Multi-Layer **Defenses**

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**Specialists at FAA summit look beyond technology
to latent and cognitive frontiers of runway risk reduction.**

Technology-driven answers to human errors dominated a December runway safety conference during which presenters discussed various delays, gaps, lost opportunities and missteps of concern in the advance of safety. Many speakers called for broader, faster and less costly solutions than technology alone offers.

Efforts during the past three years to reduce European and U.S. risks of runway incursions, excursions and confusion events have been intense, they agreed. Still, some expect the next frontier of risk reduction to require overcoming ingrained misconceptions about human performance and errors. If standard operating procedures underestimate actual risks when flight crews taxi from the gate to the runway or vice versa, the apparent safety margin may be an illusion, several presenters suggested

at the U.S. Federal Aviation Administration (FAA) International Runway Safety Summit held in Washington, D.C.

The U.S. National Transportation Safety Board (NTSB) was among organizations that have tackled broader runway issues that Chairman Deborah Hersman called as hazardous as runway incursions. "The [U.S.] runway incursion rate over the last four years stands at about six per 100,000 tower

operations," Hersman said. "While these incursions represent close calls and are measured in feet rather than in miles, it is not due to luck that we avert disaster on a daily basis. It's because of robust procedures, safe designs and well trained and alert controllers and pilots. … We firmly believe that the implementation of our recommendations, some of which are over 10 years old, will reduce the chances of runway collisions, the likelihood of a pilot mistakenly selecting an incorrect runway or taxiway … or the likelihood of an excursion."

She cited an unfinished NTSB investigation into a serious incident that calls into question the multiple layers of defense. "On Oct. 19, 2009, at about 0600, a Delta Air Lines Boeing 767 completing a flight from Rio de Janeiro to Atlanta was cleared to land on Runway 27R, but instead landed [without injuries or damage] on a parallel taxiway just north of the runway," she said. "It was dark, and visibility was reported at 10 mi [16 km]. … Preliminary information indicates that neither the flight crew nor the air traffic controllers realized that anything was wrong until the aircraft was rolling out on the taxiway."

This incident should be "entirely sufficient" to accelerate adoption of direct warning systems on aircraft and in air traffic control (ATC) facilities, Hersman said, adding, "The FAA is taking commendable action, but it is just too slow."

Chris Glaeser, director, global safety, International Air Transport Association (IATA), joined others in calling for careful examination of latent and contextual factors before closing any investigation of a runway incident or accident. He cited one airline's investigation. "The flight crew had been given taxi [instructions] to a runway on five occasions — five different clearances to go to a particular runway — then the last clearance was to take off immediately on a different runway," Glaeser said. "They got it wrong and took off on the wrong runway."

IATA's worldwide incident data for 2009 showed one attempted and three completed landings on taxiways by large commercial jets, including the Atlanta landing cited by

Hersman. IATA members' latest runway safety concerns have revolved around pressure on flight crews not to use reverse thrust at night, even on a short runway with a tail wind, because of noise abatement rules; lack of accurate measurement of runway contamination in a timely manner for flight crews; late runway changes by ATC for takeoff or landing; inaccurate airport diagrams in electronic flight bags (EFBs) for airports outside the United States that fail to depict unserviceable taxiways and taxiway construction; and lack of depiction of engineered material arresting systems (EMAS) on airport charts, which might cause pilots anticipating an overrun to steer away from an EMAS bed in a mistaken effort to avert striking the approach lights.

Aggregated voluntary pilot reports already can identify for the FAA and airlines airport hot spots of pilot/driver confusion, and recorded flight data can identify concentrations of the unstable approaches that figure into excursions (Figure 1, p. 16), said Michael Basehore, manager of the FAA's Aviation Safety Information Analysis and Sharing program (*ASW*, 8/09, pp. 12 and 32).

"We noticed a preponderance of aviation safety action program reports at one particular airport where confusion resulted from three closely spaced runway ends and numerous [runway position holding markings, Figure 2, p. 17]," Basehore said. "The triangle formed by the 'hold short' lines all in one location plus the parallel 'hold short' lines [led to] a high percentage of reports … saying, 'We are confused, there are so many hold short lines that we are not really sure where they are.' By having an aggregate of data, not just data from one airline, [we could see] a spike in the reporting so that we knew to go in and focus on this particular area."

Pilot Perspectives

"Technology is a word frequently associated with runway safety, but I want to emphasize that human factors, the human performance, is all-important whether we are talking about the snowplow driver or the air traffic controller
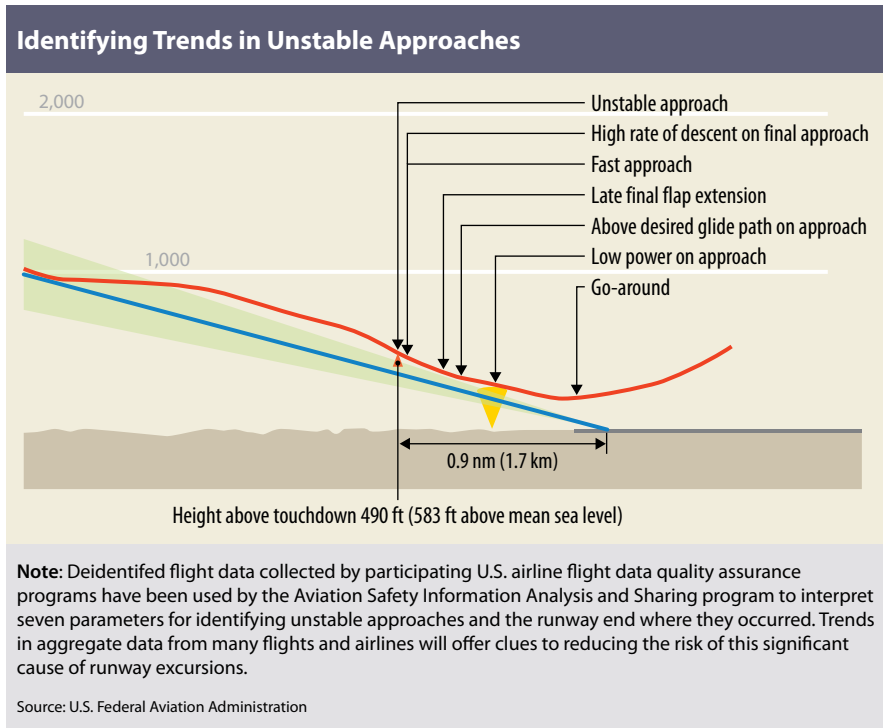
Identifying Trends in Unstable Approaches

Unstable approach
High rate of descent on final approach
Fast approach
Late final flap extension
Above desired glide path on approach
Low power on approach
Go-around

2,000
1,000

0.9 nm (1.7 km)

Height above touchdown 490 ft (583 ft above mean sea level)

Note: Deidentifed flight data collected by participating U.S. airline flight data quality assurance programs have been used by the Aviation Safety Information Analysis and Sharing program to interpret seven parameters for identifying unstable approaches and the runway end where they occurred. Trends in aggregate data from many flights and airlines will offer clues to reducing the risk of this significant cause of runway excursions.

Source: U.S. Federal Aviation Administration

Figure 1

in the control tower or, indeed, the pilot in the cockpit," said Rory Kay, an airline captain and executive air safety chairman of the Air Line Pilots Association, International (ALPA). "We have to be paying attention to the limitations of human performance, and we have to find how to deliver better training."

Another ALPA representative added that new captains tell him that the biggest challenge they face today in airline passenger operations is "How do I taxi that airplane around [the airport] and not find myself on a runway?" Charles Hogeman, an airline captain and chairman of the union's Human Factors and Training Group, said, "Sixty years ago, taxiing was not a big deal — but it is now. … We have to have company operating procedures that consider the high workload during ground operations."

Among taxi demands are head-down loading and verification of a runway and a departure procedure

in the flight management computer; weight-and-balance verification that cannot necessarily be performed at the gate; last-minute taxi amendments; runway changes requiring performance analysis; and current company responsibilities of pilots, such as engine start during taxi and other fuel-conservation practices.

Disrupted radio calls on congested frequencies during taxi also affect runway safety, and blocked calls and multiple related transmissions concern airline pilots when this prevents read-back of taxi instructions, Hogeman said. "When pilots miss [hearing] that airline name, we lose that powerful cueing for our own awareness of what we're supposed to be doing," he said.

During the landing rollout, a rapid transition in thinking and communication must occur while the aircraft is moving, he added. Based on expectation bias at a familiar airport, a flight crew verifying the latest company gate

assignment, parking position and ATC taxi clearance and routing can be caught off guard, for example, by unusual turns apparently away from the gate.

Taxi after landing involves repositioning flight controls, selecting lights and performing other checklist items while moving. Company responsibilities of pilots here include fuel-conservation measures such as an engine shutdown. "We have a lot of things going on that have made this a very high-risk area," he said.

Simple, low-tech solutions sometimes should receive high priority, said Heriberto Salazar Eguiluz, an Aeroméxico captain and vice chairman of the Aerodrome and Ground Environment Committee of the International Federation of Air Line Pilots' Associations (IFALPA). "Everywhere there is a runway that can be crossed, someone will make a mistake," he said. "So we should avoid crossing a runway whenever possible … just by constructing a perimeter taxiway."

Some IFALPA member pilots consider foreign object debris, wildlife on runways, bird strikes and inadequate infrastructure as their most pressing concerns. One runway excursion cited by Salazar involved a flight crew that rejected a takeoff because of bird ingestion and overran a runway that did not meet the international standard for a runway end safety area.

Overdue for corrective action are ATC reliance on issuing late changes of approach or assigned runway to cope with inadequate runway capacity and dense traffic; ATC reliance on visual approaches when the runway lacks the visual approach slope indicator or precision approach path indicator system that some airline standard operating procedures require for acceptance of

such a clearance; ATC policies of waiting for at least a 7 kt tail wind before changing arriving aircraft to a more favorable runway; and what IFALPA considers excessive crosswinds for line operations, Salazar said.

Training of airfield drivers must be designed in light of the turnover of the workforce and frequently reinforce awareness of threats and errors, some presenters said. Every technology helps if it enhances situational awareness, enables airfield drivers to experience hazardous scenarios and escape from danger, or identifies surface hot spots in simulators, said James Crites, executive vice president of operations at Dallas/Fort Worth International Airport (DFW). Clear communication and consistent compliance with safe practices — not new systems — remain the highest priority, he added.

Practical Theories

Multitasking and prospective-memory limitations have major implications for runway safety, said R. Key Dismukes, chief scientist, aerospace human factors, Human Systems Integration Division of the U.S. National Aeronautics and Space Administration (NASA) Ames Research Center. Multitasking in most situations actually means rapidly switching attention among discrete tasks, he said (*ASW,* 8/09, p. 18). Prospective memory refers to a person's capability to remember something he or she intends to do later, and explains why the person can forget to perform the task despite the intention.

"It takes a moment while we disengage from one task and reengage in the other task," Dismukes said. "During that moment, people reconstruct their mental model [so] the flight crew is vulnerable to error — especially if they do not have good visual cues to remind them of the state of the other task."

Among unsafe behaviors noted by NASA flight deck observers have been first officers who received an amended ATC clearance during taxi, then became fixated in head-down mode trying to solve a problem instead of monitoring the captain's actions and overall situation. In some cases, the first officer missed the only

opportunity to prevent a captain from taxiing without clearance onto an active runway.

International Concerns

Data show that 950 runway incursions — about three a day — occurred in Europe in 2008, and in 2009, preliminary numbers were regarded by Eurocontrol as "a serious problem," said Paul Wilson, head of air traffic management unit, Eurocontrol Centre of Expertise. "There are around 10 to 20 reported category A and category B incursions[1] every year in Europe, and it's proving almost impossible to deal with those … each one is different," he said. So the industry needs to think about the next evolution of safety nets, a single global concept of operations, he added. The publication of the *European Action Plan for the Prevention of Runway Incursions* has
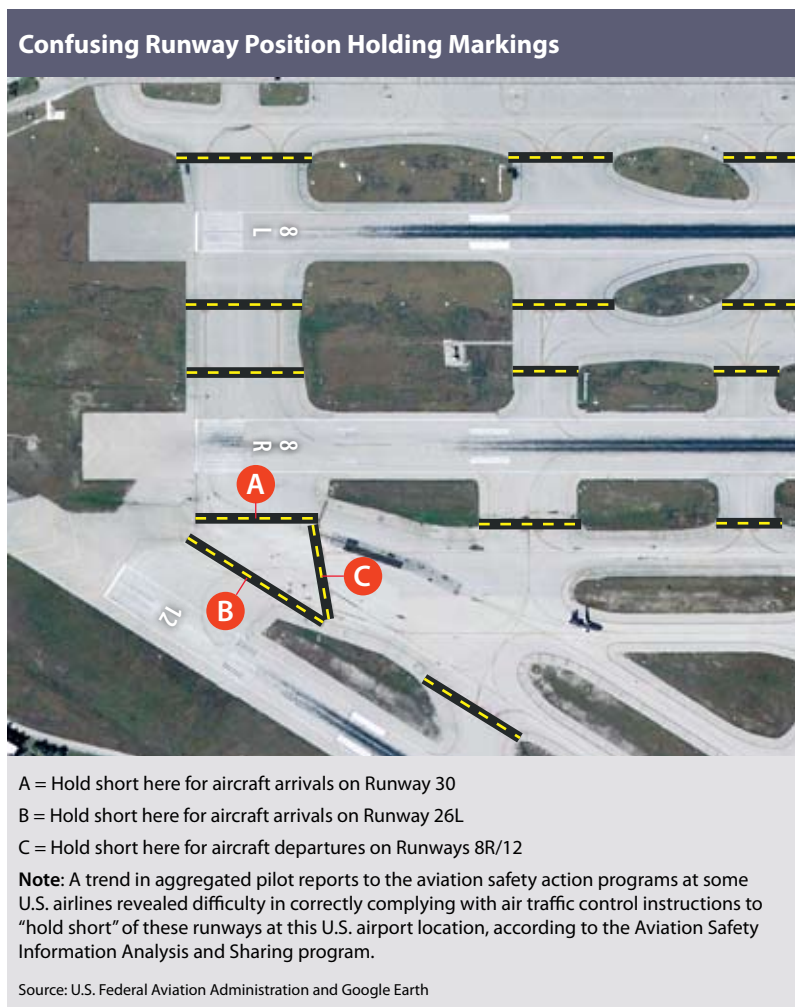

Confusing Runway Position Holding Markings

A = Hold short here for aircraft arrivals on Runway 30

B = Hold short here for aircraft arrivals on Runway 26L

C = Hold short here for aircraft departures on Runways 8R/12

Note: A trend in aggregated pilot reports to the aviation safety action programs at some U.S. airlines revealed difficulty in correctly complying with air traffic control instructions to "hold short" of these runways at this U.S. airport location, according to the Aviation Safety Information Analysis and Sharing program.

Source: U.S. Federal Aviation Administration and Google Earth

Figure 2

facilitated adoption of many recommended practices within and outside Europe, and more than 100 runway safety teams in Europe now routinely identify local issues.

Eurocontrol has provided technical advice to several airports — including Charles de Gaulle Airport in Paris and London Heathrow Airport — on enhancing stop bars and other airfield systems with a common user interface to develop — within a five- to 10-year time frame — capabilities similar to runway status lights (RWSL) in the United States, said Eric Miart, manager, airport program and environment activity for the agency. "RWSL is [compatible] with the way we currently use stop bars at European airports … to protect the runways in low-visibility conditions," he said.

"In Europe, we strongly believe that communication is at the heart of the runway incursion problem," Miart said. "One way to improve is to provide the controllers and the flight crews specific tools and safety nets, trying as much as possible [to avoid situations] where the human … will be the weak link." This year, Eurocontrol expects to add 20 recommendations to the *European Action Plan* on the use of technology and on civil-military joint use airports.

The existence of more than 70 air traffic service providers in the region complicates sharing common elements of runway safety programs, said Jem Dunn, group customer account manager for NATS UK. "The only thing that will make the next step change [occur] in runway safety is the right piece of technology, but a flight deck solution is too far away, and we still have this problem today," he said.

In a recent incursion at night, a U.K. controller left the tower position — while a vehicle was on the active runway — without placing memory-aid blocking strips, contrary to the usual practice, then handed off duties without mentioning the vehicle to a controller who had no surface surveillance display. "The first transmission of the oncoming controller was 'cleared for takeoff' to the airplane [pilot who] had just called him," Dunn said. The driver vacated the runway in time solely because of training and adherence to operational and radio-monitoring procedures, he said.

The incident captured the attention of the NATS UK chief operating officer (COO), and the COO's follow-up letter had a "profound effect" in encouraging personal responsibility for safety, he said. "We should take that as a warning … as our accident, and behave as if we had an accident; it was only a couple of fortuitous things that stopped it being an accident," the COO's letter advised controllers and airport operations directors.

Stop Bar Caveats

ICAO favors expanded use of stop bars, and entities such as NAV Canada recently have installed more of them. Any inadequate procedures or inconsistent responses to illuminated stop bars by flight crews and airfield drivers, however, can increase risk, said Bert Ruitenberg, an air traffic controller and human factors specialist for the International Federation of Air Traffic Controllers' Associations (IFATCA). A survey of ATC and airport practices[2] has kept attention focused on discrepancies, especially practices in which a pilot or driver is expected to cross an illuminated stop bar, he said (*ASW,* 8/08, p. 27).

"ICAO says that if the stop bar is switched off, the aircraft or [vehicle] can proceed," Ruitenberg said. "IFATCA does not agree — we say that a clearance is needed in addition to the switching off of the stop bar. … Having aircraft and vehicles cross lit stop bars routinely on a daily basis means that the integrity of the protection that stop bars are intended to provide is, in fact, breeched on a daily basis."

Visible NextGen Steps

FAA Administrator Randy Babbitt said that leading the agency's runway safety efforts are the 23 airport surface detection equipment, model X (ASDE-X) systems in place as of December, with a total of 35 airports slated to receive ASDE-X by April 2011 (*ASW,* 9/08, p. 46). "Data from the last fiscal year [showed] 12 category A and B incursions[3] out of more than 50 million operations," he said. "That's 12 too many, but it's a staggering achievement that we have made that reduction." Joint government-industry efforts on many fronts — not any single technology such as ASDE-X or RWSL — will further reduce collision risk, he said. "Technology can help but it is not going to replace the need for training … and overall awareness," Babbitt said.

The FAA continues research, development and testing of prototypes; expanding ASDE-X and RWSL; and moving closer to adoption of new procedures and clearance phraseology, said Michael McCormick, director, FAA terminal safety and operations support.

Building blocks for the U.S. transformation into the Next Generation Air Transportation System (NextGen) became more visible to the aviation industry in 2009 with mutually reinforcing safety and efficiency benefits, added Mike Romanowski, FAA director of NextGen integration

and implementation. In 2009, demonstration programs for widely sharing ASDE-X data at John F. Kennedy International Airport in New York and Memphis (Tennessee) International Airport enhanced situational awareness.

Integration of ASDE-X and automatic dependent surveillance–broadcast (ADS-B) also became apparent in new applications, and the first staffed NextGen ATC tower at DFW will demonstrate in early 2010 capability to manage airborne and surface traffic at remote airports, Romanowski said. "ADS-B is a remarkable success story … well on track for full nationwide deployment by 2013," he said. "We have gone operational with ATC critical services in Louisville, Kentucky, U.S., in November and [ADS-B in December] in the Gulf of Mexico. We are poised to go operational for broadcast services in Boston … Philadelphia in February and Alaska in April."

Vincent Capezzuto, FAA ADS-B program manager, considers ADS-B the key enabler for ground separation services and other runway-safety applications, noting near-term benefits as soon as airlines add the required avionics. "The next three [ADS-B development] blocks deal with the approach sequence, the final approach and runway occupancy and finally … airport surface situational awareness," he said. One such application to be tested aboard 20 US Airways Airbus A330s will be surface indications and alerting.

Other major 2010 activities include the transition of the FAA's final approach runway occupancy signal subsystem of RWSL to operational use; testing at Boston Logan International Airport of another RWSL subsystem — runway intersection lights — which soon will operate in

conjunction with runway entrance lights and takeoff hold lights at some airports (*ASW,* 9/08, p. 46); and newly designed low-cost ground surveillance for smaller air carrier airports where ASDE-X could not be justified, said Paul Fontaine, program manager, FAA Advanced Technical Development and Prototyping Group. Other sites with RWSL among 22 scheduled are DFW, San Diego International Airport and Los Angeles International Airport.

Prototyping of the low-cost ground surveillance systems begins early this year at Manchester, New Hampshire. "We have done site preparation and taken delivery of some of the equipment, and plan evaluations starting in a third quarter of 2010 to 2011 time frame," Fontaine said. Other sites are San Jose and Long Beach, California, and Reno, Nevada.

The U.S. National Air Traffic Controllers Association advocates for the near-term the use of surface surveillance technology in every control tower at the 60 busiest U.S. airports, as well as tower simulators for the most effective training, said Dale Wright, director, safety and technology. "I have stood next to controllers when [their] runway incursions happened, and it's a life-changing experience some people don't come back from," Wright said. "Our ultimate goal is that every tower have surface surveillance."

EFB Mystery

The FAA has identified 21 cases in which pilots, despite using EFBs with airport moving map and "ownship" position display, were involved in a pilot deviation and runway incursion, said Pradip Som, research and development manager, FAA Office of Runway Safety. An unresolved

question for the FAA is the degree to which safety benefits outweigh collision risks if pilots spend too much time head-down, he said.

To learn more, the FAA so far has paid for installation at each of five selected airlines up to 40 EFBs with airport moving map and ownship position, two per airplane, while targeting airports with a history of runway incursions, Som said. Analysis began in January, and after final aircraft installations by September, the FAA will survey and interview the pilots about effects on situational awareness, and develop recommendations by November 2011.

Before the FAA introduces any runway safety–related changes, time-consuming processes must be completed by a safety risk management decision panel and other officials, said the FAA's McCormick. Such processes currently operate within the Air Traffic Organization's safety management system. "Safety risk management needs to take place to ensure that we are not injecting unintended consequences or additional risk," he said. ◗

Notes

1. In a category A runway incursion, separation decreases and participants take extreme action to narrowly avoid a collision, or the event results in a collision. In a category B runway incursion, separation decreases and there is a significant potential for collision.

2. IFATCA. "IFATCA Survey Report: Stopbars." <www.ifatca.org> December 2008.

3. The FAA said in an October 2009 news release that the 12 serious runway incursions in fiscal year (FY) 2009 were 50 percent fewer than in FY 2008. Two of the serious incursions involved commercial aircraft and were considered ATC operational errors.