



P 09.24.00 Final Project Report

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Abstract

The document finalizes and shortly describes the work that was done within the project SESAR 9.24. The document describes all major activities, outcomes and recommendations of the project for the future use.

The project activities demonstrated the achievement of following main objectives:

- the possibility to add ADS-B In/Out functionalities on military A/C (especially non transport A/C) by re-using to the maximum extent possible technologies already available on-board
- to enable ADS-B/Out relying on the Mode S component fully embedded in the military IFF configuration
- to provide potential solutions tailored to fighter aircraft not equipped with TCAS.

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1 Publishable summary

Within the framework of the SESAR Programme it has been recognised the need to ensure the appropriate level of civil-military interoperability, for this purpose four specific military communications, navigation and surveillance (CNS)-related projects were started.

Among these projects the WP 9.24 is aimed to investigate how ADS-B can be enabled in military aircraft that are not equipped with standard ADS-B avionics.

Within the framework of the project it has been carried out a study phase that identified the ADS-B applications of interest for different type of military platforms (e.g. fighter, helicopter, transport).

In addition potential modifications to the existing military equipment already on-board and impacts at platform level to perform ADS-B In/Out functions, especially for aircraft not equipped with TCAS, were analysed.

As an outcome it has been demonstrated the possibility to add ADS-B In/Out functionalities on military A/C by re-using to the maximum extent possible technologies already available on-board thus giving to the military community useful indications to understand how their assets can fulfil the gaps to achieve these functionalities.

Among the investigated solutions the project demonstrated, by means of live flight trials conducted on Alenia Aermacchi C-27J, the possibility to enable ADS-B/Out taking advantage of the Mode S component fully embedded in the military IFF configuration. Likewise it has been demonstrated the possibility to benefit from the ADS-B In functionality on a military aircraft by installing a stand-alone receiver with dedicated HMI.

The studies and the positive practical results collected during the flight trials of WP 9.24 proof that the developed technical solutions for ADS-B Out and ADS-B In are technically and operationally feasible. These results can be used as the basis for the military community to discuss with their industrial partners individual technical solutions tailored to their own airframes in order to accommodate military aircraft in a mixed-mode SESAR surveillance environment.

2 Final Project Report

2.1 Project progress and contribution

The activities addressed by P09.24.00 contributed to the following system Enablers as captured in the ATM MasterPlan¹:

EN Code	EN Title	P09.24.00 activities /contributions	Maturity before project	Maturity after project
A/C-26	Airborne traffic situational awareness to support in flight operations (ATSA-AIRB), including reception (ADS-B in), processing and display	The tasks T12 - WA3.3 Installation and ground test on A/C and T13 - WA3.4 Flight Test contributed to this enabler in terms of basic ADS-B In surveillance data reception from surrounding A/C.	V1	TRL 5 (V2)
A/C-48	Air broadcast of aircraft position/vector (ADS-B OUT) compliant with DO260A	The tasks T12 - WA3.3 Installation and ground test on A/C and T13 - WA3.4 Flight Test contributed to this enabler in terms of ADS-B out data transmission.	V1	TRL 5 (V2)

Table 1 - List of enablers and project contribution

This project actively contributed to the enablers listed above especially in the tasks T12 and T13 where ground tests and flight test activities were carried out.

2.2 Project achievements

Summarizing, the project demonstrated the following objectives:

- possibility to add ADS-B In/Out functionalities on military A/C (especially non transport A/C) by re-using to the maximum extent possible technologies already available on-board.
- to enable ADS-B/Out relying on the Mode S component fully embedded in the military IFF configuration
- to provide potential solutions tailored to aircraft not equipped with TCAS (e.g. fighter aircraft).

¹ Data Set 13 is the latest publicly available at the time of writing this report,

In order to achieve these objectives the project was structured in three working areas.

In the first working area, **WA1 Concept definition (WA1 - V1)**, the following objectives have been achieved:

- Identification of the ADS-B applications to be supported by different type of military platforms (transport, fighter, training aircraft and helicopter) and capture of related requirements from existing standards.
- Development of a feasibility study aimed to investigating on the following aspects:
 - utilization of the Mode S component of IFF Transponder to transmit ADS-B Out messages providing interoperability with civil environment.
 - possibilities on the use of a ADS-B stand alone receiver that mitigates the absence of a TCAS function.

The feasibility study provides indication on the impacts on different military architecture platforms highlighting the necessary adaptations to be implemented both at equipment level and at platform integration level.

- Identification of the target a/c (i.e. Alenia Aermacchi C-27J) suitable for the validation activities with the provision of the analysis of target a/c configuration.

The second working area, **WA2 Integration phase**, pursued the following objectives:

- Definition of the interfaces (e.g. electrical, mechanical) between the SUT (System Under Test) and the target a/c that will be employed during the flight trials foreseen in the WA3.
- Description of the bench test environment, in terms of test set up and installation, to be used to demonstrate that the ADS-B In and Out functionalities provided by the SUT are performing correctly.
- Description of the test results collected during the bench test activities.

In the last working area, **WA3 Technical validation**, the activities have been oriented to the preparation of flight trials with the following approach:

- Identification of the technical objectives to be verified during flight
- Definition of the scenario for the flight trials and provision of a verification matrix that describes the procedure for the test.
- Execution of installation and ground test activities on the aircraft
- Execution of flight trials

The SUT has been tested by means of a round trip flight from Turin to Malpensa during which a real time analysis performed by the Alenia Aermacchi FTE (Flight Test Engineer) and Selex-ES operator assessed in first stage the correct ADS-B Out data transmission and reception of ADS-B In surrounding traffic. Moreover data gathering was executed by means of FTI system on board the A/C and data recording by means of ADS-B Ground Station located at Milano Malpensa Airport.

These data were analysed in a post flight analysis and confirmed, as anticipated in the feasibility study developed in WA1, the possibility to re-utilize an IFF transponder with integrated Mode S already available on the military platform, in order to achieve ADS-B Out functionality.

This provides a useful indication for the military community on the possibility to reuse to the maximum extent possible technologies already available on-board thus minimizing costs and impact on the platform.

In the same manner the flight test demonstrated in practical terms the benefit of having ADS-B In functionality on board a military platform to improve the surveillance capabilities. This is especially interesting for platform not equipped with TCAS.

2.3 Project deliverables

A summary of the project deliverables is presented in the table below:

Del. code	Del.Name	Description	Deliverable output and conclusions	Assessment Decision
D17	Final Progress status report	The deliverable (this document) comprises the P.09.24 Final Project Report.		To be assessed.
D01	WA1.1 - Functions and requirements analysis document (1st release)	Abstract of the operational and technical context of the ADS-B technology for the military platforms in the SESAR Airspace. Description of the ADS-B related Surveillance Application functions and their intended improvements.	Identification of the ADS-B applications of interest for different type of military aircraft and relevant requirements (relying on existing standards)	No reservation
D02	WA1.1 - Functions and requirements analysis document (2nd release)	Identification of the needs in terms of required information exchange between the airborne component and ground radio stations and the ADS-B In/Out applications/functions and requirements (functional, performance, HMI, configuration options)		No reservation

		required on the various types of military platforms starting from existing standard documents and documents coming from operational WPs.		
D15	WA1.1 - Functions and requirements analysis document (3rd release)	The 3rd step aimed to review the content of the document in order to take on board flight trials results.	The reader can use the document as an easy reference in order to have an overview of the requirements, identified D01 and D02, which have been covered and successfully tested during the flight test activities carried out at the end of the project.	No reservation
D03	WA1.2 - Feasibility assessment (1st release)	This document aims to analyse the logical components that can be used by the ADS-B In & Out functions and that are embedded in a military aircraft. It also analyses the potential upgrades that can be implemented on the military platforms (at surveillance equipment level and platform level) to allow them to be compliant to the ADS In & Out requirements that have been identified in the D02 concerning the following set of ADS-B Surveillance Applications(ATSA-AIRB, ATSA-VSA, ATSA-ITP, ADS-B NRA, ADS-B RAD,ADS-B APT, ATSA SURF, ASPA S&M).	Verification of the feasibility of endorsing ADS-B In/Out functionalities on a military A/C re-using the existing equipment/capabilities already on board from a functional point of view.	No reservation (P)
D04	WA1.2 - Feasibility assessment (2nd release)			No reservation (P)
D16	WA1.2 - Feasibility assessment (3rd release)	The 3rd step aimed to review the content of the document in order to take on board flight trials results.	As anticipated in D03 and D04 this document confirmed, after the analysis of flight trials results, the possibility to use the mode S embedded in a military IFF as a means to perform ADS-B Out	To be assessed

			functionality and the benefit of having ADS-B In functionality on board a military platform to improve the surveillance capabilities.	
D05	WA1.3 - System interface document	<p>The aim of the System Interface document is to provide an overview on Interfaces needed for ADS-B services to be implemented on a Military Platform.</p> <p>In the document outputs from D02 and D03 (requirements of Surveillance application based on ADS-B Technology and implementation/modification options for IFF Equipment) are recalled and attention is deserved on Interfaces and Control/Display required.</p>	Verification of the feasibility of endorsing ADS-B In/Out functionalities on a military A/C re-using the existing equipment/capabilities already on board from a system interface point of view.	No reservation (P)
D06	WA1.4 - Target a/c and configuration document	This deliverable has the objective to identify the target a/c suitable for validation activities and to provide the analysis of target a/c configuration in order to define capabilities and equipment necessary for validation activities.	Identification of the C-27J A/C as the suitable military platform to be used in the forthcoming working areas	No reservation (P)
D07	WA2.1 - Aircraft system interface document	<p>The purpose of this document is to define the interfaces (e.g. electrical, mechanical) between the validation system and the target a/c (i.e. C-27J on board station) that will be employed during the flight trials foreseen in the WA3.</p> <p>Industrial partners have considered some of the information necessary to develop this deliverable as sensitive. For this reason this set of data is not included in this release, but in a separate and specific document, as agreed with the S-JU</p>	Identification of the validation system (i.e. stand alone solution = IFF Mode S XPD + ADS-B In RX + Display) that will be hosted on the target A/C in WA3 and definition of the interfaces between validation system and target A/C.	No reservation

D08	WA2.2 - Installation report	The purpose of the document is to describe the test environment, in terms of test set up and installation, to be used to demonstrate the ADS-B In and Out functionalities provided by the ADS-B Validation System to be used in WA2 and WA3 of WP 9.24.	The test environment was duly identified and relevant test results, to verify that the validation system is working properly, were presented.	No reservation (P)
D09	WA2.3 - Lab Ground tests report	The purpose of the document is to describe the results of the test described in deliverable D08 to demonstrate that the ADS-B In and Out functionalities provided by the ADS-B Validation System are accomplished.		No reservation (P)
D10	WA3.1 - Validation plan report	<p>This deliverable describes the activities of WP 09.24 that will be conducted in the context of the verification exercise held at the end of the project.</p> <p>These activities are preliminary for a validation that will aim to satisfy SESAR surveillance needs by endorsing ADS-B technologies on military aircraft together with the evaluation of pilot and ATC behaviour.</p> <p>This document defines the technical objectives to verify that the proposed solutions work properly for surveillance purpose and as enabler for subsequent ASPA application development.</p> <p>For this reason the document is structured as a "Verification Plan".</p>	Verification objectives to be tested during the flight trials were properly identified.	No reservation (P)
D11	WA3.2 - Validation scenario report	The purpose of the document is to describe in sufficient detail the operational scenario in which the flight trials, foreseen in the task 'T013 – WA3.4 Flight test', will take	Flight test scenario and stakeholders responsibility and coordination were duly identified.	No reservation (P)

		place.		
D12	WA3.3 - Installation report (on A/C)	The purpose of the document is to describe the installation and ground test activities preliminary to the flight trials.	The activities verified that both ADS-B In and ADS-B Out segments worked as designed. This allowed to proceed with the activities relevant to the flight trials.	No reservation
D13	WA3.4 - Flight Test report	The purpose of this document is to provide the results collected during the flight trials occurred at the end of the project.	The results of the flight tests demonstrated the achievement of project main objectives and confirmed the possibility to re-utilize an IFF transponder with integrated Mode S, already available on the military platform, in order to achieve ADS-B Out functionality. Likewise it has been demonstrated the possibility to benefit from the ADS-B In functionality on a military aircraft.	No reservation
D14	Standardization activities report	Yearly follow-up report of the different standardisation groups impacting the work of the 9.24 project mainly focusing on the Surveillance technologies domain. The follow-up is divided in ATM Level Standardisation Level section and Aircraft & Equipment Level section where a sum-up of the year for the standardization groups identified is done in activity and schedule.	The monitoring of the identified standardization groups resulted in an updated status and current availability of the standardization documentation. These information could result useful in view of a possible continuation of the project.	No reservation

2.4 Contribution to standardization

With regard to standardization, P.09.24.00 closely followed the activities of EUROCAE WG51/SG3 and reflected their progress in deliverable D14 Standardization activities report.

2.5 Project Conclusions and Recommendations

The project aimed to determine how ADS-B can be enabled in military aircraft that are not equipped with standard ADS-B avionics.

The WP 9.24 concept definition investigated the possibility to re-use to the maximum extent possible technologies already available on-board military platforms to perform ADS-B In/Out functions. In addition a feasibility study was carried out to indicate potential modifications both at platform and at equipment level.

Live trials activities, conducted on Alenia Aermacchi C-72J aircraft, confirmed the possibility to re-utilize an IFF transponder with integrated Mode S, already available on military platforms, in order to achieve ADS-B Out functionality.

Likewise it has been demonstrated the possibility to benefit from the ADS-B In functionality by installing a stand-alone receiver with relevant HMI on a military aircraft.

These practical results, together with the indications provided in the feasibility study, could be of real interest for the military community to understand with their industrial partners how their assets can fill the gaps to achieve ADS-B functionalities minimizing costs and impact on their platforms.

The European Commission currently mandates implementation of ADS-B Out capability for a Transport type State Aircraft. Additionally, Roadmap on Enhanced Civil-Military CNS Interoperability and Technology Convergence states that even ADS-B In capability could become a requirement.

The achieved results are the basis for technical solutions especially for NON-Transport type State aircraft to support the future Surveillance system where cooperative Surveillance such as ADS-B Out could become mandatory. In case there was no such mandate State aircraft operators however could decide to benefit of operational advantages such Surveillance technology could deliver and develop national solutions based on the obtained results of 9.24.

From a technology state of the art point of view it has to be considered that, since the WP9.24 activities were started in 2010, the technology evolved making now possible the implementation of ADS-In capability in a IFF Transponder.

Such an equipment, embedding both ADS-B Out and In, will be the technological enabler of both functions and no additional equipment would be required thus reducing the cost of installation of ADS-B system (i.e. Out and In) in a military aircraft.

The prototypes developed in WP9.24 and the trials conducted still require one more validation step to demonstrate full feasibility when the solutions are requested to enable ASPA functionalities. Part of this validation can be envisaged to take place as part of project WP 9.3 'Interoperability of Business Trajectory and Mission Trajectory'.

The industrialization steps before such solutions can be considered are mainly ongoing in EUROCAE (WG 51) for the development of additional ADS-B applications.

3 References

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[17] [SESAR Programme Management Plan, Edition 03.00.01](#)

[18] [European ATM Master Plan, Edition 2](#)

[19] 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

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