Final Project Report

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Abstract

This deliverable contains the P.15.02.08 Final Project Report.
The project, together with its avionic counterpart developed in WP 9.20, has demonstrated the technical feasibility to transport civilian ATC information by means of a military data link (Link 16/MIDS).

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Publishable summary

The civil aviation is moving towards the extensive usage of data links to perform ATC tasks supported by the CPDLC and ADS-C applications. The aim is to reduce the workload for Pilots and ATC operators and to minimize the occurrence of mismatches in the communication.

The military community can also take significant advantage from adopting the same approach and, at the same time, improve the civil-military interoperability.

The main objective of the two military projects in SESAR: WP 9.20 *Military Datalink accommodation* (covers the avionic segment) and WP 15.2.8 *Civil-Military Data Link Interoperability* (deals with the ground segment) was to demonstrate the capacity of a military datalink to support the exchange civilian ATC information.

Moreover, the projects covered transversal issues like concept definition, consultation and technical feasibility analysis including aspects like performance, spectrum and security.

In order to achieve the objectives, starting from the existing main military aircraft configurations (transport, fighter and trainer), to maximize the technology reuse and reduce impacts on military users, Link16 communication media was selected because it is widely implemented and operative on military platforms in service.

Different solutions for exchanging ATC data messages across Link16 network have been identified and studied.

A system prototype, consisting of an airborne (WP9.20) and a ground (WP15.2.8) segment, was developed to support the CPDLC and ADS-C applications through the exchange of MIDS free text messages (encapsulation approach).

The ATC messages (CPDLC and ADS-C applications) were exchanged by means of Link16 datalink via a ground gateway prototype developed by Selex ES.

This prototype is interoperable with existing ATC infrastructure and will be under full military control.

The work done has demonstrated the main objective pursued inside the project:

- the capacity of a military datalink (Link 16/MIDS) to transport civilian ATC information

Anyway, the most interesting results of the entire project have been reached during the final flight trials activity and are considered positive because the complete set of test performed during the flight met completely the foreseen objectives.

In detail, the main flight test objectives that were, positively, achieved during the flight:

- Context Management and CPDLC (Controller Pilot Datalink Communication) applications successfully exchanged uplink and downlink messages in accordance with the ATC procedures.
- ADS-C on event and periodic contracts were successfully tested.

This demonstrates the capability for a military data link (Link 16/MIDS), already installed and largely used for operations on several military platforms, to transport civilian ATC information.

Moreover, the results of these projects (P15.2.8 and P09.20) combined with the ADS-B In/Out for Military Aircraft (P09.24) and a flight trial, provide the inputs into the Interoperability of Business Trajectory and Mission Trajectory (P09.03).

1 Final Project Report

1.1 Project progress and contribution

The activities addressed by P15.02.08 contributed to the following system Enablers as captured in the ATM Master Plan:

EN Code	EN Title	P15.02.08 activities /contributions	Maturity before project	Maturity after project
A/C-30a	Onboard prediction of wake turbulences based on aircraft data exchange.	The task T5 (Ground tests and Flight tests activities) contributed to this enabler in terms of civil ATM messages exchanged over Link16 network.	V1 TRL 2	V2 TRL 5
A/C-61	Handling of additional military datalink messages in military aircraft for ATM purpose.	The task T5 (Ground tests and Flight tests activities) contributed to this enabler in terms of civil ATM messages exchanged over Link16 network.	V1 TRL 2	V2 TRL 5

Table 1 - List of enablers and project contribution

This project actively contributed to the enablers above especially in the task T5 where ground tests and flight test activities were executed.

Projects 15.2.8 and 9.20, together, are providers of project 9.3 respectively for the Ground Gateway and the Avionic System.

1.2 Project achievements

The project achievements are duly detailed in the publishable summary. Summarizing, the project demonstrated, together with its avionic counterpart developed in WP 9.20, the possibility to transport civilian ATC information by means of a military data link (Link 16/MIDS).

Several technical options on how to transport ATC information on Link-16 have been identified and, among them, the encapsulation approach on MIDS free text messages has been selected for the demonstration.

The project was structured as follows:

- **Concept of Operations**
  - Operational Requirements coming from Ops SESAR WPs
- **Feasibility Study**
  - Existing military datalinks vs. new ATM requirements

- **Technical Solutions**
  - Messages and protocols of transmission
- **Development**
  - System Spec., System Design and Prototype Configuration
- **Integration**
  - Target aircraft and Common Architecture
- **Validation Test**
  - Scenario, Ground and Flight Test

Hereafter it is provided a recall on the work achieved during the project lifecycle.

In the **Concept Definition (Task 1)** and **Feasibility Study (Task 2)** activities, the following objectives have been fulfilled:

- Feasibility study on the utilization of a ground gateway in order to allow interoperability with MIDS/Link 16 technology, associated with a ground-based gateway for ATC CM, CPDLC and ADS-C data exchange applications.
- Identification of SESAR Data Link applications to be supported by military platforms and capture of related requirements from existing standards. The following typologies of requirements have been analysed:
  - Functional requirements;
  - Architecture requirements;
  - Performance requirements;
  - Safety requirements;
  - Maintainability requirements.

The study considers:

- Technical and performance feasibility;
- Interface Identification and Diagrams describing the data flows in applications protocols;
- Design and Construction constraints;
- Spectrum Supportability;
- Operational Integrity and Security Assessment.

In **Consultation Activities (Task 3)**, the participation to international meetings with national military authorities and relevant organizations (e.g. NATO, MNWG, EJCC) has been ensured by EUROCONTROL as necessary to solve security and institutional constrains.

In the **Gateway Definition (Task 4)** task, the following activities have been accomplished:

- Definition of MIDS/Link 16 system requirements and interface in terms of functions, messages, addresses, transmission protocols and security aspects for the ground gateway at system level which can support the required ATM data exchange. The output of these activities was the production of the deliverables D04 Preliminary Functional/Not Functional Specifications for a ground station for Military Data Link Interaction with SESAR and D05 System Specification for a Ground Station for Military Data Link Interaction with SESAR.

In the **Gateway Development and Validation** (**Task 5**) activities, the following objectives have been achieved:

- Ground Station Design requirements have been released in order to drive the software development;
- at the end of SW development, the software implementation of each component has been validated;
- An integration plan has been prepared during the last phase of SW development and the integration activity was finalized in the Alenia premises of Torino Caselle;
- The validation activity has been conducted together the project 9.20. It consisted of ground tests and flight test on board a military transport aircraft (C27J) that have tested the new ATM services between the gateway Ground Station and the C27J modified with the adapted equipment introduced by the project 9.20.

1.3 Project deliverables

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

Del. Code	Deliverable Name	Description	Conclusions	Assessment Decision
D01	Concept Definition of Military Data Link Usage in SESAR	The present deliverable aims at defining the operational concept for military aircraft equipped with military data link (MIDS/Link 16) to exchange ATM information with the SWIM infrastructure. It describes present military data link usage as the basis to define how to support ATM requirements derived from SESAR Concept of Operations in the future.	An operational concept, in terms of exchange of ATM information for a military aircraft equipped with Link-16, has been defined. Inside the document it is described how the Link-16 can support ATM requirements driven by SESAR Concept of Operations in the future.	No reservation
D02	Feasibility Study on Military Data Link Usage in SESAR	The present deliverable aims at demonstrating that the technical characteristics of MIDS/Link 16 technology, associated with a ground-based gateway, can support the required ATM data exchanges and can satisfy performance, spectrum and security requirements. This study will also delineate some inputs to the basic specifications to be detailed later in the project and used for the development of the gateway prototype. The study will discuss the system level performance requirements which are to be addressed in close connection with 9.20. In particular 15.2.8 D2 goes more in depth in some of the important technical characteristics of MIDS/Link 16 as the basis to discuss 1) Technical and Performance Feasibility, 2) Operational Integrity and Security	An analysis of the current Link-16 capabilities needed for supporting ATM interoperability was performed. At the same time, all the performance requirements, at system level, in order to satisfy the ATM needs were identified and studied. The outputs of those analyses will be used for the system definition of the Ground Gateway and its avionic counterpart (WP 9.20).	No reservation

		Assessment 3) Spectrum Supportability, 4) ATM Data Exchange Solution and 5) Institutional and Economic Feasibility. A close coordination with project 9.20 (Military Data Link Accommodation) is essential to ensure compliance with specific airborne requirements.		
D03	Report on Civil-Military Data Link Consultation Activities	The set of deliverables (1-5) aim at reporting the consultation activities conducted in the entire project lifecycle (2009-2014) in the domain of civil-military data link interoperability, in the ATM/CNS context, in order to secure stakeholder buy in for SESAR projects 15.2.8 and 9.20.	Eurocontrol has attended several international meetings in the ATM/CNS world focused on civil-military data link interoperability reporting the main topics and conclusions in the deliverables.	No reservation
D04	Preliminary Functional Not Functional Specification for a Ground Station for Military Data Link	The present deliverable aims at the preliminary definition of the functional and non-functional requirements of a ground-based gateway that supports the required ATM data exchanges over Link 16 with the satisfaction of performance, spectrum, security and other requirements. This preliminary specification includes a summary of the results obtained in the previous deliverables of project 15.2.8 and identifies the main capabilities of the system that will be developed including also the test environment foreseen during the different test phases. Functional requirements mainly deal with the ADS-C and CPDLC applications, keeping in mind that the ground gateway will be interfaced with an ATN network and will act as a MIDS LVT host with the task of	A preliminary Ground Gateway system specification was prepared. It includes the main capabilities of the system that will be developed, including also the test environment foreseen to be used during the different test phases. On the Link-16 side, the main host functions as initialization, monitoring and control of the MIDS terminal have been defined. On the ATM side, the main functional requirements dealing with the ADS-C and CPDLC applications have been defined.	No reservation

		initialization, monitoring and control of the MIDS terminal. Furthermore, the gateway system will be part of the SWIM environment infrastructure. A close co-ordination with project 9.20 (Military Data Link Accomodation) is essential to ensure compliance with specific avionics technology to be used to support ATM data exchanges. Other inputs to the ground gateway requirements are originated by project 9.3.		
D05	System Specification for a Ground Station for Military Data Link Interaction with SESAR	The present deliverable aims at the definition of the functional requirements of a ground-based gateway that supports the required ATM data exchanges over Link 16 with the satisfaction of performance, spectrum, security and other requirements. This specification includes a summary of the results obtained in the previous deliverables of project 15.2.8 and identifies the main capabilities of the system that will be developed including also the test environment foreseen during the different test phases. Functional requirements mainly deal with the ADS-C and CPDLC applications, keeping in mind that the ground gateway will be interfaced with an ATN network and will act as a MIDS LVT host with the task of initialization, monitoring and control of the MIDS terminal. Furthermore, the gateway system will be part of the SWIM environment infrastructure. A close co-ordination with project 9.20 (Military Data	A final Ground Gateway system specification was prepared. It includes the detailed capabilities of the system that will be developed. On the Link-16 side, the terminal host functions as initialization, monitoring and control of the MIDS terminal have been addressed. An algorithm on how to exchange ATM data on Link-16 and the related mechanisms has been defined. On the ATM side, the functional requirements dealing with the ADS-C and CPDLC applications and the procedures to be used have been defined. In parallel, the avionic system requirements (WP 9.20) were defined.	No reservation

		Link Accommodation) is essential to ensure compliance with specific avionics technology to be used to support ATM data exchanges.		
D06	Preliminary performance/safety report for a Ground Station for Military Data Link Interaction with SESAR	This document was not released to the SESAR JU because the entire contents were incorporated in D09.	See D09.	N.A.
D07	Design Requirement for a Ground Station for Military Data Link Interaction with SESAR	This document aim at describing ground interface solution, that will be implemented and developed by this project and specify as the GW data link 16 (GWLK16) with the main purpose to take advantage of military data links (specifically MIDS/Link 16) available in military aircraft to enable the military airborne interoperability with the G/G ATM Data Link infrastructure. This document has been developed in collaboration with Project 9.20 in order to verify and validate Ground Station model and its integration for flight plans scenario.	A detailed technical description of the Ground Gateway implementation, at software level, has been provided. The document contains the description of the software internal modules, their internal interfaces and maps the requirements for every module. For each computer system or other aggregate of computer hardware resources identified to be used in the system, describes its hardware resources (such as processors, memory, input/output devices, auxiliary storage, and communications/network equipment) - diagrams and descriptions showing the dynamic relationship of the components.	No reservation
D08	Modeling report for a Ground Station for Military Data Link Interaction with SESAR	This document aim at validating a ground interface solution, that will be implemented and developed by this project and specified as the GW data link 16 (GWLK16) with the main purpose to take advantage of military data links (specifically MIDS/Link 16) available in military aircraft to enable	The two approaches to accomplish the requirements specified in D04 and D05 are described. The first one, deals with encapsulation of the ATM messages into Link16 Free Text messages, in binary mode, using Link16 network as a carrier of	No reservation

		the military airborne interoperability with the G/G ATM Data Link infrastructure. This document has been developed in collaboration with Project 9.20 in order to verify and validate Ground Station model and its integration for flight plans scenario. The validation flight test plans and scenarios, has been emulated during LAB test and the results have been described in this document.	ATM data. The second one translates the ATM messages into dedicated Link16 messages, maintaining the information and orders addressed to aircrafts. The document describes the environment configuration used during the Lab test prior to perform flight test scenarios. The test has simulated the Air to Ground communication, with appropriate PCs that have hosted Ground and Air ATN Datalink Simulator that implements CPDLC, ADS-C and i-4DTRAD messages developed according to ATN datalink specification and connected by means of ATN/OSI or IPS interface protocol over Ethernet interface.	
D09	Performance Report for a Ground Station for Military Data Link Interaction with SESAR	This document contains an estimation of the operational performances reached by the Ground Gateway prototype that will be implemented for the Civil-Military Interoperability demonstration using the free-text option over a Link-16 communication media. For the performance calculations, several ATC operational scenarios have been used in order to have an estimation of the duration (in terms of time) of the selected procedures. All the procedures used involve an information exchange, end-to end, amongst the Ground Gateway and a military aircraft. Performances calculations have been made assuming different	Estimation, in terms of time duration, of all the ATM procedures that have been implemented for lab testing and flight testing was made. Performance calculation was made assuming different levels of availability of the communication media. The scenarios used involve an information exchange, end-to end, amongst the Ground Gateway and a military aircraft.	No reservation

		levels of availability of the communication media.		
D10	Unit Test Report for a Ground Station for Military Data Link Interaction with SESAR	This document contains the description and the report of all the tests designed and executed for the SESAR WP 15.2.8. Due to the strong relationship with WP 9.20, all those tests have been executed in a common environment for the two projects, where both the applications developed interact with each-other.	After the software implementation of the Ground Gateway, a validation activity conducted in the software laboratories was performed. This DRL contains the description of all the scenarios used during the test activity followed by the list of the test cases designed and, finally, by the report after the execution of the tests. The final result of the entire test campaign was satisfactory: all the capabilities implemented were tested with success during the activity. The entire software test campaign of the Ground Gateway has been executed in a common environment with the Avionic System developed for the project 9.20.	No reservation
D11	Integration Plan and Report for a Ground Station for Military Data Link Interaction with SESAR	The purpose of this document is to describe the integration environment and process, and to provide the procedures and results collected during the integration phase occurred after the laboratory software validation. The integration activity aim to verify that both the systems developed (Ground Gateway and avionic part) are capable to interoperate and to exchange the ATM data required.	The document describes the Integration activities, in terms of plan and report, for the Ground Gateway. Those activities have been conducted in tight coordination with WP 9.20. The unique scenario that was used during the integration campaign refers to the “Encapsulation Approach” solution proposed. More in detail, the document describes the system level preconditions and the ATM procedures that have been executed during the integration	No reservation

			phase and how they have been conducted. A collection of log files captured on the ATM application provide evidence to the results obtained for any single integration test. At the end of the integration phase, all the ATM procedures that were object of tests were successfully executed without any particular remark.	
D12	Validation Plan and Report for a Gateway for Military Data Link Interaction with SESAR	The purpose of this document is to describe the test environment and to provide test procedures and results collected during the ground and flight trials occurred at the end of the project to verify that the solutions implemented fulfil the expected system requirements.	The document provides the Verification report for the Ground Gateway. This verification campaign, composed by ground and flight tests, has been conducted together with WP 9.20 (Military Datalink Accomodation) because the implementation of two projects has been conducted in parallel. In it, are described the results of verification procedures defined in the document itself and how they have been conducted. Screenshots of the implemented application and log files captured during the test execution provide the evidence of the results obtained. At the end of the verification phase, all the ATM procedures that were object of tests were successfully executed without any remark.	No reservation
D13	Final Progress Report	The deliverable (this document) comprises the P.15.02.08 Final Project Report.	N.A.	No reservation

1.4 Project Conclusions and Recommendations

The most representative results of the entire project were collected during the flight test activity and are considered largely positive as all results of the test cases performed during the flight met completely the foreseen objectives.

The following conclusions apply:

- Different solutions for exchanging ATC data messages across Link16 network have been identified and studied;
- Among these one have been chosen for a prototype implementation and verification, having the benefit of not requiring Link16 network standard modifications, but at the cost of a less efficient use of bandwidth
- The positive results collected during the flight trials demonstrated the feasibility for a military data link (Link 16/MIDS), already installed and largely used for operations, on several military platforms, to transport civilian ATC information.
- The ATC messages have been exchanged by means of Link 16 data link via a ground and airborne gateway prototypes, to allow a transparent transport by Link 16 (no Link16 modifications required).
- This prototype is interoperable with existing ATC infrastructure and will be under full military control. A solution for interconnecting military classified ICT systems with civil ATM systems for exchanging ATC data, will also require a proper Information Exchange Gateway, which was outside the scope of the project and will require follow-on R&T activities

Anyway, other interesting solutions of usage of Link-16 to transport ATC messages (at application level) could be investigated:

- Modification of existing Link-16 messages partially compliant with ATC needs;
- Creation of a dedicated set of Link-16 messages and a relative NPG to be used for ATC purposes only.

All this is important in order to provide the military with technical options for the civil-military interoperability and the re-utilisation of existing equipment.

A further industrialization activity can be initiated only after a propaedeutic standard definition that requires a strong involvement of the military community.

2 References

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[9] Unit Test Report for a Ground Station for Military Data Link Interaction with SESAR, 15.2.8 D10, Edition 00.01.00, Date 03/10/2014

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