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**International Civil Aviation Organization  
South American Regional Office**

**FOURTH WORKSHOP/MEETING OF THE SAM IMPLEMENTATION GROUP  
(SAM/IG/4)  
REGIONAL PROJECT RLA/06/901**

**Lima, Peru, 19 to 23 October 2009**

**Agenda Item 3: Implementation of performance-based navigation (PBN) in the SAM Region**

**ANALYSIS OF RNAV 5 VOR/DME AND DME/DME OPERATIONS AT BUENOS AIRES-LIMA AND LIMA-QUITO TRAFFIC FLOWS**

(Presented by the Secretariat)

SUMMARY	
This working paper presents the results of an analysis carried out to RNAV 5 VOR/DME and DME/DME operations at the Buenos Aires-Lima and Lima-Quito traffic flows.	
<b>References:</b> <ul style="list-style-type: none"><li>• Second Workshop/Meeting (SAM/IG/2) Report (Lima, Peru, 3 to 7 November 2008);</li><li>• Third Workshop/Meeting (SAM/IG/3) Report (Lima, Peru, 20 to 24 April 2009); and</li><li>• RLA/06/901 project.</li></ul>	
<b>ICAO Strategic Objectives:</b>	A: <i>Safety</i> D: <i>Efficiency</i>

**1. Background**

1.1 The second coordination committee meeting of RLA/06/901 Project (RCC/2) (Lima, Peru, 2-3 December 2008), approved the holding of activities corresponding to the compliance of Immediate Objective No. 1: *“Development and implementation of global air navigation plan initiatives that will lead to the transition from an air traffic management system based on ground systems to another one based on aircraft performance”*.

1.2 Within the activities to develop, is the drafting of a regional data base with all VOR and DME radio navigation aid calculated coverage information to meet navigation specifications and, most of all, the reversal navigation mode in the event of loss in the GNSS systems, areas where the navigation infrastructure is unable to support RNAV 5 VOR/DME and DME/DME based operations, and areas within the TMA where the DME infrastructure would not support RNAV 2 and RNAV 1 operations, with or without the application of inertial systems.

1.3 In this sense, the ICAO South American Regional Office requested that a CNS expert and an ATM expert carry out the referred activity in the period between 14 to 25 September 2009.

1.4 The initial tasks assigned were:

- a) Elaboration of a data base with all VOR and DME radio navigation aid calculated coverage information in the SAM Region to meet navigation specifications and, most of all, the navigation reversal mode in the event of GNSS systems loss.
- b) Determine, taking into account the above data base, the areas where the navigation infrastructure would not support RNAV 5 VOR/DME and DME/DME based operations, and the TMA areas where DME infrastructure would not support RNAV 2 and RNAV 1 operations, with and without the application of inertial systems.

1.5 Upon analyzing the magnitude of the tasks assigned to calculate the VOR and DME radio navigation aid coverage, as well as a complete analysis in the SAM Region on RNAV 5 VOR/DME and DME/DME based operations, and the TMA areas where DME infrastructure would not support RNAV 2 and RNAV 1 operations, it was established that, as an initial task, VOR/DME and DME/DME coverage were calculated in FL250 partial areas corresponding to the Buenos Aires-Lima and Lima-Quito traffic flows (part of the Lima-Miami traffic flow).

## 2. Analysis

2.1 Following are the results on the analysis made to the Buenos Aires-Lima and Lima-Quito traffic flows, where the navigation infrastructure would not support RNAV 5 VOR/DME and DME/DME based operations.

### *Criteria applicable for the analysis*

2.2 The standards applicable for the analysis were taken from ICAO Annex 11, 9613 - *Performance-based Navigation (PBN) Manual* and Doc. 8168 - *Aircraft Operations*, Vol. II - *Construction of Visual and Instrument Flight Procedures*.

2.3 In accordance with the mentioned documents, operations with a RNAV 5 navigation specification are based on the use of RNAV equipment that automatically determines the aircraft's position in the horizontal plane, through one, or the combination of, the following sensors:

- a) VOR/DME;
- b) DME/DME;
- c) INS o IRS; and
- d) GNSS.

### *VOR/DME*

2.4 Verification should be made that there is an appropriate coverage available of at least one reference facility within a 60 NM range, or 75 NM for a Doppler VOR. The facilities selected should offer an optimum geometry for the track guide solution at each waypoint, in order to calculate the track's perpendicular tolerance (XTT), the parallel tolerance to the track (ATT) and the area's semi-width ( $\frac{1}{2}$  A/W) obstacle clearance at those waypoints.

*DME/DME*

2.5 The DME signals are considered enough to comply with RNAV 5 navigation specification requirements at any position where signals are received.

2.6 The following should be taken into account for RNAV 2 and RNAV 1 navigation specifications:

- a) The maximum promulgated reach of the DME facility, permitting a theoretical 160 NM maximum radio horizon of the station;
- b) The maximum and minimum intersection angle of the DME stations (between 30° and 150°); and
- c) That DME facilities within a 3 NM distance with respect to the design track should not be used for navigation.

2.7 There is no availability of the restrictions for designated operational coverage (DOC) that States have established and/or published.

*Input and tools used for the analysis*

2.8 The input and tools used were the following:

- a) VOR and DME radio navigation aid calculated coverages, and delivered in image format that were later imported and converted for the analysis to the format of the auxiliary tool.
- b) H5 sectional chart, scanned for this preliminary analysis from the United States Department of Defense Flight Information Publication, since there is still unavailability of digital electronic cartography permitting interaction with the software used for the analysis.
- c) Autocad v. 2010, software used as an auxiliary tool for the drawing of delimitating circles and their intersection with individual coverages, to identify areas with DME/DME coverage.

*Results of the analysis*

*Buenos Aires – Lima traffic flow*

**VOR/DME**

2.9 **With inertial navigation systems**, there would be sufficient coverage for operations with RNAV 5 navigation specifications. Nevertheless, a further analysis permitting to precisely determine the tolerance of the critical waypoints, in accordance with para. 2.4, the tracks of the current RNAV routes (UL 550, UL 650, etc.), as well as the future routes to be planned, is necessary.

2.10 **Without inertial navigation systems**, the current VOR/DME navigation structure would be enough for the reversal mode in the event of GNSS loss, or no inertial systems available. A further analysis is required to determine the traffic flow segments where the specified navigation performance would not maintain itself.

## DME/DME

2.11 There are intermittent openings, not very significant in the Rosario – Calama and ABN Arequipa – Pisco segments, to meet RNAV 5 navigation operations. A further analysis is required to determine the navigation feasibility in the mentioned segments, while keeping the specified navigation performance.

*Lima – Quito traffic flow*

## VOR/DME

2.12 **With inertial navigation systems**, there is sufficient and redundant coverage permitting RNAV 5 navigation operations. Nevertheless, a further analysis permitting to precisely determine the tolerance of the critical waypoints, in accordance with para. 2.4, the tracks of the current RNAV routes (UL 780), as well as the future routes to be planned, is necessary.

2.13 **Without inertial navigation systems**, the current VOR/DME navigation structure would be enough for the reversal mode in the event of GNSS loss, or no inertial systems available. A further analysis is required to determine the traffic flow segments where the specified navigation performance would not maintain itself.

## DME/DME

2.14 There is sufficient and redundant coverage in practically the whole traffic flow for RNAV 5 navigation operations. There is only a minor opening in the Chimbote – Trujillo segment.

**3. Action required**

3.1 The Meeting is invited to:

- a) Analyze the information contained in the working paper;
- b) Analyze the results of the Buenos Aires-Lima y Lima-Quito traffic flows analysis to meet RNAV 5 VOR/DME and DME/DME navigation operations;
- c) Analyze whether to continue with an analysis to the remaining flows in the Region for presentation at SAM/IG/5 meeting (May 2010); and
- d) Analyze other considerations in this respect that the Meeting might consider necessary.