



Support to standardization activities report

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Abstract

This document summarizes the scope of RTCA SC-147/EUROCAE WG-75 and describes the standardization activities performed by SESAR 9.47 members for the standardization subgroup.

The objective of this document is to:

- Make a high level status on where standardization groups stand currently.
- Make a sum up of inputs made by SESAR 9.47 to those groups and the outputs from those groups to SESAR 9.47.

This document does not aim at making a detailed technical status of the various ongoing activities and deliverables of the standardization groups. This document concludes all the activities initiated in 2012 until May 2016.

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Table of Contents

EXECUTIVE SUMMARY	5
1 INTRODUCTION	6
1.1 PURPOSE OF THE DOCUMENT	6
1.2 INTENDED READERSHIP.....	6
1.3 INPUTS FROM OTHER PROJECTS.....	6
1.4 GLOSSARY OF TERMS	6
1.5 ACRONYMS AND TERMINOLOGY	6
2 RTCA SC-147 / EUROCAE WG-75: TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM 8	
2.1 SCOPE OF RTCA SC-147 / EUROCAE WG-75.....	8
2.1.1 <i>Work organization</i>	9
2.2 MAIN SC-147/WG-75 ACTIVITIES AND ACHIEVEMENTS DURING SESAR 9.47 PROJECT DURATION.	9
2.3 LIST OF PUBLISHED STANDARDIZATION DOCUMENTS	10
2.4 SESAR 9.47 EXCHANGES WITH SC-147/WG-75.....	12
2.4.1 <i>Honeywell contribution perspective</i>	12
2.4.2 <i>DSNA contribution perspective</i>	13
2.4.3 <i>Airbus contribution perspective</i>	14
2.4.4 <i>EUROCONTROL contribution perspective</i>	14
3 ACAS X STATUS AND FUTURE	15
4 REFERENCES	17

List of tables

Table 1: List of published standards (both RTCA and EUROCAE) by 2012	11
Table 2: List of published standards (both RTCA and EUROCAE) after 2012.....	12
Table 3: List of Honeywell presentations	13
Table 4: List of DSN presentations.....	14
Table 5: List of Airbus presentations.....	14

List of figures

Figure 1: Working groups of RTCA SC-147.....	9
Figure 2: ACAS Xa/Xo timeline	15
Figure 3: ACAS Xu timeline	16

Executive summary

This document provides a summary of standardization activities performed within the SESAR 9.47 project (in relation with SESAR 4.8.1 project, an operational mirror project of SESAR 9.47) in 2012-2016 timeframe. While the technical outputs of these activities were already incorporated in the technical deliverables of the SESAR 9.47 (and also SESAR 4.8.1), this document aims to provide brief overview of RTCA SC-147/EUROCAE WG-75 scope and ongoing activities, as well as to conclude the extent of support and work performed in this context by the project members.

In 2012, when SESAR 9.47 started to contribute to SC-147 / WG-75, the standardization was mostly focusing on assessment of benefits introduced by TCAS II with Extended Hybrid Surveillance, and TCAS II v7.1 with Reduced Thresholds (scope of former SESAR 4.8.2). In the same year, FAA expressed a need for new generation of collision avoidance systems since current system is not designed for some of the reduced separations and traffic flows envisioned by FAA NextGen and SESAR initiatives. The development of ACAS X (introducing four variants addressing needs of different airspace users) became the main topic of interest of SC-147/WG-75 since 2013, with the goal to develop ACAS Xa/Xo MOPS by 2018, and ACAS Xu MOPS by 2020.

SESAR 9.47 project is primarily focusing on the surveillance (STM) part of ACAS Xa system and iterative evaluation of its performance. Such evaluations were performed in form of:

- Fast-time simulations (using model implemented according to ADD developed within SC-147), or
- Real-time simulations using Honeywell ACAS X experimental platform with code developed within SC-147.

Evaluation of treat logic (TRM) within SESAR was mostly performed within the scope of SESAR 4.8.1 project in the similar manner. The total of 23 presentations were given by SESAR 9.47 project members at SC-147/WG-75 face-to-face meetings or teleconferences. The members of SESAR 9.47 were mainly supporting the standardization by:

- Active participation on the standardization meetings;
- Iterative evaluations of proposed solutions & benefit evaluations;
- Proposing the changes to standards (DO-300A);
- Contribution to system interface requirements;
- Presenting a validation results (Extended Hybrid Surveillance, ACAS X) and providing feedback to standardization;
- Review of the working documents, providing comments and contribution to MOPS development;
- Providing the manufacturer/ANSP/aircraft manufacturer point-of-view to different discussions.

Since SESAR1 is approaching its end, the continuation of European ACAS X validation activities is expected within the scope of SESAR 2020 - PJ.11; e.g. particularly, solution PJ.11-A1 will focus on ACAS Xa, PJ.11-A2 will focus on ACAS Xu, PJ.11-A3 will focus on ACAS Xo and PJ.11-A4 will focus on ACAS Xp.

1 Introduction

1.1 Purpose of the document

This document provides a summary of standardization activities performed within the SESAR 9.47 project (in relation with SESAR 4.8.1 project, an operational mirror project of SESAR 9.47) in 2012-2016 timeframe. While the technical outputs of these activities were already incorporated in the technical deliverables of the SESAR 9.47 (and also SESAR 4.8.1), this document aims to provide brief overview of RTCA SC-147/EUROCAE WG-75 scope and ongoing activities, as well as to conclude the extent of support and work performed in this context by the project members.

1.2 Intended readership

This document is intended for the readers that are interested in standardization activities linked to TCAS evolution (Extended Hybrid Surveillance, and ACAS X).

1.3 Inputs from other projects

N/A

1.4 Glossary of terms

N/A

1.5 Acronyms and Terminology

Term	Definition
ACAS	Airborne Collision Avoidance System
ADD	Architecture Design Description
ADS-B	Automatic Dependent Surveillance – Broadcast
ASA	Aircraft Surveillance Applications
ATM	Air Traffic Management
CSPO	Closely Spaced Parallel Runway Operations
DAA	Detect and Avoid
E-ATMS	European Air Traffic Management System
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
FIM	Flight-deck Interval Management
JHU	John Hopkins University

Term	Definition
LL	MIT/Lincoln Laboratory
MIT	Massachusetts Institute of Technology
MOPS	Minimum Operational Performance Standards
OFA	Operational Focus Area
OSED	Operational Service and Environment Definition
RA	Resolution Advisory
RTCA	Radio Technical Commission for Aeronautics
SC	Special Committee (RTCA)
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
TA	Traffic Advisory
TCAS	Traffic Alert and Collision Avoidance System
TSO	Technical Standard Order
UAS	Unmanned Aircraft Systems
VALP	Validation Plan
VALR	Validation Report
WG	Working Group (EUROCAE)

2 RTCA SC-147 / EUROCAE WG-75: Traffic Alert and Collision Avoidance System

RTCA SC-147 Traffic Alert and Collision Avoidance System was established on November 1st, 1980. Since then it has defined and updated the TCAS and TCAS II performance standards, thereby contributed to one of the most significant advances in aviation safety in the past twenty years [1].

EUROCAE WG-75 works in close cooperation with RTCA SC-147 and is tasked to develop Airborne Collision Avoidance Systems (ACAS) X MOPS as a joint RTCA/EUROCAE activity, and ultimately, a joint MOPS document [2].

2.1 Scope of RTCA SC-147 / EUROCAE WG-75

In 2012, when SESAR 9.47 started to contribute to SC-147 / WG-75, the standardization was mostly focusing on assessment of benefits introduced by TCAS II with Extended Hybrid Surveillance, and TCAS II v7.1 with Reduced Thresholds (scope of former SESAR 4.8.2). In the same year, FAA expressed a need for new generation of collision avoidance systems since current system is not designed for some of the reduced separations and traffic flows envisioned by FAA NextGen and SESAR initiatives.

The FAA has funded the research and preliminary development of such a new system, referred to as Aircraft Collision Avoidance System for NextGen, or ACAS X. The concept of ACAS X consist of several variants of the system addressing needs of various airspace users.

The fundamental system, **ACAS Xa**, with the “A” denoting active surveillance will maintain the use of independent surveillance through the use of Mode S Transponder interrogations and replies, while maximizing the use of passive surveillance sources such as ADS-B to the extent safely possible to further reduce spectrum congestion on the 1090MHz frequency. ACAS Xa is expected to be a “drop-in” replacement for TCAS II.

An **ACAS Xo**, with the “O” denoting an operational specific variant is presented as additional layer of functionality allowing ACAS to work with Aircraft Surveillance Applications (ASA) that will be used for par-wise operations such as Closely Spaced Parallel Runway Operations (CSPO) and Flight-deck based Interval Management (FIM). ACAS Xo will be able to suppress Traffic Advisories (TAs) and/or Resolution Advisories (RAs) or desensitize alerting thresholds against pilot selected aircraft with which ownship is conducting a specific pair-wise operation.

The variant dedicated for UAS is known as **ACAS Xu** and is interoperable with TCAS II and other ACAS X systems. FAA funded research, testing and preliminary development with some activities being in collaboration with NASA and industry partners. ACAS Xu could provide a collision avoidance functionality for Detect and Avoid (DAA) systems being developed under RTCA SC-228.

The last version which is envisioned as a future effort, but not included in the current requested deliverables of the committee is **ACAS Xp** that will operate based on only passive surveillance. This variant is intended for general aviation (a class of aircraft not currently required to fit TCAS II) [3].

The initial version of ACAS X ConOps was introduced at the plenary meeting in June 2012. Since then, the focus of SC-147 was mostly on the continuous development and validation of ACAS Xa/Xo systems.

All of these efforts are internationally coordinated and in conjunction with EUROCAE WG-75 activities.

2.1.1 Work organization

RTCA SC-147 is currently divided into several working groups as depicted at the figure below. Each WG organizes regular meetings / teleconferences independently, where details on specific topics of interest are discussed and presented. Regular face-to-face meetings are organized quarterly in order to coordinate the activities across all the working groups, as well as to coordinate with EUROCAE WG-75. At these plenary face-to-face meetings, a regular update on SESAR activities is presented by SESAR OFA coordinator, in order to sustain and reinforce the cooperation between US and European initiatives on ACAS X development.

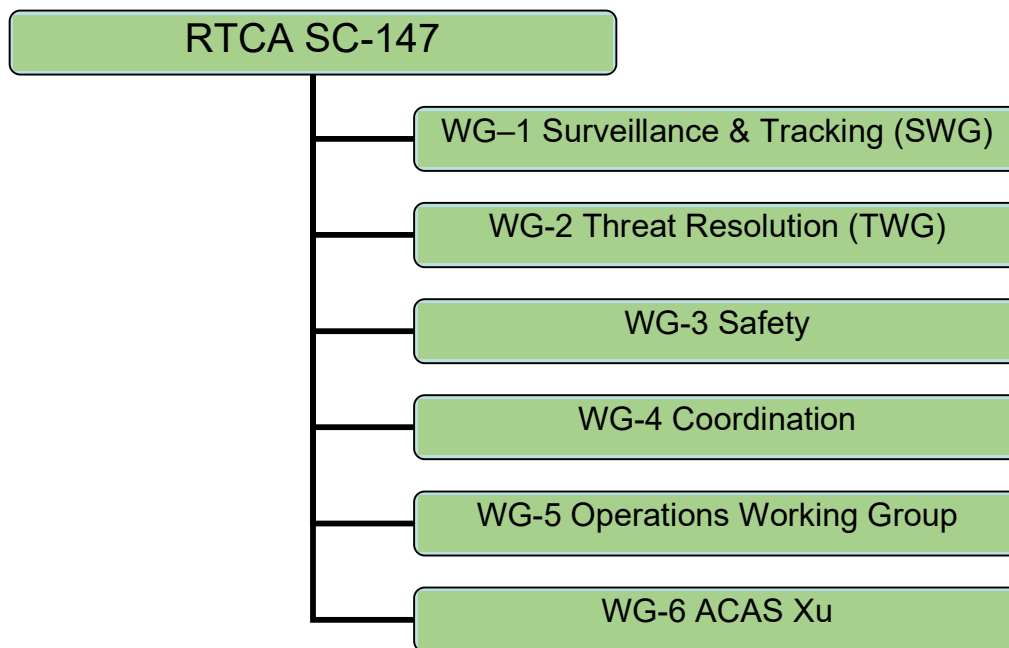


Figure 1: Working groups of RTCA SC-147

2.2 Main SC-147/WG-75 activities and achievements during SESAR 9.47 project duration

During the duration of the project, activities related to several different topics were conducted by the committee. Although only a subset was directly related to SESAR 9.47 project scope (since project is focusing mostly on a surveillance aspects of the system), the overall list of main topics is provided here for better picture:

- **Revision A of the Hybrid Surveillance MOPS** (e.g. DP-300A/ED-221) was approved. This document provided a **modifications to DO-185B** that are required to implement hybrid surveillance techniques in conjunction with other functions of the equipment. This revision introduced extended hybrid surveillance in addition to hybrid surveillance as a mean to decrease Mode S interrogations [5].
- After the **ACAS X concept** was shared within the committee, so as the concept of ACAS X surveillance and tracking module (STM) and treat resolution module (TRM), the activities on ACAS X development and validation accelerated, and different working groups continuously created.
 - **The first ACAS X proof-of-concept flight test** was held in 2013 using TCAS II surveillance in conjunction with ACAS X logic table.

- Apart from flight tests, a number of validations & analysis were completed both in US (operational suitability evaluation, coordination stress testing, continuous STM and TRM evaluations) and Europe (threat logic, operational acceptability, continuous STM and TRM evaluations).
- **ACAS X MOPS** development was initiated.
- **Inter Special-committee Requirements Agreement (ISRA) between SC-147 and SC-228, which deals with UAS**, was approved in 2014, to handle requirements interoperability between UAS collision avoidance systems and TCAS systems (including TCAS II and ACAS X).
- **ACAS Xu subgroup** was established in 2015 with two major areas for ACAS Xu: 1) the NASA/flight test work, and 2) ACAS Xu specification.
- **European acceptability criteria** were introduced in 2015.
- **DO-300A Change1 and DO-300 Change2** were approved in 2015.
- Full system flight test in 2015 with support of LL, APL, Honeywell and SESAR. **Flight testing of ACAS Xa/Xo (Run13)** was performed at FAA William J. Hughes Technical Center in Atlantic City, USA. During the flights, system matched desired alerting behaviour in the vast majority of test cases.

2.3 List of published standardization documents

During the lifetime of SC-147/WG-75, a number of documents were published. Those, which were published before SESAR 9.47 project joined the standardization are listed in the following table:

Document # (RTCA)	Document # (EUROCAE)	Title	Published
DO-184	N/A	Traffic Alert and Collision Avoidance System (TCAS) I Function Guidelines	May 1983
DO-197A	N/A	Minimum Operational Performance Standards for an Active Traffic Alert and Collision Avoidance System I (Active TCAS I)	September 1994
DO-197 Ch1	N/A	Minimum Operational Performance Standards for an Active Traffic Alert and Collision Avoidance System I (Active TCAS I)	July 1997
DO-185A	N/A	Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II) Airborne Equipment	December 1997
DO-298	N/A	Safety Analysis of Proposed Change to TCAS RA Reversal Logic	November 2005

Document # (RTCA)	Document # (EUROCAE)	Title	Published
DO-299	N/A	Report – Assessment and recommendations on Visual Alerts and Aural Annunciations for TCAS II	March 2006
DO-300	N/A	DO-300, Minimum Operational Performance Standards (MOPS) for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance	December 2006
DO-185B	ED-143	Volume I: Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System II (TCAS II). Volume II: TCAS II Collision Avoidance System (CAS) Requirements Specification Attachment A to Volume II	September 2008
DO-185B Ch1	ED-143 Ch1	Minimum Operational Performance Standards For Traffic Alert and Collision Avoidance	April 2009
N/A	ED-181	Guidance for the Development of Airborne Collision Avoidance Systems	September 2010
DO-337	N/A	Recommendations for Future Collision Avoidance Systems	March 2012

Table 1: List of published standards (both RTCA and EUROCAE) by 2012

In addition, during the duration of SESAR 9.47 project (since 2012), following documents were published. Most of them are documents related to ACAS X development. For evolving documents (such as ADD or CONOPS), only latest versions are listed.

Document # (RTCA)	Document # (EUROCAE)	Title	Published
DO-185B Ch2	ED-143 Ch2	Minimum Operational Performance Standards For Traffic Alert and Collision Avoidance (TCAS II)	April 2013
DO-300A	ED-221	MOPS for TCAS II Hybrid Surveillance	April 2013
ACAS X CONOPS (V2R0)	N/A	Concept of Operations for the Airborne Collision Avoidance System X	April 2013
ACAS X SRS V0R2	N/A	System Requirements Specification for the Active and Operational Variants (Xa/Xo) of the Airborne Collision Avoidance System X	January 2014
ACAS Xo CONOPS V2R0	N/A	Concept of Use for the Airborne Collision Avoidance System Xo	February 2015
ACAS_X_O&FSA	N/A	Airborne Collision Avoidance System X Operational and Functional Safety Assessment	March 2015
ACAS Xu	N/A	Concept of Use for the Airborne Collision	September

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Document # (RTCA)	Document # (EUROCAE)	Title	Published
CONUSE V2R0		Avoidance System (ACAS) Xu	2015
DO-300A Ch1	N/A	Minimum Performance Standards (MOPS) for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance	December 2015
DO-300 Ch2	N/A	Minimum Performance Standards (MOPS) for Traffic Alert and Collision Avoidance System II (TCAS II) Hybrid Surveillance	December 2015
ACAS X ADD V14R3	N/A	Algorithm Design Description of the Xa and Xo Airborne Collision Avoidance System X	February 2016

Table 2: List of published standards (both RTCA and EUROCAE) after 2012

2.4 SESAR 9.47 exchanges with SC-147/WG-75

SESAR 9.47 project is primarily focusing on the surveillance (STM) part of ACAS Xa system and iterative evaluation of its performance. Such evaluations were performed in form of:

- Fast-time simulations (using model implemented according to ADD developed within SC-147), or
- Real-time simulations using Honeywell ACAS X experimental platform with code developed within SC-147.

Evaluation of the treat logic (TRM) within SESAR was mostly performed within the scope of SESAR 4.8.1 project in the similar manner.

Following sections summarize per partner contribution to SC-147/WG-75.

2.4.1 Honeywell contribution perspective

- Active participation on the standardization meetings;
- Iterative evaluations of proposed solutions & benefit evaluations;
- Proposing the changes to standards (DO-300A);
- Contribution to system interface requirements;
- Presenting a validation results (Extended Hybrid Surveillance, ACAS X) and providing feedback to standardization;
- Review of the working documents, providing comments and contribution to MOPS development;
- Providing the manufacturer point-of-view to different discussions.

List of presentations delivered by Honeywell within SC-147 standardization is summarized in the table below:

Presentation title	Date
SESAR 9.47 TCAS Hybrid Surveillance Activities	June 2012
EHS preliminary results	January 2015
Initial STM performance evaluation – preliminary results	May 2015
Study of STM performance and behaviour	July 2015
Analysis of Run13 STM using 2015 ACAS Xa/Xo flight test data	March 2016

Table 3: List of Honeywell presentations

2.4.2 DSN A contribution perspective

- Active participation on the standardization meetings;
- Presenting the validation results (Extended Hybrid Surveillance, ACAS X) and providing feedback to standardization;
- Review of the working documents, providing comments and contribution to MOPS development;
- Providing the ANSP point-of-view to different discussions

List of presentations delivered by DSN A within SC-147 standardization is summarized in the table below:

Presentation title	Date
Change 2 of TCAS II v7.1 with Reduced Thresholds: Operational benefits for US and European airspaces	June 2012
European contribution to ACAS Xa validation	December 2013
European contribution to ACAS Xa validation	March 2014
European contribution to ACAS Xa validation	June 2014
European contribution to ACAS Xa (Run12) validation	June 2014
European safety encounter model results	September 2014
European contribution to ACAS Xa validation	September 2014
Results on ACAS Xa Run13 from SESAR 4.8.1 Phase 3	January 2015
European contribution to ACAS Xa validation	January 2015
SESAR initiative on acceptability criteria for ACAS Xa in Europe	April 2015
European contribution to ACAS Xa validation	July 2015
European contribution to ACAS Xa validation	September 2015

Presentation title	Date
SESAR vision of European acceptability criteria for ACAS Xa development	September 2015
SESAR current activities and way forward on ACAS X	December 2015
CDG radar data analysis	March 2016
Update on SESAR 1 work	March 2016

Table 4: List of DSN A presentations

2.4.3 Airbus contribution perspective

- Active participation on the standardization meetings;
- Providing support regarding European human-in-the-loop assessment on Airbus simulator;
- Review of DO-300A and ACAS X MOPS drafts;
- Review of the working documents, providing comments and contribution to MOPS development;
- Providing the aircraft manufacturer point of view to different discussions.

List of presentations delivered by Airbus within SC-147 standardization is summarized in the table below:

Presentation title	Date
Use of heading data by ACAS X (Quality of the heading source for TCAS use)	January 2015
TCAS and aircraft performance limits	May 2016

Table 5: List of Airbus presentations

2.4.4 EUROCONTROL contribution perspective

EUROCONTROL participated to the SC147/WG75 surveillance sub-group meetings dealing with Extended Hybrid Surveillance and ACAS X surveillance. EUROCONTROL reviewed proposed changes in DO-300A (extended Hybrid Surveillance) and proposed comments to improve the DO-300A MOPS. EUROCONTROL also supported the running of EUROCAE WG-75 (secretary).

3 ACAS X status and future

ACAS X activities within SC-147 are divided into two streams: An ACAS Xa/Xo development, and ACAS Xu development. ACAS Xa/Xo currently ongoing activities are leading to joint Minimal Operational Performance Standards (MOPS) for ACAS Xa with ACAS Xo capabilities. New ACAS X MOPS will specify minimum requirements for a collision avoidance system including surveillance, tracking and threat resolution functionalities. The delivery date for ACAS Xa/Xo MOPS is December 2018.

Meanwhile, Run15 of ACAS Xa/Xo is under preparation aiming to deliver Run15 ADD document by end of September 2016. Figure below summarizes upcoming activities and milestones in ACAS Xa/Xo development.

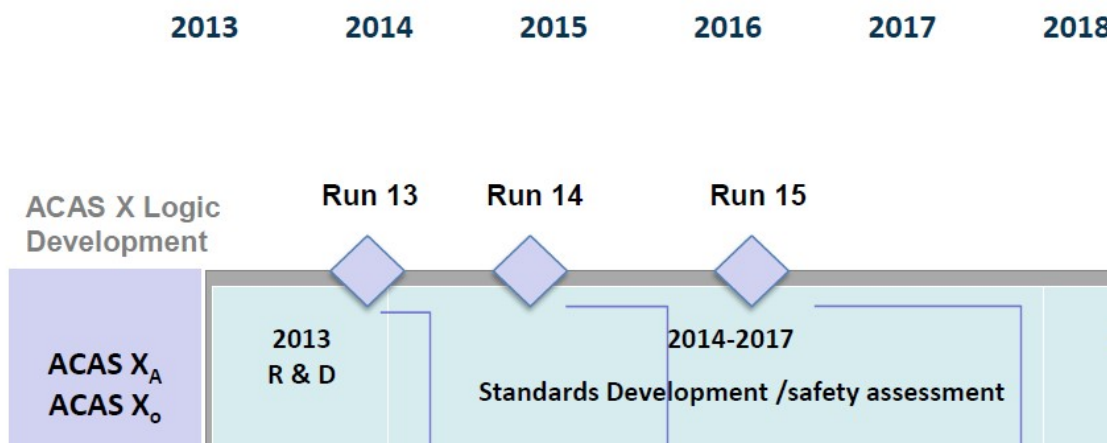


Figure 2: ACAS Xa/Xo timeline

SESAR 9.47 project team is at the time when this report is being created (June 2016) analyzing the data from first European real environment validation: a roof-top testing performed with ACAS Xa Run14 prototype (implemented according ACAS X ADD V14R3 document). In addition, the same unit (provided by SESAR 9.47) was recently used for SESAR 4.8.1 human-in-the-loop assessment. Results of both validations are planned to be shared within SC-147/WG-75.

The second stream of ongoing SC-147 activities is the development of ACAS Xu. MOPS for ACAS Xu is envisioned in September 2020 and will be used by the regulators as a basis for new or revised Technical Standard Order(s) and guidance materials as appropriate. It is expected that these MOPS will be used by RTCA SC-228 in its Phase II D&A standards developments effort [3]. The most recent release of ACAS Xu is Run2, planning to deliver Run3 code and tables by September 2016, and Run3 ADD by the end of 2016. The latest timeline of ACAS Xu development is depicted at the figure below [4].

Since SESAR1 is approaching its end, the continuation of European ACAS X validation activities is expected within the scope of SESAR 2020 - PJ.11; e.g. particularly, solution PJ.11-A1 will focus on ACAS Xa, PJ.11-A2 will focus on ACAS Xu, PJ.11-A3 will focus on ACAS Xo and PJ.11-A4 will focus on ACAS Xp.

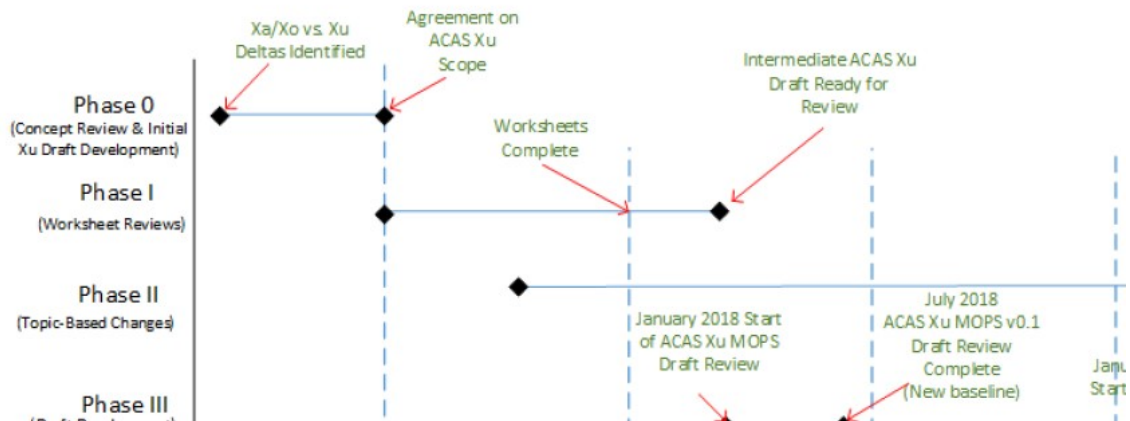


Figure 3: ACAS Xu timeline

4 References

- [1] RTCA, www.rtca.org/CMS_DOC/SC147
- [2] EUROCAE, www.eurocae.net/wgs/active/print/?wg=WG-75
- [3] Terms of reference, Special committee (SC) 147, Aircraft Collision Avoidance Systems, Revision 13, RTCA Paper No.300-15/PMC-1410, October 31, 2015
- [4] Airborne Collision Avoidance System Xu, FAA TCAS Program Office, Briefings to Xu Workshop, EUROCONTROL HQ, September, 2015
- [5] MOPS for TCAS II Hybrid Surveillance, RTCA DO-300A, March 2013.

-END OF DOCUMENT-

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