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Twenty-Second Workshop/Meeting of the SAM Implementation Group (SAM/IG/22) - Regional Project RLA/06/901
(Lima, Peru, 19 to 23 November 2018)

Agenda Item 5: Operational implementation of new ATM automated systems and integration of the existing systems

STUDY OF THE FEASIBILITY AND CONVENIENCE OF USING THE SATELLITE-BASED ADS-B SERVICE IN THE SAM REGION

(Presented by the Secretariat)

SUMMARY

This working paper presents information on the study requested by the SAM/IG/19 meeting for the purpose of analysing the feasibility and convenience of adopting the satellite-based ADS-B service at regional level.

References:

- Report of the Nineteenth meeting/workshop of the SAM Implementation Group (SAM/IG/19 - Lima, Peru, 22-26 May 2017)
- Report of the Eleventh meeting of the Coordination Committee of Project RLA/06/901 (RCC/11) - Lima, Peru, 5 October 2018)
- Report of the Twenty-First meeting/workshop of the SAM Implementation Group (SAM/IG/21 - Lima, Peru, 21-25 May 2018)
- Study of the feasibility and convenience of implementing satellite-based ADS-B at the regional level

ICAO strategic objectives:	*A – Safety* *C – Air navigation capacity and efficiency*

1. Background

1.1 The Eleventh meeting of the Coordination Committee of Regional Technical Cooperation Project RLA/06/901 (RCC/11 – Lima, 5 October 2017) approved the conduction of a study on the feasibility and convenience of adopting the satellite-based ADS-B at regional level.

1.2 For the conduction of the study, a surveillance expert (Mr. Ivan Salas) of Ecuador was hired for a period of one week, in April 2018. The expert prepared a preliminary document that was presented at the SAM/IG/21 meeting.

1.3 The SAM/IG/21 meeting (Lima, 21-25 May 2018) has requested States to review the preliminary study and provide the necessary information to complete the study. That same meeting recommended the Coordination Committee of Project RLA/06/901 to give one more week to the surveillance expert to complete the requested study together with representatives of the service provider and the staff of the ICAO Lima Regional Office.

1.4 With the approval of Project RLA/06/901 at the RCC/12 (Lima, 23-24 August 2018), the work was carried out at the ICAO Lima Regional Office between 24 and 28 September 2018.

2 Discussion

2.1 The study contains information on the characteristics, performance, coverage, and cost of current surveillance technologies that allow States to compare the adoption of the satellite-based ADS-B service with other aeronautical surveillance possibilities, such as secondary radar (SSR) and ground ADS-B stations.

2.2 Following a brief introduction to ADS-B technology and the presentation of key reference documents on the topic, the service provided is described and then gets into the main topics of the study: feasibility and convenience. **Appendix A** to this working paper resents the document in its final version.

2.3 Feasibility

2.3.1 At the SAM/IG/19 meeting, States recognised the operational benefits and advantages that could be derived from the satellite-based ADS-B service, such as:

- ✓ Coverage of existing gaps in the surveillance systems of the States in the Region;
- ✓ Coverage in boundary areas as an alternative to the exchange of surveillance data between adjacent States;
- ✓ Coverage in oceanic areas out of reach of ground surveillance systems;
- ✓ Surveillance solution for non-FIR airspace;
- ✓ Constant update of target positions, unlike periodic update provided by ADS-C.

2.3.2 The study concludes that the use of the satellite-based ADS-B system in the region is feasible due to its coverage, response time in the information transfer process or latency, and availability of information, for en-route airspaces above 10,000 feet, which was the airspace analysed in this study.

2.3.3 The following benefits of a regional implementation are identified in the study:

2.3.3.1 **Safety** – Effective surveillance in areas that currently lack coverage, definitely contributing to increased safety.

2.3.3.2 **Flight efficiency** – Effective surveillance of ADS-B information, providing the means to optimise flights and increase airspace utilisation capacity.

2.3.3.3 **Flexibility** – The service provided allows the ANSP to hire specific areas or volumes at the flight levels of operational interest, as the only means of surveillance or as augmentation of the existing surveillance infrastructure, and as redundancy in areas of critical operational interest.

2.3.3.4 **Homogeneity** – With States obtaining information from a single source, with the same parameter levels, it is possible to standardise air navigation services throughout the region.

2.3.3.5 **Environment** – Improved flight management, increasing capacity, more direct flights and reduced waiting times contribute to reduce adverse impact of aviation on the environment.

2.3.3.6 **Profitability** – With more efficient and economic flights, the profitability for aircraft operators becomes sustainable, with positive impact for the final user. From the point of view of the ANSPs, the reduction in implemented infrastructure and the required maintenance have a significant impact on this aspect.

2.4 Convenience

2.4.1 Convenience was analysed quantitatively, based on the methodology used in the preliminary study presented at the SAM/IG/21 meeting (May 2018), comparing the cost of ground SSR and ADS-B technologies with satellite-based ADS-B.

2.4.2 The approach adopted to align, in a more simple manner, the coverage limitation of ground sensors with the broad coverage capacity of satellite-based ADS-B. The approach suits better those States that have oceanic and continental areas with relatively equal traffic (homogeneous), such as Panama and Colombia. Figure 1 shows that the operational coverage in oceanic and continental areas is practically the same.

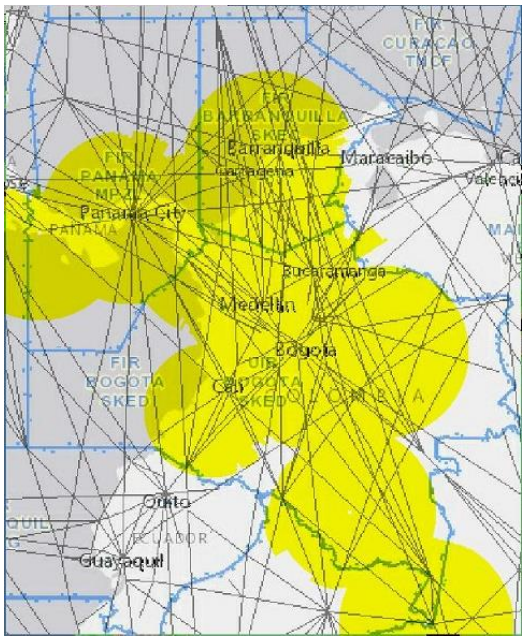

Figure 1 – States with more homogeneous oceanic and continental areas

2.4.3 Likewise, States that have a large oceanic area in the FIRs under its responsibility, the approach must be accompanied by other considerations, but it is a valid reference. Such is the case of Peru, which has a large oceanic area. In these cases, although the traffic volume is not that high as in ground areas, full airspace coverage would improve SAR operations, safety and the possibility for improving operational efficiency, using UPR (user preferred route).

2.4.4 Furthermore, the possibility of coverage in oceanic and/or remote continental areas, which is unfeasible with ground sensors, could promote the redesign of route networks based on the strategy adopted in each State.

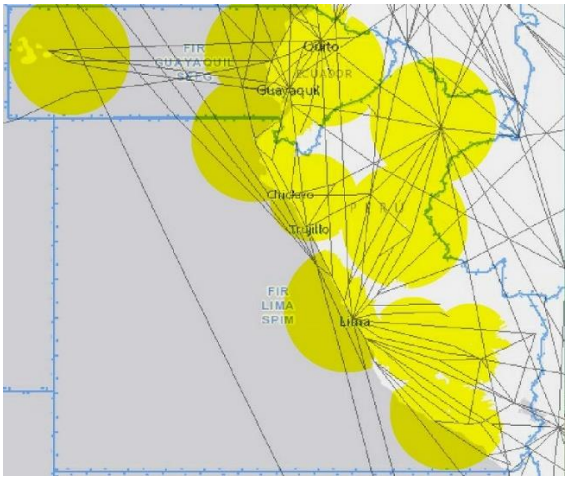

Figure 2 – States with large oceanic areas

2.4.5 The methodology adopted in the preliminary study was maintained in order to be compatible with any analysis of convenience.

2.4.6 A practical way of understanding the approach used is to consider the percentage of coverage by ground sensors with respect to the coverage of all FIR areas under the responsibility of the State.

2.4.7 The following tables show the percentage of coverage as calculated in the study, for some sample countries.

Table 1 – Percentage of coverage using ground ADS-B stations

No.	*Country*	*ADS-B*	*FIR area(s) (Km^2)*	*Continental area (Km2)*	*FIR/Cont. ratio*	*Coverage 10,000 ft*	*Coverage 15,000 ft*	*Coverage 25,000 ft*
1	FRENCH GUI.	5	1,383,199.17	83,534.00	16.56	11.67%	15.34%	16.56%
2	GUYANA	5	270,916.57	214,970.00	1.26	91.86%	96.90%	100.00%
3	PARAGUAY	6	399,136.50	406,752.00	1	92.61%	99.50%	100.00%

Table 2 – Percentage of coverage with SSR

No.	*Country*	*SSR*	*FIR area(s) (Km^2)*	*Continental area (Km2)*	*FIR/Cont. ratio*	*Coverage 10,000 ft*	*Coverage 15,000 ft*	*Coverage 25,000 ft*
1	ARGENTINA	25	17,908,074.62	2,792,573.00	6.41	12.37%	15.27%	18.58%
2	BOLIVIA	7	1,085,891.42	1,098,581.00	1	26.10%	40.85%	70.35%
3	BRASIL	84	22,110,440.00	8,514,877.00	2.6	27.86%	35.01%	46.26%
4	CHILE	11	10,038,771.54	756,102.00	13.28	8.96%	11.66%	17.55%
5	COLOMBIA	15	1,648,431.14	1,141,748.00	1.44	37.37%	49.33%	77.73%
6	ECUADOR	7	942,758.82	283,561.00	3.32	27.45%	45.74%	74.49%

No.	*Country*	*SSR*	*FIR area(s) (Km^2)*	*Continental area (Km2)*	*FIR/Cont. ratio*	*Coverage 10,000 ft*	*Coverage 15,000 ft*	*Coverage 25,000 ft*
7	FRENCH GUI.		1,383,199.17	83,534.00	16.56	n/a	n/a	n/a
8	GUYANA		270,916.57	214,970.00	1.26	n/a	n/a	n/a
9	PANAMA	3	621,464.86	74,177.00	8.38	33.70%	41.63%	59.48%
10	PARAGUAY	2	399,136.50	406,752.00	1	30.87%	40.39%	69.21%
11	PERU	8	3,564,434.95	1,285,216.00	2.77	13.14%	19.70%	43.21%
12	SURINAME		262,126.10	163,820.00	1.6	n/a	n/a	n/a
13	URUGUAY	2	2,326,000.97	176,215.00	13.2	3.18%	5.30%	7.43%
14	VENEZUELA	10	1,204,815.45	916,445.00	1.31	48.87%	65.23%	83.64%

2.4.8 The preliminary study considered a period of 15 years of useful life for radar sensors (SSR) and 20 years for ground ADS-B sensors. It also considered 20% for maintenance (personnel, equipment and spare parts), telecommunications, and infrastructure cost over the life of the ground sensors. Consequently, coverage at the indicated levels results in an annual cost per km^2 of FIR (total).

2.4.9 It is important to note that 20% for maintenance is considered to be relatively lower than what is considered in practice for maintenance of ground infrastructure, taking into account the indicated useful life periods (10 and 15 years).

2.4.10 Conversely, the annual values used for the cost of the satellite ADS-B are based on the average annual traffic estimated to 2030, considering the hiring of all the FIRs of the States for a period of 15 years. Table 3 presents the values for the four States used in the study.

Table 3 – Cost of surveillance with satellite ADS-B service

Country	Satellite ADS-B	Cost of service (US$)	% coverage FIR (10-15-25 thousand ft)	Annual cost/ Km2 FIR
Chile	1	2,022,467	100-100-100	0.20
Colombia	1	1,922,467	100-100-100	1.17
Ecuador	1	722,467	100-100-100	0.77
Peru	1	2,122,467	100-100-100	0.60

2.4.11 The study shows that, when comparing satellite ADS-B with the radar sensors, there is a substantial disadvantage in the use of this type of ground sensor.

2.4.12 Regarding ground ADS-B sensors, the comparison is more tight and although, in general, satellite ADS-B has lower costs in some States, depending on the flight level involved, the annual cost per km^2 of FIR of the ground ADS-B appears to be more interesting.

Table 4A – Cost of the surveillance service with ground ADS-B sensors / 10,000 ft

Country	No. ADS	Cost of equipment (US$)	Total cost (+ 20%)	Annual cost (10 years)	% coverage FIR (10,000 ft)	Annual cost / Km2 cont. FIR

Chile	11	3,300,000	3,960,000	396,000	8.96	5.85
Colombia	15	4,500,000	5,400,000	540,000	37.37	1.27
Ecuador	7	2,100,000	2,520,000	252,000	27.45	3.24
Peru	8	2,400,000	2,880,000	288,000	13.14	1.71

Table 4B – Costo del servicio de vigilancia con sensores terrestres ADS-B / 15.000 pies

Country	No. ADS	Cost of equipment (US$)	Total cost (+ 20%)	Annual cost (10 years)	% coverage FIR (15,000 ft)	Annual cost/ Km2 FIR
Chile	11	3,300,000	3,960,000	396,000	11.66	4.49
Colombia	15	4,500,000	5,400,000	540,000	49.33	0.96
Ecuador	7	2,100,000	2,520,000	252,000	45.74	1.94
Peru	8	2,400,000	2,880,000	288,000	19.7	1.14

Table 4C – Cost of the surveillance service with ground ADS-B sensors/ 25,000 ft

Country	No. ADS	Cost of equipment (US$)	Total cost (+ 20%)	Annual cost (10 years)	% coverage FIR (25,000 ft)	Annual cost/ Km2 FIR
Chile	11	3,300,000	3,960,000	396,000	17.55	2.98
Colombia	15	4,500,000	5,400,000	540,000	77.73	0.61
Ecuador	7	2,100,000	2,520,000	252,000	74.49	1.19
Peru	8	2,400,000	2,880,000	288,000	43.21	0.52

2.4.13 This is shown as an apparent advantage, because, due to limitations of ground sensors and factors such as terrain in the region and airspace of operational interest, it is not possible to achieve complete surveillance with the ground sensor, despite the lower annual cost per km^2 de FIR.

2.4.14 Based on the cost comparison, the study concludes that, from the financial point of view, the satellite ADS-B system is also convenient for States. Appendix B to this working paper contains a table with the non-conformities of all SAM States.

2.5 Use of REDDIG for regional distribution of surveillance information

2.5.1 The use of the SAM regional digital network (REDDIG) can lower implementation costs for States interested in hiring satellite ADS-B services. It would also expedite regional implementation. The figure below shows a basic interconnection topology through the REDDIG, among others being studied.

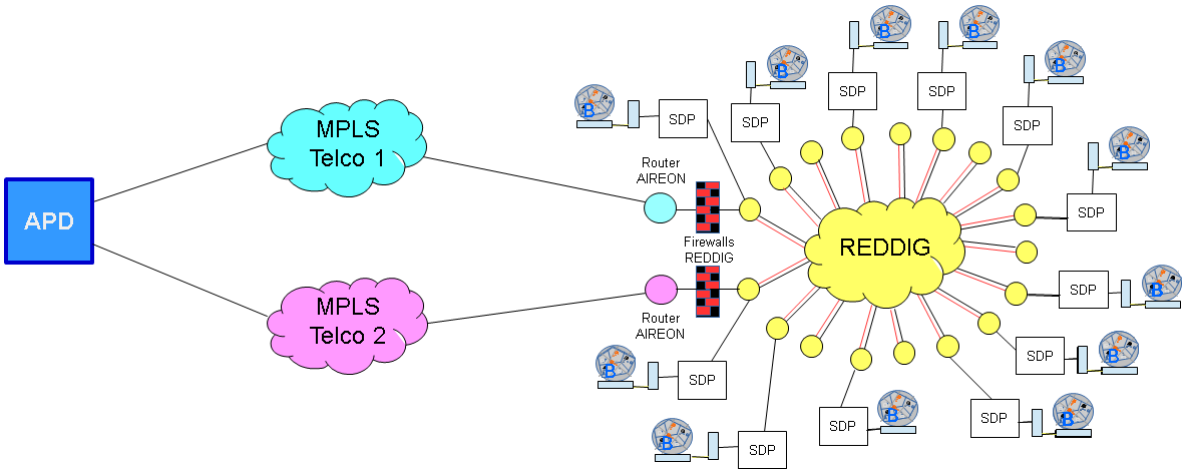

Figure 3 – Basic connection topology through REDDIG

2.5.2 Unlike that shown in SAM/IG/19 (WP/20), the company concluded that it was not possible to implement two service delivery (SDP) in the region because of the following technical and administrative peculiarities:

- ✓ Security is better ensured with individual SDPs;
- ✓ With individual SDPs in each State, service delivery control is more efficient; and
- ✓ Managing by the REDDIG Administrator is simpler and easier to implement.

2.6 Next steps for regional implementation

2.6.1 Some States (Argentina, Brazil and Peru) have already signed or are about to sign a Memorandum of Understanding (MoU) with the company for the conduction of tests and, possibly, the hiring of the service. However, it is possible that regional implementation will serve the specific interests of these States.

2.6.2 Taking into account that the study has confirmed the feasibility and convenience of adopting the satellite ADS-B service, the States of the Region must consider regional implementation of the service.

2.6.3 One possibility is to use Regional Technical Cooperation Project RLA/03/901 to implement the infrastructure to allow interested States to access the processing and distribution centre (APD) of the provider, where each State would hire the service directly (contract, SLA, acceptance tests, etc.).

2.6.4 Another possibility is for interested States to establish a new Technical Cooperation Agreement, with a new regional project, where ICAO would manage the implementation of the access infrastructure through the REDDIG (procurement of SDP equipment and communication links), and would also be in charge of hiring surveillance data services in areas of operational interest defined by the participating States, for example, in oceanic areas with no surveillance coverage.

3 Suggested action

3.1 The Meeting is invited to:

a) take note of the information contained in this working paper;

b) review the documents presented in **Appendix A** and **B** to this working paper;

c) consider the next steps for possible regional implementation.

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APPENDIX B

COMPARATIVE TABLE WITH ALL SAM REGION STATES

State (FL)	% of FIR Coverage Continental and Oceanic (Space-based ADS-B)	% of FIR Coverage Continental and Oceanic (SSR)	Space-based ADS-B (Annual Cost/km2 FIR)	SSR (Annual cost/(% of Coverage x Km2 FIR)	Terrestrial ADS-B (Annual cost/(% of Coverage x Km2 FIR)
Argentina (FL 100)	100	12,37	0,15	8,68	2,61
Argentina (FL 150)	100	15,27	0,15	7,04	2,11
Argentina (FL 250)	100	18,58	0,15	5,78	1,73
Bolivia (FL 100)	100	26,10	0,57	2,93	0,88
Bolivia (FL 150)	100	40,85	0,57	1,87	0,56
Bolivia (FL 250)	100	70,35	0,57	1,09	0,33
Brazil (FL 100)	100	27,86	0,53	4,25	1,27
Brazil (FL 150)	100	35,01	0,53	3,38	1,01
Brazil (FL 250)	100	46,26	0,53	2,56	0,77
Chile (FL 100)	100	8,96	0,20	19,48	5,85
Chile (FL 150)	100	11,66	0,20	14,97	4,49
Chile (FL 250)	100	17,55	0,20	9,95	2,98
Colombia (FL 100)	100	37,37	1,17	4,22	1,27
Colombia (FL 150)	100	49,33	1,17	3,20	0,96
Colombia (FL 250)	100	77,73	1,17	2,03	0,61
Ecuador (FL 100)	100	27,45	0,77	10,79	3,24
Ecuador (FL 150)	100	45,74	0,77	6,48	1,94
Ecuador (FL 250)	100	74,49	0,77	3,98	1,19
French Guiana (FL 100)	100	***ADS-B 11,67***	0,30		Nota b) 18,46

State (FL)	% of FIR Coverage Continental and Oceanic (Space-based ADS-B)	% of FIR Coverage Continental and Oceanic (SSR)	Space-based ADS-B (Annual Cost/km2 FIR)	SSR (Annual cost/(% of Coverage x Km2 FIR)	Terrestrial ADS-B (Annual cost/(% of Coverage x Km2 FIR)
French Guiana (FL 150)	100	***ADS-B 15,34***	0,30		Nota b) 14,05
French Guiana (FL 250)	100	***ADS-B 16,56***	0,30		Nota c) 13,01
Guyana (FL 100)	100	***ADS-B 91,86***	1,26		Nota c) 0,91
Guyana (FL 150)	100	***ADS-B 96,9***	1,26		Nota c) 0,86
Guyana (FL 250)	100	***ADS-B 100***	1,26		Nota b) 0,84
Panama (FL 100)	100	33,70	2,29	14,40	4,32
Panama (FL 150)	100	41,63	2,29	11,66	3,50
Panama (FL 250)	100	59,48	2,29	8,16	2,45
Paraguay (Fl 100)	100	***SSR- 30,87/ADS 92,61***	1,31	1,91	Nota d) 0,57
Paraguay (Fl 150)	100	***SSR - 40,39/ADS 99,5***	1,31	1,46	Nota d) 0,53
Paraguay (Fl 250)	100	***SSR - 69,21/ADS 100***	1,31	0,85	Nota d) 0,53
Peru (FL 100)	100	13,14	0,60	5,68	1,71
Peru (FL 150)	100	19,70	0,60	3,79	1,14
Peru (FL 250)	100	43,21	0,60	1,73	0,52
Surinam (Fl 100)	100		1,23		
Surinam (Fl 150)	100		1,23		
Surinam (Fl 250)	100		1,23		
Uruguay (Fl 100)	100	3,18	0,20	42,83	12,85

State (FL)	% of FIR Coverage Continental and Oceanic (Space-based ADS-B)	% of FIR Coverage Continental and Oceanic (SSR)	Space-based ADS-B (Annual Cost/km2 FIR)	SSR (Annual cost/(% of Coverage x Km2 FIR)	Terrestrial ADS-B (Annual cost/(% of Coverage x Km2 FIR)
Uruguay (Fl 150)	100	5,30	0,20	25,70	7,71
Uruguay (Fl 250)	100	7,43	0,20	18,33	5,50
Venezuela (FL 100)	100	48,87	1,18	2,68	0,80
Venezuela (FL 150)	100	65,23	1,18	2,01	0,60
Venezuela (FL 250)	100	83,64	1,18	1,57	0,47

Notes:

a) Para la mayoría de los países, se adoptó el número ficticio de estaciones de ADS-B terrestres que estarían con sus coordenadas de localización de instalación coincidentes donde están ubicados los SSR actuales.
b) Para Guayana Francesa solamente se consideró ADS-B terrestre (cinco sensores).
c) Para Guyana solamente se consideró ADS-B terrestre (cinco sensores).
d) Paraguay posee radares (dos) y ADS-B terrestre (seis). Por este motivo, los valores de Costo anual/(%Cobertura FIR x Km2 FIR) llevan en cuenta la cantidad real de cada sensor.
e) Para SSR y ADS-B Terrestre, las relaciones (Costo anual/(%Cobertura x Km2 FIR) pueden ser consideradas conservadoras con respecto a la adquisición de los equipos y por la aplicación del 20% por mantenimiento, operación, telecomunicaciones, costos con infraestructura y “spare-parts” en toda su vida útil.
f) Para los cálculos de SSR y ADS-B Terrestre, fue considerado el costo ficticio si los sensores SSR y ADS-B terrestre tuvieran cobertura del 100% en toda la FIR (oceánica y continental) de cada Estado.