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FOURTH MEETING

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Agenda Item 4: **Research and development programmes, trials and demonstrations in communications, navigation, and surveillance (CNS) and air traffic management (ATM)**
Agenda Item 5: **Air traffic management (ATM)**
Agenda Item 8: **Development of a global co-ordinated plan**

AIRCRAFT NAVIGATION USING RADAR SURVEILLANCE DATA

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SUMMARY

This paper describes how aircraft positional data derived from air traffic control (ATC) ground-based radar surveillance systems could be used to improve the accuracy and availability of on-board navigational data, and be used as a back-up of the navigation system, and for its integrity monitoring. It also proposes to investigate this issue and therefore include it in the list of tasks which need to be undertaken to support the implementation of the communications, navigation, and surveillance/air traffic management (CNS/ATM) systems.

1. INTRODUCTION

1.1 As air traffic control (ATC) also plans to use data derived from on-board navigation systems for surveillance purposes (automatic dependent surveillance (ADS)), we should consider as well the possibility of using aircraft positional data derived from the ATC ground-based radar surveillance systems for what we could name surveillance radar navigation (SRN).

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1.2 The fact is that ATC surveillance radars are already being used indirectly for navigational purposes in those cases where air traffic controllers assuming the navigation of aircraft direct them by means of radar vectoring.

2. SURVEILLANCE RADAR NAVIGATION (SRN) DEFINITION

2.1 SRN could be defined as follows:

2.1.1 Surveillance radar navigation is a function for use by aircraft flying under ATC ground-based radar and data link coverage in which the ground system automatically transmits, via a data link, data derived directly from radar stations or from radar data processing systems. As a minimum, the data includes the aircraft identification and its two dimensional position (longitude, latitude) as determined by radar. Additional data (speed as calculated by the ground system, altitude as determined by a precision approach radar (PAR) or GCA, altitude as received from the aircraft, etc.) may be provided as appropriate.

3. SRN MESSAGES

3.1 SRN messages could be exchanged between ground and air via a variety of data links (Mode S, very high frequency (VHF), satellite).

3.2 Ground-to-air messages

3.2.1 SRN positional data messages could be transmitted automatically by the ground system, either:

a) to all aircraft under radar contact when determined by the ground system. For example, immediately after the detection by the ground system (global navigation satellite system (GNSS) ground monitoring station) of a failure or degradation of the GNSS space segment. SRN messages should be sent periodically at defined intervals as established by the ground system (for example, every detection or antenna scan); and

b) to only specific aircraft upon request for just one SRN message or for a set of them to be sent periodically as above.

3.2.2 SRN messages would need to be time stamped with the radar aircraft detection time unless they are transmitted to the aircraft immediately upon radar detection (when sent periodically) or immediately after aircraft request for just one SRN message.

3.2.3 It might be necessary for SRN messages to include a figure of merit to indicate the accuracy of the radar measurement.

3.2.4 Also a **radar contact lost** message, a **closed to leave radar coverage** message and a **SRN service stop** message would probably need to be defined.

3.3 **Air-to-ground messages**

3.3.1 A set of aircraft originated **SRN service request** messages and one **SRN service stop** message would need to be defined as follows:

a) request for just one SRN message;

b) request for periodic service (after the request message has been received by the ground system, SRN messages are sent periodically to the aircraft, for the time-frame specified in the request message, until a service stop message is received from the aircraft, or until it leaves radar coverage); and

c) request to stop periodic service.

4. SRN ON-BOARD OPERATING MODES

4.1 The aircraft positional data as determined by the ATC radar surveillance system and once it has been received on board the aircraft (flight management system (FMS), etc.) via data link, it could be used after being properly processed, in four different modes of operation.

4.2 These modes are as follows:

a) surveillance monitoring mode;

b) integrity monitoring mode;

c) enhanced navigation mode; and

d) stand-alone SRN mode.

4.3 **Surveillance monitoring mode**

4.3.1 In this mode, position data and other data derived from the ATC ground radar system related to the aircraft is simply displayed in the cockpit visualization unit for evaluation or other purposes, but not used for aircraft navigation.

4.3.2 This mode could also be used to display all surrounding traffic and for short-term conflict alert detection.

4.4 **Integrity monitoring mode**

4.4.1 In this comparison-alert mode, the aircraft position as received from the ground ATC SRN is compared (cross-checked) in real-time with the aircraft position as derived from the on-board navigation system (GNSS, VOR, etc.), triggering an alarm whenever there is a discrepancy between the two. This mode permits the detection of errors in either the aircraft's navigation systems, and in the ATC radar surveillance system. Therefore it works as an integrity monitoring system.

4.5 **Enhanced navigation mode**

4.5.1 In this mode the aircraft position data as derived from the ground ATC radar system (SRN) is processed and integrated (at the FMS for example) with data derived from the on-board navigation systems (GNSS, VOR, distance measuring equipment (DME), etc.).

4.5.2 The figure of merit of the SRN message, and in some cases its time stamp, would have to be taken into account in the integration process.

4.5.3 This mode would permit the enhancement of the navigation function of the aircraft by increasing the level of integrity and availability and sometimes the accuracy of the navigational data. This mode would also include the integrity monitoring process explained above.

4.5.4 The integration of SRN data with global positioning system (GPS) could solve the problems of availability and integrity monitoring of GPS in areas covered by ground surveillance radar, permitting the early withdrawal of a large portion of the ground-based navigation aids (VOR, DME, non-directional radio beacon (NDB), etc.).

4.6 **Stand-alone SRN mode (back-up navigational system)**

4.6.1 In this mode, to be used normally when no other navigation aid is available, SRN is used by itself or in combination with the INS.

4.6.2 SRN could be the back-up system of the future GNSS in continental high density areas covered by ATC radar, where very reduced separations will be applied, and therefore a higher level of availability and redundancy will be needed.

4.6.3 One of the advantages of SRN is that is a **selective navigation system** where navigational data is only sent to those aircraft known by the ground system, and if necessary (in times of tension, crisis or war), SRN data could be limited to those aircraft properly identified and cleared to receive the data. Therefore there is no reason to disable this system, although GPS or other systems might have to be disabled, because those could be used by unauthorized traffic.

5. DISCUSSION

5.1 The elapsed time between the moment the ATC radar system determines the position of an aircraft and the moment the positional data is received by the aircraft via a data link, is a very important factor to be considered. If this time is very short, it should not be necessary to extrapolate on board to determine the current position of the aircraft.

5.2 Although several data links (Mode S, VHF, satellite) could be used to transfer the positional information (SRN) to the aircraft, the most efficient for this application might be Mode S.

5.3 A Mode S radar could determine the aircraft position, digitize it, calculate latitude and longitude, and pass it on immediately to the aircraft in the same dwell-time as its position measurement is done, therefore without needing to wait until the next scan of the mechanically rotated antenna. If this is so, it might not be necessary to use an electronically scanned antenna (ESA) in order to transfer the SRN message in the minimum time possible, and also the SRN message should not need time stamping. In any case, all this must be studied.

5.4 Current Mode S surveillance radars use beams formed by an array which itself is mechanically rotated at a fixed rate. The time available for calculations and transferring the SRN message and any other data to the aircraft depends on this rotation rate.

5.5 An ESA is a static non-rotating array producing beams which can be pointed in any direction at will, and maintained there until a data transfer has been completed. Changes of direction can be made almost instantaneously, in micro-seconds, using modern fast-switching microwave devices. It is obvious that an antenna system such as this, permitting variable dwell-time on chosen targets, could be much more efficient.

5.6 Formats, resolution, and co-ordinate reference to be used in the SRN messages, and also modifications that might be needed in the ground (Mode S stations, etc.) and on-board (FMS, etc.) systems must also be studied.

6. CONCLUSIONS

6.1 The utilization of ATC surveillance radar systems for the dual purpose of surveillance and navigation would permit the early withdrawal of a large portion of the ground-based navigation aids in the radar coverage area, and consequently reduce the expenses of the air traffic control system while still maintaining a navigation system, which is **selective**, to back-up GNSS. In addition, its integration with GNSS would increase availability, sometimes accuracy, and would allow for the integrity monitoring of both the ATC radar surveillance and GNSS systems.

7. ACTION REQUIRED

7.1 The Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II) is hereby invited to discuss this paper, accept its conclusions, and agree on a course of action to accomplish future studies on this subject. It is also proposed that this issue be included in the list of tasks which need to be undertaken to support the implementation of the ICAO CNS/ATM systems.

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