Final Project Report

Document information	
Project Title	Surveillance Infrastructure Rationalisation
Project Number	15.04.01
Project Manager	Thales
Deliverable Name	Final Project Report
Deliverable ID	D11
Edition	00.02.00
Template Version	03.00.04
Task contributors	
Thales,	

Abstract

The objective of this project was to develop a roadmap to support the introduction of changes to the Surveillance infrastructure that are identified within the ATM Masterplan. It details the methodology that will promote a rationalisation and adaptation of the Surveillance infrastructure. The methodology promotes cost effectiveness, flexibility and environmental sustainability of the infrastructure whilst ensuring safety and security of air traffic.

Authoring & Approval

Prepared By – *Authors of the document.*		
Name & Company	Position & Title	Date
[redacted] THALES	[redacted]	31/08/1016
[redacted] Eurocontrol		31/01/2014

Reviewed By – *Reviewers internal to the project.*		
Name & Company	Position & Title	Date
[redacted] THALES	[redacted]	31/08/1016
[redacted] Eurocontrol		31/01/2014
[redacted] DFS		31/01/2014

Reviewed By – *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	Position & Title	Date

Approved for submission to the SJU By – *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
[redacted] THALES	[redacted]	31/08/2016
[redacted] Eurocontrol		31/01/2014
[redacted] DFS		31/01/2014

Rejected By – *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
<Name / Company>	<Position / Title>	<DD/MM/YYYY>

Rational for rejection
None

Document History

Edition	Date	Status	Author	Justification
00.00.01	29/01/2014	Draft	[redacted]	New document
00.01.00	31/01/2014	Final		Approved version for upload
00.01.01	31/03/2016	Final		Include clarifications after SJU assessment
00.02.00	31/08/2016	Final		Include clarifications after SJU assessment

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground.

Acronyms

Acronym	Definition
ACAS	Airborne Collision Avoidance System
ADD	Aircraft Derived Data
ADS-B	Automatic Dependent Surveillance – Broadcast
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATM	Air Traffic Management
ATSAW	Air Traffic Situation AWareness
EASA	European Aviation Safety Agency
IR	Implementing Rule
MSPSR	MultiStatic Primary Surveillance Radar
PSR	Primary Surveillance Radar
RF	Radio Frequency
SESAR	Single European Sky ATM Research
SPI	Surveillance Performance and Interoperability requirements
SSR	Secondary Surveillance radar
TMA	Terminal Manoeuvring Area
VFR	Visual Flight Rules
WAM	Wide Area Multilateration

1 Project Overview

In recognition that the future surveillance infrastructure is to be leaner and more efficient in respect of a number of key performance indicators a key objective of the Surveillance Infrastructure Rationalisation (15.04.01) project was to detail a methodology that promotes a rationalisation and adaptation to the Surveillance Infrastructure.

A secondary objective of this project was to develop a roadmap to support a transition to the future Surveillance Infrastructure – as envisaged in the ATM Masterplan. The roadmap or strategy is to exploit the benefits that new and emerging surveillance techniques can bring whilst taking due cognisance of its context within the evolution of the wider Civil/Military ATM Infrastructure.

.

1.1 Project progress and contribution to the Master Plan

The project was decomposed into three phases: The first phase was to establish a baseline of the current surveillance situation, where the drivers behind the rationalisation where identifies, including the identification of regions where rationalisation would be beneficial. The second phase defined a high level rationalisation methodology. Additionally it verified the consistency of the proposed methodology on three representative cases and developed the rationalisation methodology. The last phase synthesized the findings, refined the rationalisation methodology, proposed a roadmap towards a 2030 infrastructure and obtained Stakeholders endorsement.

The project established a baseline for the civil and military Surveillance infrastructure situation. Using this information it identified where Surveillance rationalisation could provide benefits. Simulations where used to verify/endorse the technical solutions identified during the previous phases of work. As a result, the project contributed to the ATM Master Plans “Surveillance infrastructure rationalisation”, through the establishment of a methodology and roadmap supported by stakeholder endorsements.

The list of Operational Improvements related with project are listed hereafter:

Code	Name	Project contribution	Maturity at project start	Maturity at project end
AOM-0202	Enhanced Real-time Civil-Military Coordination of Airspace Utilisation	Due to confidentiality, the military surveillance has not been really studied within the project. Nevertheless, in some countries militaries run primary surveillance radars for both civil and military traffic	V1	V1
AOM-0203	Cross-Border Operations Facilitated through Collaborative Airspace Planning with Neighbours	The rationalisation methodology allows to take into account the neighbours equipment and to coordinate the surveillance infrastructure current and future use	V1	V2
IS-0302	Use of Aircraft Derived	The use of Aircraft Derived Data was	V1	V2

	Data (ADD) to Enhance ATM Ground System Performance	part of the rationalisation studies within the project. The main conclusion is that to take the benefit of this air-ground data exchange, all the aircraft of the area must be equipped with ADS-B.		

Table 1 - List of OIs

The list of relevant enablers is provided hereafter:

EN Code	EN Title	Project Contribution	Maturity at Project start	Maturity at Project end
CTE-S4a	Independent Non-cooperative Surveillance (PSR)	Demonstrated that whatever the improvements of the cooperative surveillance, the need for a PSR will remain for safety/security aspects	TRL7	TRL7
CTE-S4b	Independent Non-cooperative Surveillance (MSPSR)	Demonstrated that there are cases where the MSPSR can be an alternative to the PSR and other cases where it can be complementary.	TRL2	TRL3
CTE-S5	Independant Cooperative Surveillance sensors (SSR, WAM)	Demonstrated that the proposed rationalisation methodology allows current excessive coverage to be reduced.	TRL7	TRL7
A/C-48	Air broadcast of aircraft position/vector (ADS-B Out)	Demonstrated the gain brought by ADS-B regarding the global surveillance accuracy.	TR7	TRL7
GSURV-0101	Implementing Rules for Ground Surveillance overall functions	The project rationalization methodology is a set of rules to be used by ANSPs to optimize their surveillance infrastructure	TR2	TR4
GSURV-0103	Eurocontrol Standard Document for Radar Surveillance En-Route Airspace and Major Terminal Areas, SUR.ET1.ST01.100-STD-01-01	The project main achievements (rationalization methodology and surveillance roadmap) will be used to refine the SPI IR	TRL4	TRL5

Table 2 - List of System Enablers

1.2 Project achievements

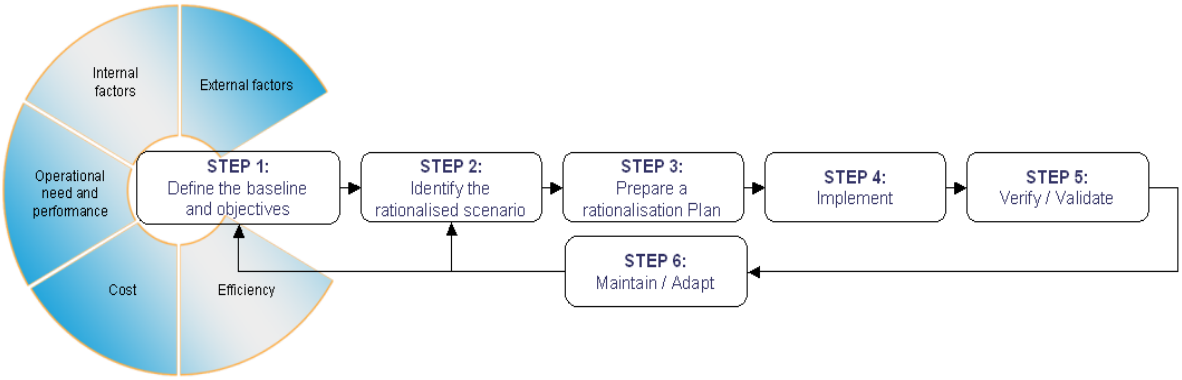
The project reached two main achievements. The first one was a rationalisation methodology that was validated through three application cases. Each case was for a particular environment (dense traffic, mountainous environment and traffic mix with a large VFR part.

The second main achievement of the project was a surveillance rationalisation roadmap towards a 2030 infrastructure, taking into account the technical progress, both on ground and on-board, and the associated legislative evolutions.

Rationalisation:

The achievement was to define a 6 steps rationalisation methodology. This methodology allows reorganising so as to eliminate uneconomic units and increase productivity/efficiency'. It involves an on-going and continual refinement of the surveillance infrastructure to meet evolving needs and exploiting emerging opportunities.

This achievement was validated through three simulations cases. Each of them was representative of a specific environment.



Surveillance Roadmap:
The second main achievement of the project was a definition of the drivers for change and a forecast of the surveillance infrastructure evolution over the next 20 years.

The objective of the surveillance infrastructure was to provide the required surveillance functionality and performance to enable a safe, efficient and cost-effective Air Traffic Management service. The current surveillance infrastructure was mainly composed of mono-pulse and sliding window (Mode A/C) Secondary Surveillance Radar (SSR), SSR Mode-S and Primary Surveillance Radars (PSRs). Recently, however, technological developments such as Automatic Dependent Surveillance–Broadcast (ADS-B) and Wide-Area Multilateration (WAM) have reached maturity and are being deployed across Europe. Emerging technologies such as Multi-Static PSR (MSPSR) and Hybrid Surveillance (ACAS using ADS-B message content) have demonstrated their feasibility and once developed, validated and deployed can influence the future surveillance infrastructure.

In parallel, new performance targets and associated operational requirements are emerging from Single European Sky and SESAR initiatives. These factors will drive changes to the existing surveillance infrastructure. This evolution needs to be managed, for it will also be influenced by an extensive range of other factors such as global interoperability, civil-military coordination, the introduction of functional airspace blocks (FABs), and changes to the composition of the aircraft fleet with the introduction of very light jets and unmanned aircraft. Furthermore, cost and radio frequency spectrum efficiency considerations will lead to a rationalisation of the current infrastructure, in which legacy systems will be phased out as soon as practicable and new, more efficient technologies will be introduced**.**

Surveillance systems are a key enabler of the SESAR future operational concept. The project achievement was to refine the system within this context of technological evolution and rising of new operational requirements.

1.3 Project Deliverables

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

Reference	Title	Description
D01	Baseline of European surveillance report	The outcome of this deliverable is a current baseline of the European surveillance infrastructure used for Air Traffic Control (ATC) purposes, both civil and military. It describes both the airborne and the ground sides in terms of requirements and of deployed systems and components. It also describes the Radio Frequency (RF) situation in Europe in the bands which are used to support the interface between the air and the ground (S band and L band with a special focus on the 1030/1090 MHz).
D02	Drivers for rationalisation report	This report describes future requirements for a surveillance infrastructure and the fundamental drivers influencing it and necessitating a rationalisation. It describes the possible impact of changing regulatory aspects such as the Implementing Rules published by the European Commission and how these will influence the future Surveillance infrastructure and provide 'windows of opportunity' in the rationalisation process. It also describes the source of future requirements and the opportunities and constraints being placed upon the current Surveillance infrastructure. The report also summarises how implementation plans are foreseen

		to evolve for Europe.
D03	Enabling system rationalisation report	The P15.04.01 project defined a methodology to support the rationalisation of the Surveillance infrastructure from both a technical and an economic perspective. The deliverable used the information included in deliverables D1 and D2 to develop a methodological approach to surveillance rationalisation
D04	Assessment of new surveillance technologies report	The deliverable focused on the emerging Air Traffic Surveillance technologies. It first summarises the characteristics of conventional Air traffic Surveillance systems (PSR & SSR). Then, emerging Air traffic Surveillance technologies are presented, as the main focus of this document. Those technologies are WAM, ADS-B, MSPSR and composite solutions. The outcome of the deliverable is an assessment of their technical and operational characteristics, contributing to the on-going SESAR rationalisation work.
D06	Application Case 1 report	This dense traffic area case study refines the current surveillance architecture over the selected traffic area. The outcome of the deliverable is an analysis of the options for infrastructure reduction and consequences, and an assessment of the impact of these surveillance infrastructure changes.
D07	Application Case 2 report	Building on the previous deliverables developed within this project, this document considers the specific needs of a mountainous TMA. The outcome is a first example of application of the rationalization methodology.
D08	Application Case 3 report	This report proposes an approach to rationalize a part of the Czech Surveillance infrastructure from both a technical and an economic perspective. The main objective of the rationalisation and upgrade is here

		to provide improved detection of VFR aircraft operating at very low altitudes around the airports studied. With this established as an objective three scenarios were proposed. The outcome of this deliverable is a quantitative analysis of these scenarios.
D12	Surveillance Rationalisation methodology report	Building upon the previous results of this project, this report describes a methodology for civil or state ANSPs to support the rationalisation of the Surveillance infrastructure from both a technical and an economic perspective. A six “Step” methodology is the outcome of this deliverable. It relies on a strong initial identification of the drivers for rationalisation to build a set of candidate rationalised scenarios. These scenarios are then evaluated against a set of criteria to select the rationalised scenario to be implemented.
D10	Final Report	This deliverable summarized the main achievements of the project. It is structured in two parts. The first result is a methodology for rationalising an Air Navigation Service Providers surveillance infrastructure to ensure that the requirements of an increasingly demanding environment can continue to be met. The second outcome consolidates the findings of the project regarding the current status of the European surveillance infrastructure, the surveillance techniques used and proposes a roadmap towards a 2030 infrastructure.

Table 3 - List of Deliverables

1.4 Contribution to Standardisation

- The project contributed to the European Commission Implementing Regulation (IR) no. 1207/2011, that lays down the requirements for the performance and interoperability of surveillance for the single European sky. This IR is considered to be the biggest single influence to the surveillance infrastructure. The project

assessed the impact of these new requirements on the surveillance infrastructure, with feedback provided for its refinement.

- The project also contributed to the development of Standards, including the ED102A / DO260B which describes the Minimum Operational Performance Standards for airborne equipment for ADS-B. It should be noted that this forms an essential element of the EC IR 1207/20111. The project assessed the gain in surveillance accuracy brought by the use of ADS-B.
- The project also provided inputs to the SPI IR refinement and for the needed additional legislation at local level to be introduced to allow full operational use of ADS-B.

1.5 Project Conclusion and Recommendations

The key conclusions of SESAR WP15.04.01 are:

- Regarding Infrastructure Aspects:
  - The demands placed upon the surveillance infrastructure are many and varied. Some demands, such as reduced cost and improved efficiency are not new. Others, such as new and additional performance demands to support new ATC applications, the introduction of new legislative instruments or new stakeholders with interest in ATM, have recently emerged. ANSPs need to ensure that they recognise the influences placed upon them by bodies such as the European Commission or EASA.
  - A comprehensive surveillance infrastructure is already established across Europe. The current trend is for SSR Mode S and/or WAM systems to replace SSR Mode A/C systems. Future trends will see WAM and ADS-B systems replacing, where appropriate, SSR Mode S and remaining SSR Mode A/C systems.
  - Excessive surveillance coverage appears currently to exist at higher altitudes however it is possible that much of this is a result of sensors that have been deployed to provide low level coverage in regions of airspace not served by other surveillance systems. If this is the case then refinements in terms of transmitted power and interrogation rates could be considered to focus the coverage of such sensors on supporting needs whilst minimising the disruptive influence in airspace where there is potential for obtaining reliable surveillance data from other sources. Such a detailed assessment was beyond the scope of this study and needs to be conducted on a local basis.
  - System rationalisation can support such drives for improved efficiency. A considered programme of rationalisation activities offers a means to help achieve legally binding performance objectives and a range of additional system improvements. Such activities should be considered as long term cyclic tasks refining the infrastructure against a set of KPAs rather than solely against cost. Benefits can be achieved through the deployment of new technologies when necessary and through data sharing when opportunities exist.
  - The RF spectrum that is used for both non-cooperative and cooperative surveillance systems is key to the operations of ATM. Demands from within ATM and from outside, such as GSM, require that its use is managed and efficient. Consequently it is recommended that some form of centralised spectrum/RF analysis is conducted.
  - The costs associated with undertaking significant system improvements may be substantial and in some cases prohibitive. The transition costs will depend critically on both the timing of the measure – measures taken at the end of the lifetime of assets will generally be less costly and upon the necessity of achieving the objective. Such costs are best addressed in the context of determining priorities for individual

programmes. Many of the possible improvement areas outlined in the deliverables can be achieved relatively cheaply and the contribution to Key Performance Indicators could be significant.

- Regarding Avionic Aspects:
  - The most significant difference between the surveillance infrastructure of the recent past and that that will be established to support long term future applications is a migration in functionality from ground based sensors to a comprehensive suite of avionics supporting a range of demanding surveillance applications. The position and other airborne parameters including short term intent indication will be provided by the airborne part of the surveillance system (ADS-B OUT) and will also be directly used by other aircraft (ADS-B IN) to support new surveillance applications. The migration of functionality paves the way to a migration of responsibility in which the air-crew have significantly improved air traffic situational awareness (ATSAW), and can perform spacing, separation and self-separation.
  - Changes to avionics are expensive and time-consuming to roll-out across all the fleet of aircraft – especially for State aircraft.
  - Retaining the ability to support legacy capabilities because some aircraft avionics do not meet published requirements is costly to all parties and improved mechanisms should be established to support prompt resolution of such issues as they can compromise the performance of the surveillance infrastructure, impede the removal of aging technologies, inhibit the roll-out of new surveillance techniques e.g. Mode S and probably also ADS-B and the retention or introduction of appropriate mitigations can significantly degrade the expected cost savings.
- Regarding Surveillance Technologies:
  - The necessary surveillance technologies are available to support foreseen needs. Newer techniques such as ADS-B, WAM and MSPSR offer more efficient solutions to ANSPs surveillance needs.
  - It is recognised that there is a military need to retain some form of independent non-cooperative detection means. Where safety and/or operational needs dictate, this requirement is also present for civilian ANSPs.
  - MSPSR offers significant benefits over aging PSR technologies. However it is recommended to have better defined operational needs and further development either through private venture funded development or sponsorship from a body such as the SJU, the European Commission or an ANSP.
  - Existing, new and emerging surveillance techniques / technologies offer ANSPs a greater choice of solutions to address their ATM needs and these can offer means to provide surveillance separation services in regions in which it was previously uneconomic or technically challenging. These techniques also offer benefits across a number of SESAR KPAs.

The European Master Plan (Ref Doc 2), a key deliverable from the SES and an influence upon the direction of SESAR activities imposes demanding targets for ATM and outlines the direction for ATM until 2030. The Surveillance Roadmap detailed in part 2 of this deliverable supports the objectives of the Masterplan whilst recognising that further adaptation may become necessary during the development of Operational Improvements in IP2 and beyond.

The changes that are necessary to ensure a surveillance infrastructure capable of meeting the demands of 2030 requires contribution and cooperation from a wide range of stakeholders.

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] SJU 15.04.01 Baseline of European surveillance report, D01, Ed. 00.01.00, 2011

[5] SJU 15.04.01 Drivers for rationalisation report, D02, Ed. 00.01.00, 2011

[6] SJU 15.04.01 Enabling system rationalisation report, D03, Ed. 00.01.00, 2011

[7] SJU 15.04.01 Assessment of new surveillance technologies report, D04, Ed. 00.01.00, 2011

[8] SJU 15.04.01 Generic surveillance infrastructure report, D05, Ed. 00.01.00, 2011

[9] SJU 15.04.01 Application Case 1 report, D06, Ed. 00.01.00, 2011

[10] SJU 15.04.01 Application Case 2 report, D07, Ed. 00.01.00, 2011

[11] SJU 15.04.01 Application Case 3 report, D08, Ed. 00.01.00, 2011

[12] SJU 15.04.01 Draft Final report, D09, Ed. 00.01.00, 2012

[13] SJU 15.04.01 Final Report, D10, Ed. 00.01.00, 2012

[14] SJU 15.04.01 Surveillance Rationalisation methodology report, D12, Ed. 00.01.00, 2012

-END OF DOCUMENT-