Final Project Report

Document information	
Project Title	ASAS - ASPA
Project Number	09.05._
Project Manager	AIRBUS
Deliverable Name	Final Project Report
Deliverable ID	D000
Edition	00.02.02
Template Version	03.00.04
Task contributors	
AIRBUS.	

Abstract

The work done in project 9.05 allowed to develop the avionics definition for the implementation of two functionalities:
- time based spacing from a designated aircraft
- situational awareness function for enhanced visual approaches.
The project 9.05 produced:
- functional specifications for the airborne implementation (updated all along the project according to the results of the real time evaluations done in the frame of the associated operational projects)
- mockups and avionics prototypes used to support the various operational exercises and flight trials.
An activity dealing with the support to standardisation also took place in the frame of this project.

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	**Position & Title**	**Date**
████████████ AIRBUS	████████████	23/09/2015
████████████ AIRBUS	████████████	06/10/2016

Reviewed By - *Reviewers internal to the project.*		
Name & Company	**Position & Title**	**Date**
████████ THALES AVIONICS	████████	07/10/2016
████████ HONEYWELL	████████	07/10/2016
████████ FINMECCANICA	████████	07/10/2016

Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	**Position & Title**	**Date**
████████ AIRBUS	████████	25/07/2016
████████ AIRBUS	████████	07/10/2016

Approved for submission to the SJU By - *Representatives of the company involved in the project.*		
Name & Company	**Position & Title**	**Date**
████████ THALES AVIONICS	████████	07/10/2016
████████ HONEYWELL	████████	07/10/2016
████████ FINMECCANICA	████████	07/10/2016
████████ AIRBUS	████████	07/10/2016

Rejected By - *Representatives of the company involved in the project.*		
Name & Company	**Position & Title**	**Date**
N/A		

Rational for rejection
None.

Document History

Edition	Date	Status	Author	Justification
00.00.01	10/12/2015	Initial draft	████████	First draft.
00.00.02	18/07/2016	Revised draft		New template (version 03.00.04) applied + rework / clarification of the content.
00.00.03	22/07/2016	Revised draft		Rework of the FPR content
00.00.04	28/07/2016	Revised draft		Integration of comments
00.01.00	29/07/2016	Final version		Final version for approval
00.01.01	03/08/2016	Final version		Corrections after SJU comments 01/08/2016: - name of the file changed from"09.05.00 Final Project

founding members

				Report 00.01.00" to "09.05-D000-Final Project Report" - project number changed from 09.05.00 to 09.05._ - deliverable ID changed from 9.5.D000 to D000 - dates of the approvals changed from the real dates to the date of re-submission to SJU
00.01.02	06/10/2016	Revised version	■■■■■	Integration of modifications after SJU comments.
00.02.00	13/10/2016	Revised version	■■■■■	Integration of modifications after reviewers new comments.
00.02.01	18/10/2016	Revised version	■■■■■	Light modifications after SJU re-assessment.
00.02.02	24/10/2016	Revised version	■■■■■	Correction of business A/C level of TRL reached at the end of SESAR 9.05 project.

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
A/C	Aircraft
ADS-B	Automatic Dependant Surveillance - Broadcast
ADS-B IN	The on-board capability to receive and process ADS-B information broadcasted by other aircraft
ASAS	Airborne Separation Assistance System
ASPA	ASAS Spacing
ATM	Air Traffic Management
ATSAW	Airborne Traffic Situational Awareness
ATSU	Air Traffic Service Unit
CAPP	CDTI-Assisted Pilot Procedure
CAVS	CDTI-Assisted Visual Separation
CDTI	Cockpit Display of Traffic Information
CPDLC	Controller Pilot Datalink Communication
CTA	Controlled Time of Arrival
E-ATMS	European Air Traffic Management System
EIS, EIS2	Electronic Instruments System
FANS	Future Air Navigation System
FG	Flight Guidance
FGE	Flight Guidance & Envelope
FIM	Flight-deck Interval Management
FMS	Flight Management System
FRD	Functional Requirements Document
HMI	Human Machine Interface
IM	Interval Management
IVT	International Validation Team

OSED	Operational Service and Environment Definition
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
S&M	Sequencing and Merging
SPR	Safety and Performance Requirements
TCAS	Traffic Collision Avoidance System
TMA	Terminal Manoeuvring Area
TS	Technical Specification

1 Project Overview

This document synthesises the work performed in SESAR project 09.05.00 in charge of defining, validating and implementing two airborne functions:

- One allowing the aircraft to execute time-based spacing instructions;

- The other providing an improved situational awareness to flight crews whenever operating visual operations.

The SESAR 09.05 ASAS-ASPA project was in charge of defining, implementing and validating two airborne functions:

- One function allowing the aircraft to execute time-based spacing instructions given by the controller, with the objective to reach pre-industrial development level (TRL6)

- The other function providing an improved situational awareness to flight crews whenever they operate visual operations relatively to a traffic, with the objective to propose a first iteration of an avionics solution (TRL3)

1.1 Project progress and contribution to the Master Plan

For mainline aircraft,

the project 9.05 allowed to progress on the avionics definition:

- Concerning ASAS spacing:

Starting from preceding studies where some cockpit mockups had been developed, the project 9.05 allowed to:

- implement the time-based spacing (ASPA S&M) function on real aircraft systems prototypes.

- refine the definition of the avionics definition and refine the spacing algorithm thanks to realistic traffic data,

- check the compatibility of following the vertical profile (including the cohabitation with continuous descent approaches) while complying with a spacing constraint from a reference aircraft;

- assess the feasibility of maintaining an accurate time spacing whatever the lateral trajectory configuration (e.g.: turns, offsets,…);

- verify the relevance of the information provided to the flight crew whenever the spacing is drifting or can't be achieved or maintained;

- consolidate the definition of the criteria to decide on the feasibility/unfeasibility of a spacing manoeuvre before activating it and once activated;

- confirm or modify the functional allocation of the ASPA S&M function on the avionics systems;

- study the air/ground datalink exchanges and the load capability into the avionics to support ASPA S&M operations on-board.

- Concerning the enhanced visual separation approaches:

A proposal for a cockpit definition, aimed at supporting operations like visual separation approaches, was prototyped on real aircraft systems, based on the existing (and certified) traffic situational awareness function (ATSAW).

For business aircraft,

- Concerning ASAS spacing: the project 9.05 permitted to develop cockpit mockups;

- Concerning the enhanced visual separation approaches: a first proposal of definition was tested on a cockpit simulator.

For regional aircraft,

the project 9.05 enabled to start the reflexions about regional aircraft implementation for ASAS spacing.

1.2 Project achievements

The project 09.05.00 main achievements are the following:

For ASAS Spacing S&M (OI step TS-0105-A):

Mainline A/C activities produced three sets of prototypes:

- the first set (including a Honeywell TCAS and a Thales FMS), implementing two manoeuvres (remain behind and merge behind), was used for the IT1 real time exercise of the SESAR operational project 5.6.6 and for the flight trial that took place in Toulouse in November 2012;

- The second set, implementing the four ASPA S&M manoeuvres (remain behind, merge behind, vector then merge and follow route then merge) was used to support the IT2 real time exercise of the SESAR operational project 5.6.6;

- The third set of prototypes was produced to allow a few corrections of the previous prototypes and to include the possibility of testing a Honeywell FMS. These prototypes were used in the frame of the SESAR project 5.3 to support two validation exercises aimed at integrating initial 4D and Stream 1 ASPA S&M and the flight trial that took place in Rome in June 2016.

After each iteration of exercises, the documents describing the functional requirements for the avionics (FRD) and the high level architecture were updated to trace the new findings and the evolutions of the stream 1 ASPA S&M function considered as necessary for.

The very latest Stream 1 ASPA Functional requirement document produced by the project (ref. [20]) is the document that will have to be considered whenever the activities on ASPA S&M start again. It traces not only functional requirements for the airborne side but also the open points that still have to be studied or confirmed for A/C-15a and A/C67.

For Enhanced Visual Separation (AUO-0507 Airborne Spacing Monitoring under IFR / ATSAW - Spacing monitoring):

Mainline A/C activities produced systems prototypes that were used during a real time evaluation exercise that took place with Airbus pilots and airspace users pilots in the loop (no connection to ATC tools nor controllers in the loop).

Business A/C activities produced a mockup that was used during the real time evaluation exercise that took place with airspace users pilots in the loop (no connection to ATC tools nor controllers in the loop).

The results of these two validation exercises (cf. ref [6]) allowed to produce a first basis for avionics functional requirements - linked to A/C-27a- necessary to support Enhanced Visual Separation operations (like CAVS).

The progress in maturity for the A/C enablers addressed by the project 9.05 is the following:

Code	Name	Project contribution	Maturity at project start	Maturity at project end
A/C - 15a	Flight management and guidance for ASAS spacing with target aircraft flying direct to metering point	Functional requirements definition (FRD). Avionics systems prototypes to support V2 and V3 operational validation exercises and flight trials.	Mainline: TRL3 Business TRL1 Regional TRL1	Mainline: TRL5 Business TRL4 Regional TRL2
A/C - 67	On-board Traffic situation for ASPA			
A/C - 31a	CPDLC compliant with ATN baseline 2 (FANS 3/C)	Contribution to WG78/SC214 ATN baseline 2 standard definition through participation to the FIM tiger team in charge of defining the ASAS spacing IM message set.		
A/C - 27a	Airborne Traffic Situational Awareness to support CDTI Assisted operations (ATSA-CAVS/CAPP), including reception (ADS-B In), processing, display, and alerts	Initial functional requirements definition. For mainline: - Avionics systems prototypes to support V1 validation exercises. For business avionics: - Mockups supporting V1 evaluations - V1 evaluations exercise involving airlines pilots and Honeywell test pilots.	Mainline: TRL1 Business:TRL1	Mainline: TRL4 Business: TRL4

1.3 Project Deliverables

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

Reference	Title	Description
D06	High Level Architecture and system specification document - issue 2	High level architecture requirements for the airborne implementation of ASAS Spacing Sequencing and Merging (ASPA S&M) application, based on the functional requirements document (SESAR 9.5.D02).
D09	Verification & Validation Plan - issue 2	Verification and Validation (V&V) Plan related to Airborne Separation Assistance System - Spacing (referred to as ASPA S&M) in the frame of 9.05 project. It focuses on the validation and verification of functional, HMI, performance and interoperability implementation of ASPA S&M on mainline aircraft.
D17	Synthesis of standardisation activities (RFG IM OSED and SPR)	Synthesis of activities performed in the frame of standardisation related to ASAS (Stream 1 ASPA

		S&M in relation with ASPA FIM and Stream2 Enhanced Visual Separation linked to CAVS use case.
D21	Functional requirement definition of ASPA S&M - issue 1 (Business Jet and regional)	Functional requirements for regional and business aircraft airborne implementation of ASPA S&M application : fist issue.
D06	High Level Architecture and system specification document - issue 2	Update of detailed aircraft system architecture for mainline A/C + feedbacks from regional and business architecture studies relevant for mainline
D26	Functional requirement definition of ASPA S&M - issue 4 (#708 and other i4D ASPA evaluation update)	Functional requirements for airborne implementation of ASPA S&M application updated after exe #708 and #805 (connected i4D / ASPA evaluations).
D28	Functional requirement definition of ASPA S&M - issue Stream2 (2) (Stream2 V2 validation)	Functional requirements for airborne implementation of ASPA S&M application updated after stream2 evaluations (exe #833 and #834).

1.4 Contribution to Standardisation

The project 9.05 contributed mainly to two EUROCAE/RTCA standardisation groups:

- WG51/SC186, dealing with ADS-B IN applications, among which the following ones are directly linked to the project 9.05:
  - CAVS: CDTI Assisted Visual Separation is an enhancement of ATSA-AIRB/VSA allowing to continue in visual separation procedure (for qualified traffic) when a visual contact is lost, based on the information provided on CDTI and supporting alertings.
  - CAPP: CDTI Assisted Pilot Procedure is an operational enhancement allowing to prepare visual separation operation (like CAVS) by giving a "not closer than" spacing instruction until the flight crew can switch to CAVS operation (if instructed by ATC). CAPP is assumed to use the CAVS onboard system.
  - FIM-Spacing: Flight deck Interval Management is an application providing the flight crew with the speed (and in some cases turn) guidance in order to achieve and maintain the interval (time or distance) behind a designated leading aircraft.
- WG78/SC214, dealing with the definition of a set of CPDLC messages for ATN Baseline 2.

The detailed description of the standardisation activities is available in the synthesis of standardisation activities document, ref. [20]

1.5 Project Conclusion and Recommendations

The project 9.05 allowed to explore in detail the on-board definition of the ASAS Spacing S&M application. It confirmed the need for pilots to have a fully automated implementation of the ASAS spacing function on board the aircraft for operations in dense TMAs.

The level of maturity reached for the airborne implementation of ASAS Spacing S&M function is not the one expected since the on-board definition is not yet the definition for an industrialised product:

some elements of definition still need to be confirmed or reworked (e.g. required spacing accuracy, need for a capability to amend ASPA manoeuvre parameters without stopping the current manoeuvre, acceptable ways on how to implement the capability to "suspend then resume an ASPA S&M manoeuvre", etc.) and the assessment of benefits is still to be consolidated by a clear operational analysis of the results obtained in the various validation exercises so as to get a real confidence in these (i.e. non biased trials).

The complexity of the implementation of ASAS spacing (with up to five avionics systems impacted for mainline A/C despite the fact that the operational hypotheses for the first step of ASAS Spacing are much simpler than the definition of the second step ASAS Spacing S&M-IM) led the projects 9.05 to work on an intermediate step so as to pave the way towards more complex applications like ASAS spacing.

This intermediate step, aimed at building on the existing traffic situational awareness product (e.g. ATSAW for mainline) to provide early quick wins for equipped airlines and facilitate the eventual deployment of more powerful and complex ADS-B IN functions, was worked on both mainline and business aircraft. This work can be considered as a preparatory work for SESAR 2020 solution PJ01-07 since it started identifying use cases were such an airborne function could be of use in some operations; it also raised issues linked to legal aspects or reluctances due to controllers practices that will have to be considered in the frame of SESAR 2020 work so as to enable the use of such functions relying on traffic information displayed in the cockpit.

The documents produced by the project 9.05 are such that:

- whenever ASAS spacing activities of the airborne side restart, the functional description of the airborne function is clear and the subjects still to be clarified or reworked are listed;

- for SESAR 2020 activities planned in the frame of PJ01 - solution 07, the work linked to enabler A/C27a can be used as inputs documents to build on.

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] SESAR 5.6.6, Final Project Report, 05.06.06.D01, 21/07/2016

[5] SESAR 5.6.6, IT2 OSED, 05.06.06.D08, 13/04/2012.

[6] SESAR 5.6.6, Stream 2 Validation report, 05.06.06.D49, 31/05/2016

[7] B.01-D83-Integrated_Roadmap_DS15_Release_Note

[8] SESAR 9.05, Functional requirement definition of ASPA S&M - issue 1 draft (mainline), 09.05.D01

[9] SESAR 9.05, Functional requirement definition of ASPA S&M - issue 2, 9.05.D02

[10] SESAR 9.05, Functional requirement definition of ASPA S&M - issue 3 (#199), 9.05.D03

[11] SESAR 9.05, High Level Architecture and system specification document - issue 1, 9.05.D05

[12] SESAR 9.05, High Level Architecture and system specification document - issue 2, 9.05.D06;

[13] SESAR 9.05, Verification & Validation Plan - issue 2, 9.05.D09,

[14] SESAR 9.05, TCAS FG FMS ATSU & EIS2 prototype delivery forms - step 1, 9.05.D11

[15] SESAR 9.05, Aircraft Integration Simulator ready for evaluation form - step 1, 9.05.D12

[16] SESAR 9.05, TCAS, FG, FMS, ATSU & EIS2 prototype delivery forms - step 2, 9.05.D13

[17] SESAR 9.05, Synthesis of standardisation activities (RFG IM OSED and SPR), 9.05.D17

[18] SESAR 9.05, Aircraft Integration Simulator ready for evaluation form - step 2, 9.05.D18

[19] SESAR 9.05, Functional requirement definition of ASPA S&M - issue 1 (Business Jet and regional), 9.05.D21

[20] SESAR 9.05, Functional requirement definition of ASPA S&M - issue 4 (#708 and #805 evaluation update), 09.05.D26, 31/07/2016

[21] SESAR 9.05, Functional requirement definition of ASPA S&M - stream2 (1) (Stream2 definition), 9.05.D27

[22] SESAR 9.05, Functional requirement definition of ASPA S&M - issue Stream2 (2) (Stream2 V2 validation), 09.05.D28, 29/07/2016

[23] SESAR 9.05, Phase III Aircraft Integration Simulator availability note, 9.05.D29

[24] SESAR 9.05, ASPA Stream2 Cockpit mock-up Availability Note, 9.05.D30

-END OF DOCUMENT-