Final Project Report

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Abstract

The project P9.12 covered the airborne subsystem aspects of the GBAS Cat II/III using GPS L1 (GBAS Approach Service Type -D) and the initial extension towards multi constellation/multi frequency (MC/MF) GBAS. The GBAS Cat II/III system allows precision approaches and guided take-off operation under low visibility conditions (LVC) down to Category 3 minima. It is composed of the GPS satellite constellation, a GBAS ground station and an airborne part in order to receive and use the GPS and GBAS signals to guide the aircraft down to the runway. Principal goal of this function is to increase the runway throughput based on the absence respectively the reduction of operational minima with respect to critical and sensitive zones. The GAST-D airborne system requirements have been validated for V3 maturity by ground and flight tests. The maturity for industrialization, approval and later deployment as SESAR solution #55 / Release 4 was confirmed by SJU. Preliminary MC/MF system requirements have been identified and verified.

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This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
A/C	Aircraft
AWO HARC	All Weather Operation Harmonization Committee
ATM	Air Traffic Management
CAT	(precision approach) category
CNS	Communication Navigation Surveillance
CSG	Category III Sub Group
DH	Decision Height
EASA	European Aviation Safety Agency
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
GAST (D)	GBAS Approach Service Type (D: to support operations down to CAT IIIb)
GBAS	Ground Based Augmentation System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
H/W	Hardware
ICAO	International Civil Aviation Organisation
IFPP	Instrument Flight Procedures Panel (at ICAO)
IGWG	International GBAS Working Group
ILS	Instrument Landing System
LATO	Landing And Take Off (focus group of EUROCONTROL)
LOC	Localizer
LVP / LVC	Low Visibility Procedure / Low Visibility Conditions
MC/MF	Multi-Constellation / Multi-Frequency
MMR	Multi-Mode Receiver

NSE	Navigation System Error
NSP	Navigation System Panel
OFA	(SESAR) Operational Focus Area
PEGASUS	Prototype EGNOS and GBAS Analysis System Using SAPPHIRE
RTCA	Radio Technical Commission for Aeronautics
RVR	Runway Visual Range
SA	Single Aisle
SARPS	Standards and Recommended Practices
SBAS	Satellite Based Augmentation System
SW	Software
TRL	Technological Readiness Level
VDB	Very High Frequency Data Broadcast
VHF	Very High Frequency
VOR	VHF Omnidirectional Range
WG	Working Group

1 Project Overview

Project 09.12 covered airborne aspects of GBAS Cat II/III solutions based on either GPS L1 (GAST-D) or an initial multi-constellation / multi-frequency (MC/MF) GBAS concept. GBAS is a satellite-based navigation technology with ground based augmentation, enabling precision approach and landing operations including Autoland, and guided Take-off. The project aimed at increasing runway throughput under low visibility conditions (LVC).

1.1 Project progress and contribution to the Master Plan

To contribute to the Master Plan, project 09.12 aimed for the achievement of 3 main objectives:

- Assess the technical feasibility of an initial GBAS CATII/III system (GAST-D) in terms of standardization,
- Validate requirements by developing and verifying an initial GBAS CATII/III airborne prototype component,
- Initiate system definition and standardization for an airborne MC/MF GBAS configuration based on the use of the signal provided by GPS and GALILEO constellation on L1/E1 and L5/E5 frequencies.

Note that ATM performances have been demonstrated by WP06.08.05.

For both the GPS L1 GBAS concept (GAST-D) as well as for its extension towards MC/MF, the goal was to enable:

- Automatic Approach and Landing down to Cat IIIb minima (including automatic roll-out, with DH < 50 ft down to no DH and RVR between 50m and 200m) for mainline A/C
- Automatic Approach and Landing down to Cat II or Cat IIIa minima (with 50 ft < DH < 200 ft and RVR between 200m and 550m) for Business and Regional A/C. Cat IIIb considerations are also taken into account for business aircraft, for possible future use.

The project succeeded in the development of GAST-D airborne receiver prototypes for mainline and business A/C. All activities focusing the conduction and evaluation of flight tests in cooperation with the Thales GBAS GAST D ground station prototype in Toulouse and the NATMIG's GBAS GAST D ground station prototype in Frankfurt were successful regarding interoperability and expected landing performance. Several flight test campaigns have been conducted in 2013 and 2014 with an A320 and an A380 in the mainline A/C segment and a Dassault F900EX in the business A/C segment, covering all objectives as defined for the concept validation/verification planning. Achievement consists in the validation of the GAST–D concept in terms of architecture and subsystem performance for mainline A/C and business A/C, to ensure interoperability independent from a specific subsystem H/W respectively S/W development. Results confirmed furthermore that the aircraft guidance related to the GAST-D functionality can be successfully applied for approach, roll-out and guided take-off operation.

Regarding the consolidation of the VDB link budget for mainline A/C types, all test results and elements for the analysis have been provided. The flight tests on A380 A/C have demonstrated the loss of VDB messages at MMR level during touch down, roll-out and taxiing due to constraining test conditions, induced by a VDB input signal strength below the specified minima. Transient reversions of the service level to GAST-C and authentication protocol alerts can be linked to this occurrence. In consequence, the recommended VDB architecture to be implemented on mainline A/C is a mix LOC/VOR antenna application. Results have been taken into account in the standardization context.

The business aircraft flight trials with Honeywell flight test aircraft F900EX with an Honeywell avionics receiver integrated with autopilot were conducted in Sep/Oct 2013 and Jun./Jul. 2014 in Frankfurt and Toulouse. Flight test campaigns in Frankfurt took place in cooperation with a NATMIG ground station

prototype. The flight test campaigns in Toulouse were flown against the Thales ground station prototype. Also, there was an additional GAST D campaign performed in Atlantic City in July 2016 to provide additional data for the GAST D concept finalization Objectives covered in the successful flight tests were performance aspects as well as interoperability. Collected data processing and the documentation of results have contributed significantly to the final GAST-D concept validation.

The task to analyse GBAS limited to Cat II in the business A/C scope was achieved in June 2015. Simulations with the GBAS noise model have been executed, providing an initial evaluation of the suitability of this model in the context of a potential CAT II concept.

The project developed respectively modified simulation tools in the context of autoland, multipath GNSS threats, availability, to establish the frame for GBAS GAST-D system implementation and certification on A/C level (airworthiness demonstration process). Autoland and Failure Mode Simulations for mainline and business A/C have been completed. A multimode receiver (MMR) model representing GBAS failures and respective geometry screening settings was developed for all mainline A/C types covering the nominal, limit and malfunction case. A range domain NSE (navigation system error) from Honeywell has been developed and verified. A good consensus of outputs with the respective model from Boeing can be confirmed. The availability simulations demonstrated fully acceptable performance for mainline and business A/C.

*Note 1: Malfunction cases for mainline A/C need to be re-evaluated due to possible modification of Certification criteria. This activities are beyond the 09.12 project scope and part of the airborne airworthiness demonstration process, as agreed at AWO HARC with FAA, EASA, Boeing, Eurocontrol and Airbus.

*Note 2: The definition of requirements concerning the Continuity performance applicable for Cat III operation (Continuity augmentation) for Business and Mainline A/C is under re-evaluation. The mainline A/C Continuity Study provided results regarding the risks on ATM when GBAS is serving multiple runways. Sufficient continuity based on the current signal characteristics needs to be confirmed for each individual aircraft configuration, as part of the airborne airworthiness demonstration process.

Activities have been dedicated to the final consolidation of a global GAST-D certification baseline regarding those airworthiness requirements relevant for GBAS Cat II/III operation for business and mainline A/C. Current efforts are allocated to the extended task to support standardization activities at aircraft level. Important contributions have been made in the frame of AWO HARC, RTCA SC159 WG4 and ICAO NSP (Navigation Systems Panel) Cat II/III Subgroup (CSG).

Standardization activities will be continued in the future, focussed on remaining GAST-D items and the MC/MF GBAS concept.

The relevant aspects for an airborne MC/MF system development (based on the use of the signal provided by GPS and GALILEO constellation on L1/E1 and L5/E5 frequencies) and implementation has been elaborated in the scope of preliminary Studies and Trade-offs. Respective results are aligned with the definitions from the MC/MF ground and system side (15.03.07). MC/MF verification objectives have been defined, enabling to conclude on the initial MC/MF GBAS airborne system specification. The verification task planning was coordinated with MC/MF projects' partners and affiliates. Initial concept verification activities have been conducted from May'16 on. Preparation of those activities was based on preliminary simulation and test results. Modifications regarding airborne modules of PEGASUS toolset which allows analysis of GNSS data collected from different SBAS and GBAS systems implementing the algorithms issued in the MOPS documents) have been finalized end 2015. Goal was to enable simulations in the multi constellation context. The MC/MF airborne receiver mock-up development resulted in the identification of two most promising processing schemes and the successful demonstration of interoperability during data collection flights with an MC/MF ground mock up installation.

An airborne multipath (MP) assessment was performed in the Toulouse airport environment and supported the analysis of the GNSS threat space. The results of the MP assessment were promising, as they implied the correctness of the 'worst case' assumptions based on multipath simulation results and absence of measurable multipath impact under operational conditions. In the scope of GNSS threats studies, the 9.12 project team has analysed position data impacted by GNSS repeater signals. Laboratory measurements were performed on ground system side to identify possible effects of GPS

repeater jamming on GBAS Cat II/III operation. A Thales GAST-D prototype MMR was applied to constitute the airborne component. The simulated reception conditions (in terms of the disturb signal strength) were representative for a GLS installed on small mainline (SA) aircraft. The mitigation of possible repercussions at component level and aircraft integration level was demonstrated.]

Project 09.12 contributed to SESAR solution #55 in "Precision approaches using GBAS CAT II/III based on GPS L1" in operational focus area "LVPs using GBAS".

The applicable technological and A/C enablers as identified in the functional architecture are listed below:

Code	Name	Project contribution	Maturity at project start	Maturity at project end
CTE-N07b	GBAS Cat II/III based on Single-Constellation / Single-Frequency GNSS (GPS L1)	Two independent developments of airborne receiver prototype have been conducted within the project. Validation Flight Tests were conducted at Toulouse and Frankfurt airports using mainline aircraft as well as business aircraft. A complete set of technical requirements and recommendations has been provided to enable future implementations, contributing to the ATM performance demonstration conducted in the scope of WP06.08.05	TRL 3	TRL 6
CTE-N07c	Ground Based Augmentation System (GBAS) Cat II/III based on Multi-Constellation / Multi-Frequency (MCMF) GNSS (GPS + GALILEO / L1 + L5)	Development of airborne receiver mock-up components has been conducted within the project.	TRL 1	TRL 2
A/C-02a	Enhanced positioning using GBAS single frequency	Definition of required elements and their implementation, Validation and Verification of Rqts. covering Navigation - Positioning - Vertical, Antennas & Sensors	TRL 3	TRL 5
A/C-56a	Flight management and guidance for Precision Approach GBAS CATII/III using GPS L1	Validation and Verification of Rqts. covering Flight Control incl. laws,- Lat/Vert	TRL 3	TRL 5

The applicable Integrated Roadmap Dataset is DS15 [44].

1.2 Project achievements

The project 9.12 has demonstrated that the airborne subsystem related aspects of GBAS CAT III L1 (GAST D) and their possible extensions towards MC/MF (GAST-E/-F) enable:

- GBAS Automatic Approach and Landing down to Cat IIIb minima for Mainline Aircraft (More sustained accuracy in aircraft guidance on final approach)

  - Automatic roll-out, DH < 50 ft down to no DH & RVR between 50m and 200m
- GBAS Automatic Approach and Landing down to Cat II or Cat IIIa minima for Business and Regional Aircraft (More sustained accuracy in aircraft guidance on final approach)
  - 50 ft < DH < 200 ft & 200 m < RVR < 550m
  - CAT IIIb considerations for Business Aircraft for possible future use
- GBAS guided take-off

The project 9.12

- Developed airborne receiver prototype (MMR) for mainline A/C and equipment manufacturers.
- Developed airborne receiver prototype for business A/C and equipment manufacturers.
- Verified the performance and interoperability on system and ground subsystem level in lab, on-site ground and with flight tests.
- Contributed to the development of concept of operations, CAT III approach criteria and took part in operational and technical safety assessments.
- Significantly contributed with the continuous and active participation in the relevant standardization working groups at ICAO NSP, EUROCAE WG-62, RTCA SC159 WG4, AWOH ARC, IFPP and LATO/IGWG, developing the applicable standards
- Contributed to GBAS cost assessment (done by project 16.06.06) in a qualitative context.

As the overall result, a GBAS CAT III L1 solution has been developed and validated to V3 maturity level, allowing starting the pre- industrial phase in preparation of deployment and certification. An initial MC/MF GBAS system concept has been identified, based on preliminary validation and verification activities.

1.3 Project Deliverables

The following table presents the relevant deliverables that have been produced by the project.

Reference	Title	Description
D01 [1]]	Airborne impact analysis - Definition of the high level system architecture	This report provides a critical analysis of the initial GBAS Cat II/III high level system architecture as defined by ICAO. In particular, it identifies the new allocation of functional and performance (accuracy, integrity, continuity) requirements by comparison with GBAS Cat I high level system architecture. Thus identifies the hard points where adaptation on airborne side is needed, based on a preliminary feasibility assessment. Eventually, it identifies a list of preliminary candidates for airborne architecture.
D02 [1]	Airborne impact analysis - Qualitative & quantitative functional, performance and safety requirement	This report defines A/C functional, performance and safety requirements and thus identifies performance margins, when applying Initial GBAS Cat II/III new high level architecture to Mainline and Business aircraft. This report selects several airborne candidate architectures according to A/C type for Mainline and Business aircraft.
D03	Airborne impact analysis - Definition of the new airborne	This report identifies and details new A/C and receiver requirements compared to existing GBAS

	functionalities.	Category I A/C and receiver architecture.
D04	Airborne impact analysis - High level definition of extension of multi-GNSS GBAS cat II/III	This report provides a roadmap to future evolution towards multi- GNSS GBAS Cat II/III from Initial GBAS Cat III. In particular, it provides potential alternatives and perform a trade-off to elaborate a consolidated roadmap recommendation with sound arguments.
D28	Technical Validation Report - Independent review of the various ground/air subsystems performances GBAS interoperability assessment report	This deliverable presents the results of the interoperability flight tests performed by Honeywell, Airbus and Eurocontrol in the context of WP9.12 and WP15.03.06. The GBAS GAST-D avionic sub-system prototypes were tested versus the INDRA and Thales ground sub-systems prototypes, assessing the experienced ground and airborne equipment performances by means of the Eurocontrol PEGASUS Toolset. It presents the performances and the interoperability results obtained in a live scenario, considering past outcomes of interoperability test planning and static tests execution. This deliverable provides the initial elements in support of the system operational validation, verifying the experienced airborne system performances in compliance with the applicable standards
D29	Technical Note - Airborne Impact Analysis - Preparation phase of WA5.t	This deliverable presents a development strategy related to the extension of the GBAS GAST-D concept towards a MC/MF GBAS concept, from the airborne perspective. It defines a roadmap toward Full GBAS Cat II/III with the focus on the components technical aspects and the feasibility of the concept, based on the initial GBAS GAST-D concept verification results. It initiates the provision of material to support the full (i.e. MC/MF) GBAS GNSS avionics specification. A work plan details the efforts needed to verify the airborne concept through definition of tasks, deliverables, schedule, milestones and risks and is closely coordinated with the SESAR 15.03.07 ground and system related tasks
D31-004 [2]	Yearly synthesis of standardization activities- Report	The deliverable is dedicated to extended GAST-D system verification in the context of the airborne multipath assessment and the examination of GNSS threats with respect to A/C implementations. Beyond that, the report will summarize the extended verification results for the verification of concepts for GBAS GAST D with multiple VDB, the ground side multipath verification, the extension of site verification to monitor and assess seasonal variation, extended (GPS) siting investigations, extended VDB Siting Investigations, ionosphere threat space assessments and cross site

		verification
D38	Technical Note - MC/MF GBAS airborne Studies and Analysis Report	This deliverable provides airborne specific MC/MF study and trade-off results elaborated in the scope of the SESAR Project 09.12 (GBAS airborne subsystem). Contents are considerably linked to the considerations and outcomes of projects 15.03.07 (MC/MF GBAS ground system) and 15.03.06 (GAST-D GBAS ground system) and refers to 06.08.05 (operational aspects) and 15.03.04 (security aspects) as well. The deliverable identifies the constraints of an architecture solution enabling MC/MF GBAS signal processing and VDB transmission, presents study results about the management of Radio Frequency (RF) perturbations related to RF interference, concludes on the activities needed to update the V&V tool box aiming to cover a multi GNSS concept and finally reconsiders the specific aspects of certification and safety relevant to demonstrate the feasibility the GNSS GBAS concept from the airborne implementation point of view.
D39	Technical Note – Preliminary MC/MF GBAS airborne system specification	This deliverable aims at providing preliminary airborne subsystem requirements to consolidate an initial specification in the multi constellation / multi frequency context. It constitutes a delta approach with respect to the existing GAST-D specifications for airborne subsystem components and implementations. Items covered by this preliminary specification are related to functional, interface, performance, safety, maintainability, quality assurance, airworthiness, environmental and testability requirements.
D41	Verification report - MC-MF Receiver Mock up development & verification Report	This deliverable provides the Verification report for preliminary verification activities performed for MC/MF GBAS Cat II/III airborne component. It describes the results for verification exercises defined in preliminary Verification Plan (D40) and how they have been conducted. The deliverable is focused on the new and critical functions and performances brought by MC/MF GBAS.

[1] The document provides qualitative and quantitative results representing an intermediate level of system development and implementation. Final requirements resp. values to be applied need to be referenced to the standardization frame work listed below:

- ICAO SARPS Annex 10, GBAS CAT II/III,
- RTCA DO-253 D,
- FAA AC 120-xLS.

[2] The report does not refer to a final conclusion on standardization documents. Activities are ongoing beyond project's closure date. Ref.to [36].

1.4 Contribution to Standardisation

Contribution to standardization meetings has been considered as key element regarding CNS-ATM aspects, as it enabled to populate technologies and rules of utilization for the benefits of aviation stakeholders, in a cost efficient way and ensuring interoperability.

09.12 project has identified the key organization related to the Cat II/III development, validation and standardization. In order to exclude misalignments of development resp. standardization efforts between the European and U.S. side, 09.12 project has decided to participate to working group meetings in order to react and above all to steer standardization in line.

Significant and relevant contributions were provided by the project on regular basis throughout the project to following standardisation organisations:

- ICAO NSP CSG,
- AWO HARC 'All Weather Operation Harmonization Aviation Rulemaking Committee (under FAA umbrella),
- EUROCAE WG-28/62, (notably with contributions to initiate and develop the ground equipment standard OPS ED-114B),
- RTCA SC159 WG4 with inputs from airborne system side primarily related to aspects of the GBAS data broadcast (VDB). Ground and system contributions were covered by project 15.03.06.

Important achievements consisted in the contribution to the GAST-D ICAO SARPS validation, based on SESAR GAST-D airborne subsystem verification results. As an integral part of the SARPS development process, a validation matrix developed in the GBAS Cat II/III projects' context. Purpose was to document the efforts linked to each proposed change of individual paragraphs of the standardization framework (GBAS Cat II/III amendment). Validation work was conducted in parallel to the implementation of the proposed SARPS changes. Among others, two main issues requiring extensive discussion and additional validation work have been solved:

- Verification that changes proposed for the VDB data link characteristics will not cause incompatibilities with respect to ILS, VOR resp. VHF communications.
- Confirmation of the feasibility of proposed ionosphere gradient mitigation requirements for the GBAS Cat II/III function.

Validation of the GAST-D SARPS has been completed. The material is to be submitted to the Air Navigation Commission end-2016 and published for state review in 2017 for applicability in late 2018.

1.5 Project Conclusion and Recommendations

Concerning GBAS Cat II/III L1 (GAST D), it has been demonstrated through several flights, ground and lab tests inclusive a large variety of simulations, that under Low Visibility Conditions (CATII/III) this SESAR Solution enabled:

- GBAS Automatic Approach and Landing down to Cat IIIb minima for Mainline Aircraft (More sustained accuracy in aircraft guidance on final approach)
    - Automatic roll-out, DH < 50 ft down to no DH & RVR between 50m and 200m
- GBAS Automatic Approach and Landing down to Cat II or Cat IIIa minima for Business and Regional Aircraft (More sustained accuracy in aircraft guidance on final approach)
    - 50 ft < DH < 200 ft & 200 m < RVR < 550m
    - CAT IIIb considerations for Business Aircraft for possible future use

- GBAS guided take-off

It improved the runway throughput in low visibility conditions, thus ensuring resilience to adverse weather conditions by using GBAS.

With the successful validation of a V3 / TRL 6 maturity of the GBAS CAT III L1 solution as a safe, cost efficient and sufficiently mature solution it is recommended to start industrialization, approval and deployment in support to achieve SESAR goals.

It is recommended to further explore future advances in terms of robustness and system flexibility by the inclusion of new GNSS constellations (Galileo) and use of dual GNSS frequency to the GBAS CAT III solution. The maturity level of such advanced technology needs to be increased.

Concerning advanced GBAS solutions (MC/MF GBAS), the project has contributed to the preliminary concept verification concerning a GBAS system supporting Low Visibility Procedures (LVP) when using additional frequencies and different GNSS constellations (i.e. GPS, Galileo).

Main key issues for a MC/MF GBAS solution have been analysed, two specific processing options have been selected and developed within an airborne component mock up. Initial system implementations have been successfully tested in cooperation with ground mock-ups.

The project recommends to continue working in this solution with prototype developments and to consolidate remaining open issues. A close coordination with core constellation responsible bodies (i.e. ESA and GSA for Galileo in Europe) and strong involvement of industry appears highly desirable.

2 References

[1] SESAR Programme Management Plan, Edition 03.00.01

[2] European ATM Master Plan

[3] Multilateral Framework Agreement ("MFA") signed between the SJU, EUROCONTROL and its 15 selected members on August 11, 2009, amended on 14 June 2010, 19 October 2010 and 2 July 2012

[4] P09.12.D01 Definition of the High Level Architecture for Mainline and Business Aircraft, edition 00.01.02, February 2011

[5] P09.12.D02 Qualitative & Quantitative Functional, Performance and Safety Requirements, edition 00.01.00, February 2011

[6] P09.12: D03 "High level Performance Allocation and Split of Responsibilities between Air and Ground", edition 00.02.00, April 2011

[7] P09 12 D004 High Level Definition of extension of Multi GNSS GBAS Cat II_III, edition 00.01.04, December 2013

[8] P09.12.D05 Mainline Aircraft simulation tools upgrade, edition 00.01.01, February 2011

[9] P09 12 D006 Definition of continuity augmentation requirements, edition 00.01.00, September 2012

[10] P09.12 D07, Initial GBAS Cat II/III Specification Definition, edition 00.02.00, March 2012

[11] P09.12 D09 Technical Validation Plan for Mainline A C - Prototype development, edition 00.01.01, March 2012

[12] P09.12 D10 Technical Validation Plan for Mainline & business A C - GBAS cat II III approach design criteria needs, edition 00.01.00, March 2012

[13] P09.12 D11 Technical Validation Report for mainline & business - Local availability, edition 00.00.01, June 2011

[14] P09.12.D12-001 Autoland Simulations and Failure Mode Simulations for Mainline Aircraft, edition 00.01.01, March 2011

[15] P09.12.D12-002 Autoland Simulations and Failure Mode Simulations for Mainline Aircraft, edition 00.02.00 April 2015

[16] P09.12.D13 Technical Validation Report for mainline & business - Static tests data from different locations, edition 00.01.01, December 2013

[17] P09.12.D14 Technical validation plan for business aircraft - Definition of continuity augmentation requirements, edition 00.00.01, December 2013

[18] P09.12.D15 Technical Validation Plan for Business A C - Prototype Development, edition 00.01.00, December 2013

[19] P09.12.D16 Technical Validation Plan for Business A C - Specification Definition, edition 00.01.00, December 2013

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[21] P09.12.D18 Autoland Simulations and Failure Mode Simulations for Business A/C, edition 00.01.00, April 2013

[22] P09.12 D19 New aircraft airworthiness requirements, edition 00.01.00, December 2012

[23] P09.12 D20 Assessment of ATM Requirements impacts on GAST-D airworthiness criteria, edition 00.01.00, December 2013

[24] P09.12.D21 Technical Note - Certification Issues - Consolidation of new A C airworthiness requirements, edition 00.00.01, May 2014

[25] P09.12.D22 Availability and Local Environmental Aspects for Initial GBAS CAT II/III for Mainline A/C, edition 00.01.00, March 2012

[26] P09.12.D23, Technical Note - Availability and Local Environment Aspects - Availability and local environment aspects for initial GBAS cat II III for business A/C, edition 00.01.00, December 2013

[27] P09.12 D24 'Mainline A/C Avionics prototype for initial GBAS Cat II/III delivery form', edition 00.01.00, December 2014

[28] P09.12.D25 Validation Plan (VALP) for Avionics Prototype for Initial GBAS CAT II/III Delivery Form, edition 00.02.01, June 2014

[29] P09.12.D26 Technical Validation Report for Mainline A C - Avionics prototype for initial GBAS cat II III delivery form, edition 00.01.00, April 2015

[30] P09.12.D27 Technical Validation Report for Business A C - Avionics prototype for initial GBAS cat II III delivery form, edition 00.01.01, December 2014

[31] P09.12.D28 Technical Validation Report - Independent review of the various ground/air subsystems performances - GBAS interoperability assessment report, edition 00.01.00, February 2015

[32] P09.12.D29 Preparation and Definition of 9.12 WA5 phase - Airborne Impact Analysis, edition 00.01.00, July 2014

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[36] P09.12.D31-004 Yearly synthesis of standardization activities, edition 00.01.00, September 2016

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[38] P09.12.D38 Study and Analysis Results Report, edition 00.01.00, January 2016

[39] P09.12 D39 MC/MF GBAS Preliminary Airborne System Specification, edition 00.01.00, September 2016

[40] P09.12 D40 MC/MF GBAS Cat II/III airborne Design Criteria - prelim. Verification Plan, edition 00.01.00, April 2016

[41] P09.12 D41 MC-MF Receiver Mock-up Development & Verification Report, edition 00.01.00, September 2016

[42] P09.12 D42 Airborne MF-MC Equipment Development Cost & Benefit Analysis Report, edition 00.01.00, August 2016

[43] RTCA DO-253C, Minimum operational performance standards for GPS local area augmentation system airborne equipment, RTCA, December 2008

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