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TECHNICAL SUMMARY: WA-TS 98.001

SUBJECT: *CRITICAL AREA, SENSITIVE AREA, AND STATIC REFLECTION SOURCES. EMPLOYING LARGE APERTURE LOCALIZER ANTENNAS TO IMPROVE AIRPORT EFFICIENCY WHILE RELAXING AIRPORT DEVELOPMENT CONSTRAINTS*

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Many articles have been written regarding congestion of the airways around large metropolitan areas. Delays are now recognized as a substantial possibility that must be considered when making travel arrangements. The delays are common on the ground while awaiting takeoff clearance and in the air while awaiting approval to land in all types of weather conditions. The problem is exacerbated when weather conditions, i.e. low ceilings and poor visibility, dictate that instrument approach procedures must be used. By logical reasoning, a delay experienced by the passenger generally represents a period of congestion in the air or on the ground where the probability of an occurrence, such as an accident, is increased. The impacts are reduced safety, a lower quality of service to the flying public, lowered reputation of the air carrier, and additional fuel requirements, which all can be attributed in some way to the cost of services. This document focuses on the role the Instrument Landing System (ILS) plays, or can play, to minimize these affects. Further elaboration is made on limits placed on commercial development on and around the airport and the application of wide aperture antennas to minimize these constraints. For purposes of this summary, only the localizer portion of the ILS is considered.

Interpreting ICAO Annex 10, Critical Area is the region near the localizer that must be kept free of aircraft, vehicles, or structures while an aircraft is making an ILS approach in instrument conditions. The sensitive area is the region, in addition to the critical area, that should be controlled via local procedures to minimize the probability of an out-of-tolerance signal existing for an aircraft on approach. Procedures are used to define the location, orientation, and migration routes of aircraft in the sensitive area. In addition, the dimensions of these areas are determined by the size of aircraft utilizing the airfield, the category of approach desired, and the amount of guidance error already produced by static sources in the airport environment: i.e., larger areas for larger aircraft; larger areas for higher categories of approach; and larger areas if the static errors are large. An interesting note is that ICAO Annex 10 reads that these areas should be protected "to the extent practicable". The quoted phrase indicates the required balance of providing quality guidance signal while permitting reasonable ground operations.

Increasing the aperture of the localizer, therefore narrowing the radiated beam, allows for the smallest critical and sensitive areas to be defined, as well as reducing the static errors. The fundamental concept is to confine the energy into the area required to provide guidance to a landing aircraft while minimizing the radiation in all other areas such as where ground traffic is necessary and desired. These concepts are by no means new, however, high density airport development and traffic requirements dictate reassessment of the benefits of employing larger aperture antennas.

The affect of reducing these areas is significant to minimizing airport efficiency and safety. For an aircraft awaiting clearance to land, it means reduced waiting periods to ensure that the critical and sensitive area requirements are met. For the aircraft awaiting take-off clearance it means that the pilot can position the aircraft closer to the runway threshold and that minimal delay can be expected. For the controller this means they can position aircraft awaiting take-off closer to the runway and landing aircraft must go a shorter distance before clearance can be given to the next aircraft in the sequence. Aircraft can now land and take-off more frequently, and more opportunity exists for the controller to position aircraft on the airfield without concern for degrading the signal quality to the approaching aircraft. In short, improved air and ground efficiency results.

One cannot consider the size of the critical area without first considering the magnitude of the guidance signal error produced by static sources of reflection in the airport environment. Examples of static sources are buildings, power lines, trees, and terrain. It is not uncommon for airport authorities to prevent a proposed construction that could significantly benefit airport or local economy growth in order to minimize static effects to the ILS. This undesirable constraint can be minimized by employing larger aperture antennas, which confine the energy to the greatest extent possible. ICAO Annex 10 defines the requirements for considering the impact of the static errors in defining the critical and sensitive areas. The formula, with variables redefined here for clarity, involves the root-sum-square of the errors produced by static sources and those produced by ground operations.

ARE = SQRT(CT^2 -ESE^2)

ARE = Allowable Remaining Error (used to determine protection area size)
CT = Category Tolerance
ESE = Existing Static Error

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An example is given here for Category III requirements for the region between the threshold and ILS point E where the composite error cannot exceed 5 uA of cross-pointer deflection. For the condition of only 1.5 uA of static error, or 30 percent of tolerance, 4.77 uA of error can be produced by ground operations. For 4 uA of static error, or 80 percent of tolerance, only 3 uA are permitted by ground operations, and the defined areas must be sufficiently large to ensure this condition. The root-sum-square method is deemed justified by ICAO because it is not likely that the errors, static and dynamic, will be received by an aircraft on approach in an in-phase condition and that the errors should not be simply added. Although this may not be likely, it is entirely possible. However, application of a formula involving a simple summation would place unrealistic constraints on ground operations and would require vast protected zones.

Of particular interest is the method used to determine the extent of the reflections caused by ground traffic and operations. The most common method is through the use of computer modeling. These models are typically very complex and are validated to predict signal scattering affects with a high degree of accuracy. Annex 10 also speaks to validating the quality of the airborne signal through flight measurements while significant sources of scattering are positioned in an operational fashion. The difficulty in both cases is that there are endless combinations of scatter positions, orientations, and many size considerations. Some of these would result in in-phase superposition of one or more error sources that would produce an out-of-tolerance condition to an approaching aircraft. This is where procedures are used by controllers to minimize a potential occurrence. However practical this may be, it is unreasonable to expect a human interface, i.e., the controller adhering to defined procedures, to detect a signal condition caused by superposition of multiple sources of reflected energy that is a mathematical feat for today's modern computers. It is, however, the best means at our disposal in the modern day.

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Conclusions: The solution to the afore-stated problems or issues is to confine the radiated energy, to the greatest extent possible, thereby preventing illumination of sources of reflections. Antennas with large electrical apertures and therefore narrow beams are necessary and effective in minimizing static reflections and reducing the size of the critical and sensitive areas.

Employing wide aperture antennas allows lateral and longitudinal reduction of the critical and sensitive areas. This reduction for the sensitive area, in some cases, could ease unnecessary constraints and regulation of areas outside the airport boundaries.

Minimizing static reflections will allow greater ground and air traffic in those areas without detriment to the signal quality provided to the approaching aircraft. Procedures could be defined to allow more flexibility in the size, number, orientation, and migration rates of aircraft utilizing the airfield. The result will be improved airport efficiency and safety.

The DOT/FAA publication, "Siting Criteria for Instrument Landing Systems," 6750.16C, provides no guidance for defining sensitive areas for the localizer system.

REFERENCES:

1. "International Standards and Recommended Practices Aeronautical Communications," ICAO Annex 10, Volume 1. (Radio Navigation Aids) including Attachment C., Fifth Edition, July 1996.

2. "Siting Criteria for Instrument Landing Systems," U.S. DOT/FAA 6750.16C, October 31, 1995.

3. "United States Standard Flight Inspection Manual," Federal Aviation Administration Order 8200.1A, May 1996.

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