Work Package Final Report

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Abstract

The Aircraft System Work Package covered the required evolutions of the aircraft platform, in particular to progressively introduce 4D Trajectory management functions in mainline, regional and business aircraft. In addition it was required to develop the necessary technological solutions in support of the SESAR operational validation and ATM solutions (e.g. GBAS, Software Define Radios, D-TAXI …). The work package addressed the development and validation at aircraft level of all airborne functions identified in the SESAR ATM Master Plan, ensured operational & functional consistency across stakeholder airborne segments, identified technical solutions for different airborne platform types such as Mainline aircraft, Regional aircraft and Business Jets, and ensured global interoperability and coordination with important external initiatives such as NextGen in the U.S.

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Rational for rejection

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Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
ATM	Air Traffic Management
SESAR	Single European Sky ATM Research
SJU	SESAR Joint Undertaking
WP	Work Package
GBAS	Ground Based Augmentation System
D-TAXI	Datalink Taxi Service
TRL	Technology Readiness Level
4D	4 Dimensions
DT	Dual Thresholds
MRAP	Multiple Runway Aiming Point
IGS	Increased Glide Slope
A-IGS	Adaptative Increased Glide Slope
GLS	GBAS Landing System
LPV	Low visibility Procedure with Vertical guidance
ILS	Instrument Landing System
GNSS	Global Navigation Satellite System
RNP	Required Navigation Performance
IFR	Instrument Flight Rules
VFR	Visual Flight Rules
FATO	Final Approach and Take Off
CTA	Controlled Time of Arrival
ASAS	Airborne Surveillance Assurance System
ASEP	Airborne SEParation
ITF	In Trail Follow
ITM	In Trail Merge

ATSAW	Airborne Traffic Situational AWareness
ADS-B	Airborne Dependent Surveillance - Broadcast
ADS-C	Airborne Dependent Surveillance - Contract
CPDLC	Controller Pilot Data Link Communication
TMA	Terminal Manoeuvring Area
ATC	Air Traffic Control
NM	Network Manager
CTO	Controlled Time of Overfly
RBT	Reference Business Trajectory
C&P	Crossing & Passing
CDO	Continuous Descent Operations
CCO	Continuous Climb Operations
ADD	Aircraft Derived Data
CNS	Communication Navigation Surveillance
GPS	Global Positioning System

1 Work Package Overview

The Aircraft System Work Package covered the required evolutions of the aircraft platform to support the Operational Improvements contained in the ATM Master Plan. In particular, 4D Trajectory management functions and related avionics were developed on mainline, regional and business aircraft to provide 4D trajectory management capabilities. In addition, all the necessary technological solution in support of the SESAR operational validation and ATM solution were developed (e.g. GBAS, Software Define Radios, D-TAXI …). The work package addressed:

- Developing and validating at aircraft level all airborne functions identified in the SESAR ATM Master Plan;
- Ensuring operational & functional consistency across stakeholder airborne segments;
- Identifying technical solutions for different airborne platform types such as Mainline aircraft, Regional aircraft and Business Jets;
- Ensuring global interoperability and coordination with important external initiatives such as NextGen in the U.S.

1.1 Work Package contribution to the Master Plan

The Aircraft Systems Work Package has been all along the programme the owner of Aircraft Enablers in The Master Plan. As such it made those enablers progress towards TRL6 and provided timely information on the maturity status of these enablers and all other relevant information to the teams in charge updating the Master Plan.

More specifically, Project 09.49 provided a globally compatible avionics roadmap supporting the transition towards the SESAR concept, to be used as a reference by avionics and airframe manufacturers for development / deployment planning, hence minimising the number of transition steps for a better cost efficiency;

The list of enablers addressed by the Work Package is shown below highlighting for each the associated OI Steps and the level of maturity reached at the end of SESAR.

Code	Name	WP contribution
A/C-02a	Enhanced positioning using GBAS single frequency	Was matured up to V3 / TRL6 by project 09.12 contributing to the validation of • AO-0505-A - Improve Low Visibility Operation using GBAS Cat II/III based on GPS L1 ➔ Solution #55 - Precision approaches using GBAS CAT II/III based on GPS L1 - in Release 4 The enabler supported as well activities performed on • AO-0308 - Enhanced Arrival Procedures using Dual Thresholds (DT) • AO-0319 - Enhanced Arrival procedures using Multiple Runway Aiming Points (MRAP) • AO-0320 - Enhanced Arrival procedures using Increased Glide Slope (IGS) • AO-0321 - Enhanced Arrival procedures using

Code	Name	WP contribution
		Adaptive Increased Glide Slope (A-IGS) • AO-0322 - Enhanced Arrival procedures using double slope approach • AOM-0605 - Enhanced Terminal Operations with RNP transition to ILS/GLS/LPV
A/C-02b	Enhanced positioning using multi constellation GNSS dual frequency	Was matured up to V2 / TRL4 by project 09.12 contributing to the validation of • AO-0505-B - Improve Low Visibility Operation using GBAS Cat II/III based on dual GNSS
A/C-07	Flight management and guidance for RNP transition to ILS/GLS/LPV	Was matured up to V3 / TRL6 by project 09.09 contributing to the validation of • AOM-0605 - Enhanced Terminal Operations with RNP transition to ILS/GLS/LPV ➔ Solution #9 - Enhanced terminal operations with automatic RNP transition to ILS/GLS - in Release 5 The enabler supported as well activities performed on • AO-0316 - Increased Airport Performance through independent IFR rotorcraft operations • AOM-0104 - Enhanced Rotorcraft Operations at VFR FATOs with specific Point-in-Space RNP procedures using satellite augmentation
A/C-11	Flight management and guidance for improved single time constraint achievement (CTA/CTO)	Was matured up to V3 / TRL6 by project 09.01 contributing to the validation of • TS-0103 - Controlled Time of Arrival (CTA) in medium density/complexity environment ➔ Solution #6 - Controlled Time of Arrival (CTA) in Medium density / medium complexity environment - in Release 5 The enabler supported as well activities performed on • CM-0403-A - Early Conflict resolution through CTO allocation in STEP1 • TS-0109 - Controlled Time of Arrival (CTA) in high density/complexity environment
A/C-15a	Flight management and guidance for ASAS spacing with target aircraft flying direct to metering point	Was matured up to V3 / TRL6 by project 09.05 contributing to the validation of • TS-0105-A - ASAS Spacing - target direct to merge point (Speed/simple geometry) ➔ Solution #16 - ASAS Spacing applications Remain behind and Merge behind - in Release 5
A/C-15b	Flight management and guidance for ASAS spacing with target aircraft flying not direct	Was matured up to V2 / TRL4 by project 09.05 contributing to the validation of • TS-0108 - ASAS Spacing - target not direct to a

Code	Name	WP contribution
	to metering point.	merge point (Speed and Lateral/more complex geometry)
A/C-16a	Flight management and guidance to support ASEP-ITF/ITM	Was matured up to V1 / TRL2 by project 09.06 contributing to the validation of • CM-0701 Ad Hoc Delegation of Separation to Flight Deck - In Trail Follow & In trail Merge Procedure (ASEP-ITF & ITM)
A/C-23a	Synthetic vision in low visibility conditions	Was matured up to V2 / TRL4 by project 09.29 contributing to the validation of • AUO-0404 - Synthetic Vision for the Pilot in Low Visibility Conditions
A/C-23b1	Combined Vision for Equivalent Visual Landing operations in LVC	Was matured up to V2 / TRL4 by project 09.29 contributing to the validation of • AUO-0405 - Equivalent Visual Landing operations in Low Visibility Conditions • SDM-0301 - Improved access into small airports in low visibility conditions
A/C-27a	Airborne Traffic Situational Awareness to support CDTI Assisted operations (ATSA-CAVS / CAPP), including reception (ADS-B In), processing, display, and alerts	Was matured up to V2 / TRL4 by project 09.05 contributing to the validation of • AUO-0507 - Airborne Spacing Monitoring under IFR (ATSAW - Spacing monitoring)
A/C-30a	Onboard prediction of wake turbulences based on aircraft data exchange	Was matured up to V1 / TRL2 by project 09.11 contributing to the validation of • AO-0327 - Reduction of Wake Turbulence Risk considering Wake Monitoring and Awareness • AUO-0504 - Dynamic Adjustment of Spacing Depending on Wake Turbulences • AUO-0505 - Improved Air safety using data exchange via e.g. ADS-B for Wake Turbulence prediction
A/C-31a	Data link communication exchange for ATN baseline 2 (FANS 3/C)	Was matured up to V3 / TRL6 by project 09.33 contributing to the validation of • TS-0103 - Controlled Time of Arrival (CTA) in medium density/complexity environment • AUO-0308-A - Datalink Services used for Provision of Ground-related Clearances and Information for Step 1 • AUO-0603-A - Enhanced Guidance Assistance to Aircraft on the Airport Surface Combined with

Code	Name	WP contribution
		Routing in Step 1 ➔ Solution #6 - Controlled Time of Arrival (CTA) in Medium density / medium complexity environment - in Release 5 ➔ Solution #23 - D-TAXI service for CPDLC application - in Release 5 The enabler supported as well activities performed on • CM-0403-A - Early Conflict resolution through CTO allocation in STEP1 • CM-0606 - Separation Management in the TMA using Pre-defined Routes with 2D RNP Specifications • AUO-0205-A - ATC-ATC, ATC/Aircraft and ATC/NM Update and Revision of the Initial Reference Business/Mission Trajectory (iRBT/iRMT) • AUO-0703 - Optimised enhanced braking information at a pre-selected runway exit coordinated with Ground ATC by Datalink • CM-0105-A - Enhanced ATC processes by the use of new CPDLC messages and related procedures • CM-0200-B - Flight-centred ATC in Non-Geographically-Constrained, Low complexity En-Route environment • CM-0605 - Separation Management in En Route using Pre-defined or User-preferred Routes with 2D RNP Specifications • TS-0109 - Controlled Time of Arrival (CTA) in high density/complexity environment
A/C-31b	Data link exchange of clearances or instructions for full 4D operations	Was matured up to V2 / TRL4 by project 09.02 contributing to the validation of • CM-0105-B - Enhanced ATC processes by the use of new CPDLC messages and related procedures in Trajectory based operations • CM-0403-B - Early Conflict resolution through CTO allocation in STEP 2 • CM-0607 - Separation Management in En Route using RBTs with 2D RNP Specifications • CM-0608 - Separation Management in the TMA using RBTs with 2D RNP Specifications
A/C-31c	Exchange of clearances or instructions in step 3	Was matured up to V1 / TRL2 by project 09.06 contributing to the validation of • CM-0701 - Ad Hoc Delegation of Separation to Flight Deck - In Trail Follow & In trail Merge

Code	Name	WP contribution
		Procedure (ASEP-ITF & ITM) • CM-0702 - Ad Hoc Delegation of Separation to Flight Deck - Crossing and Passing (C&P)
A/C-34	Onboard management of clearances or instructions revising trajectory	Was matured up to V2 / TRL4 by project 09.02 contributing to the validation of • CM-0607 - Separation Management in En Route using RBTs with 2D RNP Specifications
A/C-37a	Downlink of trajectory data according to contract terms	Was matured up to V3 / TRL6 by project 09.01 contributing to the validation of • AOM-0702-A - Continuous Descent Operations (CDO) • AOM-0705-A - Continuous Climb Operations (CCO) • CM-0403-A - Early Conflict resolution through CTO allocation in STEP1 • TS-0103 - Controlled Time of Arrival (CTA) in medium density/complexity environment • CM-0103-A - Automated Support for Traffic Complexity Assessment • CM-0104-A - Automated Controller Support for Trajectory Management • IS-0303-A - Downlink of onboard 4D trajectory data to enhance ATM ground system performance: initial and time based implementation ➔ Solution #6 - Controlled Time of Arrival (CTA) in Medium density / medium complexity environment - in Release 5 ➔ Solution #11 - Continuous Descent Operations (CDO) and Continuous Climb Operations (CCO) - in Release 5 ➔ Solution #27 - MTCD and conformance monitoring tools - in Release 5 The enabler supported as well activities performed on • AUO-0304 - Initiating Optimal Trajectories through Cruise-Climb Techniques • AOM-0501 - Free Routing for Flights both in cruise and vertically evolving within low to medium complexity environments • CM-0209 - Conflict Detection and Resolution in En Route using aircraft data in Predefined and User Preferred Routes environments • CM-0210 - Ground Based Flight Conformance Monitoring in En Route using aircraft Data • CM-0407 - Enhanced Conflict Detection and

Code	Name	WP contribution
		Resolution in En Route • CM-0408 - Enhanced Conflict Detection and Resolution in the TMA • CM-0605 - Separation Management in En Route using Pre-defined or User-preferred Routes with 2D RNP Specifications • CM-0606 - Separation Management in the TMA using Pre-defined Routes with 2D RNP Specifications • TS-0109 - Controlled Time of Arrival (CTA) in high density/complexity environment
A/C-42a	Onboard graphical display of taxi clearance using common air/ground airport database	Was matured up to V3 / TRL6 by project 09.13 contributing to the validation of • AUO-0603-A - Enhanced Guidance Assistance to Aircraft on the Airport Surface Combined with Routing in Step 1 ➔ Solution #23 - D-TAXI service for CPDLC application - in Release 5 ➔ Solution #26 - Manual taxi routing function - in Release 5
A/C-43a1	Traffic Alerts for Pilots during Runway Operations	Was brought close to V3 / TRL6 maturity by project 09.14 contributing to the validation of • AUO-0605 - Traffic Alerts for Pilots during Runway Operations
A/C-43b	Onboard alerts on airport surface related to the conformance to clearances	Was matured up to V2 / TRL4 by project 09.14 contributing to the validation of • AUO-0614 - Conformance Monitoring Safety Nets for Pilots
A/C-43c	Onboard alerts on airport surface related to the compliance to the airport configuration	Was matured up to V2 / TRL4 by project 09.14 contributing to the validation of • AUO-0614 - Conformance Monitoring Safety Nets for Pilots
A/C-48a	Air broadcast of aircraft position/vector (ADS-B OUT) compliant with DO260B	This enabler was mature before SESAR with and IOC in 2015. It was used by project 09.14 to contribute to the validation of • AUO-0605 - Traffic Alerts for Pilots during Runway Operations And by project 09.24 to contribute to the validation of • AO-0201-A - Enhanced Ground Controller Situational Awareness in all Weather Conditions for Step 1

Code	Name	WP contribution
		• IS-0302 - Use of Aircraft Derived Data (ADD) to enhance ATM ground system performance. • CM-0807-B - Enhanced Ground-based Safety Nets Using ADS-B information • TS-0105-A - ASAS Spacing - target direct to merge point (Speed/simple geometry) (military part) • TS-0108 - ASAS Spacing - target not direct to a merge point (Speed and Lateral/more complex geometry) (military part) ➔ Solution #16 - ASAS Spacing applications Remain behind and Merge behind - in Release 5
A/C-48b	Air broadcast of aircraft data (ADS-B OUT) compliant with new DO260C standard	Was matured up to V1 / TRL2 by project 09.22 contributing to the validation of • AUO-0505 - Improved Air safety using data exchange via e.g. ADS-B for Wake Turbulence prediction • CM-0701 - Ad Hoc Delegation of Separation to Flight Deck - In Trail Follow & In trail Merge Procedure (ASEP-ITF & ITM) • CM-0702 - Ad Hoc Delegation of Separation to Flight Deck - Crossing and Passing (C&P)
A/C-54a	Enhanced Airborne Collision Avoidance (ACAS)	Was matured up to V2 / TRL4 by project 09.47 contributing to the validation of • CM-0808 - Enhanced Airborne Collision Avoidance adapted to Trajectory based operations
A/C-56a	Flight management and guidance for Precision Approach GBAS CATII/III using GPS L1	Was matured up to V3 / TRL6 by project 09.12 contributing to the validation of • AO-0505-A - Improve Low Visibility Operation using GBAS Cat II/III based on GPS L1 ➔ Solution #55 - Precision approaches using GBAS CAT II/III based on GPS L1 - in Release 4 The enabler supported as well activities performed on • AO-0308 - Enhanced Arrival Procedures using Dual Thresholds (DT) • AO-0319 - Enhanced Arrival procedures using Multiple Runway Aiming Points (MRAP) • AO-0320 - Enhanced Arrival procedures using Increased Glide Slope (IGS) • AO-0321 - Enhanced Arrival procedures using Adaptive Increased Glide Slope (A-IGS) • AO-0322 - Enhanced Arrival procedures using double slope approach

Code	Name	WP contribution
A/C-56b	Flight management and guidance to support GBAS CATII/III using dual GNSS	Was matured up to V2 / TRL4 by project 09.12 contributing to the validation of • AO-0505-B - Improve Low Visibility Operation using GBAS Cat II/III based on dual GNSS
A/C-67	Onboard Traffic situation for ASPA	Was matured up to V3 / TRL6 by project 09.05 contributing to the validation of • TS-0105-A - ASAS Spacing - target direct to merge point (Speed/simple geometry) ➔ Solution #16 - ASAS Spacing applications Remain behind and Merge behind - in Release 5 The enabler supported as well activities performed on • TS-0108 - ASAS Spacing - target not direct to a merge point (Speed and Lateral/more complex geometry)
A/C-68	Onboard Traffic situation processing and display for ASAS separation applications, including reception (ADS-B in)	Was matured up to V1 / TRL2 by project 09.06 contributing to the validation of • CM-0701 - Ad Hoc Delegation of Separation to Flight Deck - In Trail Follow & In trail Merge Procedure (ASEP-ITF & ITM) • CM-0702 - Ad Hoc Delegation of Separation to Flight Deck - Crossing and Passing (C&P)
CTE-C02d		Was matured up to V3 / TRL6 by project 09.16 contributing to the validation of • AO-0206 - Enhanced Guidance Assistance to Airport Vehicle Driver Combined with Routing • AO-0215 - Airport ATC provision of ground-related clearances and information to vehicle drivers via datalink ➔ Solution #102 - AeroMACS - in Release 5

1.2 Work Package achievements

The main achievements of the Aircraft System Work Package were to:

- Achieve a greater integration of the aircraft in the centre of the performance-based European ATM system allowing an optimum exploitation of the increasing aircraft capabilities;
- Implement progressively the 4D Trajectory management functions through:
    - The development up to V3/TRL6 of the Initial 4D Trajectory capabilities including the downlink of airborne computed predictions to the ground (for example to establish a sequence on a merging point or to support conflict detection and resolutions functions through more accurate ATC trajectory prediction tools), and, then improved time constraints management capabilities both enabling Continuous Descent Approaches from Top to Descent in mid and high density areas.
    - An Initial investigation of the full exploitation of 4D Trajectory (i.e., the aircraft is able to compute and to share reliable gate to gate 4D trajectory predictions with the ground and execute the agreed reference trajectory with possibly imposed times constraints);
- Develop enhanced On-board approach functionalities and validate them to provide improved and all weather operations. Indeed, initial CAT II/III GBAS L1 approach has been completed up to V3. A second step has been also investigated regarding the implementation of full multi-constellation (GPS, GALILEO) GBAS Cat II/III in the airborne equipment
- Develop future on-board surveillance systems, including dedicated wake encounter and significant weather (e.g. clear air turbulence) avoidance functions, to reduce the risk of severe upsets due to atmospheric disturbances;
- Improve surface movement operations through the introduction of functions to initially provide guidance and then alerting on traffic;
- Ensure interoperability between civil “Business trajectories” and military “Mission Trajectories” to allow the conformance of military aircraft with new operational concepts and to enable military aircraft to fly with the same performance level than civil aircraft to better exploit airspace resource avoiding restricting part of it for military use only;
- Provide a globally compatible avionics transition roadmap supporting the different SESAR Steps, to be used as a reference by avionics and airframe manufacturers for development planning, hence minimising the number of transition steps for a better cost efficiency;
- Develop a gradual evolution of Airborne Separation Assistance services:
    - ASAS-Spacing was developed allowing an aircraft to establish and maintain time spacing from a target aircraft designated by the Air Traffic Controller.
    - On-board functions to gradually introduce ASAS Separation Crossing and Passing (C&P) manoeuvres with the aim to help controllers in resolving conflicts between aircraft by temporarily delegating to the Pilots the responsibility to do the requested manoeuvre (e.g. vertical or lateral C&P) and maintaining separation during that manoeuvre were also investigated up to a limited maturity level.
    - Following interoperability studies with NextGen, Airborne functions to support Visual Approaches and Visual Separation were investigated as well with the potential of becoming a quick win in SESAR 2020.
- Investigate enhancement and additions to the CNS Technologies, including updates to ADS-B, Airport datalink and Flexible communication avionics and improved navigation positioning technologies while addressing the different types of airborne platforms.

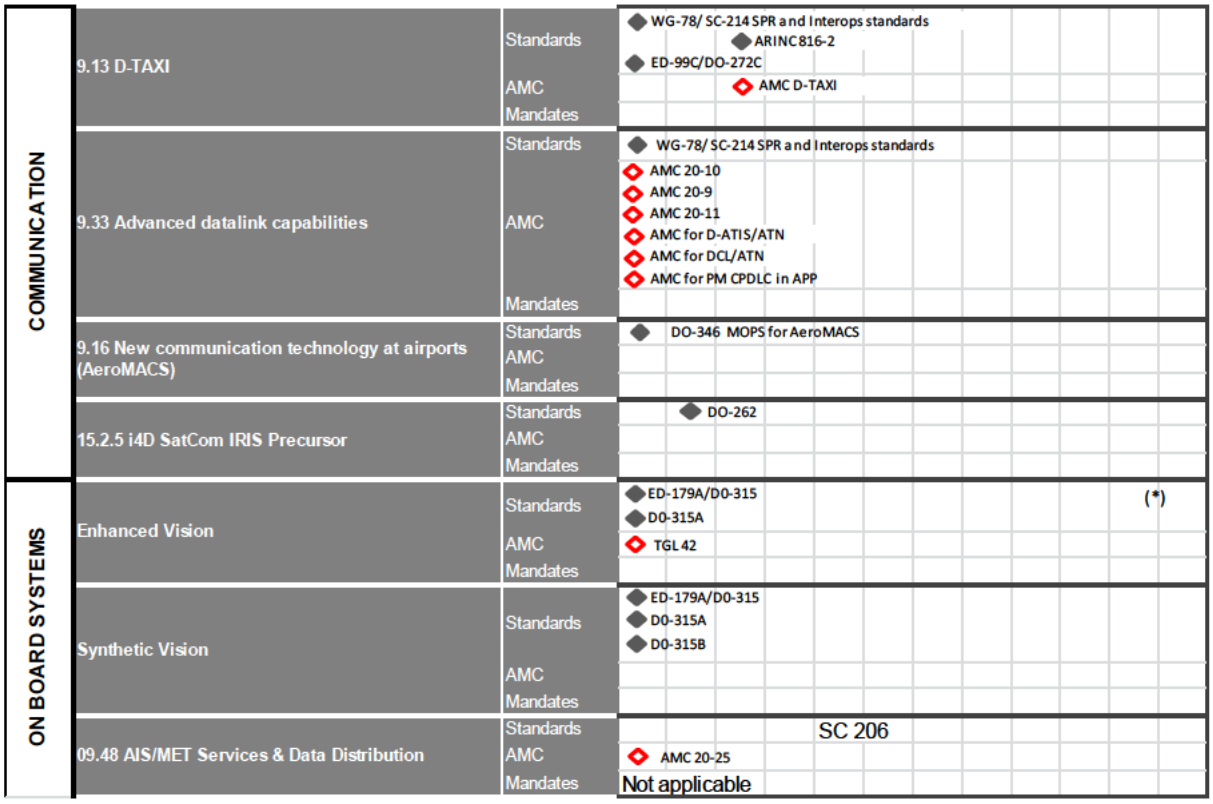
1.3 Work Package Deliverables

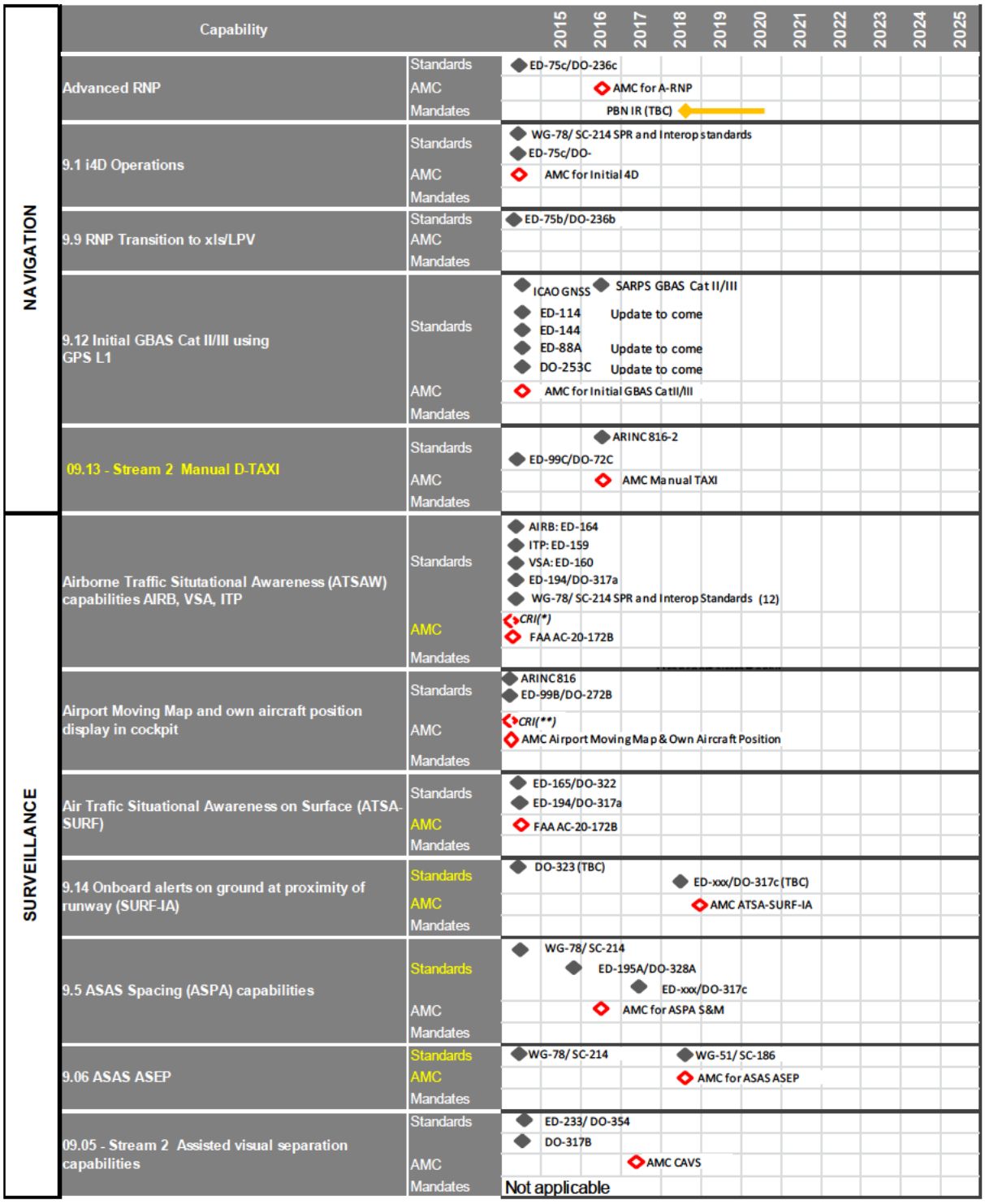
The following table presents the relevant deliverables that have been produced by the Work Package management team (if any).

Reference	Title	Description
D14	WP9 Management Report	The WP9 Management provides a synthesis of the work performed by the work package during the programme. This includes: • Contribution to the Master Plan • Contribution to the V&V Roadmap • How it has coordinated with the wider SESAR programme • Transition towards deployment • Standardization and Certification • Interoperability and Global Harmonization Risks • Conclusions and recommendations.

1.4 Contribution to Standards and Reference Material

The following roadmap provides for each aircraft capability the dates at which the standards required for industrialization are expected (as per the work plan of the responsible standardization organization) and the dates at which the certification material is needed in support of industrialization





In addition, the work package investigated the global harmonization risks associated to the concepts and systems developed by SESAR building on the outcomes of FAA/SJU Co-ordination Plan 4.2 "Avionics technology and applications roadmap", supplemented with assessments of SESAR & NextGen Aircraft Enablers and Operational Improvements.

The main elements of this investigation are summarized below, a level of criticality ("Traffic light") being assigned to each of the identified risks, as per the following definition:

SESAR and NextGen compliant avionics are Interoperable but with additional requirements for SESAR or NextGen with minor equipage and/or operational impact for users

SESAR and NextGen compliant avionics are not Interoperable : unique requirements for SESAR or NextGen with major equipage and/or operational impacts

Risk	Action	Traffic Light
There are differences between the US and European ADS-B OUT mandates.	Exchange notes on the equipage rules and associated operational issues, document the differences and potential consequences.	
Midterm difference between the US and European plans for Data Link deployment with ATNB1 Mandate then Baseline 2 may require aircraft with ATNB1 backward compatibility during the ATC transition from ATN Baseline 1 to Baseline 2	Develop a common view of the near-term data communications equipment required for US and Europe. Document the differences and potential consequences.	
Midterm differences between the US and European plans for Data Link deployment synchronization of Baseline 2 carriage between EU and US (2018+ in EU and 2025+ in US)	EU and US to harmonize the content and schedule of Baseline 2 standard, and to agree on a step deployment of Baseline 2 Initial Release then Baseline 2 Final Release	
In the mid-term US is planning a technology leap with ACAS-X, while EU plan is/was to continue step improvements building on TCAS 7.1.	Wait for Eurocae WG75 / RTCA SC147 progress on harmonized Terms of Reference and outcome. Wait for studies on 1090Mhz saturation, and operational need for ACAS-X	
US and European implementation of RNP-AR approaches are based on different Certification philosophies	None. Long standing FAA and EASA harmonization efforts have concluded on an agree to disagree	
US TOps and EU Step 1 ConOps implementation nuances	FAA to produce a Trajectory Operations (TOps) Concept of Operations (ConOps) to enable to further anticipate the nuances between the US TOps and the EU Step 1 ConOps. Under review at ANG.	Strategic issue.
Interval Management (IM) concept & implementation differences	Depending on the outcomes of EUROCAE WG-51 / SC-186 on ASAS MOPS, there may be a misalignment between US and EU that would require action for harmonization. Additional US specificities should also be introduced with the Advanced-IM that will require the update of the datacom ATN Baseline2 Final.	

Risk	Action	Traffic Light
Several regional mandates imposing the exclusive use of regional GNSS constellations	OEM to develop aircraft GNSS solutions enabling GNSS based operations with all concerned constellations with one single system	

1.5 Work Package Conclusion and Recommendations

The Aircraft Systems Work Package widely contributed to the development and validation of SESAR concepts, operational improvements and enablers.

Involving all airborne partners, it has matured airborne solutions that are needed to support SESAR concepts and deliver the necessary performance improvements to airspace users, addressing all segments (Mainline Regional, Bizjet and Military) including Boeing as an associate partners ensuring that the proposed roadmaps are widely shared.

It has developed V2 validation platforms (research simulators) and V3 prototypes (FMS, TCAS...) and IBPs (integration simulators, test A/C) to support air-ground validation activities and provided support to operational projects in understanding airborne capabilities (current & future)

The major achievement was to demonstrate, together with all ATM partners, the great potential to improve European airspace capacity and operational efficiency, defining tangible solutions to make it happen, and, these solutions being so promising that Airbus and partners have decided to launch the industrial development of Initial 4D aircraft capabilities, to be deployed throughout the European fleets, and beyond.

It addressed, through project 09.49, the retrofit challenge of the SESAR solutions which can be very different from one Solution to another. It developed a qualitative rating with 6 levels of challenge effort ranging from "none" to "very high". While these qualitative ratings cannot be correlated to quantitative retrofit efforts in Euros, they suggest that the quantitative efforts (in €) can however be quite different from one Solution to another. One recommendation could be to refine the future business cases to be undertaken for the scoping of future ATM Master Plan Essential changes. Indeed, past Master Plan business cases have only be performed with raw hypothesis on the contribution of aircraft equipage, resulting on associating systematically a "high cost" to a Solution when an aircraft Enabler is needed.

As regards worldwide interoperability, the work was focused on NextGen in the US. One recommendation would be that worldwide interoperability analysis should also consider other ATM modernisation ATM programs in China, Middle East, Australia.

Some other recommendations extracted from the analysis performed by project 09.49 are worth to be highlighted:

- Ensure that the functional architecture allows visualising the data flow in between the aircraft functional blocks and external interfaces
- Ensure that Aircraft enablers are still written and coordinated by a team of aircraft experts.
- Provide a flexible way to combine several aircraft functions as per ad-hoc criteria (e.g. functions targeting the same time horizon…) to get an architecture representation readable and usable for cross functional consolidation.
- Include the study of retrofit architecture options as part of SESAR 2020 projects having reached V3.
- Provide reference Avionics configurations and reference EU fleet composition in support to Solution project Business Case Analysis.
- Define a roadmap of credible aircraft enabler deployment, even for enablers that are not mandated, in order to have a moving EU fleet composition adapted to the specific time

horizon considered per Solutions. This roadmap should be synchronized between air and ground enablers.

- Assess the benefits of combination of functions earlier in the program, so that it can be considered within the Solution projects Business Case Analysis.
- Trials in support to worldwide interoperability analysis should also consider China, Middle East, Australia.
- Harmonization activities in SESAR 2020 should be better identified in projects so that they can be consolidated more easily at the highest level in SESAR JU.
- Within NextGen Memorandum of Cooperation between SESAR and FAA, some activities should be carried out so as to anticipate / prevent interoperability issues arising and take the appropriate corrective actions to alleviate them.
- Ensure proper synchronization in the level of details provided by Ground Industry and ANSPs on one side and airborne industry on the other side.
- The Essential Operational changes being selected on the basis of monetisable benefits, S2020 should develop a methodology for better consideration of qualitative benefits (e.g. Safety) in the criteria for down selecting these Essential Operational Changes

2 References

[1] SESAR Programme Management Plan

[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] 09.00-D14, WP9 Management Report, Ed 01.00.01, 14-June-2016

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