight deck during taxi. This includes when operating at home and familiar aerodromes. Operators should consider implementation of flight deck moving map technology, where feasible, and provide crews with training and procedures for use of moving maps, including any built-in runway incursion prevention systems.
AO11	Aircraft operators' procedures should include maintaining a sterile flight deck during all aerodrome surface movements, as well as during flight below 10,000 ft above ground level (AGL).

REF	Recommendation
AO12	Aircraft operators should implement policy and ensure procedures are in place for flight crews who doubt their exact position on the surface of an aerodrome. These procedures should include guidance on stopping the aircraft immediately and contacting ATC.
AO13	Aircraft operators should implement policy and procedures which require pilots to handle and process ATC clearances during ground manoeuvring with the same caution and attention as in-flight clearances. Operators should consider SOPs on recording and verbalising the clearance so that all crewmembers have a shared understanding of the routing, including when pilot-off-air.
	WORKLOAD MANAGEMENT AND MONITORING
AO14	Aircraft operators should publish SOPs and guidance and provide training highlighting the importance of active monitoring and effective intervention by the pilot monitoring (PM) during taxi-in and taxi-out, especially when another runway is crossed.
AO15	Aircraft operators' procedures should include policy and procedures to minimise "heads-down" activities and enable effective monitoring of the movement area whilst taxiing. For multi-pilot flight decks, "heads-down" activities for more than one pilot should be restricted to times when the aircraft is stationary with the parking brake set.
AO16	Aircraft operators should train and allow both pilots to be the pilot flying (PF) on the ground, commensurate with aircraft configuration and systems. Where not feasible, the right-seat pilot should be trained in intervention strategies and handover procedures which effectively mitigate runway incursion risks.
AO17	Aircraft operators should implement policy and procedures which encourage pilots of departing aircraft to manage workload so that the aircraft arrives at runway holding points with all crewmembers maintaining good lookout/listen-out and having strong situational awareness regarding current aircraft position, runway clearance status and other traffic (on same, parallel and intersecting runways).
AO18	Aircraft operators should implement policy and procedures which address and manage the runway incursion risks of engine-out-taxi (EOT). Policy should address risks such as "heads-down" activities, distraction and exposure to surface movement errors.
	RUNWAY OPERATIONS
AO19	Aircraft operators should discover and consider implementation of technology which increases pilot awareness of airborne traffic when approaching the runway holding positions and supports crew decision-making regarding safe runway entry, e.g., airborne traffic situation awareness (ATSAW). New runway incursion technology developments, which provide real time on-board conflict detection and collision prevention on the runway, should also be considered for implementation by operators.
AO20	Aircraft operators should implement policy and procedures that mitigate the runway incursion risks associated with using rapid exit taxiways or angled taxiways for line-up or crossing; these taxiways can limit the ability of the flight crew to see the runway threshold or the final approach area.
AO21	Aircraft operators should implement policies for flight crews in relation to extended time on the active runway before take-off and the associated runway incursion risks. The policy should include guidance on, but not limited to, entering a runway when not ready for departure, engine run-ups, departure path assessment and back-tracks.
AO22	Aircraft operators should have a strict policy that pilots shall not cross illuminated red stop bars. Policy and procedures should mandate that crews do not cross stop bars when lining up or crossing a runway (or taxiway), even with an ATC clearance but instead must challenge the clearance. Operator and aerodrome procedures should include contingency procedures to cover cases where the stop bars or controls are unserviceable.

REF	Recommendation
AO23	Aircraft operators should provide flight crews with guidance and training on ARIWS (e.g,. runway status lights (RWSL), where relevant to the operation. Guidance should include technical information, guidance on inclusion in flight crew briefings, and clear policy for dealing with activation (e.g., "Red means Stop").
AO24	Aircraft operators should ensure that flight deck procedures contain a requirement for explicit clearances to enter, cross or land on any runway, regardless of runway status (active/inactive). Operator policy should require each flight crewmember to independently hear the three parts of any runway clearance (call sign, clearance and runway), and procedures should include clear, effective means to ensure crew understanding and mitigate cognitive bias. Any doubts must be resolved immediately.
AO25	Aircraft operators' procedures should include a means (memory aid) for the pilot flying (PF) and PM to visually indicate, crosscheck and verify receipt of any ATC clearance to enter, cross, line up, take off and land.
AO26	Aircraft operators' procedures should require pilots to make optimum use of all exterior lights to increase the aircraft's detectability when approaching a runway, especially at night. All forward-facing lights should be switched on, at the latest, after receiving, confirming and verifying clearance to take off or land.
AO27	Aircraft operators should implement policy and procedures to manage the threat of early runway clearances (take off, line up, cross, land). Policy should include tools to help flight crew recognition of the threat, and if there is any uncertainty, crews shall request confirmation of clearance before entering the runway.
AO28	Aircraft operators should implement policy and procedures to manage the threat of conditional runway clearances (take off, line up, cross, land). Policy should include tools to help flight crew recognition of the threat, and if there is any uncertainty, crews shall request confirmation of clearance before entering the runway.
AO29	Aircraft operators should implement policy, technical solutions or SOPs which confirm that the aircraft is using the correct intersection and lining up on the planned runway (e.g., by verbally confirming the correct intersection and runway).
APPROACH AND LANDING	
AO30	Aircraft operators should implement policy and procedures which require flight crews conducting visual approaches to verify final approach path and runway with reference to GPS, area navigation (RNAV) position information or conventional navigation aids in order to avoid wrong-surface landings. When available, same runway instrument landing system (ILS) frequencies should be tuned, identified and displayed. Visual approaches to parallel runway systems require special risk mitigation, particularly if runways are close-spaced, have parallel taxiways or visual cues are reduced (at night, in low visibility, etc).
AO31	Aircraft operators should implement policy and procedures that flight crew, as part of the approach briefing, include planned runway exit and strategies to mitigate runway incursion threats during taxi to parking (including runway crossing or should the planned exit be missed). Operator training and policy should highlight to crews the human error potential during this phase, when crews may be distracted by events on approach/landing and after-landing tasks, and their attention may drift to the next flight or the end of duty.

RECOMMENDATIONS TO MANUFACTURERS

REF	Recommendation
MFR1	Aircraft manufacturers should consider developing a real-time, on-board functionality to provide flight crew with awareness of aircraft runway operations.
MFR2	Aircraft manufacturers should consider developing a real-time, on-board functionality to provide flight crew with alerting in case of a risk of a runway collision with another aircraft.
MFR3	Vehicle navigation system manufacturers, in collaboration with aerodrome operators, should consider developing and providing a real-time functionality to provide airside vehicle drivers with awareness and alerting in case of a risk of a runway collision between an aircraft and an airside vehicle and with real-time alerts when crossing into the protected area, such that drivers will be alerted in the event of a runway incursion.
MFR4	Aircraft manufacturers should consider developing on-board functionality that helps flight crew in the manoeuvring area to confirm their location in relation to the runway and taxiways.
MFR5	Aircraft manufacturers should consider developing real-time, on-board functionality to provide flight crew with awareness and alerting to prevent taking off or landing on a wrong runway or on a taxiway.
MFR6	Aircraft manufacturers should consider providing flight crew awareness when aircraft systems contributing to position surveillance (e.g., Mode-S, ADS-B, etc.) or runway collision–prevention functions — when available — are deactivated or failed in a phase when these functions are normally active by convention or design.

RECOMMENDATIONS TO STATES AND REGULATORS

REF	Recommendation
REG1	As part of the State's safety management activities, ensure that the establishment and operation of aerodrome local runway safety teams (LRSTs) is included in the regulator's aerodrome, flight operations and air traffic management (ATM) oversight programme.
REG2	Ensure that the GAPPRI is used in runway incursion prevention training and familiarisation for all key stakeholders — pilots, air traffic controllers and manoeuvring area vehicle drivers.
REG3	As part of the regulators oversight programme: a. Ensure that the subject of runway safety is included within initial and recurrent training with specific reference to manoeuvring area signs, markings and lights for pilots and drivers. b. Ensure that the content of training materials for pilots, air traffic controllers and drivers working in the manoeuvring area includes runway incursion prevention measures and awareness.
REG4	a. During aerodrome, ATM and flight operations oversight activities, specific assessment should be made of the role of the LRST in relation to any changes to the manoeuvring area procedures, with particular reference to a change management plan (e.g., for dealing with structural and layout changes and works in progress on the manoeuvring area). b. Conduct periodic reviews of the effectiveness of methods whereby temporary closures or repairs to runways and taxiways, and associated safety-critical infrastructure (e.g., lighting and signage) are promulgated to aircraft operators. The reviews should aim to improve the publications with regard to the ease of use and interpretation of NOTAMS or other communication means for flight crews and vehicle operators.
REG5	Promote that all vehicles on the manoeuvring area are in radio contact with the appropriate ATC service (i.e., ground and/or the tower), either directly or through an escort.
REG6	Ensure that all aerodrome vehicles are assigned unique numbers or airside identification call signs for each airside vehicle to reduce the risk of vehicle-related call sign confusion.
REG7	As part of regulatory oversight, assess the operational use of aerodrome ground lighting (e.g., stop bars) to ensure a robust policy to protect the runway from the incorrect presence of traffic. Wherever practicable, the use of H24 stop bars at all runway holding positions should be considered, as this has been shown to be an effective runway incursion prevention barrier. The use of ARIWS at all runway holding positions should also be evaluated.
REG8	National agencies charged with the oversight of aviation safety should consider how they discharge their responsibilities for runway safety risk management, which may include: a. The establishment and coordination of a national/state runway safety group that will address the prevention of runway incursions and runway collision risk. b. Define the prevention of runway incursions as a safety priority, with associated risk mitigation actions, in national aviation safety plans. c. Support the statewide promotion and coordinated implementation of GAPPRI to include incorporation of relevant elements into national aviation safety plans.
REG9	Where more than one aerodrome operator exists at a joint-use aerodrome, a leading aerodrome operator should be identified to secure a harmonised, consistent and coordinated application of the recommendations for the prevention of runway incursions.
REG10	Differences in the application of civil and military traffic procedures that can affect operational safety should be published in accordance with ICAO Annex 15, Aeronautical Information Services.

REF	Recommendation
REG11	Coordinate civil and military inspection/audit activities and subsequent safety recommendations with civil and military authorities to ensure runway incursion mitigations are jointly agreed and implemented.
REG12	GAPPRI recommendations on infrastructure (e.g., stop bars) should be implemented at civil/military joint-use aerodromes where civil aircraft operations are permitted.
REG13	International, regional and national regulatory authorities should define, clarify and standardize the size, extent and layout of the 'protected area of the runway'. Regulators should ensure that the protected area is agreed to by the aerodrome operator and the ANSP and that it recognises the relationship between the runway strips, runway cleared and graded areas, runway holding positions, obstacle free zone and any low visibility operations requirements.
REG14	International and regional regulatory authorities should review standards and guidance material for visual aids at runway holding positions to allow for more accurate aircraft positioning for all types of aircraft with varying flight crew field of vision. This includes, but is not restricted to, visibility of stop bars, aircraft low point-of-view assessment, the orientation of the lights and the view in situations where an aircraft is stopping at distance to keep sight of stop bars.
REG15	The regulator should ensure that during flying operations inspector (FOI) checks, ground and taxi manoeuvres are seen as key flight elements in flight crew briefings.
REG16	States should ensure that, as part of their safety management and oversight responsibilities, the variable level of runway incursion risk is assessed at those aerodromes that cater solely to large commercial air transport (CAT), mixed CAT with business and general aviation, and only general aviation and that actions are taken as appropriate in case of risk profile differences.

RECOMMENDATIONS FOR R&D TO STATES, INTERNATIONAL ORGANISATIONS AND THE INDUSTRY

REF	Recommendation
R&D1	Research improvements for ground-based runway collision alerting systems that improve detection-reaction times.
R&D2	Research use of high-fidelity cameras and artificial intelligence (AI) to detect ground movements on and around runways.
R&D3	Research data-driven runway collision safety by using automated analysis of air-ground communication recordings.
R&D4	Research the human performance aspects of detection and reaction to runway signs, markings and lighting, including stop bars.
R&D5	Research new ways of delivering direct auditory warnings, alarms, alerts for runway collision risk in the cockpit.
R&D6	Research and develop an on-board functionality that provides a flight crew with visual aids concerning taxi clearance and signs corresponding to runway and airport status (e.g., out-of-service zones).
R&D7	Research visual aids on the airport surface regarding ATC clearance or impediments.
R&D8	Research ways to lower the activation threshold speed of ground-based runway collision alerting systems.

Global Action Plan for the Prevention of Runway Incursions

Part 2 - Guidance and Explanatory Material

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APPENDIX A
Guidance and Explanatory Material for Aerodrome Operators

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1. SMS and LRST - General

Recommendation ADR1: Annually assess own contribution to the effectiveness of the aerodrome local runway safety teams (LRSTs), including the existence and implementation of runway safety action plans.

Recommendation ADR2: Ensure harmonised awareness of runway incursion risk management procedures, practices, and issues among the front-line operators (pilots, air traffic controllers, and manoeuvring area vehicle drivers).

Recommendation ADR3: Annually evaluate the consistency of runway safety procedures for operation on the manoeuvring area of the aerodrome (pilots and manoeuvring area vehicle drivers) at LRST meetings.

Why should aerodrome operators follow these recommendations?

It is recognized as a best practice for aerodrome operators to lead local runway safety teams (LRSTs) as a means of enhancing runway safety. However, regardless of who leads the effort, it is critical for aerodrome operators to actively participate in LRSTs. A systematic evaluation of their involvement in the LRSTs, focusing on the effectiveness of runway safety action plans (RSAPs) and the teams that implement them, is a proactive means to identify potential improvements and mitigate risk in order to strengthen the aerodrome's safety management system.

Sharing of investigative outputs carried out by each participating organisation in its respective and specific field of expertise and applying consistent and harmonised procedures contribute to a safer operational environment. To maintain a cohesive understanding of runway incursion risk management, aerodrome operators, in cooperation with air navigation service providers (ANSPs), should actively involve front-line personnel, including pilots, air traffic controllers, and vehicle drivers, in the awareness and adherence to risk management procedures, practices, and issues that play a vital role in preventing runway incursions. The goal is to promote a harmonised approach to safety procedures, ensuring a safe operational environment.

Periodic evaluations, conducted as part of LRST meetings, ensure the integrity and consistency of runway safety procedures. Such assessments allow aerodrome operators to address any discrepancies in their procedures and practices, reinforce best practices, and foster a strong safety culture within the aerodrome's manoeuvring area.

It may be necessary to convene the LRST on a more frequent basis, as appropriate. Some aerodromes may need to do so twice per year, once each quarter, or on an ad hoc basis when upcoming special events or construction projects would deem it necessary to bring together aerodrome stakeholders for runway safety discussions.

What can aerodrome operators do to implement the recommendations?

Recommendation ADR1: Aerodrome operators should establish a comprehensive process for the annual assessment of their contribution to the effectiveness of the aerodrome LRSTs.

This should include:

- Review of the existence and implementation of RSAPs;
- Identification of potential runway safety issues;
- Effectiveness of existing measures for reducing runway incursions;
- Discussion of new initiatives;
- Review of key metrics, such as the reduction in runway incursions year-over-year; and,
- Overall performance of the runway safety team.

The assessment process should be structured and systematic. It could be undertaken by every participant and then shared, or caried out jointly during the LRST meeting. The assessment process should ensure a comprehensive understanding of the effectiveness of the measures in place and identify areas for improvement. It should involve key stakeholders such as:

- Air traffic control officers (ATCOs);
- Pilots, representing all aerodrome user groups;
- Locally based and transient users, when possible;
- Relevant ground personnel; and,
- Pilot and controller associations.

The assessment should include a review of ad-hoc operational feedback by pilots and ATCOs, incident reports, safety data, and any corrective actions taken in response to previous runway safety incidents. Additionally, the assessment should consider feedback from the runway safety teams and incorporate lessons learned from past mitigated events, as well as incidents to enhance future safety measures.

Additionally, reviews of existing procedures and their completeness could be undertaken to proactively identify gaps in the routine adherence to safety procedures in order to identify any areas for improvement. Runway incursions often happen due to the alignment of gaps in barriers (as shown by the Reason, or "Swiss cheese", model used in risk analysis and risk management). Proactively checking things such as radio telephony readback, driver radio telephony skills, selection of airfield ground lighting, and correctness of runway inspections may spot emerging risks before a trend leads to an accident.

The International Civil Aviation Organisation (ICAO) Runway Safety Team Handbook provides excellent guidance on the implementation of runway safety teams and offers sample templates for agendas, forms to document the team's work, and example cases.

Related GAPPRI Recommendations: ANSP1, AO2, REG1, REG4a, REG8

Recommendation ADR2: Aerodrome operators should support harmonised awareness of runway incursion risk management procedures among front-line operators, including pilots, air traffic controllers, and manoeuvring area vehicle drivers. This involves collaboration with ANSPs to develop and implement training programs and communication strategies to enhance awareness and understanding of runway incursion risks.

Training programs should cover the latest procedures, practices, and issues related to runway incursion risk management. This includes regular updates to ensure that front-line operators are well-informed about evolving safety standards and best practices. These programs should be designed for all personnel and harmonise content with training provided to other operators, including pilots, air traffic controllers, and ground crew, to educate them about runway safety, the causes and consequences of runway incursions, and best practices for prevention.

For example, development of airport briefings or online training accessible to frontline operators that emphasises common procedures, communication protocols, and safety practices related to runway operations at the specific aerodrome. This module should include:

- Interactive scenarios simulating common runway incursion risks;
- Quizzes to test understanding; and,
- A section on airport-specific procedures, configuration and hot spots.

Training should also incorporate case studies of past incidents to highlight potential risks and the importance of adherence to procedures.

Communication strategies should facilitate the exchange of information among different stakeholders, promoting a shared understanding of the importance of runway safety and the role each party plays in mitigating risks. Regularly conducted safety campaigns and awareness programs can assist in keeping the issue of runway incursions at the forefront of airport operations. Hosting or participating in workshops and seminars can facilitate the exchange of information and experiences among different stakeholders (pilots, air traffic controllers, and vehicle drivers) to provide a more nuanced understanding of the risks and mitigations around runway incursion risk at the aerodrome.

Related GAPPRI Recommendations: ANSP2, REG3b

Recommendation ADR3: Aerodrome operators should conduct an annual evaluation of the consistency of runway safety procedures for operations on the manoeuvring area. This evaluation may be undertaken by every participant internally and then shared, and/or carried out jointly during the LRST meeting. It should involve air traffic controllers, pilots, and manoeuvring area vehicle drivers. The goal is to ensure that all relevant parties are aligned in their understanding and implementation of runway safety procedures.

The evaluation should involve:

- Systematic review of any changes to procedures related to runway operations and discussion of real-world practices and any discrepancies or challenges encountered during daily operations. (Use a checklist to ensure all aspects of runway operations are covered.)
- Comparison of current procedures with updated best practices and/or updated regulatory requirements.
- Review of recent incident reports to identify inconsistencies or gaps and develop action plans to address them.
- Discussion of practical insights from frontline operators (e.g., derived from targeted safety surveys distributed to ATCOs or aircraft operators).

The aim is to identify areas of improvement, address potential sources of confusion or misunderstanding, and enhance the overall consistency and effectiveness of runway safety procedures.

Implementing these recommendations requires a systematic and collaborative approach involving all relevant stakeholders at the aerodrome. Regular assessments, harmonised awareness programs, consistent procedures, and tailored risk

assessments are essential elements in enhancing runway safety and reducing the risk of runway incursions.

Related GAPPRI Recommendations: ANSP8, REG9

Reference materials:

ICAO Global Runway Safety Action Plan

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Runway Safety Team Handbook – Second Edition, June 2015

ICAO Runway Safety Toolkit

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

EASA Basic Regulation and Commission Regulation No 139/2014 (Aerodrome Regulation)

ACI Runway Safety Handbook – Second Edition 2022

SKYbrary.aero – Local Runway Safety Teams (LRST)

SKYbrary.aero – Hot Spots at Aerodromes

FAA Runway Safety Program – https://www.faa.gov/airports/runway_safety

2. SMS and LRST – Safety Learning and Sharing

Recommendation ADR4: Ensure that information is provided to and requested from all participating parties in an incident, so that a complete picture of causal and contributory factors can be built, lessons learned, and actions taken.

Recommendation ADR5: Share at the local, national, and international level the lessons learned and essential safety information from occurrence investigation reports and runway safety analyses.

Why should aerodrome operators follow these recommendations?

A safety culture that prioritises continuous improvement, collaborative learning, and transparency is crucial to creating a safer aviation system for all stakeholders.

By ensuring that relevant information is exchanged among all parties involved in an incident, aerodrome operators can help construct a complete and detailed picture of the events that led to an occurrence. This comprehensive understanding is essential in order to identify both the direct causes and the contributing factors of an incident, which might include operational, technical, human factors, or environmental aspects. After completing a thorough analysis of an incident, aerodrome operators can devise targeted actions and strategies that address the root causes and contributing factors, enabling them to significantly mitigate the risk of similar incidents in the future.

Sharing lessons learned and essential safety information aligns with international regulatory requirements and guidance, such as those from ICAO and the European Union Aviation Safety Agency (EASA), which promote transparency and collaboration to improve overall aviation safety. It also contributes to the collective knowledge base and the enhancement of safety standards across the aviation industry. This not only enables the aerodrome that experienced an incident to learn but also enables others to adjust their operations to prevent similar occurrences.

The dissemination of safety information and lessons learned on a wider scale — locally, nationally, and internationally — facilitates a global approach to risk mitigation. This harmonisation of safety efforts ensures that valuable insights are not restricted to one region or operator but are utilised for the benefit of the entire aviation community.

What can aerodrome operators do to implement the recommendations?

Aerodrome operators should consider the establishment of communication protocols designed to foster a comprehensive safety management system that addresses information-sharing about incidents and the dissemination of lessons learned.

Recommendation ADR4:

Aerodrome operators should consider:

- Developing or implementing an existing comprehensive electronic incident reporting system to collect pertinent information and facilitate and enhance the sharing of relevant information pertaining to incidents amongst all stakeholders involved in an incident, including pilots, ground handlers, and air traffic controllers. This may be an airport-level system, where appropriate, or a larger scale multi-user system managed by the civil aviation authority (CAA), an ANSP, or airlines.

  The system should be easily accessible and user-friendly to encourage reporting. It should prompt users for specific information, such as the time of the incident, parties involved, weather conditions, sequence of events, and other pertinent information, ensuring a comprehensive dataset.

- Implementing confidential reporting channels to protect the identity of reporters.

  Following the principles of just culture and promoting an organisational culture that encourages voluntary reporting of incidents without fear of punitive measures can be an effective way to gather more, and better, information related to incidents.

- Establishing joint committees and working groups to review incidents and share information.

  Communication between all relevant aerodrome departments and external stakeholders such as ANSPs, emergency services, and airlines can facilitate the collection of critical safety data. This can help ensure that a comprehensive investigation is completed by considering multiple perspectives and providing a more thorough understanding of the causal and contributory factors surrounding the incident.

Related GAPPRI Recommendations: ANSP4, AO1

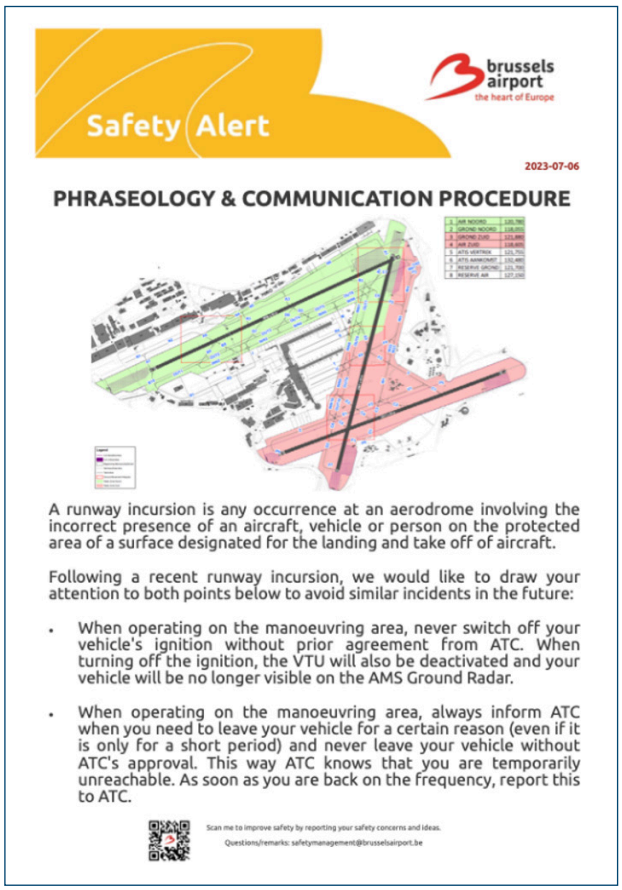
Recommendation ADR5:

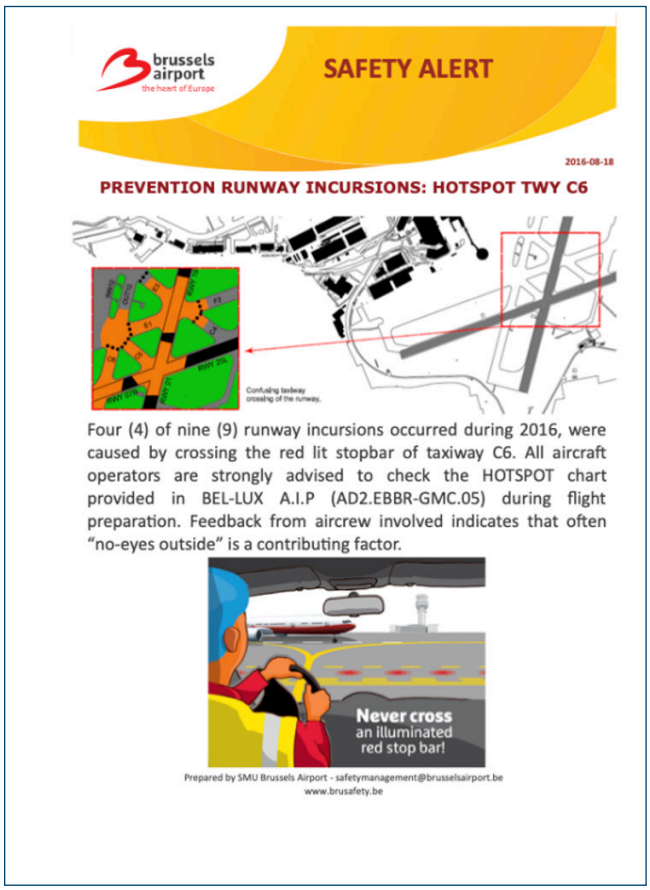
The sharing of safety information derived from the investigation and analysis of occurrences is a key component of improving systemic safety. There are many ways to facilitate communication, and it is important to select the methods that work best for your organisation. Below are some examples:

- Make use of LRSTs to facilitate the collection, sharing, and dissemination of relevant information and lessons learned from occurrence investigation and analysis.
- Develop a repository for storing and organising safety information, investigation outcomes, and best practices.
- Engage with industry groups, regulatory bodies, and safety organisations to share insights and learn from others' experiences. Host or participate in workshops, seminars, and conferences dedicated to runway safety.
- Leverage the internet and aviation safety platforms to disseminate information broadly and efficiently. Consider creating webinars, podcasts, or online courses that can reach a wide audience.
- Work with organisations such as ICAO, EASA, and Airports Council International (ACI) to align local practices with global standards. Contribute to and utilise existing safety databases such as Flight Safety Foundation's Global Safety Information Project (GSIP)), the U.S. Federal Aviation Administration's (FAA) Aviation Safety Information Analysis and Sharing (ASIAS) system, or the European Coordination Centre for Accident and Incident Reporting Systems (ECCAIRS).
- Regularly release safety bulletins and/or newsletters highlighting recent incidents, lessons learned, and preventive measures adopted. Distribute these publications to all stakeholders within the aerodrome community and beyond.

The safety bulletin examples shown below (Figure 1), is one simple and effective way to communicate important safety information to stakeholders.

Figure 1. **Safety bulletin examples**





Related GAPPRI Recommendations: ANSP5, AO3

Reference materials:

ICAO Annex19 – Safety Management Systems

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Procedures for Air Navigation Services (PANS) – Aerodromes (Doc 9981)

ICAO Global Runway Safety Action Plan

ICAO Runway Safety Team Handbook – Second Edition, June 2015

Commission Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation

European Union Aviation Safety Agency (EASA) ARA. GEN.125

ACI Runway Safety Handbook – Second Edition 2022

Airport Excellence (APEX) in Safety programme: *http://www.aci.aero/APEX*

SKYbrary.aero

FAA Advisory Circular 150/500-37, as amended – Safety Management Systems for Airports

Safety Management Systems (SMS) for Airport and Airport Projects *https://www.faa.gov/airports/airport_safety/safety_management_systems*

3. SMS and LRST – Safe Change Management

Recommendation ADR6: Coordinate changes to manoeuvring area procedures with stakeholders operating on the manoeuvring area of the aerodrome. Periodically assess the effectiveness of the arrangements and update as necessary.

Recommendation ADR7: Ensure that new aerodrome infrastructure and changes to existing infrastructure are designed to reduce the likelihood of runway incursions.

Recommendation ADR8: Assess all arrangements associated with aerodrome construction works in progress (WiP) and:

a. The potential for runway incursion during runway closure or WiP should be risk-assessed in coordination with the ANSP and resident aircraft operators, and mitigated.

b. Ensure that appropriate coordination between aerodrome operator and ANSP is in place prior to notifying the regulator.

c. Ensure that up-to-date information about temporary work areas and the consequential operational impact is adequately presented and disseminated.

d. Ensure that existing signs on related area are covered, lights are switched off, and markings are removed when appropriate.

e. Ensure that temporary signs and markings are clearly visible, adequate, and unambiguous in all applicable conditions.

Recommendation ADR9: In coordination with ANSPs and as part of management of change procedure before works, assess the sight lines from the tower visual control room (VCR) and existing visibility restrictions which have a potential impact on the controllers' ability to see the runway. Avoid such visibility restrictions or develop and implement appropriate short-term mitigations and identify longer term improvement measures whenever possible.

Why should aerodrome operators follow these recommendations?

Aerodrome operators must work proactively to prevent runway incursions within aerodrome operations. The integration of risk management, collaborative planning, continuous reassessment, and clear communication is essential to fostering a safety-oriented operational focus when introducing and managing change in the aerodrome environment.

The recommendation to ensure that arrangements are in place for coordinating changes to manoeuvring area procedures with stakeholders operating on the aerodrome is crucial for maintaining operational efficiency and safety. The manoeuvring area of an aerodrome is a dynamic environment with various activities, including aircraft movements, maintenance, and construction work. Effective coordination is essential to prevent conflicts, enhance communication among stakeholders, and mitigate potential safety hazards. Regular assessments of the coordination arrangements allow the identification of any shortcomings or evolving challenges, enabling timely updates to the procedures to align with current operational needs and industry standards. This proactive approach contributes to the overall safety and smooth functioning of the aerodrome's manoeuvring area.

Designing new or modified aerodrome infrastructure with the explicit goal of reducing runway incursions can significantly decrease the risk of accidents. This includes considering the layout, signage, lighting, and markings to minimise potential confusion or misinterpretation by pilots and ground vehicle operators.

Assessing the potential for runway incursion during any period of construction work helps in identifying and mitigating risks beforehand and should be a collaborative effort with all stakeholders.

- Working in conjunction with ANSPs and ensuring communication with regulators helps maintain operational safety and regulatory compliance.
- Keeping all stakeholders informed about temporary work areas and their operational impact prevents misunderstandings and operational errors.
- Close management of signs, lights, and markings during construction or changes ensures clarity for all aerodrome users and helps prevent incursions or confusion.

Prior to initiating construction works, ensuring the tower VCR has clear sightlines to the manoeuvring areas is crucial for air traffic controllers to maintain situational awareness and

manage traffic safely. Assessing and mitigating any visibility restrictions, through the use of cameras or other means, are essential to prevent potential safety risks associated with construction or changes to the aerodrome layout.

What can aerodrome operators do to implement the recommendations?

Recommendation ADR6: Aerodrome operators should establish a collaborative framework with all stakeholders operating within the manoeuvring area, including air traffic control, ground services, and airlines, to ensure that any procedural changes are thoroughly coordinated.

This may involve:

- Implementing a process where frontline operators can provide input on proposed changes before they are finalised;
- Establishing a formal change management committee comprising representatives from different airport stakeholders, including airline representatives, ground handling services, and ANSPs;
- Setting up regular meetings to discuss potential changes;
- Assessing the impact of these changes through simulations or phased implementation;
- Gathering feedback from stakeholders to periodically evaluate the effectiveness of procedures; and,
- Making revisions based on feedback and continuous monitoring of operations to maintain the highest safety standards.

Related GAPPRI Recommendations: ANSP6, REG4a

Recommendation ADR7: Aerodrome operators should integrate runway incursion prevention as a core objective in the design and modification of aerodrome infrastructure in accordance with ICAO DOC 9157 Part 2 "Taxiways, Aprons and Holding Bays" and ICAO Annex 14, Attachment A. This requires a proactive approach to design, considering factors such as taxiway layout, signage clarity, marking, and lighting. Operators should engage with design experts and safety specialists early in the planning stages to ensure that new infrastructure minimises confusion or conflicts that could lead to incursions. Additionally, existing infrastructure should be regularly reviewed and updated in line with the latest safety standards and technological advancements to mitigate incursion risks. This should also include a review of taxiway naming using the standard naming convention.

For example, in the United States, the Federal Aviation Administration built the Runway Incursion Mitigation (RIM) Program using 15 years' worth of runway incursion data. Over 17,500 runway incursions, and more than 6,700 non-standard runway/taxiway intersections at more than 525 airports have been georeferenced, assessed, and incorporated into a Geographic Information System Database that can, when applicable, associate incursions with non-standard geometry sites and known hot spots.

Additionally, the use of simulation software to model aircraft and vehicle movements in proposed new or modified aerodrome layouts can be effective to help predict the impact of design changes on runway safety.

Operators should:

- Engage stakeholders (pilots, vehicle drivers, and air traffic controllers) early in the design process to gain practical insights; and,
- Focus on identifying potential conflict points and designing layouts that minimise associated risks.

During the design and construction phases of Istanbul Airport (IST), simulations were utilised to evaluate air traffic movements in the air and on the ground, as well as ground vehicle flows. This approach facilitated the identification of requirements and the implementation of effective measures such as end-around taxiways (EAT) and the integration of tunnels beneath the runways and taxiways. These initiatives were aimed at mitigating aircraft-aircraft and aircraft-vehicle collisions on the airside while optimising operational efficiency.

The EAT enables two Code-F aircraft to cross paths with each other on the taxiway beneath the approach line without causing runway incursions or disruptions to operations. Simultaneously, a third Code-F aircraft can safely land on the runway above them. This configuration enhances both capacity and safety.

Similarly, the tunnels constructed beneath the runways and taxiways have significantly decreased the likelihood of aircraft-vehicle encounters on the airside, thereby preventing accidents. Thanks to the tunnels, all vehicle and aircraft traffic flows can be separated.

These proactive measures demonstrate a commitment to enhancing safety and operational effectiveness at IST.

Recommendation ADR8: When planning and carrying out works in progress on the manoeuvring area, the aerodrome operator and the ANSP should coordinate to ensure that:

- In the design stage that the changed layout does not increase the likelihood of runway incursions;
- The layout changes are disseminated in the Aeronautical Information Publication, NOTAMs or automatic terminal information service (ATIS) and local airfield notices in a timely fashion to provide clarifying information (such as pictures), as appropriate.
- Information to be promulgated should be discussed and coordinated with directly affected stakeholders and subjected to checks to ensure that its meaning is clear to potential users.

The transition into and out of any work on the aerodrome can be particularly challenging and needs to be carefully managed by ATC and the aerodrome operator to avoid misunderstandings about the status and availability of aerodrome surfaces and equipment.

The coordination between the ANSP and aerodrome operator is usually performed, in full or in part, through the aerodrome safety teams with additional arrangements, when needed, to ensure coordination effectiveness. The arrangements to coordinate changes and to periodically review the capacity enhancement procedures to identify any potential hazard should be implemented by considering the following:

- Establish a dedicated coordination mechanism: Implement a structured system for coordinating changes to manoeuvring area procedures and for periodic review of the capacity enhancement procedures, designating responsible parties and communication channels.
- Identify key stakeholders: Identify and engage relevant stakeholders operating in the manoeuvring area, including air traffic control, ground services, maintenance teams, and other involved parties.
- Develop a communication protocol: Define clear communication procedures for disseminating information about changes to manoeuvring area procedures, ensuring timely and accurate transmission to all stakeholders.
- Regularly review and update the coordination mechanisms: Conduct periodic reviews of the effectiveness of the coordination arrangements, assessing their impact on operational efficiency and safety. Update mechanisms as needed to address any identified shortcomings or changing operational requirements.
- Foster a culture of continuous improvement: Encourage feedback from stakeholders and promote a culture that values ongoing assessment and enhancement of manoeuvring area procedures to adapt to evolving circumstances and maintain optimal safety and efficiency.
- Form a review team: Create a dedicated team responsible for conducting the reviews, comprising experts in air traffic management, safety, and relevant operational areas. Team composition could be different depending on the task – review of the manoeuvring area procedures or capacity enhancement procedures.
- Identify potential hazards: During the review, systematically identify any potential hazards, considering factors such as increased traffic, weather conditions, and changes in aircraft types.
- Develop mitigation strategies: If potential hazards are identified, work collaboratively with stakeholders to develop and implement appropriate mitigation strategies. These strategies may include procedural adjustments, additional safety measures, or technological enhancements.
- Communicate findings and updates: Share the results of the reviews and any implemented mitigation strategies with relevant stakeholders to ensure a collective understanding of the changes and promote a culture of safety and continuous improvement.
- Document and maintain records: Keep detailed records of the reviews, findings, and implemented changes, maintaining a comprehensive documentation system for future reference and regulatory compliance.

Aerodromes should incorporate formal safety risk management into the planning and development processes for new airport projects. Some aerodrome operators and ANSPs may elect to upgrade the work of the aerodrome safety team and implement some form of enhanced collaborative safety management. An example of such enhanced collaborative processes is the Integrated Safety Management System implemented by the Netherlands ANSP LVNL, Amsterdam Airport Schiphol, airlines, and other partners.

Following the crash of a cargo Boeing 747 into a built-up area of Amsterdam in October 1992, various investigations were conducted. As a result, in 1996, industry partners around Amsterdam Airport Schiphol started cooperating in a platform for sharing safety information, called Integral Safety Management System ("Integraal Veiligheids Management System"). That platform was followed in 2003 by the Safety Platform Schiphol ("VPS - Veiligheidsplatform Schiphol"). The platform was better equipped and had more workgroups producing positive results but was still lacking executive power. Consequently in 2017, it was decided to progress into a

cooperative agreement to manage safety on and around the airport, called the integral safety management system (ISMS).

The ISMS was formally established by a signed covenant between the industry partners, such as ANSP, airport, airlines, and ground handlers, and the government, all committing to mutually agreed-upon targets.

The aim of the collaboration is to collectively have a better safety focus, act sector-wide on decision-making, achieve a richer safety insight, and execute integral external reporting. The system includes a safety review group, and a safety action group, and an additional integral safety office, two standing committees, and various taskforces.

It has been decided that the ISMS, to which all of the participating parties are committed, includes at least the following elements:

- Joint approach to the safety risks associated with relationships and interactions between the individual parties (interfaces); and,
- Joint investigations of incidents and proactive safety analyses.

To agree on safety measures to be taken, a crucial part of the work involves the agreed 'common risk matrix' that is collectively used to determine the acceptability (or lack thereof) of risks. Top interface risk, such as runway incursions, bird strikes, damage during docking or damage during ground handling, are assessed for their likelihood and impact by all the parties involved. This results not only in a specific point on the common risk matrix but also often in a range that defines the different assessments by the different parties. Such assessment fosters mutual understanding of the risk among all parties and supports joint decision-making for risk mitigation.

The ISMS does not replace the existing safety management systems of the individual companies; rather, it complements them by focusing on the overall risks associated with Schiphol's operations. In this way, safety risks and improvement opportunities beyond the scope of individual parties are quantified, and management of the aviation parties at Schiphol jointly decide on measures to further enhance safety.

Related GAPPRI Recommendations: ANSP6

Recommendation ADR9: When any work is planned that may impact a controller's ability to see the runway or manoeuvring areas, ensure the controllers' line of sight from the tower VCR to the runway is unobstructed, by conducting thorough visibility assessments before commencing any work. Consider the use of 3D modelling tools to assess how proposed changes will affect visibility from the control tower and identify potential visibility restrictions.

In cases where visibility restrictions are unavoidable, aerodrome operators, in coordination with ANSPs, should develop and apply short-term mitigations and strategies for long-term improvements to ensure that controllers retain visual contact with all areas of operational significance on the aerodrome and maintain safety standards.

This may include:

- Advanced surface movement guidance and control system (A-SMGCS);
- Repositioning equipment;
- Utilising additional technology like remote cameras or sensors to assist controllers in maintaining visibility of critical areas to assist in visual monitoring; and,
- Redesigning the VCR layout to improve visibility.

Reference materials:

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Runway Safety Toolkit

ICAO Annex 14, Attachment A

ICAO Annex19 – Safety Management Systems

ICAO DOC 9157 Part 2 " Taxiways, Aprons and Holding Bays"

Commission Regulation (EU) No 139/2014 regarding changes to procedures and coordination with stakeholders

Commission Regulation (EU) 2020/2148 regarding runway safety and aeronautical data

ACI Airside Safety Manual – Airports Council International

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

SKYbrary.aero – Runway Incursion and Airport Design

National Academies of Sciences, Engineering, and Medicine. 2016. Airport Safety Risk Management Panel Activities and Outcomes. Appendix E – Checklist for Airfield Construction Washington, DC: The National Academies Press. *https://doi.org/10.17226/23622*.

FAA Advisory Circular 150/5370-2, as amended – Operational Safety on Airports During Construction

FAA Runway Incursion Mitigation (RIM) Program

FAA SMS and Safety Risk Management in Airport Projects

4. SMS and LRST – Safety Performance Management

Recommendation ADR10: Implement peer reviews to assess runway safety, state of airside infrastructure, and operational processes.

Recommendation ADR11: Establish leading and lagging runway safety performance indicators.

Why should aerodrome operators follow these recommendations?

To ensure a systematic, structured, and continuous approach to managing and improving runway and airside safety, aerodrome operators need to promote and maintain a robust safety culture that not only learns from past experiences but also anticipates and prevents future safety risks.

Peer reviews foster an environment of continuous improvement and can lead to the adoption of best practices from other aerodromes. Implementing peer reviews provides an objective assessment of the state of airside infrastructure and operational processes. This allows aerodrome operators to benefit from the insights of other experienced industry professionals who may identify potential safety issues or areas for improvement that internal reviews might not uncover. This external perspective can help to ensure that the aerodrome's infrastructure and processes meet industry standards and support safe aerodrome operations.

Leading and lagging indicators are essential for measuring the effectiveness of safety management systems. Leading indicators allow for proactive management of runway safety and can help predict and prevent future incidents by measuring non-conformance or the potential for risk before it results in an incident. Lagging indicators, on the other hand, measure past occurrences, such as the number of incursions or accidents, and are used to understand the outcome of past actions and safety performance, thus highlighting areas where safety improvements are necessary. By establishing such indicators, aerodrome operators can make informed, data-driven decisions. They can track trends, understand the impact of implemented safety measures, and identify areas that require additional attention or resource allocation.

What can aerodrome operators do to implement the recommendations?

Combining peer reviews with the establishment of safety performance indicators will greatly enhance the capability of aerodrome operators to identify and mitigate risks associated with runway operations, fostering a robust safety culture.

Recommendation ADR10: Aerodrome operators should consider instituting a peer review program that promotes an exchange of safety practices and operational procedures with counterparts at other aerodromes. This initiative would involve creating a diverse panel of experts from various airports to conduct comprehensive on-site evaluations of airside infrastructure, operational processes, and safety protocols. The findings and recommendations from these assessments would be openly shared, fostering a transparent culture focused on runway safety. Following each review, aerodrome operators should devise and implement action plans to address any issues identified, ensuring a commitment to continuous improvement. It is crucial that these activities are well-documented for accountability and to serve as a future reference.

For example, an operator may organise annual peer reviews in which a team from another airport or an independent body visits the aerodrome to conduct comprehensive reviews of runway safety practices, airside infrastructure, and operational processes.

These peer reviews should include:

- Inspections;
- Interviews with staff; and,
- Review of procedures and incident data.

The operator would then use the findings from these reviews to:

- Benchmark against international standard;
- Identify areas for improvement; and,
- Develop action plans to address these areas.

Recommendation ADR11: Aerodrome operators should identify and track proactive safety performance indicators (SPIs) that include both leading indicators and lagging indicators. A robust data collection system should be implemented to gather relevant data efficiently. Operators should then regularly analyse this data to discern trends and areas in need of improvement, setting clear targets for each performance indicator. Integrating these SPIs into the aerodrome's safety management system (SMS) will enable continuous

monitoring and facilitate informed decision-making. Additionally, performance against these SPIs should be communicated across the organisation to maintain transparency and reinforce the importance of safety. The effectiveness of these indicators should be reviewed periodically, with adjustments made as necessary to reflect the dynamic nature of aerodrome operations. Finally, training and awareness initiatives should be undertaken to ensure all personnel comprehend the role they play in meeting safety objectives, and accountability measures, possibly coupled with incentive programs, should be put in place to motivate adherence to safety performance standards.

Some example SPIs could include:

Lagging SPIs:

- Number of accidents (accidents with injury or property damage);
- Number of incidents (events that could have led to an accident);
- Number of runway incursions: The total count of runway incursion incidents within a specified timeframe;
- Safety reporting rate: The rate at which safety concerns, near misses, and potential hazards are reported by personnel;
- Severity of incursions: Classification of incursions based on their severity (e.g., Categories A, B, C, D, E as per ICAO provisions);
- Incident investigation outcomes: Findings and conclusions drawn from post-incident investigations, including causal factors; and,
- Runway incursion trends: Analysis of runway incursion data over time to identify patterns or recurrent issues.

Leading SPIs:

- Implementation of runway safety measures: Assess what percentage (50%, 75%, etc.) of your planned runway safety measures have been implemented.
- Staff training: Assess what percentage (50%, 75%, etc.) of your planned staff training programs provided to airside personnel, focusing on runway safety and incursion prevention, have been completed.
- Compliance with standard operating procedure (SOP) audits: The degree to which airside operations adhere to established SOPs, including communication protocols and vehicle movement regulations.
- Effectiveness of communication systems assessments: Regular evaluation of the clarity, reliability, and timeliness of communication among pilots, air traffic control, and ground personnel.

Reference materials:

Airport Excellence (APEX) in Safety programme: *http://www.aci.aero/APEX*

ICAO Indicator Catalogue – *https://www.icao.int/safety/Pages/Indicator-Catalogue.aspx*

ICAO Airport Services Manual (Doc 9137)

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Manual of Surface Movement Guidance and Control Systems (SMGCS) (Doc 9476)

ICAO Accident/Incident Reporting Manual (Doc 9156)

ICAO Manual on Aircraft Accident and Incident Investigation (Doc 9756)

ICAO Emergency Response Guidance (Doc 9481)

ICAO Annex19 – Safety Management Systems

ICAO Annex14 – Aerodromes

ICAO Doc 9859 – Safety Management Manual

Flight Safety Foundation – Safety Performance Indicators: *https://flightsafety.org/asw-article/safety-performance-indicators/*

5. Training and Competence

Recommendation ADR12: Annually assess, and update as necessary, how the runway incursion risks and mitigations are included within initial and refresher/recurrent training of operational staff.

Recommendation ADR13: Define driver training program requirements. Periodically assess formal manoeuvring area driver permits, training, and refresher programmes (including practical training and proficiency checks) against driver training requirements.

Recommendation ADR14: Consider implementing a three-level scheme for aerodrome driving permits: apron only, manoeuvring area (excluding runways) and runways. Periodically, on a phased manner, audit airside driving permits (e.g., check recency of use), in particular those allowing access to the runways, which should be as few as possible. Adjust, if needed, the validity period of the permit.

Why should aerodrome operators follow these recommendations?

It is essential for aerodrome operators to maintain a skilled, knowledgeable, and safety-conscious workforce to ensure the highest standards of safety in airside operations. This includes defining and refining training programs and materials for driver training.

By annually assessing and updating the risk mitigation strategies within training programs, aerodrome operators can ensure that operational staff are always aware of current best practices and threats. This approach allows the incorporation of new information and experiences into training, ensuring that personnel have the needed knowledge and skills to effectively prevent runway incursions.

Regular refresher and recurrent training for operational staff is critical for maintaining a high level of alertness and awareness regarding runway incursion risks. It also supports the retention of crucial knowledge and skills over time, addressing any complacency that might develop in routine operations.

Defining driver training program requirements and regularly assessing them ensures that individuals driving in the manoeuvring area are properly educated in safety protocols and operational procedures to reduce the likelihood of accidents or incidents caused by human error. Including practical training and proficiency checks in these programs helps to reinforce theoretical knowledge with hands-on experience.

Implementing a tiered system for aerodrome driving permits allows for clear delineation of where personnel can drive, which helps in minimising unauthorised access to sensitive areas such as runways. This structured approach to granting driving permissions can also significantly reduce the risk of incursions. Including regular audits of airside driving permits, especially those granting access to runways, can help ensure that only current and proficient drivers have access to high-risk areas. As part of the audit process, checking the recency of permit use helps to confirm that drivers maintain their familiarity with the environment and the associated safety protocols. Adjusting the validity period of the permit, as necessary, can also help ensure that drivers retain the required competencies and that their knowledge and skills are up to date.

What can aerodrome operators do to implement the recommendations?

Implementing these recommendations requires a structured, systematic approach that prioritises continuous review, evaluation, and improvement of training programs and driving permit systems. Aerodrome operators must remain vigilant in their efforts to incorporate evolving safety measures into training content and to ensure strict compliance with driving permit regulations. This proactive stance on training and permits will significantly contribute to mitigating runway incursion risks and enhancing the overall safety of aerodrome operations.

Recommendation ADR12: Aerodrome operators should establish a rigorous annual review process for training programs for operational staff, ensuring that the content addresses current runway incursion risks and the latest mitigation strategies. This should entail a comprehensive assessment of the training curriculum to identify areas for enhancement. which may include:

- Integrating recent incident data;
- Considering updated safety protocols;
- Reviewing recent safety surveys; and,
- Reviewing relevant runway safety technologies implemented by the aerodrome operator or aircraft operator.

As part of this assessment, operators should involve front-line staff and training experts to ensure the training remains relevant and effective. They must also ensure that refresher or recurrent training is mandated for all operational staff to reinforce key safety principles and procedures, adapting the training content as necessary, based on the outcomes of these assessments.

Operators should review and update training programs annually to incorporate the latest safety practises, regulatory changes, and lessons learned from recent incidents.

This should include evaluating:

- The content of the training;
- The effectiveness of delivery methods (such as classroom-based, simulation, or e-learning); and,
- The performance of staff in training assessments.

Aerodrome operators may also wish to consider:

- Inclusion of practical components like simulations or on-field exercises in the training; and,
- Establishing a feedback system through which staff can provide input on the training's relevance and effectiveness, which can then be used to continuously improve the training program.

Related GAPPRI Recommendations: ANSP3, AO4, AO5, AO6, REG2

Recommendation ADR13: Defining and developing a structured driver training program is crucial. This program should outline clear requirements for both theoretical and practical competencies necessary for safe driving in the aerodrome's manoeuvring areas. Aerodrome operators must periodically review and compare the existing driver permit protocols, training, and refresher programs to these defined requirements, ensuring that they adequately prepare drivers for the complexities of airside operations. Proficiency checks should be a cornerstone of the program to maintain high standards of competence among drivers. By regularly evaluating and updating the training program, operators can ensure that drivers are well equipped to operate safely and effectively in the airside environment.

For example, a comprehensive, structured training curriculum for vehicle drivers authorised to operate in the manoeuvring area, should include classroom instruction on:

- Aerodrome layout and site-specific procedures;
- Understanding of signage, marking, and lighting;
- Communication protocols with air traffic control; and,
- Emergency and non-routine response procedures (construction, low visibility, snow and ice removal).

The program should include both classroom and practical, hands-on training on the airfield. Regular refresher courses and practical proficiency checks should also be conducted to ensure drivers maintain a high level of competency and adherence to safety protocols.

A few examples of information covered in a driver training program are below (Figure 2). This is by no means a comprehensive list but serves as an indicator of the type of information included in an effective driver training program.

Recommendation ADR14: Aerodrome operators should implement a tiered system for aerodrome driving permits. A two- or three-level scheme would categorise permits based on the areas of operation: apron-only, manoeuvring areas excluding runways, and runways. Such a stratification ensures that individuals have clear authorisation for specific operational areas, correlating with their training and job requirements. Regular audits of these driving permits should be instituted, especially for those with access to runways, to verify the recency and appropriateness of use. Given the high-risk nature of runway operations, access should be strictly controlled and limited to essential personnel only. Additionally, the validity period of these permits should be regularly evaluated and adjusted based on the audit outcomes to ensure that only current and competent personnel are granted access.

A tiered system may look like the following (tailored to the complexity and specific needs of the aerodrome):

Tier 1: Apron Only Access

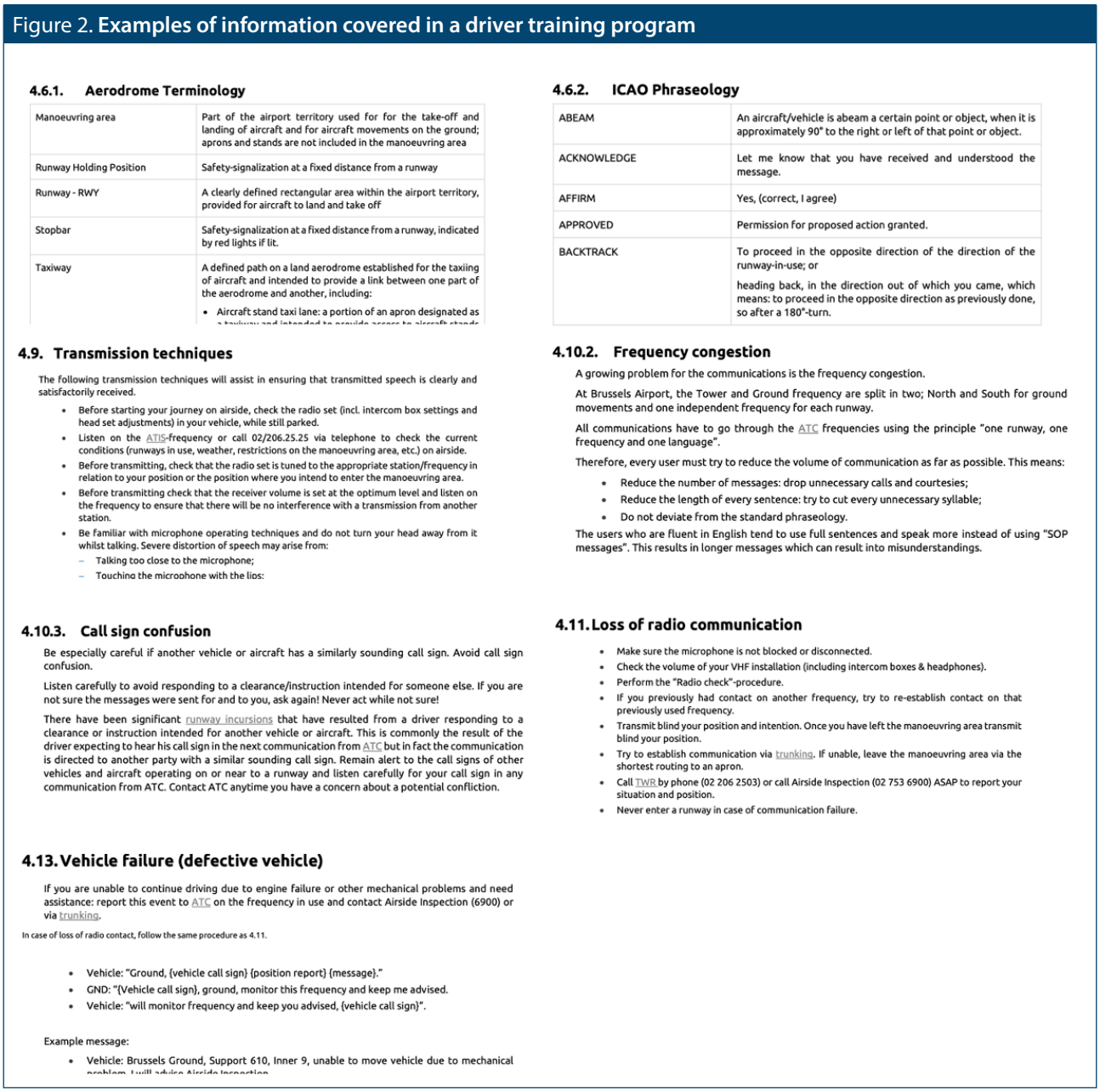
Qualifications:

- Valid driver's license; and,
- Knowledge of apron layout, lighting, markings, and signage.

Training:

- Airport driver's training program focusing on apron safety, including aircraft handling safety, pedestrian zones, and vehicle operation near aircraft; and,
- Familiarisation with airport-specific procedures and communication protocols.

Figure 2. Examples of information covered in a driver training program



4.6.1. Aerodrome Terminology

Manoeuvring area	Part of the airport territory used for for the take-off and landing of aircraft and for aircraft movements on the ground; aprons and stands are not included in the manoeuvring area
Runway Holding Position	Safety-signalization at a fixed distance from a runway
Runway - RWY	A clearly defined rectangular area within the airport territory, provided for aircraft to land and take off
Stopbar	Safety-signalization at a fixed distance from a runway, indicated by red lights if lit.
Taxiway	A defined path on a land aerodrome established for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another, including: • Aircraft stand taxi lane: a portion of an apron designated as

4.6.2. ICAO Phraseology

ABEAM	An aircraft/vehicle is abeam a certain point or object, when it is approximately 90° to the right or left of that point or object.
ACKNOWLEDGE	Let me know that you have received and understood the message.
AFFIRM	Yes, (correct, I agree)
APPROVED	Permission for proposed action granted.
BACKTRACK	To proceed in the opposite direction of the direction of the runway-in-use; or heading back, in the direction out of which you came, which means: to proceed in the opposite direction as previously done, so after a 180°-turn.

4.9. Transmission techniques

The following transmission techniques will assist in ensuring that transmitted speech is clearly and satisfactorily received.

- Before starting your journey on airside, check the radio set (incl. intercom box settings and head set adjustments) in your vehicle, while still parked.
- Listen on the ATIS-frequency or call 02/206.25.25 via telephone to check the current conditions (runways in use, weather, restrictions on the manoeuvring area, etc.) on airside.
- Before transmitting, check that the radio set is tuned to the appropriate station/frequency in relation to your position or the position where you intend to enter the manoeuvring area.
- Before transmitting check that the receiver volume is set at the optimum level and listen on the frequency to ensure that there will be no interference with a transmission from another station.
- Be familiar with microphone operating techniques and do not turn your head away from it whilst talking. Severe distortion of speech may arise from:
  - Talking too close to the microphone;
  - Touching the microphone with the lips;

4.10.2. Frequency congestion

A growing problem for the communications is the frequency congestion.

At Brussels Airport, the Tower and Ground frequency are split in two; North and South for ground movements and one independent frequency for each runway.

All communications have to go through the ATC frequencies using the principle "one runway, one frequency and one language".

Therefore, every user must try to reduce the volume of communication as far as possible. This means:

- Reduce the number of messages: drop unnecessary calls and courtesies;
- Reduce the length of every sentence: try to cut every unnecessary syllable;
- Do not deviate from the standard phraseology.

The users who are fluent in English tend to use full sentences and speak more instead of using "SOP messages". This results in longer messages which can result into misunderstandings.

4.10.3. Call sign confusion

Be especially careful if another vehicle or aircraft has a similarly sounding call sign. Avoid call sign confusion.

Listen carefully to avoid responding to a clearance/instruction intended for someone else. If you are not sure the messages were sent for and to you, ask again! Never act while not sure!

There have been significant runway incursions that have resulted from a driver responding to a clearance or instruction intended for another vehicle or aircraft. This is commonly the result of the driver expecting to hear his call sign in the next communication from ATC but in fact the communication is directed to another party with a similar sounding call sign. Remain alert to the call signs of other vehicles and aircraft operating on or near to a runway and listen carefully for your call sign in any communication from ATC. Contact ATC anytime you have a concern about a potential confliction.

4.11. Loss of radio communication

- Make sure the microphone is not blocked or disconnected.
- Check the volume of your VHF installation (including intercom boxes & headphones).
- Perform the "Radio check"-procedure.
- If you previously had contact on another frequency, try to re-establish contact on that previously used frequency.
- Transmit blind your position and intention. Once you have left the manoeuvring area transmit blind your position.
- Try to establish communication via trunking. If unable, leave the manoeuvring area via the shortest routing to an apron.
- Call TWR by phone (02 206 2503) or call Airside Inspection (02 753 6900) ASAP to report your situation and position.
- Never enter a runway in case of communication failure.

4.13. Vehicle failure (defective vehicle)

If you are unable to continue driving due to engine failure or other mechanical problems and need assistance: report this event to ATC on the frequency in use and contact Airside Inspection (6900) or via trunking.

In case of loss of radio contact, follow the same procedure as 4.11.

- Vehicle: "Ground, {vehicle call sign} {position report} {message}."
- GND: "{Vehicle call sign}, ground, monitor this frequency and keep me advised.
- Vehicle: "will monitor frequency and keep you advised, {vehicle call sign}".

Example message:

- Vehicle: Brussels Ground, Support 610, Inner 9, unable to move vehicle due to mechanical

Testing:

- Written test covering apron safety rules and regulations; and,
- Practical test demonstrating safe driving in the apron area.

Permit:

- Issued upon successful completion of tests; and,
- Periodic reassessment as per local regulations.

Tier 2: Manoeuvring Area (Excluding Runways)

Qualifications:

- Tier 1 permit; and,
- Understanding of the manoeuvring area layout, including taxiways, and holding points.

Training:

- Advanced airport driver's training program, including radio communication, understanding of ATC clearances, and recognition of visual signals; and,
- Specific training on the risks associated with the manoeuvring area and how to avoid incursions.

Testing:

- Written test on manoeuvring area rules, ATC procedures, and incident reporting; and,
- Practical test on vehicle operation in the manoeuvring area under supervision.

Permit:

- Issued upon successful completion of tests; and,
- Requires re-evaluation as per local regulations or after any significant changes to manoeuvring area or procedures.

Tier 3: Full Runway Access

Qualifications:

- Tier 2 permit; and,
- In-depth knowledge of runway operations and safety.

Training:

- Comprehensive runway safety program, including topics such as runway incursion prevention, foreign object debris (FOD) control, and emergency procedures; and,
- Hands-on training with focus on coordination with ATC and strict adherence to clearances and instructions.

Testing:

- Rigorous written and oral tests on runway safety, emergency protocols, and effective communication with ATC; and,
- Stringent practical driving test on runways, including emergency response actions.

Permit:

- Issued upon successful completion of tests; and,
- Requires re-evaluation as per local regulations or after any significant changes to manoeuvring area or procedures.

Additional Considerations:

Tracking and auditing: Aerodromes should implement a robust system to track permit issuance and expiration. Conduct random audits to ensure compliance with training requirements and frequency of permit use to ensure that drivers have the necessary training and experience for the level of access granted.

Incident response: Aerodromes should establish clear procedures for reporting and responding to any safety incidents or breaches of protocol by permit holders.

Continuous improvement: Aerodromes should regularly review the permit system and update training and testing requirements based on feedback, incident data, and changes in airport operations or infrastructure.

Coordination with stakeholders: Aerodromes should work closely with airlines, ground handlers, and ATC to ensure that the permit system integrates smoothly with operational needs and safety management systems.

The system should also be designed to restrict runway access to the minimum number of drivers necessary for operations.

Reference materials:

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

ICAO Airside Driving Training Course

ICAO PANS Aerodromes (doc 9981) Chapter 9.

SKYbrary.aero – Runway Safety – an Airside Drivers Guide *https://skybrary.aero/bookshelf/runway-safety-airside-drivers-guide*

ACI Runway Safety Handbook – Second Edition 2022

FAA Guide to Ground Vehicle Operations – *https://www.faa.gov/sites/faa.gov/files/airports/runway_safety/publications/Ground_Vehicle_Guide_Proof_Final.pdf*

FAA Advisory Circular AC 150/5210-20A, as amended – Ground Vehicle Operations to Include Taxiing or Towing an Aircraft on Airports

6. Runway Inspection

Recommendation ADR15: In collaboration with the ANSP, periodically review the procedures for runway inspections and other runway works. This should include:

a. Carrying out routine runway inspections in the opposite direction to runway movements with vehicle lights on regardless of time of day.

b. Ensuring that unidirectional lighting is inspected efficiently on the basis of risk and operational needs assessment.

c. Implementing procedures to increase overall situational awareness when vehicles occupy a runway (to be decided locally, e.g., technology, 'vehicle operation normal' calls, or other means).

d. Implementing standard routes and timings for routine runway inspections.

e. Temporarily suspending operations to allow a full runway inspection to be performed without interruption on the basis of risk and operational needs assessment.

f. The vehicles which enter a runway should be equipped with a dashboard camera recording the outside view from the vehicle, to collect information about actual and potential risks of runway incursion. The information would be used exclusively for safety improvement.

Why should aerodrome operators follow these recommendations?

Regularly reviewing and updating runway inspection procedures in collaboration with ANSPs ensures that they remain effective and responsive to the changing operational environment.

Carrying out routine runway inspections in the opposite direction to runway movements, when able, increases driver awareness of aircraft that may be utilising, intentionally or inadvertently, the runway under inspection. Full inspections should be conducted in both directions of the runway, and vary when the inspection occurs.

Temporarily suspending operations for full runway inspections allows for a thorough examination of the runway without the pressure of ongoing aircraft movements. This can be crucial in detecting issues that may not be visible during routine, faster inspections. Coordination for such inspections should consider risks and operational needs to ensure efficient inspections and minimal disruptions to aircraft movement.

Using vehicle lights, regardless of time of day, increases the visibility of the vehicle. Assessment of unidirectional lighting should take place in an efficient manner, after careful consideration of risks and operational needs, to ensure limited exposure to potential runway conflicts.

Implementing procedures to enhance situational awareness for vehicle operators on runways reduces the risk of vehicle-related incursions. This could involve technology solutions like ground movement radar, or operational protocols like clear communication procedures. Standard routes and timings for routine inspections also help to create predictable patterns of behaviour, which can be communicated to pilots and air traffic controllers, reducing the chance of misunderstandings and potential incursions.

Equipping vehicles with dashboard cameras provides a valuable data source for analysing vehicle movements and interactions with aircraft. This footage can be used for training purposes and to investigate incidents, helping to continually refine safety procedures and identify opportunities to mitigate incursion risks.

What can aerodrome operators do to implement the recommendations?

To ensure a proactive and disciplined approach to runway safety, runway inspection (e.g., routine, nonroutine, etc.) procedures should be consistent with current best practices and continuously refined based on regular risk assessments and the introduction of new safety technologies and methods. Regular review of runway inspection procedures, policies, and practises allows aerodrome operators to significantly enhance the safety of runway operations by considering

changes to the operational environment, thereby reducing the likelihood of runway incursions and ensuring a safer operational environment for both aircraft and ground vehicles.

Recommendation ADR15: Aerodrome operators, in collaboration with ANSPs, should establish a regular and systematic review process for routine and full runway inspections and works. This review process should be thorough and dynamic, adapting to the evolving operational environment and incorporating the latest risk assessments and technological advancements.

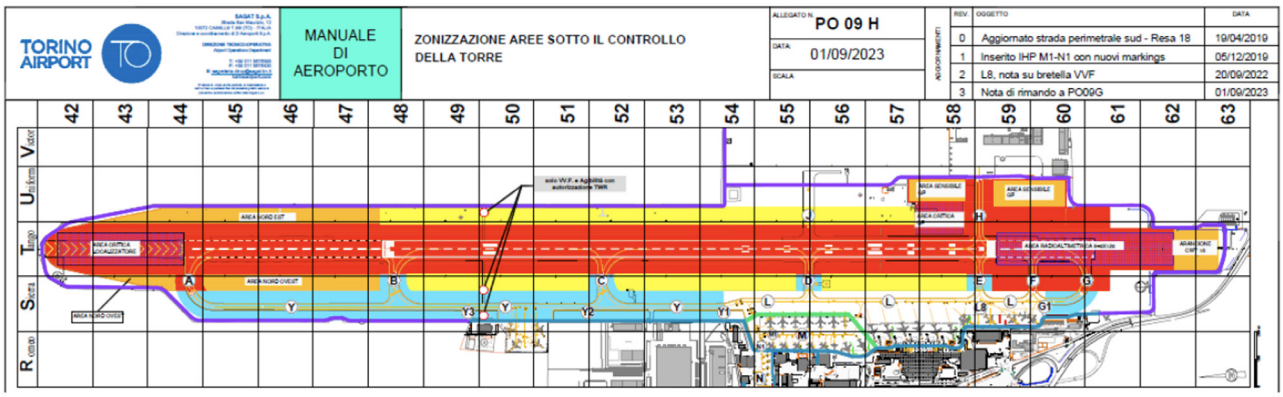
The procedures and review should cover the following:

- Routine runway inspections: Operators should mandate that routine runway inspections are conducted in the opposite direction of runway movements, with vehicle lights on to enhance visibility, regardless of the time of day. This practice helps to detect potential hazards that might not be as visible when driving in the same direction as the aircraft and ensures a higher level of vigilance.
- Full runway inspections: There should be an agreement between the ANSP and the aerodrome operator to temporarily suspend operations to allow a full, uninterrupted runway inspection, when potential risk and operational needs assessments allow. This ensures that inspectors can thoroughly examine the runway without the pressure of ongoing aircraft operations, allowing them to focus on identifying and mitigating any potential safety hazards.
- Uni-directional lighting inspections: Lighting systems should be inspected on a risk and operational needs basis. Efficient inspection protocols should be developed to ensure that uni-directional lighting, which is critical for aircraft during take-off and landing, meets ICAO-defined serviceability rates to provide the necessary guidance to pilots.
- Situational awareness procedures: Aerodrome operators should collaborate with ANSPs to implement local procedures to increase situational awareness for vehicle operators on runways. This could include the use of technology such as GPS tracking, requiring 'vehicle operation normal' calls to air traffic control, or other methods that suit the specific environment and operational context of the aerodrome.
- Standard inspection routes and timings: To minimise the risk of incursion and to ensure thorough inspections, standard routes and specific timings for routine runway inspections should be established. These should be designed to minimise interference with operational activities while ensuring complete coverage of the runway surface.
- Dashboard cameras in inspection vehicles: Aerodrome operators should equip vehicles that enter the runway with dashboard cameras to record the external view. This footage should be used exclusively for safety improvement purposes, allowing for the analysis of actual and potential runway incursion risks and the development of mitigation strategies.

Torino Airport (LIMF) has implemented a colour-based system for drivers and ATCOs that is low cost, helps to increase understanding and awareness of driver location on the aerodrome, and provides a defined set of rules for when a vehicle may be in each defined area.

The manoeuvring area is divided into 4 colour sectors:

Figure 3. **Torino Airport colour-based system**



The red area includes the runway (90 m on each side of the centreline), plus instrument landing system (ILS)-critical areas, runway end safety area (RESA) 18, and other protected areas due to displaced thresholds (on Alpha, Foxtrot, Golf, and Hotel intersections).

Orange and yellow areas indicate the runway strip (150 m on each side of the centreline), plus ILS-sensitive areas and clearway 18.

The blue area includes taxiways to Category (CAT) I runway holding position (RHP).
Note: Alpha, Foxtrot, Golf, and Hotel are CAT I/II/III RHPs.

The following rules apply to each area:

Red: cannot be occupied during landing or take-off ops;

Orange: cannot be occupied during landing or take-off ops while low visibility procedures (LVP) or VIS 2,3 and 4, or CAT II and III Ops and if vis <1,500m or crosswind > 15 kt or braking action < medium. Plus, cannot be occupied during landings for runway 18;

Yellow: cannot be occupied during landing or take-off ops while LVP or VIS 2,3 and 4, or CAT II and III Ops and if vis <1500m or crosswind > 15 kt or braking action < medium.

Blue: Bravo, Charlie, Delta, and Echo taxiways cannot be occupied while LVP or VIS 2,3 and 4, or CAT II and III Ops and if vis <1500m or crosswind > 15 kt or braking action < medium.

Protected area for landing and take-off ops is always the red area, plus yellow and/or orange areas, upon conditions.

ATCOs and drivers share an identical guidance checklist and ground radiotelephony manual in both Italian and English. Clearance to enter different parts of the manoeuvring area are requested according to the coloured area that a driver wants to occupy. (i.e., "SAGAT1 requests to enter blue yellow, west side from … . ") In the grassy areas, there are small, coloured poles to help drivers identify different coloured areas on the ground.

Figure 4. **Torino Airport colour-based system**

Note: Requests to occupy the red area and notifications about vacating the red area must be made separately from other communications (i.e., SAGAT1: "SAGAT1 requests to enter RED"; TWR: "SAGAT1 cleared to enter RED").

Related GAPPRI Recommendations: ANSP9, ANSP26

Reference materials:

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

EASA Opinion 03/2019

ICAO Annex14 – Aerodromes

ACI Runway Safety Handbook (Second Edition 2022)

FAA Advisory Circular 150/5210-18, as amended. Airport Safety Self-Inspection

7. Aerodrome Infrastructure Supporting Safe Navigation

Recommendation ADR16: Periodically assess and ensure that signs, markings, and lights on the movement area are clearly visible, adequate, and unambiguous in all appropriate conditions (e.g., in all light conditions and when wet).

Recommendation ADR17: Avoid designing closely spaced multiple parallel runway holding positions on the same taxiway. Where this cannot be done, the holding positions should be clearly segregated.

Recommendation ADR18:

In relation to aerodrome protected areas:

a. In coordination with ANSPs, identify the protected area for each runway and produce a chart/map of aerodrome protected areas.

b. Ensure that drivers of vehicles operating on the manoeuvring area are familiar with the protected area map.

Recommendation ADR19: Implement enhanced taxiway centreline markings and mandatory instruction markings at all certified airports.

Why should aerodrome operators follow these recommendations?

Well designed and implemented aerodrome infrastructure plays a vital role in contributing to the overall safety and efficiency of airport ground operations, ensuring that the risk of incidents is as low as possible. Minimising risk by enhancing the visibility of critical information, improving situational awareness, and providing clear physical demarcations of operational boundaries bolsters safety and operational efficiency.

Regular assessments of airside signage, markings, and lighting ensure they are clearly visible and understandable in all conditions, which is essential for preventing misunderstandings and potential incursions, especially during periods of low visibility or adverse weather conditions.

Avoiding the design of closely spaced parallel runway holding positions on the same taxiway prevents confusion among pilots, which could lead to runway incursions. Clear segregation of holding positions is necessary when such design cannot be avoided to maintain clear guidance for aircraft.

Coordinating with ANSPs to identify protected areas for each runway allows aerodrome operators to produce charts/maps of these critical safety zones and provide this information to users, decreasing the likelihood of unauthorized intrusion and thereby safeguarding against accidents and incursions. Ensuring that vehicle drivers are familiar with these protected areas reduces the risk of vehicle-related incursions and enables drivers to operate more confidently and safely within the manoeuvring area.

It may be helpful for the protected area map to be carried in all manoeuvring area vehicles at all times and to include the radiotelephony frequencies for the runways and the locations they apply.

Implementing enhanced taxiway centreline and mandatory instruction markings improves the guidance provided to pilots navigating the taxiways. This is particularly important for complex airport layouts and during low-visibility operations, as clear markings can significantly reduce the risk of taxiway excursions and runway incursions.

What can aerodrome operators do to implement the recommendations?

Implementing these recommendations requires proactive management of airside visual aids, careful airfield design, diligent coordination with ANSPs, and ongoing training and communication with airside personnel. Aerodrome operators should undertake a series of structured assessments and training initiatives to enhance the clarity and safety of airside operations. Any design revisions to existing infrastructure may incur significant expense; consequently, they are best used when new infrastructure is being proposed.

Recommendation ADR16: Operators should establish a regular evaluation schedule to review the visibility and clarity of airside signs, markings, and lights. This includes conducting routine assessments under various conditions, such as during different times of the day, in diverse weather conditions, and when surfaces are wet. In addition, operators should be aware that the viewing angle from vehicles, small aircraft, business

jets, or air carriers may differ significantly. Therefore, the assessment procedure or criteria should include collaboration with the ANSP partner and pilots to help address the issue. The LRST can be an effective means of accomplishing the assessment, as it is comprised of relevant stakeholders. The assessment should extend to all visual aids to ensure they are not only clearly visible and adequate but also unambiguous to all airfield users. This might involve:

- Application of reflective or high-contrast materials;
- Addition of lighting or illuminated signs; and,
- Strategic placement of markings to enhance visibility during low-light conditions or inclement weather.

Ensure that lights meet necessary brightness standards. Implement a maintenance program to ensure navigational aids are always in optimal condition, making use of advancements like LED technology for better visibility and energy efficiency. Additionally, consider the ergonomics and design of these aids to ensure they are easily interpretable by pilots and ground vehicle drivers.

Recommendation ADR17: Aerodrome operators should prioritize the design of taxiways to avoid closely spaced parallel runway holding positions. If such a design is unavoidable due to spatial constraints, it is crucial to implement clear and distinct segregation of the holding positions. This may involve using differentiated marking patterns, different coloured lights, or signposting to ensure that pilots and drivers can easily identify the correct holding position even under stress or in poor visibility conditions. Rotating or angling light fittings may also make it easier to see them on some taxiway configurations. Conduct pilot surveys to gather feedback on the clarity of these positions.

Include information about these holding positions in driver training programs to ensure they are understood and respected.

Recommendation ADR18: A collaborative approach with ANSPs is essential to accurately identify, clearly delineate, and map protected areas for each runway. Once these areas are defined, operators should produce and disseminate detailed protected area charts or maps that highlight these areas and ensure they are readily available and understood by all vehicle drivers and ground personnel. Additionally, they should incorporate this information into driver training programs to ensure that all personnel operating in manoeuvring areas are well-acquainted with these protected zones and include them in vehicle GPS systems to alert drivers when they are approaching a protected area. Regular testing and refresher training can ensure ongoing familiarity and compliance. Printed maps should be carried in all manoeuvring area vehicles and can include the radio telephony frequencies for the runways.

Related GAPPRI Recommendations: REG13

Figure 5. **Example of a map of the runway protected area**

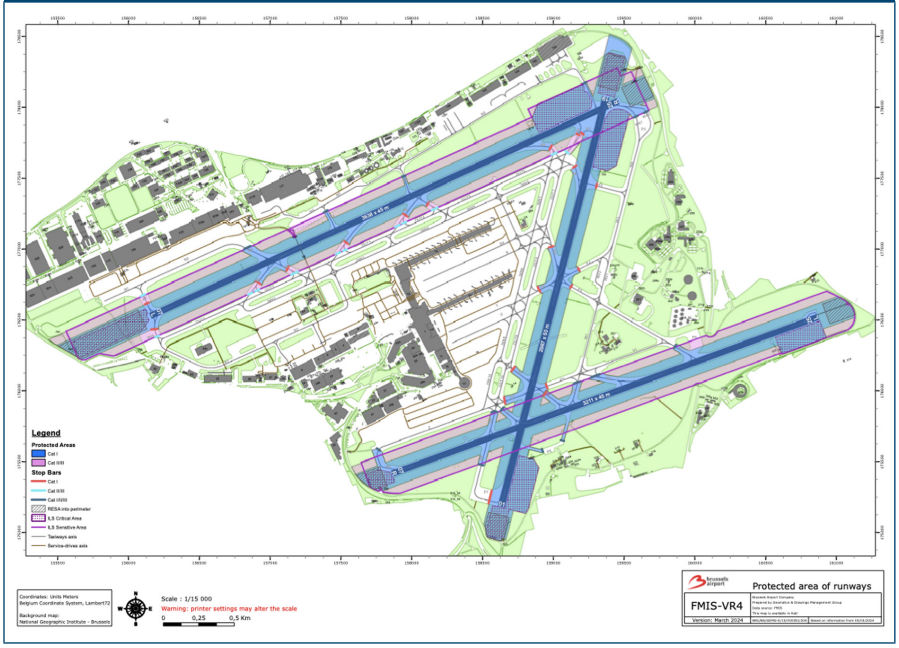


Figure 5 shows an example of a map clearly displaying the protected area of the aerodrome.

Recommendation ADR19: Aerodrome operators should implement enhanced taxiway centreline and mandatory instruction markings across all certified airports. This involves upgrading existing markings to be more conspicuous and introducing new markings where necessary to guide pilots effectively, especially in complex or high-traffic taxiway intersections. These markings should meet or exceed the standards set by relevant aviation authorities and should be subject to the same periodic visibility and adequacy assessments as other airside visual aids. They may include enhanced features such as:

- Wider lines;
- Black bordering of white and yellow markings on a light surface;
- High-contrast colours;
- Reflective materials for better visibility in low-light conditions; and,
- Runway ahead markings.

Various aerodromes have implemented 'RWY AHEAD' markings (Figure 6) and they have proved successful in raising pilot and driver awareness. While there may be national regulations governing RWY AHEAD markings within specific countries, there are various implementations globally.

Educate pilots and drivers on the significance of these enhanced markings, ensuring they understand their purpose and comply with the instructions.

Figure 6. **Example of 'RWY AHEAD' markings**

Reference materials:

ICAO Annex14 – Aerodromes

Regulation (EU) No 139/2014

ACI Apron Markings and Signs Handbook – Third Edition 2017

ICAO Aerodrome Design Manual, part 4 (Visual Aids)

SKYbrary.aero – Runway Holding Position

FAA Advisory Circular 150/5210-18, as amended. Airport Safety Self-Inspection

FAA Advisory Circular 150/5300-13, as amended – Airport Design

FAA Advisory Circular - AC 150/5210-20, as amended – Ground Vehicle Operations to include Taxiing or Towing an Aircraft on Airports

FAA Advisory Circular 150/5340-1, as amended – Standards for Airport Markings

FAA Advisory Circular 150/5340-18, as amended – Standards for Airport Sign Systems

8. Stop Bars and ARIWS

Recommendation ADR20:

a. In cooperation with ANSPs, implement H24 stop bars operation or other lighting systems (e.g., autonomous runway incursion warning systems (ARIWS) at all active runway holding positions, providing an equivalent level of safety commensurate with the level and complexity of the operations and the potential risk of runway incursion.

b. Assess the need for elevated stop bars to improve stop bar conspicuousness.

c. Consider use of LED technology and reduced spacing (e.g., spacing of 1,5 m) to improve stop bar clarity.

d. In cooperation with ANSPs, implement procedures, in line with the applicable regulations, to be followed in case of stop bar unserviceability.

Why should aerodrome operators follow these recommendations?

The installation and use of stop bars and other lighting systems intended to raise awareness about runway holding positions, in accordance with ICAO standards and recommended practices (SARPs), can substantially lower the risk of runway incursions and enhance overall safety. Such measures are particularly important given the severity of incidents that can occur due to incursions, such as collisions and near-misses.

When and where provided, these installations can be further enhanced by implementing H24 (24-hour) operation of these systems to ensure that the critical boundary of the runway is clearly marked at all times. This is especially important during night operations or in adverse weather conditions, providing a visual cue that contributes to preventing inadvertent runway entries. If unable to implement full H24 operation across the entire airport, consider a phased implementation beginning with continuously lighting stop bars at non-used or little-used holding positions. In addition, elevated stop bars can improve visibility for pilots, particularly from the cockpit perspective, where the angle of view may limit the visibility of ground-level lights. This can be particularly beneficial in complex aerodrome layouts or during conditions of reduced visibility. The elevated stop bars are also useful for crews of small aircraft, as the cockpits are low above the ground and the ability of pilots to see the full pattern of inset lights might be limited.

Utilising LED technology for its brightness and reliability, along with reduced spacing between lights, can also improve the clarity and visibility of stop bars. This aids pilots in identifying holding positions more easily, thus preventing confusion that could lead to incursions.

Establishing and implementing procedures in case of stop bar unserviceability ensures that there is a clear course of action to maintain safety standards even when the primary system fails. Developing these procedures as a collaborative effort with ANSPs ensures that all parties are aware of the procedures, which can include alternative means of marking the holding position or increased communication from air traffic control.

What can aerodrome operators do to implement the recommendations?

The goal of the above recommendation is to enhance the use of systems of visual cues and safety protocols that actively work to mitigate the risk of runway incursions. By leveraging technology, improving infrastructure, and ensuring a seamless operational response to any unserviceability, aerodrome operators can enhance the safety of runway operations.

Recommendation ADR20: Aerodrome operators and ANSPs should work collaboratively to enhance runway safety through changes in the use of advanced lighting systems and procedures that address the risk of runway incursion. Below are some ways aerodrome operators can approach this:

- H24 stop bars and equivalent lighting systems: Aerodrome operators that have stop bars or other incursion-prevention lighting systems installed to support runway incursion prevention should work with ANSPs to implement 24-hour operation of these systems. In addition, aerodrome operators without these systems should work with their ANSPs and CAAs to determine if installation of H24 stop bars or other visual aids would be appropriate as part of the aerodrome's runway incursion mitigation efforts, taking into consideration volume, complexity of operations, and potential risk of runway incursion at the aerodrome.

This means assessing current operations and tailoring the lighting solutions to meet specific needs, ensuring that these systems are always operational and effective in preventing runway incursions.

- Elevated stop bars for conspicuity: The need for elevated stop bars should be evaluated to determine if they would enhance the conspicuity of holding positions, especially in conditions that may impede visibility such as rain or fog, or at night. The decision to implement elevated stop bars should be based on a risk assessment that takes into account the local environment, historical incident data, and the potential for improved safety outcomes.
- LED technology and reduced spacing: The use of LED technology for stop bars should be considered due to its high visibility and energy efficiency. LED stop bars with reduced spacing, such as 1.5 m (4.9 ft) between lights, can provide clearer guidance to pilots and drivers, particularly in adverse weather conditions or during low light times of the day. A detailed assessment of the aerodrome layout and operational needs should guide the decision on implementing such technology.
- Procedures for stop bar unserviceability: In instances where stop bars become unserviceable, it is vital to have predefined procedures in place, developed in cooperation with ANSPs and in line with applicable regulations. These procedures should outline the steps to be taken by all relevant parties, including air traffic controllers, pilots, and vehicle drivers, to maintain safety on the manoeuvring area. Regular training and exercises should be conducted to ensure that all stakeholders are familiar with these procedures and can execute them effectively during unserviceability events.

Related GAPPRI Recommendations: ANSP28, AO22, REG7, REG12, R&D4

Reference materials:

ICAO Annex14 – Aerodromes

ICAO Aerodrome Design Manual (Part 4)

ACI Airport Service Manual

ACI Runway Safety Handbook (Second Edition 2022)

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

FAA Advisory Circular 150/5300-13, as amended – Airport Design

FAA Advisory Circular 150/5340-30, as amended – Design and Installation Details for Airport Visual Aids

9. Enhanced Procedures for Safe Runway Operations

Recommendation ADR21: Review procedures which require pilots to monitor or call secondary VHF frequencies (e.g., for ramp entry, gate location) while manoeuvring on airport taxiways to avoid high workload for the pilot handling the aircraft and ATC communication. (Wherever relevant to aerodrome operator or apron management service provider).

Recommendation ADR22: Ensure all manoeuvring area vehicle drivers are briefed at the start of a shift, including providing awareness for safety-significant airport information. The safety-significant information should also be checked also before the start of the mission.

Recommendation ADR23: Ensure that vehicle driver procedures and guidance contain a requirement for explicit ATC clearances to enter or cross on any runway, regardless of runway status (active/inactive).

Why should aerodrome operators follow these recommendations?

Aerodrome operators can reinforce the overall safety culture within the aerodrome environment by ensuring that safety protocols are clear, communication is efficient, and both pilots and vehicle drivers are adequately informed and authorised to conduct their operations.

Pilots operating within the airport environment are managing numerous tasks which require attention. Reviewing and potentially simplifying the procedures for monitoring or calling secondary VHF frequencies can reduce the cognitive load on pilots. This enables them to focus more on the critical tasks of safely manoeuvring the aircraft and maintaining clear and unambiguous communication with ATC. It is important to avoid overburdening pilots with complex communication tasks that could lead to distractions during critical phases of ground operations.

Providing vehicle drivers with briefings at the start of each shift ensures they are informed about any changes or specific conditions at the airport that may affect safety. This includes updates on construction areas, changes in taxiway availability, or special events. Keeping drivers informed is critical to preventing runway incursions and maintaining efficient airside operations.

Requiring explicit clearances for vehicles to enter or cross runways is a fundamental safety protocol. It is crucial that this requirement be applied regardless of the runway's operational status, as inactive runways can become active without prior notice to all personnel. By enforcing this requirement, aerodrome operators establish a clear protocol that contributes to preventing unauthorized runway incursions and the potential for accidents.

What can aerodrome operators do to implement the recommendations?

Recommendation ADR21: Evaluate any current airport communication procedures that require pilots to monitor or switch between multiple VHF frequencies during taxiing. This review should consider the communication load on pilots, especially during critical phases of ground operations, and the potential for missed or misunderstood communications due to frequency changes. Aerodrome operators, in collaboration with pilots, air traffic controllers, and apron management service providers, where applicable, should explore alternatives that could reduce frequency changes, such as consolidating communication channels or using data link systems, where available. The goal is to streamline communications and reduce the risk of communication errors, thereby lessening the workload for both pilots and air traffic control.

Recommendation ADR22: Ensure that all vehicle drivers operating in the manoeuvring area receive a comprehensive briefing at the start of each shift. This briefing should include the latest safety-significant airport information such as:

- Runway and taxiway closures;
- Construction projects;
- Short term work-in-progress and maintenance activities;
- Altered traffic flows;
- Weather and delays;
- Active NOTAMs;

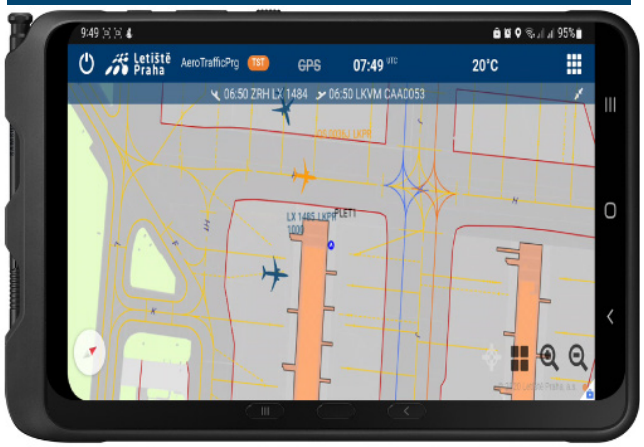
- Outstanding inspection items; and,
- Any temporary changes in procedures.

This information should be readily available and verified for accuracy before the start of each mission. Regular updates and reminders throughout the shift may also be necessary to maintain a high level of situational awareness. Consider using digital platforms or apps for real-time updates and reminders about safety protocols and operational changes.

An example of such an enhanced solution is the PRGAeroTraffic APP, internally developed by Prague Airport in the Czech Republic. The rugged tablets mounted in the cabins of more than 100 airside vehicles provide:

- A moving map with own position and live traffic from A-SMGCS;
- Meteorological information and low-visibility procedures information; and,
- Alerts to drivers:
  - Approaching runway protection zone;
  - Entering runway;
  - Entering closed area;
  - Aircraft approaching a crossing point of taxiway and service road;
  - Crossing a boundary of an aircraft stand and a taxiway;
  - Storm activity at/near the airport;
  - Low visibility procedures commencement; and,
  - Strong winds.

Figure 7. **Example of digital tool for airside vehicle drivers**



Recommendation ADR23: Ensure that the procedures and guidance for vehicle drivers include the stipulation for explicit clearances from ATC before entering or crossing any runway. This requirement should be emphasised in driver training programs and should apply regardless of whether the runway is active or inactive. Procedures should be clear and unambiguous, and compliance should be regularly monitored and enforced. In addition, operators should consider implementing additional safety measures, such as visual aids, technology solutions, or physical barriers to prevent unauthorised runway access.

Reference materials:

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO PANS-ATM (Doc 4444)

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

SKYbrary.aero – Use of aerodrome tower VHF frequency by vehicle drivers involved in runway operations

SKYbrary.aero – ATC Radio Use by Airside Vehicles

ACI – Airside Safety Handbook (4th edition)

SKYbrary.aero – Runway Crossing Incursions
https://skybrary.aero/articles/runway-crossing-incursions

10. Safe Runway Operations Communication

Recommendation ADR24: To minimise call sign confusion at aerodromes, aerodrome operators should ensure the use of predefined and process-specific unique call signs for manoeuvring area vehicles.

Recommendation ADR25: Develop and implement a phased plan for use of one frequency and English language for all communication associated with the operation of a runway. The phased plan should aim at improving the shared situational awareness of all front-line operators and should provide realistic and practicable measures that ensure adequate level of safety for each of its phases.

Recommendation ADR26: Periodically evaluate radiotelephony practices, assessing elements such as use of ICAO-compliant phraseology.

Recommendation ADR27: In cooperation with ANSPs, implement communication procedures for airside vehicles' drivers on what phraseology needs to be applied by both parties, including standard phrases for:

a. Radio checks and readability scale.
b. Radio communication failures (transmitting blind).
c. When a driver becomes lost or uncertain of the vehicle's position in the manoeuvring area.
d. Position reporting.
e. Runway access and runway crossing requests.

Why should aerodrome operators follow these recommendations?

Communication and radio telephony practices should continuously be evaluated and strengthened, where possible, to address the potential of human error in communication. A high standard of operational discipline is critical to ensure all users are contributing to a shared situational awareness that is unambiguous and that safety is paramount.

Using predefined and unique call signs for vehicles in the manoeuvring area minimises the risk of miscommunication. Call sign confusion can lead to instructions being misinterpreted or applied to the wrong vehicle, potentially causing dangerous incursions or collisions. Unique call signs ensure that communications are directed accurately and received by the correct party.

Traffic awareness is a crucial functional barrier within the multi-layered structure that equips the aviation system with comprehensive defences against the risk of runway collision. Implementing a single frequency for runway operations simplifies the communication process, reducing the likelihood of missing critical information due to frequency changes. Using English as the common language, and standard ICAO radiotelephony communication phraseology, further enhances the shared situational awareness among all operators, ensuring that the information is universally understood. A phased approach to implementing this single frequency usage allows for adjustments and training at each stage, ensuring that safety is maintained throughout the transition and that all operators are adequately prepared for the change.

Regularly evaluating and ensuring the use of ICAO-compliant phraseology promotes clarity and understanding in radio communications. This reduces the potential for misunderstandings that could lead to safety incidents.

The use of established standard ICAO phraseologies for radiotelephony communication between aircraft and ground stations is essential to avoid misunderstanding and reduce the time required for communication. Standard phraseology reduces the risk that a message will be misunderstood and aids the readback/hearback process so that any error is quickly detected. Ambiguous or non-standard phraseology has been identified as a causal or contributory factor in some

aircraft accidents and incidents. ICAO phraseology must be used in all situations for which it has been specified. When standardised phraseology for a particular situation has not been specified, plain language shall be used.

ICAO doc. 9432 Manual of Radiotelephony says:

"In the PANS-ATM [doc. 4444], it is further emphasized that the phraseologies contained therein are not intended to be exhaustive, and when circumstances differ, pilots, ATS [air traffic services] personnel and other ground personnel will be expected to use appropriate subsidiary phraseologies which should be as clear and concise as possible and designed to avoid possible confusion by those persons using a language other than one of their national languages. "Appropriate subsidiary phraseologies" can either refer to the use of plain language, or the use of regionally or locally adopted phraseologies. Either should be used in the same manner in which phraseologies are used: clearly, concisely, and unambiguously. Additionally, such appropriate subsidiary phraseologies should not be used instead of ICAO phraseologies, but in addition to ICAO phraseologies, when required, and users should keep in mind that many speakers/listeners will be using English as a second or foreign language.

3.2.4 The use of plain language required when phraseologies are not available should not be taken as licence to chat, to joke or to degrade in any way good radiotelephony techniques. All radiotelephony communications should respect both formal and informal protocols dictating clarity, brevity, and unambiguity."

What can aerodrome operators do to implement the recommendations?

Recommendation ADR24: The standardisation of ground vehicle call signs imposes fewer demands on the cognitive resources of all participants in the communication process. It aids in the identification of one's own call sign, reduces the chance of misidentification of another call sign, facilitates third parties in building and maintaining traffic awareness, and ultimately increases the reliability of the communication.

Additionally, there are reasons for global standardisation of the process-specific discrete calls signs for manoeuvring area vehicles. From a pilot perspective, ground traffic can have different call signs at the various airports pilot visit. If call signs were standardised, it would strengthen a flight crew's traffic awareness and help pilots know what type of vehicle to look out for whenever a vehicle is identified as potential traffic of interest. Some potential examples follow:

Follow-me vehicles: Vehicles that guide aircraft to their parking stands or to the runway can be assigned call signs such as "FOLLOW 1", "FOLLOW 2", etc.

Inspection vehicles: Those used for runway inspections might have call signs like "INSPECT 1", "INSPECT A", or a variation based on the specific inspection type, like "FOD 3" for foreign object debris inspection.

Emergency services: Fire trucks and medical emergency vehicles could be designated as "FIRE 1", "CRASH 2", "MEDIC", or "RESCUE A", depending on their primary function.

Snow removal: Snowplows and deicing vehicles could have call signs such as "SNOW 1", "ICE 2", or "DEICER D".

Construction: For vehicles associated with aerodrome construction or maintenance, call signs could be "CONSTRUCTION 1", "MAINTENANCE B", or "PAVEMENT E".

Baggage and cargo handling: Tugs and belt loaders could be given call signs like "BAGGAGE A", "CARGO 3", or "TUG 4".

Airfield operations: Vehicles used by airfield operations staff might have call signs such as "AIRFIELD 1", " OPS 1", or "SAFETY".

Fuelling vehicles: Fuel trucks could be labelled as "FUEL 1", or "HYDRANT 3" for those connected to an underground hydrant system.

Wildlife management: Vehicles for managing wildlife hazards could have call signs like "BIRD 1" or "WILDLIFE 1".

Airport security: Security patrol vehicles might be designated as "SECURITY 1" or " POLICE 1".

Related GAPPRI Recommendations: REG6

Recommendation ADR25: Traffic awareness is a crucial functional barrier within the multi-layered structure that equips the aviation system with comprehensive defences against the risk of runway collisions. The use of the English language, adherence to standard ICAO radiotelephony communication phraseology, and communication on a single frequency are essential enablers. They facilitate all entities operating on and around the runways to maintain traffic awareness.

After conducting a risk and feasibility assessment, consider developing a detailed, phased plan to transition, where practicable, to the use of a single frequency, and to the English language, for all communications related to runway operations. This plan should prioritise the improvement of shared situational awareness among all front-line operators, such as pilots, vehicle drivers, and air traffic controllers. Each phase of the plan should include realistic measures to maintain or

enhance safety, such as comprehensive training on the new procedures, gradual implementation to allow for adjustment, and constant monitoring to resolve any issues that arise. This approach can assist in the standardisation of exchanges and can minimise misunderstandings among international crews and local personnel.

However, in the short term, it is unrealistic to expect all airports worldwide serving civil aviation to ensure that all vehicle drivers use the standard ICAO phraseology in its entirety. This is why Recommendations ANSP10 and ADR25 propose a phased plan with intermediate stages, ensuring an adequate level of safety at each step.

To facilitate runway traffic awareness for all stakeholders, identify a recommended minimum set of runway phraseologies to be used as a professional language for runway vehicle drivers based on four normal runway operations.

Hereafter, the suggested four safe runway phraseologies are referred to as **4-4-Safety (four for safety):**

4-4-Safety: Safe Runway Phraseologies

Professional Language for Runway Vehicle Drivers

1. **Runway Entering or Crossing**

   Driver: (call sign) (Holding Point / position) REQUEST CROSS / ENTER RUNWAY (number) [FOR INSPECTION]
   ATC: (call sign) CROSS / ENTER RUNWAY (number) [REPORT VACATED]
   ATC: (call sign) NEGATIVE, HOLD SHORT OF (position)
   Driver: CROSSING / ENTERING RUNWAY (number) (call sign)

2. **Operations on Runway for an Extended Period**

   Driver: (call sign) ON RUNWAY (number)
   ATC: (call sign) ROGER, ON RUNWAY (number)

3. **Vacating Runway**

   ATC (call sign) VACATE RUNWAY (number) [IMMEDIATELY], [REPORT VACATED]
   Driver: [IMMEDIATELY] VACATING RUNWAY (number) WILCO (call sign)
   Driver: RUNWAY (number) VACATED (call sign)

4. **Hold Short of the Runway**

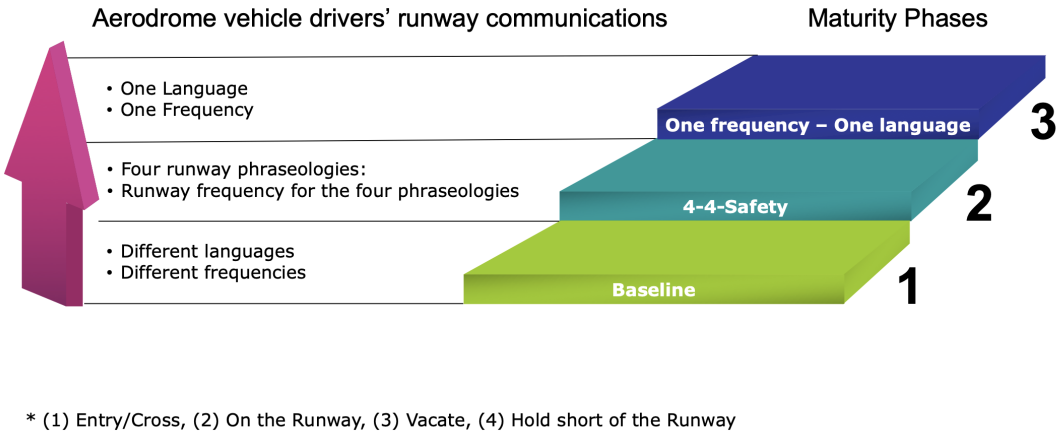
   ATC (call sign) HOLD SHORT OF (position)
   Driver: HOLDING SHORT OF (position) (call sign).

Of the four proposed sets of phraseology for vehicle drivers, two are initiated by drivers and two by controllers. It may be challenging for drivers with low English proficiency to recognise their call sign on a busy frequency, where predominantly English communication could be mostly unintelligible to them.

Different accents, depending on the native language, may also affect how the drivers are understood by others on the frequency. To ensure effective communication, drivers must have sufficient aviation English proficiency to recognise their call sign and correctly use the four phraseologies. However, the aviation English proficiency required for using the 4-4-Safety constitutes a much lower barrier compared to mastering the full extent of communications in English. Implementing predefined and process-specific discrete call signs for vehicles in the manoeuvring area could enhance the reliable application of the 4-4-Safety.

The suggested 4-4-Safety safe runway phraseologies can be introduced as an intermediate step in a phased plan. ANSPs and aerodrome operators can assess their current, baseline maturity level and plan for the necessary activities to achieve the next, second maturity phase, which involves 4-4-Safety. Subsequently, they can progress to the third maturity phase, which includes the use of the English language, adherence to standard ICAO radiotelephony communication phraseology, and communication on a single frequency for a given runway. The maturity phases are illustrated in the next figure.

Figure 8. **Example of a phased plan to assist runway traffic awareness**



* (1) Entry/Cross, (2) On the Runway, (3) Vacate, (4) Hold short of the Runway

It is recommended that, ultimately, communications for all operations on a runway (landing, departing, crossing aircraft, vehicles crossing, and runway inspections etc.) take place on the VHF frequency assigned for that runway; this will help to maintain high levels of situational awareness. To accommodate vehicles that are equipped with UHF radios only, frequency 'coupling' should be employed to ensure that all UHF communications associated with runway operations are simultaneously transmitted on the appropriate VHF frequency (and vice versa). When using RTF frequency coupling, controllers (and drivers) need to be mindful of 'clipped' transmissions, where the beginning or end of the transmission is not broadcast/received.

Concerns about runway frequency congestion due to drivers using VHF can be alleviated by treating every use of the runway as a planned traffic movement, and keeping detailed discussions (e.g., FOD descriptions) for another frequency.

Some aerodromes (e.g. Brussels Airport) have taken the principles described above further and have introduced the concept known as "Triple One": One Runway, One Frequency, One Language (English) as a means to further improve communications for all operations on a runway.

Note: Aerodromes with multiple runways may use a different frequency for each runway.

There may be other measures that support the achievement of "Triple One" and "4-4-Safety". For example, one or more of the following measures (list not exhaustive):

- Runway clearance issued by a single control tower air traffic controller.
- Runway clearance communicated to flight crew by single air traffic controller.
- Runway vehicle drivers monitor the runway frequency of the controller who gives them their runway clearance. Drivers should have English comprehension and skills to recognise critical aircraft runway use clearances to take off and land.
- Vehicle drivers are equipped with runway traffic situation displays that support their runway traffic awareness.
- Cross coupling of frequencies used to manage movements of vehicles and aircraft on the manoeuvring area.
- Aircraft are equipped with real-time on-board functionality of runway traffic operations.

Note: For aerodrome operators subject to EASA regulation, EASA has funded a study on "Triple One" that is currently underway. Prior to implementation of these concepts/recommendations, operators may wish to review the findings of this study.

Related GAPPRI Recommendations: ANSP10, AO6, REG5

Recommendation ADR26: Radiotelephony practices, including frequency loading, should be subject to periodic assessment to identify any emerging issues (e.g., systemic frequency overload, non-compliance with approved phraseology) and take appropriate risk mitigation action. The assessment period should not be too short (e.g., more than just few months) for this will be resource demanding and may lead to complacency if no issues are identified in several

consecutive assessments, nor should the assessment period be too long because a serious issue may develop and lead to a safety occurrence. A period of one year or so seems to be reasonable. Major changes in traffic and/or the operational environment should be considered when deciding on the timing of the assessments.

An effective and efficient evaluation of the radio telephony practices at an aerodrome would best be caried out by a group of communication reviewers experienced in RTF applicable to ground and airside aerodrome control.

It is recommended that communications for all operations on a runway (landing, departing, crossing aircraft, vehicles crossing, runway inspections, etc.) take place on the VHF frequency assigned for that runway; this will help pilots and vehicle drivers maintain high levels of situational awareness.

Use of established ICAO phraseologies for radiotelephony communication between aircraft and ground stations is essential to avoid misunderstanding, and to reduce the time required for communication. ICAO phraseology is to be used in all situations for which it has been specified. When evaluating radio telephony practices, the aspects and potential pitfalls described below should be considered.

In a region or country where English is the native language, operators should discourage the use of plain language by front line operators in situations where standard phraseology is to be used.

It should be noted that the words "position … and / or hold" may be misunderstood by some pilots due to the use of non-ICAO phraseology, for example use of the phraseology "taxi into position and hold…" when issuing a line up clearance. There have been a number of runway safety occurrences with the key words 'position' and 'hold' misapplied.

Caution should be exercised when using the word 'follow' at or near runway holding points, as pilots and drivers may interpret this as clearance to continue following traffic ahead of them as it enters or lines up on a runway. When an aircraft/vehicle is instructed to "follow" traffic and requires a runway crossing, the runway crossing clearance should be issued in addition (separately) to the follow instructions and/or hold short instructions, as applicable.

The phrase 'Go ahead' (meaning pass your message) should not be used in communications with aircraft or vehicles approaching or at the holding position as it may be misinterpreted as an instruction to move the vehicle or aircraft.

The procedure words, ROGER and WILCO, are insufficient acknowledgement of the instructions HOLD, HOLD POSITION, and HOLD SHORT OF (position). In each case, the acknowledgement is to be provided by using the phraseology HOLDING or HOLDING SHORT, as appropriate.

The word "cleared" should not be used to authorise aircraft to taxi or for equipment/vehicle/personnel operations. The prefix "taxi," "proceed," or "hold," should be used, as appropriate, for aircraft instructions and "proceed" or "hold" for equipment/vehicles/personnel operations.

"PROCEED AS REQUESTED" should not be used for instructing aircraft, vehicles, equipment, or personnel to cross or operate on a runway.

When passing clearance to cross a runway, if the control tower is unable to see the crossing aircraft or vehicle (night, low visibility, etc.), the instruction should always be accompanied by a request to report when the aircraft or vehicle has vacated the runway, e.g., "(call sign) CROSS RUNWAY (number), REPORT VACATED".

The use of full call signs of all traffic operating on or in close proximity to a runway has been identified as a critical element in enhancing safety for runway operations. Whilst the ICAO provisions allow for use of abbreviated call signs in certain circumstances, it is deemed best practice not to apply any shortening of call signs of traffic on the manoeuvring area of the aerodrome.

When standardised phraseology for a particular situation has not been specified, locally approved subsidiary phraseologies or plain language should be used. When plain language and/or local subsidiary phraseology are used, the communication messages should be as clear and concise as possible and designed to avoid possible confusion. All radiotelephony communications should respect both formal and informal protocols dictating clarity, brevity, and unambiguity. Further considerations and guidance are provided in section 3.2. of the ICAO Doc 9432 Manual of Radiotelephony.

As per provision 12.2.6 of Doc 4444 PANS ATM, phraseologies for the movement of vehicles, other than tow-tractors, on the manoeuvring area should be the same as those used for the movement of aircraft, with the exception of taxi instructions, in which case the word "PROCEED" should substitute the word "TAXI" when communicating with vehicles.

Speech-transmitting techniques should be such that the highest possible intelligibility is incorporated in each transmission. Fulfilment of this aim requires that when issuing

clearances, controllers should follow the transmitting techniques described in Annex 10, Volume II, 5.2.1.5.

Related GAPPRI Recommendations: ANSP11, AO6

Recommendation ADR27: When implementing this recommendation, ANSP and aerodrome operators may benefit from both general and specific guidance, as well as explanatory material provided hereafter.

General

All personnel involved in operations associated with runways should use clear, concise, and unambiguous phraseologies in a normal conversational tone. Such usage will ensure that safety levels are maintained or improved upon.

Except for an emergency, mobile phones are not to be used at any time when operating within the manoeuvring area.

ICAO Doc. 4444, PANS-ATM phraseologies for the movement of vehicles, other than tow-tractors, on the manoeuvring area should be the same as those used for the movement of aircraft, except for taxi instructions, in which case the word "PROCEED" should be substituted for the word "TAXI" when communicating with vehicles.

The procedure contained in ICAO Doc. 4444, PANS-ATM 12.2.7 makes no provision for vehicles to be included in the process of receiving a conditional clearance; they may only be the subject of a conditional clearance.

Speech transmitting technique should be such that the highest possible intelligibility is incorporated in each transmission. Fulfilment of this requires that ATC and ground personal should:

- Enunciate each word clearly and distinctly.
- Maintain an even rate of speech not exceeding 100 words per minute. When a message is transmitted, and its content needs to be recorded, the speaking rate should be slower to allow for the writing process. A slight pause preceding and following numerals makes them easier to understand.
- Maintain the speaking volume at a constant level.
- Be familiar with microphone operating techniques, particularly in relation to the maintenance of a constant distance from the microphone if a modulator with a constant levee is not used.
- Suspend speech temporarily if it becomes necessary to turn the head away from the microphone.

A. Radio checks and readability scale

It is important that all RTF transmissions are readable (i.e., clear enough and loud enough to be understood). While radios need to be tested, test transmissions should only be as long as is necessary for the test and not longer than 10 seconds.

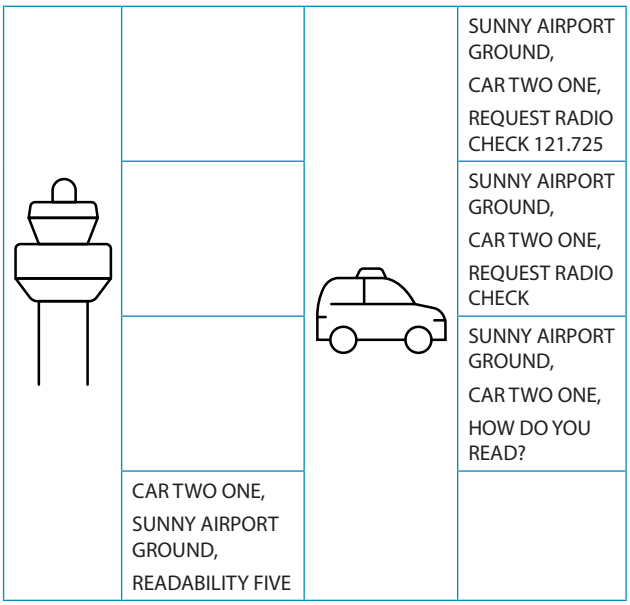
To make clear that the transmission is a test, drivers should follow the format shown below, and include the frequency being used as part of their first transmission. The radio stations will assess the transmission and advise the driver of the readability of the transmission using the following scale.

Table 1. **Radio checks and readability scale**

Readability Scale	Meaning
1	UNREADABLE
2	READABLE NOW AND THEN
3	READABLE BUT WITH DIFFICULTY
4	READABLE
5	PERFECTLY READABLE

Example phraseology:

Figure 9. **Example phraseology for radio checks and readability scale**



B. Radio communication failures (transmitting blind)

For all vehicles on the movement area, maintaining a continuous listening watch is very important. This not only ensures readiness for further instructions or information from ATC but also enables drivers to be aware of the movements of other traffic, thereby reducing the risk of confliction.

Aerodrome vehicle drivers may experience situations where radio communication with ATC cannot be established. The reasons for such communication failure can vary, including technical fault, tuning to a wrong frequency, or some other reason. It is important to note that, in such situations, vehicle drivers are not to enter a runway without authorisation. Entering a runway without a valid ATC clearance will lead to the incorrect presence of traffic on a runway and require reporting a runway incursion.

Vehicle drivers should be aware of the radio communication failure procedures at their airport.

As soon as a vehicle driver identifies a radio communication failure, the vehicle should promptly exit the runway protected area via the fastest possible route. If the vehicle is in the manoeuvring area but outside the runway protected area, it should come to a stop until proper direct or indirect communication is re-established.

When vehicle driver fails to establish contact with ATC (or other relevant aeronautical station) on the designated frequency, they should attempt to establish contact on another frequency available at the airport or establish indirect communication via available airport communication channels (e.g., tower phone number or point-to-point phone/mobile line).

If all attempts to establish communication fail, ATC and the vehicle should continue transmit messages twice on the designated frequency, preceded by the phrase "TRANSMITTING BLIND".

Airports may have special airport procedures to be used in the event of radiocommunication failure. Additionally, the controller/flight information service officer/air ground communication station operator may use the following signals to communicate with vehicles. Drivers should keep a look out for and understand these signals, which have the following meanings.

Table 2. **Radio communication failures (transmitting blind)**

Characteristics and colour of light beam or pyrotechnic	**Meaning when directed from an aerodrome to a vehicle.** Note: some signals have a different meaning when directed to an aircraft
Continuous red light	Stop
Red flashes	Move clear of the landing area
Green flashes	You may move on the manoeuvring area
White flashes	Return to starting point on the aerodrome

C. When vehicle becomes lost or uncertain of its position on the manoeuvring area

The ICAO PANS-ATM 12.2.7 provides that: "Vehicle driver in doubt as to the position of the vehicle with respect to the manoeuvring area shall immediately:

a) notify the appropriate ATS unit of the circumstances (including the last known position);

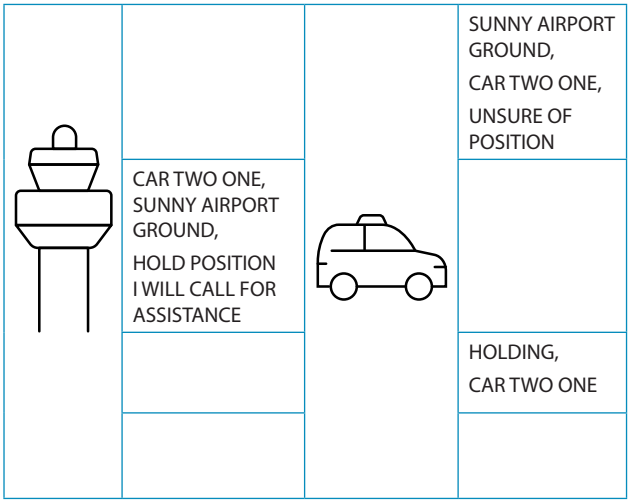
b) simultaneously, unless otherwise instructed by the ATS unit, vacate the landing area, taxiway, or other part of the manoeuvring area, to a safe distance as expeditiously as possible; and then,

c) stop the vehicle.

In the event the aerodrome controller becomes aware of an aircraft or vehicle that is lost or uncertain of its position on the manoeuvring area, appropriate action shall be taken immediately to safeguard operations and assist the aircraft or vehicle concerned to determine its position."

If a driver is lost or unsure of the vehicle's location, the driver should inform the controller/flight information service officer (FISO) immediately and follow instructions. If needed, the vehicle driver should request progressive taxi instructions.

Figure 10. **Example phraseology for when vehicle becomes lost or uncertain of its position on the manoeuvring area**



If a vehicle driver sees a person or vehicle that appears lost, the driver should stop and offer assistance.

D. Position reporting

Vehicle drivers are to report their position whenever:

- Making initial contact with any tower or ground controller, regardless of whether they have previously stated their position to a different controller;
- Requesting to enter manoeuvring area;
- Requesting to enter the protected area of the runway;
- Requesting runway crossing and runway access; And,
- Requesting to be stationary (e.g., for work) on the manoeuvring area, except for a temporary stop for less than 90 seconds.

Vehicle drivers should report their position with respect to aerodrome movement area elements such as taxiways, holding positions, and bays. While other elements from the aerodrome layout, like hangars and maintenance stations, can serve as additional cues, they should not replace the primary aerodrome movement area elements in position reporting.

In addition to verbal communications between vehicle drivers and air traffic control, vehicles themselves can be equipped with ABS-B transmitters to reduce vehicle incursions into protected areas on an Aerodrome surface. Once equipped, a runway incursion warning system (RIWS) will alarm to alert vehicle drivers when the vehicle is near or is inside the protected area of a surface that is designated for aircraft landing and take-off operations. A RIWS will also provide an alarm to the vehicle driver to avoid temporary construction areas and other protected portions of the air operations area (AOA). This system can be used to inform the proximity of hot spots to the vehicle driver. It may be used by the airport to warn the vehicle driver to avoid temporarily closed areas (e.g., a construction project area).

E. Runway access and runway crossing requests

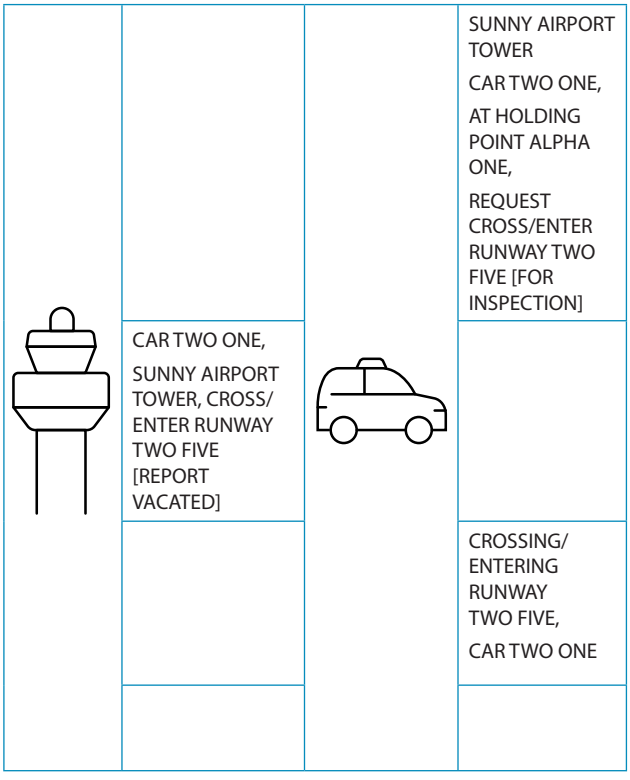
Drivers of vehicles obtain an ATC clearance and instructions before entering the manoeuvring area, which includes any taxiway or runway. Furthermore, the request for runway crossing and runway access should be made using the phraseologies defined in section 4-4-Safety, as described elsewhere in this document.

The ATC clearance and instructions for runway crossing and runway access are to be read back. When vehicle drivers request approval to enter the manoeuvring area, to cross or enter a runway, the vehicle do not proceed until the readback is completed in full. This allows ATC to confirm the vehicle is proceeding as authorised.

To prevent runway incursions, when an ATC unit issues an instruction to cross a runway, the appropriate holding point designator should be included in the instruction. A vehicle driver should query any instruction that identifies a holding point designator inconsistent with the vehicle location, or the driver's request, before proceeding onto the runway.

Example phraseology:

Figure 11. **Example phraseology for runway access and runway crossing requests**



If ATC is unable to see the crossing vehicle/person (e.g., because of darkness or low visibility), the instruction should always be accompanied by a request to report when the runway has been vacated.

The driver will, when requested, report "RUNWAY VACATED" when the vehicle is beyond the relevant runway holding position/runway protected area.

Related GAPPRI Recommendations: ANSP15

Reference materials:

SKYbrary.aero – Call-sign Confusion

SKYbrary.aero – Multi-language ATC Operations

SKYbrary.aero – Use of aerodrome Tower VHF frequency by vehicle drivers involved in runway operations/Responses

SKYbrary.aero – ATC Radio Use by Airside Vehicles

European Action Plan for Air Ground Communications Safety

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO PANS-ATM (Doc 4444)

ICAO Annex 10 – Aeronautical Telecommunications Volume II

ICAO Manual of Radiotelephony (Doc 9432)

FAA Guide to Ground Vehicle Operations

FAA Advisory Circular AC 150/5210-20, as amended – Ground Vehicle Operations to include Taxiing or Towing an Aircraft on Airports

UK CAA – Reference Guide to UK Phraseology for Aerodrome Drivers

11. Aeronautical Information

Recommendation ADR28: In collaboration with ANSPs, ensure that significant and up-to-date aerodrome information which may affect operations on the runway is provided to manoeuvring area drivers and pilots (e.g., by NOTAMS, automatic terminal information service (ATIS), radiotelephony (R/T), maps, new digital technology or other means).

Recommendation ADR29: Information on temporary changes to operating conditions at the aerodrome should be communicated in a way to increase the situational awareness of the most critical changes. When needed, an Aeronautical Information Publication (AIP) supplement with graphics and charts should be published.

Why should aerodrome operators follow these recommendations?

Aerodrome operators have an essential role in ensuring the accuracy, timeliness, and reliability of information critical for safe runway operations. Implementing measures to provide time-critical and quality aeronautical information at aerodromes significantly enhances runway incursion prevention. This should consider adherence to ICAO SARPs for data quality, protecting data integrity during processing, establishing clear processes between data originators and aeronautical information service provider (AISP), efficiently collecting operational information, and rapidly processing post-flight data.

Effective communication is the cornerstone of safe aviation operations, and by ensuring all users are well informed of current and temporary conditions, aerodrome operators can significantly reduce the likelihood of runway incursions. Temporary changes can present a significant risk as these changes may not have been included in the most recent information available to pilots and drivers. Therefore, it is essential to ensure the most critical information is communicated.

Implementing measures to provide time-critical and quality aeronautical information at aerodromes significantly enhances runway incursion prevention.

Collaborating with ANSPs to ensure that current and significant aerodrome information is disseminated to all relevant parties reduces the risk of incidents due to outdated or incorrect information. This includes pilots and drivers who operate in the manoeuvring area and must be aware of any factors that could impact runway operations.

Utilizing a range of communication methods, such as NOTAMs (Notices to Airmen, also known as Notice to Air Missions), ATIS (Automatic Terminal Information Service), radio communication, maps, and digital technologies, ensures that the information reaches all users in a format (e.g., hyperlinks) that is convenient and accessible for them, thereby enhancing compliance and operational safety.

Communicating temporary changes effectively is crucial for maintaining situational awareness among aerodrome users. The most critical changes can have significant safety implications, and ensuring that these are understood by all users helps in preventing accidents or operational disruptions.

Publishing an Aeronautical Information Publication (AIP) Supplement, especially with graphics and charts for complex or significant changes, provides a clear and authoritative reference that can be used for pre-flight planning and in-flight navigation, thereby reducing the risk of misunderstandings or non-compliance with temporary operating procedures.

What can aerodrome operators do to implement the recommendations?

Recommendation ADR28: Aerodrome operators, in collaboration with ANSPs, should establish a reliable and efficient system for disseminating vital aerodrome information that could impact runway operations. This system should leverage multiple channels to ensure redundancy and accessibility.

- NOTAMs should be issued for timely and formal communication of essential information.
- ATIS can be utilized for continuous broadcast of non-control information in voice format.
- Radiotelephony should be used for immediate and dynamic communication with manoeuvring area drivers and pilots.

Additionally, the use of up-to-date digital maps and technology platforms can enhance the understanding and visibility of any changes or restrictions. For example, integrating real-time updates into digital moving maps in vehicles or electronic

flight bags used by pilots can provide immediate access to important information. Aerodrome operators should also consider the development of various platforms like digital displays, mobile apps, and digital information boards to allow for redundancy and ensure that that information has the widest possible dissemination.

Arrangements should be made at aerodromes for the collection of information concerning the state of operations of air navigation facilities and services noted by aircrew. Special emphasis should be put on collaborative arrangements to make available information on hot spots and runway holding positions. These arrangements should ensure that the information is made available to AIS, for distribution as the circumstances necessitate.

Related GAPPRI Recommendations: ANSP17, AO7

Recommendation ADR29: It is essential that temporary changes to operating conditions are communicated effectively to all relevant parties to increase situational awareness.

When significant alterations occur, such as construction work or temporary area closures, these should not only be communicated through regular channels like NOTAMs but also visually through an AIP (Aeronautical Information Publication) Supplement. The supplement should include detailed graphics and charts to provide a clear understanding of the changes. These should be made available in both printed and digital formats to ensure they are accessible to all users, regardless of their preferred method of information consumption.

The publication of such information should be accompanied by briefings or workshops for front-line operators, including air traffic controllers, pilots, and vehicle drivers, to ensure they fully understand the implications of these changes on daily operations. This proactive approach ensures that all parties have a heightened level of situational awareness regarding temporary aerodrome conditions, which is crucial for maintaining safety and operational efficiency.

Related GAPPRI Recommendations: ANSP17, AO7

Reference materials:

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Annex 14 – Aerodromes, Volumes I and II – Ch. 2;

ICAO Annex 15 – Aeronautical Information Services

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

Advisory Circular 150/5200-28, as amended – Notice to Air Missions (NOTAMs) for Airport Operators

FAA Website – What is a NOTAM? - *https://www.faa.gov/about/initiatives/notam/what_is_a_notam*

ICAO Annex 4 – Aeronautical Charts, Appendix 6)

ICAO Doc 8126 – Aeronautical Information Services Manual

EUROCAE ED-99/RTCA DO-272, User requirements for aerodrome mapping information

EUROCAE ED76/RTCA DO 200, Standards for processing Aeronautical data

EUROCAE ED 77/RTCA DO 201, Standards for Aeronautical Information

12. Enhanced Technology for Safe Runway Operations

Recommendation ADR30: Commensurate with the level and complexity of operations and the potential risk of runway incursion, consider providing airside vehicle drivers with a real-time functionality for awareness and alerting to the potential for a runway collision between an aircraft and an airside vehicle and with real-time alerts when crossing into the protected area, such that drivers will be alerted in the event of a runway incursion.

Recommendation ADR31: Enable the tracking of vehicle movements in the manoeuvring area when possible. Facilitate situational awareness by adopting technologies that enable ATC and other parties to locate and identify traffic in the manoeuvring area

Recommendation ADR32: Assess technical feasibility and business sustainability of new procedures and technologies for runway inspection.

Recommendation ADR33: Implement policies and means to support vehicle drivers with identification of hold limits in respect to the protected area of a crossing runway (e.g., marking, geofencing, airport moving map).

Why should aerodrome operators follow these recommendations?

Technology is advancing rapidly, and it is essential that aerodrome operators stay informed and consider new and existing, technologies that can actively contribute to a safer airside environment. Using technology to enhance the operational control and safety oversight capabilities of vehicle movements can play a significant role in reducing in the likelihood and severity of runway incursions.

By equipping airside vehicle drivers with real-time functionality for situational awareness and collision alerts, aerodrome operators can significantly reduce the risk of runway incursions and potential collisions. This technology provides immediate alerts to drivers when they are in the proximity of an active runway, thereby increasing the margin of safety. Similarly, tracking vehicle movements on the manoeuvring area enhances the overall situational awareness for both ATC and airside vehicle operators. This can prevent unauthorised access and potential conflicts by ensuring that all movements are monitored and appropriately managed.

Regular assessments of the technical and economic viability of new procedures and technologies for runway inspection ensure that aerodrome operators implement only those innovations that offer practical benefits and are sustainable in the long term. This approach supports the evolution of airfield safety without imposing unnecessary financial burdens or operational disruptions.

Implementing policies and tools that help vehicle drivers recognize hold limits, such as enhanced marking, geofencing, and airport moving maps, directly contributes to preventing incursions into protected areas. These measures provide clear and precise guidance to drivers regarding where they can and cannot go, which is essential for maintaining safe separation between aircraft and vehicles.

What can aerodrome operators do to implement the recommendations?

If economically viable, aerodrome operators can significantly reduce the risk of runway incursions and enhance airside safety by implementing enhanced technologies to support vehicle drivers in safer operations. The implementation of such measures requires a careful balance between the adoption of new technologies, the training and equipping of personnel, and the ongoing assessment and refinement of airside procedures.

Recommendation ADR30: Evaluate current operations and the associated risks of runway incursions to determine the appropriate level of technology required for airside vehicle drivers. Depending on the operational complexity, consider implementing GNSS/GPS-based or mobile app real-time

alerting systems that provide immediate warnings to drivers when approaching a runway or entering a protected area. This technology could range from basic alerting mechanisms to advanced systems integrated with ATC surveillance data, providing alerts for runway incursions or when vehicles inadvertently enter protected areas. Such systems should be user-friendly and designed to minimise distraction, enhancing drivers' situational awareness without adding to their workload.

There are also great potential safety benefits for a vehicle side alerting solution for risk of collision with an aircraft. A vehicle is much easier to stop than an aircraft in a high energy state and current avionics alerting features, such as SURF-A, will not be able to detect a risk of collision with ground vehicles.

However, a system where aircraft ADS-B positions are monitored and used to compute a risk of collision or proximity alert with an aircraft and broadcast to ground vehicles would offer significant safety improvements, especially in low visibility situations.

Ground vehicles could receive this information through an on-board tablet application using the vehicle's GPS position and aircraft positions, similar to the PRGAeroTraffic APP in use at Prague Airport and discussed in ADR22.

A description of potential solutions is also available in SESAR SJU reference #4 – "Enhanced Traffic Situational Awareness and Airport Safety Nets for vehicle drivers".

The following systems are considered:

- Provision of an airport moving map in the vehicle, together with the display of the surrounding traffic, to enhance the driver's situational awareness:
  - The airport moving map function indicates the position of the vehicle on the airfield and the ground traffic display function displays other traffic operating on the movement area of the airport. The other traffic to be displayed includes both aircraft and vehicles.
- Provision of alerts to vehicle drivers to warn them of situations that, if not corrected, could lead to hazardous situations:
  - Traffic alerts to warn the vehicle driver of a potential or actual conflict with an aircraft.
  - Area infringement alerts to warn the vehicle driver when the vehicle is in a closed or restricted area while the vehicle is operating on the manoeuvring area.

Two implementations may be considered for the generation of alerts:

- Alerts may be generated by an on-board system; or
- Alerts may be generated by a centralised server (connected to the A-SMGCS) with an uplink to the vehicle.

According to the European ATM Master Plan Implementation Objectives Monitoring, this type of solution has been implemented at four European airports in Frankfurt; Paris; and Rome (EDDF, LFPG, LFPO and LIRF) and is being implemented at six additional airports.

Related GAPPRI Recommendations: ANSP32, MFR3

Recommendation ADR31: Tracking of airside vehicles is crucial for maintaining situational awareness. Aerodrome operators should adopt GPS/GNSS/ADS-B tracking technologies that allow for the precise tracking of vehicle movements on the manoeuvring area. Where possible, the data from these systems should be integrated with the ATC systems, ensuring that controllers have a real-time overview of all traffic on the manoeuvring area. This integration would facilitate better coordination between vehicle drivers and ATC, enhancing safety and operational efficiency.

Related GAPPRI Recommendations: ANSP33

Recommendation ADR32: Assess the technical and economic viability of new procedures and technologies before implementation, especially for runway inspection. This assessment should consider the benefits of new technology in terms of safety and efficiency, as well as the costs involved in acquiring, operating, and maintaining these technologies. The feasibility study should also consider the potential to integrate new systems with existing systems and procedures to ensure a seamless adoption of new technology. An example would be the use of drone technology for the inspection of runways.

Related GAPPRI Recommendations: ANSP9, ANSP26

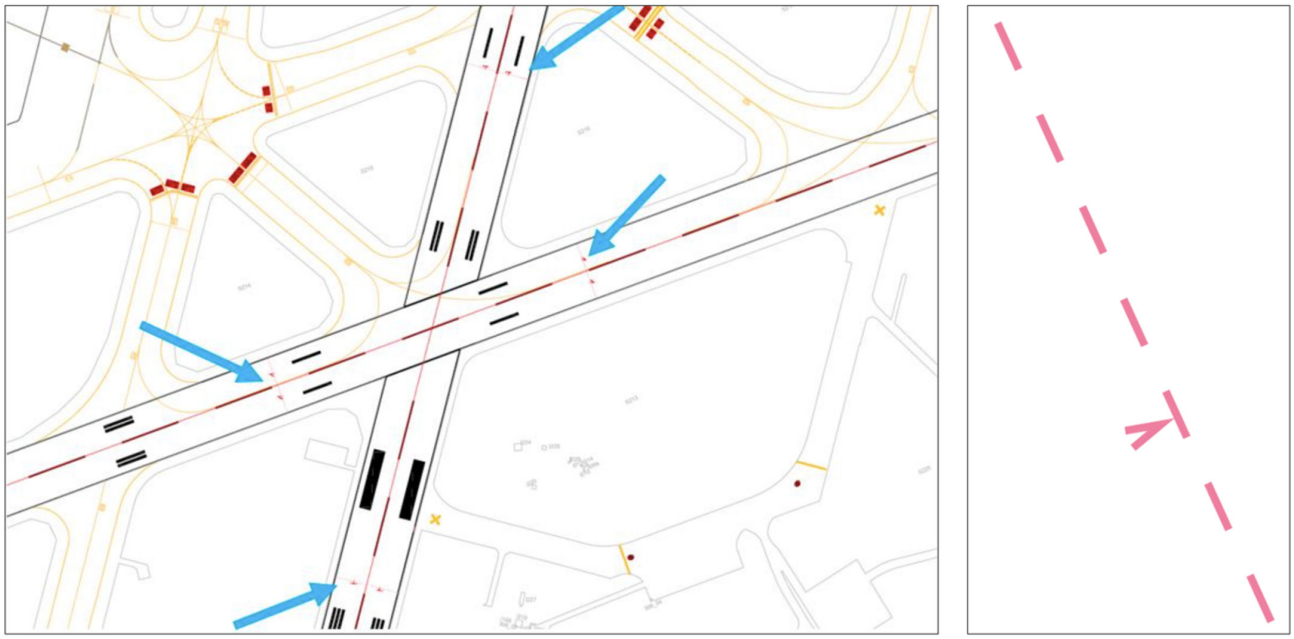
Recommendation ADR33: Policies and means should be implemented to assist vehicle drivers in identifying hold limits near protected areas of crossing runways. This could involve:

- Application of clear and distinctive markings on the pavement;
- Use of geofencing technology to provide alerts to drivers; and,
- Implementation of airport moving map applications that show the vehicle's position in relation to the hold limits.

These tools and policies must be designed to be intuitive and reliable, ensuring that even in poor visibility or high-stress situations, drivers can easily identify the limits of protected areas.

As an example, one aerodrome operator was experiencing a number of runway incursions at the intersection of two runways, where vehicles were moving on the runway and, when issued a "hold short" instruction from ATC, misjudged the distance to the intersecting runway due to lack of visual reference. After testing with different kinds of paint and taking into account ICAO/EASA/ACI guidelines on markings, it was determined that pink dashed markings across the runway were most effective at providing a visual indicator and avoiding confusion.

Figure 12. **Example of pink dashed markings**



Brussels aerodrome (EBBR) has also introduced a geofencing application to help maintain awareness of authorized and unauthorized areas for entry or works (construction or maintenance). Areas can be defined as "Do not leave this area" and "Do not enter".

Figure 13. **Example of geofencing**

Geofencing is particularly useful in situations involving vehicles that may not have transponders, work being performed in zones filtered due to clutter, large areas, a contractor workforce that is unfamiliar with aerodrome layout and specifics, winter operations, grass mowing, inspections on foot, FOD and sweeping programs, etc.

This technology allows for awareness and control by the involved parties without the need for everyone involved to have in-depth knowledge of the aerodrome layout and specifics. Users can easily tell where they are supposed to be and where they aren't supposed to be.

Reference materials:

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

ACI Airside Safety Handbook

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

SKYbrary.aero – Runway Crossing Incursions

SKYbrary.aero – Vehicle Driver Airside Safety Check List

Airservices Australia – An Airside Driver's Guide to Runway Safety

ACI Airside Safety Handbook

FAA Guide to Ground Vehicle Operations

Advisory Circular 150/5210-25, as amended – Performance Specification for Airport Vehicle Runway Incursion Warning Systems (RIWS)

Advisory Circular 150/5220-26, as amended – Airport Ground Vehicle Automatic Dependent Surveillance - Broadcast (ADS-B) Out Squitter Equipment

SESAR SJU reference #4 – "Enhanced Traffic Situational Awareness and Airport Safety Nets for vehicle drivers"

APPENDIX B
Guidance and Explanatory Material for Air Navigation Service Providers

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1. Support to Runway Safety Team

Recommendation ANSP1: Support the regulator to periodically assess the effectiveness of aerodrome local runway safety teams, including the existence and implementation of Runway Safety Action Plans. Annually assess own contribution to the effectiveness of the aerodrome local runway safety teams. Promote the creation and support the work of a National Runway Safety Team.

Recommendation ANSP2: Ensure harmonised awareness of runway incursion risk management procedures, practices and issues among the front-line operators (pilots, air traffic controllers and manoeuvring area vehicle drivers). Support aerodrome operators to develop aerodrome specific educational materials to familiarise pilots and vehicle drivers with hotspots and other aerodrome-specific safety information in the aerodrome environment.

Recommendation ANSP8: Annually assess the consistency of runway safety procedures for operation on the manoeuvring area of the aerodrome internally and at LRST meetings. The assessment should include the coordination and communication procedures and practices between ATC work positions and between ATC and the other parties operating on the manoeuvring area.

Why should ANSPs follow these recommendations?

It is recognised that it is critical for ANSPs to actively participate in Local Runway Safety Teams (LRST) as a means of enhancing runway safety. A systematic evaluation of their involvement in the LRSTs, focusing on the effectiveness of Runway Safety Action Plans and the teams that implement them is a proactive means to identify potential improvements and mitigate risk to strengthen the aerodrome's safety management.

Sharing of investigative outputs carried out by each participating organisation in its respective and specific field of expertise and applying consistent and harmonised procedures contribute to a safer operational environment. To maintain a cohesive understanding of runway incursion risk management, ANSPs, in cooperation with aerodrome operators, should actively involve front-line personnel, including pilots, air traffic controllers, and vehicle drivers in the awareness and adherence to risk management procedures, practices, and issues that play a vital role in preventing runway incursions. The goal is to promote a harmonised approach to safety procedures, ensuring a safe operational environment.

Periodic evaluations, conducted as part of Local Runway Safety Team (LRST) meetings ensure the integrity and consistency of runway safety procedures. Such assessments allow ANSPs to address any discrepancies in their procedures and practices, reinforce best practices, and foster a strong safety culture.

It may be necessary to convene the LRST on a more frequent basis, as appropriate. Some aerodromes may need to do so twice per year, once each quarter, or on an ad hoc basis when upcoming special events or construction projects would deem it necessary to bring together aerodrome stakeholders for runway safety discussions.

What can ANSPs do to implemen the recommendations?

Recommendation ANSP1: ANSPs should establish a comprehensive process for the annual assessment of their contribution to the effectiveness of the aerodrome local runway safety teams.

This should include:

- Review of the existence and implementation of Runway Safety Action Plans (RSAPs);
- Identification of potential runway safety issues;
- Review of effectiveness of existing implemented measures on reducing runway incursions;
- Discussion of new initiatives;
- Review of key metrics, such as the reduction in runway incursions year-over-year; and,
- Review of overall performance of the runway safety team.

The assessment process should be structured and systematic. It could be undertaken by every participant and then shared, or caried out jointly during the LRST meeting. The assessment process should ensure a comprehensive understanding of the effectiveness of the measures in place and identify areas for improvement it should involve key stakeholders such as:

- Air traffic controllers;
- Pilots, representing all aerodrome user groups;
- Locally based and transient users, when possible;
- Relevant ground personnel; and,
- Pilot and Controller Associations.

The assessment should include a review of ad-hoc operational feedback by pilots and ATCOs, incident reports, safety data, and any corrective actions taken in response to previous runway safety incidents. Additionally, the assessment should consider feedback from the runway safety teams and incorporate lessons learned from past mitigated events, as well as incidents to enhance future safety measures.

Recommendation ANSP2: ANSPs should support harmonised awareness of runway incursion risk management procedures among front-line operators, including pilots, air traffic controllers, and manoeuvring area vehicle drivers. This involves collaboration with aerodrome operator to develop and implement training programs and communication strategies to enhance awareness and understanding of runway incursion risks.

Training programs should cover the latest procedures, practices, and issues related to runway incursion risk management. This includes regular updates to ensure that front-line operators are well-informed about evolving safety standards and best practices. These programs should be designed for all personnel and harmonise content with training provided to other operators, including pilots, aerodrome operators, and ground crew, to educate them about runway safety, the causes and consequences of runway incursions, and best practices for prevention.

For example, development of online training accessible to frontline operators that emphasises common procedures, communication protocols, and safety practices related to runway operations. This module should include:

- Interactive scenarios simulating common runway incursion risks;
- Quizzes to test understanding; and,
- A section on airport-specific procedures, configuration and hot spots.
- Training should also incorporate case studies of past incidents to highlight potential risks and the importance of adherence to procedures.

Communication strategies should facilitate the exchange of information among different stakeholders, promoting a shared understanding of the importance of runway safety and the role each party plays in mitigating risks. Regularly conducted safety campaigns and awareness programs can assist in keeping the issue of runway incursions at the forefront of airport operations. Hosting or participating in workshops and seminars can facilitate the exchange of information and experiences between different stakeholders (pilots, air traffic controllers, and vehicle drivers) to provide a more nuanced understanding of the risks and mitigations around runway incursion risk at the aerodrome.

Recommendation ANSP8: ANSPs should conduct an annual evaluation of the consistency of runway safety procedures for operations on the manoeuvring area. This evaluation may be undertaken by every participant internally and then shared, and/or caried out jointly during the LRST meeting., It should involve air traffic controllers, pilots, and manoeuvring area vehicle drivers. The goal is to ensure that all relevant parties are aligned in their understanding and implementation of runway safety procedures.

The evaluation should involve:

- Systematic review of each procedure related to runway operations, discussion of real-world practices, and any discrepancies or challenges encountered during daily operations (Use a checklist to ensure all aspects of runway operations are covered).
- Comparison of current procedures with updated best practices and regulatory requirements.
- Review of recent incident reports to identify inconsistencies or gaps and develop action plans to address them.
- Discussion of practical insights from frontline operators (e.g. derived by targeted safety surveys distributed to ATCOs or aircraft operators)

The aim is to identify areas of improvement, address potential sources of confusion or misunderstanding, and enhance the overall consistency and effectiveness of runway safety procedures.

Implementing these recommendations requires a systematic and collaborative approach involving all relevant stakeholders at the aerodrome. Regular assessments harmonised awareness programs, consistent procedures, and tailored risk assessments are essential elements in enhancing runway safety and reducing the risk of runway incursions.

Reference materials:

ICAO Global Runway Safety Action Plan

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Runway Safety Team Handbook - Second Edition, June 2015

ICAO Runway Safety Toolkit

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

EASA Basic Regulation and Commission Regulation No 139/2014 (Aerodrome Regulation)

ACI Runway Safety Handbook – Second Edition 2022

SKYbrary.aero - Local Runway Safety Teams (LRST)

SKYbrary.aero – Hot Spots at Aerodromes

FAA Runway Safety Program - *https://www.faa.gov/airports/runway_safety*

2. Training

Recommendation ANSP3: Annually assess, and update as necessary, how runway incursion risk management is included within initial and refresher/recurrent training of operational staff.

Why should ANSPs follow these recommendations?

It is essential for ANSPs to maintain a skilled, knowledgeable, and safety-conscious workforce to ensure the highest standards of safety of operations. This includes defining and refining training programs and materials for controllers' training.

By annually assessing and updating the risk mitigation strategies within training programs, ANSPs can ensure that operational staff are always aware of current best practices and threats. This approach allows the incorporation of new information and experiences into training, ensuring that personnel have the needed knowledge and skills to effectively prevent runway incursions.

Regular refresher and recurrent training for operational staff is critical for maintaining a high level of alertness and awareness regarding runway incursion risks. It also supports the retention of crucial knowledge and skills over time, addressing any complacency that might develop in routine operations.

Defining controllers' training program requirements and regularly assessing them ensures that individuals controllers are properly educated in safety protocols and operational procedures to reduce the likelihood of accidents or incidents caused by human error. Including practical training and proficiency checks in these programs helps to reinforce the theoretical knowledge with hands-on experience, is critical for understanding the real-world implications of airside operations and the importance of adherence to safety practices.

What can ANSPs do to implement the recommendations?

Implementing this recommendation requires a structured, systematic approach that prioritises continuous review, evaluation and improvement of training programs. ANSPs must remain vigilant in their efforts to incorporate evolving safety measures into training content and to ensure strict compliance with regulations. This proactive stance on training and permits will significantly contribute to mitigating runway incursion risks and enhancing the overall safety of ANSPs.

Recommendation ANSP3: ANSPs should establish a rigorous, annual review process for the training programs of operational staff, ensuring that the content addresses current runway incursion risks and the latest mitigation strategies. This should entail a comprehensive assessment of the training curriculum to identify areas for enhancement, which may include:

- Integrating recent incident data;
- Considering updated safety protocols;
- Reviewing recent safety surveys or results from ATC familiarisation flights; and,
- Reviewing relevant runway safety technologies implemented by the aerodrome operator or aircraft operator.

As part of this assessment, ANSPs should involve frontline staff and training experts to ensure the training remains relevant and effective. They must also ensure that refresher or recurrent training is mandated for all operational staff to reinforce key safety principles and procedures, adapting the training content as necessary based on the outcomes of these assessments.

ANSPs should review and update training programs annually to incorporate the latest safety practises, regulatory changes, and lessons learned from recent incidents.

This should include evaluating:

- The content of the training;
- The effectiveness of delivery methods (such as classroom-based, simulation, or e-learning); and,
- The performance of staff in training assessments.

ANSPs may also wish to consider:

- Inclusion of practical components like simulations or on-field exercises in the training; and
- Establishing a feedback system where staff can provide input on the training's relevance and effectiveness which can then be used to continuously improve the training program.

Reference materials:

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

3. Safety Learning and Sharing

Recommendation ANSP4: Ensure that information is provided to, and requested from, all participating parties in an incident, so that a complete picture of causal and contributory factors can be built, lessons learned and actions taken.

Recommendation ANSP5: Share at local, national and international level the lessons learned and salient safety information from occurrence investigation reports and runway safety analyses.

Why should ANSPs follow these recommendations?

A safety culture that prioritises continuous improvement, collaborative learning, and transparency, is crucial to creating a safer aviation system for all stakeholders.

By ensuring that relevant information is exchanged among all parties involved in an incident, ANSPs can help construct a complete and detailed picture of the events that led to an occurrence. This comprehensive understanding is essential to identify both the direct causes and the contributing factors of an incident, which might include operational, technical, human factors, or environmental aspects. After completing a thorough analysis of an incident, ANSPs can devise targeted actions and strategies that address the root causes and contributing factors identified enabling them to mitigate the risk of similar incidents occurring in the future.

Sharing lessons learned and essential safety information aligns with international regulatory requirements and guidance, such as those from ICAO and the European Union Aviation Safety Agency (EASA), which promote transparency and collaboration to improve overall aviation safety. It also contributes to the collective knowledge base and the enhancement of safety standards across the aviation industry. This not only enables the aerodrome that experienced an incident to learn but also enables others to adjust their operations to prevent similar occurrences.

The dissemination of safety information and lessons learned on a wider scale—locally, nationally, and internationally—facilitates a global approach to risk mitigation. This harmonisation of safety efforts ensures that valuable insights are not restricted to one region or ANSP but are utilised for the benefit of the entire aviation community.

What can ANSPs do to implement the recommendations?

ANSPs should consider the establishment of communication protocols designed to foster a comprehensive safety management system that addresses information sharing about incidents and the dissemination of lessons learned.

Recommendation ANSP4:

ANSPs should consider:

- Developing or implementing a comprehensive electronic incident reporting system to collect pertinent information to facilitate and enhance the sharing of relevant information pertaining to incidents amongst all relevant stakeholders involved in an incident, including pilots, ground handlers, and air traffic controllers.
- The system should be easily accessible and user-friendly to encourage reporting. It should prompt users for specific information, such as the time of the incident, parties involved, weather conditions, sequence of events, and other pertinent information, ensuring a comprehensive dataset.
- Implementing confidential reporting channels to protect the identity of reporters.
- Following the principles of just culture and promoting an organisational culture that encourages voluntary reporting of incidents without fear of punitive measures can be an effective way to gather more, and better, information related to incidents.
- Establishing joint committees and working groups to review incidents and share information.

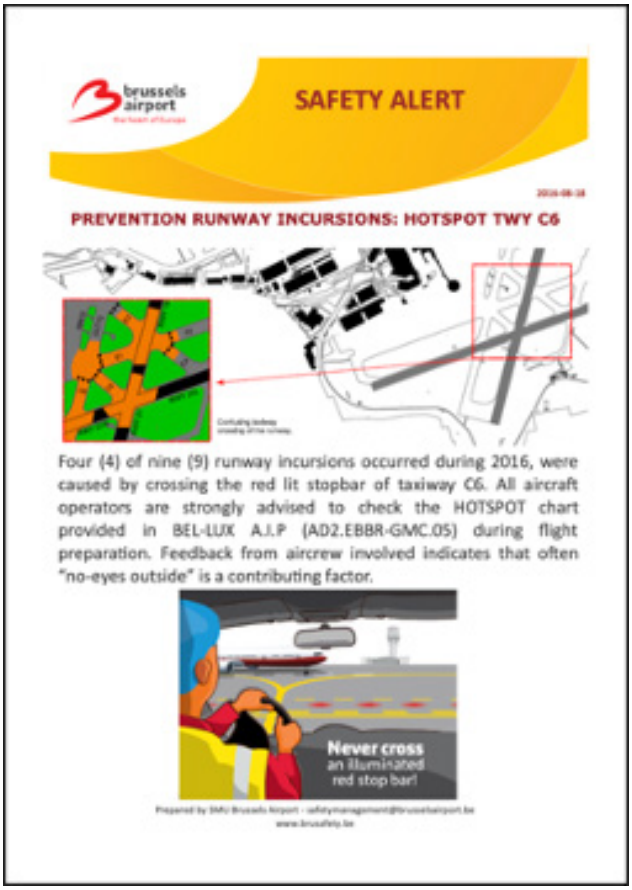
Communication between all relevant ANSP departments and external stakeholders such as aerodrome operators, emergency services and airlines can facilitate the collection of critical safety data. This can help ensure that a comprehensive investigation is completed by considering multiple perspectives and providing a more thorough understanding of the causal and contributory factors surrounding the incident.

Recommendation ANSP5:

The sharing of safety information derived from the investigation and analysis of occurrences is a key component of improving systemic safety. There are many ways to facilitate communication and it is important to select the methods that work best for your organisation. Below are some examples:

- Make use of LRSTs to facilitate the collection, sharing, and dissemination of relevant information and lessons learned from occurrence investigation and analysis.
- Develop a repository for storing and organising safety information, investigation outcomes, and best practices.
- Engage with industry groups, regulatory bodies, and safety organisations to share insights and learn from others' experiences. Host or participate in workshops, seminars, and conferences dedicated to runway safety.
- Leverage the internet and aviation safety platforms to disseminate information broadly and efficiently. Consider creating webinars, podcasts, or online courses that can reach a wide audience.
- Work with organisations such as ICAO, EASA, and Airports Council International (ACI) to align local practices with global standards. Contribute to and utilise existing safety databases such as Flight Safety Foundation's Global Safety Information Project (GSIP)), the U.S. Federal Aviation Administration's (FAA) Aviation Safety Information Analysis and Sharing (ASIAS) system, or the European Coordination Centre for Accident and Incident Reporting Systems (ECCAIRS).
- Regularly release safety bulletins and/or newsletters highlighting recent incidents, lessons learned, and preventive measures adopted. Distribute these publications to all stakeholders within the aerodrome community and beyond.
- A safety bulletin (Figure 14), examples shown below, is one simple and effective way to communicate important safety information to stakeholders.

Figure 14. **Safety bulletin examples**



Reference materials:

ICAO Annex19 – Safety Management Systems

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Global Runway Safety Action Plan

ICAO Runway Safety Team Handbook - Second Edition, June 2015

Commission Regulation (EU) 376/2014 on the reporting, analysis and follow-up of occurrences in civil aviation

European Union Aviation Safety Agency (EASA) ARA. GEN.125

SKYbrary.aero

4. Safe Change Management

Recommendation ANSP6: Ensure that arrangements are in place to coordinate changes to manoeuvring area procedures, including work in progress, with stakeholders operating on the manoeuvring area of the aerodrome. Periodically assess the effectiveness of the arrangements and update as necessary.

Recommendation ANSP7: Periodically (initially and upon change) review runway capacity enhancing procedures when used either individually or in combination (intersection departures, multiple line-up, conditional clearances etc.) to identify any potential hazards and, if necessary, develop appropriate mitigation strategies.

Why should ANSPs follow these recommendations?

The recommendation to ensure that arrangements are in place for coordinating changes to manoeuvring area procedures with stakeholders operating on the aerodrome is crucial for maintaining operational efficiency and safety. The manoeuvring area of an aerodrome is a dynamic environment with various activities, including aircraft movements, maintenance, and construction work. Effective coordination is essential to prevent conflicts, enhance communication among stakeholders, and mitigate potential safety hazards. Regular assessments of the coordination arrangements allow the identification of any shortcomings or evolving challenges, enabling timely updates to the procedures to align with current operational needs and industry standards. This proactive approach contributes to the overall safety and smooth functioning of the aerodrome's manoeuvring area.

The recommendation to periodically review runway capacity-enhancing procedures, both initially and upon any changes, is imperative for ensuring the ongoing safety and efficiency of aviation operations. Runway capacity-enhancing procedures, such as intersection departures, multiple line-ups, and conditional clearances, runway vacation requirements per type of aircraft, reduced intervals between arrivals, and between departures, play an important role in optimising airport throughput. Regular reviews of these procedures enable the identification of potential hazards associated with their implementation, considering factors such as increased traffic density and evolving operational requirements. Through conducting thorough assessments, aviation organisations can proactively identify and address emerging risks, leading to the development of appropriate mitigation strategies. This approach contributes to the continuous improvement of runway operations, maintaining a balance between capacity enhancement and safety considerations.

What can ANSPs do to implement the recommendations?

When planning and carrying out works in progress on the manoeuvring area the aerodrome operator and the ANSP should coordinate to ensure that:

- In the design stage that the changed layout does not increase the likelihood of runway incursions.
- The layout changes are disseminated in the Aeronautical Information Publication, NOTAMs or automatic terminal information service (ATIS) and local airfield notices in a timely fashion to provide clarifying information (such as pictures), as appropriate.
- Information to be promulgated should be discussed and coordinated with directly affected stakeholders and subjected to checks to ensure that its meaning is clear to potential users.

The transition into and out of any work on the aerodrome can be challenging and needs to be carefully managed by ATC and the aerodrome operator to avoid misunderstandings about the status and availability of aerodrome surfaces and equipment.

Changes in manoeuvring area, especially work in progress on the runway, taxiway and associated strips, are likely to affect traffic capacity in the aerodrome. Therefore, capacity reduction should be thoroughly discussed and agreed upon well in advance for all phases of the change. Operating in a situation where demand exceeds capacity may have a negative impact on stress and workload of controllers and pilots.

Since changes in manoeuvring area may be initiated by key stakeholders external to ANSP, it is vital that ANSP establishes

formal agreements with key stakeholders on the introduction of changes in aerodrome and the need for safety risk assessment before the change.

ANSP should have a formal change management process that aims to include the safety aspect in the project implementation. By conducting safety risk assessment activities, hazards may be identified and associated mitigations are put in place before the change may take effect. Since many runway capacity enhancing measures may involve operational and safety tradeoffs, the safety risk assessment process should involve all stakeholders in runway safety, including pilots, air traffic controllers, aerodrome operators and other specialists. Issues that have been identified through occurrences, investigations, safety surveys and lessons learned on human performance should be fed back for hazard analysis or mitigation actions.

The coordination between the ANSP and aerodrome operator is usually performed, in full or in part, through the aerodrome safety teams with additional arrangements, when needed, to ensure coordination effectiveness. The arrangements to coordinate changes and to periodically review the capacity enhancement procedures to identify any potential hazard should be implemented by considering the following:

- Establish a dedicated coordination mechanism: Implement a structured system for coordinating changes to manoeuvring area procedures and for periodic review of the capacity enhancement procedures, designating responsible parties and communication channels.
- Identify key stakeholders: Identify and engage relevant stakeholders operating in the manoeuvring area, including air traffic control, ground services, maintenance teams, and other involved parties.
- Develop a communication protocol: Define clear communication procedures for disseminating information about changes to manoeuvring area procedures, ensuring timely and accurate transmission to all stakeholders.
- Regularly review and update the coordination mechanisms: Conduct periodic reviews of the effectiveness of the coordination arrangements, assessing their impact on operational efficiency and safety. Update mechanisms as needed to address any identified shortcomings or changing operational requirements.
- Foster a culture of continuous improvement: Encourage feedback from stakeholders and promote a culture that values ongoing assessment and enhancement of manoeuvring area procedures to adapt to evolving circumstances and maintain optimal safety and efficiency.
- Form a review team: Create a dedicated team responsible for conducting the reviews, comprising experts in air traffic management, safety, and relevant operational areas. Team composition could be different depending on the task – review of the manoeuvring area procedures or capacity enhancement procedures.
- Identify potential hazards: During the review, systematically identify any potential hazards, considering factors such as increased traffic, weather conditions, and changes in aircraft types.
- Develop mitigation strategies: If potential hazards are identified, work collaboratively with stakeholders to develop and implement appropriate mitigation strategies. These strategies may include procedural adjustments, additional safety measures, or technological enhancements.
- Communicate findings and updates: Share the results of the reviews and any implemented mitigation strategies with relevant stakeholders to ensure a collective understanding of the changes and promote a culture of safety and continuous improvement.
- Document and maintain records: Keep detailed records of the reviews, findings, and implemented changes, maintaining a comprehensive documentation system for future reference and regulatory compliance.

While there are a number of factors that should be considered when identifying hazards, the following aspects may be considered for runway-related projects:

- Communication and phraseology;
- Runway and taxiway layout;
- Blind spots / Surveillance capability;
- Aircraft performance;
- Human factors (workload, fatigue, situational awareness);
- Weather; and,
- Available equipment / technology.

Depending on nature of the project, the post-implementation review or follow up may be planned after implementation. At some airports managed, a weekly coordination meeting is held between the involved parties and expert groups to assess any changes that have been introduced. It should be noted that long-term unintended impacts on human performance take longer to surface.

The purpose of the post-implementation review is to:

- Confirm that mitigation actions are successfully addressed and effective.
- Address new hazards.
- Identify trends or shifts from operational procedures.

Sources of data or information that are normally used to support the post-implementation review for runway-related projects may include feedback logs, occurrence reports and investigations, feedback from stakeholders, safety surveys, and operational specific data (e.g., surveillance data, safety indicator of the project).

Some aerodrome operators and ANSPs may elect to upgrade the work of the aerodrome safety team and implement some form of enhanced collaborative safety management. An example of such enhanced collaborative process is the Integrated Safety Management System implemented by The Netherlands ANSP LVNL, Amsterdam Airport Schiphol, airlines and other partners.

Following the crash of a cargo Boeing 747 into a built-up area of Amsterdam in October 1992, various investigations were conducted. As a result, in 1996, industry partners around Amsterdam Airport Schiphol started cooperating in a platform for sharing safety information, called Integral Safety Management System ("Integraal Veiligheids Management System"). That platform was followed in 2003 by the Safety Platform Schiphol ("VPS - Veiligheidsplatform Schiphol"). The platform was better equipped and had more workgroups producing positive results but was still lacking executive power. Consequently in 2017, it was decided to progress into a cooperative agreement to manage safety on and around the airport, called the integral safety management system (ISMS).

The ISMS was formally established by a signed covenant between the industry partners, such as ANSP, airport, airlines, and ground handlers, - and the government, all committing to mutually agreed-upon targets.

The aim of the collaboration is to collectively have a better safety focus, act sector-wide on decision-making, achieve a richer safety insight, and execute integral external reporting. The system includes a safety review group, and a safety action group, and an additional integral safety office, two standing committees, and various taskforces.

It has been decided that the ISMS, to which all of the participating parties are committed, includes at least the following elements:

- Joint approach to the safety risks associated with relationships and interactions between the individual parties (interfaces); and,
- Joint investigations of incidents and proactive safety analyses.

To agree on safety measures to be taken, a crucial part of the work involves the agreed 'common risk matrix' that is collectively used to determine the acceptability (or lack thereof) of risks. Top interface risk, such as runway incursions, bird strikes, damage during docking or damage during ground handling, are assessed for their likelihood and impact by all the parties involved. This results not only in a specific point on the common risk matrix but also often in a range that defines the different assessments by the different parties. Such assessment fosters mutual understanding of the risk among all parties and supports joint decision-making for risk mitigation.

The ISMS does not replace the existing safety management systems of the individual companies; rather, it complements them by focusing on the overall risks associated with Schiphol's operations. In this way, safety risks and improvement opportunities beyond the scope of individual parties are quantified, and management of the aviation parties at Schiphol jointly decide on measures to further enhance safety.

Reference materials:

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Runway Safety Toolkit

ICAO Annex19 – Safety Management Systems

Commission Regulation (EU) No 139/2014 regarding changes to procedures and coordination with stakeholders

Commission Regulation (EU) 2020/2148 regarding runway safety and aeronautical data

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

SKYbrary.aero - Runway Incursion and Airport Design

FAA Order JO 7110.664, Standard Taxi Routes

FAA Order 7050.1B Runway Safety, Appendix E, Airport Construction Advisory Council

CANSO Standard of Excellence in Safety Management Systems

5. Runway Inspection

Recommendation ANSP9: In coordination with the Aerodrome Operators, periodically review the procedures for runway inspections and other runway works. This should include:

a. Carrying out routine runway inspections in the opposite direction to runway movements with illuminated vehicle lights regardless of time of day.

b. Informing flight crew of the runway inspection in progress in case of aircraft on final approach or approaching the runway holding position.

c. Implementing procedures to increase overall situational awareness when vehicles occupy a runway (to be decided locally, e.g., technology, 'vehicle operation normal' calls or other means).

d. Implementing standard routes and timings for routine runway inspections.

e. Wherever practicable, approval for a planned runway inspection should be given when there is sufficient time for the inspection to be carried out without any interruption.

f. New procedures and technologies (e.g., unmanned aircraft systems) for runway inspection should be assessed for future implementation.

Why should ANSPs follow these recommendations?

Regularly reviewing and updating runway inspection procedures in collaboration with aerodrome operators ensures that they remain effective and responsive to the changing operational environment.

Carrying out routine runway inspections in the opposite direction to runway movements, when able, increases driver awareness of aircraft that may be utilising, intentionally or inadvertently, the runway under inspection. Full inspections should be conducted in both directions of the runway, and vary when the inspection occurs.

Temporarily suspending operations for full runway inspections allows for a thorough examination of the runway without the pressure of ongoing aircraft movements. This can be crucial in detecting issues that may not be visible during routine, faster inspections. Coordination for such inspections should consider risks and operational needs to ensure efficient inspections and minimal disruptions to aircraft movement.

Using vehicle lights, regardless of time of day, increases the visibility of the vehicle. Assessment of unidirectional lighting should take place in an efficient manner, after careful consideration of risks and operational needs, to ensure limited exposure to potential runway conflicts.

Implementing procedures to enhance situational awareness for vehicle operators on runways reduces the risk of vehicle-related incursions. This could involve technology solutions like ground movement radar, or operational protocols like clear communication procedures. Standard routes and timings for routine inspections also help to create predictable patterns of behaviour, which can be communicated to pilots and air traffic controllers, reducing the chance of misunderstandings and potential incursions.

What can ANSPs do to implement the recommendations?

To ensure a proactive and disciplined approach to runway safety, runway inspection (e.g., routine, nonroutine, etc.) procedures should be consistent with current best practices and continuously refined based on regular risk assessments and the introduction of new safety technologies and methods. Regular review of runway inspection procedures, policies, and practises allows ANSPs to significantly enhance the safety of runway operations by considering changes to the operational environment, thereby reducing the likelihood of runway incursions and ensuring a safer operational environment for both aircraft and ground vehicles.

Recommendation ANSP9: ANSPs, in collaboration with aerodrome operators, should establish a regular and systematic review process for routine and full runway inspections and works. This review process should be thorough and dynamic, adapting to the evolving operational environment and incorporating the latest risk assessments and technological advancements.

The procedures and review should cover the following:

- Routine runway inspections: Operators should mandate that routine runway inspections are conducted in the opposite direction of runway movements, with vehicle lights on to enhance visibility, regardless of the time of day. This practice helps to detect potential hazards that might not be as visible when driving in the same direction as the aircraft and ensures a higher level of vigilance.
- Full runway inspections: There should be an agreement between the ANSP and the aerodrome operator to temporarily suspend operations to allow a full, uninterrupted runway inspection, when potential risk and operational needs assessments allow. This ensures that inspectors can thoroughly examine the runway without the pressure of ongoing aircraft operations, allowing them to focus on identifying and mitigating any potential safety hazards.
- All runway inspections: When practicable, ANSPs should avoid approving a runway inspection of any kind while there wouldn't be sufficient time for the whole operation to be carried out completely.
- Supporting Flight Crew Situational Awareness: Informing flight crew of the runway inspection in progress in case of aircraft on final approach or approaching the runway holding position helps flight crew to build and maintain situational awareness and prevent runway incursions.
- Situational Awareness Procedures: ANSPs should collaborate with aerodrome operators to implement local procedures to increase situational awareness for vehicle operators on runways. This could include the use of technology such as GPS tracking, requiring 'vehicle operation normal' calls to air traffic control, or other methods that suit the specific environment and operational context of the aerodrome.
- Standard inspection routes and timings: To minimise the risk of incursion and to ensure thorough inspections, standard routes and specific timings for routine runway inspections should be established. These should be designed to minimise interference with operational activities while ensuring complete coverage of the runway surface.
- New Procedures and Technology for Inspection: ANSPs should support aerodrome operators to assess the technical and economic viability of new procedures and technologies for runway inspection. This assessment should consider the benefits of new technology in terms of safety and efficiency, as well as the costs involved in acquiring, operating, and maintaining these technologies. The feasibility study should also consider the potential to integrate with existing systems and procedures to ensure a seamless adoption of new technology. An example would be the use of drone technology for the inspection of runways.

Torino Airport (LIMF) has implemented a colour-based system to drivers and ATCOs that is low cost and helps to increase understanding and awareness of driver location on the aerodrome and provides a defined set of rules for when a vehicle can be in each defined area.

The manoeuvring area is divided into 4 colour sectors (Figure 15):

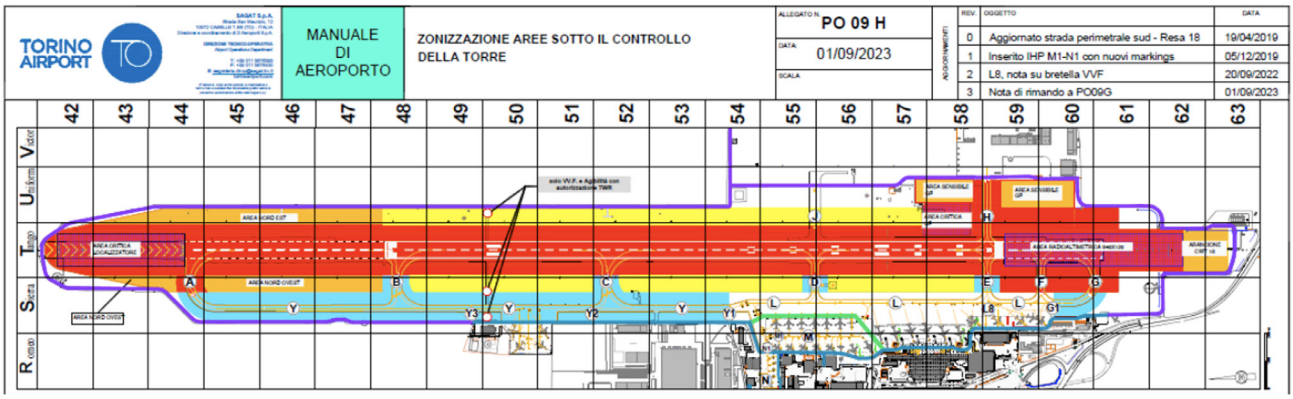
The red area includes the runway (90 m on each side of the centreline), plus instrument landing system (ILS)-critical areas, runway end safety area (RESA) 18, and other protected areas due to displaced thresholds (on Alpha,, Foxtrot, Golf, and Hotel intersections).

Orange and **yellow** areas indicate the runway strip (150 m on each side of the centreline), plus ILS-sensitive areas and clearway 18.

The **blue** area includes taxiways to Category (CAT) I runway holding position (RHP).

Note: Alpha, Foxtrot, Golf, and Hotel are CAT I/II/III RHPs.

Figure 15. **Torino Airport colour-based system**



The following rules apply to each area:

Red: cannot be occupied during landing or take-off ops.

Orange: cannot be occupied during landing or take-off ops while low visibility procedures (LVP) or VIS 2,3 and 4, or CAT II and III Ops and if vis <1,500m or crosswind > 15 kt or braking action < medium. Plus, cannot be occupied during landings for runway 18.

Yellow: cannot be occupied during landing or take-off ops while LVP or VIS 2,3 and 4, or CAT II and III Ops and if vis <1500m or crosswind > 15 kt or braking action < medium.

Blue: Bravo, Charlie, Delta, and Echo taxiways cannot be occupied while LVP or VIS 2,3 and 4, or CAT II and III Ops and if vis <1500m or crosswind > 15 kt or braking action < medium.

Protected area for landing and take-off ops is always the red area, plus yellow and/or orange areas, upon conditions.

ATCOs and drivers share an identical guidance checklist and ground radiotelephony manual in both Italian and English. Clearance to enter different parts of the manoeuvring area are requested according to the coloured area that a driver wants to occupy. (i.e., "SAGAT1 requests to enter blue yellow, west side from … . ") In the grassy areas, there are small, coloured poles to help drivers identify different coloured areas on the ground.

Figure 16. **Torino Airport colour-based system**

Note: Requests to occupy the red area and notifications about vacating the red area must be made separately from other communications (i.e., SAGAT1: "SAGAT1 requests to enter RED"; TWR: "SAGAT1 cleared to enter RED").

Reference materials:

ICAO Manual on the Prevention of Runway Incursions
(Doc 9870)

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

EASA Opinion 03/2019

ICAO Annex14 – Aerodromes

6. Safe Runway Operations Communications – Assisting Traffic Awareness

Recommendation ANSP10: Develop and implement a phased plan for use of one frequency and English language for all communication associated to the operation of a runway. The phased plan should aim at improving the shared situational awareness of all front-line operators and should include realistic and practicable measures that provide adequate level of safety for each of its phases.

Why should ANSPs follow these recommendations?

Traffic awareness is a crucial element that equips the aviation system with defences against the risk of runway collision. Implementing a single frequency for runway operations simplifies the communication process, reducing the likelihood of missing critical information due to frequency changes. Using English as the common language, and standard ICAO radiotelephony communication phraseology, further enhances the shared situational awareness among all operators, ensuring that the information is universally understood. A phased approach to implementing this single frequency usage allows for adjustments and training at each stage, ensuring that safety is maintained throughout the transition and that all operators are adequately prepared for the change.

What can ANSPs do to implement the recommendations?

Recommendation ANSP10: Traffic awareness is a crucial functional barrier within the multi-layered structure that equips the aviation system with comprehensive defences against the risk of runway collisions. The use of the English language, adherence to standard ICAO radiotelephony communication phraseology, and communication on a single frequency are essential enablers. They facilitate all entities operating on and around the runways to maintain traffic awareness.

After conducting a risk and feasibility assessment, consider developing a detailed, phased plan to transition, where practicable, to the use of a single frequency, and to the English language, for all communications related to runway operations. This plan should prioritise the improvement of shared situational awareness among all front-line operators, such as pilots, vehicle drivers, and air traffic controllers. Each phase of the plan should include realistic measures to maintain or enhance safety, such as comprehensive training on the new procedures, gradual implementation to allow for adjustment, and constant monitoring to resolve any issues that arise. This approach can assist in the standardisation of exchanges and can minimise misunderstandings among international crews and local personnel.

However, in the short term, it is unrealistic to expect all airports worldwide serving civil aviation to ensure that all vehicle drivers use the standard ICAO phraseology in its entirety. This is why Recommendations ANSP10 and ADR25 propose a phased plan with intermediate stages, ensuring an adequate level of safety at each step.

To facilitate runway traffic awareness for all stakeholders, identify a recommended minimum set of runway phraseologies to be used as a professional language for runway vehicle drivers based on four normal runway operations.

The following are the suggested four safe runway phraseologies are referred to as **4-4-Safety (four for safety):**

4-4-Safety: Safe Runway Phraseologies

Professional Language for Runway Vehicle Drivers

1. **Runway Entering or Crossing**

   Driver: (call sign) (Holding Point / position) REQUEST CROSS / ENTER RUNWAY (number) [FOR INSPECTION]
   ATC: (call sign) CROSS / ENTER RUNWAY (number) [REPORT VACATED]
   ATC: (call sign) NEGATIVE, HOLD SHORT OF (position)
   Driver: CROSSING / ENTERING RUNWAY (number) (call sign)

2. **Operations on Runway for an Extended Period**

   Driver: (call sign) ON RUNWAY (number)
   ATC: (call sign) ROGER, ON RUNWAY (number)

3. **Vacating Runway**

   ATC (call sign) VACATE RUNWAY (number) [IMMEDIATELY], [REPORT VACATED]
   Driver: [IMMEDIATELY] VACATING RUNWAY (number) WILCO (call sign)
   Driver: RUNWAY (number) VACATED (call sign)

4. **Hold Short of the Runway**

   ATC (call sign) HOLD SHORT OF (position)
   Driver: HOLDING SHORT OF (position) (call sign).

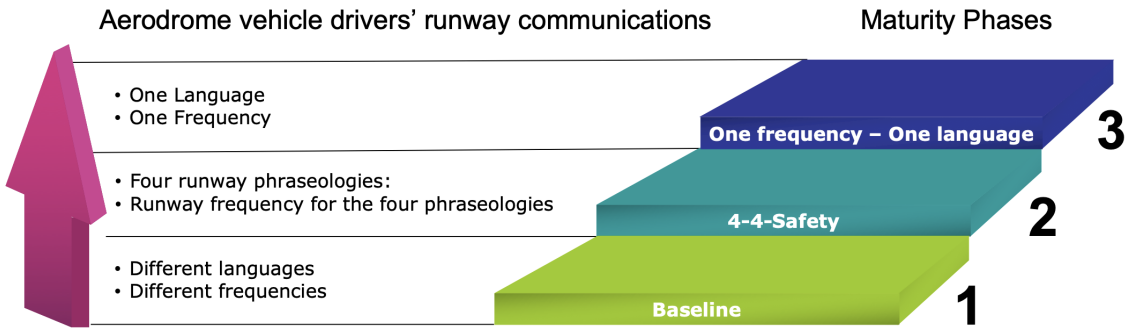
Of the four proposed sets of phraseology for vehicle drivers, two are initiated by drivers and two by controllers. It may be challenging for drivers with low English proficiency to recognise their call sign on a busy frequency, where predominantly English communication could be mostly unintelligible to them.

Different accents, depending on the native language, may also affect how the drivers are understood by others on the frequency. To ensure effective communication, drivers must have sufficient aviation English proficiency to recognise their call sign and correctly use the four phraseologies. However, the aviation English proficiency required for using the 4-4-Safety constitutes a much lower barrier compared to mastering the full extent of communications in English. Implementing predefined and process-specific discrete call signs for vehicles in the manoeuvring area could enhance the reliable application of the 4-4-Safety.

The suggested 4-4-Safety safe runway phraseologies can be introduced as an intermediate step in a phased plan. ANSPs and aerodrome operators can assess their current, baseline maturity level and plan for the necessary activities to achieve the next, second maturity phase, which involves 4-4-Safety. Subsequently, they can progress to the third maturity phase, which includes the use of the English language, adherence to standard ICAO radiotelephony communication phraseology, and communication on a single frequency for a given runway. The maturity phases are illustrated in figure 17.

It is recommended that, ultimately, communications for all operations on a runway (landing, departing, crossing aircraft, vehicles crossing, and runway inspections etc.) take place on the VHF frequency assigned for that runway; this will help to maintain high levels of situational awareness. To accommodate vehicles that are equipped with UHF radios only, frequency 'coupling' should be employed to ensure that all UHF communications associated with runway operations are simultaneously transmitted on the appropriate VHF frequency (and vice versa). When using RTF frequency coupling, controllers (and drivers) need to be mindful of 'clipped' transmissions, where the beginning or end of the transmission is not broadcast/received.

Figure 17. **Example of a phased plan to assist runway traffic awareness**



* (1) Entry/Cross, (2) On the Runway, (3) Vacate, (4) Hold short of the Runway

Concerns about runway frequency congestion due to drivers using VHF can be alleviated by treating every use of the runway as a planned traffic movement, and keeping detailed discussions (e.g., FOD descriptions) for another frequency.

Some aerodromes (e.g. Brussels Airport) have taken the principles described above further and have introduced the concept known as "Triple One": One Runway, One Frequency, One Language (English) as a means to further improve communications for all operations on a runway.

Note: Aerodromes with multiple runways may use a different frequency for each runway.

There may be other measures that support the achievement of "Triple One" and "4-4-Safety". For example, one or more of the following measures (list not exhaustive):

- Runway clearance issued by a single control tower air traffic controller.
- Runway clearance communicated to flight crew by single air traffic controller.
- Runway vehicle drivers monitor the runway frequency of the controller who gives them their runway clearance. Drivers should have English comprehension and skills to recognise critical aircraft runway use clearances to take off and land.
- Vehicle drivers are equipped with runway traffic situation displays that support their runway traffic awareness.
- Cross coupling of frequencies used to manage movements of vehicles and aircraft on the manoeuvring area.
- Aircraft are equipped with real-time on-board functionality of runway traffic operations.

Note: For aerodrome operators subject to EASA regulation, EASA has funded a study on "Triple One" that is currently underway. Prior to implementation of these concepts/recommendations, operators may wish to review the findings of this study.

Reference materials:

SKYbrary.aero - Multi-language ATC Operations

SKYbrary.aero - Use of aerodrome Tower VHF frequency by vehicle drivers involved in runway operations/Responses

SKYbrary.aero - ATC Radio Use by Airside Vehicles

European Action Plan for Air Ground Communications Safety

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO PANS-ATM (Doc 4444)

ICAO Annex 10 - Aeronautical Telecommunications Volume II

ICAO Manual of Radiotelephony (Doc 9432)

7. Safe Runway Operations Communications – Vehicle Drivers

Recommendation ANSP15: In cooperation with aerodrome operators implement procedures for airside vehicle drivers, including standard phrases for:

a. Radio checks and readability scale.

b. Radio communication failures (transmitting blind).

c. The use of predefined and process-specific discrete call signs for manoeuvring area vehicles.

d. When vehicle becomes lost or uncertain of its position on the manoeuvring area.

e. Position reporting.

f. Runway access and runway crossing requests.

Why should ANSPs follow these recommendations?

The use of established standard ICAO phraseologies for radiotelephony communication between aircraft and ground stations is essential to avoid misunderstanding and reduce the time required for communication. Standard phraseology reduces the risk that a message will be misunderstood and aids the read-back/hear-back process so that any error is quickly detected. Ambiguous or non-standard phraseology has been identified as a causal or contributory factor in some aircraft accidents and incidents. ICAO phraseology must be used in all situations for which it has been specified. When standardised phraseology for a particular situation has not been specified, plain language shall be used.

ICAO doc. 9432 Manual of Radiotelephony says:

"In the PANS-ATM [doc. 4444], it is further emphasized that the phraseologies contained therein are not intended to be exhaustive, and when circumstances differ, pilots, ATS [air traffic services] personnel and other ground personnel will be expected to use appropriate subsidiary phraseologies which should be as clear and concise as possible and designed to avoid possible confusion by those persons using a language other than one of their national languages. "Appropriate subsidiary phraseologies" can either refer to the use of plain language, or the use of regionally or locally adopted phraseologies. Either should be used in the same manner in which phraseologies are used: clearly, concisely, and unambiguously. Additionally, such appropriate subsidiary phraseologies should not be used instead of ICAO phraseologies, but in addition to ICAO phraseologies, when required, and users should keep in mind that many speakers/listeners will be using English as a second or foreign language.

The use of plain language required when phraseologies are not available should not be taken as licence to chat, to joke or to degrade in any way good radiotelephony techniques. All radiotelephony communications should respect both formal and informal protocols dictating clarity, brevity, and unambiguity."

What can ANSPs do to implement the recommendation?

When implementing this recommendation, ANSP and aerodrome operators may benefit from both general and specific guidance, as well as explanatory material provided hereafter.

General

All personnel involved in operations associated with runways should use clear, concise, and unambiguous phraseologies in a normal conversational tone. Such usage will ensure that safety levels are maintained or improved upon.

Except for an emergency, mobile phones are not to be used at any time when operating within the manoeuvring area.

ICAO Doc. 4444, PANS-ATM phraseologies for the movement of vehicles, other than tow-tractors, on the manoeuvring area should be the same as those used for the movement of aircraft, except for taxi instructions, in which case the word "PROCEED" should be substituted for the word "TAXI" when communicating with vehicles.

The procedure contained in ICAO Doc. 4444, PANS-ATM 12.2.7 makes no provision for vehicles to be included in the process of receiving a conditional clearance; they may only be the subject of a conditional clearance.

Speech transmitting technique should be such that the highest possible intelligibility is incorporated in each transmission.

Fulfilment of this requires that ATC and ground personal should:

- Enunciate each word clearly and distinctly.
- Maintain an even rate of speech not exceeding 100 words per minute. When a message is transmitted, and its content needs to be recorded, the speaking rate should be slower to allow for the writing process. A slight pause preceding and following numerals makes them easier to understand.
- Maintain the speaking volume at a constant level.
- Be familiar with microphone operating techniques, particularly in relation to the maintenance of a constant distance from the microphone if a modulator with a constant levee is not used.
- Suspend speech temporarily if it becomes necessary to turn the head away from the microphone.

A. Radio checks and readability scale

It is important that all RTF transmissions are readable (i.e., clear enough and loud enough to be understood). While radios need to be tested, test transmissions should only be as long as is necessary for the test and not longer than 10 seconds.

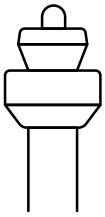
To make clear that the transmission is a test, drivers should follow the format shown below, and include the frequency being used as part of their first transmission. The radio stations will assess the transmission and advise the driver of the readability of the transmission using the following scale.

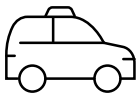
Table 3. **Radio checks and readability scale**

Readability Scale	Meaning
1	UNREADABLE
2	READABLE NOW AND THEN
3	READABLE BUT WITH DIFFICULTY
4	READABLE
5	PERFECTLY READABLE

Example phraseology:

Figure 18. **Example phraseology for radio checks and readability scale**





	SUNNY AIRPORT GROUND, CAR TWO ONE, REQUEST RADIO CHECK 121.725
	SUNNY AIRPORT GROUND, CAR TWO ONE, REQUEST RADIO CHECK
	SUNNY AIRPORT GROUND, CAR TWO ONE, HOW DO YOU READ?
CAR TWO ONE, SUNNY AIRPORT GROUND, READABILITY FIVE	

B. Radio communication failures (transmitting blind)

For all vehicles on the movement area, maintaining a continuous listening watch is very important. This not only ensures readiness for further instructions or information from ATC but also enables drivers to be aware of the movements of other traffic, thereby reducing the risk of confliction.

Aerodrome vehicle drivers may experience situations where radio communication with ATC cannot be established. The reasons for such communication failure can vary, including technical fault, tuning to a wrong frequency, or some other reason. It is important to note that, in such situations, vehicle drivers are not to enter a runway without authorisation. Entering a runway without a valid ATC clearance will lead to the incorrect presence of traffic on a runway and require reporting a runway incursion.

Vehicle drivers should be aware of the radio communication failure procedures at their airport.

As soon as a vehicle driver identifies a radio communication failure, the vehicle should promptly exit the runway protected area via the fastest possible route. If the vehicle is in the manoeuvring area but outside the runway protected area, it should come to a stop until proper direct or indirect communication is re-established.

When vehicle driver fails to establish contact with ATC (or other relevant aeronautical station) on the designated frequency, they should attempt to establish contact on another frequency available at the airport or establish indirect communication via available airport communication channels (e.g., tower phone number or point-to-point phone/mobile line).

If all attempts to establish communication fail, ATC and the vehicle should continue transmit messages twice on the designated frequency, preceded by the phrase "TRANSMITTING BLIND".

Airports may have special airport procedures to be used in the event of radiocommunication failure. Additionally, the controller/flight information service officer/air ground communication station operator may use the following signals to communicate with vehicles. Drivers should keep a look out for and understand these signals, which have the following meanings.

Table 4. **Radio communication failures (transmitting blind)**

Characteristics and colour of light beam or pyrotechnic	**Meaning when directed from an aerodrome to a vehicle.** Note: some signals have a different meaning when directed to an aircraft
Continuous red light	Stop
Red flashes	Move clear of the landing area
Green flashes	You may move on the manoeuvring area
White flashes	Return to starting point on the aerodrome

C. When vehicle becomes lost or uncertain of its position on the manoeuvring area

The ICAO PANS-ATM 12.2.7 provides that: "Vehicle driver in doubt as to the position of the vehicle with respect to the manoeuvring area shall immediately:

a) notify the appropriate ATS unit of the circumstances (including the last known position);

b) simultaneously, unless otherwise instructed by the ATS unit, vacate the landing area, taxiway, or other part of the manoeuvring area, to a safe distance as expeditiously as possible; and then,

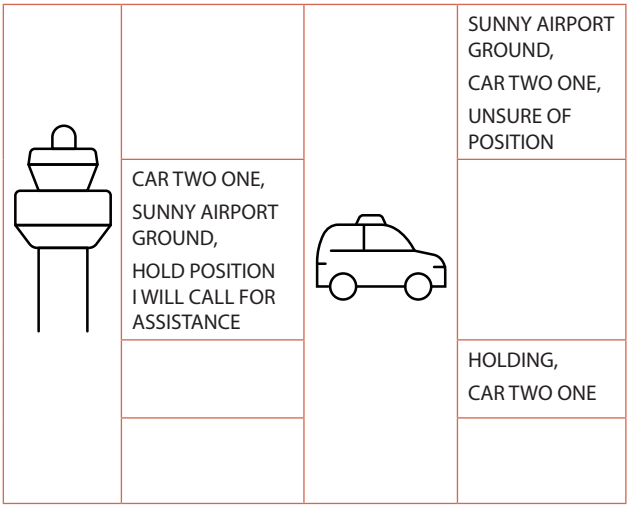
c) stop the vehicle.

In the event the aerodrome controller becomes aware of an aircraft or vehicle that is lost or uncertain of its position on the manoeuvring area, appropriate action shall be taken immediately to safeguard operations and assist the aircraft or vehicle concerned to determine its position."

If a driver is lost or unsure of the vehicle's location, the driver should inform the controller/flight information service officer (FISO) immediately and follow instructions. If needed, the vehicle driver should request progressive taxi instructions.

Example phraseology:

Figure 19. **Example phraseology for when vehicle becomes lost or uncertain of its position on the manoeuvring area**



If a vehicle driver sees a person or vehicle that appears lost, the driver should stop and offer assistance.

D. Position reporting

Vehicle drivers are to report their position whenever:

- Making initial contact with any tower or ground controller, regardless of whether they have previously stated their position to a different controller;
- Requesting to enter manoeuvring area;
- Requesting to enter the protected area of the runway;
- Requesting runway crossing and runway access; and,
- Requesting to be stationary (e.g., for work) on the manoeuvring area, except for a temporary stop for less than 90 seconds.

Vehicle drivers should report their position with respect to aerodrome movement area elements such as taxiways, holding positions, and bays. While other elements from the aerodrome layout, like hangars and maintenance stations, can serve as additional cues, they should not replace the primary aerodrome movement area elements in position reporting.

In addition to verbal communications between vehicle drivers and air traffic control, vehicles themselves can be equipped with ABS-B transmitters to reduce vehicle incursions into protected areas on an Aerodrome surface. Once equipped, a runway incursion warning system (RIWS) will alarm to alert vehicle drivers when the vehicle is near or is inside the protected area of a surface that is designated for aircraft landing and take-off operations. A RIWS will also provide an alarm to the vehicle driver to avoid temporary construction areas and other protected portions of the air operations area (AOA). This system can be used to inform the proximity of hot spots to the vehicle driver. It may be used by the airport to warn the vehicle driver to avoid temporarily closed areas (e.g., a construction project area).

E. Runway access and runway crossing requests

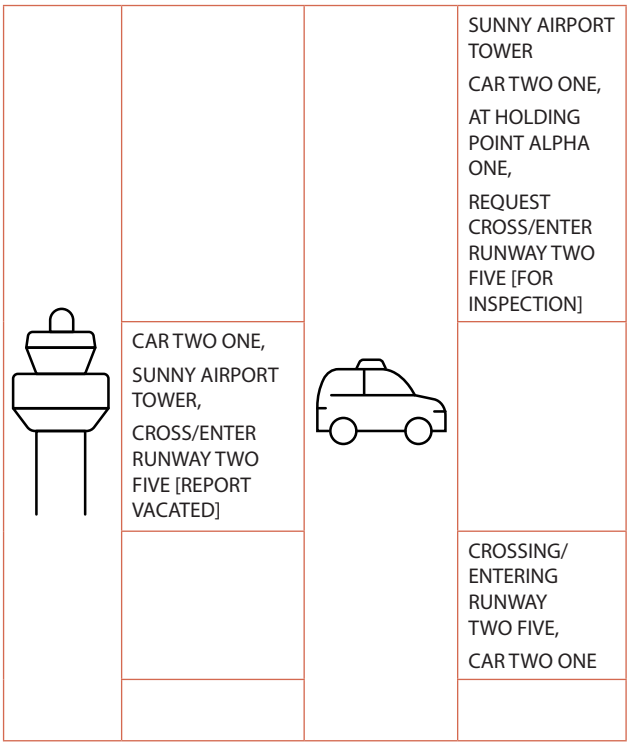
Drivers of vehicles obtain an ATC clearance and instructions before entering the manoeuvring area, which includes any taxiway or runway. Furthermore, the request for runway crossing and runway access should be made using the phraseologies defined in section 4-4-Safety, as described elsewhere in this document.

The ATC clearance and instructions for runway crossing and runway access are to be read back. When vehicle drivers request approval to enter the manoeuvring area, to cross or enter a runway, the vehicle do not proceed until the read-back is completed in full. This allows ATC to confirm the vehicle is proceeding as authorised.

To prevent runway incursions, when an ATC unit issues an instruction to cross a runway, the appropriate holding point designator should be included in the instruction. A vehicle driver should query any instruction that identifies a holding point designator inconsistent with the vehicle location, or the driver's request, before proceeding onto the runway.

Example phraseology:

Figure 20. **Example phraseology for runway access and runway crossing requests**



If ATC is unable to see the crossing vehicle/person (e.g., because of darkness or low visibility), the instruction should always be accompanied by a request to report when the runway has been vacated.

The driver will, when requested, report "RUNWAY VACATED" when the vehicle is beyond the relevant runway holding position/runway protected area.

Reference materials:

SKYbrary.aero - Use of aerodrome Tower VHF frequency by vehicle drivers involved in runway operations/Responses

SKYbrary.aero - ATC Radio Use by Airside Vehicles

European Action Plan for Air Ground Communications Safety

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO PANS-ATM (Doc 4444)

ICAO Annex 10 - Aeronautical Telecommunications Volume II

ICAO Manual of Radiotelephony (Doc 9432)

FAA Guide to Ground Vehicle Operations

UK CAA - Reference Guide to UK Phraseology for Aerodrome Drivers

FAA, Runway Safety, Airfield Drivers Resources

FAA Guide to Ground Vehicle Operations

FAA Advisory Circular 150/5210-25A, Performance Specification for Airport Vehicle Runway Incursion Warning Systems (RIWS)

8. Safe Runway Operations Communications – Conditional Clearances

Recommendation ANSP16: Recommendation ANSP16 In relation to conditional clearances:

a. The procedures should eliminate or mitigate the risk of the operational use of conditional clearances.

b. If conditional clearances are used, ensure a policy and procedures are developed and implemented in accordance with ICAO provisions.

c. Ensure that ATCOs are aware of the potential threats and errors when using conditional clearances

Why should ANSPs follow these recommendations?

Studies have demonstrated that the misapplication and misinterpretation of conditional clearances can be a contributing factor in runway incursions. It has been concluded that 6% of the serious (severity A or B) runway incursion incidents could have been prevented by a correct use of conditional clearances.

What can ANSPs do to implement the recommendations

Conditional clearances are issued only to aircraft and not to vehicles as they are ATC clearances.

The ICAO PANS-ATM 12.2.7 provides that conditional phrases, such as "behind landing aircraft" or "after departing aircraft", shall not be used for movements affecting the active runway(s), except when the aircraft or vehicles concerned are seen by the appropriate controller and pilot.

The aircraft or vehicle causing the condition in the clearance issued shall be the first aircraft/vehicle to pass in front of the other aircraft concerned.

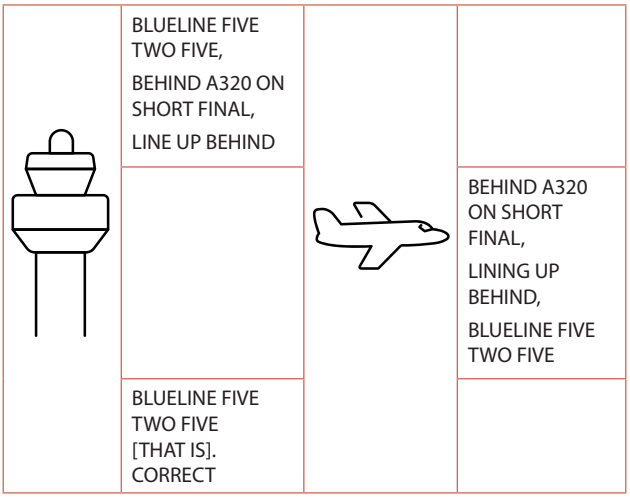
In all cases a conditional clearance shall be given in the following order and consist of:

- Identification;
- The condition;
- The clearance; and
- Brief reiteration of the condition.

The acknowledgement of a conditional clearance must contain the condition in the read-back.

Example phraseology:

Figure 21. **Example phraseology for conditional clearance**



Note - This makes explicit the need for the aircraft receiving the conditional clearance to identify the aircraft or vehicle causing the conditional clearance.

Note: The procedure also makes no provision for vehicles to be included in the process of receiving a conditional clearance. They may only be the subject of a conditional clearance

If conditional clearances are used, in accordance with ICAO provisions, ANSPs should ensure a policy and robust procedures are developed and implemented. Moreover, ANSPs should:

- Assess conditional clearance operational procedures and practices. There should be a clear operational justification for the use of conditional clearances, i.e. to help improve the flow and throughput of traffic. Conditional clearances should not be used for the convenience of the controller and/or pilot when there is no operational requirement.

Strict observations of conditional clearance conditions by controllers should be monitored as part of routine operational supervision and ongoing competency assessments. Considerations for conditional clearance operational procedures and practices include:

- Synchronising the stop bars and conditional clearance operational procedures. This includes decisions on when stop bars should be turned off after a conditional clearance and a correct read-back—whether after the read-back itself (assuming there is no time-based automatic stop bars re-activation) or after the condition is met.
- Appropriateness of using conditional clearances at CAT II or CAT III RWY holding positions that are not combined with CAT I holding positions or where there is a significant distance from the runway holding position to the runway. Appropriateness of using conditional clearances during low-visibility operations or when visibility is lower than visibility 1 conditions.
- At taxiways that are not perpendicular to the runway.
- When formation flights are involved.
- Appropriateness of using conditional clearance when the condition depends upon the movement of an arrival aircraft on or approaching the runway or a departure aircraft on a take-off roll. For example, *FAA defines* "Do not issue conditional instructions that are dependent upon the movement of an arrival aircraft on or approaching the runway or a departure aircraft established on a take-off roll. Do not say, "Line up and wait behind landing traffic," or "Taxi/proceed across Runway Three-Six behind departing/landing Citation." The above requirements do not preclude issuing instructions to follow an aircraft observed to be operating on the movement area in accordance with an ATC clearance/instruction and in such a manner that the instructions to follow are not ambiguous."
- At some aerodromes, the use of conditional clearances was removed for specific operations (specific holding positions or specific operators) associated with higher risk and/or previous incidents.

- Consider if the operational use of conditional clearances can be removed or reduced at specific aerodromes where their use cannot be justified for capacity enhancement or traffic throughput purposes.
- Assess the risks associated with the use of conditional clearances and implement appropriate mitigations.
- Ensure that ATCOs are aware of the potential threats and errors when using conditional clearances, including:
  - Aircraft or vehicles concerned may not be observed by the appropriate controller and pilot. This lack of visibility can lead the incorrect identification of the aircraft/vehicle causing the condition and subsequent incorrect entry into the runway protected area. Additionally, it can impact the controller's ability to identify runway incursion and provide conflict resolution.
  - The aircraft or vehicle causing the condition is not the first aircraft/vehicle to pass in front of the other aircraft concerned. This can result in the incorrect identification of the aircraft/vehicle causing the condition and subsequent incorrect entry into the runway protected area.
  - Incorrect communication of the conditional clearance. It can be influenced by various factors, including the use of incorrect or incomplete phraseology, pilot taking clearances intended for other aircraft (e.g., due to call sign confusion), incorrect understanding of the communication message, and incorrect or lack of read-back with hear-back not detecting the incorrect read-back.

Reference materials:

European Action Plan for Air Ground Communications Safety

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO PANS-ATM (Doc 4444)

ICAO Annex 10 - Aeronautical Telecommunications Volume II

ICAO Manual of Radiotelephony (Doc 9432)

FAA Order JO 7110.65, Air Traffic Control, Section 3-7-1, Ground Traffic Movement

FAA Order JO 7110.65, Air Traffic Control, Section 3-9-4, Line Up and Wait

9. Safe Runway Operations Communications – Effficient Communication

Recommendation ANSP11: Periodically evaluate radio telephony practices, assessing elements such as frequency loading and use of ICAO compliant phraseology. Promote wherever practical ATC teamwork in crosschecking communication messages and read backs.

Recommendation ANSP12: Ensure that ATC communication messages are not overly long or complex in order to assist pilots and vehicle drivers to maintain good situational awareness whilst taxiing or during critical stages of operations.

Recommendation ANSP13: Ensure that, whenever practicable, en route clearances are passed prior to taxi, and, in order to avoid flight crew distractions during taxi, consider passing any revision to the en route clearance whilst the aircraft is stopped.

Recommendation ANSP14: Ensure that air traffic controllers always use the phrase: "HOLD POSITION" when passing a revised clearance to an aircraft that is at a holding position or on the runway.

Why should ANSPs follow these recommendations?

Voice radio telephony (R/T) communication at airports is frequently cited as a causal or contributory factor to runway incursions.

Voice communication that works effectively in low traffic situation is sometimes strained to the breaking point during peak traffic periods. It is during these times that air traffic controllers may not be able to communicate with pilots in the way the ATC-pilot communication loop was designed to work. This can lead to an unwelcome and unintentional reduction of safety measures, such as proper timing of transmissions and read-back/hear-back, to accommodate more ATC instructions onto the crowded frequencies. Yet these are the scenarios and circumstances where the consequences of inaccuracies or omissions may be more critical, and where robust safety measures are most needed.

The demanding environment associated with operations on a runway requires that all participants accurately receive, understand, and correctly read back the air traffic control clearances and instructions. All access to a runway (even if inactive) should take place only after a positive ATC clearance has been given / received and a correct read-back has been provided / accepted.

Standard phraseology reduces the risk that a message will be misunderstood and aids the read-back/hear-back process so that any error is quickly detected. Ambiguous or nonstandard phraseology has been identified as causal or contributory factor to some aircraft accidents and incidents.

Passing enroute clearances while the aircraft are taxiing out for departure will increase flight crews' head-down time and may distract them from their primary tasks during this phase, such as navigation on the airport surface. This could lead to impaired flight crew awareness of their position on the manoeuvring area and entry onto or crossing a runway without clearance. Furthermore, it may contribute to aircraft setup error and subsequent deviation from the departure clearance.

From studies of investigation reports, and from reports/surveys of runway safety occurrences, it is apparent that communication breakdown and misunderstanding is a causal and contributory factor to runway incursion. Examples of factors leading to communication breakdown on the manoeuvring area include, but are not limited to:

- Complex ATC instructions to aircraft;
- High speech rate;
- Frequency congestion / blocked frequency; and,
- Use of non-standard phraseology.

Overly long or complex instruction can cause confusion or even make the flight crew miss out a vital part of a transmission.

What can ANSPs do to implement the recommendations?

The ATC unit training plans and ATCO competence schemes could support the implementation of this group of recommendations.

Radio telephony practices evaluation (ANSP11)

Radiotelephony practices, including frequency loading, should be subject to periodic assessment to identify any emerging issues (e.g., systemic frequency overload, non-compliance with approved phraseology) and take appropriate risk mitigation action. The assessment period should not be too short (e.g., more than just few months) for this will be resource demanding and may lead to complacency if no issues are identified in several consecutive assessments, nor should the assessment period be too long because a serious issue may develop and lead to a safety occurrence. A period of one year or so seems to be reasonable. Major changes in traffic and/or the operational environment should be considered when deciding on the timing of the assessments.

An effective and efficient evaluation of the radio telephony practices at an aerodrome would best be caried out by a group of communication reviewers experienced in RTF applicable to ground and airside aerodrome control. Preferably, it should be done remotely, i.e., frequency(ies) monitoring should not be done in the Tower cab but in another suitable location in the Control Tower that provides for observation of the manoeuvring area. This way the observers will not influence the ATCO(s) behaviour and will not affect the credibility of the collected radio telephony data.

It is recommended that communications for all operations on a runway (landing, departing, crossing aircraft, vehicles crossing, runway inspections, etc.) take place on the VHF frequency assigned for that runway; this will help pilots and vehicle drivers maintain high levels of situational awareness. Concerns about runway frequency congestion due to drivers using VHF can be alleviated by treating every use of the runway as a planned traffic movement, and keeping other conversations and detailed discussions e.g., FOD or work descriptions, on another frequency.

Use of established ICAO phraseologies for radiotelephony communication between aircraft and ground stations is essential to avoid misunderstanding, and to reduce the time required for communication. ICAO phraseology is to be used in all situations for which it has been specified. When evaluating radio telephony practices, the aspects and potential pitfalls described below should be considered.

In a region or country where English is the native language, operators should discourage the use of plain language by front line operators in situations where standard phraseology is to be used.

It should be noted that the words "position … and / or hold" may be misunderstood by some pilots due to the use of non-ICAO phraseology, for example use of the phraseology "taxi into position and hold…" when issuing a line up clearance. There have been a number of runway safety occurrences with the key words 'position' and 'hold' misapplied.

Caution should be exercised when using the word 'follow' at or near runway holding points, as pilots and drivers may interpret this as clearance to continue following traffic ahead of them as it enters or lines up on a runway. When an aircraft/vehicle is instructed to "follow" traffic and requires a runway crossing, the runway crossing clearance should be issued in addition (separately) to the follow instructions and/or hold short instructions, as applicable.

The phrase 'Go ahead' (meaning pass your message) should not be used in communications with aircraft or vehicles approaching or at the holding position as it may be misinterpreted as an instruction to move the vehicle or aircraft.

The procedure words, ROGER and WILCO, are insufficient acknowledgement of the instructions HOLD, HOLD POSITION, and HOLD SHORT OF (position). In each case, the acknowledgement is to be provided by using the phraseology HOLDING or HOLDING SHORT, as appropriate.

The word "cleared" should not be used to authorise aircraft to taxi or for equipment/vehicle/personnel operations. The prefix "taxi," "proceed," or "hold," should be used, as appropriate, for aircraft instructions and "proceed" or "hold" for equipment/vehicles/personnel operations.

"PROCEED AS REQUESTED" should not be used for instructing aircraft, vehicles, equipment, or personnel to cross or operate on a runway.

When passing clearance to cross a runway, if the control tower is unable to see the crossing aircraft or vehicle (night, low visibility, etc.), the instruction should always be accompanied by a request to report when the aircraft or vehicle has vacated the runway, e.g., "(call sign) CROSS RUNWAY (number), REPORT VACATED".

The use of full call signs of all traffic operating on or in close proximity to a runway has been identified as a critical element in enhancing safety for runway operations. Whilst the ICAO provisions allow for use of abbreviated call signs in certain circumstances, it is deemed best practice not to apply any shortening of call signs of traffic on the manoeuvring area of the aerodrome.

When standardised phraseology for a particular situation has not been specified, locally approved subsidiary phraseologies or plain language should be used. When plain language and/or local subsidiary phraseology are used, the communication messages should be as clear and concise as possible and designed to avoid possible confusion. All radiotelephony communications should respect both formal and informal protocols dictating clarity, brevity, and unambiguity. Further considerations and guidance are provided in section 3.2. of the ICAO Doc 9432 Manual of Radiotelephony.

As per provision 12.2.6 of Doc 4444 PANS ATM, phraseologies for the movement of vehicles, other than tow-tractors, on the manoeuvring area should be the same as those used for the movement of aircraft, with the exception of taxi instructions, in which case the word "PROCEED" should substitute the word "TAXI" when communicating with vehicles.

Speech-transmitting techniques should be such that the highest possible intelligibility is incorporated in each transmission. Fulfilment of this aim requires that when issuing clearances, controllers should follow the transmitting techniques described in Annex 10, Volume II, 5.2.1.5.

ATC communication messages (ANSP12)

Controllers should be made aware that passing long and complex messages/clearances[1] to vehicles and aircraft taxiing on the manoeuvring area may distract the drivers/pilots from the task at hand (navigation on the airport surface) and:

- Increase the likelihood of a runway incursion, especially at complex aerodromes or when runway crossings are involved.
- Increase the likelihood of an aircraft getting lost at complex or unfamiliar aerodromes,
- Increase the likelihood of an aircraft being at a wrong place (e.g., wrong taxiway intersection, ILS sensitive area, getting stuck and needing pushback, etc.).

Potential solutions, such as delivering the departure clearance before taxi, use of progressive taxi instructions at complex aerodromes, and use of standard taxi routes and designators could reduce the risk of reduced situational awareness of pilot/driver and runway incursion.

For correct navigation on the manoeuvring area, pilots and vehicle drivers need a general overview of the expected (taxi) routing. For more complicated taxi instructions, it may be appropriate to divide the clearance (respectively the message) into segments, placing the clearances and instructions in sequential order, to avoid the possibility of pilot/driver misunderstanding, while providing the complete picture.

Progressive taxi instructions could be used to reduce the potential for confusion in the following situations (not an exhaustive list):

- Upon pilot/operator request;
- The ATCO deems it necessary due to traffic or field conditions, e.g., construction or closed taxiways; and,
- During reduced visibility, especially when the taxi route is not visible from the Tower.

Progressive taxi instructions must not infer a clearance to cross a runway.

Passing of ATC clearances (ANSP13 and ANSP14)

There is a link between runway incursions or other ground navigation error and clearances or amended clearances being passed whilst aircraft are taxiing, backtracking or lining up.

To support compliance with pilot sterile cockpit SOP air traffic controllers should pass departure (enroute) clearances and information before the pilot begins to taxi. Digital Clearance Delivery (DCL) is the technological solution being implemented at more and more airports.

To avoid flight crew distractions (head down) during taxi, controllers should consider passing any revision to the departure (enroute) clearance whilst the aircraft is stopped.

If a late-notice tactical change to the clearance has to be issued when the aircraft is close to the runway (at the holding position) or on the runway (at the line-up position), controllers should always use the phrase "HOLD POSITION" before or after passing a revised clearance. This will ensure that the pilot has no doubt that the ATC communication does not

1 In general, a message could be considered 'complex' if it includes 3 or more single ATC clearances. In the aerodrome ATC context, a complex message would include long taxi route (many taxiways in the sequence), runway crossing(s) and frequency change(s).

constitute a clearance to line up, take off or cross the runway. Incident reports prove that this is of particular relevance when the aircraft has already lined up and the flight crew confused the re-clearance with the take-off clearance.

Reference materials:

ICAO Annex 10 - Aeronautical Telecommunications, Volume II Communication Procedures including those with PANS status

ICAO Doc 4444 – PANS ATM

ICAO Doc 9432 - Manual of Radiotelephony

CAP 413 - Radiotelephony Manual

FAA Order JO 7210.634, Quality Control, *Chapter* 3, Section 3-2, Operational Skills Assessments (OSA)

FAA Order JO 7210.634, Quality Control, Chapter 5, Section 5-2, Internal Compliance Verification (ICV) and Section 5-3, External Compliance Verification (ECV)

FAA Order JO 7110.65, Air Traffic Control, Section 3-7-2, Taxi and Ground Movement Operations

Non-Standard Phraseology, SKYbrary article

Progressive taxi instructions, SKYbrary article

Read-back Hear-back (SKYclip)

10. Aeronautical Information

Recommendation ANSP17:

In relation to aeronautical information:

a. In coordination with aerodrome operators, implement procedures to ensure that significant and up-to-date aerodrome information which may affect operations on the runway is provided to manoeuvring area drivers and pilots (e.g., by notices to airmen (NOTAMS), ATIS, R/T, maps, new digital technology or other means).

b. Information on temporary changes to operating conditions at the aerodrome should be optimised to increase the situational awareness of the most critical changes. When needed, an AIP supplement with graphics and charts should be published.

Why should ANSPs follow these recommendations?

Effective communication is the cornerstone of safe aviation operations, and by ensuring all users are well-informed of current and temporary conditions, aerodrome operators and ANSPs can significantly reduce the likelihood of runway incursions. Temporary changes can present a significant risk as they may not have been included in the most recent information available to pilots and drivers. Therefore, it is essential to ensure the most critical information is communicated.

Implementing measures to provide time-critical and quality aeronautical information at aerodromes significantly enhances runway incursion prevention. This should consider adherence to ICAO Standards and Recommended Practices (SARP) for data quality, protecting data integrity during processing, establishing clear processes between data originators and AIS Service Provider (AISP), efficiently collecting operational information, and rapidly processing post-flight data.

Collaborating with aerodrome operators to ensure that current and significant aerodrome information is disseminated to all relevant parties reduces the risk of incidents due to outdated or incorrect information. This includes pilots and drivers who operate in the manoeuvring area and must be aware of factors that could impact runway operations.

Utilising a range of communication methods, such as NOTAMs (Notices to Airmen), also known as Notice to Air Missions, ATIS (Automatic Terminal Information Service), radio communication, maps, and digital technologies, ensures that the information reaches all users in a format (e.g. hyperlinks) that is convenient and accessible for them, thereby enhancing awareness, compliance and operational safety.

Communicating temporary changes effectively is crucial for maintaining situational awareness among aerodrome users. The most critical changes can have significant safety implications, and ensuring that these are understood by all users helps prevent accidents or operational disruptions.

Publishing an Aeronautical Information Publication (AIP) Supplement, especially with graphics and charts for complex or significant changes, provides a clear and authoritative reference that can be used for pre-flight planning and in-flight navigation, thereby reducing the risk of misunderstandings or non-compliance with temporary operating procedures.

What can ANSPs do to implement the recommendations?

Recommendation ANSP17 a: ANSPs, in collaboration with aerodrome operators, should establish a reliable and efficient system for disseminating vital aerodrome information that could impact runway operations. This system should leverage multiple channels to ensure redundancy and accessibility.

- NOTAMs should be issued for timely and formal communication of essential information.
- Automatic Terminal Information Service (ATIS) can be utilised for continuous broadcast of non-control information in voice format. The ATIS message should provide operational information essential for safe landing and take-off at the airport, such as displaced runway threshold, any temporary changes to TORA, non-availability of navigation aid(s), etc.
- Radio/telephony (R/T) should be used for immediate communication of dynamic aerodrome information to the manoeuvring area drivers and pilots.

Additionally, the use of up-to-date digital maps and technology platforms can enhance understanding and visibility of any changes or restrictions. For example, integrating real-time

updates into digital moving maps in vehicles or Electronic Flight Bags (EFBs) used by pilots can provide immediate access to important information. ANSPs should also consider the development of various platforms like digital displays, mobile apps, and digital information boards to allow for redundancy and ensure that that information has the widest possible dissemination.

Arrangements should be made at aerodromes for collecting information concerning the state of operations of air navigation facilities and services noted by flight crew. Special emphasis should be put on the collaborative arrangements to make available information on hot spots and runway holding positions. These arrangements should ensure that the information is made available to AIS, for distribution as needed.

Hot spots must be published in the Aeronautical Information Publication (AIP) on relevant charts for aerodromes identified with a history of increased risks of collisions or runway incursions, necessitating enhanced awareness from pilots and drivers. The guidelines for determining a hot spot on a chart, including the symbols used, are specified in ICAO Annex 4. Further detailed guidance can be found in Annex 14 (Aerodromes, Volume 1 - Aerodrome Design and Operations), ICAO Document 9870 (Manual on the Prevention of Runway Incursion), and ICAO Document 8697 (Aeronautical Charts Manual).

Timely and accurate information regarding established runway holding positions is crucial for preventing runway incursions. This information should be published in the Aeronautical Information Publication (AIP) and displayed on (electronic) charts. The data should include geographical coordinates of runway holding positions.

Information relating to the aerodrome of departure and any inadequacies observed should be reported by Aircraft Operators (ref. Annex 6, Part 1 - Ch4 and Part II, Section II - Ch 2) and collected to enable AIS processing of post-flight information without delay (ref. Annex 15 and Doc. 8126 – Ch. 8 and Annex 14, Volume1 – Ch. 9).The aerodrome services responsible for the origination of aeronautical data should consider relevant aeronautical data quality requirements, in particular on accuracy and integrity, in accordance with applicable ICAO SARPS (Annex 11- Air Traffic Services, Ch. 2; Annex 14 – Aerodromes, Volumes I and II – Ch. 2; Annex 15 – Aeronautical Information Services, Ch. 3, Appendix 7; and Annex 4 – Aeronautical Charts, Appendix 6).

Data consistency and completeness should be ensured by AISP. For example, the European AIS Database (EAD) provides a common reference of harmonised quality-assured aeronautical information. The quality of data is enhanced by using international standards and data checking procedures, including validation and verification.

Once aerodrome data has been acquired to the required quality standards, data should be protected from corruption during collation and publication by AIS and by all industry data preparation agencies during the processing of data. Involved parties should take measures to ensure that the integrity of aeronautical data is preserved when ingesting and processing this data. Processes between originators and AISP should be in place (e.g. letters of agreement concerning data quality) with the objective to ensure that aeronautical data is provided and processed according to the relevant standards.

The transition to digital aeronautical information management is essential in today's aviation landscape. This evolution is driven by the necessity for a networked, data-centric environment, underpinned by standardized data exchange formats that enable interoperable data sharing. A critical component of this digital transformation is the Aeronautical Information Exchange Model (AIXM 5). AIXM 5 fulfils a vital role in aligning with both ICAO standards and specific user requirements for comprehensive aeronautical data, encompassing obstacle data, terminal procedures, and aerodrome mapping databases. Its robust temporality model is particularly noteworthy, as it facilitates the digital and dynamic updating of aeronautical information, including digital NOTAMs. This advancement in digital aeronautical information management is pivotal for enhancing pre-flight briefing products and ensuring that digital charts, both on the ground and airborne, are consistently updated with the latest aerodrome surface information. Embracing this digital shift is crucial for maintaining the accuracy, timeliness, and safety of aeronautical information in the modern aviation industry.

Aerodrome Mapping Databases (AMDB) are a key development in the prevention of runway incursions. Since 2013, ICAO Annex 15 has set forth provisions for States concerning aerodrome mapping data. These provisions include requirements for data provision, product specifications for aerodrome mapping, and the content and structure of the AMDB dataset. This advancement facilitates the transition of States' Aeronautical Information Service Providers (AISPs), airlines, and aerodromes towards a collaborative information-sharing environment driven by business needs. To foster collaborative efforts in preventing runway incursions, the creation of common online aerodrome mapping services is recommended.

These services should be based on the EUROCAE ED-99 series Aerodrome mapping standard and implemented with a service-oriented approach. This implementation will provide online access to shared Hot Spot information and enable electronic displays in tools such as onboard Electronic Flight Bags and devices used by operational staff in manoeuvring areas. The result is an enhanced and unified situational awareness at the aerodrome, significantly contributing to runway safety. However, controllers should be made aware that they should not assume pilots are familiar with the airport and its environment. Aircraft operation often involves short-term roster changes and base concepts leading to dispatch of pilots who have never operated at the airfield. Also, published information in AIPs or airport briefings cannot fully substitute for actual flight crew operational experience.

Recommendation ANSP17 b: It is essential that temporary changes to operating conditions are communicated effectively to all relevant parties to increase situational awareness. Notification of temporary changes to the aerodrome infrastructure is made through appropriate means of the Integrated Aeronautical Information Package (IAIP), considering the period of validity and nature of the information. AIS should follow the operating procedures as described by ICAO Doc. 8126 (AIS Manual) and the EUROCONTROL Operating Procedures for AIS Dynamic Data (OPADD). The OPADD document provides guidance on NOTAM format and content, with the purpose to achieve harmonisation in the NOTAM output for the benefit of the users.

When significant alterations occur, such as construction works or temporary area closures, these should not only be communicated through regular channels like NOTAMs but also visually through an AIP (Aeronautical Information Publication) Supplement. The supplement should include detailed graphics and charts to provide a clear understanding of the changes. These should be made available in both printed and digital formats to ensure they are accessible to all users, regardless of their preferred method of information consumption.

The publication of such information should be accompanied by briefings or workshops for front-line operators, including air traffic controllers, pilots, and vehicle drivers, to ensure they fully understand the implications of these changes on daily operations. This proactive approach ensures that all parties have a heightened level of situational awareness regarding temporary aerodrome conditions, which is crucial for maintaining safety and operational efficiency.

Reference materials:

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Annex 15 - Aeronautical Information Services

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

FAA Order JO 7210.3, Facility Operations and Administration, paragraphs 10-3-12, Airport Construction, and 10-3-13, Change in Runway Length Due to Construction

FAA Order JO 7110.65, Air Traffic Control, paragraph: 3-3-5, Braking Action Advisories

FAA Order JO 7110.65, Air Traffic Control, paragraph: 2-9-3, (ATIS) Content

FAA Runway Safety, Runway and Taxiway Construction

EUROCAE ED-99/RTCA DO-272

ICAO Annex 14 – Aerodromes, Volumes I and II – Ch. 2;

ICAO Annex 15 – Aeronautical Information Services, Ch. 3

ICAO Annex 4 – Aeronautical Charts, Appendix 6)

ICAO Doc 8126 - Aeronautical Information Services Manual

ICAO Doc 8697 - Aeronautical Chart Manual

EUROCONTROL Operating Procedures for AIS Dynamic Data - OPADD (Ed. 4.0)

www.eurocontrol.int/ead

EUROCAE ED-99/RTCA DO-272, User requirements for aerodrome mapping information

EUROCAE ED76/RTCA DO 200, Standards for processing Aeronautical data

EUROCAE ED 77/RTCA DO 201, Standards for Aeronautical Information

11. Supporting Aircraft Safe Taxi

Recommendation ANSP18:

In relation to standard taxi routes:

a. Assess the risk potential of taxiing traffic confusion on or near the runway and mitigate it by implementing, whenever practicable, the use of standard taxi routes.

b. If standard taxi routes are implemented, they should be published with clear designators.

c. To reduce complexity during taxi operations, the number of published standard taxi routes should be restricted to only the routes with potential risk of taxiing traffic confusion.

Recommendation ANSP19: When planning a runway assignment change for departing or arriving traffic, consider the time the flight crew will need to prepare/rebrief. As far as practicable, changing the runway assignment for an aircraft taxiing for departure should be avoided.

Why should ANSPs follow these recommendations?

Complex taxiway system and manoeuvring area layout could lead to reduced flight crew / vehicle driver situational awareness during taxi and taxiway confusion, and thus contribute to runway incursion, especially when a runway is to be crossed.

At aerodromes with a complex taxiway system and a high volume of traffic, standard taxi routes (STRs) simplify taxi instructions and help decrease ATCO workload (shorter taxi instructions), as well as reduce the likelihood of communication and navigation errors and confusion on or near the runway(s). Also, STRs could help reduce safety-related occurrences caused by uncontrolled vehicles on working areas of the airport.

The use of STRs would also reduce congestion on ground frequencies and make taxi clearances more predictable. STRs are an enabler for the implementation of the A-SMGCS routing function.

Late changes of the runway assignment to aircraft would lead to:

- Increased head-down time for the flight crew and interference with the sterile cockpit SOP;
- Increased likelihood of incorrect navigation on the manoeuvring area and runway incursion;
- Increased likelihood of FMS setup mistake (incorrect waypoint or MAP selection); and,
- Increased likelihood of incorrect missed approach execution.

What can ANSPs do to implement the recommendations?

Standard taxi routes (ANSP18)

Standard Airport Taxi Routes (STRs) should be published in the AIP and thereby be available not only for the ATCOs but also for flight crew and other operators at the airport. These routes should normally be described in written and charted form and should specify to the ATCO and manoeuvring area traffic which route to follow going from one position to another at the airport. An STR description should include the route (e.g. sequence of taxiways), associated use procedures and frequencies to be selected along the route.

ATS providers, in cooperation with aerodrome operators, should consider developing and publishing STRs for departures, arrivals, or both. Pilots/aircraft operators should be involved in both STR design and validation. More importantly, a set of STRs for use in low visibility conditions should be developed. The STR development should be preceded by a dedicated study or survey of the taxi-in and taxi-out routes frequently assigned to arriving and departing aircraft by the aerodrome/ground controllers, as well as of the frequently used vehicle routes. The following factors should be considered when designing STRs at an aerodrome:

- STRs through hot spot areas should be avoided, where practicable;
- Time-based changes in the direction of use of taxiways (if any);
- Taxi routes preferred by controllers;
- Availability of an ASMGCS with routing function; and,
- Other relevant local factors.

To avoid misunderstandings, the number of published STRs should not be too large, with too many restrictions for different categories of aircraft (due to taxiways characteristics). Also, the likelihood of flight crews and vehicle drivers being unfamiliar with the published STRs will increase significantly if too many STRs are published. In such a case pilots will have to consult documentation or charts, which will increase pilots' head down time and error potential. If a flight crew shows signs of uncertainty or is unable to understand the cleared by the ATC STR, the controller should use progressive taxi guidance, communicating the entire taxi route to the flight crew. When practicable controllers should issue taxi instruction to a runway HP and the runway crossing clearance in two separate R/T communications.

Local Runway Safety Teams should periodically review the use of STRs by pilots and aerodrome controllers, e.g., by means of safety survey or collection of operational feedback. The objective is to ensure the published STRs are efficient, correctly interpretable by pilots and used in operations by the controllers.

At airports with complex working area layout, STRs should include hand-over or "stop" points for transfer of control between the ATC positions. These points would normally be the clearance limit given to a traffic (aircraft or vehicle). To provide for a smooth operation, a silenced handover procedure could be implemented enabling ATCOs to deliver traffic internally between the different working positions (e.g. Apron, Ground and TWR control) without verbal coordination, but following internal standard procedures. This would enable a reduction in controller workload.

Controllers/pilots should not be mandated to use the STR's and should be provided with the flexibility to use 'non-standard' taxi routings or short-cuts to the STRs.

STR description examples:

"Standard Taxi to Runway 18

Taxi to runway 18. Turn right on taxiway K, turn right on taxiway B, hold short of taxiway HA. Contact ground control 121.85 on the taxiway B for further instructions."

"Landing ACFT on RWY 16R/34L, shall cross RWY 16L/34R and continue on TWY A without waiting any instruction by TWR controller and contact with Ground 1 on 126.3 MHz."

The STR chart (Figure 22) depicts the standard taxi-in routes ARR1A and ARR1B from RWY 34 at Istanbul airport.

Runway assignment change (ANSP19)

Runway assignment and departure clearance delivery should be done before the aircraft leaves the stand to taxi to the runway. This will give the flight crew sufficient time to plan, complete and crosscheck the necessary performance calculations, brief the departure, and set up the flight deck, e.g., select the assigned SID in the FMS or input the cleared departure route. In addition, an unexpected runway change might cause the pilot to stop the aircraft to perform these necessary tasks. Therefore, controllers should be aware that the change to the assigned runway will not only affect the flight crew workload but may also disrupt the traffic flow on the manoeuvring area.

Runway assignment or changes to the runway assignment during taxi should be an exception. Such exceptional situations may include:

- Pilot request for runway change due to flight safety considerations;
- Unexpected (sudden) runway closure; and
- Unplanned changes to the runway in use due to unexpected change of meteorological conditions (e.g., surface wind).

Changes to runway assignment for arriving traffic below 10000 ft should be avoided except for safety-related reasons.

ATS procedures related to runway assignment and departure clearance delivery should be designed with due regard to the above considerations.

Reference materials:

FAA Order JO7110.65, Air Traffic Control, Section 3-7-1, Ground Traffic Movement

FAA Order JO7110.65, Air Traffic Control, Section 3-7-2, Taxi and Ground Movement Operations

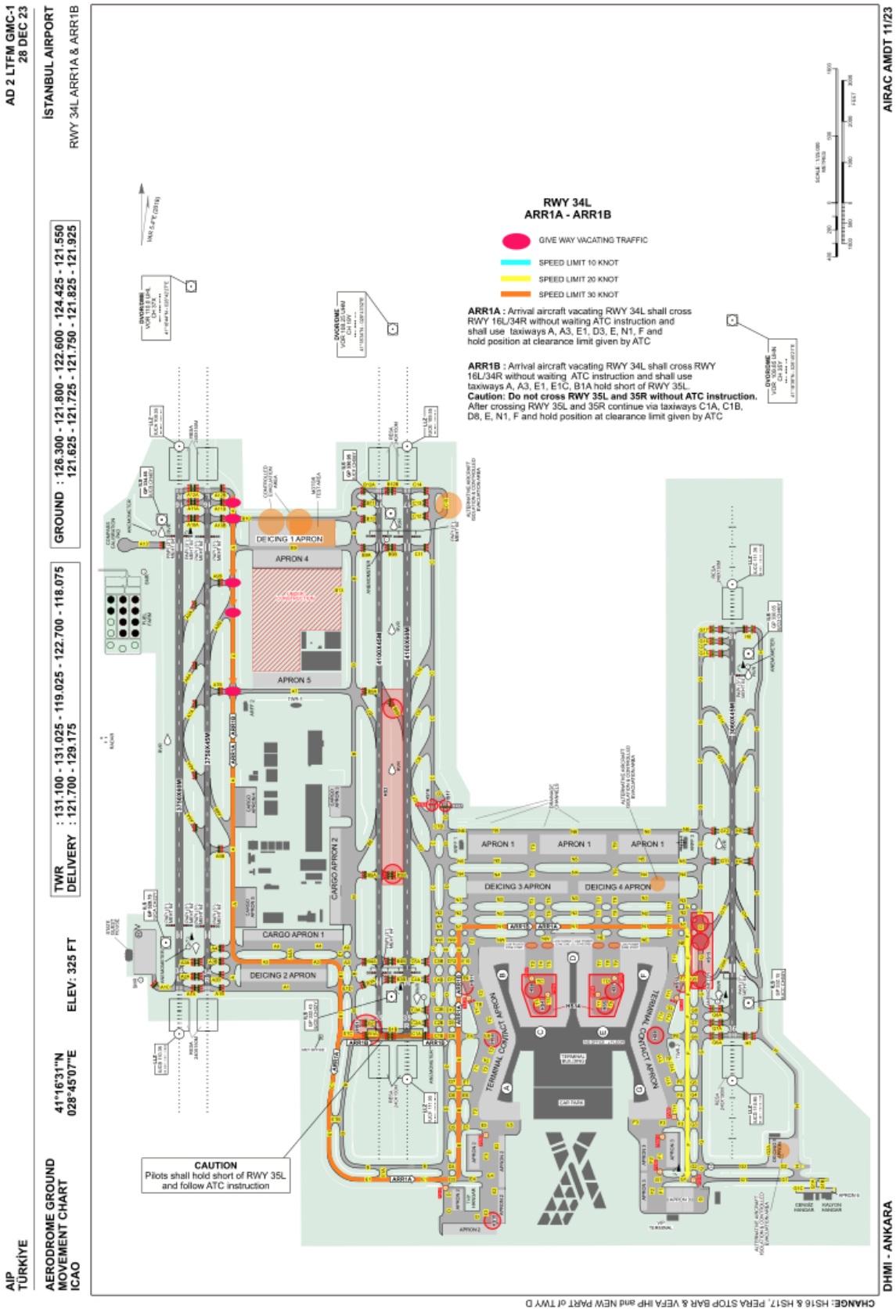
FAA Order JO 7110.664, Standard Taxi Routes

FAA Example of Standard Taxi Route Notifications

FAA Runway Safety, Flash Cards for Runway Signage and Markings

Changing Departure Runway While Taxiing (SKYclip)

Figure 22. **Example of standard taxi routes**



12. Preventing Take-Off From Wrong Surface

Recommendation ANSP20: To prevent pilots from taking the wrong intersection, a line-up and/or take-off or crossing clearance should be issued only when the aircraft is at or approaching the runway holding position and there are no intersections on the taxiway ahead of the aircraft.

Why should ANSPs follow these recommendations?

Pilots inadvertently taking the wrong intersection and incorrectly lining up, taking off, or crossing a runway pose significant safety risks. These actions can potentially result in undesirable scenarios, including:

- Initiating a runway conflict that may result in runway collision.
- Departure from the incorrect runway surface (runway or taxiway), including take-off from a closed runway, posing the risk of collision with obstacles on the runway or loss of control on the ground.
- Departure from the incorrect runway surface (runway or taxiway) or with incorrect performance settings (e.g. mismatch with minimum declared distances (TORA)), leading to a runway excursion.
- Departure from the incorrect runway surface, resulting in a conflict in the air that may lead to a mid-air collision.

Recommendation ANSP20, within the GAPPRI context, is provided to reinforce two functional barriers within the multi-layered structure that equips the aviation system with comprehensive defences against the risk of runway collisions - flight crew position awareness and aircraft routing on the aerodrome manoeuvring area.

There are multiple pressures and factors that can affect flight crew position awareness and aircraft routing on the aerodrome manoeuvring area. While these functions are flight crew's task, ATC has the function to provide runway conflict resolution and collision avoidance, regardless of the reasons for the runway conflict. It is, therefore, important for ANSPs to eliminate or minimise the possibility of a runway conflict.

Implementing recommendation ANSP20 will assist ANSPs to proactively preventing flight crew routing into an incorrect intersection. This is achieved by issuing the respective clearance only when the aircraft is at or approaching the runway holding position, and there are no intersections on the taxiway ahead of the aircraft.

This recommendation, in fact, reduces the risk in two ways: The first is by removing the possibility for flight crew mis-navigation, as the clearance is provided only after the potentially confusing intersection. The second is that giving clearance when the aircraft is at the holding position is a good nudge for controller to scan and verify the position of the aircraft.

What can ANSPs do to implement the recommendations?

ANSPs can begin their implementation by analysing the airport layout, traffic patterns, and the possible scenarios that may involve pilot inadvertently turning onto:

- A taxiway parallel to the runway;
- Another runway where there is a possibility of confusion, for example, with closely positioned thresholds;
- A closed runway; and
- Another taxiway along the route of aircraft taxiing out and taxiing in.

The identified scenarios are vulnerabilities that can result in flight crew routing into an incorrect intersection.

In case there are identified vulnerabilities, then the ANSP has a choice of:

- Applying the recommendation for all line-up and/or take-off or crossing clearances, or
- Scaling down the implementation only to the situations where the risk needs to be mitigated.

The ANSP risk analysis requires an understanding of other factors and the environment of operations that can further increase the risk of pilots routing into an incorrect intersection, including:

- Night-time operations – during night-time conditions, the visibility is restricted to only taxiway/runway lighting and the limited area that the aircraft lights can illuminate;
- Possible glare and wet conditions;
- Rain, fog, snow that can reduce the visibility, making it more difficult for pilots to see signage, surface lighting, and surface markings from the cockpit, thus making it more difficult to determine the correct airport surface to be used;

- Potentially ineffective signs, markings and lights (in any condition), known from previous reports or risk analysis;
- Work in progress that introduces additional complexity for building and maintaining positional awareness;
- Presence of a wide taxiway that may be confused with the runway. Sometimes this taxiway can be a previous, decommissioned runway. The presence of previous runway markings can further increase the risk;
- Absence of painted taxi side stripe markings to the recommended width for the existing taxiways which are wider than recommended in ICAO Annex 14;
- Multiple parallel taxiways and runways;
- Difference in runway width, with some runways narrower and others wider;
- Lack of runway centreline lights or differences in runway lighting – for example, only some runways have centreline lights;
- Lack of green centreline lights for some runway entries and exits;
- Additional ATC pressures, for instance, usual use of ATC instructions to expedite take-off;
- Lack of taxiway lead-in lights that extend all the way to the runway centreline;
- Extra paved surface area that can make it more difficult for the flight crew to determine the correct airport surface to use;
- Displaced threshold or intersection take-offs, which remove many of the normal visual references used to determine the correct airport surface to utilise;
- Runways with closely positioned or common holding positions;
- Similar numeric descriptors for taxiway and runway designation;
- Runway conspicuity, in both lighting and painted/marked areas;
- Non-standard lights or light patterns on the airport surface;
- Flight crew distractions due to additional ATC communications;
- Short taxi-out time that impose workload and possibilities for distraction for flight crew;
- No use of stop bars;
- ATC communication channel load with multiple successive clearances and combined clearances in one transmission;
- No use of standard taxi routes;
- Complex taxi routes requiring pilots to make several turns to reach the runway entry point;
- Presence of ground navigation technology like "follow the greens" that does not assist flight crew along the entire taxi-route. Such technologies can help pilots with their routing but can impact their position awareness; and
- Absence of published hot-spots with specific reference to designated taxi routes for areas with previous or potential confusions.

Additionally, ANSPs can review factors within their own system that can impact the ANSP runway conflict resolution and collision avoidance when a pilot takes a wrong intersection, including:

- Availability of manoeuvring area surveillance;
- Availability of alerting for taxiing aircraft that deviate from the cleared route;
- Availability of runway conflict alerting for controllers;
- Restricted line of sight from ATC Tower;
- ATC Tower position and lack of controller visual reference points that impact the controllers' ability to identify aircraft critical positions, especially during runway entry at night;
- Issuing line-up and take-off clearances in one transmission, restricting the controller's chance to monitor the aircraft's movement to ensure that it is on the right route to the departure runway;
- When issuing line-up clearance, not including the holding position via which the aircraft was instructed to line up on the runway; and,
- Shortening the taxi route without the pilot expecting it.

Previous knowledge of confusions, if available, helps to serve as an additional trigger to implement this recommendation. It is also important to review other factors such as improvements to signs, markings and lights within the work of the LRST.

It is to be noted that taxi-in and taxi-put phases present different risks. For example, taxi-out is a high workload phase for pilots with many tasks to be completed. This increases the possibility for distraction and/or mis-navigation. Such tasks include performance calculations and settings, securing the cabin, passenger announcements, the Line-Up Checklist, and the Take-off Checklist. The taxi-in phase can be affected by flight crew fatigue, and distractions and workload caused by unexpected taxi-in route.

As a final step, ANSPs equipped with knowledge of vulnerabilities and risk factors should implement policies, procedures, awareness, and training for controllers regarding when and where to use recommendation ANSP20.

Reference materials:

https://skybrary.aero/accidents-and-incidents/at76-canberra-australia-2019

https://skybrary.aero/accidents-and-incidents/b734-sharjah-uae-2015

https://skybrary.aero/accidents-and-incidents/a343-hong-kong-china-2010

https://skybrary.aero/accidents-and-incidents/b763-singapore-2015

https://skybrary.aero/accidents-and-incidents/a320-oslo-norway-2010

https://skybrary.aero/accidents-and-incidents/b738-oslo-gardermoen-norway-2005

https://skybrary.aero/accidents-and-incidents/b733-vehicle-amsterdam-netherlands-2010

13. Supporting Aircraft Safe Line-Up and Departure

Recommendation ANSP21: Line-up clearance should not be issued if:

a. The pilot has reported the aircraft is not ready to depart.

b. The aircraft is expected to wait on the runway for more than 90 seconds for the take-off clearance. If the aircraft holds for longer than 90 seconds, an updated instruction should be provided to the pilot.

Recommendation ANSP22: If the take-off clearance is not issued together with the line-up clearance the phrase "line-up and wait" should be used.

Recommendation ANSP23: Ensure that when an aircraft is instructed to line up and wait due to a reason other than usual runway traffic spacing, the aerodrome controller provides the reasons for waiting, e.g., provides information about traffic to cross the runway.

Recommendation ANSP25: Assess the policy, procedures and practices related to the use of "immediate departure" to avoid, as far as practicable, its use or mitigate the associated runway incursion risks.

Recommendation ANSP26: Assess the policy, procedures and practices related to the use of line-up clearance while runway inspection is in progress to avoid, as far as practicable, its use or mitigate the associated runway incursion risks.

Why should ANSPs follow these recommendations?

If an aircraft waits on the runway for take-off clearance for more than 90 seconds, the flight crew may become unsure whether they have obtained take-off clearance and start the take-off run. Also, long wating times on the runway increase the likelihood of controllers getting distracted by other tasks or forgetting about the aircraft on the runway and issuing a conflicting runway clearance to another aircraft.

Notifying the flight crew of the reason for delaying the take-off clearance (not issuing it together with or shortly after the line-up clearance) will improve the flight crew's situational awareness and reduce the likelihood of runway incursion caused by take-off initiation without clearance. Examples of related operational scenarios are runway crossing in front of the departing aircraft or an ongoing runway inspection. In the latter scenario the best risk mitigation is not to issue line-up clearance until the runway inspection has been completed and the inspection vehicle has vacated or is about to vacate the runway.

The immediate departure clearance puts pressure on the flight crew by shortening the time available to prepare for take-off and set up the flightdeck, which may not be obvious for the air traffic controller. This pressure may lead to some undesired consequences, such as flight crew not following the SOP to look out for potential conflict with aircraft on the runway or on short final before entry onto the runway. Also, a pilot may accept the clearance to depart immediately (pilots are rather inclined to accept) but may not be able to take-off within the time expected by ATC. This scenario has led to many runway incursion events when the locally defined criteria for runway incursion by a landing aircraft have been met, e.g., a landing aircraft passes the locally defined distance of 2NM from the runway threshold and the runway is still occupied by the departing aircraft.

What can ANSPs do to implement the recommendations?

The ATC unit training plans and ATCO competence schemes could provide the vehicle for the implementation of this group of recommendations.

Issue of line-up clearances (ANSP21)

Aerodrome controllers should be made aware, e.g. as part of the initial or on-the-job training, that flight crew may not be ready for take-off when reaching the runway holding position (e.g. checklists not yet done, avionics not yet set up, cabin not secured, etc.). This is particularly relevant in case of short taxi times from the stand (apron) to the holding position. In case the success of the arrival and departure sequence depends on the prompt line-up and take-off by of the departing aircraft, ATCO should verify flight crew readiness for departure before issuing the runway clearance (line-up and/or take-off).

In case a departing aircraft has not been released for departure by Approach control, TWR ATCO should not clear it for line-up if there is no reasonable certainty that the release will be granted shortly.

A provision should be included in the relevant section of the national AIP for the flight crew to notify the Tower controller before execution of the received ATC line-up instruction if the aircraft is not ready for take-off and will need more time on the runway.

If pilot replies to the line-up clearance that they will need additional time on the runway and depending on the traffic situation the controller should consider cancelling the line-up clearance, if the aircraft has not yet crossed the holding point signage and stop bar.

Moreover, at small airports with no alternative runway entry points (runway is accessible through one taxiway only), pilots should plan the commencement of their taxi-out so that they will reach the holding position ready to depart. Where necessary, this should be stated in the published AIP taxi instructions. For example, if the flight crew anticipates they will not be ready for departure when reaching the holding position, they should notify ATC and should delay their taxi to the holding position or wait a position assigned by ATC.

When an aircraft has been held at take-off position for more than 90 seconds (e.g., due to occupied runway), and if not yet able to issue the take-off clearance, the controller should instruct the flight crew to hold position and provide to the flight crew updated information about the reason for keeping the aircraft waiting on the runway. This would prevent potential pilot confusion and take-off initiation without clearance if there is no observable aircraft or vehicle on the runway from the flight deck of the departing aircraft.

At aerodromes with no parallel taxiway, aircraft may need to backtrack for both arrival and departure operation. In case a departing aircraft is cleared to backtrack behind an aircraft that has just landed, the ATCO should clear the departing aircraft to "backtrack line-up and wait."

The controller should also provide the departing flight crew with additional traffic information about arriving aircraft backtracking to vacate behind them. This would increase the situational awareness of the flight crew taxiing for departure and help prevent commencement of the take-off run by the departing aircraft immediately after backtrack completion.

The recommendation could be implemented by inclusion of relevant provisions and/or guidance in the aerodrome ATS OPS manual.

'Line up and wait' clearance (ANSP22)

This recommendation is in line with the phraseology provided in point f, section 12.3.4.10 "Preparation for take-off" of ICAO Doc 4444 PANS ATM - "LINE UP [AND WAIT]" but suggests that the optional part [AND WAIT] becomes part of the standard phrase, namely "LINE UP AND WAIT" for use in situations when the take-off clearance cannot be issued together with the line-up clearance. This would reduce the likelihood of flight crew initiating the take-off run without ATC clearance due to e.g. expectation bias.

Aerodrome controllers should be made aware of the importance of using the phrase "LINE UP AND WAIT" by appropriate means, e.g. within the scope of the initial / periodic / refresher training.

The recommendation should be implemented by inclusion of relevant provision in the aerodrome ATS OPS manual.

Advising traffic on the runway (ANSP23)

The recommendation concerns situations when the reason to delay the take-off clearance is not obvious to the flight crew of the departing aircraft, and the flight crew cannot anticipate the reason for waiting on the runway.

When multiple line-ups on the same runway are permitted and practiced, line-up instructions may be issued to more than one aircraft at different points on the same runway. In Europe, use of multiple line-ups is subject to conditions specified in section 6.5.3 of ICAO Doc 7030, including advising

pilots of the position of any essential traffic on the same runway. In addition to the standard phraseology in Chapter 12 of PANS-ATM, the following ATC phraseology should be used:

ATC (call sign) LINE UP AND WAIT RUNWAY 22, INTERSECTION ALPHA ONE, NUMBER 2 FOR DEPARTURE AFTER A BLUJET B737 DEPARTING FROM CHARLIE.

Immediate departure clearance (ANSP25)

The risk assessment of clearing an aircraft for immediate departure should account for the pressure on the flight crew created by the clearance and the related threats, for example impact on task prioritisation, which may lead to skipping/not executing a task related to runway entry. Example of such a task is to look out for potential conflicting traffic on the runway or on short final.

The risk assessment of the use of 'immediate departure' should address the information to be provided to the flight crew when asked if 'ready for immediate departure' and when cleared for 'immediate departure'. This information should include as a minimum the type of relevant traffic and distance from touchdown.

Before issuing immediate take-off clearance to an aircraft, the controller should consider the likely time the aircraft will need to commence its take-off run. Whilst a short-haul twin jet would need 30 seconds on average, a fully loaded wide-body airliner on a 12/14-hour trip would need more time, and larger engines take longer to spool up. Also, the controller should consider how quickly and by what route the aircraft could clear the runway if instructed to do so due to non-compliance with the immediate take-off clearance.

Establishment of limits should be considered for publication in the ATS OPS manual based on aircraft performance (groups of aircraft) beyond which "immediate departure" should not be used. Also, the ATC procedure for 'immediate departure' should not 'promote' it as a routine practice to issue take-off clearances to the departing aircraft as it is associated to an increased safety risk due to the increased pressure on the flight crew and increased likelihood of task rushing.

Air traffic controllers should be aware that asking for an immediate departure while an aircraft is approaching the runway holding position could lead to an expectation by the flight crew they will be cleared to line up without stopping at the HP. If traffic conditions don't match ATCO expectations and ATCO cannot issue a timely line-up and or take-off clearance that could potentially trigger a runway incursion event.

At airports where immediate departure is used to improve runway throughput, flight crews should be made aware (e.g. by publication) that asking, "Are you ready for immediate departure?" or proposing, "Be ready for immediate departure," does not imply the aircraft has been cleared to enter the runway or that a take-off clearance has been given or will be given.

Also, controllers should be made aware of the pressure on the flight crew created by the immediate departure clearance and the potential safety consequences.

Issue of runway clearances during runway inspection (ANSP26)

The aerodrome ATS provider, in cooperation with the aerodrome operator, should carry out a risk assessment of the procedure(s) and practices of clearing a departing aircraft on a runway before the completion of runway inspection. The assessment should cover as a minimum:

- Incorrect execution of the procedure;
- Communication breakdown and misunderstanding;
- Use of different frequency for the runway inspection vehicles;
- Sloped and/or humped runway surface;
- Visibility conditions; and,
- Other relevant factors of the local operational environment.

In case the procedure/practices to issue line-up clearance while the runway inspection is still ongoing cannot be cancelled/ceased due to capacity considerations, appropriate risk mitigation measures should be identified and implemented, e.g., use of phrase "LINE UP AND WAIT" and notification to the flight crew that the runway is occupied by inspection vehicle(s). Passing information to the vehicle driver about the presence of the departing aircraft on the runway should also be considered.

At some aerodromes transfer of departure traffic from the Ground Controller to the Aerodrome Controller is suspended during runway inspections or configuration changes until the inspection/change is complete.

Reference materials:

FAA Order JO 7110.65, Air Traffic Control, Paragraph 3-9-4, Line Up and Wait

Immediate Take-off Clearances, SKYbrary article

Immediate departure (SKYclip)

Multiple Line-ups (SKYclip)

14. Supporting Aircraft Safe Landing

Recommendation ANSP24: Issuance of a premature or late landing clearance should be avoided. Criteria should be decided locally (e.g., not before the final approach fix/final approach point (FAF/FAP), not below 1,000 ft above ground level).

Why should ANSPs follow these recommendations?

Early passing of line-up, take-off, or landing clearance, which may not have any capacity-related benefits, has been a contributing factor in serious runway incursion events. This practice makes controllers more prone to memory lapses because of possible changes in the operational scenario that can happen between the time of runway clearance is issued and the time the aircraft enters the runway protected area (new traffic calls or calls for runway inspections, handover, phone coordination, critical incoming operational matter, etc).

Landing clearance given at the proper time helps the flight crew execute a safe landing.

What can ANSPs do to implement the recommendations?

Several factors contribute to the issue of early (premature) landing and take-off clearances.

Controllers generally issue the landing clearance at the first logical opportunity so they can move on to the next required action. For example, this happens often during low-traffic situations when landing clearance might be issued on receipt of the first aircraft call on the TWR frequency (even further than 10 NM from touchdown). Also, early ATC clearance is often provided in the belief that the pilot is "eager" to obtain it as soon as possible.

Similarly, line-up and/or take-off clearance could be issued very early while the aircraft is taxiing still far away from the runway regardless of ICAO DOC 4444 provisions on the matter (§ 7.9.3.4).

Even during low arrival and departure demand by scheduled airlines, the Tower frequency may get busy due to communication between the Tower ATCO and other traffic, such as GA flights. To avoid late clearance issue due to occupied frequency or forgetting about the approaching to land or taxiing for departure aircraft ATCO may decide to issue the landing or line-up/take-off clearance at the first opportunity.

Proper timing in issuing clearances is a crucial element for maintaining situational awareness. Emerging tool functionality such as conflicting ATC clearances or electronic flight strips (EFS) systems can provide an effective mitigation.

ANSPs may establish at airports, as local good practice or procedure, a distance from runway threshold where the landing clearance should normally be issued and publish this information in AIPs to make pilots aware of it. For instance, FAP or where the landing rate is expressed in terms of minimum distance between succeeding arriving aircraft (5 NM) the landing clearance should not be issued earlier than 5NM from threshold. The controller may inform the pilot: "ABC123 number 1, continue approach RWY 35, expect landing clearance at 5-miles final". A pre-implementation safety assessment should be carried out considering that establishing a limit to issue a landing clearance could impact on ATCO's task prioritisation and on the likelihood of ATCO forgetting to issue the landing clearance in relation to the workload and frequency load. Pilot workload could also increase if the pilot is asked to report position on final. The assessment should consider the increased likelihood of memory errors or misunderstanding of the clearance issued during high pilot workload.

This recommendation could be implemented by inclusion of relevant provisions and guidance in the aerodrome ATS OPS manual. The guidance material should address the provision of clearances in different conditions, including LVO. For example, when a landing clearance cannot be issued according to the defined criterion/criteria, flight crew should be provided with relevant information to continue approach and expect late landing clearance: "ABC123 continue approach, report 2 NM final" or "ABC123 continue approach, expect late landing clearance, one aircraft crossing the runway".

Reference materials:

FAA Order JO 7110.65, Air Traffic Control, Paragraphs: 3-10-5 Landing Clearance, and 3-10-6 Anticipating Separation

15. Memory Aids

Recommendation ANSP27: Assess the current procedures and practices regarding runway occupancy status and ensure the use of memory aids, considering also the availability of new/emerging technologies.

Why should ANSPs follow these recommendations?

Memory can be defined as the ability to store, retain, and subsequently retrieve information. This information can include facts, events, impressions, procedures, and intentions. It involves both conscious and unconscious mental processes.

Aerodrome traffic control includes observing and reacting to events that take place on the manoeuvring area, including information acquired visually, displayed at the working position or received through voice communication. This new information must then be interpreted within the context of information already stored in memory through past experience.

Memory plays an important part in this process because of the large amount of information reaching the Controller. It is therefore necessary to manage this information in such a way that it is not missed, forgotten, or overlooked. In addition, Controllers must remember to perform actions that are interrupted, deferred, performed outside of their usual sequence, or interleaved with other tasks. Critically, due to the dynamic nature of Controllers' work, their memory tasks often also require that information be retrieved during a constrained time window.

Training, operating procedures, workstation design (including automation), and available documents help support memory. Checklists can help operators detect omission of critical items, and automation or other personnel can assist in monitoring some operator actions. As a result of these supports and safeguards, memory performance is usually successful in operations. However, studies conducted in an aviation context suggest that existing defences are less effective when retrieval must happen within a specific time window. (e.g., Dismukes, Young, & Sumwalt, 1998; Loukopoulos, Dismukes, & Barshi, 2001; Nowinski, Holbrook, & Dismukes, 2003).

When memory has to occur within a specific time window, monitoring and attention become essential – particularly when cues are less noticeable. The less likely a cue is to capture attention, the more we must monitor for its occurrence (e.g., Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). The more attention we direct to a cue, the more likely we are to recall the associated intention (e.g., West & Craik, 2001). The risk of memory errors is greatly reduced when aviation operations are highly proceduralized and overlearned. If tasks are consistently performed in the same sequence and under the same circumstances, the context begins to provide cues that prompt operators to perform each task. For instance, items in a procedure flow are less likely to be forgotten because they are routinely performed in the same order and at the same stage of preparation. Performing the first item of a flow is a reliable cue to perform the second item, which in turn is a cue to perform the third item, and so on. This is extremely useful in that it both reduces the need to devote attention to recalling each item, and reduces the likelihood of forgetting an item, so long as the routine is preserved. However, this reliance on predictable cues has a downside in that it may also make those same items more vulnerable to forgetting when the normal cues are not available, such as when the procedural flow is interrupted or operators must perform an action out of its normal sequence (Loukopoulos, Dismukes & Barshi, 2001).

Based on the discussion above, some prototypical situations in which people are vulnerable to memory failures include:

- When tasks are deferred or interrupted. When interruptions occur, either the interrupting or the interrupted task must be deferred.
- When tasks must be performed outside of their normal or habitual sequence.
- When a new unanticipated task must be performed in lieu of an habitual task

The following countermeasures should support memory performance and reduce vulnerability to memory errors:

- Recognize interruptions and deferred tasks as potentially dangerous. If possible, identify exactly when a deferred or interrupted task will be performed and what cues will be available. Use memory aids to create reminders. If possible, enlist the help of others or automation to provide reminders. At the very least, acknowledge the fact that a task is being deferred.
- Stick to established operating procedures as much as possible—they provide both obvious and subtle safeguards

against forgetting. Acknowledge those times when deviations from standard operating procedures occur, and recognize that such deviations create additional vulnerabilities to forgetting, not only for yourself but for others who might be relying on your performance as their own memory aid (e.g., pilots who rely on "expected" Controller clearances as their own memory aid).

- Recognize monitoring as a critical task, and one that is highly susceptible to disruption. The use of memory aids can relieve the burden of sustained monitoring.
- Techniques, procedures and the disciplined use of memory aids can support Controllers in their work. Memory retrieval is often benefitted when an individual encounters a cue or prompt, and the use of memory aids represents a strategy to ensure there is a cue to remember. To be a good reminder, a memory aid should have three features:
    1. It should be highly associated to the specific intention, such that it has a high probability of calling that intention to mind when it is noticed.
    2. The cue must be salient, or have a high likelihood of being noticed.
    3. The cue must be timely, such that it is noticed during the time window in which the intention must be performed.

A memory aid should be ergonomic in relation to the type of working position, the ATC task it is intended to support, the HMI and the operational environment.

What can ANSPs do to implement the recommendations?

Detecting an occupied runway:

While "detecting" may not seem like a memory task, memory is heavily relied upon for successful detection. The controller must remember to perform the detection; recall any past clearances that might lead to runway occupancy in the present and near future (which assists in supporting detection by helping the controller focus on areas of the runway where vehicles are most likely to be based on what has been happening); and remember to scan, use, or update any memory aids to indicate runway occupancy. The Controller must also remember what to do when something is detected. This includes not only remembering the procedures, but also remembering clearances that have recently been issued or that the Controller intends to issue, so they can correctly interpret the significance of the occupied runway (e.g., was it expected, was it expected at that location, does the occupancy pose a threat to another action that has been initiated, does the occupancy require replanning or deferring a future intended action, etc.).

ANSPs should provide memory aids, surveillance systems and integrated solutions for the purpose of detecting and alerting ATS units when a runway is occupied.

Controllers should follow strict local procedures related to the recording and display of the information regarding an occupied runway (either via a paper/electronic strip bay or via other established means and procedures (such as 'blanking' the anemometer/wind dials).

The effectiveness of these measures depends on operational procedures and appropriate Controller adherence to them. If, for any reason, Controllers decide to postpone the use of the available aids or rely solely on memory, the chances of forgetting things are increased.

Electronic flight strips (EFS) may help in mitigating the above issue by autonomously triggering the runway engaged status when, for instance, a vehicle strip is moved into the appropriate runway bay. The Flight Progress Board (FPB) should be designed to have only ONE position for placing aircraft and vehicle when cleared "on the runway" (as opposed to some EFS Boards that have separate bays for departure and arrival on the same runway). It should be noted that electronic systems can still fail through either misses or false alarms, based on their access to or accuracy of the triggering information (e.g., a sensor is out or malfunctioning; a software update introduces an unintended performance glitch, etc.), so Controllers should still back up all such systems with their own information and awareness.

Runway occupancy – ground vehicles:

ANSPs should introduce and promote procedures to support Controllers in performing memory-related tasks and increase overall situational awareness when ground vehicles occupy a runway. This is particularly important when there are multiple vehicles on the runway and one vehicle reports vacating, but the runway is still occupied. Other actions could include:

- During runway inspections, request vehicle drivers to call out progress checkpoints (like "1st third checked", report abeam taxiway D, etc.).
- Provide runway inspection clearances using partial/progressive clearances in order to be called out by drivers.

- For long inspections or busy context, request vehicle drivers to call out every few minutes ("Vehicle Operation Normal"). This time limit should be specified locally, and may vary under certain operational contexts (e.g., traffic load, activities, weather/visibility, time of day, etc.), but should be clearly communicated to vehicle drivers at the outset of operations. Because the passage of time is not by itself a good cue to memory (e.g., not salient), vehicle operators should have access to and use memory aids, such as timers.
- Using vehicle paper/electronic strips method or other electronic means.

Premature landing/take-off clearance:

Controllers are generally accustomed to issuing the landing clearance at the first logical opportunity so they can mentally move on to the next required sequence of actions. For example, this happens often during low-traffic situations when landing clearance might be issued on receipt of the first aircraft call (even if at 15NM on final).

Similarly, line-up and/or take-off clearances are sometimes issued very early and far away from the runway, regardless of ICAO Doc. 4444 PANS-ATM provisions on the matter (§ 7.9.3.3 and 4).

Such an early passing of line-up and/take-off or landing clearance may not have any airport capacity related[2] benefits, but are sometimes used to support Controllers' cognitive capacity. This practice, however, has contributed to several serious runway incursions, as it makes Controllers more prone to memory errors. The memory challenges in this situation include:

- The larger window for operational changes increases opportunity for distractions/interruptions to occur (e.g., new traffic calls, handovers, critical phone calls, etc.)
- For highly proceduralised decisions, the environment provides very salient cues about what step in the procedure the controller should be in. By providing (or not providing) clearances that align with the expected flow of information, this can set up discrepancies between clearance and expectation. These discrepancies make it harder to recall whether the clearance has been issued (e.g., if a clearance is delayed, but an aircraft is at a point when a clearance would normally already have been issued).

Proper timing in issuing clearances is a crucial element for maintaining situational awareness; emerging tool functionality such as conflicting ATC clearances on electronic flight strips (EFS) systems can provide an effective mitigation.

ANSPs may establish at airports, as local best practice or mandatory procedure, a distance from threshold where the landing clearance should be normally issued and publish this information in AIPs. It is important to note, however, that publishing something is not a guarantee of pilot awareness. While publishing enables access to the information, it also creates a new memory task for the pilot, who must remember to read it and to recall that information at the appropriate time.

The recommendations included here are intended to raise awareness of the challenges and consequences of events such as interruptions and diverging from well-practiced behaviours, as well as serve as guidelines for the successful development and use of memory aids.

Reference materials:

Dismukes, Young, & Sumwalt, 1998

Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995

Loukopoulos, Dismukes, & Barshi, 2001

Nowinski, Holbrook, & Dismukes, 2003)

West & Craik, 2001

FAA Order JO 7210.3, Facility Operation and Administration, Paragraph 10-1-7, Use of Active Runways, B. and C., Use of Memory Aids

FAA Order JO 7210.3, Facility Operation and Administration, Paragraph 10-1-8, Procedures for Opening and Closing Runways, B.2., and E, Memory Aids

FAA Surface Safety Portfolio, Runway Incursion Device

2 Other reasons for early clearance may include 'frequency economy' due to high RTF load from sources other than aircraft traffic, and the controller's assumption that the flight crew prefers to receive clearances as early as possible.

16. Stop Bars and ARIWS

Recommendation ANSP28:

a. In cooperation with aerodrome operators, implement H24 stop bars or other lighting systems (e.g., ARIWS) at all active runway holding positions to provide a level of safety commensurate with the level and complexity of operations and the potential risk of runway incursion.

b. Ensure that stop bars at runway holding positions are controlled by the controller in charge of the runway operations on that runway (aerodrome controller).

c. In cooperation with aerodrome operators, implement procedures, in line with the applicable regulations to be followed in case of stop bar unserviceability.

Why should ANSPs follow these recommendations?

Recognising that all airports are unique, and the particular differences between high volume/complexity airports and those of lower volume/complexity, where identified risk supports it, the installation and use of stop bars and other lighting systems intended to raise awareness about runway holding positions, in accordance with ICAO standards and recommended practices (SARPs), can substantially lower the risk of runway incursions and enhance overall safety. Such measures are particularly important given the severity of incidents that can occur due to incursions, such as collisions and near collisions.

When and where provided, these installations can be further enhanced by implementing H24 (24-hour) operation of these systems to ensure that the critical boundary of the runway is clearly marked at all times. This is especially important during night operations or in adverse weather conditions, providing a visual cue that contributes to preventing inadvertent runway entries. If unable to implement full H24 operation across the entire airport, consider a phased implementation beginning with continuously lighting stop bars at non-used or little-used holding positions. In addition, elevated stop bars can improve visibility for pilots, particularly from the cockpit perspective, where the angle of view may limit the visibility of ground-level lights. This can be particularly beneficial in complex aerodrome layouts or during conditions of reduced visibility. The elevated stop bars are also useful for crews of small aircraft, as the cockpits are low above the ground and the ability of pilots to see the full pattern of inset lights might be limited.

Establishing and implementing procedures in case of stop bar unserviceability ensures that there is a clear course of action to maintain safety standards even when the primary system fails. Developing these procedures as a collaborative effort with ANSPs ensures that all parties are aware of the procedures, which can include alternative means of marking the holding position or increased communication from air traffic control.

What can ANSPs do to implement the recommendations?

The provision of stop bars at all Runway Holding Positions and their use at night and in all visibility conditions can form part of effective runway incursion prevention measures.

Stop bars are installed to provide protection at runways and reduce the risk of runway incursions through:

- Enhanced visibility of Runway Holding Positions;
- Reinforcing the control of aircraft and vehicles in the vicinity of the runways;
- Minimising the risk of aircraft or vehicle identification error;
- Minimising the risk of ATC clearances being misinterpreted; and
- Enhancing safety during low visibility conditions.

Pilots and vehicle operators are required to stop at the Runway Holding Positions and obtain clearance from ATC prior to entering a runway; clearance to enter the runway by ATC should be issued in the following sequence:

1. ATC Aerodrome Controller shall extinguish the stop bar lights.
2. Once the stop bar lights have been extinguished, ATC will issue the pilot or vehicle with the appropriate clearance.

Note: This should happen almost simultaneously.

Ideally, stop bars would be installed at all Runway Holding Positions and used H24 irrespective of weather and/or environmental conditions. There are, however, various reasons why an airport, where stop bars are already installed, may not use them H24. The main concerns are:

- **Air traffic controllers' workload:** The use of stop bars requires ATC manual actions through the lighting control interface in the control tower, these actions are sometimes considered as additional workload to the normal ATC procedures, particularly where the lighting control interface has not been designed or does not work efficiently. Stop bars that protect the runway should be individually selectable by the runway controller and co-located with the working position.
- **Disruption of traffic flows:** Inefficient design of control interface may also negatively affect traffic flow. In addition, the stop bars may only be installed at CAT II/III Runway Holding Positions which would increase line-up times. Close cooperation between the aerodrome operator and the air traffic provider during system design, specification and testing can ensure a safe and effective implementation of stop bars.

Electronic flight strips (EFS) can provide a method of stop bar control that could alleviate ATC workload constraints combining, for instance, the issuing of the line-up clearance with the extinguishing of the stop bar lights.

ANSPs, in conjunction with Airport Operators, should provide a clear policy for the use of stop bars and for the related contingency procedures in the case of stop bar unserviceability. For example, an aircraft should not be instructed to cross illuminated stop bars when entering or crossing a runway unless contingency measures are in force. Following this procedure maintains the integrity of the stop bars, which are intended to protect the runway at any airport the pilot might visit. Contingency procedures should preferably be designed to avoid a lit stop bar crossing anytime.

When considering contingency arrangements for situations where the stop bars cannot be turned off because of a technical problem, the air traffic service provider should consider that such contingency arrangements should significantly differ from normal operations and should not undermine the principle that a lit stop bar must not be crossed.

Further guidance on possible contingency measures can be found within the EASA Easy Access Rules for Standardised European Rules of the Air (SERA) - (GM1 SERA. 3210 (d)(3) Right-of-way).

Reference materials:

ICAO Annex19 – Safety Management Systems

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Procedures for Air Navigation Services (PANS) - Aerodromes (Doc 9981)

ICAO Global Runway Safety Action Plan

ICAO Runway Safety Team Handbook - Second Edition, June 2015

Commission Regulation (EU) 376/2014 on the reporting, analysis and follow-up of occurrences in civil aviation

European Union Aviation Safety Agency (EASA) ARA.GEN.125

EASA Easy Access Rules for Standardised European Rules of the Air (SERA) - (GM1 SERA. 3210 (d)(3) Right-of-way)

ACI Runway Safety Handbook – Second Edition 2022

SKYbrary.aero

Easy Access Rules for Aerodromes (Regulation (EU) No 139/2014)

17. Enhanced Procedures for Safe Runway Operation

Recommendation ANSP29: Assess the sight lines from the tower visual control room (VCR) and existing visibility restrictions which have a potential impact on the controllers' ability to see the runway and

a. Implement appropriate short-term mitigations, and
b. Identify longer term improvement measures.

Recommendation ANSP30: Review controllers' tasks, the operational environment and operating procedures to ensure optimal "heads-up" time for aerodrome controllers.

Recommendation ANSP31: Ensure that operating procedures include monitoring of aircraft vacating runways, in particular where the exit taxiway may lead directly to another runway (crossing).

Why should ANSPs follow these recommendations?

The introduction of new technologies and functionalities can sometimes promote a 'heads down' posture. Aerodrome control still requires controllers to look out the window and maintain a continuous watch on aerodrome operations as far as is practicable. (Realising, of course, that it is impractical during reduced visibility conditions where the use of technologies can assist the controller.)

Impairment or infringement of controllers' visual lines of sight, in particular to runway thresholds, intersections, crossing points, hot spots and approaches, can compromise the fundamentals of the "heads up, eyes outside" nature of aerodrome control. It is therefore important to monitor the sight lines from the tower and ensure optimal "heads-up" time for aerodrome controllers.

Monitoring aircraft vacating runways is an inherent task within aerodrome control to ensure aircraft are only on the runway at the appropriate time. It is therefore important to ensure operating procedures include this monitoring, especially when the taxiway leads to another runway.

What can ANSPs do to implement the recommendations?

Recommendation ANSP 29:

ANSPs should assess visual sight lines from the VCR, noting any restrictions that could limit the controller's view of the runway. Known blind spots can be depicted on AIP aerodrome/hot spot charts. In addition, the conventional tower can be enhanced with cameras and other sensors to provide coverage for blind spots (i.e. implementation of Digital Towers). Temporary restrictions in visibility from the VCR due, for instance, to work in progress should be treated in the same way as permanent ones.

Longer-term solutions could include changes to procedures, technological implementations, or re-positioning of the facility/CWP to ensure the best possible solution within the limitations of the airport layout.

When planning works or new construction at the aerodrome, the ANSP and airport operator should collaborate to avoid visual line-of-sight impairment.

Recommendation ANSP 30:

ANSPs should review controllers' tasks, operational environment, and procedures to ensure optimal "heads-up" time for aerodrome controllers. Whilst this implies a predominantly "eyes outside" style of controlling, in the context of modern ATC VCRs and the increasing amount of technology available to assist the controllers, the recommendation also recognises that controllers will, inevitably, spend some time "heads down." A structured, methodical scanning technique will help controllers integrate "heads down" tasks with the need to maintain a "heads up" posture. The combination results in the optimal "heads-up" time for aerodrome operations.

ANSPs should, therefore, reinforce, on a regular basis, the fundamental importance of an aerodrome control visual scan (both inside and outside the window) and train controllers in techniques that can help to develop and maintain this skill.

Recommendation ANSP 31:

Following on from recommendation 30, it is important that controllers consistently monitor aircraft vacating the runway. This is to ensure that there will not be an infringement with the following aircraft, either an arrival or departure. It is also especially important when the exit taxiway leads to another runway. In this case there may only be a small amount of time for the controller to react to a developing situation and so they need to remain vigilant of the location of the vacating aircraft.

For closely spaced runway operations, consideration should be given to the use of a monitoring controller alongside the primary aerodrome controller. If deemed appropriate with the level of traffic, this position gives a second set of eyes on the operation in line with the four eyes principal (4EP). The monitoring position has the advantage of spending more time "heads up," observing the movements of aircraft on the airfield, and therefore can be in a better position to spot deviations. For closely space operations, where the time for a controller to act to mitigate a potential situation is small, this can provide a faster response to a deviation. However, the position does place a greater burden on the number of controllers required and therefore needs to be aligned with the level of risk foreseen in the operation.

Reference materials:

FAA Order 7210.3, Facility Operation and Administration, Paragraph 4-5-2, Letters to Airmen

FAA Order 7210.3, Facility Operation and Administration, Paragraph 10-1-5, Areas of Non-Visibility

18. Enhanced Technology for Safe Runway Operations

Recommendation ANSP32: Consider the implementation of runway safety nets and emerging technologies that can improve situational awareness of front-line operators.

Recommendation ANSP33: Improve situational awareness by adopting the use of technologies that enable location identification of traffic on the manoeuvring area (e.g., via GPS with transponder, Mode S squitter, etc.)

Why should ANSPs follow these recommendations?

Technology within the air traffic management industry is always evolving, and so ANSPs must keep track of and implement new and emerging technologies. By implementing new technologies, ANSPs can help ensure that the risks associated with runway incursions are kept to a minimum.

There are several systems already on the market that are trying to increase the situational awareness of front-line operators. Examples include ASMGCS, and in particular Airport Safety Support Service (such as Runway Monitoring Conflict Alert, Conflicting ATC Clearance and Conformance Monitoring function) and Guidance Service (such as Follow-the-Greens), Runway Status Lights, Digital Towers, etc. The industry is also researching and developing new systems; for example, SESAR voice recognition technology is being investigated to populate information on electronic flight strips within digital towers (PJ05-W2-97 DTT). This may reduce ATCO workload and improve situational awareness.

For some of these systems, implementing technologies that improve location identification can drastically improve their usefulness. GPS and Mode S can provide increased precision of the location of aircraft, and this precision can be crucial for safe runway operations, especially in conditions of low visibility or high traffic volumes.

What can ANSPs do to implement the recommendations?

ANSPs can significantly reduce the risk of runway incursions and enhance safety by implementing enhanced technologies. The implementation of such measures requires a careful balance between the adoption of new technologies; coordination with relevant parties; training and transition; and the ongoing assessment and refinement of procedures.

ANSPs should also assess and remain up to date on the progress made within the R&D recommendations (especially R&D 1-4 and 8).

Recommendation ANSP 32:

Situational awareness involves forming an accurate understanding of various factors and conditions that can influence operations. The process entails gathering and assembling disjointed information to construct a precise mental picture, while also predicting how the current situation will evolve and what the impact will be on future operations.

In this regard, front-line operators will draw information and build this mental picture through several different mechanisms. Emerging technologies have the potential to improve the situational awareness by enriching information, improving the reliability and precision of information, or even simplifying how information is presented. For example, digital tower technology can provide controllers with enhanced on-screen information to improve an ATCOs understanding of which aircraft/vehicles are where when conducting 'visual scans'.

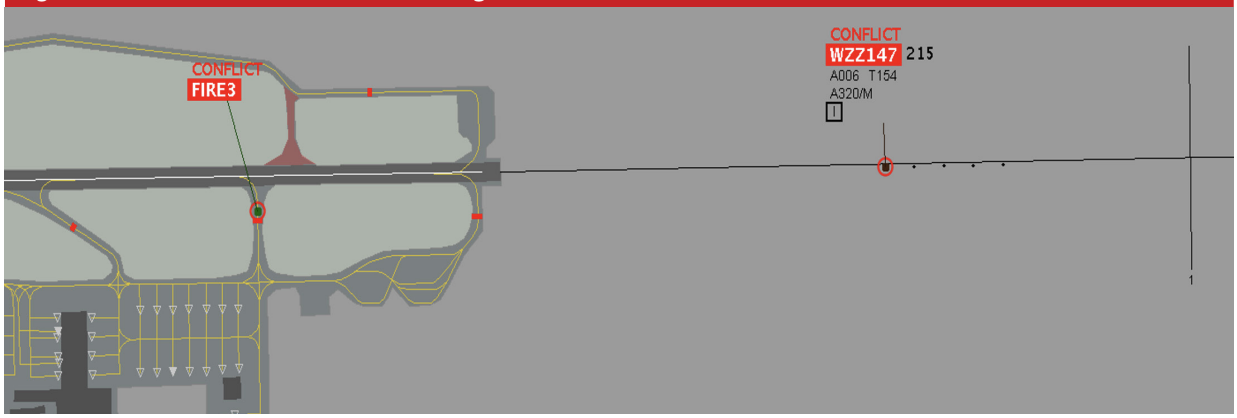
Numerous technologies are being developed. The following are examples that have been successfully deployed to improve situational awareness on the aerodrome.

Aerodrome Surface Movement system including Runway Incursion Monitoring

ASMGCS (Advanced Surface Movement Guidance & Control System) is a system that provides routing, guidance, and surveillance for the control of aircraft and vehicles at an aerodrome. ASMGCS is made up of multiple systems to ensure efficient and safe movement of aircraft and vehicles around the aerodrome. Already operationally available systems offer:

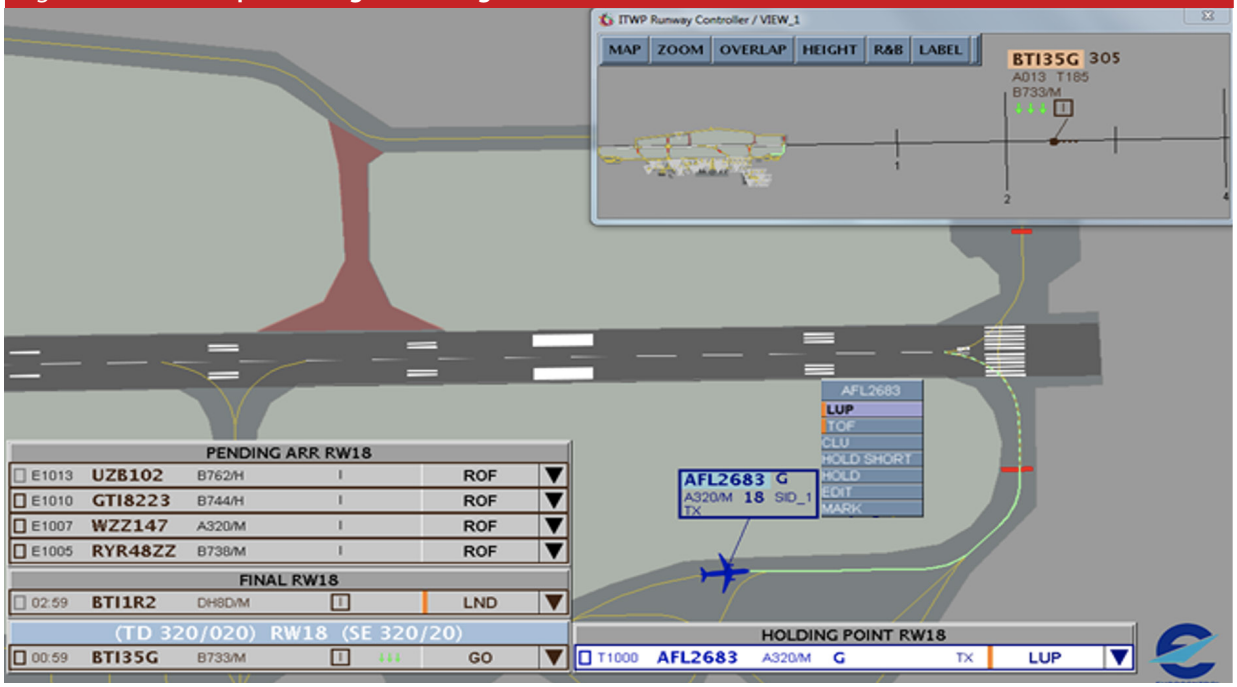
- Controller surveillance display, including position and identification of suitably equipped vehicles;
- Routing and guidance services, enabling conflict detection and solving automatically some possible on ground conflicts.
- Airport Safety Support Service including:
  - Runway Monitoring Conflicting Alerts (RMCA), preventing runway incursion based on surveillance service by detecting if a mobile is still occupying the runway when an aircraft is approaching the runway or an aircraft start taking off.

Figure 23. **RMCA alarm (arrival conflicting with a vehicle)**



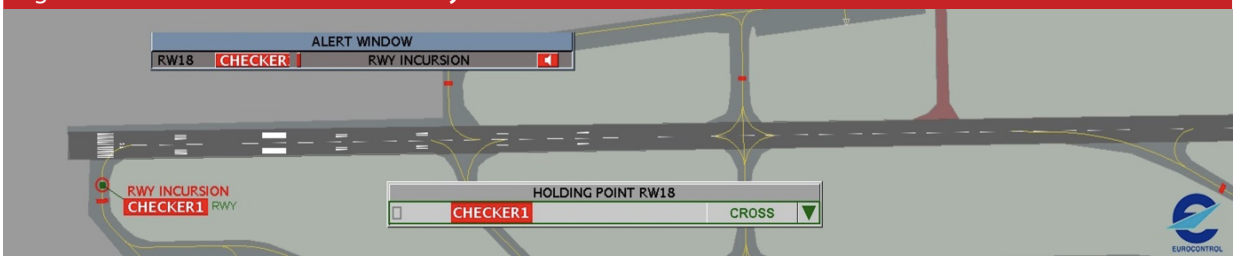
  - Conflicting ATC Clearance: Preventing wrong controlling input that can lead to a runway incursion.

Figure 24. **ASMGCS preventing conflicting ATC clearance**



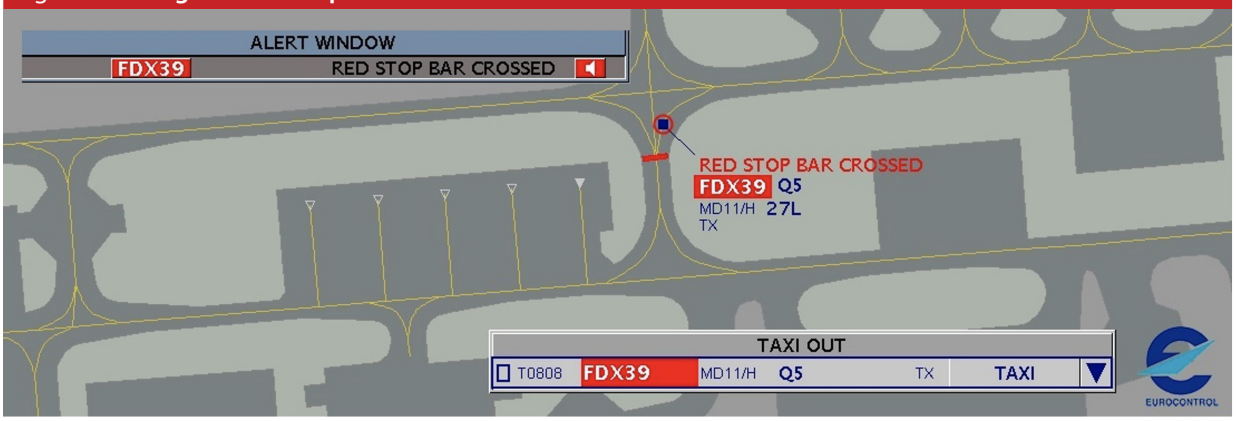
- Conformance Monitoring Alert for Controllers (CMAC): Alerting ATCOs in case of intrusion into runway protected areas without clearance.

Figure 25. **CMAC alert in case of runway incursion**



- Selective switching of taxiway lights, including stop bars at Intermediate holding positions.

Figure 26. **Integration of stop bar into ASMGCS**



Consideration should also be given to the use of ADS-B for surveillance on the aerodrome. ADS-B data is readily available at most airports and could improve situational awareness for controllers at relatively low cost.

Lead on Lights/Follow-the-Greens

Lead on Lights/Follow-the-Greens are taxiway centreline lights that can be switched on either automatically based on the selected taxi route or manually by ATC. The lights then guide the pilot along their allocated route. When there are conflicting routes for different aircraft, then one of the routes will be switched off and a stop bar switched on to hold the corresponding aircraft.

The system minimises the number of conflicts on taxiways and enables smoother traffic flows. The follow the greens system was validated as part of SESAR 2020 PJ03a-01 and has been shown to be very effective in low visibility conditions. The system improves the situational awareness of pilots taxiing on the airfield and in turn helps reduce ATC workload.

Figure 27. **Conflict management by follow the green**

Runway Status Lights (RWSL)

RWSLs are a fully automatic, advisory safety system designed to reduce the number and severity of runway incursions and thus prevent runway accidents whilst not interfering with airport operations. Being independent from air traffic control's systems, RWSLs provide an additional layer of safety in reducing runway incursion.

The RWSL increases pilot and vehicle operators' situational awareness by directly indicating the runway occupancy status through the use of autonomous illumination of in-pavement lights on both runways and taxiways. The concept of operations relies on the ability to warn at least one of the aircraft or vehicles in a conflict scenario.

There are three elements to RWSL:

- Runway Entrance Lights (RELs);
- Runway Intersection Lights (RILs); and,
- Take-off Hold Lights (THLs).

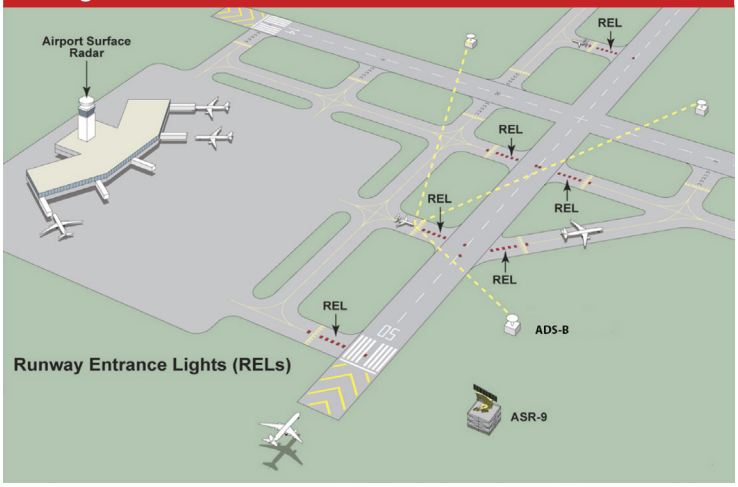
Factors to be considered by ANSPs when a respective aerodrome plans to implement RWSL:

- The system requires the adjustment of parameters, calibration of warning, and timing of alerts. Therefore, successful implementation will need to involve feedback and operational evaluation from pilots and controllers.
- Comprehensive training is provided to controllers as well as pilots and vehicle operators.
- ANSP should have procedures in place for situations when controllers are informed of ARIWS and when the system malfunctions. Controllers, pilots and vehicle operators need to agree on suitable phraseologies when communicating about ARIWS.

The Federal Aviation Administration's (FAA) is evaluating a prototype Runway Incursion Prevention through Situational Awareness (RIPSA) system. RIPSA is a simplified version of Runway Status Lights (RWSL) that includes Runway Entrance Lights (RELs), driven by surveillance data from an independent surface surveillance radar system. However, unlike RWSL, RIPSA does not include Take-off Hold Lights (THLs).

RIPSA Operational Concept Diagram

Figure 28. **Runway incursion prevention through situational awareness**



RIPSA (Figure 28) consists of Surveillance Sensors, Safety Logic and fully automated Runway Entrance Lights (RELs). RIPSA is aimed at reinforcing protection of the Runway Safety Area, by utilising "direct to pilot" safety solutions capable of providing localised detection capabilities for all aircraft or vehicles at RI hotspot locations, such as hold short lines and runway intersections. The system provides Situational Awareness only; not clearance to enter the runway. The prime technology is non-cooperative targeted surveillance Surface Movement Radar (SMR) with augmentation from cooperative sources such as ADS-B and Airport Surveillance Radar (ASR). RIPSA uses Surveillance input from the SMR and processes it using "Safety Logic," which drives a Field Lighting System (FLS) including in-ground Runway Entrance Lights (RELs) to indicate runway status.

Arrival Prediction Technologies

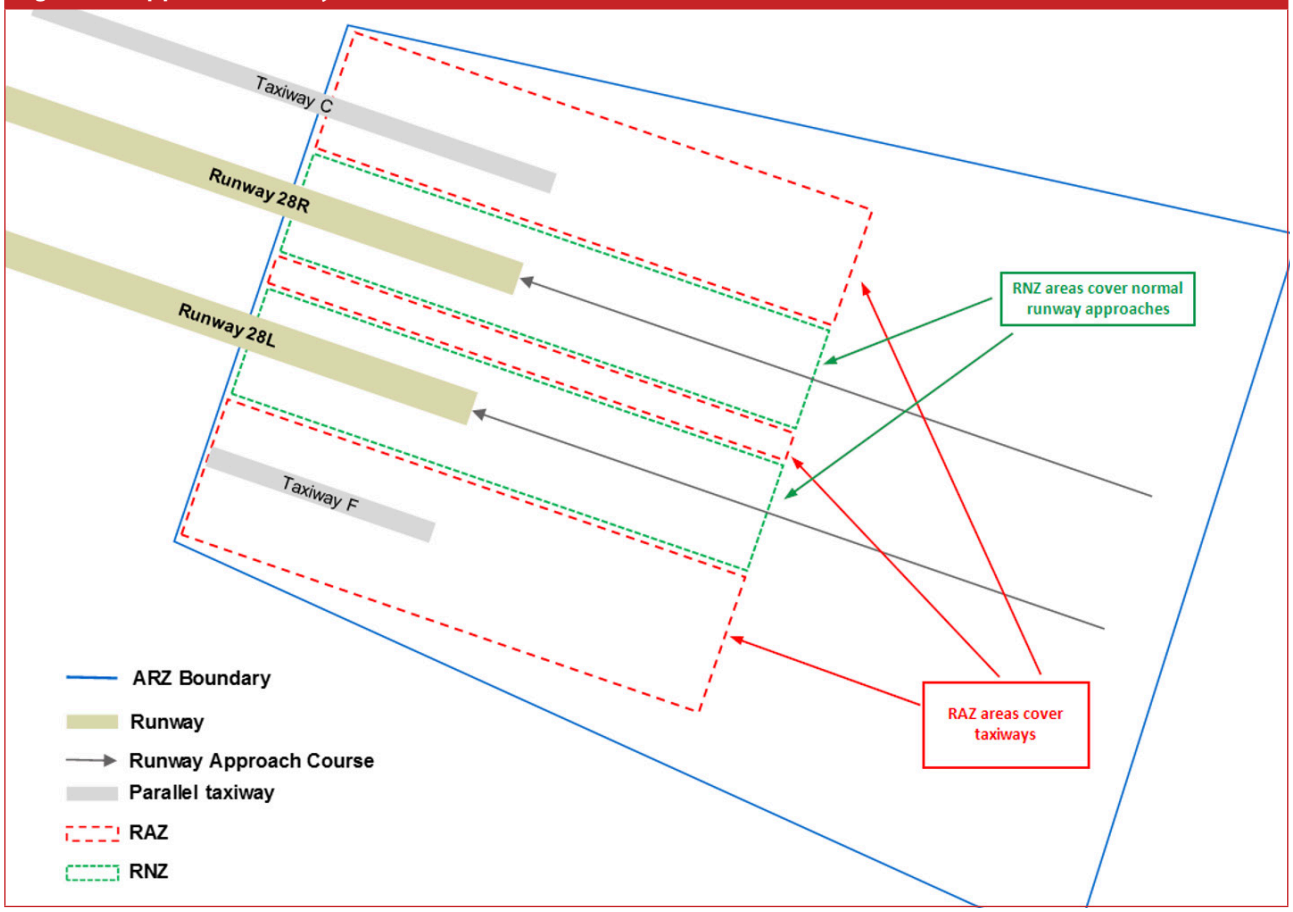
ANSPs may take advantage of opportunities to improve the functionality of existing systems to address the challenge of wrong surface alignments and landings.

For example, the Approach Runway Verification (ARV) is a function within the US FAA's terminal automation system knows as STARS. When aircraft are approaching the airport, the controller issues a landing clearance to a specific runway. The pilots may believe they are aligned with the proper runway, but could actually be lined up with an adjacent runway or even a taxiway. ARV will provide the air traffic controller with both visual and audible alerts if an aircraft on arrival is lined up with the wrong runway, a closed runway, a taxiway, or even the

wrong airport. Each airport environment can be uniquely adapted such that these alerts trigger based on the uniqueness of their surface configuration and airport arrival routes. The intent of the tool is to monitor the last two to three miles before the runway threshold to provide 60 seconds of warning at landing speeds.

Example ARV Arrival Runway Zone (ARZ)

Figure 29. **Approach runway verification tool**



The diagram (Figure 29) provides an example of how ARV can be adapted for use at each airport.

1. Aircraft on approach to runways are expected to be stabilised in Runway Normal Zones (RNZs).
2. If a track is stabilised in an RNZ, flight data is checked to ensure the runway is open. If not, an alert is generated.
3. If a track is stabilised in an RNZ, flight data is checked to make sure the aircraft is on approach to the correct runway. If not, an alert is generated.
4. If a track is determined to be stabilised in a Runway Alert Zone (RAZ), an alert is generated.

ARV is an example of extending the capabilities of existing terminal automation services provided to the air traffic controller to enhance their situational awareness and thereby take action to avoid wrong surface events.

Recommendation ANSP 33:

A lot of technologies for improving situational awareness on aerodromes (e.g. ASMGCS as mentioned above) rely on accurate, precise, and complete surveillance data. Therefore, ANSPs should utilise technologies that enable and improve on the location identification of traffic e.g. the use of GPS with transponders and Mode S squitters, and the use of location identification from cellular/wi-fi technologies.

To support this recommendation, ANSPs should also work closely with aerodrome operators and regulators to implement recommendation ADR31: "Enable the tracking of vehicle movements on the manoeuvring area when possible. Facilitate situational awareness by adopting technologies that enable ATC and other parties' location identification of traffic on the manoeuvring area." The integration of this data will facilitate better coordination between vehicle drivers and ATC, enhancing safety and operational efficiency.

Reference materials:

ICAO Manual on the Prevention of Runway Incursions (Doc 9870)

ICAO Doc. 9830: A-SMGCS Manual

SESAR Safety and Performance Requirements (SPR) for RWSL

EUROCONTROL Sudden High Energy Runway Conflict (SHERC)

EUROCONTROL Specification for A-SMGCS services (Ed2.0)

SESAR Innovation Pipeline Air traffic management research and innovation 2022 Highlights

IFATCA 57 Annual Conference – Accra, Ghana March 19-23, 2018, WP No 88, ARIWS - Autonomous Runway Incursion Warning Systems

FAA Runway Status Lights (https://www.faa.gov/air_traffic/technology/rwsl)

https://www.eurocontrol.int/service/advanced-surface-movement-guidance-and-control-system

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APPENDIX C
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1. Glossary

ACAS/TCAS	Airborne/Traffic Collision Avoidance System
ADO	Aerodrome Operator
ADS-B	Automatic Dependent Surveillance–Broadcast
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AMM	Airport Moving Map
ANSP	Air Navigation Service Provider
AO	Aircraft Operator
ARIWS	Autonomous Runway Incursion Warning Systems
ATC	Air Traffic Control
ATSAW	Airborne Traffic Situation Awareness
CA	Competent Authority
CAT	Commercial Air Transport
CRM	Crew Resource Management
EAPPRI	European Action Plan for the Prevention of Runway Incursions
EBT	Evidence Based Training
EFB	Electronic Flight Bags
GAPPRE	Global Action Plan for the Prevention of Runway Excursions
GAPPRI	Global Action Plan for the Prevention of Runway Incursion
GRASP	Global Runway Safety Action Plan (ICAO)
HF	Human Factors
KORA	Key Operational Risk Area(s)
LAO	Learning From All Operations
LRST	Local Runway Safety Team
MROT	Minimum Runway Occupancy Time
NAS	National Airspace System (U.S.)
NOTAM	Notice to Airmen/Notice to Air Mission (U.S.)
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
RAAS	Runway Awareness and Advisory System
RI	Runway Incursion
RIM	Runway Incursion Monitoring (U.S.)
RIPSA	Runway Incursion Prevention Through Situational Awareness
RPAS	Remotely Piloted Aircraft Systems
RSP	Runway Safety Programme (ICAO)
RST	Runway Safety Teams
RT/RTF	Radiotelephony
RWSL	Runway Status Lights
SARP	Standards and Recommended Practices
SIC	Second in Command
SID	Standard Instrument Departure
SMS	Safety Management System
SOP	Standard Operating Procedure(s)
SPI	Safety Performance Indicator
TCAS/ACAS	Traffic/Airborne Collision Avoidance System
TEM	Threat and Error Management

2. Guidance and Explanatory Material for Aircraft Operators

2.1 Safety Management (AO1, AO2, AO3)

Recommendation AO1: Aircraft operators should, through their safety management systems, ensure that information is collected on all runway and taxiway incursion incidents and perform analysis and risk assessments to identify risks and contributing factors.

Operators should develop and implement action plans to mitigate identified risks and monitor the implementation/effectiveness of those action plans.

Why should aircraft operators follow this recommendation?

Operators must optimise their internal safety management systems (SMS) to detect all indications of increased runway incursion (RI) risk. Each incursion or near incursion is unique and typically contains one or more latent hazards. These latent hazards, when combined with other factors internal and external to the flight crew, can lead to an undesired outcome.

Taxiway incursion incidents, while not as high risk, very often have the same causes and contributory factors as RIs. Taxiway incursion events are much more frequent, so operators should analyse and monitor all taxiway events to identify the risks for their ground operations.

Operators can use incident reports, pilot feedback, and data analysis to continuously improve procedures and training, enhancing the overall safety of their operations. Operators should support a reporting culture that highlights not only the need to report runway and taxiway incursions but also the threats and latent conditions identified by flight crews (or ground crews) before they became errors or incursions.

What can aircraft operators do to implement this recommendation?

- Establish runway and taxiway incursions (surface incidents) as safety performance indicators (SPIs).
- In addition to reporting incidents and accidents, promote reporting of "near miss" events that focuses on contributing conditions.
- Consider revisiting associated safety risk assessment(s) following any RI incident/accident.
- Synchronise data from safety reporting and investigations, as well as data from outside sources (runway safety teams [RSTs], information-sharing programs, other operator events) to determine prevalence of hazards for entry into the operator's SMS.
- Consider using International Civil Aviation Organisation (ICAO) Model Runway Incursion Causal Factors Identification Form (Doc 9870, App G) when conducting runway or taxiway incursion investigations.
- Consider adoption and implementation of Learning From All Operations methodology (more information below).
- Operators should discover and familiarise themselves with local, national, and regional RI risk reduction initiatives. For example, the Runway Incursion Mitigation (RIM) program is a U.S. Federal Aviation Administration (FAA) national initiative at airports with a history of runway incursions. The RIM program identifies airport-specific risk factors that might contribute to a runway incursion. These risk factors may include unclear taxiway markings, airport signage, and more complex issues such as runway or taxiway layout.
- Review the International Air Transport Association (IATA) Runway Safety webpage and Safety Issue Hub for support, documentation, and guidance. Attention is particularly drawn to the new Runway Incursion Bow Tie (June 2024) model available for aircraft operators.

Learning From All Operations

In an increasingly interconnected and complex aviation system, it is imperative to learn not only from things that rarely go wrong but also from things that go right. Data collection needs to expand from a focus on hazardous events to analysis of routine operational data. Accidents and serious incidents in the aviation industry are rare events, and to achieve continued improvements in aviation safety, it is necessary to learn from normal operations. This is especially applicable to safety data on RIs due to the low rate of related incidents.

While Learning From All Operations is a relatively new concept, the challenge for operators is to seek new ways to harvest everyday information from their operations and learn which measures work well and what workarounds or adaptations are necessary to make the system work.

Emphasising the significance of harnessing proactive and predictive data

It is important to recognize that while taxiway errors serve as precursors to RI events and have rightfully received attention in recommendations, they inherently remain reactive. Therefore, it is advisable to incorporate additional data streams to comprehensively assess the risk of surface incidents.

Incorporating observational programs such as line operations safety audit (LOSA) within the Learning From All Operations framework can prove instrumental in identifying precursors to surface incidents. Given the lack of alternative data streams serving as leading indicators, pinpointing threats and errors specific to In incidents becomes paramount. Examples of errors gleaned from a LOSA program (Figure 30), can serve as leading indicators, undetected in other programs.

Delving deeper, by scrutinising runway incursions and taxiway errors, each airline can ascertain the most common precursors in their events. Each airline's unique set of threats, errors, and competencies emerging from their events can then be analysed.

This understanding enables airlines to proactively assess the likelihood of surface events occurring within their operations. For instance, if deficient workload management consistently emerges from reactive data (runway incursions and taxiway errors), airlines can use this information to discern how workload management as a competency presents in 'normal observational' data — whether it is managed effectively or not. Subsequently, this insight can facilitate informed decision-making concerning policies and procedures.

Figure 30. **Example LOSA Errors (IndiGo)**

Omitted 'clear left/right' call
Fast taxi speed
Nonessential duties performed
Checklist errors
Wrong system settings

Reference Documents:

ICAO Global Runway Safety Site

ICAO Annex 19, Safety Management | SKYbrary Aviation Safety

ICAO Runway Safety Toolkit

Safety Promotion | SKYbrary Aviation Safety

Runway Incursion | SKYbrary Aviation Safety

Flight Safety Foundation, Learning From All Operations

IATA *Runway Safety webpage* and *Safety Issue Hub*

Recommendation AO2: Aircraft operators should actively participate in aerodrome local runway safety team (LRST) activities.

Why should aircraft operators follow this recommendation?

It is necessary that all aerodrome stakeholders work together and exchange safety-relevant information. In most runway incursion events, one group does not have the full picture of the circumstances or contributing factors that led to the event. This collaboration allows aircraft operators and other stakeholders to learn from each other, understand different perspectives, and create a shared picture of the threats and hazards that flight crews and air traffic controllers cope with in daily operation.

The requirement for airports to establish an RST is one of the main outcomes of the ICAO Global Runway Safety Symposium held in Montreal in 2011.

The RST should comprise representatives from aerodrome operations, air traffic controllers, airlines or aircraft operators, pilot and air traffic controller associations, and any other groups with direct involvement in runway operations.

Aircraft operators have a valuable source of information to gain knowledge about what works well and what needs improvement to mitigate runway incursion risks in daily operation — the flight crews. Aircraft operators should openly discuss events and identified trends in RSTs, as well as any mitigation and/or safety promotion efforts taken since the last RST meeting.

What can aircraft operators do to implement the recommendation?

Aircraft operators should actively seek to join RSTs at home bases and primary (hub) airports, and proactively participate to understand local issues and the viewpoints of other stakeholders, and to bring their own safety issues to the attention of other parties.

Where possible, operators should consider participation in non-home-base airports, particularly where they have significant operations and/or have experienced runway safety issues.

Ensure that data and information affecting runway safety is compiled from internal reporting systems and channelled to relevant RSTs. Likewise, any new risks or safety issues discovered through RST groups are methodically processed

and circulated to all relevant departments, personnel, and organisations that use the aerodrome.

Partner with the aerodromes' SMS programs (as applicable) when hazards are identified during RST meetings to ensure a collaborative approach to mitigate risk.

Reference Documents:

International Civil Aviation Organisation (ICAO). (2015). *Runway Safety Team Handbook (Second Edition).*

International Civil Aviation Organisation (ICAO). (2007). *Doc 9870 - Manual on the Prevention of Runway Incursions.*

Recommendation AO3: Aircraft operators should actively participate in safety information–sharing programs that would allow them to benchmark their safety performance (including runway incursions) with the industry and get a better awareness of existing and emerging safety risks.

Why should aircraft operators follow this recommendation?

To effectively mitigate runway safety events, all stakeholders must collaborate, synchronise SMS processes (including safety risk assessments), and exchange safety-relevant information to effectively monitor and manage SPIs. A proactive, collaborative approach is required to manage and mitigate hazards, risks, threats, and errors related to runway incursions.

This collaboration allows aircraft operators and other stakeholders to learn from each other, understand different perspectives, and create a shared picture of the threats and hazards that flight crews and air traffic controllers cope with in daily operations.

What can aircraft operators do to implement this recommendation?

To build or receive the required level of trust needed to establish a safety information exchange with other aircraft operators or other industry stakeholders, aircraft operators should consider the following steps (GAPPRE, 2021):

- Aircraft operators should be proactive in establishing professional contacts between the safety, flight operations, and training departments of their organisation and those of other industry stakeholders such as air navigation service providers (ANSPs) and other aircraft operators.
- Aircraft operators should include their senior and board management and communications departments in setting up safety information-sharing networks, in order to increase their understanding of how the benefits of such exchange outweigh the manageable risks of reputational problems, especially as safety information exchange does not only include negative events but positive ones as well.
- Aircraft operators should make it as easy as possible for external parties to submit safety reports directly into their SMS by publishing the relevant email address or website information. Likewise, operators should ensure their SMSs can report directly into other stakeholders' SMSs, thereby relaying firsthand and timely information on safety issues.
- Aircraft operators should consider distributing their safety newsletter or magazine to other industry stakeholders. They should also communicate to their flight crews any safety information received by information-sharing networks and encourage crewmembers to report all safety issues they encounter.
- Aircraft operators should consider registering or joining existing safety information-sharing networks or relevant organisations, which include, but are not limited to, the following:
  - European Union Aviation Safety Agency (EASA) Data4Safety;
  - European Operators Flight Data Monitoring (EOFDM);
  - FAA Aviation Safety Information Analysis and Sharing (ASIAS);
  - U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS);
  - Flight Safety Foundation and SKYbrary;
  - Industry associations (such as the European Regions Airline Association, European Business Aviation Association, Airlines for America, National Air Carrier Association, Regional Airline Association);
  - IATA Flight, Incident, and Accident Data eXchange (FDX, IDX, and ADX);
  - LRSTs;
  - Eurocontrol Voluntary Air Traffic Management (ATM) Incident Reporting (EVAIR); and,
  - Aircraft manufacturer safety programs/meetings.
- Leverage existing industry meetings such as Aviation Safety InfoShare (FAA), Safety Forum (FSF), Safety Incident Review Meeting (IATA), or other local safety meetings to discuss insights, trends, and hazards and learn from other's experiences.
- For operators of Airbus aircraft, consider participation in Airbus *Destination 10X* initiative.

Reference Documents:

International Civil Aviation Organisation (ICAO). (2015). *Runway Safety Team Handbook (Second Edition).*

International Civil Aviation Organisation (ICAO). (2007). Doc *9870 – Manual on the Prevention of Runway Incursions.*

Eurocontrol and Flight Safety Foundation. (2021). Global *Action Plan for the Prevention of Runway Excursions.* Eurocontrol.

2.2 Flight Crew Training (AO4, AO5, AO6)

Recommendation AO4: Aircraft operators should provide training for pilots regarding aerodrome signage, markings and lighting. Operators should ensure pilot competence in this area is achieved both during initial and recurrent training.

Why should aircraft operators follow this recommendation?

It might seem obvious, but the primary means of navigation for pilots during ground operations is still looking out the window. In modern flight decks, with electronic navigation displays and numerous electronic flight bag (EFB) and flight management system (FMS) interactions, there is a strong tendency towards heads down operations. Operators should ensure that flight crew procedures emphasise the importance of always looking outside.

It is essential that pilots are familiar with aerodrome signage, markings, and lighting for safe runway operations (EAPPRI, 2017). While this information is covered during primary flight training, over the course of their careers and with an increased reliance on electronic devices, pilots may forget some of these basics. Operators should ensure this knowledge is kept up to date through recurrent training.

As aerodromes become more congested and complex, aerodrome authorities continue to identify new methods to move the increasing number of aircraft. This can lead to more complex signage and markings that may not be present at the smaller airports where primary flight training often is conducted.

If pilots change aircraft type, there may be new destination airports and regions. It is important that local variations of aerodrome signage are covered in differences courses.

What can aircraft operators do to implement the recommendation?

- Ensure aerodrome signage, markings and lighting are included in all initial and recurrent training programmes. This should include training for individuals who conduct aircraft towing. Airlines often assume pilots cover this in basic training. Ensure a knowledge check during initial company training and periodic checks thereafter.
- Include training on hot spot symbology. Also include holding position markings, which can be located on runways or taxiways.
- Ensure the training emphasises aerodrome differences, including primary aerodromes, alternate aerodromes, and complex aerodromes. Training should also cover the need to watch out for airfield construction and repair, and how those activities can increase the risk of incursions.
- Include how non-standard and construction work signage/lighting/markings are conveyed to flight crews. Consider remarks in company airport pages if non-standard signage, markings, or lighting are in use at an aerodrome (including any alternate aerodromes).
- Consider the adoption of virtual reality (VR) simulation technology to enhance comprehension and visualisation of airport signage. Even experienced flight crews who are familiar with signage and markings can make mistakes, especially at busy airports and during low visibility.
- Likewise, operators can leverage platforms like "Airport Briefing" to aid crewmembers in visualisation. These platforms enable users to manipulate variables such as time of day and weather conditions, providing the most accurate and immersive preview of operational scenarios.
- Encourage flight crews to report any unserviceabilities and inadequacies in aerodrome signage and lighting. This is especially relevant for aircraft with high or low pilot eye height, as the viewing angle may differ from that of airfield inspection vehicles.
- Include aerodrome signage, markings, and lighting in periodic safety promotion materials. For example, “Black Square, You’re There” (Figure 31).

Figure 31. **Example of signage promotional material**

Knowledge of symbols and signs

ICAO Annex 14, Aerodromes, Volume 1, "Aerodrome Design and Operations," contains standards and recommended practices related to signs and markings at an airport. Of particular interest is the convention that, at a taxiway intersection, information signs shall be located prior to the intersection and in line with the intermediate holding position marking. Where there is no intermediate holding position marking, the signs shall be installed at least 60 m from the centreline of the intersecting taxiway. This often means that an information sign is closer to a taxiway other than the one to which it refers. The key message for flight crews is that signs always relate to the junction behind the sign.

Task sharing

With the increasing complexity of modern airports, flight crews frequently must navigate expansive and complex taxiway intersections. The signs and markings can be distant from the cockpit. Also, depending on the orientation of the aircraft, signs and markings can be misleading. Environmental factors (poor lighting, visibility, snow, language barrier, etc.) and airport pressures (other traffic, proximity to active runway) can contribute to flight crew errors.

Operators' procedures should set out the roles and responsibilities for pilot flying (PF), pilot monitoring (PM) and any supernumerary crewmembers with respect to looking in/out and maximising all resources (AMM, charts, etc.) available to the flight crew to navigate safely during ground operations.

It is imperative that at least one pilot (PF) always maintains a good lookout, that ground navigation is primarily conducted by external cues, and that the PM is actively monitoring ground navigation with the support of onboard navigation aids.

Reference Documents:

UK CAA *CAP 637: Visual Aids Handbook*

FAA AIM Chapter 3 Airport Marking Aids and Signs

SKYbrary Surface Markings and Signs

FAA Airport Sign and Marking – Quick Reference Guide

ICAO Annex 14 – Aerodromes

Eurocontrol. 2017. *European Action Plan for the Prevention of Runway Incursions (EAPPRI)*

Recommendation AO5: Aircraft operators and training providers should include realistic, evidence- and competency-based scenarios in their training programmes, requiring threat and error management for runway incursion prevention and mitigation.

Why should aircraft operators follow this recommendation?

While flight crew training is highly regulated, the goal of training should be not only regulatory compliance but also the development of a community of safe and proficient pilots. Training should create a competent pilot community that embraces a culture that prioritises safe runway operations over commercial pressures, emphasising the importance of taking sufficient time for critical safety tasks, promoting mental readiness, and raising awareness about fatigue. Such training should nurture positive team dynamics and encourage informed decision-making.

To achieve this goal, training should be competency-based, including evidence-based scenarios that focus on TEM. Training should include strategies and techniques to improve the pilots' ability to anticipate or recognise, and effectively mitigate runway incursion risks.

Historically, training of ground-based events tends to decrease as pilots progress in their careers. There is a reluctance to use valuable simulator resources for ground scenarios or manoeuvres, the prevailing philosophy for simulator time being to "get in the air" as fast as possible. But safety studies show that pilot proficiency and competence is important, whether in flight or on ground. The "get in the air" mindset can foster the attitude that ground operations are less safety critical than flight phases. Operators should avoid this trap and look at potential training benefits of running ground-based scenarios in the simulator (controllable time-pressure, potential to stop aircraft, etc.).

One major contributing factor to runway incursions is a lack of situational awareness during aerodrome surface operations, especially at complex airports. Conducting regular, evidence- and competency-based scenarios in various training exercises will show the importance to flight crews of managing surface movement threats.

What can aircraft operators do to implement the recommendation?

- Operators should apply the ICAO Aeroplane Pilot Competency Framework (ICAO Doc 9868 PANS TRG Third Edition) and the IATA Evidence Based Training Implementation Guide Edition 2 (January 2024) manuals in the design and implementation of their training programme.
- The operator should ensure the flight simulation training device (FSTD) visual cues replicate the real-world visual environment and represent actual airport layout.
- Use in-house data (from reports and flight data monitoring (FDM)) as well as relevant industry data to ensure realistic and relevant scenarios. The emphasis should be placed on areas where the errors could have been trapped, and on best practices for threat mitigation in similar circumstances.
- Operators should include low-visibility scenarios in training programs.
- Include single engine taxi operations (or two-engine taxi with four-engine aircraft if allowed by the operator) to highlight appropriate times to conduct engine start or stop procedures.
- Operators training programs should include rejected take-off (RTO) scenarios, which focus on pilot decision making and execution of RTO's, following ATC instruction or for aircraft on runway scenario, during low and high speed phases.
- EBT should enforce the active monitoring role of pilot monitoring (PM), including nudges and other active intervention during surface movement. Even junior first officers should not hesitate to speak up when they see a problem.

RI training scenarios should include the following competencies and behaviours:

- Aeroplane Flight Path Management, manual control: Ensure smooth, accurate handling of aircraft, including single-engine taxi and adverse weather conditions, while maintaining intended routing. Both pilots should be monitored for ground navigation competence using aids such as external lights/signs, aerodrome charts, and, if applicable, an aerodrome moving map.
- Application of procedures and compliance with regulations: Apply relevant techniques and procedures, standard callouts during taxi, use of headsets, and sterile cockpit.
- Communication: Ensure effective communication between crewmembers and with ATC. Training should focus on accurately receiving and verbalising ATC clearances. Ensure all simulator scenarios foster a culture of standard radiotelephony (RT) communications. Crews should be expected to maintain good radio discipline throughout (avoid "it's only the simulator" attitude). This also requires training or guidance to instructors on how to deliver realistic and accurate ATCO roles during the EBT session (see also Recommendation AO6).
- Workload management: Task prioritisation and management of distractions. Focus on crew workload management, particularly for short-distance or time-constrained scenarios. Include the management of threats based on evidence such as last-minute runway change, adverse weather conditions, management of malfunctions etc. During the threat management, the pilots should demonstrate specifically the competencies of leadership and teamwork, and problem solving and decision-making.
- Situational awareness and management of information: Monitoring the general environment as it may affect the operation. Particularly demonstrating awareness of RI threats and the presence of other traffic when approaching runways.

Reference Documents:

Commercial Aviation Safety Team (CAST) Safety Enhancement, 2018. Wrong Runway Departures- Scenario-Based Training for Pilots.

IATA Evidence Based Training Implementation Guide Edition 2 (January 2024)

Competency framework (ICAO Doc 9868 PANS TRG Third Edition)

Recommendation AO6: Aircraft operators should, through their initial and recurrent training programmes, ensure pilots use standard RT phraseology, in the English language, and are aware of the runway incursion risks of non-standard RT procedures.

Flight crews should be trained to recognise and increase own vigilance when local ATC procedures are non-standard, when ATCOs speak too quickly or when frequencies are congested.

Why should aircraft operators follow this recommendation?

The demanding environment associated with runway operations requires that all participants accurately receive, understand, and correctly read back all clearances and instructions. RT phraseology and communication procedures, including communication speed, were found to be contributory in 11 events from an analysed sample of 68 runway incursion accidents and serious incidents involving at least one multiengine commercial air transport (CAT) aircraft in the six-year period 2016–2021 (GAPPRI Data Finding).

At times, the volume, speed of delivery, and complexity of RT instructions can cause difficulty for controllers, vehicle drivers, and/or pilots, especially when the instructions are not in their native language. Transient crews not speaking in their native language are susceptible to misunderstandings due to the use of colloquialisms. Therefore, the use of ICAO standard phraseology and phonetics is critical to enhancing the safety of operations.

It is important that operators ensure their flight crews know the risks of non-standard RT, that crews are trained in standard RT procedures, and that crews receive periodic refresher training and checking. When crews operate in a region with common use of non-standard RT, they can be tempted to adopt the local practice. Operators' policy and training should include awareness of this threat and re-emphasise the importance of maintaining radio discipline at all times.

Good RT discipline has obvious benefits for communication, but it also plays an important role in situational awareness. As aircraft and vehicles manoeuvre near runways, it is often difficult for the pilots and drivers to see all parts of the runway system (low visibility, ground slope, eyesight limitations, low cloud, etc). To compensate for this and to build a mental picture of traffic around the runway, pilots and drivers rely on listening to the ATC RT frequency. Use of one common language (English) by all runway users helps everyone understand all transmissions and build a mental picture. This mental picture is an important source of resilience for the system because it provides opportunities for error trapping and threat recognition.

What can aircraft operators do to implement the recommendation?

- Ensure initial and recurrent pilot training is in accordance with ICAO Docs 9432 and 4444. See also ICAO Doc 9870, Appendix A, Communication Best Practices.
- Ensure all simulator scenarios foster a culture of standard RT communications. (See Recommendation AO5)
- Ensure that operator policies and procedures enforce the use of English language in all RT transmissions.

Operators should provide procedures and training on threats of the use of non-standard RT by others and the need to maintain discipline in these situations. Include non-standard phraseology, non-English language, excessive speaking rates, etc., as threats that must be mitigated by flight crews.

When operating in a non-standard RT environment, operators should encourage pilots to:

- Maintain standard phraseology as much as possible. Speak clearly and slowly.
- Listen actively, interpret, and process the contents of the message. This applies to all crewmembers on the flight deck., including any augmented crewmemebers.
- If there is doubt over a clearance, pilots should seek clarification. Check with ATC. Ensure route and clearance limit are understood.
- If there is doubt over a clearance, do not pass a taxiway intersection until the message is clarified. Stop if necessary.
- If an ATC clearance includes too much information, note and read back what you can and ask controllers to repeat the message.

Operators should be aware of the GAPPRI initiative for ANSP and aerodrome operators to foster a professional language for runway drivers. Pilot use of the English language for RT communications is standard ICAO procedure, but it is especially critical for all runway operations. In partnership with the ANSP and aerodrome operators, the goal is one language for all runway users so that they have optimum awareness of all runway movements.

Professional Language for Runway Vehicle Drivers

Recommendations ANSP10 and ADR 25 call for a phased plan to be developed and implemented by ANSPs and aerodrome operators to improve ttraffic awareness for all runway traffic – runway vehicle drivers and aircraft.

Traffic awareness is a crucial functional barrier within the multi-layered structure that equips the aviation system with comprehensive defences against the risk of runway collisions. The use of the English language, adherence to standard ICAO radiotelephony communication phraseology, and communication on a single frequency are essential enablers.

However, in the short term, it is unrealistic to expect all airports worldwide serving civil aviation to ensure that all vehicle drivers use the standard ICAO phraseology in its entirety. This is why Recommendations ANSP10 and ADR25 propose a phased plan with intermediate stages, ensuring an adequate level of safety at each step.

To facilitate runway traffic awareness for all stakeholders, identify a recommended minimum set of runway phraseologies to be used as a professional language for runway vehicle drivers based on four normal runway operations.

The following are the suggested four safe runway phraseologies are referred to as **4-4-Safety (four for safety)**:

Aircraft operators can use this information in their recurrent training to raise awareness of flight crews regarding different language abilities of vehicle drivers.

Reference Documents:

Civil Aviation Authority (UK) Safety Sense RT Discipline

Civil Aviation Authority (UK) Radiotelephony Manual CAP 413

ICAO Doc 9432 Manual of Radiotelephony

Eurocontrol All Clear Guide to ICAO Standard Phraseology

ICAO Doc 4444 Procedures for Air Navigation Services (PANS) – Air Traffic Management (Doc 4444)

4-4-Safety: Safe Runway Phraseologies

Professional Language for Runway Vehicle Drivers

1. **Runway Entering or Crossing**

   Driver: (call sign) (Holding Point / position) REQUEST CROSS / ENTER RUNWAY (number) [FOR INSPECTION]
   ATC: (call sign) CROSS / ENTER RUNWAY (number) [REPORT VACATED]
   ATC: (call sign) NEGATIVE, HOLD SHORT OF (position)
   Driver: CROSSING / ENTERING RUNWAY (number) (call sign)

2. **Operations on Runway for an Extended Period**

   Driver: (call sign) ON RUNWAY (number)
   ATC: (call sign) ROGER, ON RUNWAY (number)

3. **Vacating Runway**

   ATC (call sign) VACATE RUNWAY (number) [IMMEDIATELY], [REPORT VACATED]
   Driver: [IMMEDIATELY] VACATING RUNWAY (number) WILCO (call sign)
   Driver: RUNWAY (number) VACATED (call sign)

4. **Hold Short of the Runway**

   ATC (call sign) HOLD SHORT OF (position)
   Driver: HOLDING SHORT OF (position) (call sign).

2.3 Ground Operations — Preparation and Briefing (AO7, AO8)

Recommendation AO7: Aircraft operators should implement policy and procedures that enable flight crews to plan ground operations effectively, by providing up-to-date airport charts, relevant NOTAMs, active runway configuration, latest weather/airfield conditions, and airport briefing sheets, in order to provide optimum situational awareness and reduce runway incursion–related risks.

Why should aircraft operators follow this recommendation?

Taxi is often a dynamic phase, with multiple competing demands on the pilot's attention. The priority for the pilot or flight crew is always the safe path of the aircraft, just as during flight phases. Preparation and planning of the taxi phase is critical to managing the workload and ensuring safe ground operations.

A key component for flight crew preparation for the taxi phase is familiarity with the airport. The most common question on the flight deck when flying to a new airport is, "Have you been here before?" This is usually followed by, "Which runway did you use?" and "Where did you park?" Operators should use that knowledge base and ensure it is shared across pilot groups so that inexperienced crews are equally prepared.

In the same way, taxi relevant safety information should be shared across the pilot group with focus on previous incidents, hot spots, airport hazards, etc. The source of this information could be internal, from a well-functioning SMS, or external, through safety data sharing and/or LRSTs (see Recommendation AO3).

This information should be easily accessible in flight and on the ground, both during flight planning and, if possible, before flight planning when pilots familiarise themselves with routes and aerodromes.

With increasing air traffic and pressure on airport facilities, flight crews must contend with airport work-in-progress daily. The NOTAM system that has been used for decades is outdated and overloaded due to a philosophy of "if in doubt, put it out." Many of these NOTAMs are lengthy, irrelevant, and not easily decoded. This increases the workload for the flight crews and sets up an environment which leads to pilot omissions and errors. Aircraft operators should ensure their NOTAM processing and presentation is end-user-friendly and that key safety information is filtered and highlighted.

Whether it is a single-pilot visual flight rules (VFR) flight or a multi-pilot, international scheduled flight, there are many possible inputs to flight preparation:

- Flight plan and fuel calculations
- Charts and maps, including taxi charts (focus on hot spot areas);
- Weather;
- NOTAMs;
- Aircraft performance data;
- Manufacturer flight crew operations manuals, including any revisions;
- Minimum equipment list (MEL);
- Airline operations manuals, including revisions; and,
- Airline, airport and route briefing documents, including safety information.

The flight planning process must be agile enough to deal with the dynamic aviation system but robust enough to ensure all relevant information is presented to flight crew in a timely manner. Flight preparation can begin days in advance of the flight, but it is important to remember that, very often, pilots and crews carry out their final preparations during the last hour or two before departure.

What can aircraft operators do to implement the recommendation?

The time available to the crew for carrying out final planning can be short for a variety of reasons, such as duty time limitations, multiple sectors, security and immigration, and delays. Operators should ensure their flight documentation is designed with flight crew needs in mind:

- Information is compiled into a concise format.
- The information is up to date and reflects any late changes.
- Important information is prioritised.
- Late changes are easily recognised.
- Information is structured and, if possible, searchable.

Since airport maintenance is an everyday occurrence, effective presentation of NOTAM information is critically important to ground operations and runway incursion prevention. Closures

of taxiways and runways can lead to unusual taxi routes and associated threats. Unserviceability of functional barriers such as stop bars can remove a crucial layer of defence, and their absence can further lead to unwanted actions such as lining up without clearance (see Recommendation AO22). Operators should ensure their policy and procedures encourage flight crews to review and project consequences of all relevant NOTAMs.

Standard taxi routes (STRs) are being employed at many airports now to reduce controller workload, but they bring a potential for ground errors. Operators should ensure that procedures are in place to inform crews of their use and provide clear documentation on the routes available. Crews should review and brief the routes in time to avoid confusion and error during taxi phases. Company operational briefing sheets could be used to increase pilot knowledge on the use of STRs at specific airports.

Operators should consider disseminating their FDM data on typical taxiway and runway use. There are new applications, such as General Electric's (GE) FlightPulse that allow pilots to leverage operator data to identify common taxi routes and runways. This information can be used in preflight planning, or during approach briefings to highlight common taxi routes with focus on runway crossings.

Operators usually provide specific aerodrome briefings for special-category airports (CAT B or C), but not for all airports. However, in the interest of runway incursion prevention, operators should consider providing an airport briefing for every airport. This would include showing frequently used parking positions, taxi hot spots, and typical taxi-out or taxi-in routes used by ATC. Such information would help flight crews create a mental risk picture early.

Recommendation AO8: Aircraft operators should consider implementing threat and error management–based briefings which focus on threats for the taxi phase and runway incursions.

Why should aircraft operators follow this recommendation?

A key element of the crew preparation for taxi is conducting effective briefings. These briefings should familiarise crew members with the geographic layout and possible threats during the taxi phase and ensure a shared mental model.

The conventional pilot briefings model is a decades-old method that has neither adapted to next-generation flight decks nor incorporated breakthroughs in our understanding of human cognition. Today's typical standard operating procedure (SOP) briefing is too long (due to years of adding more and more items determined to be "too important not to discuss.") Additionally, briefings have become one-size-fits-all solutions, serving as repositories for redundant verbal crosschecks of highly automated, highly reliable systems. Finally, too often, briefings are one-sided conversations that lack involvement from the pilot monitoring (PM). Recent industry accident trends indicate that PMs play a primary role in maintaining safety margins. (FSF, 2018).

Threat and Error Management (TEM) was developed as a product of collective aviation industry experience. Such experience fostered the recognition that past studies and, most importantly, operational consideration of human performance in aviation had largely overlooked the most important factor influencing human performance in dynamic work environments: the interaction between people and the operational context (i.e., organisational, regulatory and environmental factors) in which they discharged their duties (SKYbrary).

Many airlines and manufacturers have adopted threat-based briefings to better equip crews in anticipating, avoiding, and managing threats and errors. This is especially applicable during ground operations, where aircraft move through complex airport systems, and where human error is a frequent source of the undesired state.

A frequent cause of taxiway and runway incursion is crew expectation bias. Expectation bias occurs when a pilot hears

or sees something that he or she expects to hear or see rather than what actually may be occurring. Crew briefings naturally focus on the expected taxi route and destination, but an effective threat based briefing should include mitigations such as possible alternative routes, as well as identifying expectation bias itself as a threat (See also AO13).

What can aircraft operators do to implement the recommendation?

The taxi phase is critical and should be carefully briefed. Use the following guidelines as an outline for effective taxi briefings (SKYbrary):

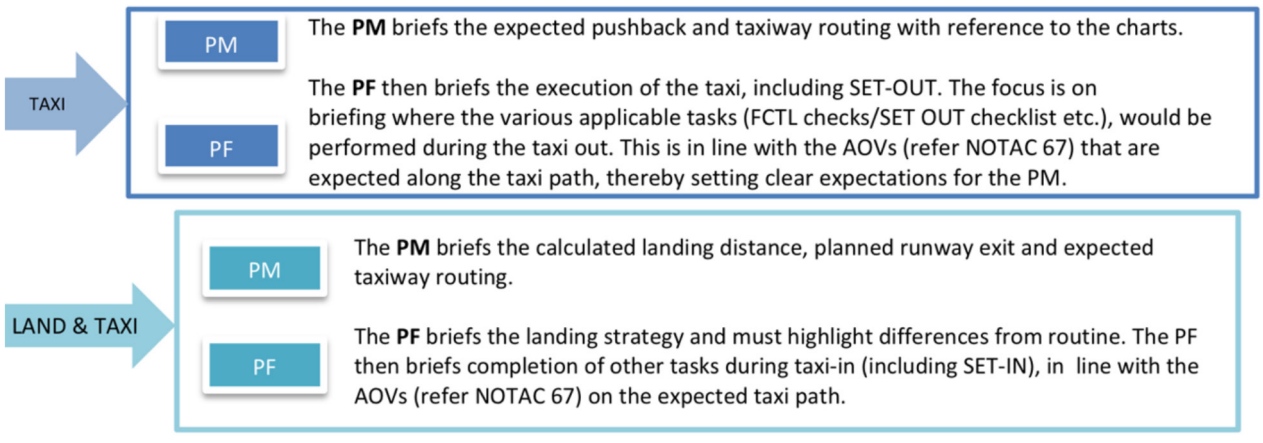
- Review expected taxi routes, using the airport chart, with special attention to taxi phase threats. Emphasise runway crossings and hot spots such as intersections where the risk of confusion and the resulting risk of a taxiway or runway incursion may exist.
- Refer again to the airport diagram when taxi instructions are received from ATC. The PF and PM should agree on the assigned runway and taxi route, including instructions to hold short of or cross a runway. The pilots should verbally confirm their agreement. The expectations established during the departure briefing can be altered with an unexpected taxi clearance. Pilots should be prepared to follow the clearance received, not the clearance expected.
- Discuss low-visibility taxi procedures and routes (if published and applicable to the flight) and the characteristics of the airport Surface Movement Guidance and Control System (SMGCS).
- Plan the execution of checks and actions to be performed during taxi to prevent distraction when approaching hot spots. Pay particular attention to temporary situations such as work in progress, other unusual activity, and recent changes in airport layout. The Areas of Vulnerability concept (Section 2.5) is an example of a tool to help crews plan workload during ground operations and increase situational awareness and monitoring.

The crossing of runways during taxi presents a significant runway incursion threat and should always be included in briefings. Crews should verbalise if and where a runway crossing is likely. The crew should identify any escalating factors, such as high workload, angled taxiway, RT procedures, or weather, and ensure effective mitigations are in place. These mitigations could include heightened crew monitoring, pausing checklists, good listen/look out, etc. Crews should also consider if the crossing point has potential for conflict with high-energy aircraft (for example, crossing near the touchdown zone or rotation point of an aircraft on the runway).

Crew briefings require balancing the requirement for the crew to familiarise themselves with the likely taxi route and the potential for bias towards that route. The natural tendency for crews is to brief the likely route, based on where they expect to start (stand or runway exit) and their expected taxi destination (runway intersection or stand). There are many unknowns at the briefing stage, so operators should provide crews with policy and training on:

- Keeping the briefing threat based;
- Focusing on familiarity with layout, such as taxiway names, hot spots, runway crossing points, etc.
- Identifying expectation bias as a threat; and,
- Ensuring a critical re-brief of the route after clearance is received.

Figure 32. **Example of interactive, threat-based briefing format (Source: IndiGo Airlines)**



Threat-based briefings are widely used as a structured approach for crews to address "what-if" scenarios. One example is the Threats-Plan-Considerations (T-P-C) model as developed by Capt. Rich Loudon, Alaska Airlines, and Capt. David Moriarty, Royal Aeronautical Society's Human Factors Group. More details are available at the Flight Safety Foundation link below (Figures 33 and 34).

Figure 33. **T-P-C briefing format**

▲ DEPARTURE BRIEFING

Threats (PM, PF)
Plan
- Taxi, Dept Rwy
- Route (Clearance/Flight Plan – FMC RTE crosscheck)
- Return (emerg, T/O alt)
- T/O perf valid, perf/config issues

Considerations
- Any specific PM duties, other considerations
- Recap as needed

▲ APPROACH BRIEFING

Threats (PM, PF)
Plan
- Route (STAR, Approach, Approach Mode, M/A, Alt fuel-route)
- Lnd Rwy, Assessment, LTP, Exit, Taxi
- Autobrakes
- Flaps, VREF, Target Speed

Considerations
- Any specific PM duties, other considerations
- Recap as needed

DEBRIEF

To improve performance:
1. How do you think that went?
   Note: Debrief both excellent performance and areas to improve.
2. If we could do it again, what would we do differently?
3. Are there any reports to complete/submit?

Figure 34. **Example taxi phase threats**

Example of taxi phase threats:	
Airport	• Hotspots • Runway crossing or proximity • Airport layout- complex, busy, intersecting runways • Airport layout- short or long taxi • Airport layout- non-standard holding points
Conditions	• Weather- visibility, darkness, precipitation • Weather- remote de-icing, ice shedding • Surface contamination- reduced braking & handling • Surface contamination- obscured markings, signs, & taxiway edges • Aircraft- weight, defects
NOTAMS	• Taxiway closures, changed layout, restrictions to use, and runways used as taxiways. • Construction work- temporary signage and lights
Workload	• Reduced Engine Taxi • Runway change
Crew	• PM Role- Pilot off-air, Pilot heads down • Crew Familiarity (too little or too much!) • Crew Fatigue • Expectation Bias

Reference Documents:

Rethinking the briefing – Flight Safety Foundation. (2018, January 3). Flight Safety Foundation. *https://flightsafety.org/asw-article/rethinking-the-briefing/*

Wilson, R. 2024. *Seven deadly shortcuts cognitive biases and aviation*. Flight Safety Australia

Flight Preparation and Conducting Effective Briefings (OGHFA BN) | SKYbrary Aviation Safety. (n.d.). *https://skybrary.aero/articles/flight-preparation-and-conducting-effective-briefings-oghfa-bn*

2.4 Ground Operations — Taxi Routing (AO9, AO10, AO11, AO12, AO13)

Recommendation AO9: Aircraft operators should implement policies or standard operating procedures (SOPs) for flight crews not to conduct a take-off or an approach following any runway change until the appropriate set-up, planning, performance calculations and re-briefings are completed. When a take-off runway change is received whilst taxiing, set-up, planning, performance calculations and re-briefings should be performed by the flight crew without rushing and when the aircraft is stationary.

Why should aircraft operators follow this recommendation?

Although not classified as a critical phase of flight by all regulatory agencies and competent authorities, many operators include the taxi phase in their critical phase of flight definitions. This is due to the dynamic aerodrome surface environment, workloads, and key operational risk area (KORA) exposure. Revisions to taxi, runway, and departure clearances are common in the aviation industry and normally require the operating crew to complete additional planning, setup, performance, checklist, and briefing requirements prior to departure. Such "heads-down" activities are often included in RI root causes and can be mitigated through appropriate policies and procedures.

During the preflight briefing, crews should be encouraged to look for cues and anticipate possible changes to the briefed plan. The briefing should centre around crews thinking critically, and continuously asking, "What else is likely to happen?" When a change occurs, the crew should have a plan for managing the change. For most changes, there will be an increased workload for the crew. It is critical that the crew recognise and manage this workload so other tasks such as navigation, monitoring, and maintaining situational awareness are not impaired. Operator policy should ensure crews take the required time, depending on the size of the change and the prior preparedness of the crew, to complete a full cockpit setup, performance calculation, and re-brief. If the workload involves significant heads-down time, then the aircraft should be stopped to allow both pilots to focus on the changes before resuming taxi.

A departure runway change while taxiing presents a double threat to the flight crew in that the workload (preparing for new departure, etc.) is increased while the taxi route (to new runway) has also changed. This combination has the potential to create a split cockpit with one pilot heads-down while the other pilot is manoeuvring the aircraft to an unplanned and unbriefed runway. The risk for runway incursion (and excursion) is increased significantly, and the most effective mitigation is to stop the aircraft. Because pilots don't have the luxury of being able to simply stop in flight, they sometimes are reluctant to do so on the ground. Pilots often operate at at busy airfields where they are accustomed to fitting into a flow of traffic. They instinctively want to stay in that flow and not lose their place in the queue. However, it is a pilot's responsibility to counteract this tendency for efficiency (press-on-itis!) and put safety first, even though it sometimes takes a conscious and unnatural effort simply to stop.

For arrival aircraft, whenever there is a change to a landing runway, there will be a change to the taxi route. As part of the approach re-brief, it is essential that flight crews consider the changed taxi route and any new runway incursion risks such as new runway crossings, a shorter route with workload impact, changes of ground frequency, etc.

Very often these changes coincide with operational disruption, which can place time pressures on flight crews. The perils of a rushed departure are well documented through aviation history. It is imperative that operator policy supports flight crews in prioritising safety critical tasks ahead of commercial pressures. Crews should feel enabled (and expected) to stop or hold to carry out all necessary preparation before takeoff or landing.

What can aircraft operators do to implement this recommendation?

Ensure operator policy and procedure for revised runway clearances incorporates:

- Standardised, structured guidance for managing runway or departure/approach changes.
- Guidance for managing revised departure clearances:
  - Avoid conducting activities associated with departure runway or SID clearance revisions whilst taxiing or on an active runway.
  - Complete revised runway/departure activities whilst stationary with parking brake set.

- Utilise TEM strategies and techniques to mitigate perceived time pressure and rushing.
- Do not accept clearance to cross or line up on a runway prior to completing all activities associated with a standard instrument departure (SID) and/or runway change.

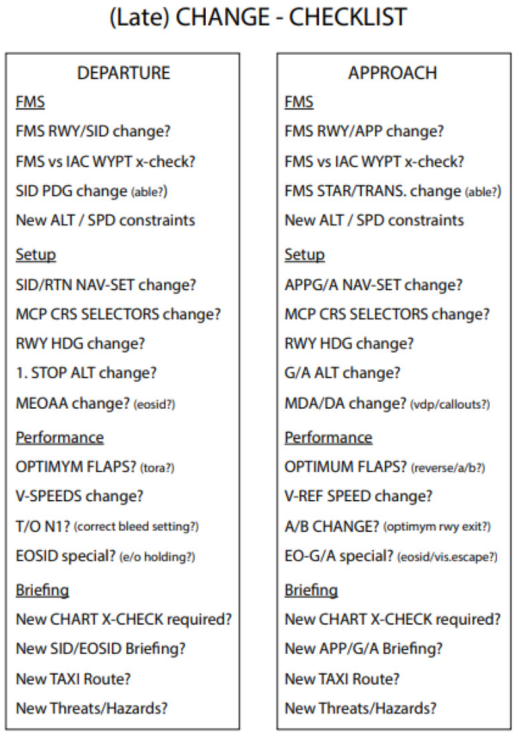
- Guidance for managing revised arrival clearances
  - Do not accept approach clearance prior to completing all activities associated with an approach and/or runway change.
  - Empower pilots not to accept a late runway change during landing if flight safety would be jeopardised.

In addition, operators can:

- Consider implementation of a runway change checklist or runway change items on the normal checklist (Figure 35). Also consider a requirement for crews to establish the latest time for completion of a checklist (e.g., runway holding point).
- Ensure good information management so that crews know about possible and regular changes at specific airports.
- Ensure crews anticipate possible changes as part of their TEM briefing and preparation.
- For changes to the approach or to the landing runway, ensure the re-brief includes the expected vacating taxiway and the new taxi route to parking, with associated threats. In a time-critical situation, the re-brief should, at a minimum, include the expected vacating taxiway and first turns until the aircraft clears the runway. Then a more thorough taxi familiarisation and brief can be carried out on the ground, with the aircraft stopped if necessary. (see AO31.
- Encourage crews to use technological aids such as secondary flight plans, electronic charting, and multiple performance calculations to reduce workload associated with changes.
- Operators, as part of the flight crew's crew resource management (CRM) training programme, should include focus on pilots' own awareness of task overload. Often, crews get drawn into the immediacy of task completion and the higher-level functions such as monitoring and situational awareness are de-prioritised. Pilots should be trained to monitor for signs of overload and fixation (for example, missed standard calls, unexpected autopilot mode changes, etc.) and strategies for prevention and mitigation.

A technique by one airline for departure changes is to categorise them into two types: those necessitating immediate, or short-term changes, such as modifications made on the flight control unit (FCU) while maintaining "both heads up;" and those requiring more involved, or long-term changes, involving "heads down" activity, such as performance calculations, re-briefing, and checklists. To optimise flight operations efficiency, it may be beneficial to differentiate between these types, indicating that short-term changes may be performed with the aircraft moving, using appropriate task sharing, and long-term changes should be performed while the aircraft is stationary.

Figure 35. **Change Checklist (GAPPRE OPS8)**



References:

Global Action Plan for the Prevention of Runway Excursions (GAPPRE).

Recommendation AO10: Aircraft operators should implement policy and procedures that aerodrome charts must be displayed on the flight deck during taxi. This includes when operating at home and familiar aerodromes.

Operators should consider implementation of flight deck moving map technology, where feasible, and provide crews with training and procedures for use of moving maps, including any built-in runway incursion prevention systems.

Why should aircraft operators follow this recommendation?

The display and use of charts is a basic airmanship skill instilled in pilots from basic training. The use of charting by the flight crew is an important tool in ensuring a shared understanding of the route, avoiding any errors, recognising threats, and enabling effective monitoring from the PM.

Pilots will always refer to ground taxi charts in new or unfamiliar airfields, but the temptation is to work from memory in familiar and home airfields ("I know the way!). Unfortunately, a significant proportion of ground deviations occur in familiar airfields. Crews need to maintain taxi vigilance and attentiveness at all airfields. Operator policy should draw attention to the threat of over-familiarity or complacency. Procedures should ensure crews continue to observe best practices, especially in their home airfields. This includes the continuous display and use of charts and airport diagrams.

As the use of EFBs becomes more widespread, electronic charting provides operators with an enhanced method of displaying charts. These electronic charts are easily available, easily updated, and accessible for crews.

Many electronic chart systems also allow for airport moving map (AMM) technology. This feature is a strong countermeasure to ground deviations, as it shows pilots their own position accurately and instantaneously. This has obvious benefits in poor weather and at large, unfamiliar airfields. But even at familiar airfields, it will help crews avoid making a wrong turn where they are in different location to where they think.

Moving map technology is developing all the time and some providers offer the following functionality:

- Display of ATC cleared routing;
- Mark taxi destination;
- Show traffic information (using ADS-B In); and,
- Provide runway awareness and alerting functions (including wrong runway departures).

What can aircraft operators do to implement the recommendation?

Operators should:

- Ensure that policy and SOPs mandate flight crew use of charts at all airfields, especially at home and familiar airfields.
- Ensure that processes are in place to keep all charts up to date.
- Consider implementing electronic charting if not already in place. Example providers are Jeppesen, Boeing Aero QTR_02.12, and LIDO, part of the Lufthansa group.
- If EFBs are implemented, ensure that appropriate ICAO standards and recommended practices (SARPs) are followed. (IOSA Standards Manual (ISM) Edition 16 Revision 2, FLT 3.5.3)
- Consider implementing a moving map display function with display of own ship position.
- Consider equipping aircraft with technologies to assist in improving situational awareness, especially during low-visibility operations, such as improved resolution AMMs, EFBs, enhanced vision systems, and head-up displays (HUD).

In all cases, operators should ensure that crews are required to mutually cross-check their understanding of the received ATC taxi clearance before starting to taxi. Operators should ensure by policy, SOPs, and training that crews feel free to take the time needed to translate the received information using the charts and to detect possible misunderstandings or clarify doubts. To assist their crews in practice, operators should highlight in LRST- meetings that crews are not expected to start taxiing instantly after receiving a clearance, but might need time to ensure proper understanding of the clearance (See also AO13).

If an electronic charting system is in use, ensure flight crew training and procedures are provided for:

- Familiarisation with software and user interface;
- SOPs for use, including PF/PM display guidance;
- Application of NOTAMs;

- When using moving map function with own ship position, the primary reference remains the external visual references;
- Where runway awareness and alerting functionality is available, crew training should include knowledge of the system, standardised responses to system indications, callouts, and crew actions in the event of system alerts;
- Consideration of nuisance and distracting alerts; and,
- Contingencies for system malfunctions.

Reference Documents:

Commercial Aviation Safety Team (CAST) Safety Enhancement, 2018. *Wrong Runway Departures- Scenario-Based Training for Pilots* (SKYbrary).

Recommendation AO11: Aircraft operators' procedures should include maintaining a sterile flight deck during all aerodrome surface movements, as well as during flight below 10,000 ft above ground level (AGL).

Why should aircraft operators follow this recommendation?

Although not classified as a critical phase of flight by all regulatory agencies and CAs, many operators include the taxi phase in their critical phase of flight definitions. This is due to the dynamic aerodrome surface environment, workloads, and KORA exposure. Distraction and loss of situational awareness are common contributory factors to taxiway and runway incursions. Often, the sources of distraction are workload demands such as SOPs, traffic, and weather. But, unfortunately, accident and incident data show that non-operational discussion and tasks can also be the source of distraction. Both EASA and the FAA (FAR 121.542) include ground operations as a critical phase of flight.

The "sterile flight deck" concept while taxiing should be adopted according to ICAO Doc 9870. During movement of the aircraft, the flight crew must be able to focus on their duties without being distracted by non-flight-related matters. Cabin crew should be made aware of this requirement if it is not an SOP. The following definition of a "sterile flight deck" is offered as a reference:

> *Sterile flight deck. Any period of time when the flight crew should not be disturbed, except for matters critical to the safe operation of the aircraft.*

According to SKYbrary, the sterile cockpit/flight deck concept involves the restriction of crewmember activity to that which is operationally essential during busy phases of flight: taxi out, take-off, initial climb, intermediate and final approach, landing, and taxi in.

An added benefit to maintaining a sterile cockpit during ground operations is that when crews maintain active listening on ATC RT frequencies, they will increase situational awareness regarding other aircraft in the vicinity. This will provide an additional layer of resilience and safety barriers.

What can aircraft operators do to implement the recommendation?

There are two elements to a sterile cockpit environment. The first is maintaining operational discipline with respect to activities and conversation between flight crewmembers. The second is managing disturbances from sources external to the flight deck.

Disturbances may include, but not be limited to, calls received from non-operational areas (e.g. company), entry onto the flight deck by cabin crew, and extraneous conversations not related to the current phase of flight. It is generally accepted that the need for a sterile cockpit commences as follows (ICAO Doc 9870):

- Departure: when the aircraft engine(s) are started and ceases when the aircraft reaches 10,000 000 ft above the departure aerodrome;
- Arrival: when the aircraft reaches 10,000 ft above the arrival aerodrome until the engine(s) are shut down after landing; and,
- At any other time determined and announced by the flight crew (e.g. in-flight emergency, security alert).

The following excerpt from the ICAO Operational Safety Audit (IOSA) Standards Manual (ISM) Edition 16 Revision 2 (FLT 3.11.17) specifies that the operator shall have a policy and procedures that define a sterile flight deck during critical phases of flight, to include:

- A protocol for intra-flight deck communication;
- If the operator conducts passenger flights with cabin crew, a protocol for communication between the flight crew and cabin crew;
- The mandatory use of headsets and boom or throat microphones for communication with ATC below the transition level/altitude; and,
- A restriction of flight crew activities to essential operational matters. (GM)

While not included in the ICAO definition, another phase which should be considered by operators for inclusion in their sterile cockpit policy is during flight crew departure briefings. As discussed in Recommendation AO8, the briefing process is a key component in TEM for flight crews. Any disturbances or distraction during the briefing could potentially lead to flight crew errors or omissions. Some operators have introduced policy and procedures for cabin crew, engineers, and ground staff not to disturb (except for safety-critical reasons) the flight crew at certain times, such as when the cockpit door is closed, or if the "Briefing" sign is up (Figure 36).

Figure 36. **Do Not Disturb (IndiGo Airlines)**

Sterile cockpit policy should also consider the use of mobile phones and other electronic devices, including listing the allowable uses of a crewmember's EFB during the sterile phases of flight. These can be a useful operational tool but present significant potential for distraction of crewmembers.

Operators should include guidelines for long delays on the ground, with the parking brake set, which allow for flight crews to engage in activities that help maintain alertness, and allow for communications with company personnel, without adversely affecting situational awareness.

Reference Documents:

ICAO, 2007. Doc 9870 Manual on the Prevention of Runway Incursions. First Edition.

SKYbrary Sterile Cockpit Concept.

EASA "What are Sterile Cockpit Procedures?"

Recommendation AO12: Aircraft operators should implement policy and ensure procedures are in place for flight crews who doubt their exact position on the surface of an aerodrome. These procedures should include guidance on stopping the aircraft immediately and contacting ATC.

Why should aircraft operators follow this recommendation?

Pilots and airside manoeuvring area drivers do not knowingly enter a runway without a valid ATC clearance. When this happens, it is most likely because the pilot or driver is uncertain of their position and situational awareness has been lost.

The 1999 runway incursion in *Providence, Rhode Island, U.S.*, still serves as a reminder of the potential consequences when an aircraft flight crew becomes unsure of their position on an airfield, especially when operating in poor weather conditions. In this scenario, a Boeing 757 crew failed to follow the taxi-in clearance after a night landing in fog and ended up at the edge of the same runway that they had just landed on as a departing 727 passed close overhead. Despite being advised by the 757 crew that they were uncertain of the airplane's position but believed it was on an active runway, the tower controller twice cleared a 737 to take off on the same runway. The crew of that aircraft declined both clearances until they were certain of the 757's position.

It is logical that if flight crews are uncertain of their position on an airfield that they immediately stop the aircraft. However, they sometimes are reluctant to do so. Cultural issues (loss of face), rush factors, and the human tendency to press on all influence the crew in continuing. In addition, if a crew is uncertain of the aircraft's position but suspects it may be on a runway, then stopping may not be the safest course of action as it may increase the risk of collision.

For these reasons, it is critical that operators support crews with policy and procedures that enable them to deal with all scenarios in which they may be unsure of their position. The principles of good CRM and just culture should apply, also. This will help crewmembers feel empowered to speak up when they are unsure of position, and to take whatever action they feel is appropriate to ensure the safety of the aircraft.

Caution is needed, too, when crews think they know their position. This requires critical thinking and self challenging, either individually or as a crew. Confirmation bias will frame the available cues to support the pilot's mental picture.

Operators should make pilots aware of this human tendency and arm the pilots with tools to look for contradictory clues.

What can aircraft operators do to implement the recommendation?

- Operators should make clear in their policy and even support crews in making the decision, that when not absolutely sure of the geographic position of the aircraft, crews should stop the aircraft, or at least not proceed past the next intersection, before confirming the aircraft position.
- If the crew is unsure of position but suspects the aircraft is on a runway, then the crew should recognise the potential for collision and take immediate action to ensure the safety of the aircraft.
- Operators should consult regulatory bodies, airport operators, etc., when drafting policy and procedures.
- Aircraft operators should avoid putting crews under undue commercial pressure to make on-time performance or other time constraints (calculated take-off time [CTOT], curfew, etc). Operators must understand the possible impact that rushing can have on safety, particularly during ground operations.
- Operator policy, procedures, and training should deal with human factors such as confirmation bias and expectation bias, as well as the human tendency to avoid negative confrontation with ATC for stopping.
- "Doubt is a fact:" If any crewmember expresses doubt as to their position, this should be treated as crew doubt and lead to instant action.
- Operators' policy should include actions for low visibility procedures.

Excerpt from ICAO Doc. 4444 PANS-ATM - "UNCERTAINTY OF POSITION ON THE MANOEUVRING AREA:

When a pilot is in doubt as to the position of the aircraft with respect to the manoeuvring area shall immediately:

a) stop the aircraft; and

b) simultaneously notify the appropriate ATS unit of the circumstances (including the last known position).

In those situations where a pilot is in doubt as to the position of the aircraft with respect to the manoeuvring area, but recognizes that the aircraft is on a runway, the pilot shall immediately:

a) notify the appropriate ATS unit of the circumstances (including the last known position);

b) if able to locate a nearby suitable taxiway, vacate the runway as expeditiously as possible, unless otherwise instructed by the ATS unit; and then,

c) stop the aircraft.

A vehicle driver in doubt as to the position of the vehicle with respect to the manoeuvring area shall immediately:

a) notify the appropriate ATS unit of the circumstances (including the last known position);

b) simultaneously, unless otherwise instructed by the ATS unit, vacate the landing area, taxiway, or other part of the manoeuvring area, to a safe distance as expeditiously as possible; and then,

c) stop the vehicle.

Reference Documents:

European Action Plan for the Prevention of Runway Incursions (EAPPRI)

ICAO Procedures for Air Navigation Services (PANS) - Air Traffic Management (Doc 4444), 16th Edition, 2016

Recommendation AO13: Aircraft operators should implement policy and procedures which require pilots to handle and process ATC clearances during ground manoeuvring with the same caution and attention as in-flight clearances. Operators should consider SOPs on recording and verbalising the clearance so that all crewmembers have a shared understanding of the routing, including when pilot-off-air.

Why should aircraft operators follow this recommendation?

There is always a temptation for pilots to treat ground operations as a less critical or challenging phase of flight. This is understandable since the airborne phases get more attention during training, have more SOPs, and present more threats and hazards.

RIs are relatively rare but, as demonstrated by the 1977 Tenerife accident — in which 583 people were killed in the runway collision of two 747s — the consequences can be catastrophic. Taxiway Incursions, on the other hand, occur much more frequently (although with less potential for serious consequences), and it is widely accepted that the causes of both types of incursions are similar.

Therefore, to reduce the risk of RIs, operators should work to reduce their taxiway incursion rate. This can be achieved by strengthening SOPs and ensuring crews process all taxi instructions with the utmost care and diligence.

By requiring crews to record and verbalise all ATC clearances, the process is formalised and helps to avoid a casual approach to ground operations. It is useful to record long clearances to help flight crew understanding, read-back and recall. Verbalising is an important step in ensuring the clearance was understood correctly by all crewmembers and that there is a shared mental model of the taxi instruction.

What can aircraft operators do to implement the recommendation?

- Review policy and SOPs regarding how ATC clearances are processed by crews. Their fitness for purpose, in the context of operational requirements and considering any previous company taxiway incursion incidents, should be reassessed.
- Implement policy and training that clearly define roles and responsibilities for the PF and PM for the receipt, recording, and verbalising of all ATC instructions. It should also be a requirement that crew members agree their common understanding, including interventions by PM, of the taxi route before proceeding. When a clearance is received during other tasks (e.g. when completing a checklist), the task should be paused, and priority given to ensuring the clearance is processed and understood.
- Flight crews should expect ATC taxi clearances to have two components: the routing and a clearance limit. Policy should ensure that if any doubt exists about the cleared route or limit, it is clarified with ATC immediately. Any crewmember's doubts should be treated as though the entire crew has doubts, and the matter can only be resolved by checking with ATC.
- The threat of bias towards the expected or briefed route should also be revisited when flight crew receive the ATC clearance. Operators should provide crews with de-biasing tools and techniques to ensure the crew follow the cleared route instead of the expected route.
- Policy should also deal with scenarios where a clearance is received while a pilot is off-air. Both pilots should hear the clearance first-hand from ATC so if a pilot is off-air, the clearance should be confirmed with ATC when both pilots are listening. Where third or fourth flight crewmembers are present, policy should ensure these crewmembers have a clear role in reducing runway incursion risks and any potential for distraction or line-check pressure is mitigated.
- Operators with paperless cockpits should investigate and put procedures in place for pilots to record ATC clearances as they are received, enabling crew confirmation and easy recall. Examples include scribble screen on EFB, scratchpad, notepad, etc.

An example of the taxi procedures adopted by one airline is presented in Figure 37.

Expectation Bias

A frequent cause of pilot deviations on the ground is expectation bias. There have been many incidents in which the pilot or crew formed a mental model of the taxi route and followed that route, even after being cleared and reading back a different route.

The "expected route" mental model can be formed at various stages; from previous flights ("this is the route we always take"), from preflight briefing ("this is the route we expect today"), or in response to visual or audio cues sensed by the crew ("another aircraft is on Taxiway A, so we will probably be cleared on Taxiway B").

A potentially more serious version of this expectation error occurs when the flight crew have an incorrect mental model of the active runway(s). This can lead to taxiway incursions, when the route followed is to the wrong runway, or directly to a runway incursion when crew are not aware of runway status (active/inactive). When airports change runway configuration, it is often the responsibility of the crew to discover that there has been a change by checking for the new automated terminal information service (ATIS) or asking ATC. They also learn of this change by looking and listening, and by maintaining good situational awareness. The important thing is that a runway change is not always pushed out immediately to crews.

To mitigate the potential risks from expectation bias, operators should consider the following steps:

- Increase pilot awareness of expectation bias through inclusion in initial and recurrent crew training.
- Review crew procedures for robustness and potential to trap any expectation bias errors.
- Recognise the value of using previous experience to prepare for what's happening next, while maintaining vigilance to avoid falling into the expectation bias trap. This can happen at a personal level or at a crew level.
- Ensure crew briefings are threat- and error-based and discuss possibilities for events not going as planned. Include expectation bias as a threat.
- Discover technological solutions: For example, marking of route on EFB/AMM.
- Encourage crews to look out for change: Both pilots (but emphasise in PM role) should look for cues which indicate changes to plan. Ensure critical thinking: "What is different?" Crewmembers should verbalise all contrary cues. Ensure procedures require crews to check for ATIS updates regularly.

- Collaborate with ANSPs, through LRST or otherwise, to ensure cross-role understanding. Urge ATCOs to emphasise any change from the routine. Help controllers understand pilot expectations.
- Always ensure effective monitoring of the taxi route by PM.

Figure 37. **Safe taxi procedure (Aer Lingus)**

Safe Taxi Procedure:

The safe processing and implementing of taxi clearances should be given priority over all other tasks. Checklists and task flows should be delayed or positively held until the taxi clearance has been received, recorded, understood, and agreed. All taxi clearances (initial, changes, or onward clearances) require the same level of caution and attention from crew members.

Any ambiguity or uncertainty by a crew member regarding the aircraft current position, cleared taxi route or clearance limit must be resolved immediately. If necessary, the aircraft should be stopped at soonest, safe opportunity and clear of runways. Ensure clearance limit is clearly defined by crew and ATC.

Task sharing:

PF	PM
Listen out	Receives and records ATC taxi instruction. *- Clearance to be written on Operational Flight Plan, include routing and clearance limit.*
Understands and agrees taxi route and limit.	Confirm and verbalise taxi route and limit using AMM (AGC if AMM not available). *- Particular attention should be given to crossing runways* *- Be alert to taxi-as-expected bias.* *- Share/mirror taxi chart with PF as required.*
Manoeuvres aircraft. Calls for any switching and taxi guidance, including display of charts, when aircraft moving.	Continually monitor the progress of the taxi *- Taxi threats, eg Runway Crossing, should be clearly identified and mitigated* *- Where necessary, provide the PF with information on the next turn*

Management of distraction during taxi phase is critical:
- Minimise non-operational conversation.
- Strictly no personal use of mobile phones. If mobile phone is required for operational reasons, it should be used with aircraft stopped and parking brake set.
- Minimise heads down; at all times, primary task for PM is monitoring aircraft path.
- Minimise pilot off-air; any ATC clearances should be re-confirmed and recorded by the PM.

2.5 Monitoring (AO14, AO15, AO16)

Recommendation AO14: Aircraft operators should publish SOPs and guidance and provide training highlighting the importance of active monitoring and effective intervention by the pilot monitoring (PM) during taxi-in and taxi-out, especially when another runway is crossed.

Recommendation AO15: Aircraft operators' procedures should include policy and procedures to minimise "heads-down" activities and enable effective monitoring of the movement area whilst taxiing. For multi-pilot flight decks, "heads-down" activities for more than one pilot should be restricted to times when the aircraft is stationary with the parking brake set.

Why should aircraft operators follow these recommendations?

The commercial aviation industry worldwide has identified a need for improved pilot monitoring and awareness. More specifically, aviation safety data indicate that failures in pilots' flight path management (FPM) monitoring and awareness have contributed to a range of undesired outcomes: accidents, major upsets, and non-compliance with ATC guidance. The FAA has further stated that these types of FPM failures are likely to worsen with the increasingly complex air traffic control systems and FPM concepts proposed for NextGen operations. Adding to this complexity is the introduction of increasingly automated aircraft systems that can increase monitoring burdens. One potential mitigation for this situation is to enhance pilot training for effective monitoring (NASA, 2020).

Active monitoring and advocacy not only mitigates airborne KORA exposure but also RI and other surface manoeuvring related incidents and accidents. Active monitoring and advocacy by all flight deck occupants during taxi and approach phases of flight is essential to mitigating RI. Operators should ensure that their policy and training of pilots in effective PM roles includes ground phases.

Operators should also ensure in their taxi incident investigation and analysis that the effectiveness of the PM role is evaluated. It is often obvious that the pilot at the controls took a wrong turn, but that raises the question of what the PM was doing at the time and why the necessary monitoring was not effective. The investigator should establish whether there was a shared mental plan of the taxi routing by all crewmembers. Monitoring of PF actions is only possible if the PM has the same expectation of those actions.

A robust operator monitoring policy should include procedures and guidance on intervention steps for the PM. This might extend from verbal nudging towards physically taking away control or braking by the PM, irrespective of rank or experience. Especially regarding RI-prevention, there might be situations when a forced stop may become necessary (e.g., to prevent unauthorized runway entry). Those scenarios need to be trained to ensure proper application of technical and non-technical pilot skills.

What can aircraft operators do to implement these recommendations?

During ground operations there is more potential for a cockpit split where the PF taxis the aircraft while the PM carries out other tasks (e.g. programming FMS, off-air, etc). There is often also a mindset that ground operations can be less critical than flight phases. Operators should ensure by policy and procedure that the monitoring duties of the PM are always prioritised above other tasks.

Operators should:

- Ensure active monitoring of taxi clearances and routing by all flight deck occupants, including guidance on the sequential identification and verbalisation of routing, signage/markings, and manoeuvres required to comply with ATC clearances and mitigate RI risks.
- Implement CRM policy and guidance emphasising advocacy and active monitoring during taxi operations. Active monitoring means catching the wrong turn before it happens!
- Consider policy on crew lookout, for example:
  - Always one pilot looking out;
  - Two pilots should be looking out at junctions;
  - Two pilots always looking out when approaching a runway;
  - Guidance is required on roles for supernumerary and augmented crewmembers.
- Consider a policy that, if the monitoring capability of the crew is reduced or workload becomes too high, the crew must coordinate with ATC and bring the aircraft to a stop.
- Revisit operational guidance, policies, and procedures following RI-related event SMS processes.
- Review reference websites to ensure best practices.

Aircraft operators should implement standardised intervention methods to be used by the flight crew both for mutual intervention within the cockpit team and towards ATC. These methods should be incorporated as SOPs in the aircraft operators' operations manuals and should clearly describe when and how the PM should intervene, depending on the situation. This should include taking away control from the PF, and the permitted reactions by the PF. On one hand, this will help to reduce barriers preventing the PM from using interventions appropriately without fear of jeopardising the cockpit work atmosphere ('nit-picking' or status considerations). It will also ensure timely intervention, which otherwise could be inhibited by the PM worrying about intervening too early (e.g., if the PM wants to give the PF time to correct, which may be inadequate in some situations. On the other hand, this will ensure that the reactions by the PF are appropriate. (GAPPRE, 2021)

An example of intervention cascades on top of the usual deviation callouts are the use of 'CUS' wordings by the PM like 'I'm concerned', 'I'm uncomfortable', 'This is a safety issue' or 'Stop theOther wordings might be useful, depending on the culture and maturity of the pilot workforce.

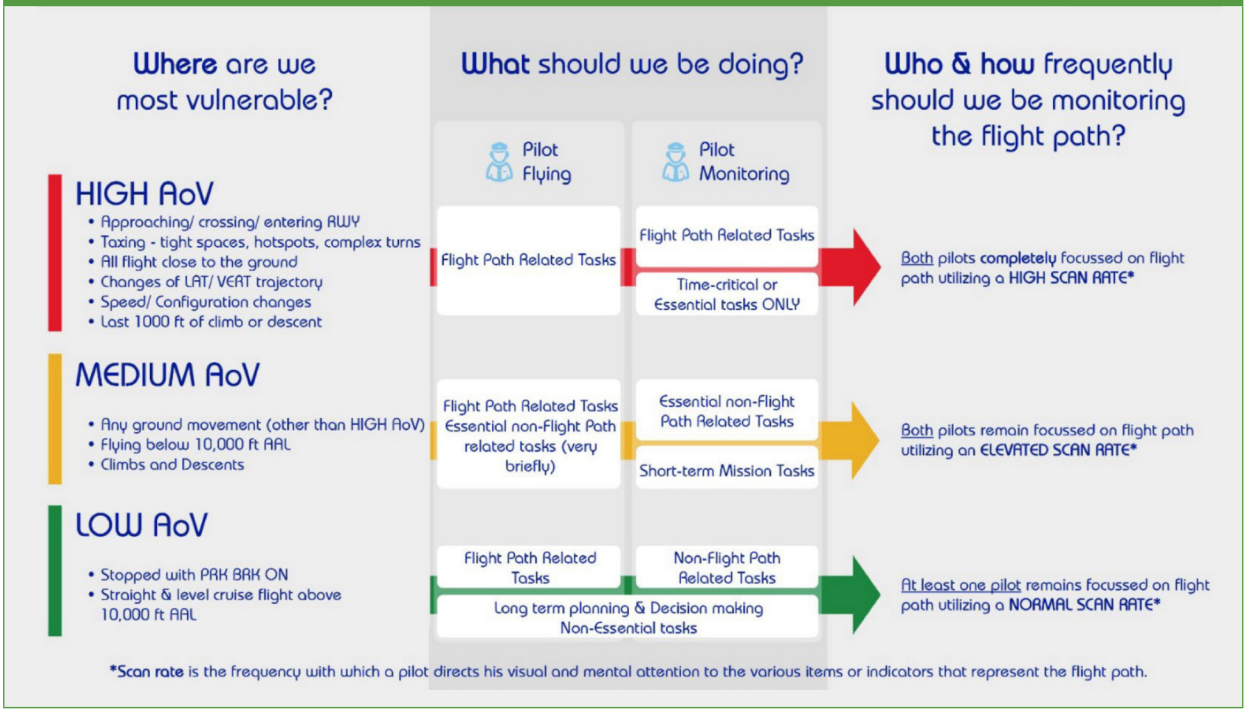
The role description in the operations manual for the second-in-command (SIC) and PM should include the authority for effective intervention irrespective of rank and experience. Any intervention policy should incorporate additional crewmembers on the flight deck such as qualified supernumerary, enlarged crew, or training staff. The scope of intervention towards ATC should include the wording "unable" as promoted by CANSO, the International Federation of Air Traffic Controllers' Associations (IFATCA), and the International Federation of Air Line Pilots' Associations (IFALPA).

Active Flight Path Monitoring and Areas of Vulnerability

In 2014, Flight Safety Foundation and the Active Pilot Monitoring Working Group published "*A Practical Guide for Improving Flight Path Monitoring*". The group was tasked with studying ineffective monitoring as a factor in aviation occurrences and creating practical guidelines intended for use by aviation managers to improve the effectiveness of monitoring. The output was 20 Recommendations for Aircraft Operators for all phases of flight. Recommendation No. 3 in that paper introduces the concept of areas of vulnerability (AOV):

> *"If pilots could recognize the flight phases when they are most vulnerable to flight path deviations or little time exists to correct deviations, they could strategically plan workload and manage distractions to maximize monitoring during those areas of vulnerability (AOV). Similarly, if pilots could recognize the flight phases when they are least vulnerable to flight path deviations or have sufficient time to recover from deviations, they could relax monitoring to some degree and complete tasks that are not flight path related. This suggests something new: Monitoring requirements vary depending on phase-of-flight circumstances (activity, period and/or area)."*

Figure 38. **Flight Path Monitoring Model (IndiGo Airlines)**



Aircraft operators should review this publication to ensure best practice is applied in their flight crew monitoring policy and procedures. Figure 38 is an example of the application of this concept by one operator, IndiGo Airlines.

Reference Documents:

FAA Advisory Circular 120-71B Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck

NASA Analysis of Pilot Monitoring Skills and a Review of Training Effectiveness 2020

Monitoring Skills| SKYbrary Aviation Safety

Flight Path Monitoring | SKYbrary Aviation Safety

Crew Resource Management (CRM) | SKYbrary Aviation Safety

Flight Safety Foundation. 2014. *A Practical Guide for Improving Flight Path Monitoring.*

UK CAA Monitoring Matters – Guidance on the Development of Pilot Monitoring Skills, CAA Paper 2013/02

Global Action Plan for the Prevention of Runway Excursions (GAPPRE).

CUS – method based on the approach of "Team STEPPS" (Team Strategies and Tools to Enhance Performance and Patient Safety), a healthcare solution for improving patient safety.

Recommendation AO16: Aircraft operators should train and allow both pilots to be the pilot flying (PF) on the ground, commensurate with aircraft configuration and systems. Where not feasible, the right-seat pilot should be trained in intervention strategies and handover procedures which effectively mitigate runway incursion risks.

Why should aircraft operators follow this recommendation?

The prevention of runway incursions is primarily a matter of the flight crews' situational awareness. Manoeuvring on unfamiliar airports requires extra care, but even on familiar airports, dynamic situations during taxi may arise which increase complexity on the flight deck and impairing the situational awareness of crews. A control change after landing, or the combination of ATC communication and after-landing procedures for the PM, serve as examples of such complex situations. In such demanding cases and during non-normal operation, some studies recommend that the PIC delegate the PF role to the SIC to facilitate keeping the "big picture" and making safe decisions (Sexton et al, 2004, Becker & Ayton, 2024).

While this is achievable in flight, it is not always possible on the ground either because no steering device (tiller) is available for the right-seat pilot, or because airline

policies do not allow the SIC to taxi the aircraft. Where possible, operators should consider changing this paradigm. The SIC is a competent pilot and can be trained in taxiing without restrictions. This is already done by some airlines and manufacturers.

There are several safety advantages in letting the SIC taxi the aircraft:

- First, during taxi-out, the PIC can better see the big picture and thus better monitor and intervene, if necessary.
- Second, the "production effect," meaning the dual action of speaking and hearing oneself (which is what the PM usually does when reading back a taxi clearance) has a beneficial impact on memory (Forrin & MacLeod, 2018). This helps the crewmember better understand and translate taxi instructions. Thus, having the PIC act as PM on the ground may help prevent runway incursions.
- Third, having the PIC not at the controls on the ground may help the flight crew more safely deal with operational pressures such as schedule, night curfew, or other issues. Reports frequently reveal that due to the status hierarchy on the flight deck, psychological barriers can make it hard for the SIC to raise concerns or intervene. It is much easier for the PIC to actively intervene or set the pace of operations. Therefore, having the SIC at the controls on the ground makes it easier for him or her to set the pace without challenging the authority of the PIC.

In addition, eliminating a control change after landing allows both the PM and the PF to concentrate on the taxi instructions instead of getting distracted by the control change, ATC communication, or the after-landing procedures.

What can aircraft operators do to implement the recommendation?

Operators should review their policy with respect to PF/PM roles during ground operations in context of the above quoted research. Policies such as those that say the PIC always handles the aircraft should be reconsidered, especially for cases of high workload and/or abnormal scenarios. Airlines which currently do not allow the SIC to taxi should consult with other airlines allowing the SIC to taxi (for example, via the manufacturers) to get information about current and past experiences with this task-sharing model.

In airlines which already allow the SIC to taxi the aircraft it might be sufficient to review monitoring and intervention training to ensure there are no barriers for the PM to actively intervene. Furthermore, the review could examine whether current SOPs lead to task overload of the PM in combination with ATC communication.

In general, the "production effect" should be incorporated into initial and recurrent pilot trainings as a training topic and be known to policy makers and those who develop pilots' SOPs.

For airlines that operate aircraft not fitted with a steering device/tiller for the right-seat pilot, the best option is to retrofit. If this is not feasible, it will help to provide monitoring and intervention policies and training for line pilots to enable effective intervention and optimum task sharing. Approach briefings should include a discussion of conditions that could make a control change riskier. Such conditions might include land and hold short operations (LAHSO), complex runway exits, and short distances between runways. Furthermore, safety surveys, LOSA, learning reviews, or other methods can be used to assess current SOPs for taxi operations. The goal should ensure undisturbed ATC communication and avoid task-saturation and mental overload for the PF and PM.

Reference Documents:

J. Bryan Sexton. 2004. *The Better the Team, the Safer the World: Golden Rules of Group Interaction in High Risk Environments ; Evidence Based Suggestions for Improving Performance.* Gottlieb Daimler and Karl Benz Foundation.

Becker, T., & Ayton, P. (2024). *Effects of flight crew role assignment on aviation accidents and incidents: Evidence of a systemic safety issue.* Safety Science, 170, 106352.

Forrin ND, MacLeod CM. *This time it's personal: the memory benefit of hearing oneself.* Memory. 2018

2.6 Workload Management (AO17, AO18)

Recommendation AO17: Aircraft operators should implement policy and procedures which encourage pilots of departing aircraft to manage workload so that the aircraft arrives at runway holding points with all crewmembers maintaining good lookout/listen-out and having strong situational awareness regarding current aircraft position, runway clearance status and other traffic (on same, parallel and intersecting runways).

Recommendation AO18: Aircraft operators should implement policy and procedures which address and manage the runway incursion risks of engine-out-taxi (EOT). Policy should address risks such as "heads-down" activities, distraction and exposure to surface movement errors.

Why should aircraft operators follow these recommendations?

One of the high-level findings of the GAPPRI data analysis was that runway incursions predominantly arise from scenarios involving human performance. Individuals at the forefront of the aviation system, including pilots, air traffic controllers, and vehicle drivers on aerodrome manoeuvring areas, consistently adapt to varying pressures and workloads, balancing multiple goals within an increasingly complex operational environment. While this adaptability contributes to the safe functioning of the system, it can sometimes interact unfavourably with operational conditions, leading to issues such as distraction, miscommunication, misidentification, or misapplication of operational processes, which have resulted in serious incidents.

An analysis of 68 RI accidents and serious incidents in the six-year period 2016–2021 worldwide that involved at least one multiengine CAT aircraft showed several events in which departing aircraft crossed runway holding points without clearance. These errors happened while flight crews were dealing with high workloads or distractions (GAPPRI Data Finding).

The workload demands on crews of departing aircraft can vary considerably, affected by factors such as airport layout, adverse weather, crew familiarity, technical issues, etc. No matter the workload, crews should always feel supported to take the necessary time to complete these tasks in a safe and unhurried fashion. To achieve this, operators should ensure policy always puts runway safety ahead of any commercial or punctuality pressures.

By supporting crews to take a structured and unhurried approach to predeparture task completion, the crews will maintain good awareness with respect to geographic position and traffic, will have time for more effective communications and most importantly be less likely to make errors.

With this support, flight crews should be enabled to manage workload on every taxi out so that they arrive at runway holding points with all tasks complete (operationally ready for departure) and with the cognitive capacity to mentally prepare for entering the runway and/or take-off (mentally ready for departure).

Increased situational awareness is a key element to building resilience against serious RI incidents. As aircraft approach runways, crews will have the capacity to look out and listen out before entering or accepting clearance to enter the runway. Any errors by other could potentially, and have been, trapped in this manner.

All airlines are increasing their focus on fuel-saving methods such as EOT. However, as such procedures are introduced, operators should recognise the increased workload and potential for distraction and time pressure that can transfer to the flight crews. Operators should ensure that safety is still the priority. For that reason, operators should ensure that EOT not be an individual performance measure to prevent subtle operational pressures on flight crews.

Sustainability related aviation safety pressures were discussed at the 2022 Annual Safety Forum. The event was focused on "Safe Sustainability" and the Safety Forum Report deals with such pressures, including EOT, along with resilience capabilities to counterbalance those pressures.

What can aircraft operators do to implement these recommendations?

Operators should have clear policy that crews take time necessary to complete all pre-departure tasks and checks in a safe, methodical and unhurried way. Policy should put safety before all commercial and time pressures.

Operators should review normal pre-departure SOPs and tasks and assess what work could be completed before pushback. Examples include weight-and-balance tasks, items from Taxi and Before Take-off Checklists, announcements to passengers, etc. In addition, if any changes to ground phase procedures are to be introduced, consideration should be given to the impact on workload management and monitoring capability of flight crews.

Operators should collaborate with Internal and LRST groups to reduce or eliminate any local procedures which require crews to monitor or call on other frequencies, e.g. ramp control, and so avoid pilot out of the loop with associated reduction in monitoring.

Operators should provide training for recognising scenarios where workload is too high, cognitive capacity is limited, and effective monitoring of the flight path is reduced. Training should include tools to help recognise the overload and formulate possible solutions.

Workload management techniques for crews:

- Slow down or stop taxi.
- Clear assignment of duties, with one pilot always in control and looking out.
- PM's primary task is to monitor, other tasks are secondary.
- Anticipate workload peaks and get ahead with tasks, if possible.
- Anticipate possible changes through thorough TEM briefing.

Flight crews that rush through tasks, regardless of their ability to prioritise, delegate or otherwise manage their time, are more likely to make errors and have lower situational awareness. As airports worldwide struggle to cope with increasing demand, runway utilisation has become a focal point. ATC tries to achieve maximum runway usage, normally measured in numbers of departures/arrivals per hour. For this reason, ATC controllers can, either consciously or subconsciously, create a sense of urgency in the minds of flight crew. (Emirates Airlines, 2024)

Operators should provide training and guidance to crews to be assertive with ATC if feeling rushed. Crews should be encouraged to communicate any additional time requirements to ATC as early as possible so that traffic capacity can be managed effectively. This will also increase awareness and acceptance of local ATCOs when pilots require more time than anticipated.

Engine-Out Taxi operations:

- Aircraft operators should perform risk assessment for EOT and the impact on runway incursion risks. Operators can refer to 2022 Safety Forum Report for sustainability pressures and resilience capabilities.
- Guidance should be provided on conducting EOT when runways are to be crossed.
- EOT should be performed only when a proper briefing is conducted, and the flight crew must be aware of local regulations and all relevant factors such as weather, taxiway slope, and ATC requirements. Crews should manage time and workload to avoid rushing and heads-down time.
- Flight crew briefings should include where the engine start procedure can be safely carried out so that crews arrive at the runway operationally and mentally ready.
- Guidance should also be provided to crews for the case of receiving take-off clearance earlier than expected while conducting EOT, for example slot time change..

Reference:

Emirates Group Safety. 2024. RUNWAY/TAXIWAY INCURSIONS 2024. INFORMATION PAPER FOR PILOTS.

Flight Safety Foundation, Eurocontrol, and European Regions Airline Association. *2022 Safety Forum "Safe Sustainability".*

SKYbrary Workload Briefing Note.

2.7 Runway Operations- Traffic Awareness (AO19, AO20, AO21)

Recommendation AO19: Aircraft operators should discover and consider implementation of technology which increases pilot awareness of airborne traffic when approaching the runway holding positions and supports crew decision-making regarding safe runway entry, e.g., airborne traffic situation awareness (ATSAW). New runway incursion technology developments, which provide real time on-board conflict detection and collision prevention on the runway, should also be considered for implementation by operators.

Why should aircraft operators follow this recommendation?

The ultimate runway incursion hazard is the potential for collision between an aircraft and another aircraft or vehicle. Sometimes the last line of defence is a visual scan. Pilots are taught in basic training to look both ways and maintain a vigilant lookout when entering or landing on a runway. This visual search can be limited due to several factors such as visibility, slope, time of day, etc. This limitation can be overcome with the use of technology to display relevant traffic to the flight crew. Such systems are now being further developed to provide alerting and warning when conflict exists.

Situational awareness is a broad concept for pilots, but in terms of aerodrome manoeuvring it can be broken into 3 component parts:

- Awareness of own position;
- Awareness of taxi route; and,
- Awareness of other traffic.

The awareness of other traffic is a key element, and ultimately it may prevent a conflict. But it also allows flight crews to build a mental model of their place in the ATC system and to plan their workload accordingly. The crew can also assess if traffic spacing is appropriate and, if not, advise ATC.

Further, traffic awareness provides essential resilience in that pilots can verify if clearances (or perceived clearances) make sense in the context of other traffic. For example, pilots will question a lineup clearance if they see another aircraft on the approach or runway.

The traffic-alert and collision avoidance system/airborne collision avoidance system (TCAS/ACAS) is the most widely used traffic awareness tool and is well established in the industry. Its use on the ground is constrained by system limitations, but pilots should use it tactically, within given SOPs, prior to lineup or during taxi to gain the required awareness. TCAS/ACAS is continuing to develop and allow for new technologies such as automatic dependent surveillance–Broadcast (ADS-B) and remotely piloted aircraft systems (RPAS). (Further details available on SKYbrary *ACAS X* page.) Operators should ensure their technical departments discover and consider adoption of new technology, especially to counteract new threats such as RPAS.

The proliferation of ADS-B technology is also continuing and can be a valuable source of traffic information. ATSAW is one solution which uses ADS-B technology and can provide crews with information on other ADS-B equipped aircraft or ground vehicles.

What can aircraft operators do to implement the recommendation?

Operators should:

- Ensure TCAS is switched on and checked prior to lineup.
- Provide guidance to flight crews on the optimal use of TCAS to increase traffic awareness during ground operations, especially when crossing and entering runways. This prevents TCAS overload while providing a good picture of the traffic situation.
- Operator policy and procedure should support pilots in making a critical assessment and questioning clearance if they see insufficient traffic spacing for crossing, lineup, or takeoff.
- Understand the complexity of operations in order to design good procedures and integrate the expertise of well-trained pilots as interactions of technology, human and airports environment.
- Consider benefits of ATSAW and ADS-B–based traffic display for flight crews.
- Discover new and emerging on-board traffic awareness and alerting technologies. For example; Airbus *SURF-A,* Jeppesen *FDPro*, Honeywell *Runway Awareness and Advisory System* (RAAS), Collins Aerospace *Surface Management System*, and Garmin *SurfaceWatch*.
- Consider development and implementation of tailored in-house traffic display solutions which increase flight crew

traffic awareness. (For example, the Lufthansa system that uses A-SMGCS traffic information and ADS-B traffic information displayed on aircraft AMM.)

Further information on available technologies is available on the FAA website, *Runway Safety Technologies and Progressions Runway Safety | Federal Aviation Administration (faa.gov)*

ADS-B Based traffic information is readily available through online air traffic following websites, for example Flightradar24.

References:

Airbus Safety Innovation 13 Avoiding Ground Collisions

SKYbrary Automatic Dependent Surveillance- Broadcast

SKYbrary ACAS-X

Recommendation AO20: Aircraft operators should implement policy and procedures that mitigate the runway incursion risks associated with using rapid exit taxiways or angled taxiways for line-up or crossing; these taxiways can limit the ability of the flight crew to see the runway threshold or the final approach area.

Why should aircraft operators follow this recommendation?

Numerous studies have concluded that problematic taxiway/runway geometry was a contributing factor in many runway incursions. Right-angled intersections are the standard design for all taxiway/runway entrance intersections. Right-angled intersections provide the best visual perspective to a pilot of the entire runway (left and right) when approaching the intersection. If a taxiway intersects a runway at any angle other than a right angle, the chance of a landing/departing aircraft colliding with an errant taxiing aircraft increases. Preliminary analysis shows the most frequently occurring problematic geometries were (1) short taxiway distance from ramp/apron area to a runway, (2) direct taxi access to runways from ramp areas, and (3) taxiways intersecting a runway at other than a right angle. (FAA, 2018) From the same study, another airport design linked to increased runway incursion risks was a wide expanse of pavement entering a runway.

At every runway lineup, the view out of the cockpit window is the last line of defense to avoid a runway incursion with a possible collision. If the view from the flight deck of the runway or the approach sector is limited, this last line of defense erodes. As an example, the lack of visibility due to an alignment of a runway by a rapid exit taxiway (RET) was a contributory factor in a runway incursion which led to a collision in *May 2000 at Paris Charles de Gaulle Airport.*

As a result, modern airport design methods restrict the use of angled taxiways to aircraft vacating runways, and use right-angled taxiways for aircraft crossing and lineup. However, this best practice is not achievable in many older airports due to space and cost limitations.

It is also recommended as best practice for ANSPs to avoid using angled taxiways for runway crossing or lineup for the same reasons. However, very often due to capacity pressures, angled taxiways are still used for lineup and crossing.

As long as these angled taxiways continue to be used, operators should ensure flight crews know the associated risks and have policy and procedures to mitigate those risks.

Though not exclusive to angled taxiways, another airport geometry risk is "unexpected location of a holding position marking on a parallel/entrance taxiway". This was found in the 2018 FAA study as the factor most prone to runway incursions with, on average, four runway incursions occurring at locations where this type of geometry exists. With the increasing standardisation of airport layouts and markings, flight crews expect holding points will be located close to the runway and usually on the intersection taxiway. Where this is not the case, the risk of flight crews not observing the holding point increases, which raises the risk of runway incursion.

What can aircraft operators do to implement the recommendation?

Aircraft operators should:

- Ensure crews always keep a good lookout; scan the entire runway and approach in both directions before entering a runway. If in doubt, seek clarification.
- Avoid accepting RETs or angled taxiways for a lineup that limit the ability of the flight crew to see the runway threshold or the final approach area.
- Where use of angled taxiways is unavoidable, operators should manage the risk by including it as briefing item. Crews should also scan on TCAS and listen closely on the ATC frequency.

- Use ATSAW and traffic display on EFBs as an additional source, which could help identify traffic on the runway or approaching the runway. Remember that some aircraft are not transmitting ADS-B and may not appear on such displays.
- Provide guidance for crews to be alert for non-standard placement of runway holding points. Crews should manage the associated risks through threat and error–based briefings, active PM alertness, and robust taxi procedures.
- Provide guidance for crews to be alert for increased RI risks with certain airport geometries such as short taxi routes, runway close to apron, and runway holding points with wide expanse of pavement. The latter case can be particularly challenging for crews due to distant and non-standard signage and lighting, combined with potential for left/right direction confusion in ATC instructions.

References:

ICAO 2020. Aerodrome Design Manual – Runways (Doc 9157 Part 1). 4th Edition.

U.S. Department of Transportation Federal Aviation Administration (FAA). 2018. Problematic Taxiway Geometry Study Overview. DOT/FAA/TC-18/2.

Recommendation AO21: Aircraft operators should implement policies for flight crews in relation to extended time on the active runway before take-off and the associated runway incursion risks. The policy should include guidance on, but not limited to, entering a runway when not ready for departure, engine run-ups, departure path assessment and back-tracks.

Why should aircraft operators follow this recommendation?

The focus of Recommendation AO17 is that operator policy and procedures should ensure departing aircraft arrive at the runway holding point with all predeparture tasks complete. This helps flight crew members keep a high level of situational awareness and stay prepared (mentally and operationally) for departure. Nonetheless, sometimes crews need extra time on the runway between lineup and takeoff.

Current ICAO provisions establish a separation minimum of 5.0 nm between departing and arriving aircraft on the same, crossing, or dependent parallel runways. This value may be decreased to 3.0 nm or even 2.5 nm under certain conditions. Foremost, these requirements incorporate wake turbulence considerations but do not account for human factors and operational requirements on aircraft flight decks. Current minimum runway occupancy time (MROT) requirements do not incorporate these factors, and on most high-density-traffic airports, it is assumed that pilots are ready for an immediate departure if they do not state otherwise. This paradigm significantly increases RI risks, especially if ATCOs apply the separation values as targets instead of hard limits. This applies to all airport layouts, but airports with a single runway or with crossing or dependent parallel runways with high traffic density are especially prone to this risk.

Reasons for delay can be technical (engine run-up, application of MEL items, etc.) or environmental (ice shedding, departure path weather scanning). Even in the normal task sequence, calculating wind components and crew coordination take time to complete after the takeoff clearance is given. It is important that when crews anticipate increased time on the runway, they tell ATC as early as possible so controllers can ensure adequate spacing and increase awareness of other aircraft and vehicles. Prolonged presence of vehicles or aircraft on runways increases the risk of RIs or collisions, and human error may lead to forgetting traffic on runways.

Backtracking

Backtracking on runways is used widely in certain airfields. Studies have shown that backtracking, when combined with a short taxi distance from apron to runway, can present an increased risk of RI. There are two factors to be considered:

- Workload and task sequence — The normal predeparture task flow is based on aircraft taxiing from the apron, along the taxiway system, then arriving at the runway holding point. When the routing requires the aircraft to enter the runway for backtrack, the time available for tasks is shorter. The sequence of tasks may need to be altered, with lineup actions happening before or during the taxi tasks. The cabin may not be secure, and other usual pre-takeoff checks may not be complete before entering the runway. This out-of-sequence task completion can lead to errors and omissionss well as reducing crew capacity for situational awareness.
- Increased time on runway. It is logical that more time on the runway increases exposure to traffic conflict. Visual scan for flight crew is critical but the aircraft is now further from the approach end of runway. Requirement for backtrack also makes the ATC traffic planning and sequencing more difficult, and there is potential for time pressure on the departing aircraft to prevent arriving aircraft having to go-around.

What can aircraft operators do to implement the recommendation?

Operators have several options to reduce the RI risk associated with extended time on the runway:

- Operators should provide policy that prioritises safety above efficiency, and crews should take the time to complete all pre-departure tasks without undue commercial or time pressure.
- Guidance should include that ATC´s expectation is that the aircraft will be ready to line up when it reaches the holding point and once lined up, the aircraft will be ready for takeoff without undue delay.
- Flight crew should not enter a runway for departure if not ready to take off (unless for backtrack). Flight crew must advise ATC on first contact if additional time on the runway is required. Pilots know best how much time they need on a runway and should coordinate with ATC with as much advance notice as possible. This allows ATC to plan their sequence and maintain operational efficiency while avoiding the scenario where pilots may feel rushed.
- Operators should provide pilots with policies and SOPs ensuring that pilots feel psychologically safe to refuse difficult ATC clearances. Crews should use the word "unable" (CANSO), if they anticipate that the spacing will be too tight.
- Operators should use LRST meetings to ensure mutual understanding with ANSPs and airport operators on solutions allowing pilots to perform a safe line-up and take-off roll and to effectively reduce the runway incursion risks.
- Operators should provide training and guidance on the concept of "Ready," differentiating between operational and mental readiness (see GAPPRE 2021).
- Operators should provide policy that crews should ask about any unexplained delay on the runway more than 90 seconds in case the delay results from a possible loss of communication or ATC omission error (Recommendation ANSP21).

Where relevant to their operation, operators should include policy and procedures for flight crews to deal with short taxi and/or long backtracks (e.g. half the runway or more) including guidance on:

- Workload/task management during taxi and back-track.
- Before entering the runway for a backtrack, ensure pilots complete all relevant tasks related to a runway entry and lineup. Include guidance on cabin secure procedures.
- Ensure crews build a high level of situational awareness with respect to traffic before entering the runway and while on the runway.
- Ensure the preflight briefing includes the workload and task management aspects of the taxi and backtrack phase, as well as the potential for disorientation and wrong-runway departure associated with backtracks.

Reference Documents:

Eurocontrol. 2017. *European Action Plan for the Prevention of Runway Incursions (EAPPRI)*

Global Action Plan for the Prevention of Runway Excursions (GAPPRE).

CANSO, IFATCA, IFALPA paper. *Avoiding Unstable Approaches.*

2.8 Runway Operations- Safety Barriers (AO22, AO23)

Recommendation AO22: Aircraft operators should have a strict policy that pilots shall not cross illuminated red stop bars. Policy and procedures should mandate that crews do not cross stop bars when lining up or crossing a runway (or taxiway), even with an ATC clearance but instead must challenge the clearance.

Operator and aerodrome procedures should include contingency procedures to cover cases where the stop bars or controls are unserviceable.

Why should aircraft operators follow this recommendation?

The most common cause of runway incursions is pilot deviation from their ATC clearance (GAPPRI Data Finding). In a sample of serious (severity A or B) runway incursion incidents, 23 percent of incidents could have been prevented by available and correctly used stop bars. There is a need for a functional barrier (for example, stop bars) to protect the runway against unauthorised entry. (GAPPRI Data Finding).

A stop-bar consists of a single row of flush or semi-flush inset lights installed laterally across a taxiway, showing red towards the intended direction of approach. The root causes behind pilot deviations are numerous, but regardless of the cause, stop bars can provide an unambiguous visual backup to reinforce a verbal ATC clearance.

There are several possible explanations for aircraft improperly crossing stop bars. However, inconsistency of stop bar operation policies at different airports has been cited as a contributory factor in runway incursions (SKYbrary). Therefore, at present, stop bar lighting is not achieving its full potential to address the most common cause of runway incursions.

Pilots should be aware that even where stop bars are installed and serviceable they may not always be used outside low visibility operations (LVOs). A common reason for this is controller workload. While the most modern systems are capable of automated control of stop bars, other installations need a level of manual control that may be difficult to achieve during busy periods. Further, some airport operators may use stop bars for active runways but not for other runways.

Contingencies

There are two principal stop bar failure modes that should be considered by operators:

1. Stop bar cannot be extinguished ('Stuck on')

There may be circumstances when pilots have no alternative but to cross a "stuck on" stop bar to reach the departure runway or the parking gate. Without adequate contingency procedures, these circumstances could lead to weakening of the "Red means Stop" principle. While air navigation service providers (ANSPs) have been encouraged to develop procedures that do not undermine that principle (see for example GM1 SERA.3210 (d) (3) Right-of-way), this does not relieve operators of the responsibility to prescribe appropriate crew procedures.

2. Stop bar cannot be illuminated ('Stuck off')

As pilots become accustomed to increased use of stop bars, including outside LVOs, there is a risk that removal of this visual cue could make errors more likely. It may be difficult for air navigation service providers (ANSPs) to design contingency procedures that would provide an equivalent level of safety to a serviceable stop bar. The absence of a stop bar (either due to unserviceability or outside hours of operation) could contribute to an erroneous belief that the aircraft may continue beyond that point. Several runway incursion incidents have been associated with an extinguished stop bar being misinterpreted as a clearance to proceed (SKYbrary). Therefore, it is essential that operators ensure robust operating procedures on the flight deck.

What can aircraft operators do to implement the recommendation?

- Operators should provide robust policies and procedures for flight crews operation where stop bars are used.
- Operators should provide guidance to their crews that: Red Means Stop. Even with ATC clearance, flight crews should NOT cross the stop bar. This simple policy is applicable both to stop bars and runway status lights (AO23).
- Pilots should be aware that there may be circumstances (e.g. snow cover) in which serviceable stop bars may not be visible.
- Where possible the aircraft should be stopped sufficiently far back from the holding point that the stop bar can be seen. This allows for confirmation that the stop bar has

been extinguished before the aircraft is moved beyond that point.

- An extinguished stop bar does not on its own constitute clearance to proceed. Crews should have no doubt that an explicit ATC clearance is always required to cross a runway holding point. (ICAO Doc 9870)
- Data from some airports where stop bars are used only during LVOs shows a heightened risk when LVOs are in effect due to low ceiling rather than reduced visibility. This has been associated with more instances of inadvertently crossing the stop bar marking at a Cat II/III holding point (GAPPRI Data Finding).
- Operators should ensure that NOTAMs are available to crew in a manner that facilitates easy identification of safety-critical information regarding stop bar operation or serviceability. This should take account of the limited time often available for flight preparation.
- Operators should encourage flight crews to report all cases of stop bar unserviceability, compile data on these events, and collaborate with airport operators to minimize the occurrence rate. This is critical to building pilot confidence in the system and reducing use of contingency procedures.

Contingencies:

Procedures should require pilots to consider during their departure briefing how to manage the threat of an unserviceable stop bar. For example, pilots may consider a reduced taxi speed, or re-organizing the task flow so that cockpit checks are not done when the aircraft is moving and approaching a runway. Electronic charting may allow the position of the defective stop bar to be marked on the airfield chart to enhance crew awareness. This is particularly effective when a moving map display is available.

In some cases, national aviation authorities (NAAs) or ANSPs publish contingency procedures to deal with unserviceable stop bars. These may be contained in an Aeronautical Information Publication, Air Traffic Control manual, or similar document not normally available to pilots in the cockpit (for example, AIP Australia ENR 1.1 Para 2.4.3; UK CAP 493 Section 2: Chapter 1 11A.7). Operators should ensure that pilots have access to such procedures.

1. Stop Bar cannot be extinguished

Operators should develop their own procedures to complement those published by NAAs or ANSPs and to provide a framework for pilots where no other published procedures exist.

Procedures should be sufficiently different from normal operations to make it obvious that they reflect exceptional circumstances. This mirrors the guidance in GM1 SERA.3210 (d) (3) Right-of-Way that "air traffic service provider[s] should take into account that such contingency arrangements should significantly differ from normal operations and should not undermine the principle that a lit stop bar must not be crossed."

Possible contingency procedures could include a requirement to:

- Request an alternative route if possible.
- Request a follow-me escort to cross an illuminated stop bar.
- Obtain confirmation from a second source (e.g. ATIS, NOTAM, separate ATC communication) that the stop bar is stuck on.
- Avoid a continuous taxi "through" an illuminated stop bar but instead bring the aircraft to a complete stop at the stop bar and then obtain a specific clearance to cross.
- Re-emphasise the importance of good lookout and traffic awareness.

2. Stop Bar cannot be illuminated

Where this is known before flight, pilots should consider appropriate mitigation measures during their departure briefing, bearing in mind that most runway incursions occur during the taxi out/departure phase (EAPRI v.3 Appendix D).

Emphasis should be placed on reviewing applicable NOTAMs for runways and taxiways to be used or crossed. Stop bar information is sometimes included with other inoperative lighting for a taxiway or runway and may not be easily identified.

The runway holding point is an obvious risk location when stop bars are unavailable, but pilots should also use caution where an intermediate point on the taxi routing requires a sharp turn to avoid a runway. In this case, the absence of red lights to highlight the danger of continuing straight ahead onto a runway requires additional vigilance.

Reference Documents:

SKYbrary. *Runway Incursion Prevention - Runway-holding Position, Stop Bars and ATC Clearance.*

Airservices Australia. *Safety net - Runway Stop Bars - what every pilot must know.*

Recommendation AO23: Aircraft operators should provide flight crews with guidance and training on ARIWS (e.g,. runway status lights (RWSL), where relevant to the operation. Guidance should include technical information, guidance on inclusion in flight crew briefings, and clear policy for dealing with activation (e.g., "Red means Stop").

Why should aircraft operators follow this recommendation?

When an aircraft or vehicle fails to hold short, the next line of defence is the ATCO's ability to detect that deviation. This detection can be by visual methods or technological aids. However, there can be challenges in the reaction time of ATCOs, especially during critical phases such as takeoff.

Autonomous Runway Incursion Warning System (ARIWS) is a system which provides autonomous detection of a potential incursion and a direct warning to a flight crew or a vehicle operator. It is independent of ATC and can provide a quicker warning to pilots/drivers.

Runway Status Lights (RWSL) are the most commonly used ARIWS system. These lights are designed to provide real-time situational awareness to pilots and vehicle operators. The system is integrated with surveillance and runway occupancy sensors, allowing it to automatically detect the presence of aircraft or vehicles on the runway. When the runway is occupied, the lights are illuminated, signalling to the pilots and ground operators that they should not proceed.

By providing a visual indication directly on the runway, RWSL helps reduce the dependence on controller response time. Pilots and vehicle operators can visually confirm the status of the runway before entering, adding an extra layer of safety.

It is important to note that a comprehensive approach to runway safety includes a combination of technology, procedures, and training. The integration of systems like RIMCAS and RWSL, along with effective communication and collaboration among all stakeholders, contributes to a robust runway safety environment. Aircraft operators should ensure that where these technologies are used, their flight crews have training and procedures to ensure competence in the use of and reaction to these systems.

What can aircraft operators do to implement the recommendation?

Operators should ensure flight guidance and training includes:

- Explaining the purpose and functioning of relevant ARIWS systems, focusing on RWSL.
- Provide details on the components of the ARIWS, including runway lights, in-pavement sensors, and other relevant technology.
- Clearly defining the different indications provided by the system, such as red lights indicating a runway incursion risk: **Red means Stop.**
- Emphasising to crews that RWSL lights extinguishing does NOT imply clearance to continue. Crews must confirm ATC clearance.

Operators should ensure that preflight preparation and briefings include awareness of any ARIWS systems in place:

- **Pre-flight Briefings:** Include ARIWS information in pre-flight briefings to ensure all flight crew members are aware of the system and its significance.
- **Operational Relevance:** Emphasize the importance of understanding ARIWS in relation to taxiing, crossing runways, and other ground movements.

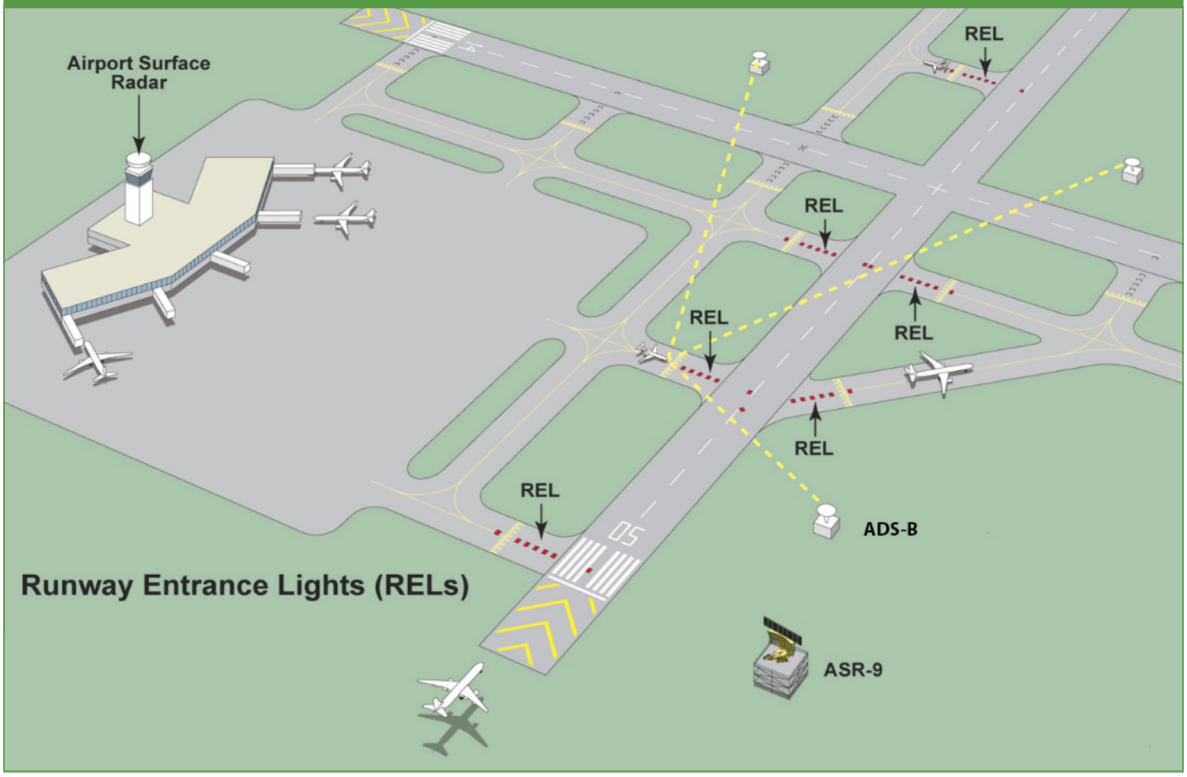
Operators should have a clear policy for dealing with activations:

- **Clear Activation Protocols:** Establish a straightforward policy for responding to ARIWS indications, such as "Red means Stop." Define the actions to be taken in case of different indications.
- **Communication Protocols:** Specify communication procedures in case of ARIWS activation, ensuring effective coordination among flight crew members and with air traffic control.

Where simulation devices support ARIWS, training should include:

- **Training Scenarios:** Develop training scenarios that simulate various ARIWS activations, allowing flight crews to practice appropriate responses.
- **Hands-On Exercises:** Provide hands-on exercises where flight crews can experience and respond to simulated ARIWS indications in a controlled environment.
- **Decision Making:** Include high-speed and low-speed RTO scenarios

Figure 39. **RIPSA Operational Concept Diagram**



Example ARIWS Systems:

- Runway Status Lights (RWSL), e.g. LFPG, KJFK.
- *Final Approach Runway Occupancy Signal* (FAROS) system for airborne aircraft.
- Runway Incursion Alerting System (RIAS), e.g. EDDF new installation 25C.
- The Federal Aviation Administration (FAA) is evaluating a prototype Runway Incursion Prevention through Situational Awareness (RIPSA) system. RIPSA is a simplified version of runway status lights (RWSL) that includes runway entrance lights (RELs) receiving data from an independent surface surveillance radar system (Figure 39). However, unlike RWSL, RIPSA does not include takeoff hold lights (THLs).

Reference Documents:

FAA Runway Status Lights

2.9 Runway Operations- Clearance Procedures (AO24, AO25, AO26, AO27, AO28, AO29)

Recommendation AO24: Aircraft operators should ensure that flight deck procedures contain a requirement for explicit clearances to enter, cross or land on any runway, regardless of runway status (active/inactive).

Operator policy should require each flight crewmember to independently hear the three parts of any runway clearance (call sign, clearance and runway), and procedures should include clear, effective means to ensure crew understanding and mitigate cognitive bias. Any doubts must be resolved immediately.

Why should aircraft operators follow this recommendation?

An analysis of 68 RI accidents and serious incidents in the six-year period 2016-2021, involving at least one multiengine CAT aircraft, showed several events with flight crew members not having a clear understanding of their runway clearance either individually or collectively (GAPPRI Data Finding). Numerous accidents over the years were because of RIs where the handling or state of the clearance was a contributing factor.

The handling of all ATC clearances during ground manoeuvring is safety critical, but clearances involving runways should be given special attention. Concise and unambiguous voice communication is the foundation for safe operations on and near runways. Principles such as readback/hearback and redundancies through active listening by all crew members are essential to avoiding misunderstandings. Operators should also understand the different language proficiencies of their own pilots and the ATC units with whom they communicate.

Operators should ensure that each flight crew member hears the 3 key parts of the clearance:

	Callsign →	**Clearance** →	**Runway Designator**
e.g.	*"Fastjet123*	*Line-up*	*Runway 23"*

If a crew member has any doubt about the communication, or if a crew member is off air, then the clearance should be verified with ATC. This should be done as soon as possible and always before crossing any runway hold points or landing.

Once all crew members have heard and understand the clearance, procedures should then include a crew verbalisation and confirmation to ensure there is a common understanding of the clearance.

The handling of clearances for active and inactive runways should be treated in the same manner; a runway is a runway! This is because of the possibility of runway status changing without the crew's knowledge. It is also good to build the same level of discipline for all runways, regardless of status, and avoid any complacency when it comes to entering runways.

What can aircraft operators do to implement the recommendation?

- Implement procedures for each crew member to independently hear clearances directly from ATC, including supernumerary crew members and pilot-off-air.
- Provide guidance that an aircraft should have no more than one runway clearance at a time. (ATC controllers should not transmit clearance to cross more than one runway at a time.) Where this is not the practice, extra caution is required by the crew. (For example, an intersecting runway scenario: "Backtrack ___, hold short ___")
- Good CRM principles should encourage crew members to speak up regardless of experience levels.
- Ensure that policy deals with the particular risk of airports which routinely use runways as taxiways and airports with standby runways (e.g. EGKK). The potential for crews adopting local workarounds and bad habits should be mitigated by operator risk assessment and procedures.
- Provide guidance for possible ATC clearance to take off with no line-up clearance transmitted, and possible risks associated with no "lineup" trigger for cockpit tasks.
- Require flight crew members to confirm runway clearance amongst each other. Some airlines use a "confirm read-back" call between pilots for all runway clearances. This is a proceduralised step to ensure both pilots understand and agree on the clearance.
- Use open questions as a crew, potentially before every entering of a runway (e.g. CM1: "Confirm our clearance?").
- Always question ambiguity and use clear and concise phraseology regarding runway instructions. Use open questions when querying ATC; "Confirm clearance?" instead of "Confirm we're cleared to cross R24?."

- Enforce stabilised approach criteria. This will allow crews of landing aircraft to pay attention to the situation at runway holding points . Also, this gives crew members more mental capacity for listening to the radios.

Reference:

Active/Inactive Runway

Stand-by runways: Where there's a will, there's a way - ACI World Insights

Recommendation AO25: Aircraft operators' procedures should include a means (memory aid) for the pilot flying (PF) and PM to visually indicate, crosscheck and verify receipt of any ATC clearance to enter, cross, line up, take off and land.

Why should aircraft operators follow this recommendation?

As discussed in the previous section, the processing of a runway clearance requires special attention from the flight crew. The crew must ensure correct hearing and understanding of the clearance at a personal level and at a crew level. This clearance, once verbalised and agreed, has the effect of a binary switching: The aircraft clearance status changes from "Not Cleared" to "Cleared," and this status should be displayed and remembered by the crew. The retention step might seem obvious, but with workload demands, multiple sector days, and use of motor skills, the clearance status can be easily forgotten by the crew or individual crew members. All too often, crew members ask each other, "Were we cleared to land?" There are obvious risks with crews forgetting a clearance to line up or land but the reverse case of crews forgetting they were NOT cleared can cause a runway incursion.

Cognitive effects also can negatively influence our perception and memory, e.g. source memory confusion (believing a lineup clearance has been received but this memory is from a previous flight) or expectation bias (the runway to be crossed was never in use at this airport so it won't be today). See also Guidance Material for Recommendation ANSP27 in this document for more details.

Recommendations AO27 and ANSP24 deal with the threat of early issuance of clearances by ATC. It is recommended that ATC avoid giving takeoff or landing clearances too early or too late, but for various reasons it still happens. For example, some airports issue landing clearance on first contact with tower, even when the aircraft is 10-15nm away and not number one for landing. Other airports issue clearance inside 1nm. The use of memory aids is especially necessary to manage this threat.

Clearance memory recall is not a new issue, and many pilots and airlines have developed solutions over the years. These vary from highly proceduralised checklist items to informal personal reminders such as a clip on a pilot's necktie. Writing down or noting the clearance is another method, but this might not be possible or appropriate during dynamic phases. The switching of exterior lights is often linked to clearance receipt, as well. Operators should recognise the value of having such mechanisms in place and ensure they are formalised and standardised across the airline or fleet.

What can aircraft operators do to implement the recommendation?

Operators should consider implementing a memory aid mechanism for crew to display and recall the current runway clearance status. The mechanism should be standardised across the fleet, and where possible across the airline, and should be specified for departure and landing phases.

Operators should check manufacturer manuals and procedures to ensure compatibility.

Examples include: Landing lights on for takeoff clearance, taxi lights on for landing clearance, strobes on for line-up/crossing notate on flight plan, typing in FMS scratchpad.

Recommendation AO26: Aircraft operators' procedures should require pilots to make optimum use of all exterior lights to increase the aircraft's detectability when approaching a runway, especially at night. All forward-facing lights should be switched on, at the latest, after receiving, confirming and verifying clearance to take off or land.

Why should aircraft operators follow this recommendation?

The situational awareness of all stakeholders is an essential last line of defence and depends on the visibility of aircraft and vehicles operating on or near a runway. "See and Be Seen!"

As a runway system is usually not illuminated with floodlights, the visibility of all objects which need to be detectable depends on their own lighting (runway or taxiway lights, lighted signs, as well as any aircraft or vehicle). Most strong aircraft lights are directional (e.g. landing lights), while non-directional lights are often small and not easily discernible. Any object's detectability increases with lighting, and therefore any means should be taken to maximise aircraft visibility.

What can aircraft operators do to implement the recommendation?

- Operators should review policy and procedures for use of aircraft exterior lights during ground and flight operations to ensure optimum aircraft detectability when operating on or close to runways.
- The switching of lights in conjunction with receiving ATC clearances, both as confirmatory indication to ATC and as a crew memory aid, should be considered.
- Operators should strongly consider adopting a policy to switch on strobe lighting when crossing, taxiing, and lining up on runways.
- In reviewing policy, operating limitations and manufacturer operating procedures should be observed. The below IFALPA document provides further guidance.
- Operators should consider the impact of dazzle effect from strobes, landing lights, and high-power taxi lights. Crews should consider turning off certain lights in certain weather conditions (snow, fog etc.). They should also consider how bright lights such as strobes can impair the vision of pilots in other aircraft.
- Operators should provide guidance on use of wing and logo lights to increase aircraft visibility approaching a runway (including when crossing runways). Any lights increasing the lighted area of an aircraft, and therefore improving the visibility, should be considered for use at night when taxiing.
- The use of lighting, including "pulse" lighting, for other functions such as bird scaring should also be incorporated in an external lights policy.
- Operators should not limit the use of external lighting by their crews for commercial considerations (e.g. reduction of maintenance costs).

Reference Documents:

IFALPA Aerodrome and Ground Briefing Leaflet. 2008. *Use of aircraft external lights to aid runway incursion prevention.*

Recommendation AO27: Aircraft operators should implement policy and procedures to manage the threat of early runway clearances (take off, line up, cross, land). Policy should include tools to help flight crew recognition of the threat, and if there is any uncertainty, crews shall request confirmation of clearance before entering the runway.

Why should aircraft operators follow this recommendation?

The practice of early issuance of lineup, takeoff, or landing clearances, regardless of ICAO provisions, is still used widely at certain airports. It can have airport capacity related benefits and sometimes is used to support controllers' cognitive capacity. This practice, however, has contributed to several serious runway incursions and leads to short-term memory errors by flight crew and air traffic controllers.

The practice also may create a situation where crews receive a clearance at a time when their focus is on other tasks:

- On the ground before departure, the crew may be still completing checklists and tasks.
- An early clearance before landing could be received while the crew are still busy configuring for approach. Their primary focus should be on a stabilised approach and not yet on the landing.

Recommendation ANSP24 aims to increase ATC awareness of this threat and reduce its operational use. In conjunction, operators should ensure that their own policy and procedures highlight the threat to their own crews and support them in mitigating the risks.

What can aircraft operators do to implement the recommendation?

Aircraft operators should:

- Provide guidance on definition of "early clearance". Consider establishing gates such as before 1000' aal (or stabilisation gate) for landing aircraft and when flight crew have visual contact with holding point and/or Runway Environment for departing aircraft (if reduced visibility, crews have to be nearer runway).
- Assess and highlight to crews the risks associated with early clearances, e.g. the potential for memory lapse (cleared or not cleared), incorrect runway, incorrect intersection, out of sequence task trigger, etc.
- Ensure flight crews include potential for early clearance as part of TEM Briefing (See Rec AO8).
- Consider use of memory aids(See Rec AO25.).
- Use LRST forum to highlight potential risks and to seek workable, joint solutions with ANSP.
- Run an operational learning review on this topic to find hotspots in their route network where early clearances are frequently used by ATCOs. Include information on early clearances as a possible threat in the respective airport briefing document.

Recommendation AO28: Aircraft operators should implement policy and procedures to manage the threat of conditional runway clearances (take off, line up, cross, land). Policy should include tools to help flight crew recognition of the threat, and if there is any uncertainty, crews shall request confirmation of clearance before entering the runway.

Why should aircraft operators follow this recommendation?

Studies have demonstrated that the misapplication and misinterpretation of conditional clearances can contribute to runway incursions. Six percent of the analysed sample of serious (severity A or B) runway incursion incidents could have been prevented by correct use of conditional clearances (GAPPRI data findings). As an example, a 2017 accident in Medan, Indonesia, attributed the use of conditional clearances as contributory factor.

While conditional clearances can help speed up the flow of traffic, there are also risks associated with misunderstanding that need to be considered (SKYbrary):

- The flight crew might misinterpret the conditional clearance as a lineup or takeoff clearance (e.g., due to mishearing or due to expectation bias).
- The flight crew might misidentify one or more elements of the conditional clearance (e.g., if instructed to follow specific aircraft on final).
- The controller might issue an ambiguous or unclear instruction or use non-standard phraseology.

The use of conditional clearances by ATC is discussed in ANSP7 and ANSP16, which recommend avoiding their use in most circumstances. Further, conditional clearances should be used only when there is a clear operational benefit and only with strict procedures.

From an operator's perspective, conditional clearances put increased responsibility on flight crews to ensure the condition is heard, understood, and applied correctly. This introduces more opportunities for error and so must be managed with robust policy and procedure.

It is important for operators to educate crews on best practice and regulations around use of conditional clearances. There are several factors that need to be considered when receiving a conditional clearance. While not safety hazards on their own, these factors can easily contribute to a runway incursion if neglected:

- Aerodrome layout — e.g., taxiways crossing the runway at acute angles might prevent the flight crew from seeing the conflicting traffic.
- Premature acceptance – when the flight crew acknowledges a conditional clearance before identifying the conflicting aircraft.
- Aircraft paint mismatching the aircraft call sign – e.g., if an operator is doing a flight on behalf of another operator.
- Low sun angles may prevent the departing aircraft from correctly identifying (or even spotting) the conflicting aircraft.
- More than one aircraft on final (e.g., one aircraft is about to land, and there is another aircraft 5 nm from touchdown).

What can aircraft operators do to implement the recommendation?

Operators should:

- Highlight to crews the risks associated with conditional clearances and include the subject in recurrent ground school and simulator training.
- Highlight to crews that they should have visual contact with the "conditional" aircraft and must have no doubt about which aircraft the condition is dependent on.
- Ensure flight crews include conditional clearances as part of their TEM Briefing. (See Rec AO8).
- Use the LRST forum to highlight potential risks and to seek workable, joint solutions with ANSP.
- Highlight the importance of correct ATC readback: The acknowledgement of a conditional clearance must contain the condition in the readback, e.g., "BEHIND LANDING DC9 on SHORT FINAL, LINING UP BEHIND, call sign". Ref: EAPPRI
- Include land and hold short operations guidance in documentation and training.

To raise awareness of the importance of the correct application of conditional clearances, a SKYbrary Skyclip has been produced which can be viewed at link below.

Reference Documents:

SKYbrary *Conditional Clearance Runway Incursions*

SKYbrary *Skyclip Conditional Clearances*

Recommendation AO29: Aircraft operators should implement policy, technical solutions or SOPs which confirm that the aircraft is using the correct intersection and lining up on the planned runway (e.g., by verbally confirming the correct intersection and runway).

Why should aircraft operators follow this recommendation?

The FAA, EASA, and IATA are among the regulators and industry organisations that have warned since 2017 about an increasing trend of wrong-surface events, incorrect-airport approaches and landings, or use of the wrong runway.

The risks associated with inappropriate use of a runway or taxiway for departure include possible collision with other traffic or with ground structures. Multiple factors are involved, and these are well covered in the SKYbrary article on *Inappropriate Use of Runway or Taxiway.*

The situations to be considered include takeoff from:

- Taxiway;
- Wrong runway;
- Wrong intersection; or,
- Wrong direction from intersection.

These situations can also lead to runway excursions, and many of the mitigations are common and covered in the GAPPRE documents.

What can aircraft operators do to implement the recommendation?

To make it easy for their flight crews to avoid lineup errors, aircraft operators should consider:

- Ensuring that SOPs require flight crews to positively identify (by external reference) and call out the runway and intersection before lineup (e.g., the PF or PM calls out: 'RWY 08R, Intersection A4 – identified').
- Requiring that flight crews check that aircraft heading is reasonable for cleared runway departure, especially in low-visibility conditions.
- Technical solutions: Modern EFB solutions provide AMM functions, allowing flight crews to always monitor their position. This increases situational awareness and reduces the risk of using wrong runway intersections for takeoff. Other tools, like the runway advisory and awareness system (RAAS) or take-off securing function (TOS) by Airbus may provide additional support for flight crews by using aural

advisories or FMS messages on runway entry. The proper use of such tools should be documented and trained, including hints on how to use marking or highlighting of taxi routes, hot spots or intersections.

- Flight crew briefings: Complex airports with complicated taxi routes and numerous options for different runway intersections may pose additional incursion risks. Flight crews should consider the lineup procedures available or expected by ATC for the respective runway or intersection.
- By providing comprehensive airport briefing documents, aircraft operators can ensure that all their flight crews, including those who have not visited a specific airport before, are sufficiently aware of hot spots or runway incursion risks. Good airline processes to implement or maintain airport briefings include the proactive involvement of the aircraft operator's and airport's safety departments, which may add valuable information on frequent errors or occurrences reported by flight crews, ATCOs or airport staff.
- Ensure flight crews manage workload so they arrive at the runway with tasks completed, and are ready for departure with good situational awareness. (Recommendation AO17).

Reference Documents:

Eurocontrol. (2021). *Global Action Plan for the Prevention of Runway Excursions (GAPPRE)*

SKYbrary *Inappropriate use of Runway or Taxiway*

SKYbrary *Wrong Surface Events*

Skyclip "Taxiway Take-off"

FAA Safety Briefing - July/August 2018. *Is that my Runway?*

Safety Information Bulletin (SIB) No. 2018-06. *"Incorrect Airport Surface Approaches and Landings"*,

Eurocontrol. (2017) *European Action Plan for the Prevention of Runway Incursions (EAPPRI) – V3.0*

2.10 Approach and Landing (AO30, AO31)

Recommendation AO30: Aircraft operators should implement policy and procedures which require flight crews conducting visual approaches to verify final approach path and runway with reference to GPS, area navigation (RNAV) position information or conventional navigation aids in order to avoid wrong-surface landings. When available, same runway instrument landing system (ILS) frequencies should be tuned, identified and displayed.

Visual approaches to parallel runway systems require special risk mitigation, particularly if runways are close-spaced, have parallel taxiways or visual cues are reduced (at night, in low visibility, etc).

Why should aircraft operators follow this recommendation?

An analysis of 68 RI accidents and serious incidents involving at least one multiengine CAT aircraft in the six-year period 2016–2021 showed all incidents involving an aircraft landing on the wrong runway/surface followed visual approaches (GAPPRI Data Findings). There were at least two incidents in which aircraft landed at the wrong airport. These incidents both followed flights conducted under VFR,, and both times, the aircraft landed at closed airfields.

According to EASA SIB 2018-06, the following threats affect aircraft involved in wrong-surface approaches and landings:

- **Visual illusions:** Several factors affect the flight crew's ability to perceive the environment, resulting in visual illusions. Among these there are ground texture, off-airport light patterns, "black hole effect," approach lighting, and runway lighting. Visual illusions affect the flight crew's situational awareness, particularly during final approach.
- **Wrong visual approaches clues:** Conducting a visual approach, especially at night, can lead to the risk of using wrong visual clues. Therefore, it is important to use all available navigational aids to confirm the aircraft's position during the approach.
- **Fatigue**: Fatigue reduces the flight crew's alertness and impairs decision-making. When a flight crewmember feels fatigued during the approach, he or she should rely as much as possible on the available automation to reduce the workload. This is especially true during night duties and at the end of long flight duty periods.
- **Reduce situational awareness during go-around:** If a crew realises they are approaching the wrong airport and elect to go around, they should remember the go-around procedure briefed and loaded in the aircraft navigation system may be the wrong one to fly (e.g., approach to a parallel runway with a different go-around initial turn). In such a case, the "startle" effect may contribute to a further loss of situational awareness, increasing the probability of mismanaging the go-around.

On 8 June 2022, the crew of a *Boeing 757-200 making a night visual approach to Tulsa, Oklahoma, U.S.*, inadvertently landed on Runway 18R instead of Runway 18L, as briefed and cleared. ATC did not intervene, and neither pilot realised the error until the captain realised that, having intentionally landed long because the turn off was at the end of the much longer 18R, there was less runway ahead than he had expected. Although both pilots reported not being fatigued, it was concluded that lack of recognition of their error suggested otherwise and probably facilitated plan continuation bias aided by inability to efficiently integrate available information.

What can aircraft operators do to implement the recommendation?

Operators should develop and publish guidance on best practices for flight crew to reduce the risk of misalignments, including but not limited to:

- Backing up visual approaches with instrument approach procedures that contain at least lateral guidance to the runway of intended landing. Where available, the landing runway ILS should be tuned, identified and displayed.
- Ensuring crews apply stabilized approach criteria to visual approaches.
- Ensuring robust use of automation policy for flight crew on visual approaches. This should be in accordance with manufacturer recommendations and consider flight crew workload, time of day, etc.
- Ensuring effective monitoring of visual cues by the PM: (Are precision approach path indicators (PAPI) or visual approach slope indicator (VASI) lights on the left or right of intended runway? Are geographic features (terminal building/hanger/taxiway/river/coastline) where they should be? The PM should apply an effective cross-check by scanning the flight path, navigational aids, and other

visual clues. If something does not look right, this should be verbalised and resolved without delay.

- Coordinating and cross-checking between flight crewmembers when executing changes related to arrival and approach in the flight management system (FMS).
- Creating policies related to flight crew communication and coordination for any time a runway assignment is briefed, expected, assigned, or changed (See AO9).
- Establishing a recurrent ground school module on risk and mitigation associated with visual approaches. Include expectation bias, continuation bias, effects of fatigue, and visual illusions.
- Establishing recurrent EBT simulator modules and scenarios utilizing industry events.
- Adopting technologies providing additional situational awareness, such as head-up displays (HUD), synthetic vision systems (SVS), enhanced vision systems (EVS), and moving maps that include a depiction of the whole airport rather than just the flightpath to the FMS-programmed runway. Also adopt technologies providing alerts when aligning to "not a runway" or "not a flight management computer (FMC)–programmed runway."
- Ensuring the NOTAM system highlights relevant taxiway and runway closures.
- For U.S. operations, see FAA *Arrival Alert Notices* for graphics visually depicting an approach to a particular airport with a history of misalignment risk.
- Operators should consider the possible impact of GPS interference or spoofing on any systems used for guidance or verification when conducting visual approaches.

Reference Documents:

EASA Safety Information Bulletin (SIB) 2018-06

Tulsa, B757 Fedex, Final report (2022) NTSB

NASA Aviation Safety Reporting System; Beware the Visual Approach

CAST Safety Enhancement 233, Approach and Landing Misalignment – Air Carrier Procedures and Training

SKYbrary *Continuation Bias*

FAA From the Flight Deck – *Wrong Surfac Landings*

NTSB Incident Report *NTSB/AIR-18/01*. Taxiway Overflight Airbus A320. San Francisco.

SE233: Approach and Landing Misalignment – Air Carrier Procedures and Training | SKYbrary Aviation Safety -CAST

FAA *Arrival Alert Notice Wrong* surface landings following visual approach

Recommendation AO31: Aircraft operators should implement policy and procedures that flight crew, as part of the approach briefing, include planned runway exit and strategies to mitigate runway incursion threats during taxi to parking (including runway crossing or should the planned exit be missed).

Operator training and policy should highlight to crews the human error potential during this phase, when crews may be distracted by events on approach/landing and after-landing tasks, and their attention may drift to the next flight or the end of duty.

Why should aircraft operators follow this recommendation?

An analysis of 68 RI accidents and serious incidents worldwide in the six-year period 2016–2021, involving at least one multiengine CAT aircraft, showed most RI incidents involving aircraft crossing runways without clearance occur during the after-landing phase (GAPPRI Data Finding). Airline safety data show almost two-thirds of ground deviations occur during the after-landing phase. Contributory factors include lack of attention, distraction with after-landing tasks, and lack of briefing or preparation.

Approach and landing can be a time of peak workload and high demands on the crew's attention and skills. This is usually followed by a less demanding taxi phase. The human tendency can be to "switch-off," or for the crew to be still thinking about events on the approach while taxiing to the gate.

The effect of being "close to home or hotel" should also be considered. It is a widely proved and generally intuitive correlation in vehicle accidents; the closer to home you drive, the more likely you are to have an accident. This could be due to familiarity and a lapse in concentration, and/or susceptibility to distraction due to the perceived reduced

risk in the ground environment. (Emirates, 2024. Burdett et all, 2017).

Operators should increase awareness of human factor threats during the post-landing phase to ensure pilots maintain vigilance until the aircraft is safely parked and engines shut down.

Flight crews should prepare for this phase by discussing runway exits and taxi threats during the approach briefing. This type of briefing:

- Facilitates effective communication and coordination by the flight crew. It ensures that all members are on the same page regarding the intended taxi route and any specific considerations related to the runway exit.
- Enhances situational awareness: Knowing the intended exit allows pilots to anticipate the taxi route and make better-informed decisions during the taxi phase. This is especially important in busy airports where multiple runways and taxiways may be in use. Having strategies in place for mitigating runway incursion threats encourages proactive decision-making. This includes being prepared for unexpected events or deviations from the planned taxi route and having contingency plans to address these situations.
- Establishes a standardised process for flight crews. Standardisation is crucial for ensuring that important information is consistently communicated and considered during each approach.

Operators should ensure crews know when they have fully vacated the active runway, and that if not vacating at the expected exit, this could cause a traffic conflict and potential runway incursion. If this occurs, crews should immediately notify ATC of their continuing presence on runway. This is especially important in reduced visibility and at airports utilising minimum runway occupancy times (MROT)

What can aircraft operators do to implement the recommendation?

- Flight crews should include runway exits as part of their approach briefing: Plan and consider latest touchdown point, exit point, and braking required. The crew should use landing performance calculations and apply local preferential taxiway information when deciding on possible exit taxiways. This should be SOP as part of a safe landing policy.
- Strategies to mitigate runway incursion threats during taxi to parking should be discussed during the briefing. Include local procedures such as standard taxi routes and hot spots. Give special focus to any runways to be crossed. Include reminders about maintaining focus and attention during taxi after landing.
- Aircraft should never vacate the runway after landing and then taxi onto another runway without ATC clearance.
- Operator training should emphasise the human error potential during the after-landing taxi phase, particularly when crews may be distracted by events during approach/landing and after-landing tasks. Recognise that due to human nature, attention may drift to the next flight or the end of duty.
- Consider policy and procedures that no after landing tasks are to be completed until the taxi instructions have been received and understood.
- Specific taxi routes for departure and arrival should be briefed, but crews should remain aware of the potential for expectation bias.
- Guidance for busy runways; runway occupancy time should be minimised and the level of braking to be used to leave the runway to the chosen or instructed exit should be briefed, noting whether this is a 90° turnoff or an RET.
- Consider requiring that crews conduct a postflight debrief on things they did well or could do better. Highlight hazards that could have had potential for incidents. Operators should encourage reporting of hazards and all safety-relevant information.

By implementing these measures, aircraft operators can enhance the safety of operations during the taxi phase, reduce the risk of runway incursions, and contribute to an overall culture of safety within their organisation.

Reference Documents:

Bridget R.D. Burdett, Nicola J. Starkey, Samuel G. Charlton. 2017. *The close to home effect in road crashes, Safety Science,* Volume 98,

Emirates Group Safety. 2024. RUNWAY/TAXIWAY INCURSIONS 2024. INFORMATION PAPER FOR PILOTS.

3. Reference Documents

European Action Plan for the Prevention of Runway Incursions, V3.0, published 2017	*European Action Plan for the Prevention of Runway Incursions (EAPPRI) | SKYbrary Aviation Safety*
ICAO Runway Safety webpage (including links to other organisations)	*Runway Safety Program iKit (icao.int)*
Global Action Plan for the Prevention of Runway Excursions (GAPPRE), 2021	*Global Action Plan for the Prevention of Runway Excursions (GAPPRE) | EUROCONTROL*
ICAO Global Runway Safety Site	*ICAO GLobal Runway Safety Plan*
ICAO Global Aviation Safety Plan	*ICAO Global Aviation Safety Plan*
ICAO Runway Safety Team Handbook	*https://www.icao.int/safety/RunwaySafety/Documents%20and%20Toolkits/ICAO%20RST%20Handbook%202nd%20Edition%202015%20REV2.pdf*
ICAO Doc 9870 Manual on the Prevention of Runway Incursions	*ICAODOC9870 (icao.int)*
FAA Runway Safety	*Runway Safety Program (faa.gov)* *Runway Safety Fact Sheet Sep 2023 (faa.gov)*
IFALPA Runway Safety	*Runway Safety | IFALPA*
ACI Runway Safety	*ACI Runway Safety Handbook 2014 v2 low.pdf (icao.int)*
SKYbrary Runway Incursion Page	*Runway Incursion | SKYbrary Aviation Safety*
Air Services Australia	*Runway safety - Airservices (airservicesaustralia.com)*
UK CAA Resources	*Safety initiatives and resources | Civil Aviation Authority (caa.co.uk)*
Navcanada Runway Safety	*NAV CANADA Runway Safety*
IATA ISM	*IATA Standards Manual*
IATA Safety Issue Hub – Runway Safety tab	https://www.iata.org/en/programs/safety/safety-risk/safety-issue-hub/
FAA Advisory Circular (AC) 120-74B	*Flightcrew Procedures During Taxi Operations*

Appendix D
Guidance For Manufacturers

1. Traffic Awareness and Collision Avoidance Alerting (MFR1, MFR2, MFR3) 178

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3. Runway Incursion Factors Mitigation (MFR6) 189

1. Traffic Awareness and Collision Avoidance Alerting

Recommendation MFR1: Aircraft manufacturers should consider developing a real-time, on-board functionality to provide flight crew with awareness of aircraft runway operations.

Recommendation MFR2: Aircraft manufacturers should consider developing a real-time, on-board functionality to provide flight crew alerting in case of risk of runway collision with another aircraft.

Why are these recommendations needed?

The risk of runway collisions remains a reality with worsening trends.

For instance, EASA Annual Safety Reports (from 2018 to 2022) show an aggregated risk increasing over the years, leading to runway collision being in the top three risk areas for commercial transport aircraft - ref. to *EASA Annual Safety Review (2022 update)*, Figure 21.

High-risk events involving a decrease of separation with significant potential for collision, or leading to extreme actions to avoid a collision, are continuously observed in the air transport system. This includes accidents such as LATAM Airlines Perú Flight 2213 or Japan Airlines Flight 516.

The risk of runway incursion with inherent potential for collision is likely to further increase as airport and air traffic management (ATM) infrastructure capabilities fail to keep pace with traffic growth. This will add additional pressures, on top of existing runway incursion contributory factors such as breakdowns in communications, flight crew factors, air traffic control factors, airside vehicle driver factors, and aerodrome design factors.

Various statistical analyses tend to concur that, on average, ~20 percent of these high-risk events involve airport vehicles. Refer, for instance, to the *"EUROCONTROL NM Top 5 Safety Priorities Safety Functions Map Analysis of European A and B severity safety incidents, 2022 data sample",* chapter 6.7.3.

Currently, the primary barriers against runway collision risk rely on ATC practices, such as the use of stop bars and various ground surveillance and safety systems. These systems include SMGCS (surface movement guidance and control system), A-SMGCS (advanced surface movement guidance and control system), RIMCAS (runway incursion monitoring and conflict alert system); ASDE-X (airport surface detection equipment, model X); AMASS (airport movement area safety system); ASSC (airport surface surveillance capability) and RWSL (runway status lights).

Nevertheless, the analysis of in-service events shows that human error (e.g. wrong ATC clearance, misunderstanding clearances, loss of position awareness, etc.) is a common factor; and that the efficiency of ground surveillance and safety systems — when available — relies on the capability to detect the conflict, alert the air traffic controller in a timely manner, and correct and timely communication between the controller and the involved aircraft or vehicles.

Airports operating state-of-the-art ground surveillance systems have recently highlighted in the framework of this GAPPRI exercise that the number of nuisance alerts remains high. This leads to the need for ATC operators to verify any collision alert before relaying any control order to the flight crews. The time required for analysis may be detrimental to the overall efficiency. On-board alerting systems can reduce the flight crew alerting time saving previous seconds when it comes to avoiding a collision.

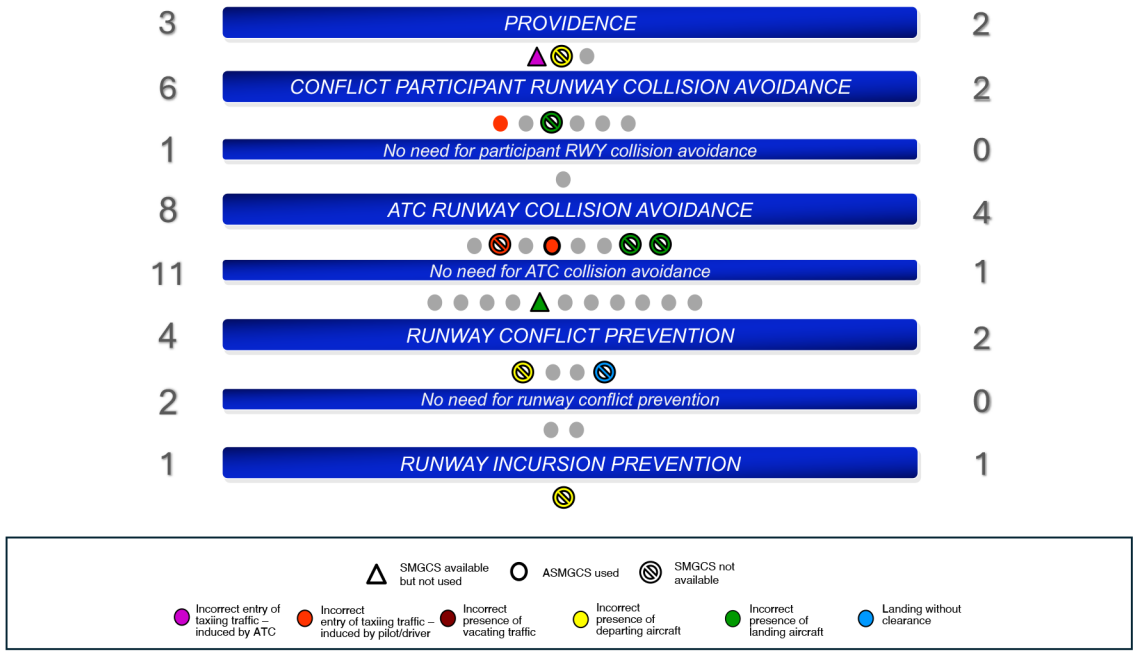
In the "EUROCONTROL NM Top 5 Safety Priorities Safety Functions Map Analysis of European A and B severity safety incidents, 2021 data sample", the analysis of the "Use of SMGCS in runway collision prevention" (chapter 6.9) shows that the SMGCS was either not available or available but not used on several of the critical events that have been considered.

On commercial aircraft models currently performing most operations, some available technologies, may partially mitigate the risk of collision by increasing crew situational awareness and therefore preventing airport navigation errors. These technologies include:

- Airport moving maps, which may include visual advisories when approaching or entering a runway.
- Position awareness systems such as Honeywell Smart Runway, that provide advisories such as Approaching Runway' and 'On Runway'.

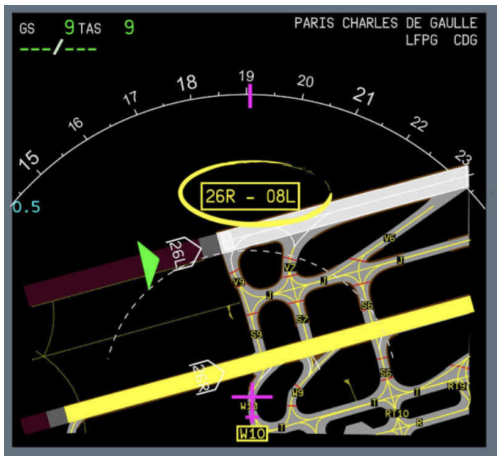
Nevertheless, there is currently no onboard function addressing the full scope of scenarios observed in-service and therefore efficiently covering the risk of runway collision.

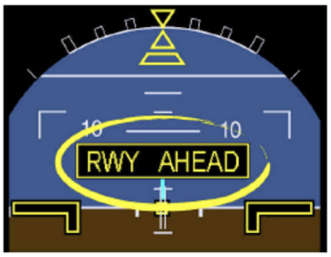
Figure 40. **EUROCONTROL NM Top 5 Safety Priorities Safety Functions Map Analysis of European A and B severity safety incidents, 2021 data sample - chapter 6.9 "Use of SMGCS in runway collision prevention"**



NOTE: In the figure above, each row represents a different barrier, considering the barrier model for runway collision SAFMAP (Safety Functions Map). The incidents develop from the bottom barrier (runway incursion prevention) to the top (providence, i.e., the chance that an aircraft involved in a given encounter, albeit in close proximity, would not actually collide), being that each incident that is stopped by the corresponding barrier is depicted as a gray circle sign (○). Incidents involving SMGC available but not used are depicted through the triangle (△), and incidents for which there is an information that SMGCS was not available are depicted through prohibition sign (⊘). Further use of colors on the triangle or the prohibition signs indicate further details associated with the incident, according to the figure's legend. The number shown to the left of a barrier identifies the total number of incidents stopped by that barrier. The number shown to the right of barrier bar identifies the number of incidents stopped by that barrier considering the use and availability of SMGCS display in the ATC Tower.

Figure 41. **Airport moving map with aircraft location and visual advisory on the moving map, the primary flight display (PFD) and the head up display (HUD) when approaching a runway. Airbus A350 design shown.**





NOTE: The departure runway of the FMS has a green triangle near the associated threshold.

In recent years, the number of flights performed by automatic dependent surveillance–broadcast (ADS-B) v2 equipped aircraft has considerably increased, ref. for instance the EUROCONTROL analysis *"Automatic Dependent Surveillance - Broadcast Airborne Equipage Monitoring"*. This provides an opportunity to develop on-board systems that use this traffic information for awareness and/or alerting purposes.

Considering the above elements, the intent of recommendations **MFR1** and **MFR2** is to encourage development and implementation of onboard systems that, in addition to other barriers such as ATC procedures, airport design or ground surveillance systems, further reduce the likelihood of a runway collision by enhancing aircraft crew awareness of the relevant traffic and/or by alerting them in case of risk of collision.

Examples of potential, prospective and actual implementations.

Since the early 2000s standardisation committees have leveraged onboard ADS-B In capability for surface area management. This activity resulted in 2010 in the definition of two main functionalities:

- **ATSA-SURF** (airborne traffic situational awareness (ATSA) for surface (SURF) operations), which aims at enhancing the situational awareness of flight crews by displaying relevant traffic (final approach, landing; and taxiing and take-off operations) on an airport moving map. This is described in the EUROCAE ED-165 and RTCA DO-322 standards. It is considered that the implementation of such a functionality would answer recommendation MFR1.
- **SURF-IA** (enhanced traffic situational awareness on the airport surface with indications and alerts), which aims to detect potential and actual risk of collision with other traffic during runway operations and provide crews with traffic and runway status indications and alerts. This solution can be implemented on aircraft models that feature an airport moving map. This is described in standard RTCA DO-323. It is considered that the implementation of such a functionality would answer recommendation MFR2.

It should also be noted that current electronic flight bags (EFBs) can provide airport traffic depiction on an airport moving map to enhance situational awareness. One example is the Jeppesen FliteDeck Pro's airport moving map integrated with ADS-B-In information to support situation awareness of both aircraft and non-aircraft traffic on the ground.

Figure 42. **Example of SURF-IA prototype implementation (Honeywell).**

Also, since 2010, further work has been done within the Single European Sky ATM Research (SESAR) framework. Considering the fact that some aircraft models may not feature an airport moving map, an additional potential solution, which emerges from the overall SURF-IA concept presented in RTCA DO-323, has been developed and described in the frame of *SESAR PJ.03B-05 - "Traffic alerts for pilots for airport operations"*:

SURF-A (surface traffic alerts on runways for pilots without display (CDTI – Cockpit Display Traffic Information)), which aims at detecting actual risk of collision with other traffic

Figure 43. **Example of SURF-A implementation showing a PFD - and the associated audio - alert (Airbus).**

during runway operations and providing the Flight Crew with alerts but without traffic display. This solution mainly targets aircraft models that do not feature an Airport Moving Map. It is considered that the implementation of such a functionality would answer recommendation MFR2.

Reference materials:

RTCA DO-317C / EUROCAE ED-194B – Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System, June 2020.

RTCA DO-322 / EUROCAE ED-165 - Safety, Performance and Interoperability Requirements document for ATSA-SURF application, December 2010.

RTCA DO-323 - Safety, Performance and Interoperability Requirements Document for Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (SURF-IA), December 2010.

SESAR PJ.03B-05 - "Traffic alerts for pilots for airport operations".

ADS-B Connectivity Pack for Jeppesen FliteDeck Pro, web page https://ww2.jeppesen.com/wp-content/uploads/2021/03/FliteDeck-Pro-ADS-B-Connectivity-Pack-Fact-Sheet.pdf

Recommendation MFR3: Vehicle navigation system manufacturers in collaboration with Aerodrome Operators should consider developing and providing a real-time functionality to provide airside vehicle drivers with awareness and alerting for runway collision between aircraft and airside vehicle and with real-time alerts when crossing into the protected area, such that drivers will be alerted in the event of a runway incursion.

Why is this recommendation needed?

Driving an airfield vehicle may lead to a runway incursion, especially during dense fog or nighttime conditions, or when there are inadequate signage/markings or a complicated airport design where runways cross, among other factors. These conditions may jeopardize the airside vehicle safety, for example, driving incorrectly into a safety critical area without proper clearance.

Statistical analyses tend to concur that, on average, ~20 percent of these high-risk events involve airport vehicles. Refer to the *"EUROCONTROL NM Top 5 Safety Priorities Safety Functions Map Analysis of European A and B severity safety incidents, 2022 data sample"*, chapter 6.7.3.

Consideration of airport vehicles by an aircraft onboard system seems currently not feasible due to the dynamics of

the airport vehicles' trajectories, which are difficult to predict, and would be prone to nuisance alerts. On the other hand, the consideration of aircraft traffic from the vehicle perspective seems more feasible, given the more predictable dynamics of aircraft trajectories and the lower impact of nuisance alerts for the vehicle system.

Many airports monitor airfield activity using a range of sensors and tracking systems. This information could also be used by vehicle drivers to improve the situation awareness of airside vehicle drivers and increase overall safety. By fitting a display in the vehicle, the driver could access an airport moving map, see information regarding surrounding traffic, and receive alerts if an unsafe situation arises. Alerts can include those related to possible collisions with an aircraft on a runway or taxiway, infringements of a runway, or a closed or restricted area, thus likely avoiding potential runway incursion situations.

Therefore, the intent of recommendation **MFR3** is to encourage the development and implementation of systems for airside vehicles that further reduce the likelihood of a runway collision by enhancing driver awareness of relevant aircraft traffic and/or by alerting drivers in case of risk of collision.

Examples of potential, prospective and actual implementations.

One way to implement this recommendation is for airside vehicles to be equipped with:

(i) A global navigation satellite system (GNSS), to provide the airside vehicle position.

(ii) A transmitter (such as an ADS-B Out transponder equipment), to broadcast the airside vehicle position to other vehicles, aircraft and ATC.

(iii) A receiver (such as an ADS-B In equipment), to acquire the position of the nearby aircraft and other airside vehicles.

(iv) A display (such as a tablet), with a moving map, to make visible to the airside vehicle all the surrounding traffic. The other traffic to be displayed includes both aircraft and vehicles. and,

(v) An alert system to issue alerts.

Provision of alerts to drivers to warn them of situations that if not corrected could end up in unsafe situations incudes:

- Traffic alerts to warn the vehicle driver of a potential or impending conflict with an aircraft.
- Area infringement alerts to warn the vehicle driver when the vehicle is in a closed or restricted area while the vehicle is operating on the manoeuvring area.

Two implementations may be considered for the generation of alerts:

- Alerts may be generated by an on-board system; or
- Alerts may be generated by, for instance, a centralised server (connected to the A-SMGCS, for example) with an uplink to the vehicle. In this configuration, alerts would be broadcast to the vehicle, and the vehicle's alert system would issue them for the airside vehicle driver to get his/her attention in order for him/her to take the appropriate action.

Some examples of actual system implementations are:

- Leonardo's AeroBOSS Runway Incursion Warning System (RIWS).
- Ansart's Airport Drivers Navigation and Alert System (ADNAS).
- Foreflight's Sentry.

Some aerodromes have also implemented this recommendation, such as:

- EDDF - Frankfurt am Main.
- EDDS - Stuttgart Airport.
- LFPG - Paris Charles de Gaulle.
- LFPO – Paris-Orly.

A description of potential solutions is available in *SESAR SJU reference #4 - "Enhanced Traffic Situational Awareness and Airport Safety Nets for vehicle drivers".*

According to the *European ATM Master Plan Implementation Objectives Monitoring,* this type of solution (ref. AOP15) has been implemented in 4 European airports (EDDF, LFPG, LFPO and LIRF) and is being implemented in 6 additional ones.

Reference materials:

EUROCONTROL's LSSIP (Local Single Sky Implementation) Year 2022 for Germany – Implementation Overview

EUROCONTROL's LSSIP (Local Single Sky Implementation) Year 2022 for France – Implementation Overview

FAA AC 20-172B, "Airworthiness Approval for ADS-B In Systems and Applications".

FAA AC 150/5220-26, "Airport Ground Vehicle Automatic Dependent Surveillance – Broadcast (ADS-B) Out Squitter Equipment"

ICAO Annex 14 to the Convention on International Civil Aviation – Aerodromes – Volume I – Aerodrome Design and Operations – item 9.12 (Autonomous Runway Incursion Warning System)

RIWS web page: *https://aeroboss.info/*

Sentry web page: *https://foreflight.com/products/portable-ads-b-receivers/*

RTCA DO-322 / EUROCAE ED-165 - Safety, Performance and Interoperability Requirements document for ATSA-SURF application, December 2010.

RTCA DO-323 - Safety, Performance and Interoperability Requirements Document for Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (SURF-IA), December 2010.

SESAR PJ.03B-05 - "Traffic alerts for pilots for airport operations".

SESAR SJU reference #4 - "Enhanced Traffic Situational Awareness and Airport Safety Nets for vehicle drivers".

2. Position Awareness, Routing and Alerting

Recommendation MFR4: Aircraft manufacturers should consider developing on board functionality that helps flight crew in the manoeuvring area to confirm their location in relation to the runways and taxiways.

Why is this recommendation needed?

As worldwide aircraft traffic volume expands, there is a need to address the potential increase of runway incursions. One of the ways to address this issue is through an onboard awareness system that aids flight crews in the manoeuvring area by confirming their position in relation to the runway and taxiways.

It is important to emphasize that when such a system is installed and operating, it improves the flight crew's situational awareness by, potentially:

(i) Enhancing the perception of elements of the environment in which the aircraft is in.

(ii) Increasing the comprehension of the aircraft current status and the environment.

(iii) Aiding on the projection of the future status of the aircraft.

Through this enhancement of the liveware-software interaction[1], it is expected that certain contributory factors[2] of a runway incursion situation may be thwarted.

Currently there are various technologies deployed that address this recommendation: systems that make use of GNSS position; aircraft heading information; and runway database information to provide awareness, on a moving map, or through aural messages, of the location of the aircraft in relation to the runway and taxiways.

Examples of potential, prospective and actual implementations.

There are different ways to implement this functionality. One way to meet this recommendation is for the aircraft to be equipped with:

(i) A GNSS, to calculate the aircraft position.

(ii) An AHRS (attitude heading reference system) or IRS (inertial reference system), to calculate the aircraft heading.

(iii) A runway database, to determine the aircraft location in regard to a map of runways and taxiways.

(iv) A display (head up or head down), with a moving map; and/or an aural message system to enable awareness of aircraft location.

Some implementation examples are presented in Figure 44 and Figure 45. See Figure 46 for an example of an airport map on an EFB. An example of an implementation on a HUD is shown in Figure 47. Note the synthetic representation of the runway and runway distance remaining markers in Figure 47a when the aircraft is lined up for the correct runway during approach. Figure 47b shows an aircraft that is not lined up on the FMS departure runway. Note the absence of the runway distance remaining markers.

It is important to note that some of these systems present a moving map display to enhance flight crew situational awareness, while others may only issue aural messages to indicate which runway the aircraft is on, or if the aircraft is inadvertently taking off from a taxiway. In addition, for some legacy airplanes, an airport map on an EFB may be the only practical solution to provide this functionality (due to avionics architecture limitations).

Further possible enhancements to be considered include electronic taxi guidance to assist flight crews. This may be especially effective in reducing crew confusion and helping crews remember taxi instructions.

Regarding ATSA-SURF, although it is mainly focused on addressing adjacent traffic through the use of ADS-B Out information broadcast by the surrounding aircraft and/or ground vehicles (which is an excellent option to meet recommendation MFR1), the superimposed moving map display of the airport surface along with a plan view relative to own-ship, also enhances the flight crew situational awareness and fully meets this recommendation.

1 And here it is adopted the SHELL model nomenclature, as described by ICAO Doc. 9859, Safety Management Manual, and ICAO circular 216-AN31, which describe different components of Human Factors: Software, Hardware, Environment and Liveware.

2 Pilot factors that may reduce the flight crew situational awareness. Refer to ICAO Doc. 9870, Manual on the Prevention of Runway Incursions, for examples of such factors.

Figure 44. **Collins' Surface Management System with airport moving map and integrated charts. Embraer's Praetor 500/600 design shown.**

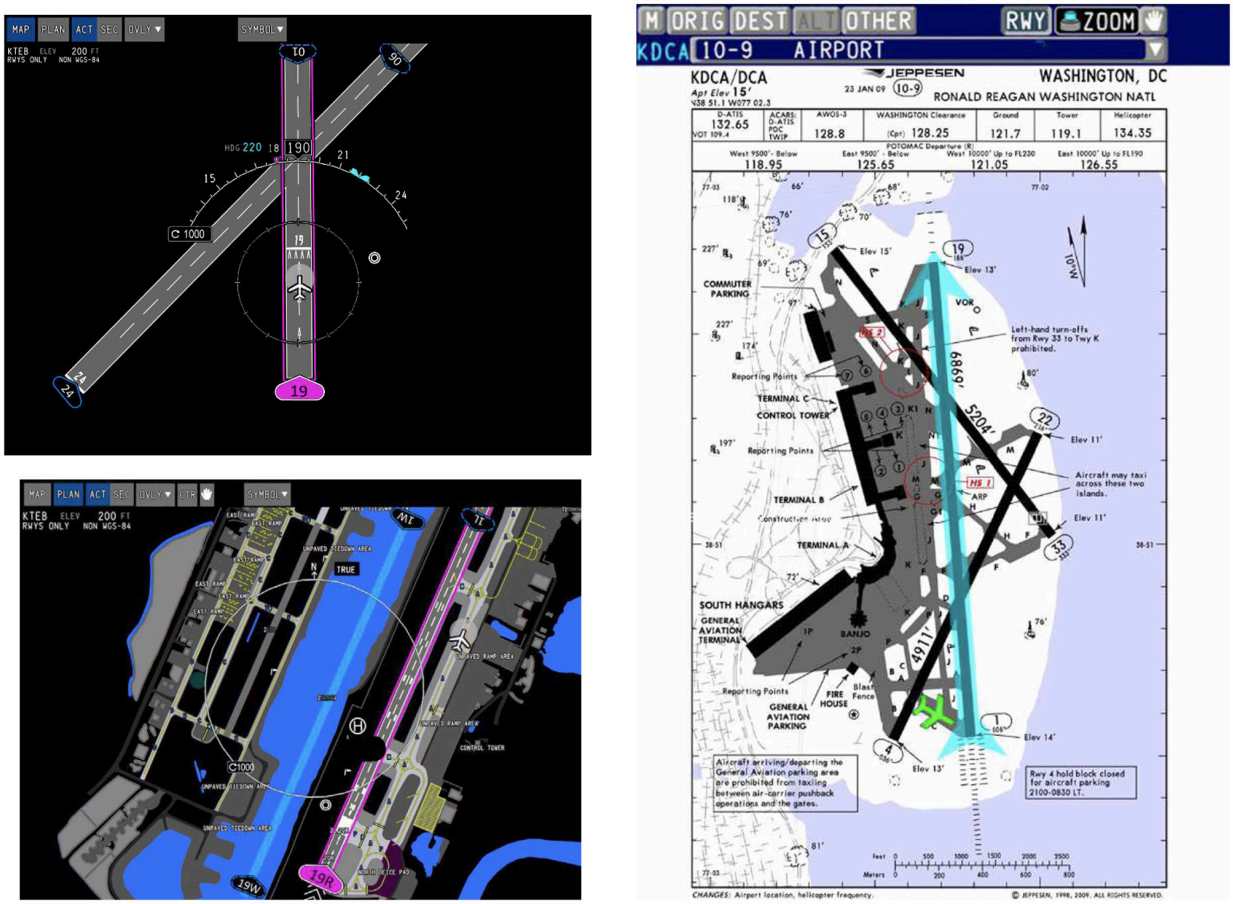


Figure 45. **Honeywell's three-dimensional airport moving maps (AMM). Gulfstream's G650/G650ER design shown.**

Figure 46. **Example of an airport moving map on EFB (© Jeppesen/Boeing).**

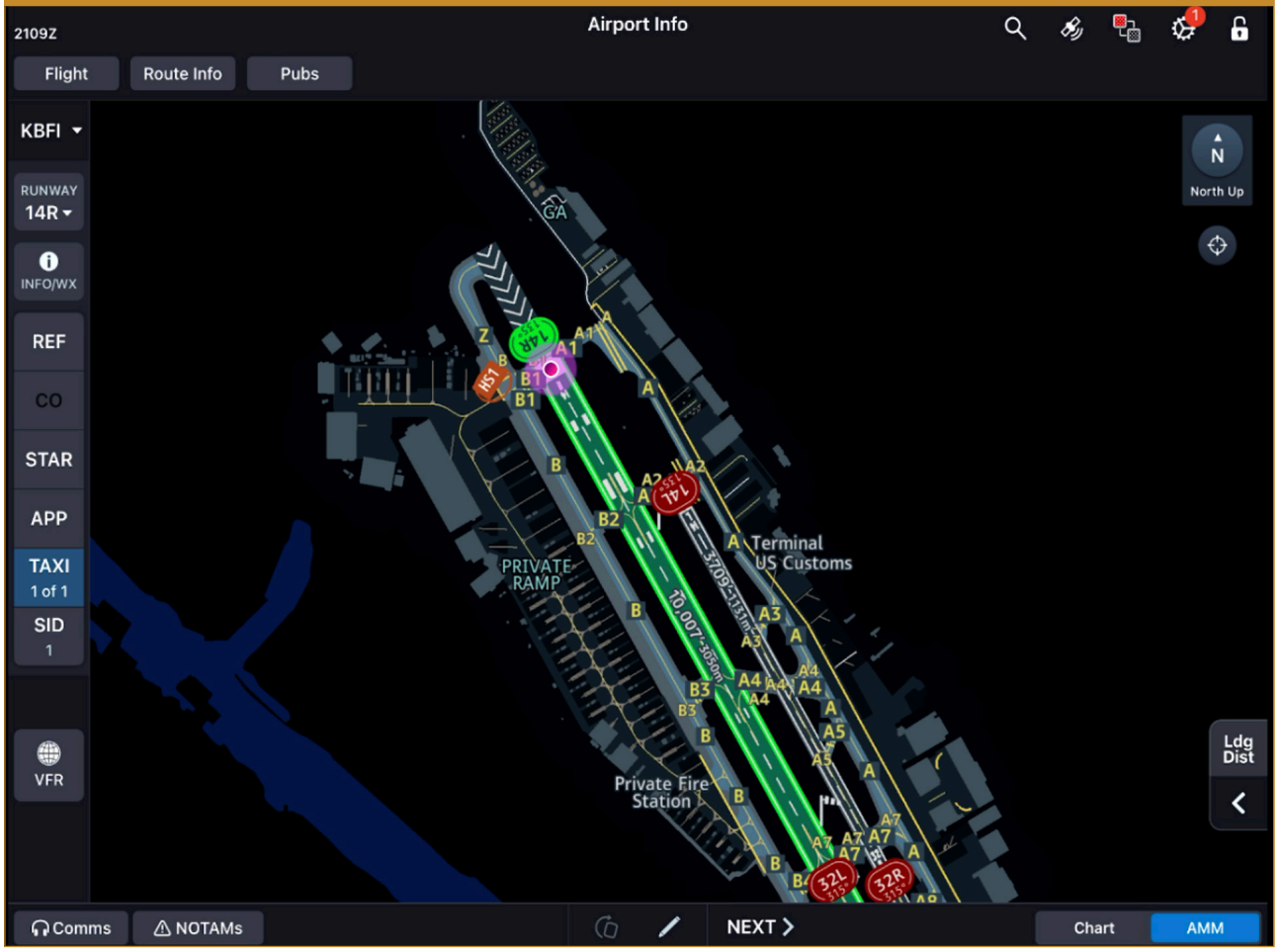


Figure 47a. **Collins HUD on a Boeing 737 - final approach (© Boeing)**

Figure 47b. **Collins HUD on a Boeing 737 - line up on incorrect runway (© Boeing)**

Currently, the industry has already developed certain systems that encompass – and surpass[3] – this recommendation. Some examples are provided below:

- Honeywell's Runway Awareness and Alert System (RAAS) / SmartRunway and SmartLanding.
- L-3's ACSS Surface Area Movement Management (SAMM).
- Garmin's SafeTaxi and SurfaceWatch.
- Collins, Garmin and Honeywell 2D airport moving maps (AMM).
- Honeywell's 3D airport moving map (integrated on a Synthetic Vision Display) (See Figure 45).
- EFBs that provide an airport moving map, for example provided by Jeppesen FliteDeck Pro, see Figure 46. Airbus/Thales Airport Moving Map (A380/A350 ANF - Airport navigation Function) - reference to "Figure 41 in the MFR1/ MFR2 section.

Reference materials:

ICAO Doc. 9870 Manual on the Prevention of Runway Incursions

FAA AC 20-172B, "Airworthiness Approval for ADS-B In Systems and Applications"

FAA TSO-C195c, "Avionics Supporting Automatic Dependent Surveillance – Broadcast (ADS-B) Aircraft Surveillance Applications (ASA)"

RTCA DO-322 / EUROCAE ED-165, "Safety, Performance and Interoperability Requirements Document for ATSA-SURF Application"

Honeywell's Product Description SmartRunway and SmartLanding functions of the Enhanced Ground Proximity Warning System: *https://aerospace.honeywell.com/content/dam/aerobt/en/documents/learn/products/terrain-and-traffic-awareness/technical-information/060-4564-001D-Product-Description.pdf*

Garmin's SafeTaxi web page: *https://www.garmin.com/en-US/blog/aviation/terminal-environment-safety-garmin-safetaxi/*

Collins' Flight Database Services – *Pro Line Fusion web page*

Jeppesen Airport Moving Map web page *https://ww2.jeppesen.com/navigation-solutions/airport-moving-maps/*

Recommendation MFR5: Aircraft manufacturers should consider developing real-time, on-board functionality to provide flight crew with awareness and alerting to prevent taking off or landing on a wrong runway or on a taxiway.

Why is this recommendation needed?

This recommendation complements recommendation MFR4, but MFR5 also adds an alerting function. Therefore, the previous reasoning also applies for this recommendation, which was based on increased traffic volume and corresponding enhancement to the flight crew's situational awareness.

There are currently several technologies deployed that addresses recommendation MFR5: systems that make use of GNSS position; aircraft heading information; and runway database information to provide awareness and alerting of possible runway incursion situations.

Examples of potential, prospective and actual implementations.

There are several ways to implement this functionality. One way to meet this recommendation is for the aircraft is to be equipped with:

(i) A GNSS, to calculate the aircraft position.

(ii) An AHRS (attitude heading reference system) or IRS, to calculate the aircraft heading.

(iii) An FMS (flight management system), to store the aircraft's flight plan.

(v) A runway database, to determine the aircraft's location in regard to the map of runways or taxiways.

(vi) Terrain avoidance and warning system (TAWS) that may host the runway awareness and advisory system (RAAS).

(iv) A display (head up or head down), with a moving map and an aural alerting system to make the flight crew aware of aircraft location and alert the pilots whenever necessary.

3 In the early developments of such systems, at the beginning of this century, most of them were focused on increasing flight crew awareness but not providing alerts per se. But as time went by, the majority of these systems have evolved to contemplate alerting functions, as well.

Typically, these systems can check multiple parameters, including:

- Upon take-off, if the aircraft is on a runway.
- Upon runway entry for take-off, the runway the aircraft is lined up with.
- upon starting take-off, if the runway the aircraft is on is the same runway that it is programmed in the aircraft's FMS flight plan.
- Before landing, if the aircraft is lined up with a runway or taxiway, and the runway the aircraft is lined up (aligned) with.

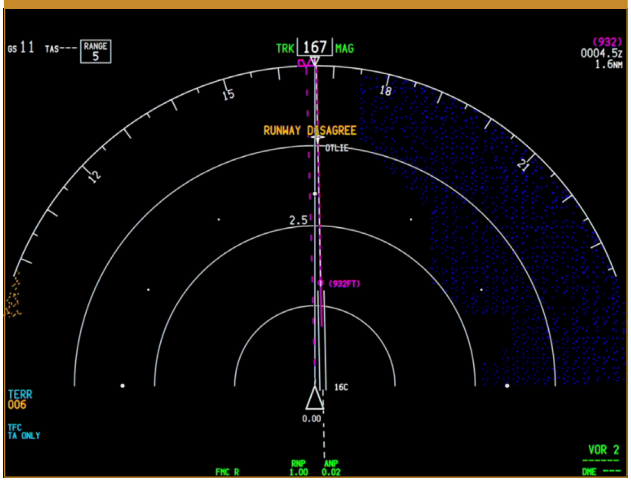
If there is divergence between the aircraft position/heading information and the flight plan/runway database information, the system issues alerts to elicit a flight crew response to avoid a runway incursion situation.

Currently, the industry has already developed certain systems that already encompass this recommendation. Some examples are provided below.

- Boeing FMS Runway Disagree Alert. see Figure 48 and Figure 49. Note that the aircraft is not lined up on the runway with the solid magenta line that represents the FMS flight plan. The white parallel lines either side of the solid magenta line represent the FMS planned departure runway (Figure 48). The engine indicating and crew alerting system (EICAS) would provide an alert for this condition. Fig 49 shows the FMS runway disagree alert on the navigation display for an implementation that does not host an airport moving map or an EICAS.
- Collins' Surface Management System (SMS).
- Garmin's Surface Watch.
- Airbus TOS functions, namely "NAV ON TAXIWAY", "NAV NOT ON FMS RUNWAY" (https://safetyfirst.airbus.com/take-off-surveillance-monitoring-functions/), as they cover some of the above scenarios.
- Honeywell SmartRunway & SmartLanding.
- "Taxiway Landing Monitoring" in Airbus / ACSS T3CAS.

Figure 48. **Example of aircraft on incorrect runway depicted on the navigation display (© Boeing)**

Figure 49. **FMS runway disagree alert on the navigation display without airport map (© Boeing)**



Reference materials:

FAA AC 25.1322-1, "Flightcrew Alerting"

EASA AMC 25.1322, "Flight Crew Alerting"

3. Runway Incursion Factors Mitigation

Recommendation MFR6: Aircraft manufacturers should consider providing flight crew awareness when aircraft systems contributing to position surveillance (e.g., Mode-S, ADS-B, etc.) or runway collision prevention functions - when available - are deactivated or failed in a phase where these functions are normally active by convention or design.

Why this recommendation needed?

The purpose of this recommendation is to encourage aircraft and avionics manufacturers to provide an alert or similar awareness to flight crews so they are aware that their surveillance system is not operating in its highest functional mode when it would typically be operating. Data from the aircraft surveillance system is typically used to provide the aircraft's location while on-ground as well as in-air to ANSPs and other aircraft via Mode-C, Mode-S, and ADS-B data.

Although adoption of this recommendation is unlikely to directly prevent the host aircraft from having a runway incursion, it may allow other safety systems that exist either on other aircraft or within the airport infrastructure to perform their intended functions and prevent an incursion from becoming an incident or accident. In the FAA's FAR/AIM section 4-1-20, paragraph 3 suggests that the transponder and ADS-B Out be active at all airports anytime the aircraft is positioned in the airport movement area. The FAA noted in SAFO 15006 (May 2015) that there were 20 transponder-off taxi operations per day being reported in the United States.

Implementation of this recommendation has the additional benefit of providing flight crew awareness if the transponder and ADS-B functionality is intentionally or unintentionally deactivated in-flight, which could inhibit TCAS functionality as well as other ANSP efforts to provide traffic and terrain separation.

Examples of potential, prospective and actual implementations.

An obvious way to implement this recommendation would be to use existing cockpit alerting systems or other already-existing alert systems. It would not be unprecedented to use other known aircraft conditions, such as engine(s)-running, main door closed, or ground speed above a certain value to arm such an alert. It is left to the manufacturer to properly determine the activation logic and the appropriate severity of such an alert. It is worth considering that there are times when the surveillance / transponder system is intentionally deactivated, such as at the request of the ANSP or during formation flight.

Reference materials:

FAA's FAR/AIM section 4-1-20

FAA SAFO 15006

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APPENDIX E
Guidance and Explanatory Material For States and Regulators

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1. The Key Role of Regulators in Implementing GAPPRI

The recommendations contained in the Global Action Plan for the Prevention of Runway Incursions (GAPPRI) for regulators have been developed over time in co-operation with other regulators and key industry stakeholders. These recommendations should be considered as 'strong guidance' in lieu of full regulation and the respective safety promotion.

It is incumbent on all regulators to promote aviation safety. Safety promotion should aim to develop, sustain, and improve aviation safety through raising awareness and changing behaviours, enabling the operation of aircraft and vehicles with sufficient safety margins. Safety promotion is also about sharing best practices from industry and regulators based on the collection and analysis of relevant accident, incident, and occurrence data. Safety promotion is one of the four key elements of safety management, along with safety policy, safety risk management, and safety assurance.

Regulators are encouraged to use the GAPPRI recommendations appropriately as part of their state safety plan under the domain of runway safety. By utilising the recommendations, they will also educate, inform, and raise awareness of the runway incursion risk within the flight operations, air traffic management, and aerodromes sectors of the industry. These recommendations could be used as part of targeted or thematic inspection/oversight activities, again encouraging industry to assess and comply with specific domain recommendations.

Using this action plan, in co-operation with industry, should encourage a stronger and more open relationship between the regulator and its key stakeholders. The use of the recommendations should allow a better understanding of the runway incursion risk at each of the aerodromes that is regulated within the State. This risk could vary depending on the volume of aircraft movements, the mix of traffic type, and the complexity of the aerodrome layout.

The International Civil Aviation Organisation (ICAO) should support and promote GAPPRI as part of the ICAO Runway Safety Programme, its regional activities, and the work of the respective panels and working groups. Issues dealing with runway safety should form a regular agenda item at key ICAO Panels such as the Aerodrome Design and Operations Panel (ADOP), the Flight Operations panel (FLOPSP), and the Air Traffic Management Ops Panel (ATMOSP).

ICAO should ensure the continuity of leadership in addressing runway safety, including runway incursion, leveraging the collaborative ICAO mechanisms. ICAO should, working with States and industry, further develop provisions on the establishment and implementation of State runway safety programmes considering the GAPPRI content.

2. Oversight of the Effectiveness of Safety Management

Recommendation REG1: As part of the State's safety management activities, ensure that the establishment and operation of aerodrome local runway safety teams (LRSTs) is included in the regulator's aerodrome, flight operations and air traffic management (ATM) oversight programme.

Recommendation REG4

a. During aerodrome, ATM and flight operations oversight activities, specific assessment should be made of the role of the LRST in relation to any changes to the manoeuvring area procedures, with particular reference to a change management plan (e.g., for dealing with structural and layout changes and works in progress on the manoeuvring area).

b. Conduct periodic reviews of the effectiveness of methods whereby temporary closures or repairs to runways and taxiways, and associated safety-critical infrastructure (e.g., lighting and signage) are promulgated to aircraft operators. The reviews should aim to improve the publications with regard to the ease of use and interpretation of NOTAMS or other communication means for flight crews and vehicle operators.

Recommendation REG8: National agencies charged with the oversight of aviation safety should consider how they discharge their responsibilities for runway safety risk management, which may include:

a. The establishment and coordination of a national/state runway safety group that will address the prevention of runway incursions and runway collision risk.

b. Define the prevention of runway incursions as a safety priority, with associated risk mitigation actions, in national aviation safety plans.

c. Support the statewide promotion and coordinated implementation of GAPPRI to include incorporation of relevant elements into national aviation safety plans.

Recommendation REG16: States should ensure that, as part of their safety management and oversight responsibilities, the variable level of runway incursion risk is assessed at those aerodromes that cater solely to large commercial air transport (CAT), mixed CAT with business and general aviation, and only general aviation and that actions are taken as appropriate in case of risk profile differences.

Effective oversight of runway, aerodrome and flight operations should continue to form an important part of the safety management system of the aerodrome operator, air navigation service provider (ANSP), aircraft operator, other stakeholders, and state safety program activities.

Under the Convention on International Civil Aviation, States are responsible to ensure safety, regularity and efficiency of aircraft operations, air navigation services, and operations at aerodromes under their jurisdiction. Therefore, it is essential that the State exercises its safety oversight responsibilities and ensures that aircraft operators, ANSPs, and aerodrome operators comply with the applicable national/regional regulations, which are built on the relevant ICAO standards and recommended practices. The regulatory authority responsible for safety oversight should conduct regulatory oversight and inspections on aircraft and aerodrome operators as well as ANSPs in order to monitor the safe provision of these operations and to verify compliance with the regulatory requirements.

The oversight of aircraft operators, ANSPs, and aerodrome operators by their regulator should include at least the following:

- Ensuring that aircraft operators, ANSPs, and aerodrome operators have developed, implemented, and continue to maintain an effective runway incursion prevention programme that meets national/regional requirements.
- Conducting audits and inspections to examine the interfaces between the aerodrome operators and other stakeholders involved in runway incursion prevention (e.g., communication of safety-significant information regarding changing surface conditions in real time to the appropriate air traffic services providers).

In addition to regulatory oversight, it is beneficial that a regulator keeps a high level, national focus on the risk of runway incursions. This can be achieved by establishing a national runway safety team. Membership in the national team should include representatives from aerodromes, aircraft operators' flight operations, air traffic services, industry safety groups, local runway safety teams, and the regulatory authority. Terms of reference for such a team should be to:

- Address specific hazards identified nationally, coordinating this through sub-groups or external agencies as required.
- Promote good practices and information-sharing, raise awareness through publicity, and educate the industry.
- Actively enhance industry safety efforts and act as a point of coordination for industry.
- Identify and investigate which technologies are available that may reduce runway incursion risks and promote their use.
- Review current aerodrome, air traffic control, and aircraft operational procedures and, if necessary, make recommendations on future policy, guidance, and advisory material for all stakeholders to reduce the risk of runway incursions.
- Oversee the reporting of runway incursion incidents and utilise the data to highlight issues and trends. Regulators should continue to actively support and promote GAPPRI as part of state safety program activities. Although GAPPRI contains recommendations only, regulators should ensure that it is given appropriate consideration in oversight activities by:
  - Promoting awareness of GAPPRI;
  - Conducting an operators' gap analysis to ensure that all relevant recommendations are implemented;
  - Ensuring that runway safety and the prevention of runway incursions are addressed in regular audit inspections;
  - Ensuring that the findings and recommendations arising from audits are implemented; and,
  - Working collaboratively with other regulators and ICAO to ensure that the signs, markings and lighting systems of the runway environment and associated procedures are appropriate for all day, night, and reduced visibility operations and, where necessary, develop improvements and enhancements as required.

3. Promoting Enhanced Measures for Runway Collision Prevention

Recommendation REG5: Promote that all vehicles on the manoeuvring area are in radio contact with the appropriate ATC service (i.e., ground and/or the tower), either directly or through an escort.

Recommendation REG6: Ensure that all aerodrome vehicles are assigned unique numbers or airside identification call signs for each airside vehicle to reduce the risk of vehicle-related call sign confusion.

Recommendation REG7: As part of regulatory oversight, assess the operational use of aerodrome ground lighting (e.g., stop bars) to ensure a robust policy to protect the runway from the incorrect presence of traffic. Wherever practicable, the use of H24 stop bars at all runway holding positions should be considered, as this has been shown to be an effective runway incursion prevention barrier. The use of ARIWS at all runway holding positions should also be evaluated.

Recommendation REG15: The regulator should ensure that during flying operations inspector (FOI) checks, ground and taxi manoeuvres are seen as key flight elements in flight crew briefings.

Regulators should be aware of existing and future developments in technology that assist in detecting and preventing runway incursions. ICAO has defined an ARIWS, which is a system that provides autonomous detection of a potential incursion or of the occupancy of an active runway and a direct warning to a flight crew or a vehicle operator. Other systems can warn controllers of possible runway incursions through surveillance and radar technology. Regulators working with industry should evaluate the effectiveness and appropriateness of such systems as part of an overall assessment of runway safety.

Additionally, GAPPRI recommendations for ANSPs, aircraft operators and aerodrome operators offer enhanced procedures, practices, and technology for safe runway operations. Examples include the use of unique numbers or airside identification call signs for each airside vehicle and considering the use, where practicable, of H24 stop bars at all runway holding positions. Regulators should be aware of these recommendations and facilitate their implementation with whatever actions are available to them.

4. Oversight of Aviation Personnel Competence

Recommendation REG2: Ensure that the GAPPRI is used in runway incursion prevention training and familiarisation for all key stakeholders — pilots, air traffic controllers and manoeuvring area vehicle drivers.

Recommendation REG3: As part of the regulator's oversight programme:

a. Ensure that the subject of runway safety is included within initial and recurrent training with specific reference to manoeuvring area signs, markings and lights for pilots and drivers.

b. Ensure that the content of training materials for pilots, air traffic controllers and drivers working in the manoeuvring area includes runway incursion prevention measures and awareness.

Reviewing and continuously improving the training program for pilots, air traffic controllers, and aerodrome personnel on runway incursion prevention measures, should include:

- Reviewing operators' incident prevention programs, including occurrence reporting relating to runway incursions for aircraft operators;
- Reviewing operators' training programs to ensure that runway incursion prevention measures and awareness are included;
- Reviewing the training programs for air traffic controllers to ensure that the subject of runway incursion prevention is included in initial and recurrent training;
- Reviewing the training programs for pilots to ensure that the subject of runway safety is included in initial and recurrent training with specific reference to manoeuvring area signs, markings, and lights for pilots and drivers; and,
- Reviewing the training programs for pilots and airside drivers who operate on the manoeuvring area with particular reference to runway and taxiway operations.

5. Joint-Use Aerodromes

Recommendation REG9: Where more than one aerodrome operator exists at a joint-use aerodrome, a leading aerodrome operator should be identified to secure a harmonised, consistent and coordinated application of the recommendations for the prevention of runway incursions.

Recommendation REG10: Differences in the application of civil and military traffic procedures that can affect operational safety should be published in accordance with ICAO Annex 15, Aeronautical Information Services.

Recommendation REG11: Coordinate civil and military inspection/audit activities and subsequent safety recommendations with civil and military authorities to ensure runway incursion mitigations are jointly agreed and implemented.

Recommendation REG12: GAPPRI recommendations on infrastructure (e.g., stop bars) should be implemented at civil/military joint-use aerodromes where civil aircraft operations are permitted.

One approach to increasing airport capacity is to operate from joint-use aerodromes. A number of communities see the opening of military airbases for civilian use as an opportunity for local economies. Joint-use aerodromes may be used for the training/flight checking of airline pilots or as bases for technical and test flights.

The military aviation community is not immune from runway incursions. Military personnel can therefore contribute to the prevention of runway incursions. Like all staff operating on the manoeuvring area, military personnel need to be aware of the potential hazards.

In respect to the application of GAPPRI recommendations, the regulators have a role to ensure the military should be involved as:

- Regulator: military aviation authority (MAA) or equivalent national regulatory body;
- Aerodrome operator: military aerodrome and military unit co-located with a civilian aerodrome;
- ANSP: where the military provides aerodrome air traffic services to civil airspace users; and,
- Aircraft operator: military aircraft operator based/operating at joint-use aerodromes (i.e., where the aerodrome operator is civilian and the air traffic services provider is civilian.

Note that for some States there is one regulator responsible for all ATM matters, civil and military, and in others, there may be two regulators with discrete civil or military responsibilities.

There are three main areas at aerodromes where civil and military operations interact: the apron, the manoeuvring area, and approach/terminal airspace.

There are joint-use aerodromes where one aerodrome operator (civil or military) is wholly responsible for manoeuvring area operations. There are also joint-use aerodromes where more than one aerodrome operator is responsible for a specific segment of the aerodrome movement area.

The civil and/or military aerodrome regulator may perform the task of re-certifying an aerodrome and may clarify roles and responsibilities. To clarify roles and responsibilities, one of the aerodrome operators should take the lead in coordination of the application of GAPPRI recommendations.

One characteristic of joint-use aerodromes is the responsibility of two regulatory and supervisory authorities, one civil and one military. Although different States have different relationships between their military and civil regulators, military authorities are, in most cases, independent of their respective civil aviation authorities.

In certain cases, as a consequence, two auditing/oversight authorities perform audits at the same aerodrome independently. There is an opportunity to perform a coordinated inspection/audit and propose common conclusions and recommendations.

Joint-use aerodromes facilitate both types of flights, civil and military. The majority of applicable ICAO provisions are identical, although differences may be found regarding

procedures for formation flying or other military functions. The application of different types of procedures could create confusion during aerodrome operations.

For instance, conditional clearances should not be used for civilian traffic during military formation flight operations, and during surface movement, a formation of aircraft is considered as a single aircraft in terms of right-of-way. When an individual aircraft and a formation are on a converging course, a formation of aircraft should be treated as one entity.

Timely and effective coordination between the various airport entities responsible for ground operations is important. One of the practices at joint-use aerodromes is regular coordination between civil and military entities facilitating mixed types of operations. The means of coordination can range from a joint civil-military coordination body to a liaison officer assisting with daily coordination. In certain cases, the representative of a flying unit is present in the tower during military operations.

The civil and military authorities responsible for flight safety at the aerodrome should identify the potential risk regarding the unauthorised use of the runway and other portions of the manoeuvring area and implement measures to prevent events resulting in potential or actual runway incursions.

States should consider implementing recommendations and guidance material identified in GAPPRI for their application at joint-use aerodromes.

6. International Standardisation

Recommendation REG13: International, regional and national regulatory authorities should define, clarify and standardize the size, extent and layout of the 'protected area of the runway'. Regulators should ensure that the protected area is agreed to by the aerodrome operator and the ANSP and that it recognises the relationship between the runway strips, runway cleared and graded areas, runway holding positions, obstacle free zone and any low visibility operations requirements.

Recommendation REG14: International and regional regulatory authorities should review standards and guidance material for visual aids at runway holding positions to allow for more accurate aircraft positioning for all types of aircraft with varying flight crew field of vision. This includes, but is not restricted to, visibility of stop bars, aircraft low point-of-view assessment, the orientation of the lights and the view in situations where an aircraft is stopping at distance to keep sight of stop bars.

Regulators should use GAPPRI to facilitate discussions regarding what is considered to be the 'protected area of a runway' within the ICAO definition and to ensure that the standardised area is understood by pilots, airside drivers, and controllers. Ensuring a consistent approach will allow the analysis of data to be based on known criteria.

Regulators should promote the use of GAPPRI guidance on the consistent use of the runway incursion definition.

Regulators should review standards and guidance for visual aids at the runway holding positions to allow for more accurate aircraft positioning for all types of aircraft with varying crew fields of vision. This should be specifically performed as a measure to manage the risk associated with runway collision.

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APPENDIX F
Guidance and Explanatory Material R&D Recommendations for States, International Organisations & the Industry

GEM Recommendation R&D 1 202

GEM Recommendation R&D 2 202

GEM Recommendation R&D 3 203

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R&D1: International, Research improvements for ground-based runway collision alerting systems that improve the detection-reaction times.

Several airports have installed ground-based runway collision alerting systems. This safety net provides alerts to the controller of potential conflicts between aircraft or with vehicles on the runways and at their entrances and exits. Typically, it generates two kinds of alerts: alarms and warnings. An alarm indicates that there is an imminent danger of collision, and the air traffic controller must respond to the situation immediately. An alarm could be preceded by a warning if possible. This gives the controller the opportunity to determine whether the risk of a collision might arise and allows for rapid intervention. The involved aircraft need to have a minimum groundspeed to generate alerts to avoid nuisance alerts from taxiing aircraft. The alerts generated by the ground-based runway collision systems are provided to the controller only. The controller has to take action and relay the alert to the flight crew(s). Studies of human performance conducted by the MITRE Corporation suggest controllers like to gather as much information about the situation, within a reasonable amount of time, before they begin issuing instructions to aircraft involved in a conflict. Together with the time the flight crew take to make their actions, a considerable time may have progressed between the generation of the alert and, for instance, the start of the deceleration of an aircraft. Examples of past occurrences have shown that such delays reduce the effectiveness of the runway safety net, especially in conflicts involving departing aircraft.

Research is needed to find ways to reduce the detection-reaction time of the air traffic controller in using ground-based runway collision alerting systems. This can be achieved through improved training, reducing task loads, etc. The safety logic and alerting system could also be improved by the use of artificial intelligence (AI) that can aid the controller in speeding up the decision-making process. The most effective ways to reduce the detection-reaction time need to be explored.

Sanchez J., Smith E. C., Chong R. S. 2009, Controller and Pilot Response Times to Runway Safety Alerts, MTR090237, The MITRE Corporation, McLean, VA.

https://skybrary.aero/sites/default/files/bookshelf/3258.pdf

R&D2: Research use of high-fidelity cameras and artificial intelligence (AI) to detect ground movements on and around runways.

High fidelity cameras that are located at strategic locations around airports and taxiways are able to monitor the ground movements of aircraft and vehicles. With current AI technology, it is possible to recognise and detect individual aircraft and vehicles. These recordings can be analysed by AI- based software to predict potential conflicts on the runway. Combining this with the automatic analysis of air traffic communication with aircraft and ground vehicles could improve the effectiveness. Research is needed to develop this type of system and to explore its potential for reducing runway incursions. Pursue the integration of infrared technology into the ground surveillance systems or as additional system, especially, but not only for remote controlled towers.

R&D3: Research data-driven runway collision safety by using automated analysis of air-ground communication recordings.

Air-ground communication errors can lead to safety critical events such as runway incursions. Most safety information comes from occurrence reports. However, there is no knowledge of how often errors go undetected or are being resolved (safety barrier efficiency). A better understanding of these events can reduce the number of air-ground communication errors. Research is needed to automatically analyse recorded ATC communication data. Tools are needed that can covert audio data into text which can be further analysed using data-mining techniques (e.g., machine learning). This could detect read-back/hear-back errors and, asking again corrections and call sign confusion. The converting tools must be able to understand aviation English. The possibilities of generating real-time warnings to air traffic controllers should also be explored in the research.

R&D4: Research the human performance aspects of detection and reaction to runway signs, markings and lighting, including stop bars.

Airports use a wide variety of signs, markings, and lighting to improve situational awareness of flight crews and vehicle drivers and to alert them that they are entering an active runway. Many of these signs, markings, and lights were designed years ago. The human performance aspects of detection and reaction (information processing) to these signs, markings, and lights might either not be as effective as initially thought or even the lights might produce glare depending on bulb or (combined) LED light system usage. Research should focus on studying this and possibly improve existing or introduce new systems.

R&D5: Research new ways of delivering direct auditory warnings, alarms, alerts for runway collision risk in the cockpit.

Ground-based runway collision alerting systems available at a number of airports provide alerts to the controller only which after processing are provided to the flight crew. This introduces delays. Bypassing the controller and directly transmitting the alert to the flight crew or vehicle operators could reduce the delay. This concept has been considered in the past, but false alerts remained a significant source of disturbances and limited user-confidence in these systems. Research is needed to explore and develop methods and/or a system that generates alerts to the flight crew or vehicle operators with the fewest possible false and nuisance alerts. Research examples include real-time computation of runway collision risk with automatic dependent surveillance–broadcast (ADS-B) -capable aircraft using new detection and alerting algorithms. Research on new forms of visual and auditory alerting should not be restricted to the aircraft cockpit. Control Tower alerts could also be considered.

Duane Ludwig, Direct alerting to the cockpit for runway incursions, IEEE/AIAA 26th Digital Avionics Systems Conference, 2007.

Daniel Lopez Fernandez, Runway incursions and collisions prevention: Onboard solutions, ICAO Runway Safety Seminar: Technology, Paris, 22 - 24 March 2022

R&D6: Research and develop an on-board functionality that provides a flight crew with visual aids concerning taxi clearance and signs corresponding to runway and airport status (e.g., out-of-service zones).

Research on flight crew coordination and taxiing standard operating procedures (SOPs e.g., determination of who has the role of pilot flying [PF] during taxi) can help to assess whether current solutions effectively mitigate taxiing errors and runway incursion risks.

R&D7: Research visual aids on the airport surface regarding ATC clearance or impediments.

A means should be found to bring the clearance to the flight. The way the clearance is integrated on the flight deck display should be explored such as an integration onto the airport moving map or other means. The runway and taxiways associated with the clearance should be clearly depicted. In addition, providing alerts if the aircraft deviates from the cleared path should be considered.

R&D8: Research ways to lower the activation threshold speed of ground-based runway collision alerting systems.

Several airports have installed ground-based runway collision alerting systems. This safety net provides alerts to the controller of potential conflicts between aircraft or between aircraft and vehicles on the runways and at their entrances and exits. The involved aircraft need to have a minimum groundspeed to generate alerts to avoid nuisance alerts from taxiing aircraft. Typical thresholds are 40 knots for departing aircraft and 30 knots for arriving aircraft. Lowering these values will more quickly inform controllers of a potential conflict. Research should examine the possibilities for lowering the thresholds without introducing too many nuisance alerts, which would make the system useless. This could be achieved by using additional data sources to confirm a departure or arrival (e.g., using voice communication data that is automatically analysed with advanced audio text converters that are able to handle aviation communication voice data).

APPENDIX G
Runway Incursion Classification

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1. Runway Incursion Definition Context

The International Civil Aviation Organization (ICAO) definition of runway incursion, introduced in November 2004, is:

> *"Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft".*

Whilst the definition has been widely accepted — and no change to it is proposed — it has become apparent that determining whether an event is a runway incursion is still subjective and opinions vary considerably.

At a national level, to ensure consistency in runway collision–prevention actions, it is suggested that an interdisciplinary group for the interpretation of the runway incursion definition be formed. This group could be a part of the national runway safety team and should involve aerodrome operators, air navigation service providers, aircraft operators, and the national civil aviation regulator. The tasks of the group should include:

- Agreeing on and publishing the national interpretation and criteria for the definition of runway incursion; and,
- Reviewing events where there are disagreements or ambiguities about whether they can be classified as runway incursions. The reviews should be conducted according to the published national interpretation and criteria and should augment those if needed.

To support the work of the national group for the interpretation of runway incursion definition, the following are some best practices and guidance for possible interpretations, together with some examples. It is important to note that these examples and criteria are one possible way to interpret the runway incursion definition, and an approach should be adopted nationally.

Sometimes, discussions about whether an event should be classified as a runway incursion are driven by concerns related to regulatory compliance and performance measurement. While this motivation for arguing for or against a classification is understandable, a different approach is adopted here. This approach advocates for the analysis of all events that provide insights into the aviation system's risk and resilience, and for lessons to be learnt, regardless of how an event is classified. In this respect, the label assigned to an event is less important than learning from it.

To further facilitate learning lessons from events, it is recommended that involvement in a runway incursion event should not in itself imply blame or error. Instead, the entire situation should be classified as the incursion and not merely the human action within it. This supports the philosophy of a just culture.

2. Runway Incursion Definition Criteria

There are three key elements in the ICAO definition that, when locally refined, can serve as criteria for assessing whether an event should be classified as a runway incursion:

A. "Surface designated for the landing and take-off of aircraft". This element refers to the status of the runway, specifying which statuses are considered in the context of runway incursion (for example, whether runways are active, inactive, suspended, closed, or decommissioned). Typically, if the presence of traffic on a runway is considered incorrect, then it falls within the scope of the definition. This means that if traffic is required to have clearance to operate on the runway but operates without one, or if the traffic operates with clearance on a runway where it is not permitted to do so (for example, due to work in progress), then the event can be classified as a runway incursion. An exception exists for operations on closed runways that are conducted in accordance with local plans or letters of agreement.

B. "Protected area". The protected area should be defined locally between the air navigation service provider (ANSP) and the aerodrome operator for each airport. The map of the protected area should be produced and made available to all persons operating on the manoeuvring area of the aerodrome (e.g., pilots and vehicle drivers). In the context of runway incursions, the protected area of a surface designated for the landing and take-off of aircraft is defined by ICAO[1] (Runway Safety Team Handbook – 2nd Edition, June 2015) to be comprised of:

a) The runway;

b) The stopway;

c) The runway end safety area (RESA);

d) The area along each side of the runway whose width is the runway-holding position distance; and,

e) If provided, the clearway.

Additionally, some regional[2] and national provisions include in the protected area:

f) The instrument landing system (ILS) glide path and localiser critical areas;

g) The ILS-sensitive areas during low visibility procedures; and,

h) Regarding d. where operations are being conducted during low visibility operations this should be the holding position appropriate to the procedures in force.

C. "Incorrect presence". The incorrect presence of an aircraft, vehicle or person (further referred to as traffic) can involve one of the following four generic cases:

a) **Unauthorised Presence:** This involves the unauthorised entry of traffic onto a protected area or traffic remaining unauthorised on the protected area after an initially authorised entry is no longer valid. Examples of the latter case include the incorrect presence of traffic that is supposed to have vacated the runway's protected area (e.g., after a wrong position report or uncertain position) or the opening of a runway while traffic is incorrectly still within the runway's protected area. Unauthorised presence does not include, for example, the cleared presence of a landing aircraft taking more time to vacate than expected by air traffic control (ATC).

b) **ATC-Induced Incorrect Presence of Non-Conflicting Traffic.** ATC incorrectly authorises traffic onto the runway protected area when there is no conflicting runway traffic at the moment of the clearance and the cleared traffic enters onto the runway protected area. This may occur due to incorrect position awareness of the traffic (e.g., an air traffic control officer [ATCO] believing the traffic is at another position), incorrect planning (e.g., an ATCO not realising the clearance would bring the traffic onto the runway protected area), or incorrect executions (e.g., a slip of the tongue). These cases are most often associated with an ATCO authorising traffic onto the runway without intending to do so. The absence of any conflicting traffic often results in these events not being reported. Note that the issuing of an incorrect clearance by the controller does

1 The ICAO Runway Safety Handbook says that "In the context of runway incursions, the protected area of a surface designated for the landing and take-off of aircraft is comprised of: the runway, the stopway, the runway end safety area (RESA), the area along each side of the runway whose width is the runway-holding position distance and, if provided, the clearway."

2 EASA EU Regulation No 139/2014 GM says that "The 'protected area of a surface designated for the landing and take-off of aircraft' is to be interpreted as the physical surface of a runway, from the centreline to the holding point appropriate to the type of runway. Where operations are being conducted during low visibility operations this should be the holding point appropriate to the procedures in force. The 'protected surface' includes the ILS glide-path and localiser critical areas at all times, and the ILS sensitive areas during low visibility procedures."

not automatically mean that an incursion has happened at that precise moment — an incursion happens only when the traffic actually moves onto the runway/ protected area. It is at this point that the presence is incorrect.

c) **ATC Induced Runway Conflict.** ATC clearances or instructions result in a situation where an aircraft which is landing or taking off and other traffic are simultaneously present and converging within the protected area.

d) **Infringed Distances.** At least one traffic is within the protected area when there is an infringement of the minimum defined distances for:

   i. A departing aircraft followed by a landing aircraft;

   ii. A departing aircraft followed by another departing aircraft;

   iii. A departing aircraft followed by an aircraft going around[3];

   iv. A landing aircraft followed by another landing aircraft; and,

   v. A landing aircraft and other traffic on the runway protected area (excluding the cases defined above).

   The distances could be locally defined, and ICAO PANS ATM Chapter 7 (7.9, 7.10, and 7.11) criteria are relevant for these cases. This does not include ICAO PANS ATM Chapter 5 separation minima.

3 The specific situations and infringed distances that should be considered runway incursions are defined locally.

3. Examples

Example	Runway Incursion	Not Incursion[4]	Rationale
1. ATC-TXI ATC induced incorrect entry of a taxiing traffic or person onto the runway protected area.			
Controller incorrectly clears an aircraft, vehicle, or person to enter or cross a runway, and the runway is entered (i.e., the controller issues a clearance he or she wouldn't have issued if s/he was conscious of the whole situation.	Yes		It is the movement onto the runway or protected area that creates the incorrect presence – not the incorrect R/T transmission. The R/T transmission does not mean an RI occurs at that moment.
An aircraft is cleared to enter the runway after a landing clearance has been given to another aircraft and the aircraft has not crossed the runway holding point (yet).		Runway safety event	The R/T clearance does not mean an incursion has immediately happened.
An aircraft is cleared to enter the runway and does so, after a landing clearance has been given to another aircraft.	Yes		It is an incorrect presence.
2. PIL-TXI Pilot-induced incorrect entry of a taxiing aircraft onto the runway protected area.			
An aircraft is cleared correctly to enter or cross a runway and proceeds as cleared but does not read back the clearance.		Runway safety event	There is no incorrect presence. Failing to read back does not cre-ate an incursion.
An aircraft enters runway without clearance.	Yes		This is an incorrect presence.
An aircraft is cleared to enter the runway and does so as instructed and intended, but before the red stop bar has been switched off ("dropped"). At this airport, local procedures define crossing a red stop bar at runway holding position as an incorrect presence.	Yes		This is an incorrect presence.
An aircraft crosses a (runway holding position) lit red stop bar protecting the runway without ATC clearance, and enters the runway protected area.	Yes		This is an incorrect presence.
An aircraft enters the runway via the incorrect taxiway, not the taxiway the aircraft had been cleared to enter.	Yes		At this location on the runway, it is an incorrect presence.
Aircraft lines up out of sequence.	Yes		This is an incorrect presence.
Taxiway green lights are selected along a route onto the runway, but the ATC clearance is only part way along that route and the aircraft proceeds onto the runway beyond the stated clear-ance limit.	Yes		This is an incorrect presence.
Aircraft crosses a lit red stop bar but stays outside the protected area of the runway (e.g., stop bar at Cat III position but low visibility conditions not present).		Runway safety event	No incorrect presence on the runway or protected area. However, **pilots shall not cross lit red stop bars and shall check with the controller.**
An aircraft taxies up to a runway holding position and stops, with the undercarriage short of the holding posi-tion but the nose/radome beyond the holding position.	Yes		This is an incorrect presence.
A helicopter flies or ground-taxies along part of the runway length without clearance to do so.	Yes		This is an incorrect presence.
An aircraft correctly reads back the conditional clear-ance but enters the runway before the condition is met.	Yes		This is an incorrect presence.
A departing aircraft is given a conditional line-up clearance at the correct runway holding position which is read back correctly. The aircraft enters the runway at the correct time in terms of the conditional clearance, but in doing so, crosses a lit stop bar. At this airport, local procedures define crossing a red stop bar at runway holding position as an incorrect presence.	Yes		This is an incorrect presence.

4 Sometimes classified as a "runway safety event" or "surface incident", or "potential runway incursion" when, for example, conflicting clearances are issued.

Example	Runway Incursion	Not Incursion	Rationale
3. VEH-TXI Vehicle driver–induced incorrect entry/presence of a taxiing traffic onto the RWY protected area.			
Vehicle crosses a lit red stop bar but stays outside the protected area of the runway (e.g., stop bar at Cat III position but low visibility conditions not present).		Runway safety event	No incorrect presence on the runway or protected area. However, **drivers shall not cross lit red stop bars and shall check with the controller.**
During Cat III operations, a vehicle crosses the Cat III runway holding position without ATC clearance.	Yes		It is an incorrect presence.
During Cat I operations, a vehicle crosses the Cat I runway holding position without ATC clearance.	Yes		It is an incorrect presence.
Two airfield ops vehicles and two fire service vehicles call ATC and obtain permission to enter the runway correctly, which is done. Another vehicle joins the back of the convoy without communication and five vehicles cross the runway.	Yes		In this example, the fifth vehicle is an incorrect presence.
A vehicle is cleared correctly to enter or cross a runway and proceeds as cleared but does not read back the clearance.		Runway safety event	There is no incorrect presence. Failing to read back does not create an incursion.
A vehicle enters runway without clearance.	Yes		This is an incorrect presence.
A vehicle crosses a lit red stop bar at a runway holding point protecting the runway without ATC clearance, and enters the runway protected area.	Yes		It is an incorrect presence.
A vehicle enters the runway via the incorrect taxiway, not the taxiway the vehicle had previously been cleared to enter.	Yes		At this location on the runway, it is an incorrect presence.
4. PIL-VAC Incorrect presence of a vacating aircraft on the runway protected area.			
An aircraft vacates the runway at the incorrect runway exit.		Runway safety event	There is no incorrect presence on the runway.
The controller clears an aircraft to vacate the runway. While the aircraft is still on the runway protected area, the pilot reports it vacated, However, the controller does not see the respective taxiway and clears another aircraft for departure, leading to a conflict.	Yes		It is an incorrect presence of the vacating aircraft.
5. VEH-VAC Incorrect presence of a vacating vehicle on the runway protected area.			
A vehicle vacates the runway at the incorrect runway exit.		Runway safety event	There is no incorrect presence on the runway.
The controller clears a vehicle to vacate the runway. While the vehicle is still on the runway protected area, the driver reports it vacated, However, the controller does not see the respective taxiway and clears another aircraft for departure, leading to a conflict.	Yes		It is an incorrect presence of the vacating vehicle.

Example	Runway Incursion	Not Incursion	Rationale
6. ATC-DEP ATC-induced incorrect presence of a departing aircraft onto runway protected area.			
Two aircraft are correctly present on the runway after lining up: one for full length departure at the beginning of the runway and the other for an intersection take-off. The controller erroneously gives a take-off clearance to the aircraft at the beginning of the runway. The pilots of the aircraft realise the error, communicate with the controller and do not start to move.		Runway safety event	There is no incorrect presence.
Two aircraft are correctly present on the runway after lining up: one for full length departure at the beginning of the runway and the other for an intersection take-off. The controller erroneously gives a take-off clearance to the aircraft at the beginning of the runway. The pilots of the aircraft do not realise the error and the full length departure starts to roll.	Yes		It is an incorrect presence.
An aircraft is cleared to take-off and a vehicle is on the runway correctly and the pilot recognises the situation and refuses to move.		Runway safety event	There is no incorrect presence.
An aircraft is cleared to take-off and a vehicle is on the runway correctly and the aircraft commences its take-off roll.	Yes		It is an incorrect presence once the aircraft begins its take-off roll.
The tower controller erroneously clears an incorrect aircraft for take-off. He or she immediately realises the error and corrects the clearance. The aircraft does not move and remains at the holding position.		Runway safety event	There is no incorrect presence.
Controller incorrectly clears an aircraft to take-off and the aircraft does so (i.e., the controller issues a clearance he or she wouldn't have issued if s/he was conscious of the whole situation).	Yes		It is an incorrect presence. It is the movement onto the runway or protected area that creates the incorrect presence – not the incorrect R/T transmission. The RT transmission does not mean an RI occurs at that moment.
7. PIL-DEP Pilot–induced incorrect presence of a departing aircraft onto runway protected area.			
An aircraft enters the runway correctly but faces in the wrong direction (e.g., cleared to enter Runway 23 but lines up facing 05 direction) and starts its roll.	Yes		It is an incorrect presence once it starts take-off roll.
Aircraft takes off without clearance.	Yes		The aircraft was only cleared to line up. Thus, it is an incorrect presence once take-off is commenced.
An aircraft is cleared correctly to take off and proceeds as cleared but does not read back the clearance.		Runway safety event	There is no incorrect presence. Failing to read back does not create an incursion.
Aircraft is cleared to take off on Runway 04. Runways 04 and 36 have collocated thresholds. Aircraft starts to take off on Runway 36 and the take-off is cancelled by ATC.	Yes		This is a runway incursion as the aircraft has entered Runway36 without a clearance.
An aircraft takes off from a taxiway.		Runway safety event	There is an incorrect presence but not on a surface designated for the landing and take-off of aircraft.

Example	Runway Incursion	Not Incursion	Rationale
8. ATC-LND ATC-induced incorrect presence of a landing aircraft.			
Controller incorrectly clears an aircraft to land and the aircraft does so (i.e., the controller issues a clearance he or she **wouldn't** have issued if s/he was conscious of the whole situation).	Yes		It is an incorrect presence. It is the movement onto the runway or protected area that creates the incorrect presence – not the incorrect R/T transmission. The R/T transmission does not mean an RI occurs at that moment.
9. PIL-LND Pilot-induced incorrect presence of a landing aircraft.			
An aircraft is cleared correctly to land and proceeds as cleared but does not read back the clearance.		Runway safety event	There is no incorrect presence. Failing to read back does not create an incursion.
Aircraft lands without clearance being issued by the controller.	Yes		This is an incorrect presence.
Aircraft is to land Runway 12L with a correct readback. Aircraft lands on Runway 12R.	Yes		This is an incorrect presence on 12R and therefore a runway incursion.
Aircraft lands without clearance being received by the flight crew, after a go-around instruction from ATC.	Yes		Once a go-around instruction is given, it is an incorrect presence to land on the runway.
Aircraft lands without clearance, and evidence shows that the pilot was acting appropriately in accordance with loss of communication procedures due to R/T failure.		Runway safety event	There is no incorrect presence.
A pilot lands an aircraft without clearance on a runway that is closed and has been communicated as such by a NOTAM. At this specific airport, the local procedures require a clearance to enter a closed runway.	Yes		This is an incorrect presence. Aircraft landed without clearance on a closed runway.
An aircraft lands on a taxiway.		Runway safety event	There is an incorrect presence but not on a surface designated for the landing and take-off of aircraft.
10. PSN Person-induced incorrect presence.			
A person vacates the runway at the incorrect runway exit.		Runway safety event	There is no incorrect presence on the runway.
Person crosses a lit red stop bar but stays outside the protected area of the runway (e.g., stop bar at Cat III position but low visibility conditions not present).		Runway safety event	No incorrect presence on the runway or protected area. However, **persons shall not cross lit red stop bars and shall check with the controller.**
A person is cleared correctly to enter or cross a runway and proceeds as cleared but does not read back the clearance.		Runway safety vent	There is no incorrect presence. Failing to read back does not create an incursion.
A person enters runway without clearance.	Yes		This is an incorrect presence.
A person crosses a (runway holding position) red stop bar protecting the runway without ATC clearance, and enters the runway protected area.	Yes		It is an incorrect presence.
A person enters the runway via the incorrect taxiway, not the taxiway previously cleared.	Yes		At this location on the runway, it is an incorrect presence.

ATC = air traffic control, DEP = departure, LND = landing, PIL = pilot, PSN = person, RI = runway incursion, R/T = radiotelephony, TXI = taxi, VAC = vacating, VEH = vehicle

APPENDIX H
GAPPRI RIRRA (Runway Incursion Risk and Resilience Assessment): Data & Knowledge Methodology

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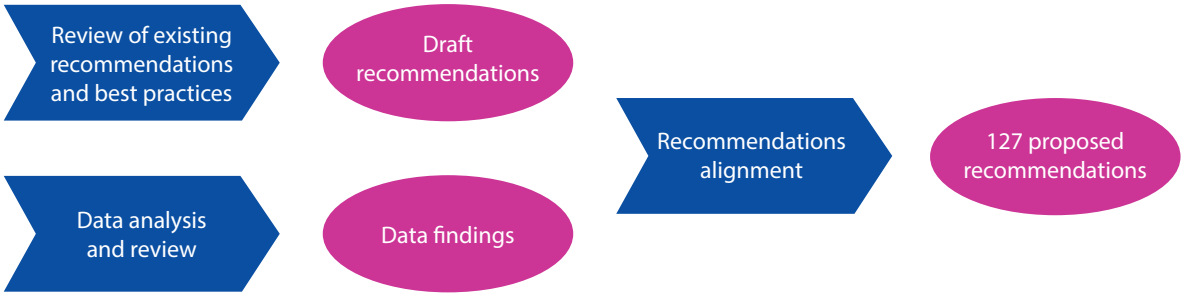
1. Introduction

This document describes the approach undertaken within the Global Action Plan for the Prevention of Runway Incursions (GAPPRI) initiative to formulate the respective recommendations. It outlines the GAPPRI Runway Incursion Risk and Resilience Assessment (RIRRA) methodology. The purpose of this document is to provide transparency regarding the origin of GAPPRI recommendations, and to document the unique approach and RIRRA methodology used and to promote them to those who may find them useful within their own activities.

2. The Process of Developing GAPPRI Recommendations

The overall process of developing GAPPRI recommendations is illustrated in Figure 50.

Figure 50. **Learning From All Operations Concepts as Applied to the Case Study**



The process elements include:

- Utilising the extensive expertise of a diverse group of 200 aviation professionals who shared, discussed, and vetted a set of best practices and existing local and regional recommendations for their global applicability. This part of the process produced a set of draft recommendations.
- Using various data sources to formulate data findings. This part of the process resulted in 42 data findings that were further used in the process.
- Aligning and synchronising the recommendations across the six GAPPRI groups. This part of the process resulted in a set of proposed recommendations that was widely communicated and reviewed within the aviation community before being published as GAPPRI Volume I in December 2023.

The process steps involved several iterations of discussions, comments, and updates of specific review sheets:

- Review of existing recommendations based on experience;
- Review of data conclusions;
- Cross-group review of recommendations;
- Open review by wider aviation community, followed by an alignment. The alignment included another cross-group review for interdependencies and a safety barrier analysis to ensure a systematic approach in addressing risk and resilience; and,
- Final review within the work groups and consolidation of proposed recommendations.

The review process was staggered over time, with the work groups performing the specific review that was previously conducted by the work group leadership teams (Figure 51).

Figure 51. **The review process steps staggered in time**

	Month 1	Month 2	Month 3	Month 4	Month 5&6	Month 7&8
Lead teams	Experience review	Data review	Cross-groups	Draft recommendations	Draft recommendations open review and alignment	Proposed recommendations
Work groups		Experience review	Data review	Cross-groups	Draft recommendations open review and alignment	Proposed recommendations

The following sections of this document will describe the three process elements.

3. Review of Existing Recommendations and Best Practices

3.1 Learning from existing recommendations

As part of the process to develop recommendations, the GAPPRI group actively searched for, collected, and discussed existing recommendations. The analysed recommendations came from regional safety initiatives, national safety plans, and individual organisations' safety management processes.

To demonstrate the nature of the reviewed recommendations, here are some examples that were reported and considered during the GAPPRI review process:

- The U.S. Federal Aviation Administration (FAA) reported that at larger airports with ground radar (ASDE-X), they are implementing a taxiway arrival prediction (ATAP) alert. This system allows controllers to send an aircraft around if it is aligned on a wrong surface.
- The FAA reported an initiative to produce aerodrome-specific pilot information booklets. These booklets complement existing aeronautical information by providing additional airport information, airport-specific videos, and various aviation sources in one digital, compact resource for pilots.
- The FAA reported another outreach effort to raise surface safety awareness through the pilot simulator tool. The runway safety pilot simulator includes numerous real-world redacted scenarios that provide lessons learnt from actual runway incursions and wrong-surface operations that have occurred in the U.S. airspace system.
- In version 3.0 of the European Action Plan for the Prevention of Runway Incursions (EAPPRI), it is recommended that new aerodrome infrastructure and changes to existing infrastructure should be designed to reduce the likelihood of runway incursions.
- EAPPRI recommends that aerodrome operators, in conjunction with air navigation service providers (ANSPs), review procedures for runway inspections, including carrying out runway inspections in the opposite direction to runway movements, implementing measures to ensure that unidirectional lighting is inspected effectively, and temporarily suspending operations to allow full runway inspections to be carried out without interruption.
- EAPPRI recommends that aerodrome operators and ANSPs, where practicable, improve situational awareness by conducting all communications associated with runway operations using aviation English and on a common or cross-coupled frequency.
- EAPPRI recommends that aircraft operators ensure aerodrome charts or an equivalent electronic device is displayed on the flight deck during taxi.
- EAPPRI recommends that ANSPs adopt procedures to ensure that when an aircraft is at a holding position or on the runway, air traffic control (ATC) always uses the phrase "HOLD POSITION" before issuing a revised clearance.

Once collected, the recommendations were iteratively discussed in a transparent and traceable manner. Specific review sheets were drafted for each of the work groups and document-controlled for each of the iterations.

3.2 Learning from resilience

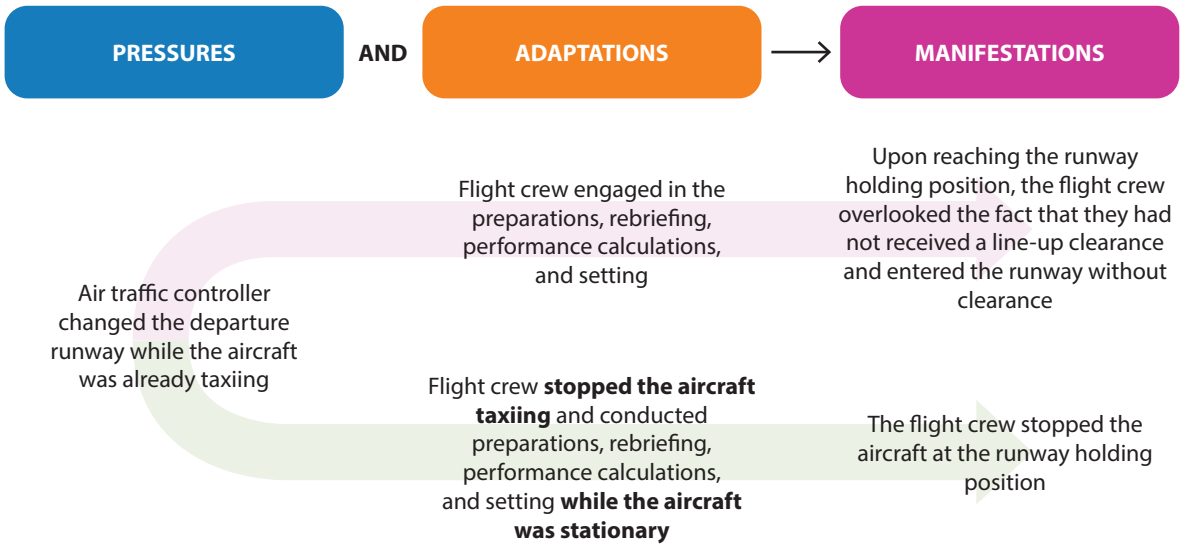
The RIRRA methodology adopted by the GAPPRI group was knowledge-based and data-driven. Utilising Learning from All Operations, a strategy pioneered by Flight Safety Foundation, the group expanded its focus from merely hazardous events to include learning from best practices.

The key to the process is to learn not just from accidents and incidents, which are the outcome effects of the operational processes, but also to examine the mechanisms in terms of the overall system adaptive processes and the factors that influence these operational processes — the system pressures. This approach is based on the FSF Pressures, Adaptations, and Manifestations model (PAM). An example is provided in Figure 52.

In the example, pressure follows ATC's action changing the departure runway while the aircraft was already taxiing. The GAPPRI work group learned about this pressure in two ways:

- Safety incidents were reported in which, following the pressure, the flight crew engaged in preparation, rebriefing, performance calculations, and settings. As a result, upon reaching the runway holding positions, the flight crew omitted the fact that they had not received a line-up clearance and entered the runway without clearance. This resulted in a runway incursion.
- A best practice was reported for situations in which such ATC pressure exists and when the risk may be elevated (e.g., airports with short taxi times from the apron to the runway holding position). The reported best practice is for the flight crew to stop taxiing and perform the preparation, rebriefing, performance calculations, and settings while the aircraft is stationary. Using this practice reduces the likelihood of a runway incursion and helps ensure the flight is uneventful. There is much to be learned from this best practice without waiting for a safety incident to occur.

Figure 52. **An example of using the FSF Pressures, Adaptations, and Manifestations model**



In this particular case, some GAPPRI recommendations were proposed, reviewed, and included in the published GAPPRI Volume I. For example:

- Recommendation for aircraft operators–AO9: When a take-off runway change is received whilst taxiing, the set-up, planning, performance calculations, and re-briefings should be performed by flight crew without rushing and when the aircraft is stationary.
- Recommendation for ANSPs–ANSP19: When planning runway assignment change for departing or arriving traffic, consider the time the flight crew will need to prepare/rebrief. As far as practicable, a change to the runway assignment for an aircraft taxiing for departure should be avoided.

4. Data Analysis and Review

As described in the previous section, the GAPPRI recommendations were informed by the extensive knowledge and experience of a large group of safety professionals with diverse operational backgrounds, from different aviation sectors and global regions. Moreover, the recommendations were firmly based on evidence, ensured though the dedicated data analysis effort.

GAPPRI data analysis used several data sets. In some instances, the conclusions derived by the partnering organisations were shared and in other instances, the data set was analysed by the GAPPRI work group. In summary, two global and two regional data sets were used to inform the GAPPRI recommendations.

The two global data sets used to support GAPPRI are:

- Analysis of global six-year sample of 68 accidents and serious incidents. This data set was compiled and analysed by the GAPPRI work group.
- International Air Transport Association (IATA) Incident Data eXchange (IDX) data set of runway incursions from January 2020 through December 2022. IATA performed this analysis and shared the results specifically to support the GAPPRI work.

The two regional data sets used to support GAPPRI are:

- The FAA shared conclusions from its data analysis.
- EUROCONTROL shared conclusions and data insights from the EUROCONTROL Network Manager safety prioritisation process (annual Top 5 process).

From the analysis of the data and insights from the different data sets, some candidate data findings were proposed. The candidate data findings were subsequently assessed for their global applicability. Those considered globally applicable and relevant for GAPPRI formed a list of 42 data findings; a list is provided in Annex 3. Later in this document, some of the data findings are discussed and presented. These data findings come from different data sets but were considered globally relevant and applicable for GAPPRI. It is important to note that the statistics may not necessarily be the same for each region, state, or organisation. However, the conclusion of the GAPPRI group was that these findings are relevant for formulating recommendations.

To support the data analysis and consolidation of data conclusions, as part of the RIRRA methodology, the GAPPRI work group formulated explicit runway incursion scenarios. These scenarios were based on the review of available data, data insights from the data sets, and the experience of the group members. Subsequently, the scenarios were widely communicated and validated by the GAPPRI work group. The list of detailed scenarios is provided in Annex 1.

These scenarios comprise a systematic, structured full set of plausible runway incursions. For example:

- One of the scenarios is "Pilot induced incorrect presence of taxiing aircraft onto the runway protected area".
- One of the sub-scenarios to the above scenario is "A taxiing aircraft correctly understands the ATC clearance but follows it incorrectly".
- Examples of such scenarios seen in the data sets include crossing the holding position after incorrectly identifying it. Contributing factors in some cases were weather conditions, night-time, wet surface conditions and glare, and not very visible markings. In some reported events, there was confusion between closely positioned runway end lights and stop bars during dawn and reduced visibility conditions.

Using an operationally meaningful scenario approach was found to be helpful. First, the prevention and mitigation strategies for the different scenarios are not necessarily the same. Using operationally meaningful scenarios allows the risk to be targeted most efficiently.

Second, the analysis helps to measure the criticality of the scenarios. Not all scenarios are equally critical. This is especially true when the analysis is conducted on an airport-by-airport basis, allowing the correct risk to be targeted.

Analysis of the prominence of the scenarios in the sub-set of the most serious runway incursions (those classified with Severity A or B) based on some of the available data sets is illustrated in Figure 53. The data set size is 362 incidents. The scenarios are represented by the rows in the table. The columns identify what generic barrier helped prevent the scenario from further developing — essentially, which barrier worked and stopped the scenario:

- RIP denotes runway incursion prevention.
- RCP denotes runway conflict prevention.
- ATC-CA denotes ATC collision avoidance.
- P-CA denotes pilot collision avoidance.
- PROV denotes providence (chance).

By showing how many incidents of each scenario type were prevented by which barrier, this information helps build an understanding of how frequent the scenarios are and how critical they are (i.e., prevented by some of the last available barriers).

Figure 53. **Prominence of the runway incursion scenarios in absolute figures**

	TOTAL	RIP	RCP	ATC-CA	P-CA	PROV	TOTAL
1. ATC-TXI	33	2	6	10	12	3	33
2. PIL-TXI	84	1	15	44	22	2	84
3. VEH-TXI	22	0	2	12	7	1	22
4. PIL-VAC	6	0	1	2	3	0	6
5. VEH-VAC	4	0	0	0	4	0	4
6. ATC-DEP	56	2	13	19	17	5	56
7. PIL-DEP	18	0	8	5	2	3	18
8. ATC-LND	103	1	23	60	18	1	103
9. PIL-LND	35	0	12	6	17	0	35
10. PSN	1	0	0	0	0	1	1
TOTAL	362	6	80	158	102	16	362

The results from the previous table can also be represented as percentages of the overall analysed sample. The results are shown in Figure 54. Cells highlighted in red indicate areas determined to be important to address further through recommendations.

Figure 54. **Prominence of the runway incursion scenarios as a share from the sample**

	TOTAL	RIP	RCP	ATC-CA	P-CA	PROV	TOTAL
1. ATC-TXI	9,12%	0,55%	1,66%	2,76%	3,31%	0,83%	9,12%
2. PIL-TXI	23,20%	0,28%	4,14%	12,15%	6,08%	0,55%	23,20%
3. VEH-TXI	6,08%	0,00%	0,55%	3,31%	1,93%	0,28%	6,08%
4. PIL-VAC	1,66%	0,00%	0,28%	0,55%	0,83%	0,00%	1,66%
5. VEH-VAC	1,10%	0,00%	0,00%	0,00%	1,10%	0,00%	1,10%
6. ATC-DEP	15,47%	0,55%	3,59%	5,25%	4,70%	1,38%	15,47%
7. PIL-DEP	4,97%	0,00%	2,21%	1,38%	0,55%	0,83%	4,97%
8. ATC-LND	28,45%	0,28%	6,35%	16,57%	4,97%	0,28%	28,45%
9. PIL-LND	9,67%	0,00%	3,31%	1,66%	4,70%	0,00%	9,67%
10. PSN	0,28%	0,00%	0,00%	0,00%	0,00%	0,28%	0,28%
TOTAL%	100,00%	1,66%	22,10%	43,65%	28,18%	4,42%	100,00%

The GAPPRI group also analysed the distribution of the data across the generic barriers for each scenario. This provides more information about the barrier efficiencies per scenario. As in Figure 55, cells highlighted in red indicate areas identified through comparative analysis of each scenario that need to be further discussed as part of the recommendations formulation.

Figure 55. **Prominence of the runway incursion scenarios as a share from the scenario size**

	TOTAL	RIP	RCP	ATC-CA	P-CA	PROV	TOTAL
1. ATC-TXI	33	6,06%	18,18%	30,30%	36,36%	9,09%	100,00%
2. PIL-TXI	84	1,19%	17,86%	52,38%	26,19%	2,38%	100,00%
3. VEH-TXI	22	0,00%	9,09%	54,55%	31,82%	4,55%	100,00%
4. PIL-VAC	6	0,00%	16,67%	33,33%	50,00%	0,00%	100,00%
5. VEH-VAC	4	0,00%	0,00%	0,00%	100,00%	0,00%	100,00%
6. ATC-DEP	56	3,57%	23,21%	33,93%	30,36%	8,93%	100,00%
7. PIL-DEP	18	0,00%	44,44%	27,78%	11,11%	16,67%	100,00%
8. ATC-LND	103	0,97%	22,33%	58,25%	17,48%	0,97%	100,00%
9. PIL-LND	35	0,00%	34,29%	17,14%	48,57%	0,00%	100,00%
10. PSN	1	0,00%	0,00%	0,00%	0,00%	100,00%	100,00%
AVERAGE%		1,68%	24,20%	39,19%	28,84%	6,08%	

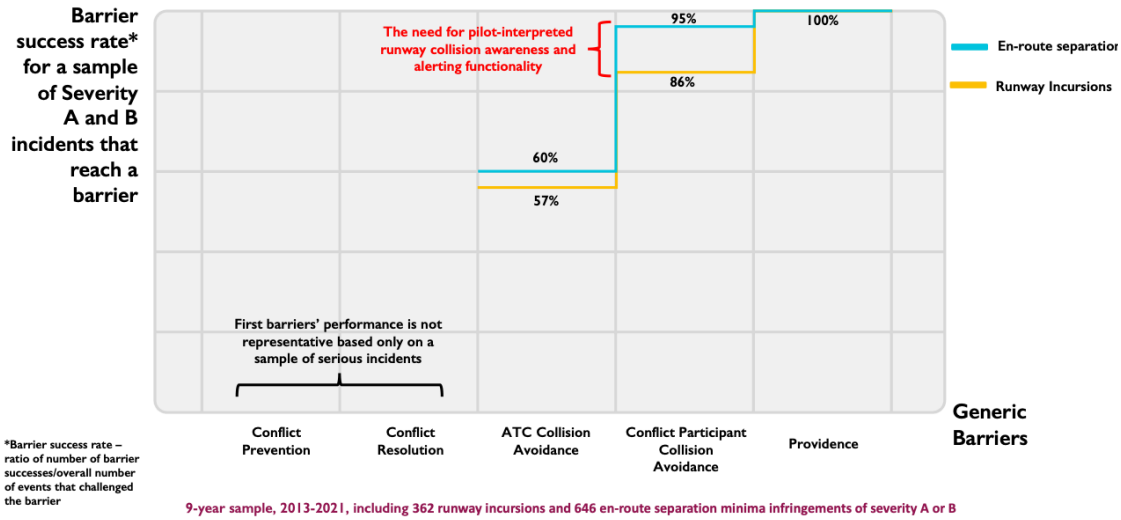
The analyses of the barriers also raised the question of how successful the barriers were. This is not immediately evident in the previous figures because they show only the absolute number of incidents stopped by each barrier. To show barrier efficiency, it is necessary to normalise these against the number of incidents that challenged the barrier. The ratio of the number of barrier successes to the overall number of events that challenged the barrier is the barrier success rate. The barrier success rates for the last three barriers are provided in Figure 56. The barriers' success rates for preventing midair collisions in en-route airspace are shown in blue. The barriers' success rates for preventing runway collision are shown in yellow. Barrier success rates are not provided for the first two barriers — conflict prevention and conflict resolution — due to the characteristics of the samples used, as Severity A and B incidents are most often stopped by the last barriers.

functionality for runway collision awareness and alerting using positional data.

During the GAPPRI data and knowledge review process, a question arose about the resilience potential of the different aviation system constituents. For example, research was conducted on the resilience potential associated with the air traffic controller's identification of potential runway conflict.

In practice, this involves the controller identifying an occupied or about-to-be occupied runway before clearing other traffic to use the runway. It is important to note that the study examined resilience potential. Some scenarios are triggered by controller-induced incorrect clearances after forgetting and not detecting a previously cleared runway use. However, some of the scenarios are tiggered by an incorrect presence on the runway because of actions by other actors, not the controller. An example would be an incorrect entry

Figure 56. **Comparing barriers' success rates**



An examination of Figure 56 shows that the main difference in barriers' success rates between en-route airspace and on the runway is for the conflict participant collision avoidance barrier (aircraft in the air and aircraft and vehicles on the ground).

The barrier "conflict participant collision avoidance barrier" for runway incursion incidents is around 10 percent less efficient compared to the same barrier for en-route losses of separation incidents. This is an important GAPPRI data finding. A conclusion was made that there is a need to strengthen this barrier, including investigating development and implementation of real-time, pilot-interpreted autonomous

onto the runway protected area of a ground vehicle and a subsequent conflicting clearance for a departing aircraft. In the later scenario, although the controller was not the initiator of the incorrect presence, the controller could have identified it before issuing the subsequent conflicting clearance.

Figure 57 provides some information about the sharing of such resilience potential from the sample of Severity A and B incidents — 148 of 362 incidents. This means that 41 percent of the most serious incidents could have been prevented if the controller had identified the potential conflict before clearing other traffic to the runway.

Figure 57. Resilience potential and differentiating factors — controller detection of potential runway conflict

	Vehicles involved	On-the-job training	Weather	Positions hand over take over	ATCO Workload	LVP
Overall sample of studied incidents (362)	26%	5%	7%	4%	7%	7%
ATCO not detecting potential RWY conflict (148)	38%	4%	10%	6%	11%	10%

Additionally, Figure 57 provides information on the shares of some of the factors (for example, during adverse weather, controller position hand over or low visibility procedures (LVP)) in the overall sample and in the sub-sample of the incidents that could have been prevented by controller identification of potential runway conflict. For example, vehicles were involved in 26 percent of the most serious incidents but were involved in a much larger share — 38 percent — of the incidents which the controller could have prevented by identifying potential runway conflict.

To provide more operational context, Figure 58 illustrates the discussed resilience potential differentiated by the following operational scenarios:

- 68 incidents (19 percent of the sample of serious incidents) could have been prevented by controller identification of potential conflict against other traffic before clearing an aircraft to land.
- 17 incidents (5 percent of the sample of serious incidents) could have been prevented by controller identification of potential conflict against other traffic before clearing taxiing traffic to the runway.
- 63 incidents (17 percent of the sample of serious incidents) could have been prevented by controller identification of potential conflict against other traffic before clearing an aircraft to take off.

Figure 58. Resilience potential and operational scenarios — controller detection of potential runway conflict

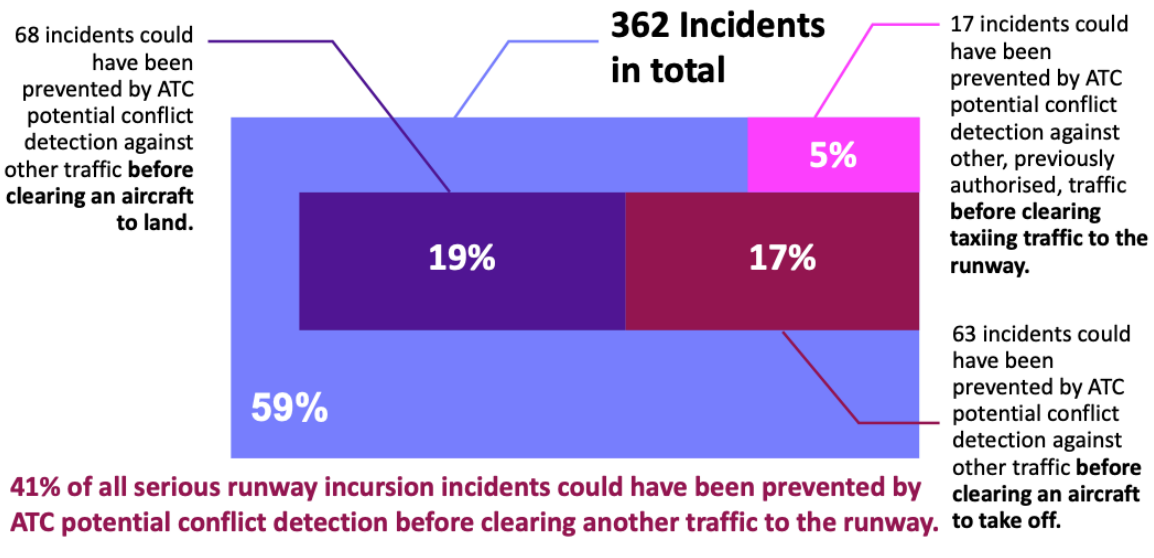
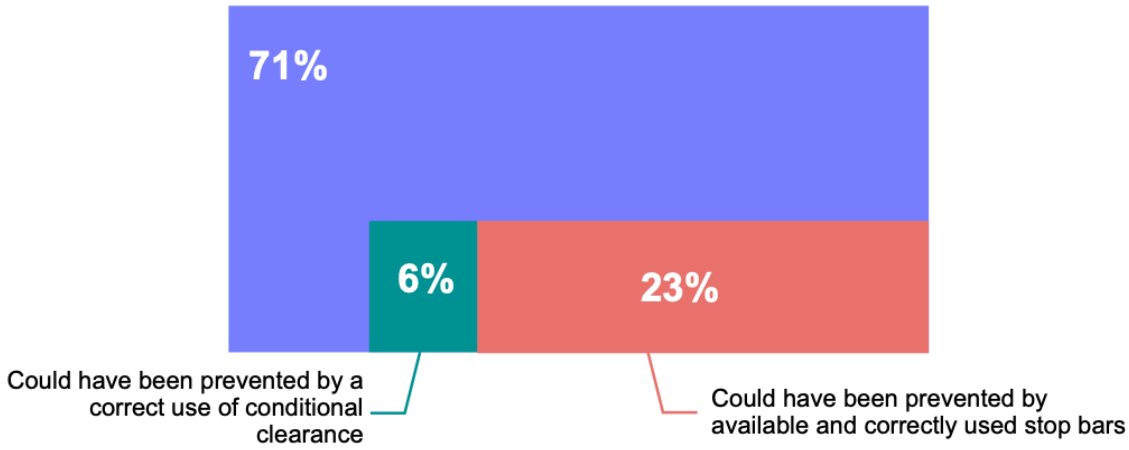


Figure 59. **Resilience potential –use of stop bars and correct use of conditional clearances**



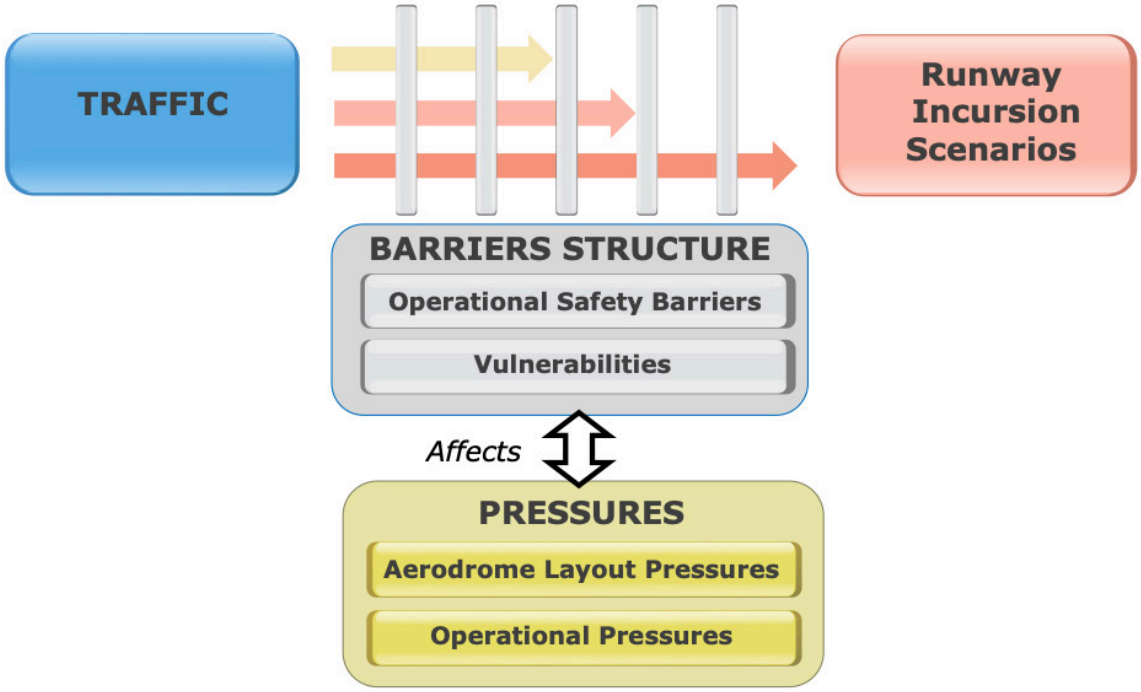
A similar approach was applied to assess the resilience potential associated with the use of stop bars and the correct use of conditional clearances. The results are illustrated in Figure 59.

In similar way, specific data insights or data findings shared by the partners were compiled and assessed for global relevance. The resulting list of GAPPRI data findings is provided in Annex 3.

5. Recommendations Alignment

The RIRRA methodology conceptual framework is described further in this document and is illustrated in Figure 60.

Figure 60. **RIIRRA Conceptual Framework**



GAPPRI documented a list of draft recommendations. As described previously, the sources were:

- Knowledge-based review of existing recommendations and best practices; and,
- Data-driven approach identifying data findings and relevant draft recommendations.

Once a list of draft recommendations was defined, the next step in the GAPPRI RIRRA methodology was to align these recommendations:

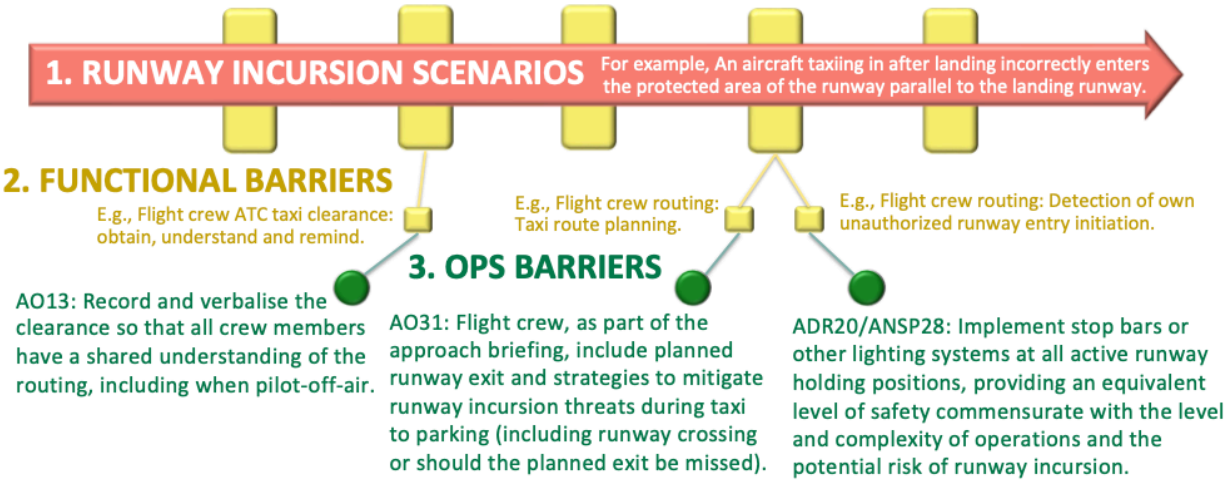
- Aligning the recommendations to be synchronised for all six GAPPRI work groups; and,
- Aligning the recommendations to systematically address risk and resilience.

The alignment was carried out in three steps:

- Review of the runway incursion scenarios formulated to help the data analysis (Annex 1). This review resulted in fine tuning and increased granularity of the scenarios and sub-scenarios.
- Developing specific RIRRA safety barrier models for ANSPs and aircraft operators to address the risk of iden-tified scenarios from Annex 1. The barrier models are for the risk of runway collision and were developed by reviewing the EUROCONTROL Safety Functions Maps (SAFMAPs) barrier models. This involved selecting the relevant functional barriers and grouping them to ANSP or aircraft operators' models, depending on which actor uses them in operations. For example, "Pilot position awareness" was allocated to the aircraft operators' model, "ATC non-conflicting clearances plan, techniques and execution" was allocated to the ANSP model, and "Traffic awareness" was allocated to both ANSP and aircraft operators' models. The RIRRA barrier models are provided in Annex 2.
- Mapping the GAPPRI draft recommendations to the barriers they could support (for example, by mitigating the relevant pressures) and analysing how the recommendations address risk and resilience. The mapping involves recommendations that directly support the efficiency of a barrier or indirectly support it, for example, through safety management activities.

The three steps alignment process
is illustrated with an example in Figure 61.

Figure 61. **The three steps alignment process**



The example from Figure 61 involves:

- Scenario — An aircraft taxiing in after landing incorrectly enters the protected area of the runway parallel to the landing runway.
- Identified preventive functional barriers for flight crew:
  - Flight crew ATC taxi clearance: obtain, understand and remind.
  - Flight crew routing: Taxi route planning.
  - Flight crew routing: Detection of own unauthorised runway entry initiation.
- The following recommendations to support the functional barriers were identified (as it can be seen, the recommendations are not only for aircraft operators but also are aligned across different work groups):
  - AO13–"Aircraft operators should implement policy and procedures which require pilots to handle and process ATC clearances during ground manoeuvring with the same caution and attention as in-flight clearances. Operators should consider SOPs on recording and verbalising the clearance so that all crewmembers have a shared understanding of the routing, including when pilot-off-air."
  - AO31–"Aircraft operators should implement policy and procedures that flight crew, as part of the approach briefing, include planned runway exit and strategies to mitigate runway incursion threats during taxi to parking (including runway crossing or should the planned exit be missed).
    "Operator training and policy should highlight to crews the human error potential during this phase, when crews may be distracted by events on approach/landing and after-landing tasks, and their attention may drift to the next flight or the end of duty."
  - ADR20 a./ANSP28 a. "Implement H24 stop bars or other lighting systems (e.g., autonomous runway incursion warning system [ARIWS]) at all active runway holding positions to provide a level of safety commensurate with the level and complexity of operations and the potential risk of runway incursion."

Such alignment mapping was performed for all the recommendations. An illustration of the mapping of the aircraft operators' recommendations to the aircraft operators' barriers is provided in Figure 62.

Figure 62. **The three steps alignment process**

	Position Awareness					ATC Clearance							Routing							Traffic Awareness						Collision Avoidance				
Barrier Reference:	1,1	1,2	1,3	1,4	1,5	2,1	2,2	2,3	2,4	2,5	2,6	2,7	3,1	3,2	3,3	3,4	3,5	3,6	3,7	4,1	4,2	4,3	4,4	4,5	4,6	5,1	5,2	5,3	5,4	
Barrier Count	4	6	3	1	2	3	4	5	5	6	4	4	5	4	5	9	13	4	3	5	3	2	5	4	2	6	0	0	0	
Rec. Number																														Count
1																														0
2																														0
3																														0
4	1	1	1		1									1	1	1	1													8
5																														0
6						1	1	1	1	1	1									1	1	1								9
7	1												1																	2
8													1										1							2
9																														0
10	1	1	1		1								1	1	1	1	1													9
11																														0
12															1															1
13						1	1	1	1	1	1	1		1	1															9
14																														0
15	1													1	1	1				1						1				6
16										1	1																			2
17																														0
18																														0
19		1															1	1		1	1		1	1	1	1				9
20																	1			1			1	1		1				5
21																														0
22		1														1	1													3
23		1														1	1	1	1	1	1	1	1	1		1				11
24							1	1	1	1																				4
25							1	1	1	1		1					1	1	1											8
26												1											1	1	1	1				5
27												1																		1
28								1	1	1																1				4
29		1	1														1	1												4
30				1															1											2
31						1					1		1																	3

Annex 1
GAPPRI RIRRA Methodology Scenarios

Scenario No	Scenario Description
1. ATC-TXI **ATC induced incorrect entry of a taxiing traffic or person onto the RWY protected area.**	**A.** Controller has forgotten about, and/or does not detect, a landing aircraft on an active RWY, and clears: **a.** Taxiing aircraft onto the RWY protected area and the taxiing aircraft enters onto the RWY protected area. **b.** A vehicle onto the RWY protected area and the vehicle enters onto the RWY protected area. **c.** A person onto the RWY protected area and the person enters onto the RWY protected area.
	B. Controller has forgotten about, and/or does not detect, a cleared for take-off aircraft on an active RWY and clears: **a.** Taxiing aircraft onto the RWY protected area and the taxiing aircraft enters onto the RWY protected area ahead of the taking-off aircraft. **b.** A vehicle onto the RWY protected area and the vehicle enters onto the RWY protected area ahead of the taking-off aircraft. **c.** A person onto the RWY protected area and the person enters onto the RWY protected area ahead of the taking-off aircraft.
	C. Controller is aware of a landing aircraft but develops an incorrect plan of work (e.g., because of misjudgment of RWY separation or incorrect interpretation of the traffic situation) and clears: **a.** Taxiing aircraft onto the RWY protected area and the taxiing aircraft enters onto the RWY protected area when the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met. **b.** A vehicle onto the RWY protected area and the vehicle enters onto the RWY protected area when the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met. **c.** A person onto the RWY protected area and the person enters onto the RWY protected area when the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met.
	D. Controller is aware of a cleared for take-off aircraft but develops an incorrect plan of work and clears: **a.** Taxiing aircraft onto the RWY protected area and the taxiing aircraft enters onto the RWY protected area ahead of the taking-off aircraft. **b.** A vehicle onto the RWY protected area and the vehicle enters onto the RWY protected area ahead of the taking-off aircraft. **c.** A person onto the RWY protected area and the person enters onto the RWY protected area ahead of the taking-off aircraft.
	E. Controller is aware of a landing aircraft, develops a correct plan of work but incorrectly executes (e.g., slip of the tongue) the plan of work and clears: a. Taxiing aircraft onto the RWY protected area and the taxiing aircraft enters onto the RWY protected area when the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met. b. A vehicle onto the RWY protected area and the taxiing vehicle enters onto the RWY protected area when the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met. c. A person onto the RWY protected area and the person enters onto the RWY protected area when the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met.
	F. Controller is aware of a cleared for take-off aircraft, develops a correct plan of work but incorrectly executes (e.g., slip of the tongue) the plan of work and clears: a. Taxiing aircraft onto the RWY protected area and the taxiing aircraft enters onto the RWY protected area ahead of the taking-off aircraft. b. A vehicle onto the RWY protected area and the vehicle enters onto the RWY protected area ahead of the taking-off aircraft. c. A person onto the RWY protected area and the person enters onto the RWY protected area ahead of the taking-off aircraft.

Scenario No	Scenario Description
	G. Controller incorrectly clears taxiing aircraft, vehicle or person onto the runway protected area when there is no conflicting runway traffic at the moment of the clearance and the cleared traffic enters onto the RWY protected area. This may occur due to incorrect traffic positional awareness (e.g., believing the traffic is at another position), incorrect planning (e.g., not realising the clearance will bring the traffic onto the runway protected area) or incorrect executions (e.g., slip of the tongue or incorrectly assuming the clearance meaning).
2. PIL-TXI **Pilot induced incorrect entry of a taxiing aircraft onto the runway protected area.**	**A.** A taxiing aircraft (including hover-taxi and wheeled taxi helicopter) has an incorrect positional awareness and enters: **a.** Onto the RWY protected area without ATC clearance. **b.** Onto the RWY protected area at the incorrect holding point.
	B. A taxiing aircraft (including hover-taxi and wheeled taxi helicopter) overlooks the lack of ATC RWY entry clearance and enters onto the RWY protected area without ATC clearance.
	C. A taxiing aircraft (including hover-taxi and wheeled taxi helicopter) misunderstands the cleared taxi route, the RWY entry clearance or the clearance limit and enters: **a.** Onto the RWY protected area without ATC clearance, e.g., out of sequence. **b.** Onto the RWY protected area at the incorrect holding point.
	D. A taxiing aircraft (including hover-taxi and wheeled taxi helicopter) correctly understands the ATC clearance but follows it incorrectly (e.g., incorrect handling of aircraft movement, incorrect identification of the RWY Holding Point, cleared to enter onto the runway protected area but crosses lit stop bar, moves before stop bar / traffic light has been switched off, incorrect identification of other traffic in case of conditional clearance) and enters onto the RWY protected area without ATC clearance.
3. VEH-TXI **Vehicle driver induced incorrect entry/presence of a taxiing traffic onto the RWY protected area.**	**A.** A vehicle has an incorrect positional awareness and enters: **a.** Onto the runway protected area without ATC clearance. **b.** Onto the runway protected area at the incorrect holding point.
	B. A vehicle overlooks the lack of ATC runway entry clearance and enters onto the runway protected area without ATC clearance.
	C. A vehicle misunderstands the cleared taxi route, the RWY entry clearance or the clearance limit and enters: **a.** Onto the runway protected area without ATC clearance. **b.** Onto the runway protected area at the incorrect holding point.
	D. A vehicle correctly understands the ATC clearance but follows it incorrectly (e.g., incorrect handling of vehicle movement, incorrect identification of the RWY Holding Point, cleared to enter onto the runway protected area but crosses lit stop bar, moves before stop bar / traffic light has been switched off, distraction with other activities) and enters onto the RWY protected area without ATC clearance.
	E. Incorrect presence of vehicle after correct entry onto the runway protected area (e.g., airport opening of runway with vehicles still in the runway protected area).
4. PIL-VAC **Incorrect presence of a vacating aircraft on the runway protected area.**	Controller clears aircraft to vacate the RWY, the aircraft is still on the RWY protected area but controller incorrectly determines that the RWY is vacated (local procedures to verify vacated RWY vary - pilot report and/or ATC observations) and clears another potentially conflicting landing or departing traffic. The reasons for aircraft still on the runway after controller assume it vacated can vary, e.g., blocked runway exit, aircraft malfunction, vacating at a later runway exit after runway exit confusion, runway exit misunderstanding, deceleration performance, or deliberate non-compliance.
5. VEH-VAC **Incorrect presence of a vacating vehicle on the runway protected area.**	Controller clears vehicle to vacate the RWY, the vehicle is still on the RWY protected area but controller incorrectly determines that the RWY is vacated (local procedures to verify vacated RWY vary - pilot report and/or ATC observations) and clears another potentially conflicting landing or departing traffic. The reasons for vehicle still on the runway after controller assume it vacated can vary, e.g., blocked runway exit, vehicle malfunction, vacating at a later runway exit after runway exit confusion, runway exit misunderstanding, or deliberate non-compliance.
6. ATC-DEP	**A.** Controller forgets about, and does not detect, a issued runway (including crossing runway) use clearance (for traffic that are on or may not have entered yet onto the RWY protected area), clears an aircraft to take-off and the aircraft commences its take-off run with the conflict ahead of it.

Scenario No	Scenario Description
ATC induced incorrect presence of a departing aircraft onto runway protected area.	**B.** Controller is aware of the issued runway (including crossing runway) use clearance (for traffic that are on or may not have entered yet onto the RWY protected area), but develops an incorrect plan of work (e.g., because of misjudgment of RWY separation or incorrect interpretation of the traffic situation) and clears an aircraft to take-off and the aircraft commences its take-off run with the conflict ahead of it.
	C. Controller is aware of the issued runway (including crossing runway) use clearance (for traffic that are on or may not have entered yet onto the RWY protected area), develops a correct plan of work but incorrectly executes (e.g., slip of the tongue) and clears an aircraft to take-off and the aircraft commences its take-off run with the conflict ahead of it.
7. PIL-DEP **Pilot induced incorrect presence of a departing aircraft onto runway protected area**	**A.** Pilot takes the ATC clearance given to another aircraft and commences a take-off run.
	B. Aircraft commences take-off run on a runway different to the one communicated in the ATC clearance – e.g., in the opposite direction for an intersection take-off, on an intersecting at the beginning runways or confusing runway thresholds that are in close proximity.
	C. Aircraft commences take-off run without ATC clearance.
8. ATC-LND **ATC induced incorrect presence of a landing aircraft**	**A.** Controller forgets about, and does not detect, a issued runway (including crossing runway) use clearance (for traffic that are on or may not have entered yet onto the RWY protected area), and the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met.
	B. Controller is aware of the issued runway (including crossing runway) use clearance (for traffic that are on or may not have entered yet onto the RWY protected area), but develops an incorrect plan of work (e.g., because of misjudgment of RWY separation or incorrect interpretation of the traffic situation) and the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met.
	C. Controller is aware of the issued runway (including crossing runway) use clearance (for traffic that are on or may not have entered yet onto the RWY protected area), develops a correct plan of work but incorrectly executes (e.g., slip of the tongue) and the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met.
9. PIL-LND **Pilot induced incorrect presence of a landing aircraft**	**A.** Pilot takes the ATC clearance given to another aircraft or for another RWY, continues approach and the position of the landing aircraft is such that the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold) are met.
	B. Aircraft without clearance for the runway it is aligned at is at a position that meets the local runway conflict criteria (e.g., landing clearance and/or distance from RWY threshold).
10. PSN **Person induced-incorrect presence**	Person incorrect RWY entry onto the RWY protected area:
	A. A person has an incorrect positional awareness and enters: **a.** Onto the RWY protected area without ATC clearance. **b.** Onto the RWY protected area at the incorrect access point.
	B. A person overlooks the lack of ATC runway entry clearance and enters onto the runway protected area without ATC clearance.
	C. A person misunderstands the cleared route or the RWY entry clearance and enters: **a.** Onto the runway protected area without ATC clearance. **b.** Onto the runway protected area at the incorrect access point.
	D. A person correctly understands the ATC clearance but follows it incorrectly (e.g., incorrect identification of the RWY access point, distraction with other activities) and enters onto the RWY protected area without ATC clearance.
	E. Incorrect presence of a vacating person on the runway protected area. Controller instructs person to vacate the RWY, the person is still on the RWY protected area, but controller incorrectly determines that the RWY is vacated (local procedures to verify vacated RWY vary - person report and/or ATC observations) and clears a potentially conflicting landing or departing traffic.

Annex 2
RIRRA Safety Barriers

Aircraft Operators - Runway Collision Prevention Safety Barriers

1. **Position awareness:**
   - 1.1. Taxiing (own) a/c position awareness.
   - 1.2. Own incorrect RWY entry detection.
   - 1.3. Lining-up (own) a/c position awareness.
   - 1.4. Landing (own) a/c position awareness.
   - 1.5. Runway (not) vacated detection (own a/c).
2. **ATC clearance – obtain, understand, and remind:**
   - 2.1. Taxi clearance - obtain and understand.
   - 2.2. Crossing clearance understanding - obtain and understand.
   - 2.3. Line-up clearance understanding - obtain and understand.
   - 2.4. Landing clearance understanding - obtain and understand.
   - 2.5. Take-off clearance understanding - obtain and understand.
   - 2.6. Vacating clearance understanding - obtain and understand.
   - 2.7. Clearances' memory refresh – e.g., via a memory aid.
3. **Routing:**
   - 3.1. Taxi route planning.
   - 3.2. Taxi route following.
   - 3.3. Taxi route deviation detection.
   - 3.4. RWY ahead detection.
   - 3.5. Detection of own unauthorized RWY entry initiation.
   - 3.6. Detection of own unauthorized take-off initiation.
   - 3.7. Detection of own unauthorized approach for landing or alignment to incorrect RWY.
4. **Traffic awareness:**
   - 4.1. Detection (pre-entry) of conflicting RWY entry clearance (own or someone else's).
   - 4.2. Detection of conflicting take-off clearance (own or someone else's).
   - 4.3. Detection of conflicting landing clearance (own or someone else's).
   - 4.4. Detection of potential RWY conflict (e.g., see approaching a/c before incorrect RWY entry).
   - 4.5. Detection of occupied RWY.
   - 4.6. Detection of conditional clearance traffic.
5. **Collision avoidance:**
   - 5.1. Detection of RWY conflict
   - 5.2. Conflict resolution for taxiing aircraft – supported or not by a conflict advisory technology and including stop/expedite crossing decision making.
   - 5.3. Conflict resolution for landing aircraft – supported or not by conflict advisory technology and including go-around decision making and
   - 5.4. Conflict resolution for departing aircraft - supported or not by conflict advisory technology and including stop/go decision making.

ANSPs - Runway Collision Prevention Safety Barriers

1. **Traffic awareness: positions and trajectories:**
   - 1.1. Taxi traffic awareness – ATC.
   - 1.2. Runway presence traffic awareness – ATC.
   - 1.3. Landing aircraft awareness – ATC.
   - 1.4. Departing aircraft awareness – ATC.
   - 1.5. Runway vacating awareness – ATC.
2. **ATC non-conflicting clearances plan, techniques, and execution:**
   - 2.1. ATC non-conflicting plan of work.
   - 2.2. ATC non-conflicting coordination communication.
   - 2.3. ATC non-conflicting plan execution.
3. **Air-ground communications.**
   - 3.1. Air-ground communication is functional.
   - 3.2. Correct communication and understanding of the call-sign.
   - 3.3. Correct communication and understanding of the communication message.
   - 3.4. Correct ATCO hear-back.
4. **Collision Avoidance:**
   - 4.1. Conflict detection* & resolution landing aircraft and traffic on the RWY.
   - 4.2. Conflict detection* & resolution departing aircraft and traffic on the RWY.
   - 4.3. Conflict detection* & resolution for intersecting RWYs.

* Detection of RWY conflict - direct and via conflict participants

Annex 3
Data Findings

Reference and No	Finding
Region A – 1	The frequency of runway incursions during 2022 is 33 per one million take-offs and landings. There is an upward trend of the rate of most serious runway incursions (severity A and B).
Region A – 2	The most frequent contributor to runway incursion events is pilot deviation - over a 5-year timespan pilot deviation accounted to 64% of the runway incursions, followed by vehicle/pedestrian deviation (19%) and operational incidents related to Air Traffic Controllers (17%).
Region A – 3	A general aviation aircraft was involved in 70% of the runway incursion incidents over a 5-year timespan. There is a need for specific, targeted regulatory and industry actions to address the general aviation risk of runway incursion.
Region A – 4	Within the highest-ranking runway incursion risk factors is ATC cleared aircraft to land/depart on an occupied runway (see also Region B - 2)
Region A – 5	Within the highest-ranking runway incursion risk factors is Pilot Failed to Hold Short of Runway as Instructed (see also Region B - 3)
Region A – 6	Within the highest-ranking runway incursion risk factors is Driver entered runway without Authorisation / Driver failed to Hold Short of Runway (see also Region B - 3).
Region A – 7	One of the highest times for a runway incursion to occur is during the Taxi Out phase of the flight. Pilots are instructed to taxi to a runway, but either taxi the wrong route and cross a runway or they taxi to the correct runway and cross the hold line. We are trying to understand why. Technology may assist in this area, but it may also be a distraction. If pilots are concentrating on the equipment in the aircraft, they may miss a turn or a hold short line.
Region A – 8	There are many incursions where a controller used a memory aid, but it was not effective. Air Traffic Controllers need to do two things. They need to develop the memory aid, but they need to use it effectively. If a memory aid is not going to be effective, it doesn't matter what type of memory aid is in use, it will not work. We are currently looking into a program for Runway Incursion Devices. It is an electronic memory aid that is placed in the tower and will alarm when the controller makes a transmission to a pilot.
Region B – 1	The barrier "Conflict participant collision avoidance barrier" for runway incursion incidents is around 10% less efficient compared to the same barrier for the en-route losses of separation incidents. There is a need to strengthen the barrier, including investigating development and implementation of real-time, pilot interpreted autonomous functionality for runway collision awareness and alerting using positional data.
Region B – 2	41% of the analysed sample of serious (severity A or B) runway incursion incident could have been prevented by Controller detection of potential runway conflict. These includes situations of authorized and unauthorised presence on the runway protected area that could have been detected before issuing a conflicting landing or take-off clearance. Factors like vehicles involved in the scenario, Controller workload, hand-over/take-over of ATC operational positions, inefficient use of memory aids,

	long time runway presence and lack of efficient ATC surveillance and alerting functionality increase the likelihood of these events.
Region B – 3	23% of the analysed sample of serious (severity A or B) runway incursion incident could have been prevented by available and correctly used stop-bars. There is a need for a functional barrier (e.g., stop-bars) to protect the runway against an unauthorised entry.
Region B – 4	6% of the analysed sample of serious (severity A or B) runway incursion incidents could have been prevented by a correct use of conditional clearances. Note: Conditional clearances are often used when not operationally necessary and perhaps a recommendation that they should be 'necessary' should be considered.
A&I Analysis – 1	R/T phraseology and communication procedures, including communication speed, were found to be contributory to 11 events from the analysed sample of 68 runway incursion accidents and serious incidents involving at least one multi engine CAT aircraft in the 6-year period 2016-2021. Note: Poor/non-standard phraseology and excessive speed of delivery are independent problems and may justify independent recommendations.
A&I Analysis – 2	Several events from the analysed sample of 68 runway incursion accidents and serious incidents involved use of different radio channels and/or language for communication between ATC and vehicles authorised for airside operations. This impacted situational awareness of other traffic and prevented their conflict resolution.
A&I Analysis – 3	Several events from the analysed sample of 68 runway incursion accidents and serious incidents involved controllers not checking whether potentially critical clearances were being complied with. There is a need to strengthen the barrier, including investigating development and implementation of ATC clearances compliance monitoring functionality. Note: Including both normal and low visibility scenarios and mitigation of visual monitoring capability by fixed obstructions (or removal of the latter by physical or operational (controller repositioning) changes.
A&I Analysis – 4	An investigation recommendation with potential global significance is "… adopt, in all units, a sterile control room concept by implementing and enforcing measures which include a no-tolerance policy towards the presence of mobile devices or any other device likely to create distraction at controller workstations and control rooms and by imposing strict rules restricting the presence of non-active staff and conversations unrelated to the activity taking place in the control room".
A&I Analysis – 5	An investigation recommendation with potential global significance is "…install and certify reliable and user-friendly air-band equipment in Follow-Me vehicles…which also allow the implementation of a common frequency for all movements of vehicles and aircraft in the manoeuvring area"
A&I Analysis – 6	An investigation recommendation with potential global significance is "the navigation service provider should reinforce its tower controllers' training in visual observation and the use of the surface radar".
A&I Analysis – 7	An investigation recommendation with potential global significance is "..assess the need to include an item on line-up/take-off clearance before entering a runway in its Before Takeoff Checklist". Note: Potential but not insurmountable difficulty since only one checklist for (potentially) two clearances (line up only as necessary, takeoff required).
A&I Analysis – 8	An investigation recommendation with potential global significance is "… clarify the definition of runway vacation…".

	Note: This will mitigate the risk of situation when runway is still occupied by a vacating traffic but ATC incorrectly assumes it is clear.
A&I Analysis – 9	An investigation recommendation with potential global significance is "…develops a system to ensure the process of closing an airport is subject to proper oversight". Note: Such a recommendation could perhaps usefully be extended in scope to add the (operational or longer term) closure of an individual runway.
A&I Analysis – 10	An investigation recommendation with potential global significance is "Take-off clearance must be heard by each crew member and confirmed between the crew members. If confirmation is not achieved, clarification must be requested from ATC." Note: Generally included in operator's SOPs but a recommendation to ensure this could be justified.
A&I Analysis – 11	All incidents involving an aircraft landing on the wrong runway/surface followed visual approaches. Suggest recommendation that operators implement policy/procedures which require flight crews conducting visual approaches to verify final approach path with reference to GPS, RNAV position information, or conventional navigation aids. Visual approach to parallel runway systems requires special risk mitigation, particularly if runways are close-spaced, visual cues are reduced (night, low visibility, etc), or parallel taxiways.
A&I Analysis – 12	Several incidents where departing aircraft cross runway holding points without clearance involve flight crews dealing with high workload or distraction. Suggest recommendation that aircraft operators implement policy/procedures which encourage pilots to manage workload so that the aircraft arrives at runway holding points with all crew members maintaining good lookout/listen-out and having strong situational awareness regarding current aircraft position, runway clearance status and other traffic. This is a key element to building resilience against serious RI incidents and Operators should ensure policy puts runway safety ahead of any commercial or punctuality pressures. Operator policy should address particular threats to crew workload management during pre-departure phase such as (but not limited to); short taxi routings, multiple sector days, technical issues, weight and balance tasks, Reduced Engine Taxi, line training, and changes to ATC departure clearance. Note: Many operators distinguish between OM content and pilot training and managing time available during taxi out is seen as in the latter category.
A&I Analysis – 13	The vast majority of RI incidents involving aircraft taxiing across runway without clearance occur during after-landing phase. Suggest recommendation that operators implement policy/procedures that address the RI risk after landing. Flight crew as part of their approach preparation should include expected runway vacating taxiway (using available Landing Performance calculations or local preferential taxiway information) and strategies to mitigate RI threats for after-landing phase. Operator training and policy should highlight to crews the human error potential during this phase when crews may be distracted by events on approach/landing, after-landing tasks, and attention drift to next flight or end of duty. Note: One of the main (currently not universal) requirements is for ALL active runway crossing clearances to be obtained on the (only) frequency used for the active runway

	to be crossed and that it is given with a condition to actively listen out until making a mandatory 'clear of runway' call after completing the crossing.
A&I Analysis – 14	Several RI events involve flight crew members not having a clear understanding of their current runway clearance either individually or collectively. Operator policy should require flights crews to Hear, Understand and Agree the three parts of any runway operation clearance; the Aircraft or Flight Identifier, Clearance (hold short/enter/cross/back track/land/take-off) and Runway Identifier. All flight crew members should hear the clearance firsthand from ATC controller and any doubts must be resolved immediately. At any one time an aircraft should have no more than one runway clearance (ATC Controllers should not transmit clearance to cross more than one runway at a time). Operators and manufacturers should collaborate to develop procedures (e.g. Standard Calls, Checklists) that trap any errors or misunderstandings by flight crew regarding their current ATC clearance. Consideration should also be given to developing technological solutions that record and display the current runway clearance on the flight deck. Note: Suggestion confirmation of both pilots' understanding of ATC ground clearances to be verbalised by the PF and confirmed by the PM whenever it involves entry to or crossing of an active runway. Where appropriate, the pre departure and approach/landing briefings to include reference to any currently active runways other than the one to be used for takeoff or landing.
IATA IDX – 1	There is an upward trend of the rate of IATA Incident Data Exchange (IDX) reported runway incursion incidents during the period Jan 2020 – Dec 2022. The most reported events came from EUR region (35%), followed by LATAM/CAR (26%) and NAM (18%).
IATA IDX – 2	The most frequently reported flight phase for the runway incursion incidents is taxi-out (34%), followed by approach (17%) and taxi-in (16%). This share varies for different global regions.
Airports – 1	Proposal for a new topic to be addressed in GAPPRI is crossing a lit stop bar. Four out of the total five RIs of 2022 were accompanied by crossing the illuminated stop bar and also the only RI of this year was of this kind. in all cases the cloudbase LVP was in force, recorded on ATIS and instructed by ATCOs, but the crews crossed CAT II/III anyway. In our investigations they reported that the visibility on the ground was ok and they did not expected the LVP and stop bars to be on. Therefore, we published the Safety Brief saying that the LVP does not mean just fog; also a low cloud base could be the reason. It is the new thing as there were no problems with not respecting stop bars before. The infrastructure is ok and the same as before. At the LRST and workshops with aircraft operators, therefore, it is proposed to include the topic of stop bars and LVP into the crew training.
Airports – 2	Based on runway incursions data since 2016, 7 RWY incursions involving vehicles/vehicle drivers have occurred at the crossing of 2 RWYs, where vehicles were moving on a RWY, approaching an intersecting RWY, received ATC "hold short" instruction to the approaching RWY (with correct readback) but still (partially) drove within or through the protected area of the approaching RWY. The root cause or contributing factor for these incidents was always the lack of visual reference towards RWYs of the limit of the protected area with a misjudging of the distance to the intersecting runway as a consequence. A recurring recommendation in the various investigation reports was to investigate installing a sign/marking/beacon on crossing runways on 90m/150m from the centerlines which can't be crossed by vehicle drivers without ATC approval and to better visualize the limits of the protected area. Proposal new recommendation: visualise the hold limits in respect of the protected area of the approaching crossing RWY.

Airports – 3	When evaluating the runway incursions that have occurred at the Airport, R/T (Radio/Telephone) misunderstandings between ATC (Air Traffic Control) and pilots emerge as a prominent source. Misunderstandings during the readback and hearback stages, leading to incorrect actions despite the R/T being correct, have been the underlying cause of runway incursion issues we have experienced so far. Implementing a communication approach for the runway controller, delivering instructions in clear and concise manner with a speaking rate not exceeding 100 words per minute, has resulted in a significant reduction in such incidents.
Airlines – 1	Research suggestion. Ineffective RT communications is a contributory factor in many runway incursion incidents. Investigate possible use of Machine Learning/ AI to monitor ATC radio frequencies for loading (under load and overload), missed calls, incorrect read back, Pilot compliance etc. Possible use as Leading Indicator of runway safety and for manpower planning.
Airlines – 2	Simultaneously Utilising Multiple Frequencies or Communication Devices – Data may not have level of supportive detail necessary, but this is a contributory factor in various incursion scenarios where there are other work related communication demands besides the primary ATC frequency. This is true with regard to one pilot being off frequency, vehicle drivers needing to communicate with other parties, and controllers working multiple positions during slower periods. Robust protocols or additional personnel are needed to mitigate the risk associated with this form of multi-tasking.
Airlines – 3	Runway / Taxiway Closures – Rerouting leads to disorientation and potential error. Adequate planning for and communication of closures is needed to reduce the risk of confusion.
Airlines – 4	There have been cases where vehicles cross an active runway while not being on the tower frequency assigned to that runway. Suggest to have one frequency, one runway, one language. These reports demonstrate that there is a risk of loss of situational awareness.
Airlines – 5	For the period 2020 - Mar 2023 there were 81 runway incursions the information for which was shared. 21 of those involved vehicles and the most frequent category of involvement was fire brigade vehicle (9 events).
Airlines – 6	There have been cases where mechanics crossed holding lines because they were not aware of the meaning of the various markings on the taxiways. Suggest to improve airport markings training for staff performing aircraft systems checks on ground. It generally is ok for those performing towing. So special attention could be put on those doing taxi tests and those not being out on the operational area so often.
ANSPs – 1	**Human Factors - Distraction** – various reasons and not always associated with low workload or volume of traffic. Causes can include: • Dealing with technical issues; • Handover (pre/during/after phases – including within 10 minutes of taking over); • General distraction in the control room (non-operational discussions, discussion with supervisor); and, • Distracted by other operational tasks especially when operating in a combined position (e.g. passing departure clearance).
ANSPs – 2	**Human Factors – Blind spots/visual scan:** • Misidentification of subject traffic at the holding point or in arrival sequence; • Visual scan issues – Flight Progress strip board, missing vehicles on the runway; and, • Various other elements including incorrect use of flight progress strips (runway blocking strips).

ANSPs – 3	**Human Factors - Misapplication or mis-understanding of procedures (all stakeholders):** • This has been evident with 'non-standard' runway configurations or during Low Visibility Operations; • Events where aircraft have followed greens inappropriately onto the runway (e.g. stop bar was dropped for previous aircraft); • Incorrect application of conditional clearances; • Definition of runway vacated and application of procedures associated with this (e.g. after the departing cleared to land); and, • Incorrect use of phraseology, and incorrect clearance limit instructions.
ANSPs – 4	**Runway inspections. Various elements noted here including**: • Perceived 'pressure' to complete inspections; • 'Pushing the gap'; • Incorrect coordination of gaps; and, • The situational awareness of airport operations crew.
ANSPs – 5	**Landing without clearance (or late or incorrect landing clearance).** Various reasons but predominantly associated with aircraft not being on the tower frequency (late handover or error by crew).

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August 2024 Disclaimer:

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