



Regional Workshop on SSR Mode S II Code and 24 Bits Addresses assignment

Accra, Ghana, 24-27 October 2023



MODULE 1: Assignment of aircraft 24 bits address for SSR Mode S Operation

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Module 1 Headlines

- I. Background on the limitation of Mode A and Mode C interrogation
- II. Background on Mod S Selective interrogations and its performance
- III. Technical specifications and 24 bits addressing scheme.
- IV. Planning for the development of a national 24 bits addresses register





Objectives of the Module



Based on the limitations experienced in SSR Mode A/C operations and the opportunities provided by Mode S SSR operation:

- Increase States and the industry awareness in SSR Mode S 24-bit addresses assignment
- Harmonize practices in Mode S address planning

At the end of the Module, the participants will be able to develop a National 24 bits addresses Plan





Background on the limitation of Mode A and Mode C interrogations

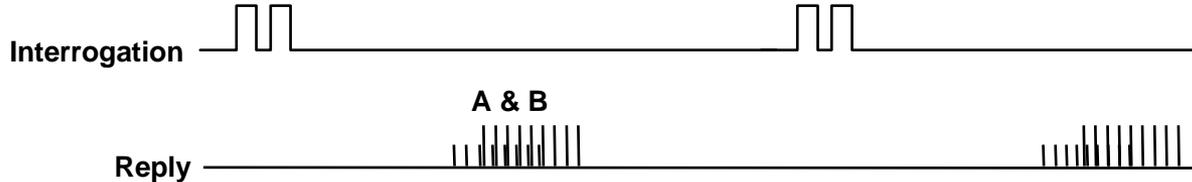




Synchronous Garbling of Transponder Replies



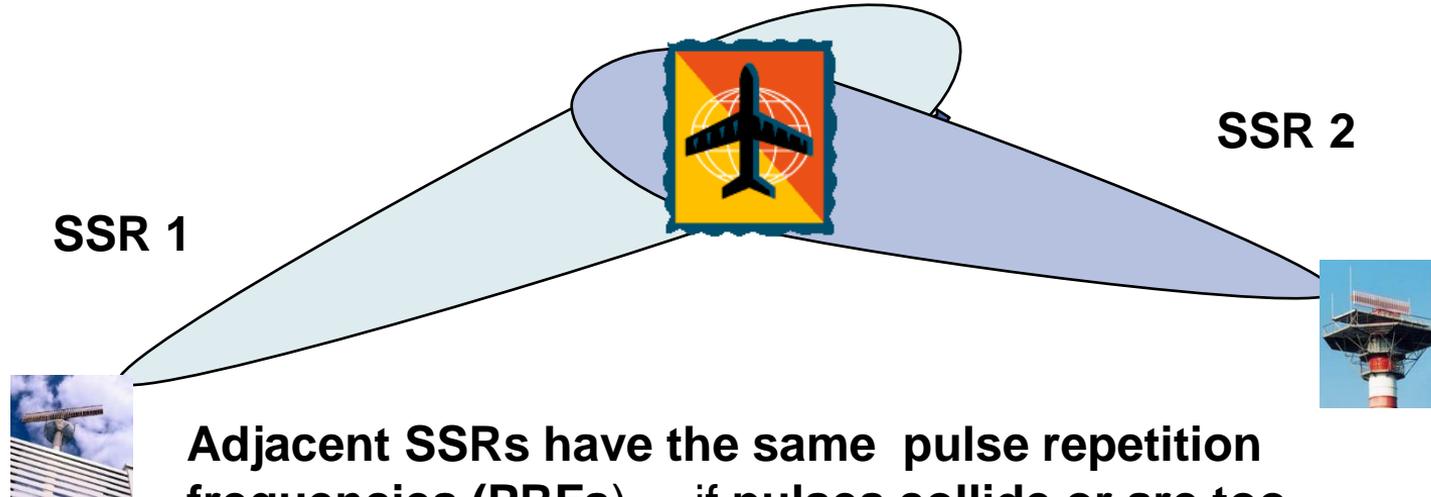
A problem in busy areas resulting in some aircraft not being detected



- Replies A & B Garble When Aircraft Are < 2 Miles Apart in Slant Range



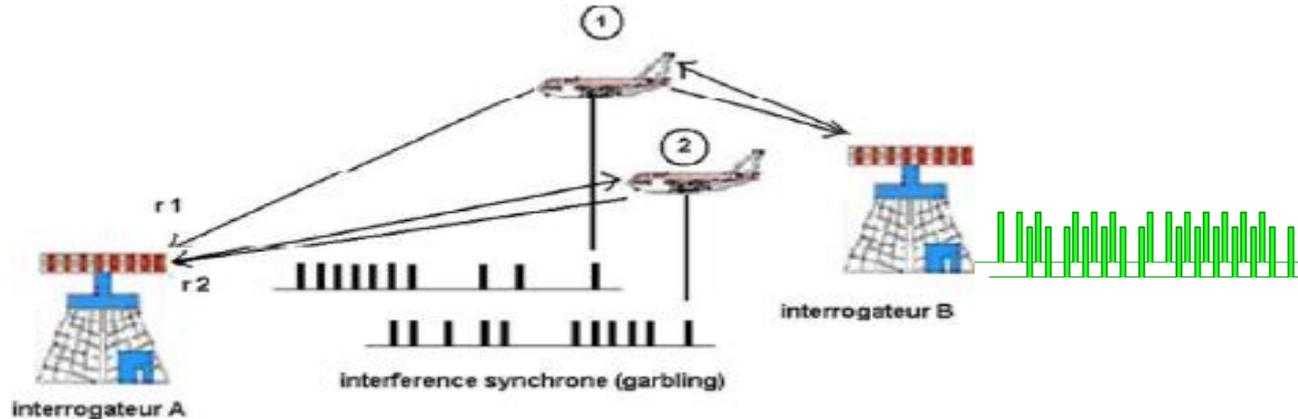
Garbling of interrogations



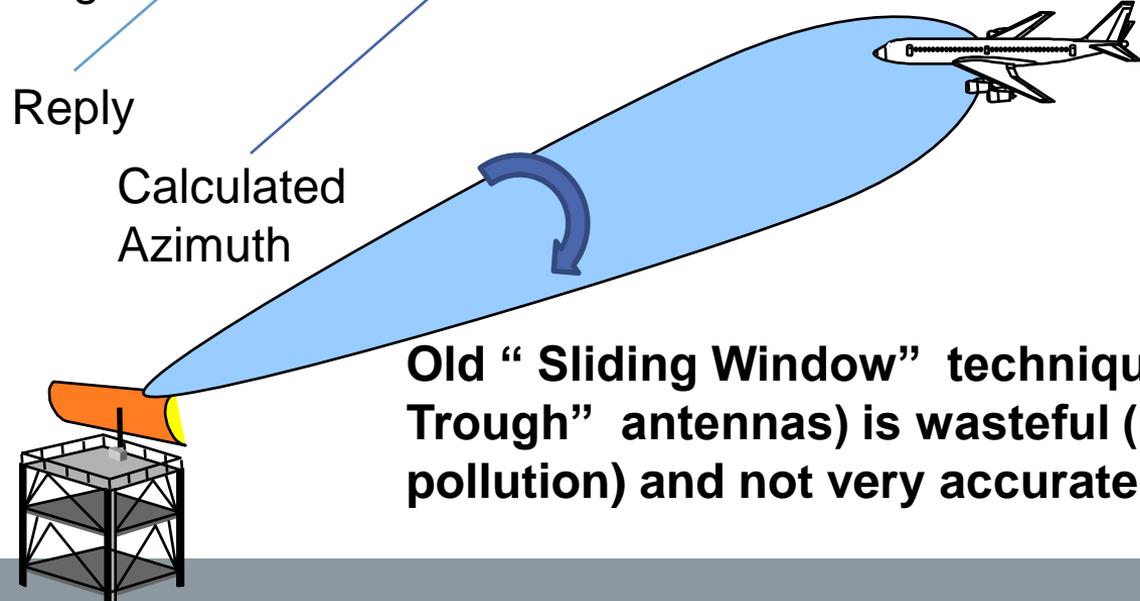
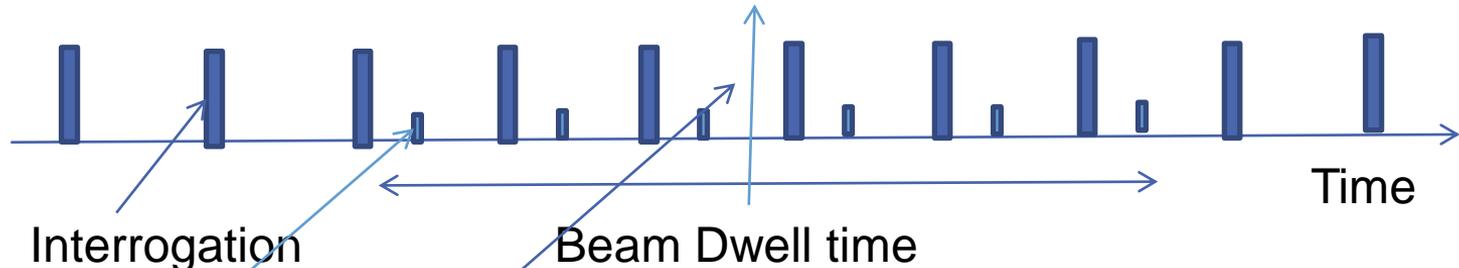
Adjacent SSRs have the same pulse repetition frequencies (PRFs) – if pulses collide or are too close, the aircraft won't be detected



False Replies Unsynchronized In Time (FRUIT)



- Station **B** Transmits to *A/C 1* and receives a correct synchronous response; although this response is dedicated to B Interrogator **A** also received (**R1**)
- Interrogator **A** Transmits to *A/C 2* and receives a correct synchronous response **R2** but this response is garbled by unsynchronised response **R1**



Old “ Sliding Window” technique (using “ Hog Trough” antennas) is wasteful (in terms of RF pollution) and not very accurate

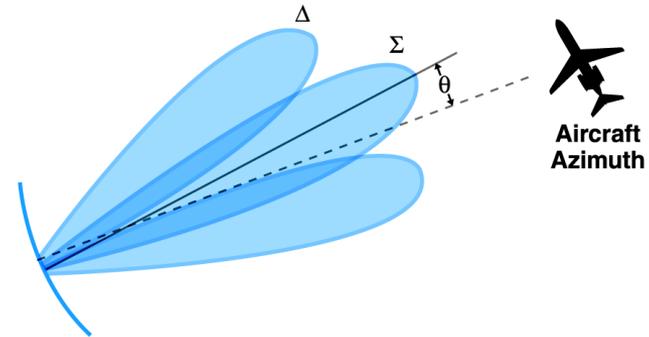
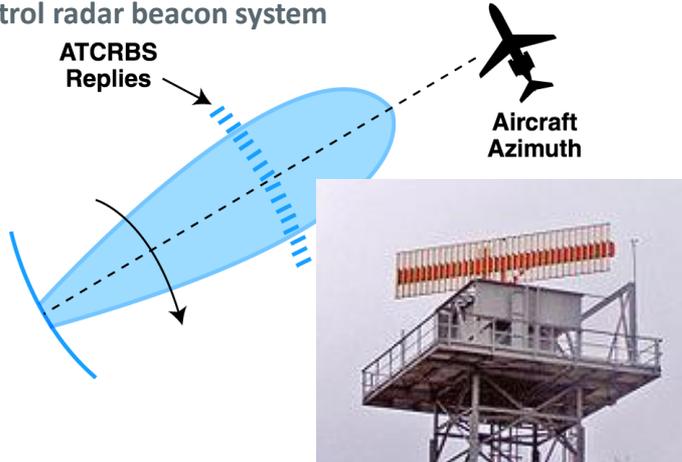


Monopulse Direction Finding (with Large Vertical Aperture (LVA) antenna)

ATCRBS SENSORS USE
SLIDING WINDOW DETECTOR

MODE S SENSORS USE
MONOPULSE TECHNIQUE

ATCRBS: Air traffic control radar beacon system



CHARACTERISTICS:

- SUSCEPTIBLE TO AZIMUTH SPLITS
- HIGH PULSE REPETITION FREQUENCY
- USES ANTENNA SUM & DIFFERENCE BEAMS TO ESTIMATE AZIMUTH FOR EACH REPLY
- ALLOWS LOWER PULSE REPETITION FREQUENCY



Summary

- **SSR Limitations due to garblings and FRUIT**
- **SSR Codes are assigned by ATCOs and only 4096 Codes are available**
- **Allocation can be in conflict if not properly coordinate**



Background on Mod S Selective interrogations and its performance

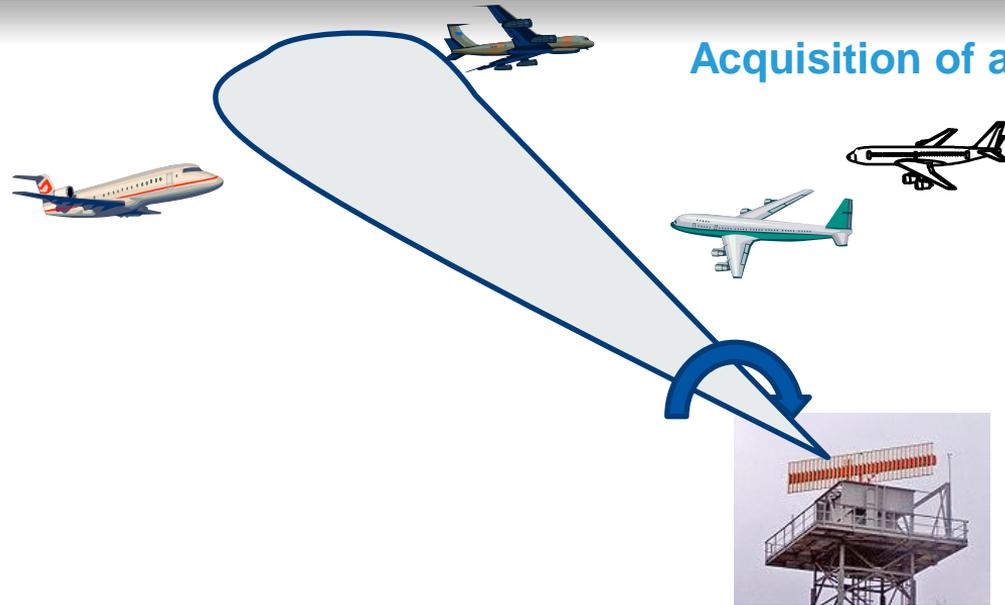




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Acquisition of all aircraft in coverage by the interrogator

- 1: The interrogator sends out an All-Call signal with its Identification Code (1 to 15)
2. Each A/C in coverage replies giving its 24 bits address 16 777 214 24-bit aircraft addresses)
3. Having acquired all A/c in coverage, the interrogator selectively interrogates every A/C (roll-call)



Mode S Acquisition and Lock out

Once an aircraft is “**acquired**” by the ground radar, ideally it should not reply to subsequent **All-call** interrogations.

That is why the interrogator can “**lock out**” an already detected aircraft from replying to further **All-call** interrogations.

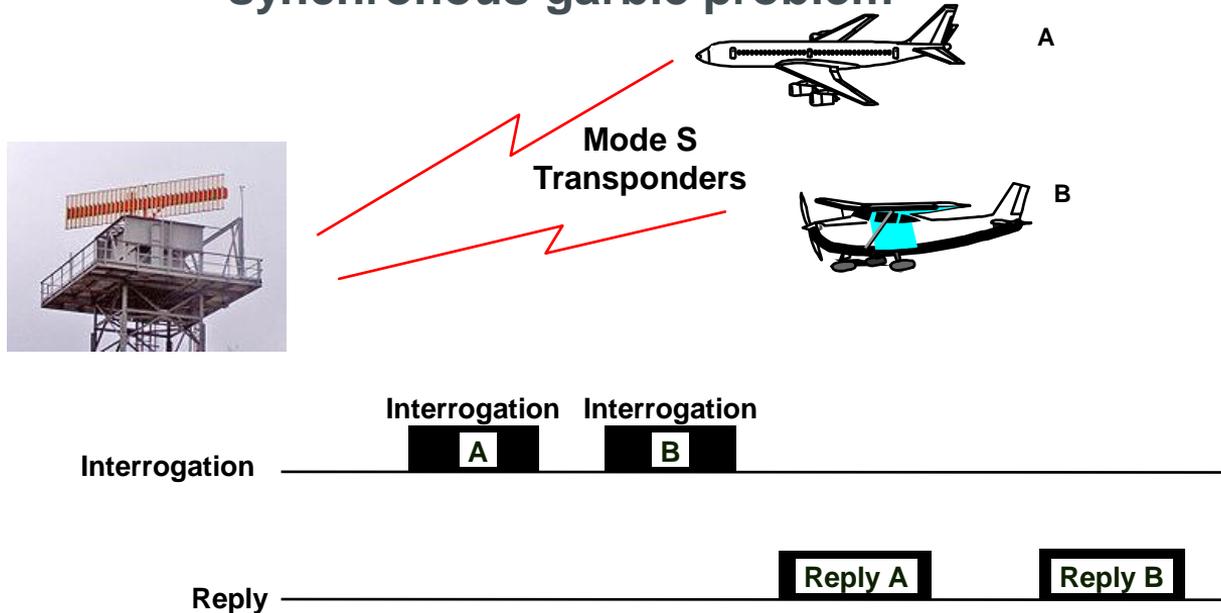
However, the aircraft should be able to reply to **All-call** interrogations **from other/adjacent radars**.

This is why each interrogator can have its own “**Interrogator Code (IC)**”.





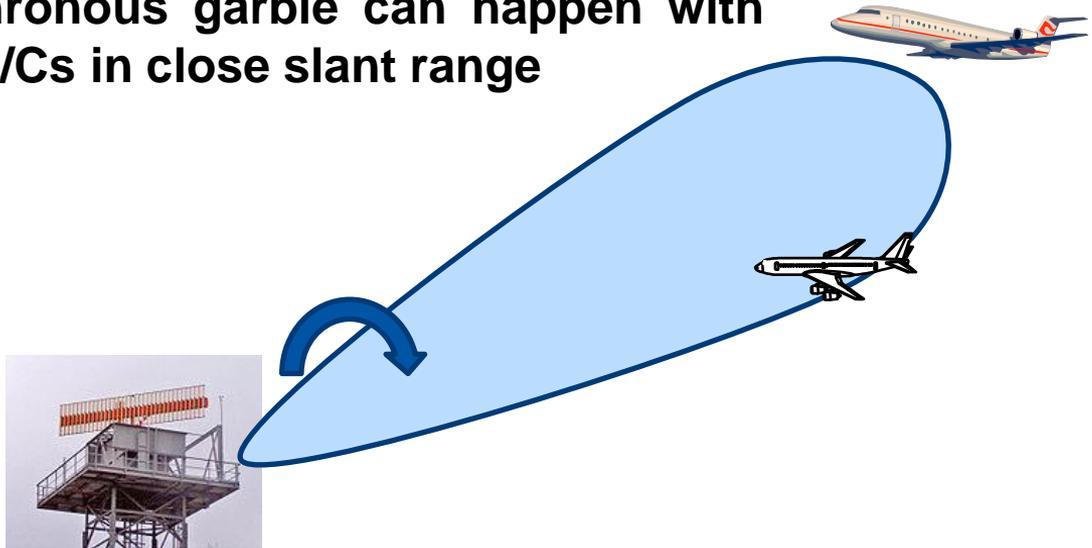
Mode S and Monopulse technique can solve the synchronous garble problem



But the interrogator needs to know each aircraft 24 bits address before it can selectively interrogate them



So the same synchronous garble can happen with Mode S as well for A/Cs in close slant range



However, Mode S can do adaptive interrogations. The Stochastic All-call interrogation asks for replies to be sent with a probability of less than 1. Chances are the two A/Cs come up with different probabilities so both don't reply to each interrogation. So both are acquired.



Summary

- **SSR Mode S selectively interrogate the A/C using a Unique 24 bits address for each A/C 2^{24} (≥ 16 Millions addresses b) Mode S codes are available**
- **Reduction of synchronous garbling**
- **Opportunity for Data Link**
- **Increased safety of ACAS operation**
- **Mode S transponders with their 24-bit addresses are oriented towards the application of ACAS, ELT, SSR Mode S, and ATN with VDL, AMSS, and other functions**



Aircraft Addressing System





General

- The use of global CNS systems is based on the assignment of exclusive 24-bit aircraft addresses.
- Each aircraft is identified unequivocally through an invariable 24-bit identifier assigned by the State where an aircraft is registered in accordance with standards established by ICAO for Mode S transponders.
- In no case will an aircraft address be assigned to more than one aircraft



Allocation of aircraft 24 bits addresses

- **Blocks of consecutive addresses defined by a fixed pattern of the first 4, 6, 9, 12 or 14 bits of the 24-bit address (Table 9-1 of Annex X Volume III Part I Chap.9).**
- **Blocks of different sizes: 1 048 576, 262 144, 32 768, 4 096 and 1 024 consecutive addresses, respectively**
- **Management of the scheme: ICAO shall administer the scheme so that appropriate international distribution of aircraft addresses can be maintained.**
- **Allocation of aircraft addresses: Blocks of aircraft addresses allocated by ICAO to State of Registry or common mark registering in accordance with Table 9-1 of Annex X Volume III Part I Chap.9**



Allocation of aircraft 24 bits addresses

- **State of Registry or common mark registering authority shall notify ICAO when allocation to that State of an additional block of addresses is required for assignment to aircraft.**
- **Blocks of aircraft addresses not yet allocated shall be distributed on the basis of the relevant ICAO region with the following addresses starting bit combinations:**

00100: AFI region

01101: ASIA region

00101: SAM region

1001: NAM and PAC regions

0101: EUR and NAT regions

111011: CAR region

01100: MID region



Allocation of aircraft 24 bits addresses

- Aircraft addresses starting with bit combinations 1011, 1101 and 1111 have been reserved for future use.
- Any future requirement for additional aircraft addresses shall be accommodated through coordination between ICAO and States
- A request for additional aircraft addresses shall only be made by a registering authority when at least 75 per cent of the number of addresses already allocated to that registering authority have been assigned to aircraft
- ICAO shall allocate blocks of aircraft addresses to non-Contracting States upon request

Assignment of aircraft 24 bits addresses

- **State of Registry or common mark registering authority assigns an individual aircraft address to each suitably equipped aircraft entered on a national or international register using its allocated block of addresses (Table 9-1) in accordance the following principles:**
- **At any one time, no address shall be assigned to more than one aircraft with the exception of aerodrome surface vehicles on surface movement areas separated by at least more than 1 000 km;**
- **Only one address shall be assigned to an aircraft, irrespective of the composition of equipment on board**
- **In the case of shared removable transponder by several light aviation aircraft such as balloons or gliders it shall be possible to assign a unique address to the removable transponder**
 - ✓ **The registers 08_{16} , 20_{16} , 21_{16} , 22_{16} and 25_{16} of the removable transponder shall be correctly updated each time it is installed in any aircraft**



Assignment of aircraft 24 bits addresses

- **Aircraft 24 bits address shall not be changed except under exceptional circumstances and shall not be changed during flight**
- **When an aircraft changes its State of Registry, the new registering State shall assign the aircraft a new address from its own allocation address block, and the old aircraft address shall be returned to the allocation address block of the State that previously registered the aircraft;**
- **Aircraft 24 bits address shall serve only a technical role for addressing and identification of aircraft and shall not be used to convey any specific information;**
- **Addresses composed of 24 ZEROS or 24 ONES shall not be assigned to aircraft.**



Application of aircraft 24 bits addresses

- **Aircraft addresses is used in applications which require the routing of information to or from individual suitably equipped aircraft**
- **Examples of applications aeronautical telecommunication network (ATN) applications: SSR Mode S and airborne collision avoidance system (ACAS);**
- **Standard does not preclude assigning the aircraft addresses for special applications associated with the general applications defined therein: 24-bit address in a pseudo-aeronautical earth station to monitor the AMSS ground earth station and in the fixed Mode S beacon to monitor the Mode S ground station operation (s specified in Annex 10, Volume IV, 3.1.2.6.10.1.2)**
- **Address assignments for special applications are to be carried out in conformance with the procedure established by the State to manage the 24-bit address assignments to aircraft;**
- **An address consisting of 24 ZEROs shall not be used for any application**



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Administration of temporary aircraft 24 bits address assignment

- **ICAO strongly encouraged States to assign 24 Bits addresses in their allocated addresses block**
- **However, Temporary addresses can be assigned by ICAO to aircraft in exceptional circumstances, such as when operators have been unable to obtain an address from their individual States of Registry or Common Mark Registering Authority in a timely manner**
- **ICAO shall assign temporary addresses from the block “ICAO¹” shown in Table 9-1**



Administration of temporary aircraft 24 bits address assignment

- Request of a temporary address contains aircraft identification, type and make of aircraft, name and address of the operator, and an explanation of the reason for the request;
- Upon issuance of the temporary address to the aircraft operators, ICAO shall inform the State of Registry of the issuance of the temporary address, reason and duration
- Aircraft operator informs the State of Registry of the temporary assignment, reiterate the request for a permanent address, and inform the airframe manufacturer



Administration of temporary aircraft 24 bits address assignment

When the permanent aircraft address is obtained from the State of Registry, the operator:

- **informs ICAO without delay**
- **Relinquishes his/her temporary address; and**
- **Arrange for encoding of the valid unique address within 180 calendar days**



Administration of Temporary Aircraft Address assignment

- **If a permanent address is not obtained within one year, the aircraft operator shall reapply for a new temporary aircraft address**
- **Under no circumstances a temporary aircraft address shall be used by the aircraft operator for over one year**



Summary

- **Worldwide Scheme for the Allocation, Assignment and Application of Aircraft Addresses**
- **Description/Management of the scheme: 24 bits addresses dedicated to identifying aircraft**
- **Allocation of aircraft addresses: 24 bits addresses blocks of various size allocated to each State**



Summary

- **Assignment of aircraft addresses: 24 bits addresses from State block assigned unequivocally to each aircraft**
- **Application of aircraft addresses: ANT applications (Mode S, VDL, ACAS...)**
- **Administration of Temporary Aircraft Address assignment: Temporary addresses not encouraged by ICAO but assigned in exceptional circumstances by ICAO for a duration less than one year**



Planning for the development of a national 24 bits addresses register





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Exercise