IASMS

IN-TIME AVIATION SAFETY MANAGEMENT SYSTEM

ROADMAP WORKSHOP

FLIGHT SAFETY FOUNDATION

independent • impartial • international

Legend	2020 - 2025			2025-2030			2030-2035			2035-2040			2040-2045		
	Key safety capabilities introduced:			Key safety capabilities introduced:			Key safety capabilities introduced:			Key safety capabilities introduced			Key safety capabiliteis introduced		
	Key research initiatives	Technology & Stds	Policy initiatives	Key research initiatives	Technology & Stds	Policy initiatives	Key research initiatives	Technology & Stds	Policy initiatives	Key research initiatives	Technology & Stds	Policy initiatives	Key research initiatives	Technology & Stds	Policy initiatives
Safety data and resilience analysis	2.1.1 Initial safety performance metrics for UAS 2.1.2 Integrated methodology to assess system risk and resilience 2.1.3 Broader ANSP adoption of internal safety data analysis			2.2.1 Safety database and funded post-analysis capability for new entrants 2.2.2 State safety programs expand monitoring of SMSs 2.2.3 Sharing of safety data among regulators			2.3.1 AAM, new entrants and traditional operations real-time critical safety data collection and aggregation 2.3.2 Expansion of State Safety Programs to include monitoring of UAS SMS			2.4.1 In-time identification of emerging safety hazards and associated mitigation strategies, for all operations (AI in combination with human contributions)			2.5.1 Autonomous identification and mitigation of emerging risks affecting airspace safety (plus people)		
	2.1.4 Prototype safety database & analysis capability with new entrants (database needs to be broad) 2.1.5 Develop LFAO methodology to assess resilience practices 2.1.6 Explore policy mechanisms that can mitigate safety impacts of significantly disruptive events	2.1.7 Develop international standards for ANSP safety data analysis	2.1.8 Determine mechanism to ensure new entrant safety data is available and an analysis capability is funded 2.1.9 Identify pathway to expand and harmonize SMS for UAS programs	2.2.4 Post-operational in-time analysis of safety data for traditional ops 2.2.5 Analysis of new entrant safety data 2.2.6 Explore historical safety data to identify predictive techniques	2.2.7 LFAO metrics established 2.2.8 Initial common SPI definitions for UAS	2.2.9 Guidance on integrating business COO with SMS 2.2.10 Broader adoption of "just cultures" and non-punitive safety reporting (align language with Annex 19 principles for protection of safety data/info for appro use) 2.2.11 International standards established for UAS SMS	2.3.3 Refine algorithms to identify emerging risks 2.3.4 Existing prediction methods are researched to create predictive SMS	2.3.5 Establish international standard for information exchange 2.3.6 Testing and validating predictive management system methodologies		2.4.2 Develop algorithms for analysis of integrated real time and post-operational safety data	2.4.3 Publish international standard for safety information exchange				
Strategic conflict management	3.1.1 Limited strategic management for low-altitude, BVLOS UAS ops			3.2.1 Services for UAS support a common operating picture (COP) and deconfliction (BVLOS included) – need add'l research in previous epoch (currently in experimental/demo phase)			3.3.1 Airspace Volume complexity management with alerts (includes but not limited to autonomous ops management?) 3.3.2 Static airspace volumes segregate autonomously managed traffic 3.3.3 Reduced airspace volume protection for space launch, reentry, and recovery (balancing right to airspace between a/c and space launch. Priority? No $ contribution to ATM system)			3.4.1 Flexible airspace volumes for segregating autonomously managed traffic Integration of autonomous vehicles/autonomous conflict management with crewed vehicles in the same airspace (all airspace classes, including Class B) 3.4.2 Integrated airspace supports both crewed vehicles and autonomously managed vehicles			3.5.1 Flexible airspace volumes and operations, autonomously managed 3.5.2 Autonomous strategic conflict and separation management		
	3.1.2 Right of way and prioritization approach (Move ROW to tactical?) 3.1.3 Framework for pairwise vehicle separation requirements 3.1.4 Common Operating Picture (move to Individual Vehicle mgmt) Improved Common operating picture (COP), including intent, NOTAMS, etc	3.1.5 Standards for xTM coordination across service providers and service boundaries		3.2.2 Requirements for dynamic debris field protection 3.2.3 Flexible airspace concepts and requirements 3.2.4 Airspace volume capacity and complexity management (including operator margins for flexibility) 3.2.5 ~~xTM~~ Traffic Mangement for very high-altitude operations	3.2.6 TBO Strategic conflict management incorporates complexity and new entrants	3.2.7 Right of way, prioritization, and separation requirements (education on broader operational modes/behaviors; move ROW to tactical) 3.2.8 BVLOS operator requirement to share flight plan information	3.3.4 OpEval of human roles, responsibilities, and CHI needs for autonomous strategic conflict management	3.3.5 Airspace volume complexity monitoring, forecasting, and management requirements 3.3.6 Operator-to-operator conflict management standards	3.3.7 Policy capturing new flight rules and safety roles in autonomously managed airspace Policy/rulemaking on flight rules (what precedes this?)	3.4.3 Autonomous management of arrivals and departures (eg converging on a non-towered airport) (what's the separation? move that part to tactical?)	3.4.4 Standards for facilities and capabilities enabling conflict management Support facilities for the "last mile" (approach/departure/airports & vertiports) enabling conflict management	3.4.5 Strategic conflict management and autonomous procedure harmonization (Harmonization across CAAs for conflict management & autonomous procedures)			
Tactical separation management	4.1.1 UAS ability to avoid static obstacles for low altitude BVLOS Operations			4.2.1 DAA for UAS self-separation and VFR enhanced safety 4.2.2 BVLOS operators have real-time surveillance information 4.2.3 Routine Semi-autonomous small package delivery with human oversight (aggressive? Should this be limited semi-autonomous pkg delivery with human oversight?)			4.3.1 Conflict Advisory Alert and routing guidance for UAS 4.3.2 UAM & larger UAS autonomous tactical separation 4.3.3 Limited autonomous cargo operations (next step – multi users in same airspace, multiuser collaboration including incumbent cargo ops)			4.4.1 Performance-Based Adaptive Separation			4.5.1 Autonomous tactical separation management for large transport and AAM operations		
	4.1.2 Develop test suite for DAA 4.1.3 Lightweight technology for surveillance supporting DAA 4.1.4 Pair-wise separation and collision avoidance 4.1.5 Simultaneous management of multiple BVLOS vehicles Consider how a single pilot can manage multiple aircraft depending on operational design domain	4.1.6 Operational requirements for performance-based separation management	4.1.7 BVLOS rulemaking more rulemaking to support 4.2.3 m:n rule (Is this too aggressive?)	4.2.4 Operational and safety performance needs for advanced operations 4.2.5 Adaptative separation in TBO operations 4.2.6 Deconfliction between huamn and autonomously managed traffic		4.2.7 Equipage requirement policy for desegregated airspace operations	4.3.4 Human & machine roles for autonomous separation of human-carrying vehicles is in place 4.3.5 Oversight of multiple AAM vehicle flights by a single individual	4.3.6 Adaptive Buffer Zone requirements	4.3.7 Integration of segregated airspaces 4.3.8 Workforce acceptance of roles for autonomous operations (what needs to happen in advance? Need to address sooner) 4.3.9 Regulations allowing ground-based back-up pilots for some commercial ops (cargo initially, after some experience using reduced crew on a/c with monitoring from ground)	4.4.2 OpEval of autonomous self-separation of large vehicles in lower-density airspace volumes	(ICAO work on autonomy for crossing FIRs?)				
Individual vehicle flight management	5.1.1 Unsheltered population mapping tools 5.1.2 UAS Flight Planning Service			5.2.1 BVLOS Ground risk assessment capability 5.2.2 Expanded terrain and obstacle information 5.2.3 Real-time vehicle risk assessment			5.3.1 Vehicle self-monitoring and healing 5.3.2 Limited autonomous cargo operations 5.3.3 DAA capability for cUAS per national strategy 5.3.4 Remotely piloted AAM-like passenger operations			5.4.1 Single pilot operations with self-separation for large transport/cargo with ground-based backup pilots 5.4.2 Limited remotely piloted commercial operations			5.5.1 Autonomous aircraft operations end-to-end		
	5.1.3 Crowdsourcing of terrain and obstacle information 5.1.4 Identify criteria for requiring specific USS safety services 5.1.5 Analysis on safety margins for AAM operations	5.1.6 Definition for UAS flight plan (eg, including mission zone/volume, 4DT)		5.2.4 Vehicle self-monitoring, healing and SPIs 5.2.5 Counter-UAS (cUAS) strategies for intervention 5.2.6 Remotely piloted AAM-like operations		5.2.7 Regulations (and guidance) for UAS flight planning safety margins 5.2.8 Policy to allow cUAS intervention 5.2.9 Policy to define conditions for mandatory participation in USS	5.3.5 Operational evaluations of single-pilot large transport ops with back-up pilot on ground 5.3.6 Research for autonomous contingency management (move contingency management for vehicle operation to assurance?)		5.3.7 Regulations allowing ground-based back-up pilots for some commercial ops	5.4.3 OpEvals for autonomous large cargo operations	5.4.4 Contingency management standards	5.4.5 Safety-critical communications using datalink			
Weather	*(no major capabilities added this timeframe)*			6.2.1 Qualified third party weather service providers 6.2.2 Qualified microclimate now-casting for urban weather (too aggressive, move to later timeframe)			6.3.1 ~~Qualified~~ Validated microclimate forecasting for ~~urban weather~~ all environments urban weather 6.3.2 Validated upper atmosphere ~~enhanced~~ weather forecasts			*(no major capabilities added this timeframe)*			*(no major capabilities added this timeframe)*		
	6.1.1 Initial assessment of weather needs for new entrants 6.1.2 Research collection of weather data, including low altitude data avail in all envir, with focus on urban areas and develop now-casting methodologies Research data available and weather needs to support HALE missions	6.1.3 Weather standards for UAS mission types 6.1.4 Develop means of compliance to meeting initial UAS weather standard	Develop process to initially qualify 3rd party wx providers	6.2.3 Nowcasting and Forecasting conditions for very-high-altitude operations 6.2.4 Demonstration and validation of urban weather microclimate now-casting and forecasting	6.2.5 Advanced weather decision support tools 6.2.6 Performance based weather standards for UAS mission type (replace with something that reflects this updated standard will address now-casting and a 3rd standard will address forecasting)			6.3.3 Very High-Altitude weather impact safety analysis methodology							
Assure: System & vehicle design assurance and validation	7.1.1 Complex airspace simulation environment for research (or - accredit testing/simulation tools/environment)			7.2.1 Modernized certification and qualification processes for smart architectures			*(no major capabilities added this timeframe)*			7.4.1 Simulation capability to validate the design safety of AI-managed airspace and autonomous vehicles			7.5.1 Vehicle and system certification is accomplished by analysis and simulation with minimal flight testing		
	7.1.2 Mature high-fidelity modeling capabilities to enhance regulatory agility	7.1.3 Framework to assess capability maturity of highly automated and autonomous systems	7.1.4 Qualification criteria and regulatory scheme for third party service providers 7.1.5 Harmonized certification criteria for small UAS	7.2.2 Explore policy and regulations regarding accountability for anomalies in autonomous separation 7.2.3 Safety risk assessment and SMS methodologies for uncertified systems	7.2.4 Publish best practices for design of highly automatic and autonomous systems	7.2.5 Harmonized approval criteria for third party service providers 7.2.6 Harmonized approval criteria for uncrewed systems 7.2.7 Harmonized certification criteria for UAS performing advanced operations 7.2.8 Harmonized safety risk assessments and approvals of uncrewed operations	7.3.1 Minimum flight testing versus modeling requirements (where is the tipping point between flight test and simulation for a given operation in a given environment/operational design domain)					7.4.2 Limited certification by analysis for increasingly complex systems				
Cross-cutting research & development	(no major capabilities added this timeframe)			8.2.1 Underlying computing capability and cross-model communications infrastructure			8.3.1 Capability to validate the safety of human-managed airspace and vehicles with autonomous vehicles Possibly add Data Link for critical communications			8.4.1 Modernized system architectures implemented to strengthen cyber-resilience and protections			*(no major capabilities added this timeframe)*		
	8.1.1 Initial requirements for future high-fidelity airspace and vehicle modeling	Consider looking at multimodal transportation strategies, learning from other industries, v-to-v automotive industry, for ex	8.1.2 Promotion of safety culture practices among new entrants	8.2.2 Autonomy recognition of data qualities (including spectrum and data availability, and 'tagging' data with integrity and confidence levels) 8.2.3 Government, Industry, and Community collaboration on airspace evolution strategy	8.2.4 Aviation communications architecture and requirements for UAS and AAM operations 8.2.5 Development and validation of a digital twin for human-managed airspace and operations 8.2.6 Development and validation of vehicle digital twins (The military accredits simulations, civil aviation doesn't have this approach. There are sim acceptance criteria for training, but not for assurance. Maybe certificated as BVLOS ARC used.)	8.2.7 Spectrum policy for AAM and UAS vehicle communications (consider spectrum & data availability while using the spectrum) 8.2.8 Essential air service policy to reflect AAM services 8.2.9 Decision on creating new airspace classification and access requirements for low-altitude UAS	8.3.2 Validation of high-fidelity simulation capability for AI-managed airspace and operations 8.3.3 Integration of, and migration to modern cyber-resilience architectures for safety service providers		8.3.4 Updated airspace access equipage and performance requirements							