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Agenda Item 2: Safety Oversight –
2.5 Safety - Related Topics

RUNWAY SAFETY AREAS/ENGINEERED MATERIALS ARRESTING SYSTEMS

(Presented by the United States of America)

SUMMARY

An Engineered Materials Arresting System (EMAS) is a recent development now available for safely stopping aircraft that overrun runways. The Engineered Arresting Systems Corporation (ESCO), the Federal Aviation Administration (FAA), and the Port Authority of New York and New Jersey (PANYNJ) developed the system in a cooperative effort. The resulting system, composed of aerated Portland Cement (Foamcrete), has proven successful in operation and is described in the FAA's Advisory Circular 150/5220-22, *Engineered Materials Arresting Systems (EMAS) for Aircraft Overruns.*

1. Introduction

1.1. On February 28, 1984, a Scandinavian Airline System DC-10-30 aircraft overran runway 4R after landing at John F. Kennedy International Airport (JFK), New York City, New York, and plunged into Thurston Basin. The accident report indicated that the DC-10 departed the end of the runway at about 75 knots and entered Thurston Basin 600 feet later still moving at about 38 knots. Overruns such as this one often result in loss of life, serious injury to passengers and crew, and extensive damage to aircraft.

1.2. Overruns in the United States average about ten per year. Since 1982 there have been 23 fatalities, over 300 injuries, and uncounted millions of dollars in aircraft damage at United States airports certified under 14 Code of Federal Regulations (CFR) Part 139, *Certification of Airports.* The majority of the severe overruns occurred at airports where the runway does not have a safety area that extends the full-recommended 1000 feet (300m) beyond the runway end.

1.3. An overrun, by definition, occurs anytime an aircraft passes beyond the departure end of a runway during an aborted takeoff or while landing. There are many reasons for an overrun: engine failures which result in insufficient power to complete the takeoff, thrust reverse failures, brake failures, improper flap settings, pilot misjudgments, and snow/ice on the runway surface.

2. Discussion

2.1. Accident reports published by the National Transportation Safety Board (NTSB) and the International Civil Aviation Organization (ICAO) have provided information on the weight, speed, location, runway conditions, and injuries for many aircraft overrun accidents. From these reports, it can be shown that approximately 90% of aircraft overruns come to rest within 1000 feet (300m) of the end of the runway.

2.2. In order to minimize the negative consequences of excursions from runways, the Federal Aviation Administration (FAA) requires a safety area 500 feet (150m) wide, extending 1000 feet (300m) in length beyond each end of air carrier runways (FAA Advisory Circular 150/5300-13, *Airport Design*, available electronically via Internet at http://www.faa.gov/arp/pdf/5300-13.pdf.) Many runways, however, were constructed before the adoption of this requirement and many safety areas do not extend the required 1000 feet (300m) beyond the end of the runway. There are many reasons these runway safety areas do not meet existing design standards: existing structures, bodies of water, large drop-offs, railroads, highways, or other development. The relocation of these impediments is often economically impractical or environmentally unacceptable. Consequently, it was necessary to develop a means of safely stopping an overrunning aircraft in less than 1000 feet (300m).

2.3. Studies conducted in Great Britain in the late 1960's and 1970's involved the use of urea formaldehyde foam beds in an effort to arrest moving aircraft. The tests provided significant information towards the development of a prediction method for determining the behavior of aircraft in a soft material environment.

2.4. The FAA William J. Hughes Technical Center initiated a study in 1986, in partnership with the Port Authority of New York and New Jersey (PANYNJ) and Engineered Arresting Systems Corporation (ESCO), to determine the feasibility of using this soft ground technology to arrest overrunning commercial aircraft. Initial qualification of candidate materials included evaluation of their effects on fuel-spill fires. Only those materials that did not promote combustion were chosen for further testing. After initial trials, phenolic foam was chosen as the most promising material.

2.5. The study began with the development of a mathematical model of the wheel/ground interface to accurately predict the aircraft gear loads, deceleration, and stopping distance within the arrestor bed. A series of field tests in 1991 validated the mathematical model. In 1993, a full-scale arrestor bed, constructed with phenolic foam, safely stopped a Boeing 727 aircraft traveling at 50 and 60 knots respectively within the arrestor bed. The aircraft was brought to a stop close to the point predicted by the math model in each test.

2.6. In 1994, the FAA and ESCO entered into a Cooperative Research and Development Agreement (CRDA) to test new materials and methods related to the practical aspects of soft ground arrestors. Further refinement of the model and continued testing of materials resulted in selection of aerated Portland Cement (Foamcrete) for additional tests in 1995-96. The tests showed good correlation between the actual stopping distance within the arrestor bed and the predicted stop distance from the math model. The material was shown to be easily traversable by Aircraft Rescue and Fire Fighting equipment operating during an emergency.

2.7. After the successful completion of the Foamcrete test, FAA’s Office of Airport Safety and Standards issued advisory circular 150/5220-22, *Engineered Materials Arresting Systems (EMAS) for Aircraft Overruns* (available electronically via Internet at http://www.faa.gov/arp/pdf/5220-22.pdf). In 1998, the first prototype EMAS Foamcrete system was installed on runway 4R at JFK International Airport.

2.8. On May 8, 1999 a Saab 340 commuter aircraft with 27 people aboard overran runway 4R at JFK International Airport, the same runway overrun by the Scandinavian Airlines DC-10 in 1984. The runway exit speed is estimated to be as much as 130 mph (113 kt). Computer modeling indicates that in the absence of the EMAS, an exit speed of only 80-mph (70 kt) would have resulted in the aircraft reaching Thurston Basin. The aircraft entered the EMAS, however, and after traveling 248 feet, it was brought to a halt with only minor damage. The only injury occurred during the evacuation of the aircraft when a passenger twisted an ankle.

2.9. The runway safety area on runway 4R at Little Rock International Airport, Little Rock, Arkansas extends 450 feet beyond the end of the runway, ending at a levee sloping down into the Arkansas River. The safety area was scheduled to have an EMAS installed. However, on June 1, 1999, before construction began, an American Airlines McDonnell Douglas DC-9-82 (MD-82) aircraft overran the runway. The aircraft ran off the side of the runway before reaching its end and then traversed back toward the extended runway centerline and ran into one of the approach light support towers. The approach light support towers beyond the runway safety are not of the breakaway type because they are located in the river flood plain. The pilot and several passengers were killed. A natural question is “would an EMAS have stopped the aircraft?” Analysis has shown that the aircraft would have only partially engaged an EMAS and although it would have slowed, it would not have stopped. It also exited the runway in a yawed attitude – a condition that was not considered in the development of EMAS.

2.10. On March 5, 2000, a Southwest Airlines Boeing 737-300 overran the departure end of runway 8 after landing at Burbank-Glendale-Pasadena Airport, Burbank, California. The aircraft overran the runway at approximately 32 knots, collided with a metal blast fence, and came to rest on a city street off airport property. Of the 142 persons on board, two sustained serious injuries; 41 sustained minor injuries and the aircraft sustained extensive damage. An EMAS was completed in February 2002 on this runway safety area. Because of site constraints, the EMAS was designed to completely stop a B-737 overrunning the runway at 50 knots instead of 70 knots. FAA standards recommend designing for 70-knot performance, but allow a lower design speed where available space precludes the higher standard. The system installed would have arrested the actual overrun.

2.11 An early problem with the EMAS top coating related to jet-blast damage has been solved. At the time an EMAS was installed on the rollout end of Runway 22 at La Guardia, New York, the recommended setback distance was for the arresting system to start 100 feet from the runway end. Due to a very short safety area and a desire to obtain as much arresting capability as possible, the LaGuardia EMAS started 35 feet (10.5m) from the runway end. Repeated exposure to jet-blast from departures damaged the EMAS beyond repair and it was removed. A new jet blast-resistant (JBR) coating was developed and successfully tested, including a one-year demonstration installation at LaGuardia runway 22 which permitted EMAS installations to start at 75 feet (22.5m) from the runway end. A recent improvement to the JBR block protection system is a new plastic lid and bottom tray that replaces the current JBR coating system. The new system will reduce maintenance costs and provide improved moisture resistance for EMAS. Improved JBR also allows the construction of EMAS nearer the runway end.

3. Conclusions

3.1. The FAA places a high priority on improving the safety of the operational environment at airports. The runway safety area is an important component of enhancing airport safety. Each runway safety area that does not meet current standards poses an increased risk to any aircraft that leaves the runway surface during takeoff and landing operations. Emphasis has been placed toward accelerating improvements to runway safety areas that do not meet current standards, with a goal to improve non-standard runway safety areas to the extent practicable.

3.2. EMAS will continue to be installed where it is shown to be the best alternative to enhance safety when a standard runway safety area cannot be constructed. To date, 18 EMAS installations at 14 airports have been completed with others in the planning and design stages. The FAA has recently completed an analysis that demonstrates that a standard EMAS provides a level of safety that is generally equivalent to a standard 1,000 feet (300m) long safety area in stopping an overrunning aircraft at 70 knots or less. We have revised our policy to now permit an EMAS in place of the standard 1,000 feet (300m) long safety area when economic and environmental considerations indicate EMAS is the more practical solution. The revised policy provides protection for aircraft that land short of the runway as well as those that overrun.

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