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## MANUAL ON THE SECONDARY SURVEILLANCE RADAR (SSR) SYSTEMS

THIRD EDITION — 2004

### AMENDMENT NO. 1

To incorporate this amendment:

- a) replace existing pages (vi), (vii), 6-1 to 6-19 and 8-4 to 8-7 with the attached new pages dated 20/1/06;
- b) record the entry of this amendment on page (ii).

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# **Manual on the Secondary Surveillance Radar (SSR) Systems**

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Approved by the Secretary General  
and published under his authority

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## FOREWORD

Secondary surveillance radar (SSR) is a major system for surveillance purposes in most air traffic control (ATC) systems. One of the important updates was the standardization of Mode S systems in 1985. Mode S has a data link capability which is part of the aeronautical telecommunication network (ATN).

The purpose of this document is to describe all the system characteristics not only of the ground station but also the airborne transponder. This document should be read together with Annex 10 for the relevant Standards and Recommended Practices (SARPs).

Several chapters describe Mode S surveillance and communications functions, including the implementation aspects of Mode S, interference considerations and the Mode S subnetwork of the ATN.

There is a specific chapter on Mode S extended squitter concept, technique and applications. The Mode S extended squitter system is subject to patent rights from the MIT Lincoln Laboratory. On 22 August 1996, MIT Lincoln Laboratory issued a notice in the Commerce Business Daily (CBD) of its intent not to assert its rights as patent owner

against any and all persons in the commercial or non-commercial practice of the patent, in order to promote widest possible use of the Mode S extended squitter technology. Further, by letter to ICAO dated 27 August 1998, MIT Lincoln Laboratory confirmed that the CBD notice was provided to satisfy ICAO requirements for a statement of patent rights for techniques that are included in SARPs, and that “the patent holders offer this technique freely for any use”.

This document consists for the most part of material developed by the Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel (SICASP).

Comments on this manual from States and other parties outside ICAO concerned with SSR systems development and provision of services would be appreciated. Comments should be addressed to:

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## GLOSSARY

**Aircraft address.** A unique combination of 24 bits available for assignment to an aircraft for the purpose of air-ground communications, navigation and surveillance.

*Note.*— The aircraft address is also referred to as the Mode S address or the aircraft Mode S address.

**All-call.** An intermode or Mode S interrogation that elicits replies from more than one transponder.

**All-call (Mode A/C-only).** An intermode interrogation that elicits replies from Mode A/C transponders only. Mode S transponders do not accept this interrogation.

**All-call (Mode A/C/S).** An intermode interrogation that elicits Mode A/C replies from Mode A/C transponders and all-call replies from Mode S transponders that are currently not in the lockout state.

**All-call (Mode S-only).** A Mode S interrogation that elicits all-call replies from Mode S transponders that are currently not in the lockout state.

**All-call (stochastic).** A Mode S-only all-call that elicits all-call replies from only a random subset of the Mode S transponders that are currently not in the lockout state.

**Altitude.** The vertical distance of a level, point or an object measured above mean sea level.

**Antenna (electronically scanned, E-Scan).** An SSR antenna consisting of a number of planar arrays or a circular array of radiating elements. A beam former unit allows it to electronically steer the beam to the desired azimuth angle by applying phase shifting. The antenna elements may either be active or passive, depending on the order in which the beam former and transmitter(s) are set up.

**Antenna (hog-trough).** An SSR antenna comprising a horizontal linear array of radiating elements installed in an extended corner reflector assembly (resembling in shape a hog-trough). The linear array is usually of sufficient length to give an azimuth beam width of between 2° and 3° and the hog-trough reflector

achieves typically between  $\pm 40^\circ$  and  $45^\circ$  vertical beamwidth. For special purposes shorter arrays can be used. These have increased azimuth beam width.

**Antenna (large vertical aperture, LVA).** An SSR antenna comprising two-dimensional array radiating elements. A typical LVA consists of a number of columns (each consisting of a vertical linear array designed to produce beam shaping in the vertical plane) arranged in a horizontal linear array to produce between 2° and 3° azimuth beamwidth. Typically, LVA antennas are a pre-requisite for monopulse SSR systems.

**Antenna (linear array).** An antenna consisting of a “battery” or array of radiating elements in a straight line. The desired radiation characteristic of the antenna is obtained by the varied distribution of radio frequency energy in amplitude or phase so as to produce the shaped “beam” or wave front.

**Antenna (sum and difference).** A hog-trough or LVA antenna which is electrically split into two halves. The two half-antenna outputs are added in phase at one output port (sum,  $\Sigma$ ) and added in antiphase at a second output port (difference,  $\Delta$ ) to produce output signals which are sensitive to the azimuth angle of arrival of received signals, enabling an off-boresite angle for the signal source to be obtained.

**Antenna (reflector).** An antenna producing the beam by a method analogous to optics. In most cases the “reflector” surface of the antenna is illuminated by a radio frequency source (e.g. a radio-frequency “horn” assembly). The dimensions of the reflector antenna both in the horizontal and vertical plane, together with the characteristics of the illuminating source, determine the shape and magnitude of the radar beam produced.

**Antenna elevation (tilt).** An angle between the direction of maximum gain of the antenna and the tangent to the surface of the earth. A distinction is sometimes made between electronic (radio signal) and mechanical tilt, especially for SSR LVA antennas. In this case the mechanical tilt may be zero while the antenna is radiating at the electronic tilt of 3°.