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Solutions Target Chronic Hazards to Aircraft During Airport Construction

International practices, discrepancy data from airport inspectors, accidents and incidents influence airport operators' methods of reducing construction-related risks. New advisory information continues to address safety-area encroachments, unauthorized/improper vehicle operations and unmarked/uncovered holes and trenches as the most prevalent issues.

FSF Editorial Staff

Current standards and recommended practices published in 1983 by the International Civil Aviation Organization (ICAO) and May 2002 revisions of a 1984 U.S. Federal Aviation Administration (FAA) advisory circular (AC) show similar methods of addressing the safety risks to aircraft when aviation activities and construction activities occur simultaneously at an airport. FAA's new recommendations to airport operators, however, take into account recent construction-related accidents, incidents, reports from inspectors and priorities such as the prevention of runway incursions and the prevention of takeoffs/landings on closed runways. The ICAO Airports and Ground Aids Section currently is revising construction-related guidance for airport operators.[1]

ICAO considers the airport operator to be responsible for reporting to appropriate civil aviation authorities any proposed construction involving an obstacle (including electronic aids and visual aids) to be located on airport property.[2] The ICAO term "temporary hazard" on an airport includes "work in progress at the sides or ends of a runway in connection with airport construction or maintenance … [and] the plant, machinery and material arising from such work, and aircraft immobilized near runways."[3]

To enable airport operators to control construction work near runways, ICAO has defined three zones adjacent to runways, with distances based on the runway type and its use as a noninstrument runway, a nonprecision-approach runway or a precision-approach runway. Restrictions specify in which zones construction is permissible or is permissible on only one side of a runway at a time; the required propeller clearance or jet-engine pod clearance (to a maximum of one meter [3.3 feet] above the ground); whether any facilities, equipment or vehicles are permitted to operate in a zone when the runway is in use; required runway-surface conditions, crosswind conditions and weather conditions; the horizontal extent of trenches and excavated material; and the maximum overall height of excavated material (two meters [6.6 feet]).

As part of this guidance, ICAO also provides that any piles of earth or debris that could damage an aircraft or aircraft engines must be removed from the zone(s) as specified, and that trenches or other excavations should be backfilled and compacted as soon as possible. All construction equipment should be mobile and should be kept within normal height limits; work in zones associated with nonprecision approach runways should not interfere with the operation of radio

navigational aids; and no work should be permitted on any part of the movement area[4] when a precision-approach runway is being used (as specified for low-visibility conditions in the airport's surface movement guidance and control system, including specifications that all equipment should be outside the obstacle-free zone[5] and all personnel should be withdrawn from the movement area).

In general, the airport operator should meet with construction contractors well in advance of construction to reach agreement on how construction vehicles will be controlled to minimize interference with aircraft operations; how to schedule construction activity to coincide as much as possible with the periods of minimum aircraft activity; and how to remove excavated materials, store construction equipment and materials, and leave the construction site in satisfactory condition at the end of the project, ICAO said.

For minor construction work on active parts of the airport movement area, ICAO said that a system of work permits should be used to ensure the following:

- "No work takes place on the active movement area without the knowledge of airport operations staff and air traffic control;
- "Permitted times of work are strictly followed; and,
- "All individuals taking part in the work are briefed in detail on … precise areas in which work may be done; routes to be followed to and from the working area; the radiotelephony procedures to be used; the safety precautions to be observed; the maintenance of a listening watch and the use of lookouts; and the reporting procedure to be followed on completion of work."[6]

For substantial/major construction work on the airport movement area, ICAO said that a group representing the interests of the airport operations department, airport maintenance department, air traffic control and construction contractor should meet as necessary to ensure the following:

- Use of conspicuously marked and lighted physical barriers to isolate the construction areas from active parts of the movement area, to warn pilots and to "preclude work vehicles inadvertently straying onto the movement area;"
- Establishment of general working rules (schedules, routes, staffing of critical control points with relatively high risk of conflict between aircraft and vehicles, radio communications and vehicle escorts, permitted equipment heights and prevention of electrical interference with aircraft communications or navigation aids);
- Written warnings to construction contractors of possible hazards to workers in the airport environment (including jet blast and noise) and requirements to wear high-visibility clothing;
- Inspection of paved areas, debris removal and cleaning of debris at frequent intervals;
- Continual observation of construction-related marking and lighting so that they do not become degraded below acceptable limits; and,
- Analyzing effects of construction equipment on electronic landing aids, obstacle-clearance limits and dominant obstacle allowances to minimize limitations on airport operations.

ICAO also recommends that during low-visibility procedures, the appropriate authority should restrict construction activities or maintenance activities in the proximity of airport electrical systems.[7]

In international aviation, some construction-related aircraft accidents at airports have involved issues such as miscommunication and failure of communication. Data from the Airclaims *World Aircraft Accident Summary* and Airclaims *Major Loss Record* included the following examples from several countries:

- On May 14, 1997, following a visual approach in daylight and "good" weather to Runway 35 at Porto, Portugal, the crew of a Regional Líneas Aéreas Saab 340B undershot the available part of the runway, touching down in an area of construction work short of the displaced threshold. After rolling about 200 meters (656 feet), the aircraft crossed a trench, which tore off the main gear and nose gear. There were no injuries to three crewmembers and 35 passengers; the aircraft was destroyed. The preliminary report said that the threshold of Runway 35 was displaced by 760 meters (2,493 feet) because of construction and that a notice to airmen (NOTAM) contained this information, but the flight crew was not aware of the displaced threshold and had not flown to the airport since the construction work had begun. The preliminary report said that air traffic control (ATC) did not advise the flight crew about the displaced threshold during the approach;[8]
- On Nov. 6, 1996, during arrival at Ust-Nera Airport, Russia, the flight crew of a Yakutsk Air Enterprise Antonov An-24RV began an approach to a runway under construction. The preliminary report said that at a late stage during this approach, ATC warned the pilot of the runway construction and the crew initiated a go-around. Before the descent could be stopped, the aircraft touched down on the runway and the landing gear was retracted. There were no injuries to five crewmembers and 24 passengers; aircraft damage information was incomplete;[9]

- On Oct. 12, 1995, the flight crew of an Air Group Gulfstream II undershot the usable part of Runway 23L at Cleveland (Ohio, U.S.) Hopkins International Airport, touched down at or just before the displaced threshold of the runway and struck a construction barricade. The aircraft's main undercarriage subsequently collapsed; the aircraft was substantially damaged and there were no injuries to two crewmembers and six passengers. The preliminary report said that the landing followed a localizer-only approach (glide slope inoperative) in daylight and clear weather, and that the crew was aware of the displaced threshold and said that sun glare affected visibility; and,[10]

- On July 24, 1996, the flight crew of a Myanma Airways Fokker F27-600 touched down before reaching the available portion of Runway 18 at Myeik, Myanmar, during the final stage of a straight-in visual approach. The aircraft touched down in an area of construction work about 800 feet (244 meters) short of the runway threshold, traveled about 600 feet (183 meters) over the graded gravel surface of a planned runway extension, fell into an excavated trench measuring 25 feet (7.6 meters) wide by 4 feet (1.2 meters) deep and struck the side of the trench. Eight fatalities and 16 serious injuries were reported among 44 passengers; no serious injuries were reported among five crewmembers. The aircraft was destroyed. The preliminary report said that there was no fire and that the accident occurred in daylight with an overcast ceiling of 800 feet and visibility of one nautical mile (1.9 kilometers) in rain showers. The pilot subsequently said that he had been unable to stop the descent.[11]

In the United States, the FAA Accident/Incident Data System (AIDS) contained the following occurrences involving, or exacerbated by, the presence of construction activity:

- The captain of a Continental Airlines Boeing 737 briefed and flew wake-avoidance procedures behind a Boeing 757 to Runway 26 at George Bush Intercontinental Airport, Houston, Texas, U.S. ATC said that the B-737 was never closer than 4.5 nautical miles (8.3 kilometers) behind the B-757. The B-737 captain briefed the first officer that he was going to land beyond the B-757's landing point. The B-737 ran off the end of Runway 26 through construction barricades and sandbags, and stopped on the closed portion of the runway. No aircraft damage or injuries were reported. The pilot entered a remark in the aircraft maintenance log that he could not stop safely or make the last high-speed exit from Runway 26;[12]

- The flight crew of a United Airlines Boeing 727 felt a slight thump and believed that an aircraft tire had run over an object while taxiing to Gate 22 after an uneventful landing at Rochester (New York, U.S.) International Airport. At the time, the aircraft was being taxied with the nose gear on the yellow centerline of the taxiway. A post-flight inspection revealed that the right wing tip was heavily damaged and a long piece of metal was dangling from the wing tip. Minor aircraft damage was reported, and no injuries occurred. The crew then learned that the aircraft had struck a truck that was parked just off the apron in a construction area adjacent to the taxiway. The yellow centerline had been repainted on the taxiway by contractors involved in the construction activities, displacing the previous centerline several feet to provide clearance for the construction vehicles working at the perimeter of the taxiway;[13]

- The pilot of a United Airlines B-727 was taxiing the aircraft to Gate 12 at Newark (New Jersey, U.S.) International Airport without the assistance of a guide when the left wing tip struck a contractor's dump truck that was parked by workers conducting surface-repair work. Minor aircraft damage was reported involving the left wing tip and outboard leading edge slat. An accident report by the airport operator said that the pilot was taxiing to the right side, the "safe side," of the yellow line and that the construction vehicle was positioned improperly and created an unlighted hazard to the incident aircraft; and,[14]

- After landing on Runway 06R at Ted Stevens Anchorage (Alaska, U.S.) International Airport, the aircraft flight crew of a Reeve Aleutian Airways B-727 was cleared by ATC to cross Runway 06L to Taxiway G, then to taxi via Taxiway K. The aircraft crew misidentified the taxiway lighting of Taxiway R and entered a construction area. The aircraft nose wheel sank four inches (10 centimeters) into new asphalt, then was towed to the gate. No aircraft damage or injuries were reported. The report said that Taxiway G had a 30-degree turn that was difficult for pilots to see in the prevailing conditions of darkness and rain.[15]

In addition to ICAO guidance, some information has been available to airport operators through Airports Council International (ACI), which has discussed the subject in committees comprising representatives of airports in many countries. David Gamper, ACI director of technical safety and facilitation, said that the most significant causes of construction-related safety problems worldwide include construction-vehicle movements to transport materials and wind-blown scattering of dropped debris that causes foreign object damage (FOD) to aircraft. Gamper said that current ACI policies relevant to construction safety include the following:[16]

- "Special attention should be [given] when construction works are in progress at the airport, and immediate checks should be made when pilots advise sightings of debris, etc.[; and,]

- "A written program should be established, setting out the practices and procedures required [to minimize FOD]. This should include the practices expected of airport users such as airlines, handling agents, airport tenants, contractors, etc., to minimize FOD (contractors should be expected to sign a contract clause taking responsibility for FOD). Regular consultation should take place with users, e.g., in FOD committees, to obtain widespread support for FOD-prevention measures."[17]

Lawrence Smith, a civil engineer, former senior director of construction management and director of facilities at Tampa (Florida, U.S.) International Airport and immediate past chairman of the ACI Technical/Safety Committee, said that a consensus has emerged from ACI committee discussions about the dynamics of construction-related risks.[18]

"Incursions are a greater risk during construction because the contract workers are not career airport people and do not have the deep sense of caution and respect that comes with years of air operations area [AOA][19] presence, day and night," Smith said. "Bad weather, temporary route changes in taxiway movements and many other issues challenge safety during construction, and also affect certain navigational aids, guidance signs and other cues that pilots have relied on prior to construction. Routing changes create an additional burden on pilots, and sometimes — because the changes are only for a short duration — the construction program may try to make do with nonstandard signage or confusing cues.

"Many seasoned construction workers are aware of the dangers. But in relative terms, airport employees around the world are clearly more safety-driven. The typical construction worker may never have operated on an airport. The construction mindset is focused on achieving tasks and deadlines and meeting adversity with expeditious solutions that appear to save time. Many AOA restrictions appear to waste time in the interest of safety, and that can lead to conflicting judgments in hurry-up construction scenarios.

"The construction-related FOD issue is similar in cause but not as severe a risk as a runway incursion because airport employees are usually responsible for inspections before opening AOA areas to traffic. The risk-taking of construction workers is somewhat governed by the presence of an inspector or enforcer, and construction workers are unusually prone to a misguided philosophy of risk taking: to take risks in the absence of enforcers — that is, if no one sees an incursion, did it really happen? The most accepted viewpoint among airport operators is that high levels of inspection and construction coordination by experienced airport employees or experienced consultants are essential to maximize safety during AOA projects."

Before issuing the revised AC 150/5370-2D, *Operational Safety on Airports During Construction*, effective May 31, 2002, FAA reminded airport certification safety inspectors and airport operators about methods of preventing hazards to aircraft during airport construction. FAA said in January 2002, "In other incidents, aircraft have landed and departed closed runways with contractor [personnel] and airport personnel still on the runway. In several of these instances, the airport operator had issued a NOTAM about the runway closure."[20]

FAA said that airport operators' actions should include the coordination and notification of runway closures; the use on or near the runway designation of standard closed-runway markings (yellow "X") that would not be moved by prop wash, jet blast or wind, and preferably a lighted "X" signal for temporary closure; providing lighted and highly reflective frangible barricades on, "at a minimum, those taxiways where an aircraft [crew] intending to take off might access the runway" and the use of proper lighting configurations to depict open portions and closed portions of the affected runway.

Edge lights and threshold lights on closed portions of a runway should be disconnected or covered in a manner that prevents light leakage, and if an entire runway is closed, electrical lockout-and-tagging procedures (mechanical systems and attached documents) should be used to prevent accidental activation of these lights and hazards to construction personnel who may work on circuits or other electrical equipment, FAA said.[21]

FAA provided the following recent examples of U.S. runway incursions that have involved airport construction:[22]

- "On Sept. 24, 2002, a vehicle/pedestrian deviation [VPD][23], occurred at Joe Foss Field, Sioux Falls, South Dakota when a construction vehicle crossed Runway 15/33 at Taxiway A without authorization. No conflicts were reported;

- "On May 14, 2002, a VPD occurred at Missoula International Airport, Montana, when a construction vehicle disregarded a flagperson and ran up to the edge of Runway 25 just west of Taxiway D, without authorization. A Cessna 210 was cleared for takeoff on Runway 25. The aircraft takeoff clearance was canceled twice by local control, but never acknowledged. The vehicle stopped short of the runway due to either sighting the aircraft or the flagperson located across the runway. The aircraft passed the vehicle during the takeoff roll. Horizontal separation of aircraft to vehicle was estimated at 20 feet [6.1 meters]. The construction was stopped immediately;

- "On Nov. 11, 2001, a VPD occurred at Fort Smith [Arkansas] Regional Airport when an unauthorized passenger vehicle owned by a private citizen entered on 74th Street through the guarded construction gate. The guard unsuccessfully attempted to halt the vehicle, which was observed by the ground controller westbound on Runway 07. The vehicle arrived at the west end of the runway, turned around and drove back to the east. The

ground controller requested that airport vehicle 5 intercept the unauthorized vehicle and instruct the driver to exit the runway. A Cessna T-37 military jet trainer was issued a go-around instruction by ATC while on a three-nautical-mile [5.6-kilometer] final to ensure separation; [and,]

- "On Sept. 27, 2001, a VPD occurred at Fort Worth [Texas] Meacham International Airport when a construction vehicle was eastbound on Runway 9/27 approaching Runway 16L/34R. The vehicle entered Runway 16L without tower clearance and exited on Taxiway C west of Runway 16L. A Beechcraft Bonanza was airborne and departing from Runway 16L at the time of the incident."

Winsome Lenfert, the FAA airport certification safety and compliance specialist responsible for completing AC 150/5370-2D, said that this version more strongly emphasizes runway safety and the prevention of runway incursions by adding significant information on training, fencing and vehicle lighting. The AC also adds information on hazard marking, runway operations and runway/taxiway safety area operations. Lenfert said that a revision to the AC currently is in draft stage.[24]

In the current AC (and its predecessor), FAA said that safety-area encroachments, unauthorized/improper ground vehicle operations and unmarked/uncovered holes and trenches near aircraft operating surfaces have posed the three most prevalent threats to airport operational safety during airport construction.

"Construction is a special circumstance in preventing runway incursions," Lenfert said. "We wanted to make sure that this is an important subject in the current AC because contractors often are not used to working on airports. Airport operators told us that they needed more guidance to give to contractors about airport construction safety. This AC provides standards and best practices for airport operators to use. As guidance material, it shows methods that we prefer but an airport operator may be able to show FAA either methods above and beyond the AC or an acceptable alternative. By following the AC, airport operators certificated under U.S. Federal Aviation Regulations (FARs) Part 139, *Certification and Operation: Land Airports Serving Certain Air Carriers,* ensure that they meet the regulatory requirements. Some parts of the AC are based on the experience of FAA inspectors and project managers in FAA airport district offices and FAA regional offices; some had input from airport consultants and airport operators. Other changes are based on aircraft accidents."

Although noncertificated airports without federal grant agreements are not required to adhere to the AC guidelines, FAA said that doing so will help airports to maintain operational safety during construction projects.

U.S. accidents/incidents and non-U.S. accidents — including the collision of a Boeing 747-400 with concrete barriers, runway-construction pits and construction equipment during takeoff from a partially closed runway at an airport in Taiwan in October 2000 — were studied during FAA's AC-revision process, she said.[25] Another influential U.S. incident in 2001 involved takeoff by the crew of a jet cargo aircraft from a closed runway in Denver, Colorado, she said.[26]

To address the problem of VPDs, the AC said that airport operators should control access routes to prevent inadvertent/unauthorized entry of people, vehicles or animals onto the AOA, which includes aircraft movement areas and nonmovement areas.

According to the AC, the vehicle plan should contain the following items:

- "Airport operator's rules and regulations for vehicle marking, lighting and operation;
- "During daylight hours, mark vehicles with orange-and-white-checked flags or flashing yellow beacons;
- "Mark vehicles used for nighttime or low-visibility operations with flashing yellow beacons;
- "Affix a flag to construction vehicles requiring escorts;
- "Mark and identify vehicles in accordance with AC 150/5210-5, *Painting, Marking and Lighting of Vehicles Used on an Airport;*
- "Describe proper vehicle operations on movement [areas] and nonmovement areas under normal [communications], lost communications and emergency conditions;
- "Describe the penalties for noncompliance with driving rules and regulations;
- "Describe training for vehicle drivers to ensure compliance with the airport operator's vehicle rules and regulations; [and,]
- "Provide radio communication training for construction contractor personnel engaged in construction activities around aircraft movement areas. This training may not be necessary for all drivers, such as construction drivers under escort."

To address the hazards to aircraft associated with construction-related airport excavation, the current AC said that construction contractors must mark prominently open trenches and excavations at the construction site with red flags or orange flags (as approved by the airport operator) and light these areas with red lights (if accessible to aircraft) or yellow lights during hours of restricted visibility or darkness.

"Open trenches or excavations are not permitted within 200 feet (60 meters) of the runway centerline and at least the existing [runway safety area (RSA)][27] distance from the runway threshold while the runway is open," the AC said. "If the runway must be opened before excavations are backfilled, cover the excavations appropriately. Coverings for open trenches or excavations must be of sufficient strength to support the weight of the heaviest aircraft operating on the runway. … Excavations and open trenches may be permitted up to the edge of a structural taxiway and apron pavement, provided the dropoff is marked and lighted [as specified in the AC]."

FAA also said that inspections of construction activity by airport operators and contractors should include the following potentially hazardous conditions and situations identified from accidents, incidents and the experience of FAA inspectors:

- "Excavation adjacent to runways, taxiways and aprons;
- "Mounds of earth, construction materials, temporary structures and other obstacles near any open runway, taxiway or taxi lane, or in the related object-free [areas][28] and aircraft-approach [areas/zones] or [aircraft-]departure areas/zones;
- "Runway-resurfacing projects resulting in lips exceeding three inches (7.62 centimeters) from pavement edges and ends;
- "Heavy equipment, stationary or mobile, operating or idle near AOAs, in runway approaches [areas] and departures areas, or in object-free areas;
- "Equipment or material near [navigational aids (NAVAIDS)] that may degrade or impair radiated signals and/or the monitoring of navigational and visual aids. Unauthorized or improper vehicle operations in localizer or glide slope critical areas, resulting in electronic interference and/or facility shutdown;
- "Tall and, especially, relatively low-visibility units (i.e., equipment with slim profiles — cranes, drills and similar objects — located in critical areas such as obstacle-free zones and approach zones;
- "Improperly positioned or malfunctioning lights or unlighted airport hazards, such as holes or excavations, on any apron, open taxiway or open taxi lane, or in related safety [areas], approach [areas] or departure areas;
- "Obstacles, loose pavement, trash and other debris on or near AOAs. Construction debris (gravel, sand, mud, paving materials, etc.) on airport pavements, resulting in aircraft [propeller damage], turbine engine [damage] or tire damage. Also loose materials that may be subject to being blown about, potentially causing personal injury or equipment damage;
- "Inappropriate or poorly maintained fencing during construction intended to deter human and animal intrusions into the AOA. Fencing and other markings that are inadequate to separate construction areas from open aircraft operating areas create aviation hazards;
- "Improper or inadequate marking or lighting of runways (especially thresholds that have been displaced) and taxiways. Inadequate or improper methods of marking, barricading and lighting temporarily closed portions of airport operating areas create aviation hazards;
- "Wildlife attractants, such as trash (food scraps not collected from construction personnel activity), grass seeding or ponded water on or near airports;
- "Obliterated or faded markings on active operational areas;
- "Misleading [obstruction lights] or malfunctioning obstruction lights. Unlighted [obstructions] or unmarked obstructions in the approach to any open runway pose aviation hazards;
- "Failure to issue, update or cancel NOTAMs about airport or runway closures or other construction-related airport conditions;
- "Failure to mark and identify utilities or power cables. Damage to utilities and power cables during construction activity can result in the loss of runway/taxiway lighting; loss of navigational [aids], visual [aids] or approach aids; disruption of weather reporting services; and/or loss of communications;
- "Restrictions on [aircraft rescue and fire fighting (ARFF)] access from fire stations to the runway-taxiway system or airport buildings;
- "Lack of radio communications with construction vehicles in airport movement areas;
- "Objects, regardless of whether they are marked or flagged, or activities anywhere on or near an airport that could be distracting, confusing or alarming to pilots during aircraft operations;
- "Water, snow, dirt, debris or other contaminants, which temporarily obscure or derogate the visibility of runway/taxiway marking, lighting and pavement edges. Any condition or factor that obscures or diminishes the visibility of areas under construction;
- "Spillage from vehicles (gasoline, diesel fuel, oil) on active pavement areas, such as runways, taxiways, ramps and airport roadways;

- "Failure to maintain drainage system integrity during construction (e.g., no temporary drainage provided when working on a drainage system);

- "Failure to provide for proper electrical lockout-and-tagging procedures. At larger airports with multiple maintenance shifts/workers, construction contractors should make provisions for coordinating work on circuits;

- "Failure to control dust. Consider limiting the amount of area from which the contractor is allowed to strip turf;

- "Exposed wiring that creates an electrocution [hazard] or fire-ignition hazard. Identify and secure wiring and place it in conduit or bury it; [and,]

- "Site burning, which can cause possible obscuration."

Lenfert said that from FAA's perspective, the most significant AC changes include the following:

- Recommendation (in a safety-plan checklist) that airport operators consider imposing penalties for contractor noncompliance with the safety plan;

- Expanded recommendations for vehicle marking, lighting, training and operation because of the number of construction vehicles that have caused runway incursions;

- Reiteration throughout the AC of hazard-marking measures to prevent aircraft takeoff on a closed runway;

- Increased detail and emphasis in guidelines on marking and lighting temporary runway-threshold displacements;

- Clarifying appropriate types of marking for a short-term temporary runway threshold;

- Providing one example of an acceptable retroreflective, elevated marker to indicate a temporary runway threshold. Green reflective material on one side of this type of marker denotes the approach end of the runway; the red reflective material on the other side of the marker is seen by pilots during aircraft rollout;

- Describing methods for temporary use of outboard elevated threshold bars or outboard flush threshold bars (that is, markings outside the runway pavement surface on each side of the runway);

- Emphasizing and providing additional methods to mark a closed runway, such as the lighted 'X' signal placed on or near the runway-designation numbers, the activation of stop bars and the placement of reflective barricades with 'DO NOT ENTER' signs on taxiway centerlines at major entrances to runways to physically prevent pilots from taxiing onto a closed runway;

- Distinguishing the types and configurations of hazard-marking barricades allowed in nonmovement areas (frangible barricades or nonfrangible barricades with diagonal orange/white alternating stripes supplemented by alternating orange flags and white flags) vs. movement areas (alternating orange/white flag lines, traffic cones, omnidirectional red flashers and signs that are frangible at grade level or not more than three inches [7.6 centimeters] above grade level if affixed to the surface);

- Specifying that nonfrangible hazard markings — such as railroad ties, Jersey barriers (types of concrete barriers invented in the 1960s in New Jersey, U.S., for highway uses) and metal-drum-type barricades — not be used in airport movement areas. Lenfert said that the draft AC specifically says that railroad ties cannot be used in locations where any aircraft is operated at high speed (such as runways); and,

- Providing dimensions and specific guidance for construction activities in RSAs, including runway edges and runway ends.

"Previously, there were no horizontal dimensions to control construction activities in the safety area off the end of the runway but construction was not permitted along runway edges closer than 200 feet [61 meters], with case-by-case exceptions," Lenfert said. "Currently, construction is not allowed within 200 feet of the runway centerline unless the runway is closed or restricted to certain types of aircraft, and construction is restricted in certain areas off the end of the runway depending on the type of approach and construction activity."

FAA also included a special caution regarding partial runway closures and displaced thresholds because of past incidents. For example, instead of initiating a NOTAM for runway closure, the NOTAMs sometimes have entered the distribution system notifying pilots of a displaced threshold — miscommunicating that pilots had an additional runway available, Lenfert said.

"Hazard marking and lighting is a big change, one that has raised a lot of questions in the airport industry about what we intended," she said. "The current AC version says that hazard lights should be red in movement areas and hazard lights should be yellow or red in nonmovement areas. The draft AC says that lights should be red to delineate hazardous areas in both movement areas and nonmovement areas. One reason for the pending standardization of red hazard lights was pilot complaints that they have been confused by a 'sea of yellow' — that runway in-pavement guard lights have a yellow flash pattern that pilots have confused with flashing yellow lights on construction barricades. Pilots are allowed to cross areas

marked by flashing yellow lights, but red lights — as recommended by ICAO — are known to pilots as a signal to stop. Another reason why we proposed only red lights for hazard marking in the draft AC is to eliminate the difficulty of distinguishing hazards in movement areas vs. hazards in nonmovement areas — for example, construction in an unpaved area between a taxiway and a runway."

Although the current AC adds a "boilerplate" safety planning guide, FAA said that this guide should serve as a starting point for customization by the airport operator.

"We have seen airport operators submit — as their safety plan — everything from just a list of the numbers and types of barricades to a large document that covered all aspects of their construction project," Lenfert said. "We wanted this AC safety planning guide to help airports, contractors and engineers to operate safely during construction on an airport — knowing that this may be or may not be the first airport project for the contractor or consultant. We also encourage airports to combine these guidelines with federal, state and local guidelines — such as U.S. Occupational Safety and Health Administration [OSHA] guidance — to create a comprehensive safety plan tailored to their projects."

The draft AC also will clarify wording about taxiway safety areas[29] and clarify types of material to be used as part of marking requirements for temporary runway thresholds, she said.

For airport construction projects other than those involving FARs Part 139 airports or airports conducting federal grant projects, FAA involvement varies by the complexity of the construction project and by project-oversight decisions in FAA regional offices or FAA district offices, she said. FAA participation may range from an FAA program manager's attendance at weekly preconstruction/construction meetings at the airport to periodic review of safety-related aspects of written construction progress reports prepared by an airport's consultants or engineers.

"The biggest construction-safety issue that FAA inspectors have seen is not enough contractor oversight by the airport operator or by the consultant or engineer who has ultimate responsibility for the project," Lenfert said. "We also see construction-personnel training as a significant problem — from airport operating rules to construction-vehicle driver training, many things listed in the AC relate to proper training. Airport operators often can identify and prevent problems during design and preconstruction phases. If the airport operator has a continual construction inspection/monitoring program, small things with potentially adverse consequences can be identified. For example, FAA inspectors have seen situations in which the contractor dug holes 60 feet [18.3 meters] from the correct location, cutting into a cable and penetrating the runway safety area. They also have found barricades where lights have failed. Many safety problems could be prevented by continual inspections."

Craig Spence, airport operations officer and Dulles construction coordinator for Washington (D.C., U.S.) Dulles International Airport, said that, in his opinion, FAA's current AC covers the key issues involved in construction-safety planning, but large airports consider this guidance to be a "starting block" for their locally tailored safety practices. He said that future versions of this AC should clarify some recommendations and address additional problems experienced by airport operators.[30]

For example, he said that some airport operators using the current AC have identified the following concerns:

- The distance formula for limiting construction in taxiway safety areas yields results similar to the previous formula but with more difficulty. To use the new formula, airport operators look up the wingspan of the largest aircraft as published by FAA. The taxiway object-free area's wingtip clearance then must be 1.4 times this airplane wingspan plus 20 feet [6.1 meters];

- References to the use of a flagperson to direct movement of construction equipment in a taxiway safety area have not specified the employment qualifications (such as English language proficiency or ability to monitor by radio local controllers' instructions to pilots of taxiing aircraft) or standard signals for vehicles to stay in place, cross or conduct an emergency stop;

- Current guidelines for issuance of NOTAMs by FAA prevent some safety information from being distributed, information that airport operators believe would be beneficial to pilots. For example, Dulles procedures require that all cranes be lighted, marked and lowered at night yet these safety measures preclude FAA from including information about the presence of cranes unless they are unlighted hazards;

- The AC's restriction on the use of electric blasting caps — the type of blasting cap required by OSHA — may need to be modified to allow blasting caps that provide the safety characteristics of electric blasting caps but do not generate the radio-frequency interference of concern in the aviation environment;

- Arguments have been made by some airport operators that the use of only red lights on barriers delineating construction areas communicates incorrectly to pilots that the entire construction area is a hazard; and,

- Airport operators typically want to use frangible mountings for barricades that mark construction areas — as specified in the current AC — but most products on the market do not withstand jet blast and can become an FOD hazard to aircraft or a hazard to construction personnel.

Dulles, like other major U.S. airports, has worked to improve safety during construction by implementing the following

practices that, in some cases, exceed the specific AC recommendations, Spence said:

- The airport strictly limits construction on the airport movement area during daytime hours when runways are open. Construction in areas that typically are active during the day requires the area to be clearly marked as closed and/or to have other appropriate safety precautions. Scheduling 42 current construction projects between 11 p.m. and 6 a.m. has been a "daunting challenge" at times, but the basic practice has helped to prevent construction personnel from entering safety areas or affecting instrument landing system (ILS) critical areas;

- The airport makes extensive use of appropriate construction barriers and orange flag lines (a series of flags sunk into the ground on frangible mounts) to clearly delineate the limits of each construction area;

- Requiring attendance at weekly "toolbox meetings" at the construction area to explain any construction changes, vehicle routing changes, new work limits, opening of a new taxiway segment, etc.;

- Wide use of a sign that shows "STOP — AIRCRAFT MOVEMENT AREA" on one side (as viewed by construction personnel) and shows an internationally recognizable symbol meaning "do not enter" (as viewed by aircraft approaching the construction area from runways, aprons or taxiways);

- Dulles added a consultant who provides full-time oversight of contractor safety;

- Dulles requires each contractor performing construction work (above a specified level of complexity) to provide on each work shift a full-time safety officer whose only responsibility is to ensure compliance with airport safety requirements in the construction safety plan and with OSHA requirements. To work airside, the safety officers must have relevant previous aviation experience to ensure full understanding of the significance of AOA hazards. Contractors on large projects also typically provide services of a safety engineer; and,

- Dulles requires comprehensive safety programs in which an airport authority representative monitors the work performed by the contractors' safety officer(s). "It may seem to be a luxury to have this system, although other airports have similar systems, but we will shut down the construction project and send everybody home because of safety violations," Spence said.

Although some U.S. airport operators have participated in airport construction-management workshops and airport operational safety schools, Spence said that he currently is not aware of any conference or forum specifically designed for airport operators to exchange their experiences and best practices for ensuring operational safety during airport construction.

As ICAO, FAA and non-U.S. civil aviation authorities update their standards and recommended practices, recent lessons from worldwide successes and failures in preventing construction-related aircraft accidents will help airport operators to conduct safer project planning and implementation.♦

Notes

1. Cooper, Denise. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S., Oct. 3, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S. The International Civil Aviation Organization (ICAO) Airports and Ground Aids Section is revising *Airport Services Manual*, Part 8, "Airport Operational Services," Chapter 8, "Control of Work in Progress on the Movement Area and Precautions to Be Taken." Document 9137–AN/898 Part 8, 1983.

2. ICAO. *Airport Services Manual*, Part 6, "Control of Obstacles," Chapter 2, "Controlling Obstacles at an Airport." Document 9137–AN/898 Part 6, 1983.

3. ICAO. *Airport Services Manual*, Part 6, "Control of Obstacles," Chapter 3, "Temporary Hazards." 20.

4. The U.S. Federal Aviation Administration (FAA) said that the movement area of an airport comprises the runways, taxiways and other areas of an airport that are used for taxiing, hover taxiing, air taxiing, takeoff or landing of aircraft, excluding loading ramps and aircraft parking areas.

5. FAA said that an obstacle-free zone is a design standard that describes the surfaces of a three-dimensional volume of space near a runway. The obstacle-free zone supports the transition of ground-to-air aircraft operations and air-to-ground aircraft operations by precluding penetrations by taxiing airplanes, parked airplanes or objects other than frangible visual navigational aids that are required because of their function, in accordance with FAA Advisory Circular (AC) 150/5300-13, *Airport Design.*

6. ICAO. *Airport Services Manual*, Part 8, Chapter 8.

7. ICAO. Annex 14, *Aerodromes.* Paragraph 9.4.32.

8. Airclaims. *Major Loss Record.* Operators Volume 2 (Issue 125): PLU:11.

9. Airclaims. *Major Loss Record.* Operators Volume 2 (Issue 119): TRB:47.

10. Airclaims. *World Aircraft Accident Summary.* (Issue 05/97): A95:31

11. Airclaims. *Major Loss Record.* Operators Volume 2 (Issue 124): MMM:6.

12. FAA Accident/Incident Data System (AIDS) report no. 20000229020239C. Feb. 29, 2000.

13. FAA AIDS report no. 19991105031139C. Nov. 5, 1999.

14. FAA AIDS report no. 19990914031149C. Sept. 14, 1999.

15. FAA AIDS report no. 19990912028809C. Sept. 12, 1999.

16. Gamper, David. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S., Sept. 23, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

17. Airports Council International. *ACI Policy Handbook*, "Runway Inspections," paragraph 5.20.3 and paragraph 5.21.2.

18. Smith, Lawrence. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S., Sept. 23, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

19. FAA defines the air operations area as any area of the airport used or intended to be used for the landing, takeoff or maneuvering of aircraft.

20. FAA. *CertAlert* no. 02-01. "Aircraft Departing/Landing on Closed Runways." Jan. 8, 2002.

21. Ibid.

22. Lenfert, Winsome. E-mail communication with Rosenkrans, Wayne. Alexandria, Virginia, U.S., Sept. 26, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

23. FAA said that a vehicle/pedestrian deviation includes pedestrians, vehicles or other objects interfering with aircraft operations by entering or moving on the runway movement area without authorization from air traffic control.

24. Lenfert. Interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S., Sept. 19, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

25. The Aviation Safety Council (ASC) of Taiwan Accident Report no. ASC–AAR–02–04–001, *Crashed on a Partially Closed Runway During Takeoff, Singapore Airlines Flight 006, Boeing 747-400, 9V-SPK, CKS Airport, Taoyuan, Taiwan, October 31, 2000,* said that Singapore Airlines Flight SQ006, a Boeing 747-400, struck concrete barriers, runway construction pits and construction equipment during takeoff on Runway 05R, which was partially closed for maintenance, at Chiang Kai-Shek International Airport, Taoyuan, Taiwan, on Oct. 31, 2000. Four cabin crewmembers and 79 passengers were killed; four cabin crewmembers and 35 passengers received serious injuries; and one flight crewmember, nine cabin crewmembers and 22 passengers received minor injuries. The airplane was destroyed by collision forces and post-accident fire. ASC findings related to probable cause said, in part, that heavy rain and strong winds from a typhoon prevailed when the takeoff clearance for Runway 05L was issued; that a notice to airmen (NOTAM) about Runway 05R construction had been issued and that the flight crew was aware that Runway 05R was available only for taxi; and that the flight crew incorrectly navigated the aircraft to Runway 05R and began the takeoff roll.

26. U.S. National Aeronautics and Space Administration (NASA). Aviation Safety Reporting System. Report no. 525866, September 2001. This preliminary report said that the crew of a Boeing 757 cargo aircraft conducted a takeoff from a closed runway at Denver (Colorado, U.S.) International Airport for a night freight operation during clear visual meteorological conditions and night light conditions. The two flight crewmembers were not injured and the aircraft was not damaged. The pilot-in-command (PIC) said, "On taxi out, we were cleared to taxi to, and subsequently cleared to take off from Runway 8. Men and equipment were on Taxiway R7. Normal takeoff and climbout [were conducted]. On departure, all runway [lights] and taxiway lights were illuminated. It was later reported [that] we departed from a closed runway, and missed a barricade by 12 feet [3.7 meters]. The runway was not NOTAMed [as] closed." Based on ASRS callback conversation with the PIC, the report said, "The flight had been originally cleared to Runway 35L but the crew had then requested Runway 8 for performance considerations, which was granted by [air traffic control]. The PIC stated that the [automatic terminal information service (ATIS)] was not monitored by the crew as they received their ATIS information by [aircraft communications addressing and reporting system (ACARS)]. The crew was tired as they were on the back side of the clock and this was their fourth leg that evening. The barricade was not noted on rotation as there was a dust cloud during the takeoff roll that had been created by the construction activity by Taxiway R7. The crew received a call later the next day from the chief pilot regarding this event, stating that the [aircraft] also narrowly missed a construction light pole. … It was further surmised that improper procedures were used in that the runway

lights, the lead-in lights and the taxiway lights associated with the runway used were all in an operational mode. [The PIC subsequently said,] 'I was unsure as of today if Runway 8 was NOTAMed [as] closed. We radioed Denver Tower [that] we were ready to take off on Runway 8 and received clearance to take off. Men and equipment were working on Taxiway R7 but were not on the runway.'" NASA ASRS is a confidential incident-reporting system. The ASRS Program Overview said, "Pilots, air traffic controllers, flight attendants, mechanics, ground personnel and others involved in aviation operations submit reports to the ASRS when they are involved in, or observe, an incident or situation in which aviation safety was compromised. … ASRS de-identifies reports before entering them into the incident database. All personal and organizational names are removed. Dates, times, and related information, which could be used to infer an identity, are either generalized or eliminated." ASRS acknowledges that its data have certain limitations. ASRS *Directline* (December 1998) said, "Reporters to ASRS may introduce biases that result from a greater tendency to report serious events than minor ones; from organizational and geographic influences; and from many other factors. All of these potential influences reduce the confidence that can be attached to statistical findings based on ASRS data. However, the proportions of consistently reported incidents to ASRS, such as altitude deviations, have been remarkably stable over many years. Therefore, users of ASRS may presume that incident reports drawn from a time interval of several or more years will reflect patterns that are broadly representative of the total universe of aviation-safety incidents of that type."

27. FAA said that a runway safety area is a defined surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot or excursion from the runway, in accordance with AC 150/5300-13.

28. FAA said that an object-free area is an area on the ground centered on the runway centerline, taxiway centerline or taxilane centerline provided to enhance the safety of aircraft operations by having the area free of objects except for those objects required for air navigation or aircraft ground-maneuvering purposes, in accordance with AC 150/5300-13.

29. FAA said that a taxiway safety area is a defined surface alongside the taxiway prepared or suitable for reducing the risk of damage to an airplane unintentionally departing the taxiway, in accordance with AC 150/5300-13.

30. Spence, Craig. Interview with Rosenkrans, Wayne. Alexandria, Virginia, U.S., Oct. 2, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

Further Reading From FSF Publications

FSF Editorial Staff. "Accident Report Provides Lessons Learned About Preventing Takeoff on a Closed Runway." *Accident Prevention* Volume 59 (July 2002).

FSF Editorial Staff. "Maintaining Visual Aids Helps to Prevent Runway Incursions." *Airport Operations* Volume 28 (May–June 2002).

FSF Editorial Staff. "Controller's Misperception of Aircraft Positions Sets Stage for Collision on Runway in Paris." *Accident Prevention* Volume 59 (May 2002).

U.S. Federal Aviation Administration. "Runway Incursion Severity Trends at Towered Airports in the United States: 1997–2000." *Flight Safety Digest* Volume 21 (February 2002).

FSF Editorial Staff. "Airfield Driver Training, Enforcement Help Prevent Aircraft-Vehicle Collisions." *Airport Operations* Volume 26 (September–October 2000).

FSF Editorial Staff. "Gulfstream II Collides With Stalled, Unlighted Vehicle After Tower Controller's Clearance to Land." *Airport Operations* Volume 25 (July–August 1999).

Spence, Craig. "Maintaining Safety and Security During On-airport Construction." *Airport Operations* Volume 16 (November–December 1990).

Hewes, B. Victor. "Design Airports for Safety." *Airport Operations* Volume 16 (July–August 1990).

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