

SESAR SOLUTIONS CATALOGUE 2019

Third edition



Copyright of images

Page 24 © SESAR JU; **Page 26** © Dassault; **Page 27** © SESAR JU; **Page 28** © Eurocontrol; **Page 29** © G Tipene/Shutterstock.com; **Page 30** © (1) Petronilo G. Dangoy Jr./Shutterstock.com, (2) Airbus 2011; **Page 31** © Fraport AG on behalf of SEAC; **Page 32** © Shutterstock.com/ Cylonphoto; **Page 33** © Eurocontrol; **Page 34** © Shutterstock.com/Jaromir Chalabala; **Page 35** © DSNA; **Page 36** © Groupe ADP; Page 37 © Shutterstock.com/Denisklimov; **Page 38** © Shutterstock.com/Aerovista Luchtfotografie; **Page 39** © NATS Press Office; **Page 40** © Gregory Lambert; **Page 41** © SAAB AG ; **Page 42** © SAAB AG; **Page 43** © Enaire/Indra; **Page 44** © NATS Press Office; **Page 45** © LHR Airports Limited; **Page 46** © Shutterstock.com/Melanie Braun; **Page 48** © SESAR JU; **Page 49** © Adrian Pingstone; **Page 50** © DSNA; **Page 51** © SESAR JU; **Page 52** © SESAR Project 05.07.04 ; **Page 53** © SESAR Project 04.07.03 ; **Page 54** © SESAR Project 06.08.08; **Page 55** © UK Aeronautical Information Publication; **Page 56** © Shutterstock.com/Andre Klaassen; **Page 57** © SESAR JU; **Page 58** © DFS Deutsche Flugsicherung GmbH; **Page 59** © Airbus S.A.S. 2012 - photo by e'm company P. PIGEYRE; **Page 60** © DSNA; **Page 61** © DSNA; **Page 62** © NATS Press Office; **Page 63** © SESAR EXE-04.07.02-VP-501; **Page 64** © Eurocontrol; **Page 65** © SESAR JU; **Page 66** © Eurocontrol; **Page 67** © Ludovic Legros; **Page 68** © ENAV; **Page 69** © AIRBUS S.A.S. 2015- photo by H. Gousse; **Page 71** © Eurocontrol; **Page 72** © SESAR JU; Page 73 © Airbus Group; **Page 74** © Eurocontrol; **Page 75** © Eurocontrol; **Page 76** © Shutterstock.com/SAHACHAT SANEHA; **Page 77** © Eurocontrol; **Page 78** © Eurocontrol; **Page 80** © SESAR JU; **Page 81** © Alexey Y. Petrov/shutterstock.com © PANSA; **Page 82** © DFS Deutsche Flugsicherung GmbH; **Page 83** © Eurocontrol; **Page 85** © FREQUENTIS AG; **Page 85** © FR SAT 24; **Page 86** © SESAR JU; **Page 87** © DFS Deutsche Flugsicherung GmbH; **Page 88** © SESAR JU; **Page 89** © SESAR JU; Page 90 © ESA-P Carril; **Page 91** © SESAR JU; **Page 92** © SESAR JU; **Page 94** © NATS Press Office; **Page 95** © Honeywell; **Page 95** © Eurocontrol; **Page 96** © Shutterstock.com; **Page 96** © Shutterstock.com/Joaquin Ossorio Castillo; **Page 97** © LfV-COOPANS; **Page 97** © NAIS s.r.l.; **Page 98** © Eurocontrol; **Page 98** © Honeywell; **Page 99** © Dassault Aviation; **Page 99** © Air Expeditionary Wing Public Affairs; **Page 100** © DSNA; **Page 100** © Thales and Leonardo; **Page 101** © Honeywell; **Page 101** © DSNA; **Page 102** © Shutterstock.com; **Page 102** © DLR; **Page 103** © Indra-LfV-DLR-HungaroControl; **Page 103** © B4-COOPANS-DFS-ENAV-HungaroControl-AT-One-Indra-Frequentis-NATMIG; **Page 104** © Shutterstock.com Jaromir Chalabada; **Page 105** © NATS Press Office; **Page 106** © DFS; **Page 106** © Shutterstock.com/Kevin Teh Ooi Keat; **Page 107** © DSNA; **Page 107** © NLR; **Page 108** © DLR; **Page 108** © Shutterstock.com/Josegmsphoto; **Page 109** © Eurocontrol; **Page 109** © PANSA; **Page 110** © DFS; **Page 110** © DLR; **Page 111** © NATS Press Office; **Page 111** © DSNA; **Page 112** © NATS Press Office; **Page 112** © Giovanni Riccardi; **Page 113** © SESAR Project PJ.10; **Page 113** © Shutterstock.com/muratart; **Page 114** © SESAR JU; **Page 114** © Shutterstock.com; **Page 115** © Shutterstock.com; **Page 115** © Shutterstock.com; **Page 116** © Eurocontrol **Page 117** © Eurocontrol; **Page 118** © Eurocontrol; **Page 118** © Eurocontrol; **Page 119** © NATS Press Office; **Page 119** © ENAV; **Page 120** © Shutterstock.com; **Page 120** © Thales and Indra; **Page 121** © Eurocontrol; **Page 122** © SESAR JU; **Page 123** © Frequentis; **Page 123** © Thales; **Page 124** © Frequentis; **Page 124** © DFS; **Page 125** © DFS; **Page 125** © SESAR Project PJ.14; **Page 126** © DLR; **Page 126** © AustroControl; **Page 127** © Airbus; **Page 127** © SESAR Project PJ.15; **Page 128** © DFS; **Page 128** © Shutterstock.com; **Page 129** © SESAR Project PJ.15; **Page 129** © Eurocontrol; **Page 130** © Shutterstock.com; **Page 130** © SESAR JU; **Page 131** © DLR; **Page 131** © SESAR Project PJ.17; **Page 132** © Airbus; **Page 132** © Airbus; **Page 133** © Eurocontrol; **Page 133** © SESAR Project PJ.18; **Page 134** © Shutterstock.com; **Page 134** © Shutterstock.com; **Page 135** © Shutterstock.com; **Page 135** © Shutterstock.com; **Page 136** © Shutterstock.com; **Page 136** © Shutterstock.com/manjik; **Page 139** © PNOWWA; **Page 140** © Shutterstock.com; **Page 141** © DART; **Page 142** © MALORCA; **Page 143** © RETINA; **Page 144** © COPTRA; **Page 145** © R-WAKE

***Europe Direct is a service to help you find answers
to your questions about the European Union.***

Freephone number (*):
00 800 6 7 8 9 10 11

(* The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

More information on the European Union is available on the internet (<http://europa.eu>).

Luxembourg: Publications Office of the European Union, 2019

Print	ISBN 978-92-9216-109-5	doi:10.2829/369731	MG-07-18-083-EN-C
PDF	ISBN 978-92-9216-108-8	doi:10.2829/998701	MG-07-18-083-EN-N

© SESAR Joint Undertaking, 2019

Reproduction is authorised provided the source is acknowledged.

For any use or reproduction of photos or other material that is not under the SESAR copyright, permission must be sought directly from the copyright holders.

Printed by Bietlot in Belgium

SESAR SOLUTIONS CATALOGUE 2019

Third edition



Table of contents

Message from the European Commissioner for Transport	7
Message from the founding members	8
Foreword	9
Introduction	10
Changing world of aviation	10
SESAR vision	10
European ATM Master Plan.....	11
SESAR innovation pipeline and solutions	14
Addressing the needs of the entire ATM community.....	15
Out of the lab and tested in real operations	16
What's in this edition?.....	17
Improving performance	18
Delivering SESAR Solutions for industrialisation and subsequent deployment	18
A catalogue for its time.....	21
Delivered solutions	23
 High-performing airport operations	24
Precision approaches using GBAS Category II/III	25
Reducing landing minima in low-visibility conditions using EFVS to land	26
Time-based separation	27
Automated assistance to controllers for surface movement planning and routing	28
D-TAXI service for controller-pilot datalink communications (CPDLC) application	29
Manual taxi routing function	30
Guidance assistance through airfield ground lighting	31
Virtual block control in low-visibility procedures	32
Airport safety nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances	33
Enhanced ground controller situational awareness in all weather conditions.....	34
Runway status lights.....	35
Enhanced traffic situational awareness and airport safety nets for vehicle drivers.....	36
Departure manager (DMAN) baseline for integrated AMAN DMAN	37
Pre-departure sequencing supported by route planning.....	38
Flow-based integration of arrival and departure management	39
ATC and AFIS service in a single low-density aerodrome from a remote controller working position (CWP)	40
Single remote tower operations for medium traffic volumes.....	41
Remote tower for two low-density aerodromes	42
Remotely-provided air traffic services for contingency situations at aerodromes	43
A low-cost and simple departure data entry panel for the airport controller working position.....	44
Airport operations plan (AOP) and its seamless integration with the network operations plan (NOP).....	45
De-icing management tool.....	46



Advanced air traffic services 47

Extended arrival management (AMAN) horizon	48
Point merge in complex terminal airspace.....	49
Arrival management (AMAN) and point merge	50
Continuous descent operations (CDO) using point merge.....	51
Precision area navigation (P-RNAV) in a complex terminal airspace.....	52
Optimised route network using advanced required navigation performance (RNP)	53
Enhanced terminal operations with RNP transition to ILS/GLS.....	54
Enhanced terminal operations with RNP transition to LPV.....	55
Approach procedures with vertical guidance	56
Optimised low-level instrument flight rules (IFR) routes for rotorcraft	57
Arrival management into multiple airports	58
Controlled time of arrival (CTA) in medium-density/medium-complexity environments	59
Sector team operations - en-route air traffic organiser	60
Basic extended ATC planning (bEAP).....	61
Multi-sector planning	62
Enhanced tactical conflict detection & resolution (CD&R) services and conformance monitoring tools for en-route.....	63
User-preferred routing	64
Free route through the use of direct routing for flights both in cruise and vertically evolving in cross ACC/FIR borders and in high complexity environments	65
Free route through the use of free routing for flights both in cruise and vertically evolving in cross ACC/FIR borders and within permanently low to medium complexity environments.....	66
Enhanced short-term conflict alert (STCA) for terminal manoeuvring areas (TMAs)	67
Enhanced short-term conflict alerts (STCA) with downlinked parameters	68
Enhanced airborne collision avoidance system (ACAS) operations using the autoflight system.....	69



Optimised ATM network services 70

Initial collaborative network operations plan (NOP)	71
Automated support for dynamic sectorisation	72
Variable profile military reserved areas and enhanced civil-military collaboration	73
Automated support for traffic complexity detection and resolution.....	74
Advanced short-term ATFCM measures (STAMs).....	75
Calculated take-off time (CTOT) and target time of arrival (TTA)	76
Enhanced air traffic flow management (ATFM) slot swapping	77
User-driven prioritisation process (UDPP) departure.....	78



Enabling aviation infrastructure 79

Initial ground-ground interoperability.....	80
Extended projected profile (EPP) availability on the ground	81
AOC data increasing trajectory prediction accuracy	82
Extended flight plan.....	83
Digital integrated briefing.....	84
Meteorological information exchange	85
Initial system-wide information management (SWIM) technology solution	86
ACAS ground monitoring and presentation system	87
Extended hybrid surveillance	88
Aeronautical mobile airport communication system (AeroMACS)	89
Air traffic services (ATS) datalink using Iris Precursor	90
ADS-B surveillance of aircraft in flight and on the surface	91
Composite cooperative surveillance automatic dependent surveillance – broadcast/Wide area multilateration (ADS-B/WAM)	92



High-performing airport operations 94

Wake turbulence separation optimisation	94
Enhanced approach procedures enabled by satellite technologies	95
Minimum-pair separations based on required surveillance performance (RSP)	95
Independent rotorcraft operations at airports.....	96
Improved access into secondary airports in low-visibility conditions	96
Traffic optimisation on single and multiple runway airports	97
Enhanced terminal area for efficient curved operations	97
Enhanced guidance assistance to aircraft and vehicles on the airport surface combined with routing	98
Enhanced navigation accuracy in low-visibility conditions on airport surfaces.....	98
Enhanced visual operations	99
Surface operations by remotely-piloted aircraft systems (RPAS).....	99
Enhanced airport safety nets for controllers.....	100
Conformance monitoring safety nets for pilots	100
Traffic alerts for pilots for airport operations.....	101
Safety support tools for runway excursions	101
Enhanced collaborative airport performance planning and monitoring	102
Enhanced collaborative airport performance management	102
Remotely-provided air traffic services for multiple aerodromes.....	103
Flexible and dynamic allocation of remote tower modules	103
Automatic METAR at (manned or unmanned) airports.....	104



Advanced air traffic services 105

Extended arrival management with overlapping AMAN operations and interaction DCB and CTA.....	105
Use of arrival and departure management information for traffic optimisation within the TMA	106
Improved parallel operations	106
Dynamic extended TMA (E-TMA) for advanced continuous climb and descent operations	107
Airborne spacing flight deck interval management	107
Enhanced rotorcraft and general aviation operations in the TMA.....	108
Approach improvement through assisted visual separation	108
Optimised traffic management to enable free routing in high and very high complexity environment	109
Performance-based free routing in lower airspace	109
High productivity controller team organisation	110
Flight-centric air traffic control	110
Collaborative control.....	111
Improved performance in the provision of separation	111
Advanced separation management	112
Integration of RPAS under IFR	112
Generic (non-geographical) controller validations	113
Enhanced airborne collision avoidance for commercial air transport normal operations - ACAS Xa.....	113
Airborne collision avoidance for remotely piloted aircraft systems – ACAS Xu	114
ACAS for commercial air transport specific operations – ACAS Xo	114
Airborne collision avoidance for general aviation and rotorcraft – ACAS Xp	115
Enhanced ground-based safety nets adapted to future operations	115
Trajectory-based operations	116



Optimised ATM network services 117

AU Processes for trajectory definition	117
Airspace user fleet prioritisation (UDPP)	118
Mission trajectory driven processes	118
Management of dynamic airspace configurations	119

Dynamic airspace configuration supporting moving areas	119
Network prediction and performance	120
Integrated local DCB processes	120
Collaborative network management	121



Enabling aviation infrastructure..... 122

CNS environment evolution.....	122
Future communication infrastructure (FCI) terrestrial datalink	123
Future satellite communications datalink (FCI datalink)	123
FCI network technologies	124
Development of new services similar to flight information system broadcast (FIS-B) to support ADS-B solutions for general aviation.....	124
GBAS (for challenging environments).....	125
Multi-constellation/Dual frequency (MC/DMF) GNSS	125
Alternative position, navigation and timing (A-PNT)	126
Surveillance performance monitoring	126
Cooperative and non-cooperative surveillance	127
Sub-regional demand capacity balancing common service	127
E-AMAN common service	128
Trajectory prediction common service	128
Delegation of air traffic services (ATS) and contingency.....	129
Static aeronautical data common service	129
Aeronautical digital map common service	130
Work station, service interface definition and virtual centre	130
Workstation, controller productivity.....	131
Air-ground advisory information sharing (SWIM TI purple profile)	131
SWIM TI green profile for ground-ground civil-military information sharing	132
SWIM TI purple profile for air-ground safety-critical information sharing	132
SWIM-TI common runtime registry	133
Flight object interoperability	133
EFPL supporting SBT transition to RBT	134
Improved AIM Information.....	134
Improved MET Information.....	135
Improved use of MET and AIM in cockpit.....	135
ATC planned trajectory performance improvement	136
Tactical and NM trajectory performance improvement	136

On the horizon 137

Meteorological uncertainty management for trajectory-based operations – TBO-Met .	138
Probabilistic Nowcasting of Winter Weather for Airports -PNOWWA	139
ATM-COCTA Flexible and efficient ATM service provision in Europe	140
Data driven aircraft trajectory prediction research - DART	141
Machine learning of speech recognition models for controller assistance – MALORCA	142
Resilient synthetic vision for advanced control tower air navigation service provision - RETINA.....	143
Combining probable trajectories – COPTRA.....	144
Wake vortex simulation and analysis to enhance en-route separation management in Europe - R-WAKE	145

Conclusion 146

ANNEX 1 — Reaching research maturity.....	147
ANNEX 2 — Glossary.....	150

SESAR (Joint Undertaking)

As the technological pillar of the Single European Sky (SES) to modernise Europe's air traffic management (ATM) system, SESAR is now making significant progress in transforming the performance of Europe's ATM network. The SESAR Joint Undertaking (SESAR JU) was established in 2007 as a public-private partnership to support this endeavour. It does so by pooling the knowledge and resources of the entire ATM community in order to define, research, develop and validate innovative technological and operational solutions. The SESAR JU is also responsible for the execution of the European ATM Master Plan, which defines the EU priorities for research and development (R&D) and implementation. Founded by the European Union and EUROCONTROL, the SESAR JU has 19 members, who together with their partners and affiliate associations represent over 100 companies working in Europe and beyond. The SESAR JU also works closely with staff associations, regulators, airport operators, airspace users, the military and the scientific community.



European ATM Master Plan

- ▶ A roadmap for ATM modernisation
- ▶ Meeting the performance objectives of the Single European Sky
- ▶ Ensuring support with ICAO's global air navigation plan

- ▶ Exploring & developing operational & technology Solutions
- ▶ Validating & demonstrating Solutions in real-operational environments
- ▶ Delivering a catalogue of Solutions to transform ATM

- ▶ Implementation of SESAR Solutions to answer local needs
- ▶ Synchronised deployment to deliver Europe-wide benefits



Message from the European Commissioner for Transport

When I took office in 2014, I did so with a clear mandate from President Juncker. This was to ensure maximum connectivity for Europe's travelling public, and to promote innovation and investment for a more efficient transport system. SESAR has played an important part in fulfilling this task, as well as the broader objectives of the Single European Sky and EU's Aviation Strategy.

With air traffic growing once again, Europe needs more than ever a modern and efficient air traffic management system! The SESAR JU is doing a stellar job in advancing technologies, from artificial intelligence to satellite-based solutions, to enable a more automated and resilient system that can meet people's growing demands for air travel while minimising delays and environmental impacts. Above all, these advancements allow us to maintain the highest possible safety standards both within the EU and globally.

This Catalogue, now in its third edition, demonstrates progress not just in R&D, but also in the uptake of these innovations at local, European and international levels. It shows that through unity, solidarity and collaboration at EU level, we can effect positive change. I invite all stakeholders to continue to work together, making use of the SESAR Solutions Catalogue to accelerate the transformation of ATM and aviation in Europe.

Violeta Bulc,
European Commissioner
for Mobility and Transport

The SESAR JU is doing a stellar job in advancing technologies, from artificial intelligence to satellite-based solutions, to enable a more automated and resilient system that can meet people's growing demands for air travel while minimising delays and environmental impacts.

Message from the SESAR JU founding members



Henrik Hololei,
Director-General for
Mobility and Transport
at the European
Commission, and
Chair of the SESAR JU
Administrative Board

Airspace capacity and congestion in the air and on the ground, together with environmental impact, are the biggest challenges facing European aviation today. These challenges concern all of us - the States, aviation regulators, economic operators and, of course, the travelling public. To address them, we must forge ahead with the drivers for sustainable growth outlined in the EU Aviation Strategy, such as the Single European Sky initiative and the related innovation activities driven by SESAR.

The SESAR Solutions Catalogue is a very comprehensive overview of the status of the R&D activities of the SESAR JU. It shows that Europe is embracing innovation, digitalisation as well as automation to increase capacity and flight efficiency.

This is achieved while in parallel continuing to pursue the highest standards in safety and contributing to the sustainability of the aviation sector.

We want to see Europe leading globally on digital innovations that are making a difference and being interoperable as well as cyber-secured systems. I am proud that SESAR, as illustrated in this catalogue, is keeping Europe at the cutting edge of technology and innovation.



Eamonn Brennan,
Director General,
EUROCONTROL,
and Vice-Chairman
of the SESAR JU
Administrative Board

A new age of digitalisation, big data and artificial intelligence is dawning for European aviation, with resilience and cyber-security major future challenges. At the same time, traffic is growing steadily, putting huge pressure on airspace design and airport capacity

Alongside the daily work of the EUROCONTROL Network Manager to find solutions to capacity issues, SESAR Solutions have from the start played an invaluable role in ensuring that Europe harnesses its formidable R&D know-how to deliver tangible improvements to Europe's ATM system.

This third catalogue gives an excellent overview of all SESAR Solutions that have been designed, developed, validated and deployed, or are being worked on. The impressive array of projects is designed to help European aviation take full advantage of innovative technologies, both now and in the future, and guard against inherent risks.

SESAR R&D follows the European ATM Master Plan and the EU Aviation Strategy in addressing areas of major concern such as safety (always paramount, and increasingly a challenge in an era of growing drone use), capacity, costs and environmental impact. We can be proud that over the years a series of workable, scalable and tangible ideas have been put forward to prepare for the near future. And not just for Europe: SESAR Solutions are designed to be interoperable, and as such are entirely compatible with ICAO's standards and with the Global Air Navigation Plan, giving them the potential to be used in ATM environments across the globe.

I am delighted that EUROCONTROL as a founding member of the SESAR JU is continuing to play a central role in driving these SESAR Solutions forward and addressing the capacity challenges of the future.

Foreword



Florian Guillermet,
Executive Director,
SESAR Joint Undertaking

This third edition of the SESAR Solutions Catalogue aims to provide readers with a holistic view of the status of SESAR R&D in 2019.

It covers the results of the first R&D programme (SESAR 1); more than 60 solutions, many of which are in the process of deployment at local and European levels. It also presents details of the ongoing R&D (candidate solutions) as we reach midway in the current programme, SESAR 2020. Finally, the catalogue gives a flavour of some of the promising results coming out of our dedicated exploratory research programme.

This Catalogue is the result of strong collaboration between the public-private partners that make up the SESAR JU. Together we have created a SESAR innovation pipeline through which concepts are transformed into tangible solutions. The pipeline is composed of 85 research projects and demonstrators, more than 50 test sites and is staffed by 2,500 researchers, controllers, pilots and engineers from across Europe. Not only do our members come together to pool their resources and expertise, they also make sure that R&D is carried out in a cooperative and integrated manner following the vision of the European ATM Master Plan – the main planning tool for ATM modernisation – and in support of SES and the EU Aviation Strategy.

Recognising the changing landscape of aviation and the challenges facing our sector, with this latest edition, we have sought to shine a light on some of the solutions (delivered and candidate) that have been identified as essential enablers for optimising capacity and airspace management, as well as for rendering the system more scalable and resilient. Performance benefits are also expected in other key areas, such as safety, security, efficiency and the environment, which the Catalogue highlights.

This Catalogue is a living document and will be updated as more solutions become ready for industrialisation and deployment within the framework of SESAR 2020.

This Catalogue is the result of strong collaboration between the public-private partners that make up the SESAR JU. Together we have created a SESAR innovation pipeline through which concepts are transformed into tangible solutions.

Introduction

Air traffic management (ATM) is a key enabler for European air transport and aviation, connecting cities and people citizens as well as boosting jobs and growth.

Changing world of aviation

As highlighted by the EU Aviation Strategy, air traffic management (ATM) is a key enabler for European air transport and aviation, connecting cities and people, as well as boosting jobs and growth. Close to 30,000 flights pass through Europe daily, representing 26% of the world market, which are managed by ATM in a safe and sustainable manner. However, the landscape of European and global aviation is changing. Starting with the aircraft, which are set to become more autonomous, connected, intelligent and diverse. And then there is traffic, which is projected to grow significantly, from several thousand conventional aircraft to potentially hundreds of thousands of air vehicles (such as drones), operating in all types of airspace, including cities. Added to that are increasing demands from passengers for smart and personalised mobility options that allow them to travel seamlessly and without delay.

In support of the EU Aviation Strategy and the Single European Sky (SES), SESAR aims to deliver an ATM system for Europe that is fit for the 21st century.

SESAR vision

In support of the EU Aviation Strategy and the Single European Sky (SES), SESAR aims to deliver an ATM system for Europe that is fit for the 21st century and capable of handling the growth and diversity of traffic safely and efficiently, while improving environmental performance. This vision relies on a concept of operations underpinned by digital technologies that enable improvements at every stage of the flight. Put simply, the vision sees the integration of all air vehicles with higher levels of autonomy and digital connectivity coupled with a more automated support for the management of the traffic.

In this new paradigm, the vehicles can fly their optimum trajectories, relying on improved data sharing between vehicles and the ground infrastructure using mobile, terrestrial and satellite-based communication links. SESAR also addresses airport operational and technical system capacity and efficiency, introducing technologies such as satellite-based tools for more accurate navigation and landing, and mobile communications to improve safety on the airport surface. Meanwhile, artificial intelligence, such as big data analytics and improved data sharing through system-wide information management are allowing for better flight planning, airport operations and their integration into the overall Network.

European ATM Master Plan

The SESAR vision is captured within the European ATM Master Plan - a collaboratively agreed roadmap for ATM modernisation. The MasterPlan is regularly updated to reflect the changing landscape in order to prioritise R&D activities and the solutions needed.

These activities are underpinned by a concept of operations and an integrated approach to addressing different aspects of system. In this respect, SESAR conducts transversal activities between R&D projects to ensure that the resulting solutions are interoperable and bring expected performance in terms of capacity, cost-efficiency, the environment and safety, as outlined in the European ATM Master Plan. This focus on consistency and coherence across all the research projects is a unique feature of SESAR.

A key tool to achieving integration is the European ATM Architecture Framework (EATMA). This data repository allows experts to follow progress as well as enabling projects to collaborate with other projects, plan modelling activity and identify gaps. Access is via the eATM portal, which captures, maintains, validates and reports on architecture-related content.

A common methodology is also used to monitor and assess the performance results of solutions, measured against shared objectives in safety, security, human performance, the environment and cost-benefit. This ensures all SESAR Solutions delivered throughout the SESAR programme are consistent with and contribute to EU-wide performance targets.

The European ATM Master Plan is a collaboratively-agreed roadmap for ATM modernisation. The Master Plan is regularly updated to reflect the changing landscape in order to prioritise research and innovation activities and the solutions needed.

 www.atmmasterplan.eu



To deliver this new era of air travel, digitalisation is key

Digital transformation

To deliver the SESAR vision, digital transformation is key - whether it's through harnessing the Internet of Things, big data, artificial intelligence digital transformation and augmented reality. We need to embrace the technologies on offer to build an aviation ecosystem that can handle the growth and diversity of traffic efficiently, safely and with minimum environmental impact. In doing so, we will be able to deliver the best possible passenger experience while also unlocking tremendous economic value for Europe.

This future aviation landscape is characterised by:



Higher levels of autonomy and connectivity of all (air) vehicles

coupled with a smarter, more automated management of the traffic, and enabled by an "intranet of flight".



Mobile, terrestrial and satellite-based communications,

which are used to provide real-time vehicle trajectory information, shared between vehicles and with the ground infrastructure.



Digital and automated tools

provided on board the air vehicle itself, or as part of the ground-based infrastructure.



Virtual technologies

to decouple the physical infrastructure such as sensors, communication or navigation devices from the services that are provided to manage the airspace.



High-tech video, synthetic and enhanced sensor technologies to

operate air traffic services for airports or to enable aircraft to land in low-visibility conditions.



Big data analytics and open source cyber secure data usage

to encourage the creation of new services and to allow for better integrated transport delivery for the passenger.



System modularity

to allow for scalable and easier upgrades and greater interoperability.



System flexibility

to handle increasing number of air vehicles, such as drones.

More details of the SESAR vision and operational concept are outlined in the European ATM Master Plan¹ (level 1-3) – see page 16.

[1] European ATM Master Plan - <https://www.atmmasterplan.eu/>

SESAR is making progress towards more high-performing aviation for Europe underpinned by technologies in several key areas of R&D: automation, virtualisation, connectivity, data sharing, and cybersecurity. This progress is captured in this catalogue.

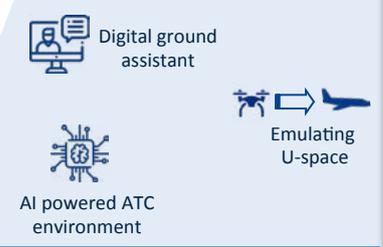
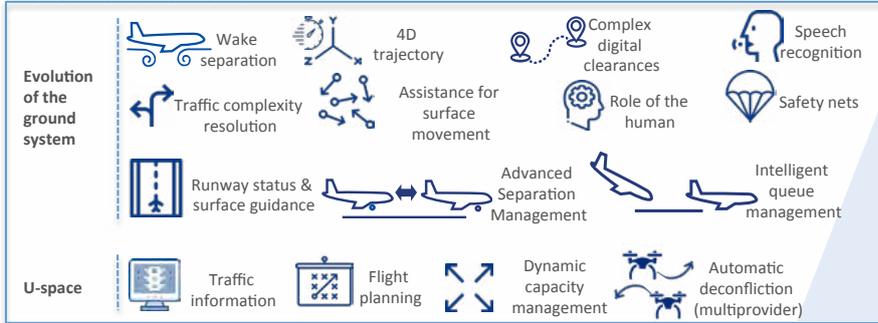
SESAR Solutions (delivered/in the pipeline)

Future innovations

Airborne automation



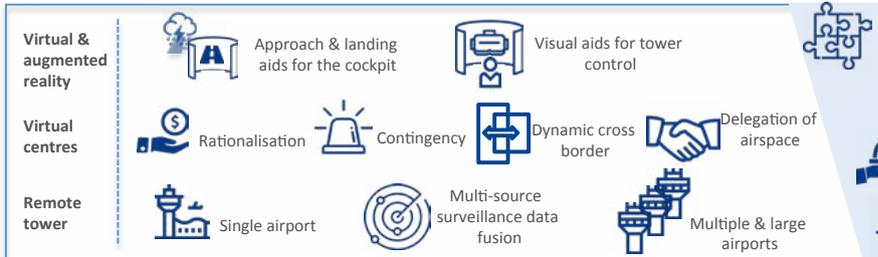
Ground automation



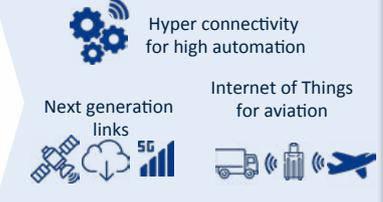
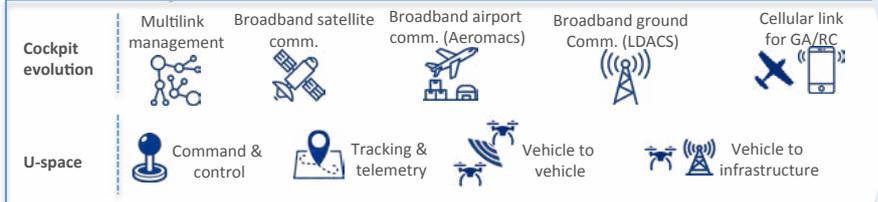
Automation levels

Progressive levels of automation

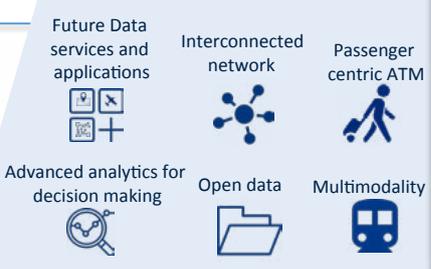
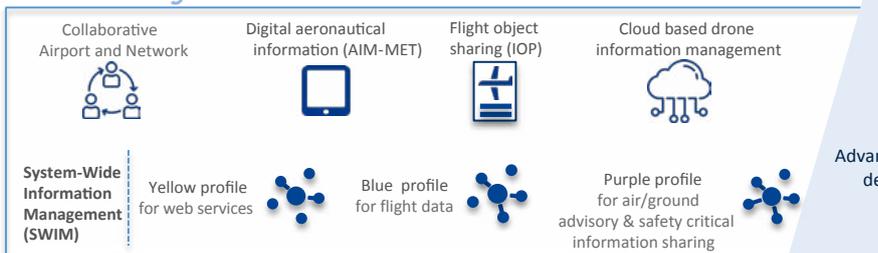
Virtualisation



Connectivity



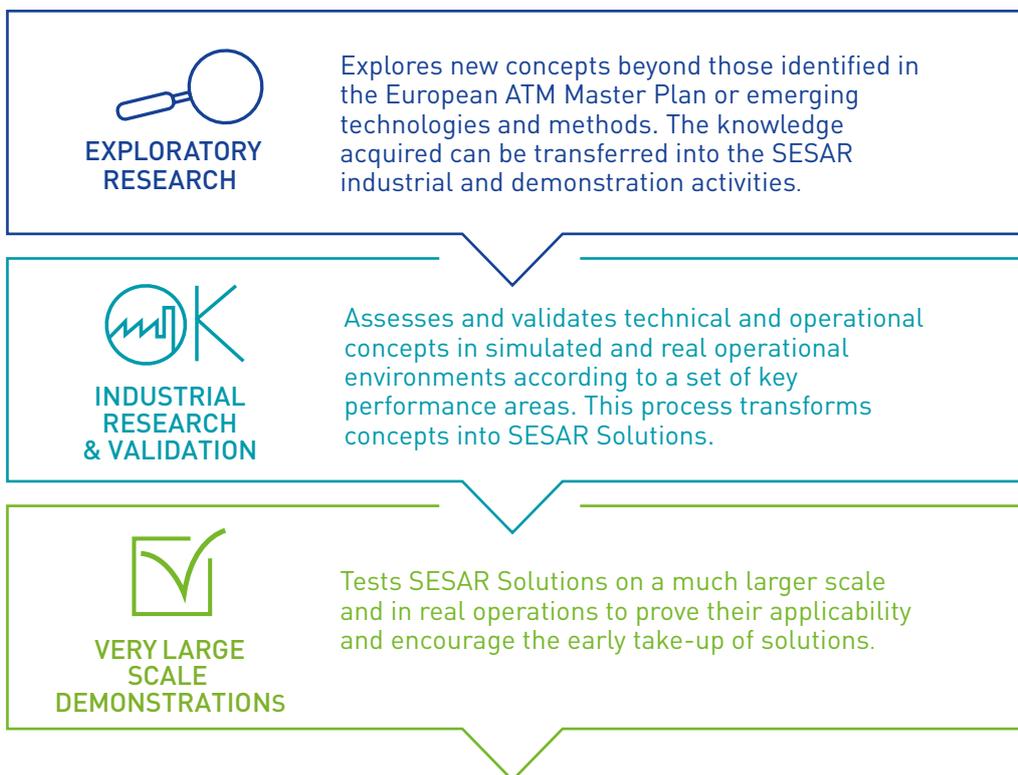
Data sharing



New standards for safety and security

SESAR innovation pipeline and solutions

The SESAR JU is exploiting these technologies in its R&D categorised into three stands: exploratory research, industrial research and validation, and very large-scale demonstrations. These strands form an innovation pipeline, through which ideas are transformed into tangible solutions. The SESAR innovation pipeline is composed currently of 85 research projects and demonstrators, staffed by 2,500 researchers, controllers, pilots and engineers from across Europe, reflecting the SESAR 2020 R&D programme.



SESAR Solutions refer to new or improved operational procedures or technologies that are designed to meet the essential operational improvements outlined in the European ATM Master Plan. They are also developed in full accordance with the International Civil Aviation Organization (ICAO) and the Global Air Navigation Plan (GANP) and therefore applicable to ATM environments worldwide.

Each solution is accompanied by a set of documents, available on the SESAR JU website, to support its implementation. The documentation includes:

- Operational services and environment descriptions
- Safety, performance and interoperability requirements
- Technical specifications
- Regulatory recommendations
- Safety and security assessments
- Human and environmental performance reports
- Relevant ICAO and industry standards needed for implementation

Addressing the needs of the entire ATM community

Before a concept is selected for research and development, with a view to becoming a SESAR Solution, it must show that it meets a business need in several key areas (key features):



High-performing airport operations, including total airport management, remote towers, runway throughput capabilities, navigation and routing tools, airport safety alerts for controller & pilots



Advanced air traffic services, including time-based separation & European wake vortex recategorisation (RECAT-EU), better sequencing of traffic, automation support tools, integration of all vehicles



Optimised network operations, including dynamic collaborative tools to manage ATC airspace configuration (sectors), and civil-military collaboration for greater predictability and management of operations & airspace use.



Enabling infrastructure, including CNS integration to facilitate economies of scale & seamless service delivery; and system-wide information management governance, architecture and technology solutions & services for information exchange.

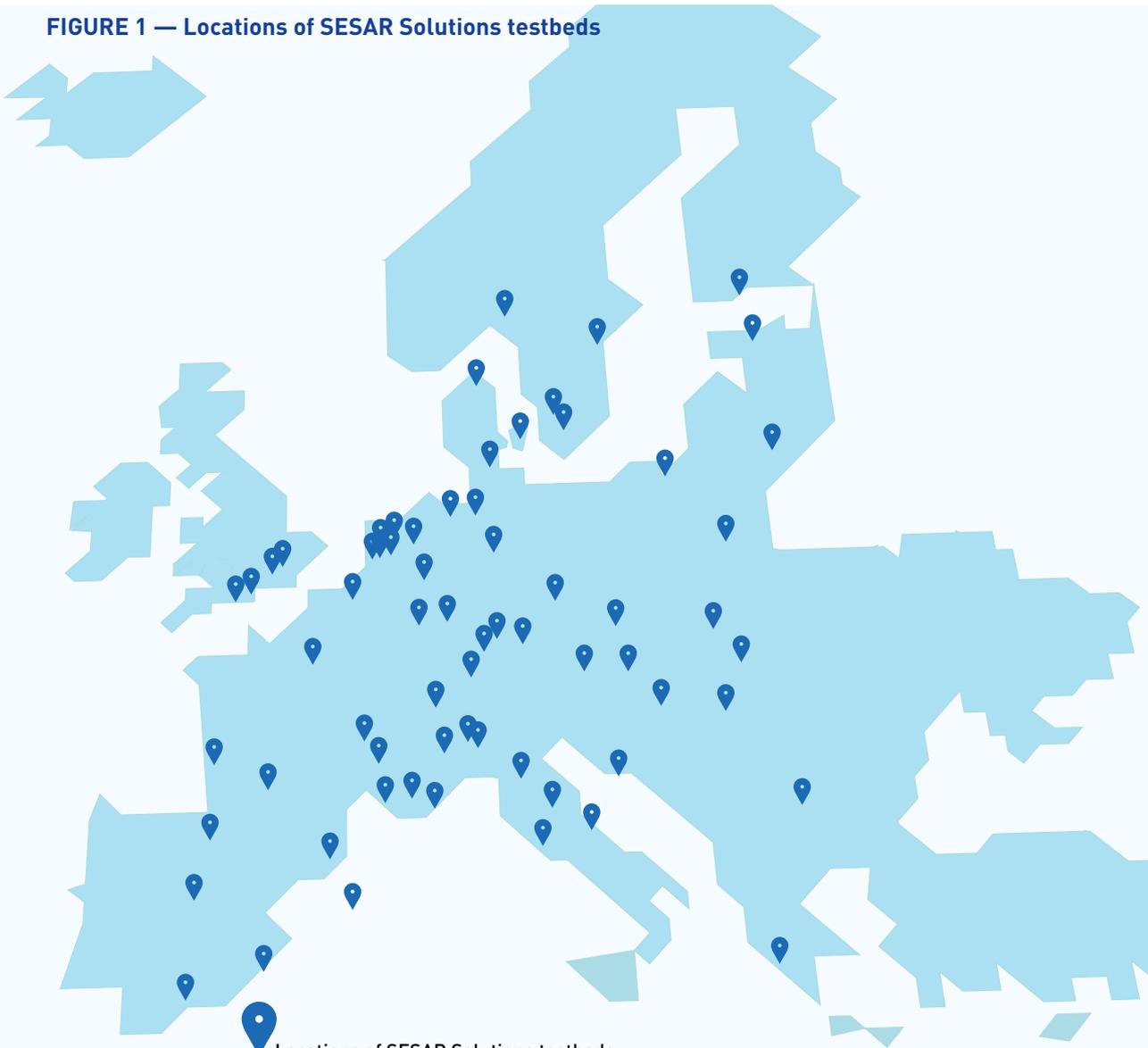
WHO BENEFITS?
 SESAR Solutions meet the business needs of a range of ATM stakeholders. For each solution, the stakeholders targeted by the solution is indicated using the following key:

- ANSP** airspace navigation service providers (civil and military)
- AO** airport operators (civil and military)
- AU** Airspace users (civil and military)
- NM** Network Manager

Out of the lab and tested in real operations

The solutions are the result of collaborative research and development between a wide range of aviation stakeholders, including air navigation service providers (ANSPs) regulators, airport operators, airspace users, the military, manufacturers (air and ground) staff organisations and the scientific community. They follow a process put in place by the SESAR JU known as the release process whereby solutions are tested or validated in real operational environments. Since 2016, SESAR JU members and partners have run over 200 validations at over 50 test beds across Europe (simulation platforms, on-board commercial flights, dedicated airport testbeds and air traffic control centres). Exercises are not limited to a specific location, but can be used to test multiple environments irrespective of the location where the physical validation is held.

FIGURE 1 — Locations of SESAR Solutions testbeds



Locations of SESAR Solutions testbeds

Aalborg, Alicante, Amsterdam, Antwerp, Barcelona, Bordeaux, Bratislava, Braunschweig, Bremen, Brno, Brussels, Budapest, Cascina Costa, Copenhagen, Delft, Ditzingen, Donauwoerth, Eelde, Enschede, Florence, Frankfurt, Gdansk, Geneva, Hamburg, Helsinki, Istres, Logroño, London, Lyon, Maastricht, Madrid, Malmo, Milan, Missolonghi,

Montmagny, Munich, Nice, Odense, Oslo, Palma de Mallorca, Paris, Pescara, Poprad-Tatry, Pourrières, Prague, Prestwick, Rieti, Rome, Rotterdam, Saarbrücken, Sofia, Southampton, Split, Stockholm, Sturup, Stuttgart, Swanwick, Tallinn, Tenerife, Toulouse, Turin, Valence, Vienna, Villacarrillo, Vilnius, Warsaw, Zurich

 Tenerife

What's in this edition?

This edition of the SESAR Solutions Catalogue is divided into three sections:

1

Delivered solutions

This section features 63 solutions, which reached maturity during the first R&D programme, which ran from 2008 to 2016 (SESAR 1). A number of these are mandated for synchronised deployment in Europe in the framework of the Pilot Common Project⁽¹⁾, which requires ANSPs and airspace users to roll out the solutions in a timely and coordinated way. At the same time, local implementation have also started.

2

Candidate solutions in the pipeline

Building on SESAR 1, R&D is underway on a further 79 candidate solutions. A portion of these solutions are on track to be delivered in 2019 (referenced as Release 9), while further testing will continue on the remainder (as candidates for the second wave of R&D), in addition to initiating research on newly-identified candidate solutions.

It should be noted, however, that the contents of this section is subject to re-orientation in light of the next edition of the European ATM Master Plan. This section therefore is very much a look at work in progress, meaning that some of these candidate solutions may not reach maturity or the end of the innovation pipeline.

In addition to some already delivered, a number of candidate solutions have been identified as enablers for optimising the airspace organisation and capacity, as well as bringing scalability and resilience to the system.

3

On the horizon

SESAR looks beyond current research and development to investigate new ideas, concepts and technologies. By advancing promising research ideas and embedding them in a broader programme of work, SESAR is helping to future-proof Europe's aviation industry and to maintain its global competitive edge. This section gives a flavour of this work.

⁽¹⁾ Commission Implementing Regulation (EU) No 716/2014 of 27 June 2014 on the establishment of the Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan Text with EEA relevance

Improving performance

Performance is at the heart of SESAR, which is why every SESAR Solution is assessed and documented according to a set of key performance areas, notably safety, cost efficiency, operational efficiency, capacity, environment, security and human performance. Some solutions bring specific local value, for example the introduction of remote tower services at small regional airports. Others are organised to deliver benefits in a synchronised manner across Europe.

The performance of SESAR Solutions can be measured according to several key performance areas:



Improved predictability: measured by the variability in the duration of the flight;



Reduced costs: refers to the costs associated with air navigation service provision;



Increased airport capacity: refers to runway throughput at 'best-in-class' airports which already operate close to their capacity limit;



Increased en-route airspace capacity: refers to en-route airspace, which is close to saturation



Increased TMA airspace capacity: refers to airspace in the surrounding area of one or more airports (terminal manoeuvring area)



Reduced fuel consumption and emissions: refers to the average reduction in fuel consumption per flight in Europe (at the level of European Civil Aviation Conference).

Delivering SESAR Solutions for industrialisation and subsequent deployment



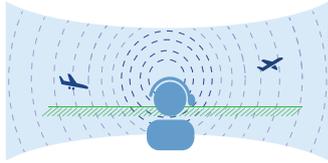
SESAR Solutions that are part of the synchronised deployment plans (PCP) are highlighted in the catalogue with this stamp

Work is underway to industrialise and subsequently deploy many of the delivered solutions in the catalogue (Section 1). This includes the development of operational systems, standardisation activities and development of procedures and systems (up to certification based on the availability of regulatory material).

Over 20 of the already delivered SESAR Solutions are already in this implementation phase or are part of procurement specifications for implementation in many locations across Europe. Examples of these local implementations are given in the catalogue and can be further referenced in the Master Plan Level 2 and 3. At the same time, 27 mature SESAR Solutions have gone into synchronised deployment as part of the EU's Pilot Common Project (PCP)^[2]. The SESAR Deployment Programme, which is managed by the SESAR Deployment Manager, is working to ensure that these solutions delivered by the SESAR JU are synchronised for entrance into everyday operations across Europe, resulting in benefits for airspace users and the environment.

Furthermore, SESAR Solutions are designed in full accordance with the ICAO standards and the Global Air Navigation Plan (GANP) and are therefore applicable to ATM environments. This has led to their take-up in other world regions.

^[2] Commission Implementing Regulation (EU) No 716/2014 of 27 June 2014 on the establishment of the Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan Text with EEA relevance, OJ L 190, 28.6.2014, p. 19-44



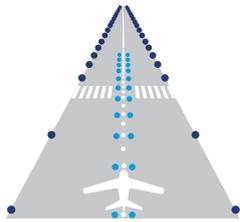
Remote technology at your service

Using the latest video and sensor technologies SESAR is showing how traffic in and out of airports, no matter where they are, can be managed safely from a distance. This enables airports in the remotest parts of Europe to stay open for business and remain connected to the rest of the continent. In 2015, the world's first SESAR remote tower services opened for business in Sundsvall, serving Örnsköldsvik airport over 150 km away. This first deployment has encouraged similar implementation plans, and not just at small airports: Plans are underway at London City and Budapest Airports to deploy this SESAR Solution.



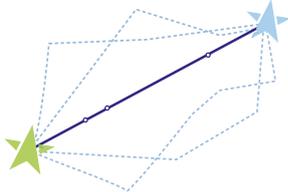
Assigning holding to history

Extended-arrival management (E-AMAN) allows for the sequencing of arrival traffic much earlier than currently the case, so allowing more smooth traffic management. London-Heathrow has implemented the solution and has already cut holding times its arrival stacks by one minute, reducing noise emissions and saving airlines over EUR 2 million in fuel bills and 7,5000 tonnes of carbon dioxide annually. The solution is part of synchronised deployment.



Lights, runway, increased capacity!

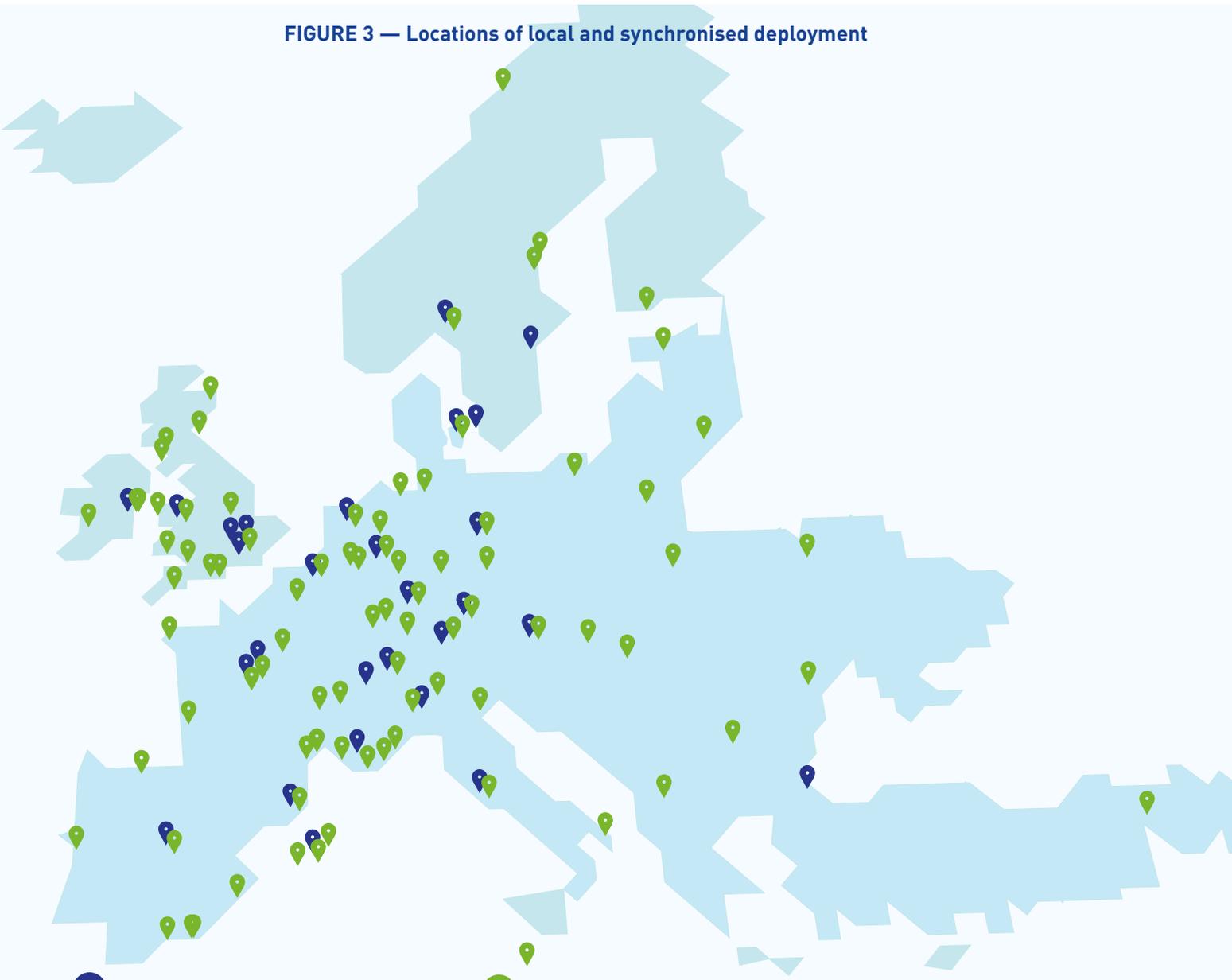
Paris-CDG is one of the busiest airport in Europe with 4 runways and 1,500 flights per day. In 2016, the airport inaugurated Europe's first runway status lights. This solution is a fully automated safety system which provides crews and vehicle drivers with immediate and accurate indication of the runway occupancy status. The system is expected to reduce runway incursion by between 50% to 70% while increasing the airport's runway capacity.



Free route – more choice, less fuel

Currently, aircraft fly an average of 20 km further than the most direct route between two points. With the SESAR Solution, free route, allows airlines to fly the most optimised route in terms of flight and fuel efficiency. The solution is part of Europe's synchronised deployment. For example, in December 2016, free route airspace was implemented in Italian airspace saving airlines 30 million kg of fuel and 95 million kg in CO2 emissions in just one year. When deployed Europe-wide, it is estimated that free route could reduce flying distances by approximately 7.5 million nautical miles, representing the equivalent of 45,000 tonnes of fuel saved, or a reduction in emissions of 150,000 tonnes, or EUR 37 million.

FIGURE 3 — Locations of local and synchronised deployment



Airports deploying SESAR Solutions as part of the EU's Pilot Common Project (Synchronised deployment)

Amsterdam Schiphol, Barcelona El Prat, Berlin Brandenburg, Brussels National, Copenhagen Kastrup, Dublin, Düsseldorf, Frankfurt Int, Istanbul Ataturk, London Gatwick, London Heathrow, London Stansted, Madrid Barajas, Manchester Ringway, Milan Malpensa, Munich Franz Josef Strauss, Nice Cote d'Azur, Oslo Gardermoen, Palma De Mallorca, Paris-CDG, Paris-Orly, Rome Fiumicino, Stockholm Arlanda, Vienna Schwechat, Zurich Kloten

Sample of locations where local SESAR deployments are taking place

Aberdeen, Alicante, Almeria, Amsterdam, Barcelona, Basel, Bergamo Orio al Serio, Berlin, Bodø, Bordeaux, Bremen, Brest, Brindisi, Bristol, Bucharest, Budapest, Canarias, Cannes, Cardiff, Chisinau, Copenhagen, Cote D'azur, Cranfield, Dresden, Dublin, Dusseldorf, Edinburgh, Erfurt, Exeter, Frankfurt, Gdansk, Geneva, Glasgow, Gran Canaria, Helsinki, Ibiza, Karlsruhe, Kiev, Langen, Lisbon, Liverpool, London, Lublin, Lyon, Maastricht, Maastricht, Madrid, Malaga, Malta, Manchester, Marseille, Menorca, Milan, Montpellier, Munich, Munster, Nice, Nîmes, Olsztyn-Mazury, Oslo, Padua, Palma de Mallorca, Paris, Prague, Prestwick, Reims, Riga, Rome, Saarbrücken, Saint-Pierre*, Santander, Santiago & Asturias sectors, Seville, Shannon, Skopje, Strasbourg, Sundsvall, Swanwick, Tallinn, Tenerife, Valenciennes, Vichy, Vienna, Vilnius, Warsaw, Yerevan, Zurich, Örnköldsvik

A catalogue for its time

Addressing the capacity crunch

Europe's skies are experiencing unprecedented congestion while traffic is predicted to increase by 50 % by 2040. The latest edition of the catalogue shines a light on the technology enablers that, if combined with new approaches to airspace configuration and management, can bring capacity to the airspace in the right place and the right time. Closely linked are the enablers for greater scalability and resilience of the system.

Building on what is already delivered in SESAR 1, SESAR 2020 addresses demand and capacity balancing in a series of candidate solutions, which focus on local hotspots and integrate these into the extended planning environment, while others address dynamic airspace configuration measures, flow management and shared trajectory planning to deliver more efficient resource management.

Candidate solutions that support the progressive automation of the system, as well as the virtualisation of data services and enhancements to the CNS infrastructure all offer great potential to optimise the productivity and capacity of the system.

Look out for capacity enablers!



Solutions acting as capacity enablers are highlighted using this icon

Examples of candidate solutions enabling capacity, as well as resilience and scalability:

Management of dynamic airspace configurations (PJ.08-01)

The dynamic airspace configuration (DAC) allows ANSPs to organise, plan, and manage airspace configurations with enough flexibility to respond to changes in traffic demand. The aim is to harmonise airspace management, flow management, and air traffic control during planning phases to deliver a seamless and dynamic process enabled by collaborative decision-making (CDM) between stakeholders.

Collaborative control (PJ.10-01c)

The need for controllers to coordinate traffic at sector boundaries is not always necessary. Seamless airspace allows coordination between air traffic control sectors by exception rather than procedure, and introduces concepts such as sharing of airspace, flight intent and controller intent.

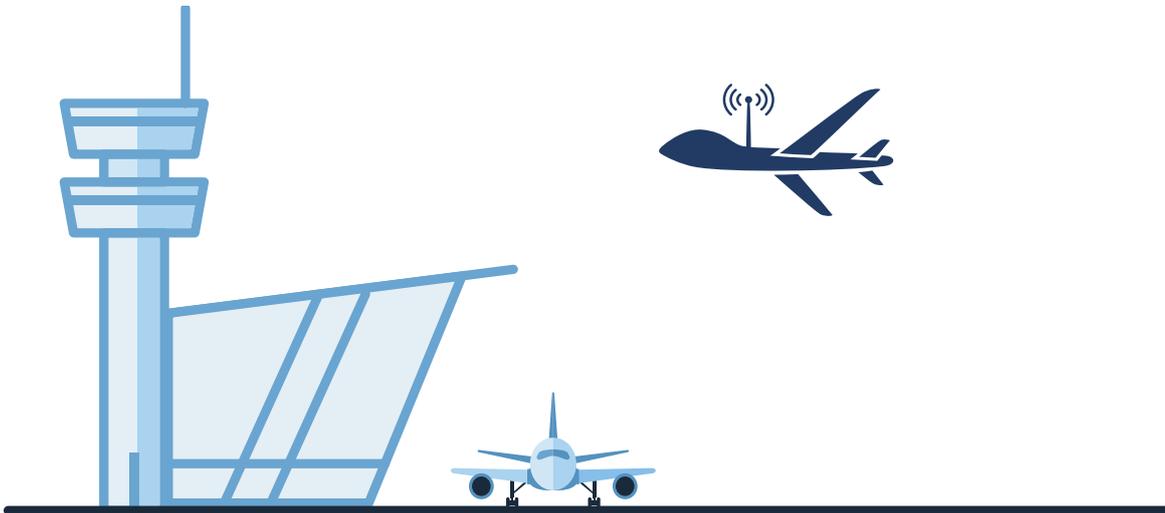
The solution makes use of advanced controller tools to reduce the need for co-ordination agreements, requires fewer boundary constraints, and enables constraints to be applied mid-sector rather than on the boundary.

Delegation of air traffic services (ATS) and contingency (PJ.15-09)

With virtual centres, Europe is breaking away from the conventional architecture for air traffic management. These centres aim to decouple the physical controller working position (CWP) from the remote provision of ATM data and technical services, such as flight data distribution and management. The aim is to enable greater flexibility when it comes to organising air traffic control operations and, in doing so, seamless and more cost-efficient service provision to airlines and other airspace users.

Integrating remotely-piloted aircraft systems into commercial airspace... (PJ.10-05)

SESAR JU is investigating how best to integrate remotely-piloted aircraft systems into non-segregated airspace alongside commercial traffic, particularly in the approach segment of the airspace near airports. Recent tests took place in Malta, Italy and France with future generation civil cargo drone vehicles inserted into commercial manned traffic. The tests assessed how controllers managed the traffic mix and dealt with some of the specificities of large drones, such as the fact that they travel at a lower speed than conventional aircraft.



... and airport surface (PJ.03a-09)

Work is also underway on a solution to enable remotely-piloted aircraft systems access to the airport surface, examining their integration with manned aircraft and compliance with air traffic control requirements. These drones are subject to the same rules, procedures and appropriate performance requirements as any other airport user so, in order to ensure safe airport surface operations. They therefore must be able to interface with ground-based airport systems and demonstrate their ability to act and respond to air traffic control, and other surface users just like conventional aircraft.

The SESAR JU is also researching safe, efficient and secure access to airspace for drones in very low-level (VLL) airspace, within the framework of U-space, an initiative of the European Commission. The services and technologies under development are not presented in this catalogue. More information is available: www.sesarju.eu/Uspace

1 Delivered solutions



High performing airport operations



Advanced air traffic services



Optimised network operations



Enabling aviation infrastructure

This section features 63 solutions, which reached maturity during the first R&D programme, which ran from 2008 to 2016 (SESAR 1). A number of these are mandated for synchronised deployment in Europe in the framework of the PCP, which requires ANSPs and airspace users to roll out the solutions in a timely and coordinated way. At the same time, local implementation have also started.

High-performing airport operations

The future European ATM system relies on the full integration of airports as nodes into the network. This implies enhanced airport operations, ensuring a seamless process through collaborative decision making (CDM), in both normal and adverse conditions. This feature addresses the enhancement of runway throughput, integrated surface management, airport safety nets and total airport management.

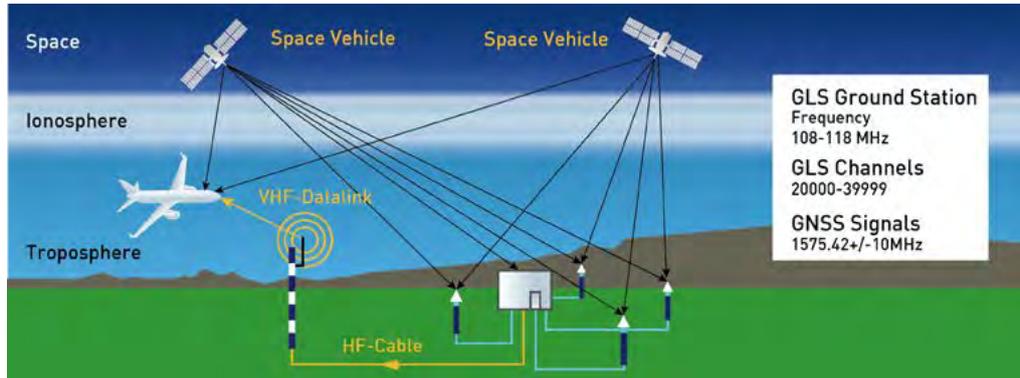




SATELLITES DELIVER PRECISION LANDING GUIDANCE

SJU references:
#55/Release 4

Precision approaches using GBAS Category II/III



STAKEHOLDERS
ANSP
A0
AU
NM

For more than 50 years airports have relied on instrument landing systems (ILS) to provide pilots with approach and landing guidance in low-visibility conditions, such as heavy rain and low cloud. Although the system has proved to be reliable and functional, ILS is costly to maintain and has operational limitations that reduce runway capacity in certain conditions. It is no surprise then that airports are turning to other solutions, such as ground-based augmentation of satellite navigation systems (GBAS), to meet their capacity needs and reduce delays and disruptions for airspace users and passengers.

GBAS uses four global navigation satellite system (GNSS) reference receivers and a VHF broadcast transmitter system. Its ground system measures distances to GNSS satellites (e.g. Galileo), and computes error corrections and integrity data based on signal quality and known fixed positions of the GNSS reference receivers. Together with the approach path and quality information the corrections are broadcast as digital-coded data to all GNSS landing system (GLS)-equipped aircraft within range. The aircraft receives this information, calculates the (differentially) corrected position and deviations from the selected approach path, allowing it to land automatically in low-visibility conditions.

GBAS CAT II/III can enable precision landing in low-visibility conditions, helping to maintain safety and capacity performance. SESAR validations have shown that the GBAS CAT II/III can overcome challenges posed by low-visibility conditions, reducing runway blocking times and thereby increasing arrival capacity (by between two and six aircraft per hour) compared to ILS.

Over 90 flights were conducted using several prototype systems, and the results are being used to help develop common standards at an international level. The work continues in parallel with the development of airborne GNSS landing system (GLS), the avionics required for GBAS-controlled landings. Assuming that standardisation and regulation progress as planned, the entry into service of GBAS Category II/III is expected in the 2018-2019 timeframe.

GBAS requires lower installation and maintenance costs compared to conventional instrument landing systems (ILS)

This solution is linked to ICAO's Annex 10 on Gost D standard and EUROCAE's ED-114

BENEFITS

- Improved resilience by limiting the capacity reduction in degraded situations and by avoiding critical and sensitive areas)
- Reduced installation and maintenance costs compared to ILS
- Maintained level of safety
- Greater frequency efficiency
- Improved environmental impact due to shorter routes and noise abatement

This solution is planned for implementation in at least 11 airports in 7 Member States: Germany, Spain, France, Italy, Poland, Portugal, and Sweden.



SJU references:
#117/Release 7

ENABLING ACCESS TO AIRPORTS IN LOW-VISIBILITY CONDITIONS

Reducing landing minima in low-visibility conditions using EFVS to land

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Improved access to secondary airports
- Operational and cost efficiency

With the main airport hubs becoming busier, secondary gateways will come to the fore, dealing not only in an increasing number of scheduled flights but also acting as an important alternative for diverted flights. It is therefore crucial that accessibility to those airports in degraded weather conditions is enhanced. However, these airports have limited resources to invest in advanced ground infrastructure.

One option is to take advantage of enhanced flight vision systems (EFVS) that are located on board the aircraft and can be used by all aircraft types. Delivered by SESAR in 2018, the system can be displayed to the pilot using a heads-up display (HUD) or equivalent display such as coloured helmet-mounted display, and advanced vision sensors. These technologies provide the required enhanced flight visibility in certain visibility-limiting conditions.

These features make the solution a useful capability for airspace users in the business aviation regional and even commercial airspace users, to access to secondary non CATII/III airport, fitted with performance-based navigation (PBN) or ILS instrument approach procedures. This solution allows secondary airports operators with limited resources to reduce landing minima with no additional infrastructure and maintenance cost, provided the aerodrome has been declared suitable for EFVS operations.

The solution in line with EASA's regulatory framework for all weather operations (NPA 2018-06), and is undergoing pre-deployment trials as part of SESAR's Augmented Approaches to Land (AAL2) large-scale demonstration.

Research continues on new emerging sensors technologies such as radar, in order to further enhance performance levels in very low visibility operations (see #PJ.03a-4).



CAPACITY GAINS WITH TIME-BASED ARRIVALS

SJU references:
#64/Release 2

Time-based separation



Today, aircraft making their final approach to land are obliged to maintain minimum separation distances. These distances are fixed whatever the wind conditions. When keeping to these distances in strong headwinds longer gaps of time develop between aircraft. This means fewer flights landing per hour (reduced airport capacity), leading to delays and increased holding at busy times, which results in increased fuel burn.

SESAR's time-based separation (TBS) replaces current distance separations with time intervals in order to adapt to weather conditions. It provides consistent time-based spacing between arriving aircraft in order to maintain runway approach capacity.

The TBS software uses real-time information about the weather, airspeed, ground speed, heading and altitude to display time-based separation and arrival speed information to the approach controller. No changes are required on board the aircraft, but the controller uses the real-time separation indicators to manage the final approach separations.

TBS research included analysis of the arrival paths of over 100,000 aircraft using state-of-the-art equipment to measure the behaviour of aircraft wake vortices. The procedure now is in daily use at London Heathrow, where, in strong wind conditions, it delivers up to five additional aircraft landings with TBS per hour compared to traditional distance-based separation procedures. TBS results in an average reduction of 0.9 minutes holding time, and an average reduction of 1.4 minutes between stack-entry and touchdown times.

The SESAR Solution is available for industrialisation. TBS entered into full-time service at London-Heathrow in March 2015. The solution is part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.

Analysis has shown that there has been no increased risk to wake turbulence encounters, and no increase in the number of go-arounds following introduction of time-based separation at London Heathrow

This solution is linked to Eurocontrol's TBS specifications (STD-065)

STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- Improved airport capacity as a result of increased aircraft landing rates in strong headwind conditions
- Reduction in holding times as well as stack entry to touchdown times
- Increased situational awareness





SJU references:
#22/ Release 5

EFFICIENT PLANNING AROUND THE AIRPORT

Automated assistance to controllers for surface movement planning and routing

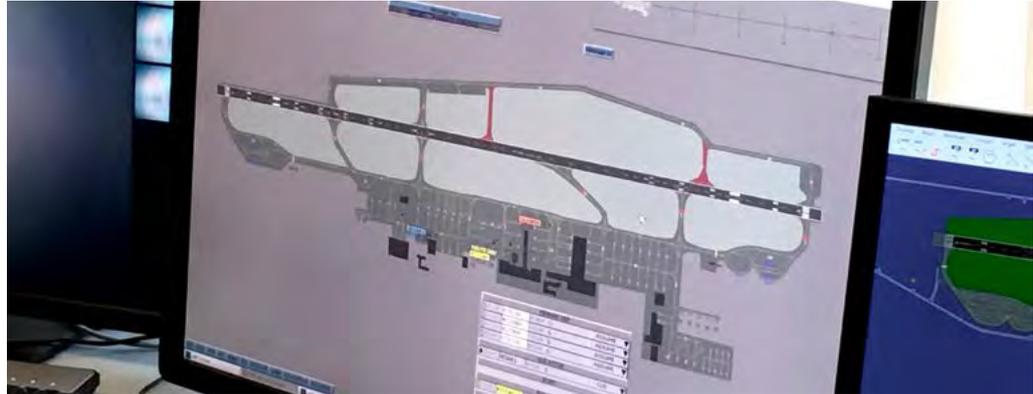
STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Improved predictability**
- **Enhanced safety**
- **Increased capacity**
- **Improved taxi times resulting in reduced fuel burn**

The SESAR surface route planning function automatically generates taxi routes which are then displayed on the controller working position. The software uses flight plans and current operational data to calculate the optimum route for each aircraft. It also calculates the taxi time, which can then be used for departure planning purposes. The controller can graphically edit the route before relaying it to the pilot by voice, or where possible by datalink.

By generating an electronic route plan, the information can be shared not just with the cockpit, but also with the airline operations centre, air traffic control and other operators on the airfield. It is less prone to error than route plans agreed solely based on controller/pilot communication, and it increases air navigation service productivity. The route plan is also available for use with other solutions such as enhanced guidance assistance tools (through airport moving maps in aircraft and vehicles or through the airfield ground lighting) to provide guidance instructions for pilots or vehicle drivers on the airfield.

Trials revealed a reduction in variability between the planned and actual taxi time compared with current operating methods. Efficiency of surface operations is also improved since pilots and vehicle drivers can receive optimum route plans. Safety is also enhanced, particularly in low visibility, as controllers can rely on a graphical display of the routes assigned to aircraft and vehicles.

This SESAR solution is available for industrialisation. The solution is part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.

The route planning functionality allows controllers to graphically edit routes and automatically compute estimated taxi times, contributing to more predictable surface operations

This solution is linked to EUROCAE standards ED-87C and ED-87D





IMPROVED COMMUNICATIONS THANKS TO DATALINK

D-TAXI service for controller-pilot datalink communications (CPDLC) application

SJU references:
#23/Release 5



Radio channels become congested and hard to access during periods of busy traffic. Yet the majority of transmissions are routine exchanges between the controller and the flight deck to confirm instructions such as pushback clearance, start-up and taxi instructions. Datalink provides a more efficient means to relay these messages and is less prone to error.

Aircraft already use datalink in oceanic airspace to send position updates and request route changes, and the technology even now delivers pre-departure instructions to pilots at the gate. SESAR is testing message exchanges on the airfield using controller-pilot datalink communications (CPDLC) on board modern aircraft. The service is supported at some airports with advanced controller working positions, and simulations are also underway looking at protocols and operational procedures. The delivery by datalink of information and clearances during the taxi phase is known as D-TAXI. The solution aims to reduce voice communications by exchanging non-critical message between controllers and flight crew by datalink. Radio remains available at any time and is still used on first contact with the controller for radio check and for safety or time critical clearances like line-up and take-off.

A combination of simulations and live trials assessed the performance of the solution in different traffic densities, with different levels of aircraft equipage. Datalink messages were exchanged to initiate start-up, push back, taxi, revised taxi and further route information (such as de-icing). The exercises also used SESAR routing and planning functions to obtain the most suitable taxi route. The activity aims to improve the safety of surface movements.

This solution is planned for implementation in Lisbon and three airports in Germany.

This service aims to reduce radio transmissions by exchanging routine and non-safety critical messages by datalink

This solution is linked to RTCA and EUROCAE standards, namely DO-350A/ED-228A, DO-351A/ED-229B

STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- Provides reliable, repeatable message sets for non-safety critical exchanges
- Frees up congested radio channels enhances safety at busy airports
- Delivers instructions more effectively, allowing the pilot and controller to focus on other operational issues



SJU references:
#26/Release 5

TAXI ROUTE DISPLAY FOR PILOTS

Manual taxi routing function

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Enhanced safety**
- **Improved predictability**
- **Increased efficiency in surface operations**
- **Reduced fuel burn and emissions**

Navigating the route between the departure gate and the runway can be complex and becomes harder during low-visibility conditions or at night. To provide extra guidance - in addition to today's airfield signage and ground lighting - SESAR is developing other tools to help the pilot.

Presenting a graphical display of the taxi route instructions received from air traffic control provides another means for the flight crew to check they are following the right route. The on-board moving map of the airfield can be overlaid with the taxi route so the pilot can see exactly where the aircraft is in relation to the cleared route. If the taxi clearance is sent via datalink, through the D-TAXI service, the corresponding message is interpreted and translated as a graphical path by the on-board moving map database. If the taxi clearance is sent via voice, the flight crew can enter it manually into the airport moving map.

The solution uses technology, such as the electronic route planning system the controller employs, to select the optimum taxi route. It also makes use of controller-pilot datalink communications (CPDLC) to relay the route to the cockpit, and could be linked with airport safety nets to warn of potential hazards. The graphical display of the taxi route instructions increases the flight crew's situational awareness, notably in low-visibility conditions and at aerodromes with which they are not familiar. The solution provides an extra layer of safety for the flight crew, in addition to visual signals and voice communications. Aircraft are more likely to comply with taxi route instructions without delay.

This SESAR Solution is available for industrialisation.

A graphical display of the taxi route on the airport moving map increases the flight crew's situational awareness, notably in low-visibility conditions or an airport with which they are not familiar

This solution is linked to several industry standards: RTCA DO-272D/EUROCAE ED-99D, RTCA DO-291C/EUROCAE ED-119C, RTCA DO-342/EUROCAE ED-220, ARINC 816-3



FOLLOW-THE-GREENS

Guidance assistance through airfield ground lighting

SJU references:
#47/ Release 5



Airfield ground lighting offers a unique opportunity to guide aircraft and vehicles around the airport. By linking the lighting infrastructure with the taxi route management system, the airport can provide an unambiguous route for the flight crew and vehicle driver to follow.

The solution requires advanced technology within the lights themselves, and in the ramp control tower. The airfield lighting control system needs to turn on the lights ahead of an aircraft, and off immediately behind. To achieve this, taxiway centre line lights are automatically and progressively switched on in segments (or individually) as the aircraft (or the vehicle) moves along its assigned route. Pilots and vehicle drivers receive a single instruction to 'follow-the-greens' from air traffic control (ATC). If stop bars are implemented to protect no-go areas, they are also automatically commanded. The solution also relies on the surface movement guidance and control system to provide accurate aircraft position data.

The solution improves the safety of surface operations, especially during low-visibility conditions, through a reduction of runway incursions, taxi route deviations and holding position overruns. It increases situational awareness and improves the predictability of surface movement through a reduction in the variability of taxi times. The fewer speed changes also result in lower fuel consumption. As taxi speeds are globally increased, apron throughput is improved.

SESAR validations used a combination of simulation exercises, shadow-mode trials using vehicles to represent aircraft and several live trials with commercial aircraft. In all cases, the trials showed that the use of the lighting system can significantly help to reduce taxi times and also reduce the duration of stops during taxiing, improving efficiency. Fewer radio transmissions were required, freeing up controllers' time for other tasks. Based on more than 650 movements, one of the airports at which the solution was validated recorded a 25 % reduction in taxi time, while radio transmissions fell by the same amount. Clearance delays (the time between the pilot's push back request and actual clearance) fell by two thirds.

This solution is now implemented in Riga and planned for Zurich, Schiphol and Lisbon airports.

STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- Improved predictability
- Enhanced safety
- Reduced fuel burn, noise and emissions
- Increased apron throughput

This solution couples taxi route management with the airfield ground lighting, in order to provide flight crew and vehicle drivers with supplementary means of guidance

This solution is linked to EUROCAE standards ED-87C and ED-87D



SJU references:
#48/ Release 5

ENHANCING SAFETY WITH VIRTUAL STOP BARS

Virtual block control in low-visibility procedures

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Improved predictability
- Enhanced safety
- Reduced fuel burn and emissions

Supporting controllers and flight crew is especially important in low-visibility conditions. A line of red lights, known as stop bars, are already used to prevent aircraft entering a runway without air traffic control clearance. In addition to these physical safety nets, SESAR is advancing a novel virtual stop bar solution.

During low-visibility conditions, the ground controller can introduce procedural control to maintain safe separation, requiring clearance for aircraft to enter different areas. SESAR has developed virtual stop bars to support the ground controller in providing surface movement guidance at these times, displaying red stop lights on the controller's display. The virtual stop bars can be used by the controller to reduce block sizes according to the conditions.

If the airport surface surveillance system identifies an infringement, the controller's display receives an alert. These virtual stop bars are a valuable defence against aircraft and vehicles inadvertently entering an area without clearance from the ground controller. Providing alerts on the ground controller's display enhances safety.

Real time simulations tested the solution also investigating the use of datalink communications with aircraft as well as airfield vehicles.

This solution is now implemented in Riga and planned for implementation in Gdańsk.

Virtual block control is an operational concept for improving weather resilience and safety at airports

Virtual stop bars alert controllers of any kind of unauthorised movement by aircraft or vehicles in the area of the runway

This solution is linked to EUROCAE standards ED- 87C and ED-87D



ENHANCING SAFETY AT BUSY AIRPORTS

SJU references:
#02/Release 5

Airport safety nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

As traffic rises, airports face the challenge of more ground operations and surface traffic moving across runways, taxiways and aprons. In addition to safety initiatives driven by ICAO, a series of automation tools have been developed by SESAR partners to provide valuable safety nets in this area.

BENEFITS

- Increased situational awareness
- Improved safety in airport operations
- Enhanced safety and situational awareness

As part of advanced surface movement guidance and control systems (A-SMGCS) activities, new generation automation systems have been included in validations to see how various tools can operate together to provide integrated airport safety nets. These validations assessed the relevance of alerts to tower controllers in case of conflicting clearances (e.g. line up and landing clearances given at the same time on the same runway) and in case of mobile behavior (i.e. aircraft or vehicle) not complying with ATC instructions or procedures.

The introduction of electronic flight strips in many control towers means that instructions given by a controller are available electronically and can be integrated with other data such as flight plan, surveillance, routing and published rules and procedures. The integration of this data allows the system to monitor the information and alert the controller when inconsistencies are detected.

This solution highlights potential conflicts much sooner than current safety nets for runway operations which rely only on surveillance data to trigger an alarm. Moreover, the automatic conflicting ATC clearances (CATC) alert system can be configured to detect non-conformance to ATC instructions or procedures anywhere in the movement area.

This SESAR solution is available for industrialisation. These airport safety nets are part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.

This solution is linked to EUROCAE standards ED-87C and ED-87D





SJU references:
#70/Release 3

SURFACE SAFETY IN ALL WEATHER CONDITIONS

Enhanced ground controller situational awareness in all weather conditions

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Operational acceptance of airport safety nets**
- **Increased situational awareness in low visibility conditions**
- **Enhanced safety thanks to the generation of real alerts**

Ground controllers face the challenge of managing not just arriving and departing aircraft, but also guiding the service and emergency vehicles that support safe operations at the airfield. Adding surface safety nets to the controller's display offers a means to provide early warning of potential conflict situations.

Developing and implementing airport safety tools is fundamental to SESAR objectives to triple capacity and increase safety by a factor of 10. Safety nets rely on information received from surface surveillance (automatic dependent surveillance – broadcast (ADS-B) messages emitted by aircraft and vehicles), flight data including clearances given, and taxi routes assigned. Built-in monitoring rules can be configured to an individual aerodrome in order to trigger alerts for the main conflict situations. Warnings can also be activated when meteorological data signals adverse weather.

The solution develops further ADS-B applications to improve ground surveillance systems in terms of safety, performance, interoperability and security. Data quality is increased with regard to the current surveillance system by means of improved surveillance data. The ADS-B ground station is enhanced to check the validity of the ADS-B derived data and to discard possible spoofing messages as well as messages transmitted by erratic ADS-B transponders, guaranteeing an improvement of the surveillance in terms of security and safety

SESAR validation activities demonstrated an increased situational awareness in low-visibility conditions. As a result of the operational acceptance of the research, the solutions were seen as suitable for development as part of surface movement guidance and control activity.

This solution is ready for industrialisation. The solution has been implemented in Budapest, Geneva, Helsinki, Riga, Paris Charles de Gaulle and Paris Orly, Vienna, Zurich. Implementations are planned in Germany, Denmark, Estonia, Poland and Portugal.

The solution provides the controller with the position and automatic identity of all relevant aircraft and vehicles in the movement area

Developing and implementing airport safety tools is fundamental to SESAR objectives to triple capacity and increase safety by a factor of 10

This solution is linked to RTCA standard DO-260B



VISUAL SIGNALS TO SAFEGUARD RUNWAY USERS

Runway status lights

SJU references:
#01/Release 5



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

Runway incursions are among the greatest risks in airport operations today. By installing lights which automatically alert when it is unsafe to enter a runway, airports can provide runway users with an early warning of a potential hazard.

Major airports rely on surface surveillance systems such as surface movement radar (SMR) to provide the tower controller with a visual picture of surface movements in real time. Adding safety tools for controllers, for example, to highlight non-conformance alerts or route deviation, ensure safe and accurate guidance around the airport by virtue of the advanced surface movement guidance and control system (A-SMGCS). A pilot navigating to and from the runway also relies on visual signage, and this equipment can receive information at the same time as the tower, saving crucial seconds.

Runway status lights (RWSL) include three types of high intensity LED lights: runway entrance lights (RELs), warning an aircraft about to enter the runway from a taxiway that the runway is not safe to enter, take-off hold lights (THLs) warning pilots that it is not safe to take-off from the runway, and runway intersection lights (RILs) to prevent flight crew and vehicle drivers from entering or crossing an active runway that is already occupied. Embedded in the pavement, the red warning lights alert the pilot or the vehicle driver the instant the runway is unsafe due to the detection of mobile behavior by the A-SMGCS.

Runway status lights (RWSL) are fully automatic and require no input from controllers, airport operators or flight crew

Linking intelligence about airfield surface movements with airfield lighting enhances surface safety for aircraft and vehicle movements

The RWSL are unique in providing instant visual alerts, and operate simultaneously with, and in addition to, other safety nets such as on-board alerts and air traffic control safety nets. The system improves awareness of runway usage, and reduces the risk of collisions on the runway. It applies equally to aircraft and vehicle traffic and does not require additional equipment in the cockpit or driver's cab.

This solution is now implemented in Zurich and Paris Charles de Gaulle airports.

BENEFITS

- **Enhanced runway safety**
- **Increased situational awareness**



SJU references:
#04/Release 5

PROVIDING VEHICLE DRIVERS WITH ENHANCED VISUAL TOOLS

Enhanced traffic situational awareness and airport safety nets for vehicle drivers

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Increased situational awareness
- Increased safety in airport operations

Driving an airfield vehicle on the airport should be straightforward in normal operational conditions. But how do you ensure you are following the correct route when in dense fog, or at night, or when an unforeseen event occurs? And more importantly, how do you ensure that you are not entering a safety critical area without a clearance, putting you and the other mobiles' safety at risk?

Busy airports monitor airfield activity using a range of sensors and tracking systems. This information can also be used by vehicle drivers to improve safety. By fitting a screen in the vehicle, the driver can access an airport moving map, can see information regarding surrounding traffic, and can receive alerts if a dangerous situation arises. Warnings can include those related to possible collisions with an aircraft on a runway or taxiway, infringements of a runway, or a closed or restricted area.

SESAR has carried out a series of validation exercises in different locations in various traffic and visibility conditions. Alerts were generated either by an on-board system on the dashboard, or were uplinked from the ground aerodrome surveillance system enhanced with a dedicated function calculating alert situations relevant for vehicle drivers.

The trials developed the requirements for the display of information related to the surrounding traffic, including aircraft and vehicles operating on or near an active runway. The tests also established connectivity between the central system and vehicle, as well as the use of mobile devices.

This solution is planned in Vienna, Copenhagen, Paris Orly, Milan Malpensa and Rome Fiumicino.

SESAR demonstrated through extensive live trials the significant benefits of this SESAR Solution in terms of situational awareness and safety

This solution is linked to EUROCAE standards ED-102, ED-102A and ED-102+



A BASELINE FOR ON-TIME DEPARTURE

SJU references:
#106/Release 1

Departure manager (DMAN) baseline for integrated AMAN DMAN



Waiting in a queue for take-off burns unnecessary fuel, generates delay and unpredictability and is frustrating for passengers. Fortunately, we encounter these queues less and less, due to a large extent to the way the departure management process is transforming departure time from an informed estimate into a precise art.

The departure manager (DMAN) tool takes into account the scheduled departure times, slot constraints, runway constraints and airport factors. In doing so, it improves traffic predictability, cost efficiency and environmental sustainability, as well as safety. By taking into consideration information such as the aircraft's readiness to leave its parking stand, runway capacity and slot constraints, tower controllers can optimise the pre-departure sequence.

In order to calculate reliable sequences, DMAN needs access to accurate information about the status of individual flights and airport resources from different systems. The airport collaborative decision-making (A-CDM) platform supports this information exchange. For example, the airline or ground handler can provide the target off-block time (TOBT), while the tower controller uses tables which generate variable taxi times to achieve the target take-off time (TTOT). Information about departure slots or calculated take-off times (CTOTs) is sourced from the Network Manager, responsible for flow control across the whole of Europe.

SESAR's baseline DMAN was validated in a series of live trials with a particular focus on delay reduction. Controllers were able to establish pre-departure sequences by using DMAN in conjunction with airport collaborative decision-making procedures involving local airport and airline partners. The system provides a baseline for further development of DMAN procedures, taking advantage of the wider adoption of airport collaborative decision making among stakeholders. The basic operational concept also supports DMAN integration with arrival manager (AMAN) and advanced surface movement guidance and control system (A-SMGCS).

The trials demonstrated improved performance in terms of predictability of off-block time by 7.8 %, with 85 % of flights achieving the five-minute window available. It decreased average taxi times by 9 %, and improved adherence to flow management slots, with 81 % of flights departing on their allocated slot compared with 76 % prior to DMAN. The solution contributed to average reduction of 14.6 kg of fuel per flight, and also supports enhanced tactical scheduling.

The solution has been implemented at Paris Charles de Gaulle Airport.

STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- Improved predictability and stability of departure sequence, start-up approval time and off-time blocks
- Enhanced tactical runway scheduling
- Reduced waiting and taxi times and runway delays
- Significant reduction in fuel burn and CO₂ emissions

DMAN lends itself to tactical scheduling by calculating optimum pre-departure sequences based on information provided by airport, airline and air traffic control sources (A-CDM processes)

This solution is linked to EUROCAE standards ED-87C and ED-87D



SJU references:
#53/Release 4

IMPROVING ON-TIME DEPARTURE

Pre-departure sequencing supported by route planning

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Reduced waiting time at the runway holding point, which saves fuel and allows air navigation service efficiency**
- **Increased accuracy of taxi time-out predication and hence take-off time predictability, which in turn allows the aircraft to adhere to their target take-off time (TTOT)**
- **Provision of a more stable pre-departure sequence**

A row of aircraft lined up ready to depart might deliver maximum runway efficiency, but contributes little to efficient fuel use and reducing noise and emissions. While all departures are carefully planned, SESAR is looking at ways to enhance the process and introduce efficiencies right from push-back.

Pre-departure management delivers optimal traffic flow to the runway by factoring in accurate taxi time forecasts and route planning derived from static data. This can help to reduce waiting time at runway holding points, and improve take-off time predictability. Accuracy can be improved if the departure manager (DMAN) takes into consideration data provided by the advanced surface movement guidance and control system (A-SMGCS). This can account for where the aircraft is parked, taxi route length and tactical adjustments such as temporary restrictions. Just how much current operations - which rely on collaborative decision making to estimate taxi times - can be enhanced by access to dynamic data depends upon the individual airport and the quality of data available.

SESAR trials using this dynamic route planning information resulted in more accurate calculations of the departure sequence, and improved predictability and stability of both target times and actual times. In particular, the sequence assigned to each flight for target start-up time, and for target take-off time, improved with the use of route planning information. For busy single runway airports, predictable operations result in better use of the available capacity.

Trials showed that the solution leads to reduced waiting time at the runway holding point, saving fuel and improving efficiency. It also increases the accuracy of estimated taxi time and hence take-off time predictability, which in turn allows the aircraft to adhere to target take-off time. Finally, the more stable departure sequence benefits airport operations overall, and is used in turn by the Network Manager to optimise traffic flow.

This solution is available for industrialisation. DMAN synchronised with pre-departure sequencing is part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.

Airports where taxi route lengths can vary significantly benefit the most from taxi times calculated using planning information from the surface movement guidance and control system

This solution is linked to EUROCAE standards ED-87C and ED-87D





EXTENDING THE PLANNING HORIZON

Flow-based integration of arrival and departure management

SJU references:
#54/Release 4



Knowing exactly when an aircraft is due to arrive has a direct impact on airport efficiency, especially if arrivals and departures are handled on the same runway, or on dependent runways. Improving coordination between en-route controllers, approach and tower controllers results in more accurate information about the arrival sequence that can lead to more predictable airport operations.

By integrating the activities of the arrival manager (AMAN) and the departure manager (DMAN) tools, an optimisation algorithm can calculate the ideal traffic flow that takes account of both arriving and departing aircraft. Departure flow to the runway is managed by the pre-departure sequencing planning tool, while arrival flow to the runway is managed by arrival metering. Arrival and departure flows to the same runway (or for dependent runways) are integrated by setting up a fixed arrival-departure pattern for defined periods. The successive pattern might be chosen by the operators or provided by an optimisation algorithm which takes account of arrival and departure demand. The solution is an enabler for accurate runway sequencing and facilitates long-range planning such as extended arrival management. It results in increased predictability, which leads to high capacity and less fuel burn, and better coordination between controllers.

The concept of coupling AMAN-DMAN to produce an accurate runway sequence has been validated at an exceptionally busy single-runway airport. The advanced surface movement guidance and control system also provided data on target push-back, taxi- and take-off times. The tests resulted in increased predictability in terms of target take-off time and target landing time, because the sequence offered by the system contributed to more accurate controller clearances.

This solution is planned for implementation at the following airports: Vienna, Paris Charles de Gaulle, Milan Malpensa, Rome Fiumicino, Riga, Warsaw Chopin.

Controllers delivered positive feedback about the integrated sequence, information sharing and the ability to input multiple runway patterns

STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- Increased predictability resulting in increased runway throughput
- Reduced fuel burn



SJU references:
#71/Release 3

REMOTE TOWER SERVICES FOR SMALL AIRPORTS

ATC and AFIS service in a single low-density aerodrome from a remote controller working position (CWP)

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Increased cost efficiency**
- **Increased accessibility to and support for regional economies**

Small or local airports are a life-line for a local economy, however they cannot always afford to operate a control tower around the clock. SESAR's remote tower services offer the means to provide air traffic services in a cost-efficient way to such airports, as well as non-towered ones.

By installing sensors (mainly video cameras) around the airfield, the operator can monitor activity such as runway occupancy, weather, and visibility in real time. Data is relayed back to a remote control centre where a qualified operator is on hand to provide aerodrome flight information services (AFIS) or air traffic control services for arrivals and departures. With access to a range of visual, audio, and meteorological data, the remote facility can provide services which may not be available onsite around the clock.

In a series of real-time simulations and passive shadow-mode trials (i.e. the controllers participating in the validation 'shadowing' the instructions given by the operational controllers in the real tower), controllers used high resolution imagery and enhanced functionalities to provide advisory services to a remote location. As a result, safety was maintained in normal and degraded conditions and controllers welcomed the enhanced visual tools. The concept supports extended operational hours with lower overall staffing costs. It also supports development of regional economies.

The solution is available for industrialisation. Conclusive validation results prompted Sweden to build the world's first remotely operated tower at Örnköldsvik, controlled remotely from Sundsvall centre over 150 km away. The facility was fully certified by the Swedish Aviation Authority in 2014, and two more regional airports are implementing similar technology. In 2018, air traffic controllers from DFS, the German air navigation service provider, began controlling traffic at Saarbrücken Airport from a site 450 kilometres away to the east in Leipzig.

In 2014, the world's first remotely-operated tower was opened at Örnköldsvik, controlled remotely from Sundsvall centre over 150 km away

Operational standards for remote tower services (addressed by EUROCAE WG-100) currently match those for real operations and approval is based on the same service delivery requirements as existing ICAO rules



REMOTE TOWER SERVICES BENEFIT MEDIUM-SIZED AIRPORTS

SJU references:
#12/Release 5

Single remote tower operations for medium traffic volumes



STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- **Increased cost efficiency**

Conventional control towers are expensive to operate and maintain, and even at a medium-sized airport can become too costly if the number of flights is insufficient to cover the running costs. SESAR's remote tower services offer the possibility to enhance safety and efficiency at airports where it is too expensive to build, maintain and staff conventional tower facilities and services. The solution is already deployed at small airports, and is under test at medium-sized airports.

Providing air traffic control services from a remote location can spread staffing costs, improve service continuity with the option to extend hours of service, and share training and support costs. The out-of-the-window view from the tower can be captured and reproduced at a remote facility where controllers can access all the information usually found in the tower. The visual reproduction can also be overlaid with information from additional sources and enhanced through technology for use in all visibility conditions. In addition, the controllers have access to all the necessary remote controls, including communications, lighting, flight data, and meteorological information.

Tests have demonstrated the solution's feasibility using different technology and sensors. Sophisticated camera equipment, some sourced from the military sector, are considered in the scope of this solution; while day/night cameras, infrared, and pan-tilt-zoom functions deliver the level of detail and accuracy required to safely provide ATS services. The tower-like environment at the remote facility can be enhanced with visual alerts, track labels added to flight targets, and hot spots regularly camera-checked to deliver additional safety features.

Single remote towers offer an efficient way to deploy operational staff resources by means of a remote tower centre providing single tower services to a number of airports

The standardisation work on remote towers is addressed by EUROCAE WG-100

Shadow-mode exercises used a video-based panorama camera system as well as infrared technology to give controllers a detailed view of the airfield. The tests provided enhanced views of the airfield and terminal area, even during adverse weather conditions and at night. Single airport operations will apply in each case, but controllers will have the option to cross-train for more than one airport.

The SESAR Solution is available for industrialisation and is the model for the ongoing projects in Norway, Germany, UK, Hungary and Ireland.



SJU references:
#52/Release 4

MANAGING MULTIPLE SMALL AIRPORTS, REMOTELY

Remote tower for two low-density aerodromes

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Operational and technology-related cost efficiency

Having proved controllers can provide air traffic control services to an airport remotely, SESAR validated the feasibility of providing simultaneous services to two airports from a single location.

The solution offers new possibilities for small or local airports where building, maintaining, and staffing a conventional tower is unaffordable. It promises more efficient and cost-effective deployment of operational resources, improving service continuity and maintaining safety at the same time.

The concept draws on a range of advanced technology, including high-definition cameras, Infrared, and pan-tilt-zoom cameras to deliver the information the controller wants to see in real time. Video camera data can be integrated with existing surveillance sources to identify and track targets.

In SESAR validations, a control facility provided controllers with an out-of-the-window view and working position that supported two low-traffic density airports located remotely, and allowed the controller to switch seamlessly between the two. Like an onsite manned tower, the controller has access to data from supplementary sensors and software tools that significantly enhance the visual information on display, and SESAR partners have identified a core set of functionalities needed to deliver air traffic services to multiple airports.

This solution is available for industrialisation. Since 2018, Norway is delivering aeronautical flight information services to five small airports from one central facility at Bodø.

Multiple remotely controlled airports contribute to SESAR cost-efficiency performance targets

The standardisation work on remote towers is addressed by EUROCAE WG-100



PROVIDING BACKUP REMOTELY

Remotely-provided air traffic services for contingency situations at aerodromes

SJU references:
#13/ Release 5



Security alerts can shut down control towers. How does the airport ensure minimum disruption in an emergency? This question has been addressed by SESAR looking at contingency situations for airports.

Contingency towers are not new, and already operate at London, Brussels, and near-completion at Budapest. They provide operational resilience and safety assurance should the primary tower be compromised. This solution brings additional technology into play, and addresses issues including accessibility, training and security to deliver more resilience and a higher efficiency in degraded situations.

A remote facility offers a cost-efficient alternative to building new infrastructure onsite. It can provide air traffic control services as close to full-operating capacity as possible, and can feature additional information feeds to enhance the data available. Most importantly, it can maintain safe flight operations, with minimum disruption to the flights operating to and from the airport affected.

Shadow-mode exercises have been carried out to examine exactly how a remote tower facility can provide contingency services at medium-sized airports. The exercises assessed the transition time necessary to switch from the primary tower to the contingency facility, what level of service can be provided in the absence of an out-of-the-window view, and what information can be accessed by controllers. They also looked at controller workload, situational awareness, and human performance.

This solution is implemented in Denmark, Spain, Hungary and Lithuania and planned for Austria and The Netherlands.

Contingency towers deliver increased operational resilience for medium-sized airports

Building infrastructure off-site is more cost-efficient, and easier to maintain

The standardisation work on remote towers is addressed by EUROCAE WG-100

STAKEHOLDERS

ANSP

A0

AU

NM

BENEFITS

- **Increased cost efficiency**
- **Improved resilience in degraded situations**



SJU references:
#61/ Release 1

LINKING SMALL AIRPORTS TO THE NETWORK

A low-cost and simple departure data entry panel for the airport controller working position

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Significant improvement in traffic predictability**
- **Increased network capacity**
- **Better runway configuration and management**

Many airports in Europe, particularly regional and small airports, are not equipped with electronic flight data processing systems (eFDPs) but rely on paper flight strips and voice communications. As a result, the integration of these airports into the air traffic management network is often limited and leads to a lack of predictability of air traffic from these airports. SESAR has developed affordable ways to link these airports to the wider network.

The use of a simple airport departure data entry panel (ADDEP) provides a low-cost solution to compute and share aircraft electronic pre-departure data across the air traffic management network, between the tower and approach controllers, as well as the tower and the Network Manager. Trials carried out at a small airport tested a standalone panel which the controllers used to input data such as push-back clearance, taxi and cleared for take-off. This ADDEP then generated departure messages which could be used to update the local flow management centre and the Network Manager.

The validation activities showed that the application of the solution improved accuracy of estimated take-off times when compared with operations without the panel. Previously, over 40 % of take-off times were at variance with estimated times (often set hours in advance), and this dropped to less than 10 % when controllers had access to the ADDEP. The extra panel did not impact on safety, and could be easily accommodated by the controller working position.

This solution is implemented in 19 airports in Germany, United Kingdom, Spain and France, and planned for 18 airports in Spain, Poland, United Kingdom and the Czech Republic.

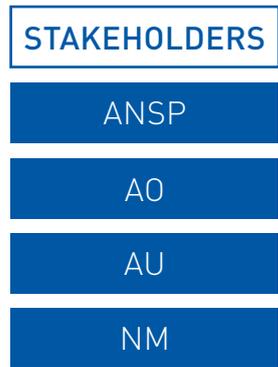
Once an airport has installed an ADDEP application, it can be adapted to provide other services, such as combined arrivals and departures provision for the tower



AIRPORTS ARE THE NODES OF THE NETWORK

SJU references:
#21/ Release 5

Airport operations plan (AOP) and its seamless integration with the network operations plan (NOP)



Airports are the nodes of the airspace network, linking flights for seamless traffic flow. They can also act as bottlenecks of the network and need to be integrated into the system as a whole. The network operates according to a pre-defined network operations plan (NOP), so why not airports? SESAR is introducing the additional means to manage airport operations in a collaborative and proactive way, through the airport operations plan (AOP) and the airport operations centre (APOC).

BENEFITS

- Enhanced predictability
- Improved airport resilience/limiting capacity reduction in degraded situations

The AOP is a single, common and collaboratively-agreed rolling plan for an individual airport. The AOP relies on information from different players including airlines, ground handlers, air traffic control, security, emergency services, meteorology and airport management. Set against specific performance targets, the airport monitors the progress of the plan and mitigates the impact of any deviations that may occur.

Daily airport operations are managed by the APOC, which can be a physical facility or a virtual collaboration between stakeholders. The alignment between planned and executed operations is continuously monitored, with changes being made to the AOP as required. As stakeholders update their intentions, or accurate flight progress information is received, the AOP is refined and used to manage resources and coordinate operations. Integration with the NOP extends the planning activities to include air traffic demand and improved target time coordination.

The aim with this solution is to provide processes and tools to maintain airport performance in all operating conditions, and to share information with the wider network. Two principal services are provided by this solution: to establish appropriate performance goals and to monitor the performance during the execution timeframe. Ultimately the AOP and APOC make airports more resilient to disruptions by enhancing the common situational awareness of ATM stakeholders through the sharing of real-time information.

This solution contributed to the revision of Eurocontrol's Airport CDM manual

SESAR validations looked in detail at information requirements, alerts and information sharing in order to optimise the use of airport capacity and resources. Real-time simulations as well as shadow-mode exercises were used to validate airport performance monitoring and management. Finally, a live trial took place to integrate landside operations with the airside environment by integrating data related to passenger milestones in the AOP.

In 2014, London Heathrow and Paris Charles de Gaulle partially implemented the solution. The full solution is now available for industrialisation and synchronised deployment is underway as part of the European Commission's Pilot Common Project.





SJU references:
#116/Release 5

IMPROVED WINTER WEATHER FORECASTING FOR DE-ICING OPERATIONS

De-icing management tool

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Improved situational awareness of aircraft de-icing operations
- Increased predictability

The winter season at European airports can last from a few days to many months and during this time de-icing services may be needed. The procedure of applying required de-icing fluids to aircraft at most airports is primarily a business process that takes place between an airline and a specialised ground handling agent. The SESAR de-icing management tool (DMIT) refers to a system capable of improving the predictability of aircraft de-icing operations at European airports by taking data inputs from meteorological service providers and involving the relevant airport stakeholders.

The solution increases the accuracy of information related to when the procedure is going to take place, how long it will take and when the aircraft will be ready to taxi for departure, which is currently calculated by predetermined estimates. The solution means that air traffic controllers no longer need to work without situational awareness of de-icing activities and needing to make their own estimates of when aircraft are ready for departure. The solution envisages that de-icing operations are no longer characterised by the A-CDM concept as 'adverse conditions', i.e. a state that is in need of collaborative recovery procedures, but rather a part of normal operations in the winter period.

The DMIT allows for the scheduling and monitoring of de-icing operations. It is an internet browser-based tool that addresses three distinct procedures for de-icing:

- Remote de-icing, which occurs at a specific location on the airport away from the parking stand;
- On-stand de-icing, which occurs just before the aircraft leaves its stand; and
- After-push de-icing, which occurs after the aircraft has pushed back from the stand and is positioned to start taxiing after de-icing.

With the involvement of airport operations data base (AODB), the tool subscribes to flight information and produces information in the form of time stamps for use by coordinators, managing the de-icing of aircraft.

This solution is available for industrialisation. The solution has been implemented in Helsinki, Paris Charles de Gaulle, Vienna and Zurich. Implementations are planned in Hungary, The Netherlands, Poland and Sweden.

The de-icing coordinator and the de-icing agent can refine the sequence through the DMIT user interface to account for any ad hoc situations that are not handled by the tool

The DMIT produces estimated de-icing time (EDIT), estimated commencement of de-icing time (ECZT) and estimated end of de-icing Time (EEZT) time stamps and publishes these to the A-CDM platform, both improving the quality of de-icing milestone information and increasing common situational awareness for other airport actors

Advanced air traffic services

The future European ATM system will be characterised by advanced service provision, underpinned by the development of automation tools to support controllers in routine tasks. The feature reflects this move towards further automation with activities addressing enhanced arrivals and departures, separation management, enhanced air and ground safety nets and trajectory and performance-based free routing. The increased use of digital connectivity enables increased virtualisation of service provision, opening up more options for ATM service delivery.



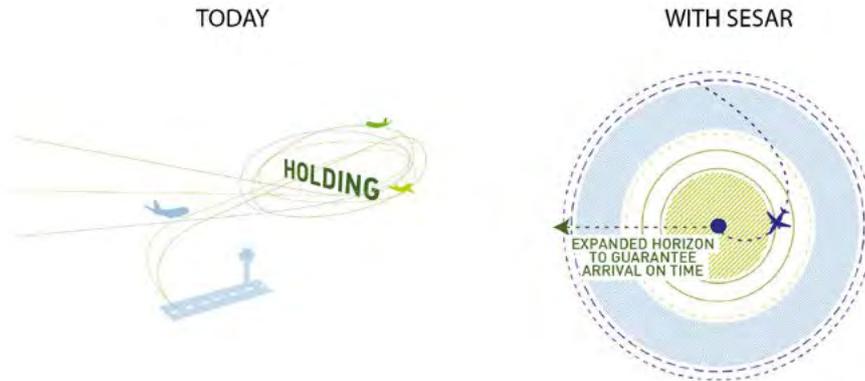


SJU references:
#05/Release 4

ASSIGNING HOLDING STACKS TO HISTORY

Extended arrival management (AMAN) horizon

STAKEHOLDERS
ANSP
AO
AU
NM



BENEFITS

- Improved operational efficiency by reducing holding times
- Improved operational efficiency by reducing fuel burn and emissions
- Efficiency in terms of air navigation service provision
- Improved safety and quality of service

Today, arriving traffic is managed and sequenced in the airspace close to the airport. Faced with increasing traffic, airports are looking for ways to overcome congestion and reduce the need for holding. Planning arrivals into a busy airport an hour or more before touchdown cuts down holding time, reduces noise and saves fuel.

Extended-AMAN (E-AMAN) allows for the sequencing of arrival traffic much earlier than is currently the case, by extending the AMAN horizon from the airspace close to the airport to further upstream and so allowing more smooth traffic management. Controllers in the upstream sectors, which may be in a different control centre or even a different functional airspace block (FAB), obtain system advisories to support an earlier pre-sequencing of aircraft. Controllers implement those advisories by, for example, instructing pilots to adjust the aircraft speed along the descent or even before top-of-descent, thus reducing the need for holding and decreasing fuel consumption.

E-AMAN is supported by sharing the airport's arrival management information with upstream sectors in real time. All parties share the same information using a system-wide information management (SWIM) service.

SESAR partners have shown that E-AMAN can be extended up to 200 nautical miles (NM) from the airport.

This solution is available for industrialisation. Already used at London Heathrow, the solution is part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.

London-Heathrow has cut holding times in its arrival stacks by one minute, reducing noise emissions and saving airlines EUR 2.9 million in fuel savings and a reduction of over 4,700 tonnes of carbon dioxide annually

This solution is related to the EUROCAE standard covering the extended horizon AMAN upstream coordination service (AMAN SWIM Service)





IMPROVING ARRIVAL EFFICIENCY AND PREDICTABILITY

SJU references:
#107/Release 2

Point merge in complex terminal airspace



STAKEHOLDERS

- ANSP
- AO**
- AU
- NM

The point merge route structure provides a more efficient way to vector aircraft down to the final approach path. It allows departure and arrival streams to operate independently without risk of conflict, and delivers more predictable arrival times. The concept is simple. By designing standard sequencing legs ahead of the final approach point, aircraft can be guided along shorter or longer distances in order to reach a single entry point. For a busy terminal area controllers can start to sequence arrivals at an earlier stage, while pilots receive fewer interventions so can fly a more efficient approach path down to the runway.

BENEFITS

- Increased capacity in the terminal airspace
- Improved safety levels
- Improved air navigation service provision
- Reduced fuel consumption and emissions

At the extremity of the terminal airspace, arriving aircraft are vectored along an arc from where the timing of their turn towards the merge point determines the landing sequence. The procedure takes advantage of precision navigation technology (P-RNAV) on board modern aircraft, enabling them to fly precise pathways in the sky. The simplicity of point merge means that it is intuitive for the controllers to use, and requires fewer radio exchanges with the pilot. Fewer radar vectors also means less uncertainty on the flight deck with regard to the anticipated tactical route and the distance to go. The pilot can fly a continuous descent approach (CDA) path - rather than stepped height changes - consuming less fuel, while non P-RNAV equipped aircraft can still be vectored to the final approach point.

Point merge systems provide a high degree of structure and standardisation, which can be applied to multiple airports

Point merge requires no changes on board the aircraft, however does require redesign of the terminal airspace

Live trials have demonstrated the potential to increase airspace capacity in more complex environments, while maintaining or improving safety, air navigation provision efficiency and reducing emissions.

This solution is available for industrialisation. SESAR validation activities successfully demonstrated the application of point merge procedures in complex TMAs. Point merge is already providing more efficient arrival streams into Ireland's Dublin Airport, Oslo in Norway and the Canary Islands.



SJU references:
#108/Release 2

ELIMINATING HOLDING PATTERNS IN THE EXTENDED TERMINAL AREA

Arrival management (AMAN) and point merge

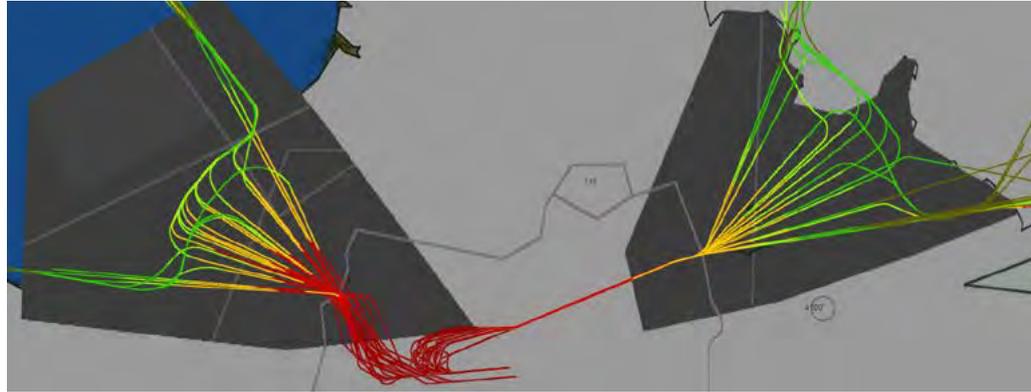
STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Better management of human resources
- Improved pilot situational awareness through the application of more standardised procedures
- Enhanced safety
- Reduced noise impact

Point merge not only delivers a more efficient arrival route structure in the terminal airspace, it can be applied to the extended terminal airspace area for pre-sequencing traffic. SESAR has developed point merge for this environment to enable the arrival manager (AMAN) to establish a more predictable arrival sequence. Integrating and optimising arrival streams contributes to the overall arrival management process both in terms of aircraft efficiency and airport operations. It is this predictability which can significantly improve capacity in dense and complex terminal airspace, and avoid unnecessary holding.

The solution is composed of a point merge system coupled with an arrival management tool that provides sequencing support based on trajectory prediction. Rather than entering holding patterns, aircraft in the extended terminal area enter PBN routes referred to as point merge legs, where they fly briefly in a level-off lateral holding situation where the distance to the merge point remains constant. When the spacing with the preceding aircraft is attained, the controller will instruct the next aircraft on the leg to turn direct to the merge point. Unlike conventional traffic streams which are individually vectored, the turn the aircraft needs to perform in the point merge leg is always the same, which simplifies the controller's tasks. The flight crew's task is also simplified by the use of this standardised manoeuvre which is predictable and repeatable.

Flight trials have demonstrated the workability of the concept. Controllers commented on the reduction in radio communications and experienced a more orderly traffic flow. There was better adherence to AMAN advisories before aircraft reached terminal airspace, and delays tended to be absorbed in the extended terminal area, reducing noise emissions at lower altitudes.

Airspace users have the opportunity to fly continuous descent operations from the point merge legs to the merge point. The point merge legs can be flown with different PBN capabilities, which allows a mixed navigation capability to operate within the same airspace.

This solution is implemented in Germany, France and Ireland and planned in Italy and Portugal.

Point merge is one of the ICAO Aviation System Block Upgrades and is referenced as a technique to support continuous descent operations

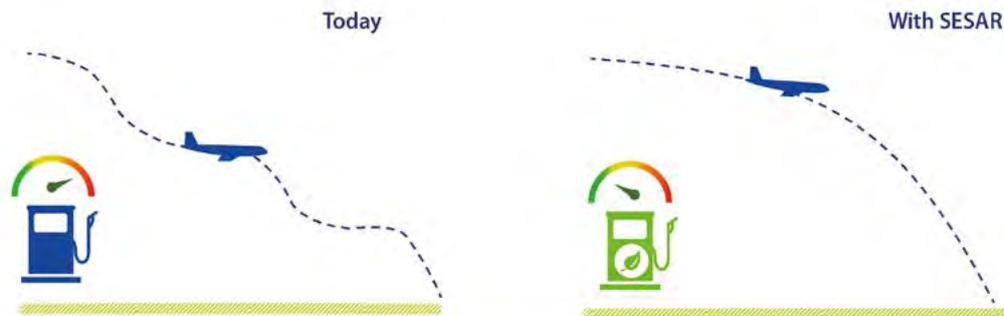
Applicable for terminal airspace handling over 100 hourly movements and en-route airspace handling over 300 hourly movements during peak hours



SMOOTHER, QUIETER, AND MORE EFFICIENT

Continuous descent operations (CDO) using point merge

SJU references:
#11/Release 5



Aircraft engines have become quieter but an aircraft's flight path can also help reduce noise levels by following a smooth descent down to the runway threshold rather than a conventional stepped approach. Up until now, these continuous descent operations (CDOs) have been restricted to low and medium traffic density environments due to their impact on airport capacity. By combining it with point merge techniques, SESAR has extended the solution so it can be applied to high-density traffic environments at a lower altitude and in a small and very constrained airspace.

During the validation of the solution, aircraft were vectored to a common merge point from where they followed a single air navigation trajectory (RNAV) procedure to intercept the instrument landing system (ILS). Since all sequencing procedures were completed by the merge point, from there pilots could follow an unconstrained descent path. In this procedure, controllers do not need to issue any level-off clearances after the merge point, while fewer level-offs are required earlier during the vectoring to merge point procedure. This results in higher profiles in the vicinity of the airport.

Results showed that noise levels for inhabitants living near the airport were reduced with the introduction of the vector to point merge procedure. The solution also allows better control of the geographical area impacted by the noise using the RNAV trajectory capabilities, which allows the concentration or dispersion of traffic depending on the characteristics of the local area. This data is collected using a series of noise stations placed under the arrival paths to test the noise impact of the traffic before and after the flight trials.

This solution is implemented in Austria, Germany, France, Hungary and Ireland and planned in Italy, Lithuania, Latvia and Portugal.

STAKEHOLDERS

- ANSP
- AO
- AU
- NM

BENEFITS

- Reduced fuel burn and emissions
- Reduced environmental impact of airports on their neighbouring communities
- Noise reduction

Making CDOs possible in complex airspace

Simulations and live flight trials allowed aircraft to fly higher approach paths resulting in less noise impact and lower emissions in the vicinity of the airport

This solution is linked to the ICAO PBN Manual (Doc 9613), EUROCAE ILS standards and ICAO's PANS OPS (8168), as well as various avionics sensor standards



SJU references:
#62/Release 1

FLYING MORE EFFICIENT ROUTES

Precision area navigation (P-RNAV) in a complex terminal airspace

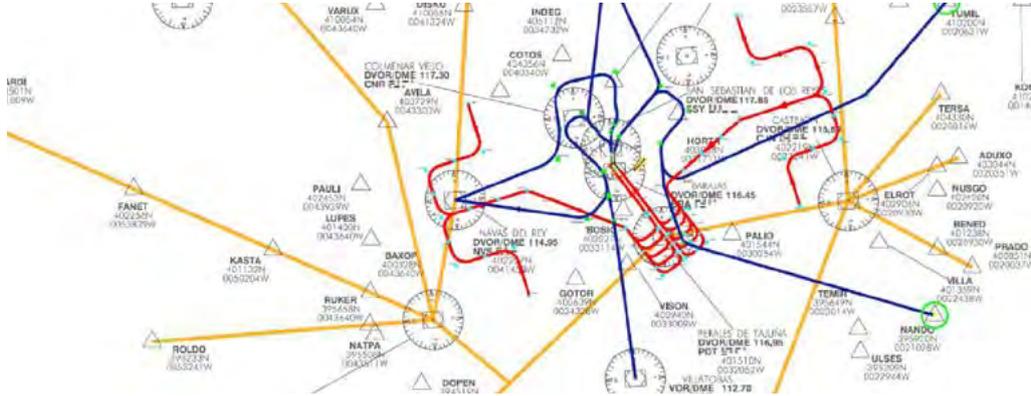
STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Enhanced safety thanks to better precision
- Reduced fuel burn and emissions
- Improved air navigation service provision

Equipped to fly to within an accuracy of one nautical mile (NM), modern aircraft have the capability to follow very flexible routes, for example reducing noise impact on populated areas and easing bottlenecks. This navigation capability is especially useful in busy terminal airspace, where the increased accuracy allows more approach paths, which can release capacity, reduce holding and cut emissions.

Introducing precision area navigation (P-RNAV) procedures improves the design and organisation of the airspace allowing the aircraft's on-board navigation system to fly optimised flight paths.

P-RNAV supports more efficient continuous descent approaches and continuous climb departures in place of traditional stepped flight profiles issued by a controller. P-RNAV also supports curved approach paths which can avoid complex interaction between inbound and outbound traffic, heavily populated areas, and can reduce track miles for inbound aircraft.

SESAR partners carried out real-time simulations of P-RNAV implementation, where the new approach paths were introduced to reduce congestion experienced with existing arrival streams. P-RNAV procedures were integrated with conventional routes, resulting in a reduction of airborne holding time enabled by the path-stretching possibilities offered by the new route structure.

The validation site used is representative of many high-density terminal airspace encountered elsewhere in Europe, where the introduction of P-RNAV procedures offer the possibility of reducing fuel consumption and environmental impact as a result of the increased flexibility in airspace design, which allows strategic de-confliction of routes that enable better climb and descent profiles.

The solution is already implemented in several airports, including Madrid.

P-RNAV procedures can deliver reductions in fuel burn and emissions as they allow increased possibilities for strategic route de-confliction, which enable smooth, low fuel consumption continuous descent and climb operations

This solution is linked to the ICAO PBN Manual (Doc 9613), EUROCAE ILS standards and ICAO's PANS OPS (8168), as well as various avionics sensor standards



DESIGNING MORE EFFICIENT AIRSPACE

Optimised route network using advanced required navigation performance (RNP)

SJU references:
#10/Release 5



New possibilities in advanced airspace design solutions and options are now possible thanks to the precision in airborne navigation using the improved navigation performance provided by required navigation performance (RNP) on board modern aircraft. This solution supports connectivity between free route airspace and TMA's thanks to advanced RNP below flight level 310.

Aircraft with RNP specifications are equipped with on-board performance monitoring and alerting to continually check conformance. Aircraft flying advanced A-RNP procedures can be relied on to stay within one mile on either side of the nominal flight path whether flying a straight leg or a turn. In practical terms, this means that controllers can have greater confidence in the track-keeping performance of the aircraft and this greater confidence translates into being able to place routes closer together. Nominal RNP1 routes can be designed as close as seven nautical miles (NM) in en-route sectors and as close as five NM in terminal airspace. Advanced RNP (A-RNP) routes support precise flight profiles such as spaced parallel routes, fixed radius transition (FRT) and tactical parallel offset (TPO).

One of the main benefits provided by A-RNP is the potential to increase the overall efficiency of the air traffic management system, as a result of the greater flexibility of airspace design. This allows, for example, being able to place flight paths, arrival and departure routes, in the most convenient place. The predictable turn performance inherent in A-RNP in en-route and terminal airspace also makes it possible - due to enhanced track keeping in the turn - to place routes where they cannot necessarily be placed today using less advanced navigation capabilities.

This solution is planned for implementation in Germany, Italy and the Netherlands.

STAKEHOLDERS

ANSP

A0

AU

NM

BENEFITS

- Enhanced safety
- Improved operational efficiency by reducing fuel burn and emissions
- Improved air navigation service provision

A-RNP with on-board performance monitoring results in more predictable aircraft behaviour

This solution is linked to ICAO's performance-based navigation (PBN) manual edition 4 and edition 5 (Doc 9613)



SJU references:
#09/Release 5

FLEXIBLE ARRIVALS AND DEPARTURES

Enhanced terminal operations with RNP transition to ILS/GLS

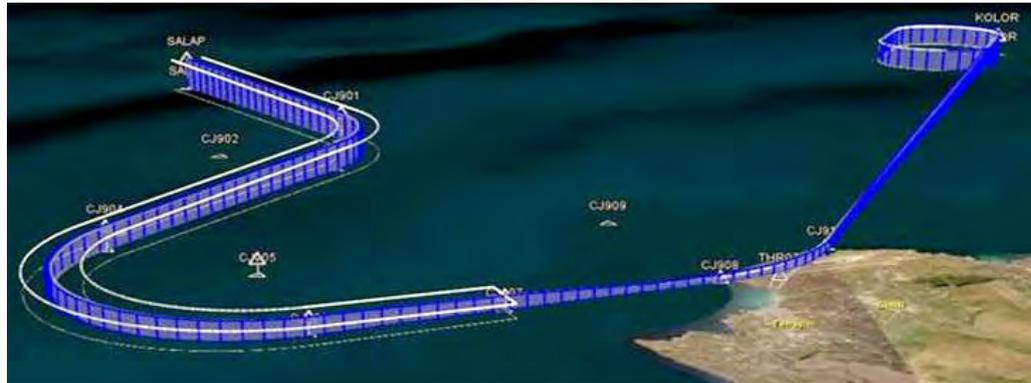
STAKEHOLDERS

ANSP

A0

AU

NM



BENEFITS

- Improved fuel efficiency
- Increased runway throughput (GBAS)
- Enhanced safety

The focus on efficient, green operations at European airports has led to the development of more flexible arrival and departure routes which take advantage of the satellite-based navigation capability on board modern aircraft. This solution refers to the use of curved procedures enabled by advanced required navigation performance (RNP) with a transition to ILS/GLS. This allows aircraft to follow new approach paths, for example to avoid noise emissions over populated areas, reduce track miles, and add new flight paths, while also achieving ILS landing guidance to low-minima of 200 ft and below.

Modern flight management systems have the ability to fly a repeatable curved trajectory, known as radius-to-fix (RF), which some airports are adding to their arrival and departure procedures. SESAR has worked on the introduction of these turns by supporting the design of new procedures that connect the route structure to the final approach path. Final approach guidance may be provided by existing ILS, but for GBAS-equipped airports they may also be provided by new ground-based augmentation system (GBAS) landing systems (GLS), using constellations such as Galileo.

Flight trials were carried out to validate new arrival procedures based on the use of different glide path angles for two arriving aircraft aiming at different touchdown zones on the runway to reduce the risk of wake encounter. The exercise sets out to confirm the operational feasibility of the procedure, including its impact on the situational awareness of controllers and pilots.

This solution is available for industrialisation and part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.

Advanced RNP procedures improve access to busy airports, help to maintain all-weather operations, and reduce environmental impact

This solution is linked to ICAO's performance-based navigation (PBN) manual edition 4 and edition 5 (Doc 9613)





TRANSITIONING TO FINAL APPROACH

Enhanced terminal operations with RNP transition to LPV

SJU references:
#51/Release 4



STAKEHOLDERS
ANSP
AO
AU
NM

Satellite-based navigation systems, including Galileo, enable aircraft to follow precise flight paths independently of ground-based infrastructure. The technology supports additional approach paths without the need to add instrument landing systems (ILS), and can be used as part of a fall-back procedure in case of airborne or ground ILS equipment malfunction.

This SESAR solution defines required navigation performance (RNP) transitions to localiser performance with vertical guidance (LPV) to enhance terminal operations. SESAR supports wider use of advanced RNP to enhance terminal area operations. SESAR's advanced approach procedures with vertical guidance (APV) include the smooth transition from RNP arrival routes into RNP approach flight paths with barometric descent guidance that then transition to the LPV approach segment with geometric descent guidance. The transitions may include radius-to-fix (RF) turns that leave the aircraft aligned with the runway as close as three nautical miles (NM) before the threshold. From that point, the satellite-based guidance allows the pilot to descend safely down to a decision height of 200 ft which is equivalent to ILS Cat I minima. Advanced APV allows increased flexibility in planning arrival paths in terminal airspace, making it possible to design procedures that control the noise impact of the airport or reduce track miles to cut fuel consumption.

Several validation exercises focused on preparing ways to introduce A-RNP transition to LPV procedures by examining the impact on both the ground and air segments. The new transitions increased predictability for controllers and pilots, while reducing track miles, saving fuel and emissions.

This solution is linked to ICAO's performance-based navigation (PBN) manual edition 4 and edition 5 (Doc 9613)

This solution is available for industrialisation. Enhanced terminal operations with LPV procedures are part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.

BENEFITS

- Increased flexibility in the design of TMA route layouts and landing procedures, which result in fuel savings and reduced noise impact on the communities neighbouring the airport
- Increased predictability
- Improved safety





SJU references:
#103/Release 1

PREPARING TO LAND

Approach procedures with vertical guidance

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Improved access to airports in all weather conditions, without the need to install ground equipment**
- **Improved descent profile and reduced track miles, resulting in reduced fuel burn**
- **Reduced noise footprint**
- **Improved safety**

Satellite-based technology, supported by constellations such as Galileo, provides approach guidance without the need for ground-based navigational aids, increasing accessibility and safety at many airports. An aircraft can fly instrument approaches similar to a conventional instrument landing system (ILS) - down to a 200ft decision height. A localiser performance with vertical guidance (LPV) approach uses global navigation satellite system (GNSS) signals augmented by the European geostationary navigation overlay service (EGNOS), the three-satellite constellation that improves the precision of GNSS in the European area and was certified for safety of life (SoL) service in 2011.

LPV procedures do not require any new equipment at the airport which makes them an ideal low-cost alternative to increase access to secondary airports that may not be ILS-equipped on all runways. For ILS-equipped runways, the new approach design may be useful either to shorten the flightpath for certain traffic flows or simply to overlay the existing ILS and be used as a fall-back procedure in case of airborne or ground ILS equipment malfunction.

SESAR validation activities demonstrated that LPV approaches can be safely integrated into the operational environment. The exercises showed that the implementation of LPV procedures allowed aircraft coming from a downwind inbound route saved track miles compared to the traditional ILS approach. Moreover, in low traffic conditions controllers were able to safely integrate LPV aircraft flying short downwind approaches with ILS aircraft flying longer downwind approaches while allowing the LPV aircraft to execute the LPV descent profile. Using satellite-based technology also means avoiding costs associated with airport closure or flight diversions due to bad weather conditions. The exercises provided valuable lessons learnt for the design of LPV procedures, such as the importance of defining and using standard phraseology.

By the end of 2015, more than 250 LPV procedures had been published across Europe, and the number continues to rise sharply. The new procedures have enabled some states to decommission ILS services at some regional airports, saving costs.

The solution is available for industrialisation.

ICAO supports integration of satellite-based navigation with vertical guidance into the airspace environment

Airport landing rate can be maintained with LPV procedures

This solution is linked to the ICAO PBN Manual (Doc 9613), EASA AMC 20-27 and ICAO's PANS OPS (8168)



ENABLING ROTORCRAFT OPERATIONS IN BUSY AIRSPACE SURROUNDING AIRPORTS

Optimised low-level instrument flight rules (IFR) routes for rotorcraft

SJU references:
#113/Release 5



STAKEHOLDERS
ANSP
AO
AU
NM

Due to their different operational characteristics to fixed-wing aircraft, especially their lower speed and vulnerability to bad weather, rotorcraft operations inside controlled airspace and terminal manoeuvring areas (TMA) are often limited to visual flight rules (VFR) flights in visual meteorological conditions (VMC). Flights under instrument flight rules (IFR) are often severely constrained or even prohibited altogether. The introduction of IFR procedures specifically designed for rotorcraft enables their safe integration into controlled airspace without adversely affecting existing fixed-wing operations.

This SESAR Solution enables the design of IFR routes at very low level, based on the ability of suitably-equipped rotorcraft to navigate very accurately using global navigation satellite systems (GNSS) using the European satellite-based augmentation system (SBAS): the European Geostationary Navigation Overlay Service (EGNOS). Routes are designed to an enhanced required navigation performance (RNP) standard that allows an optimised use of the airspace within medium and dense/complex TMAs. Routes are designed to either RNP 1 or RNP 0.3 depending on the altitude and degree of precision needed as a result of neighbouring procedures, airspace and/or terrain.

Dedicated low-level IFR routes for rotorcraft not only improve safety, equity and accessibility in the airspace inside the TMA, but may also increase TMA capacity

This solution is linked to the ICAO PBN Manual (Doc 9613) and PANS OPS (8168), as well as various avionics sensor standards

BENEFITS

- Increases access to TMAs for rotorcraft
- Increases safety and resilience of rotorcraft operations
- Reduced noise

Provision of the IFR routes in controlled airspace procedurally separates rotorcraft and fixed-wing traffic. The integration of an optimised low-level IFR route network for rotorcraft can enhance flight safety and weather resilience of rotorcraft operations. Benefits for the environment may also be expected due to fewer VFR flights at very low altitude and avoidance of noise-sensitive areas thanks to narrow and/or curved low-level procedures.

These low-level IFR routes can be directly linked to dedicated point-in-space (PinS) arrival and departure procedures, where published, enabling simultaneous non-interfering (SNI) operations that are procedurally segregated from conventional fixed-wing operations.



SJU references:
#08/Release 5

STREAMLINING TRAFFIC FLOW INTO MULTIPLE AIRPORTS

Arrival management into multiple airports

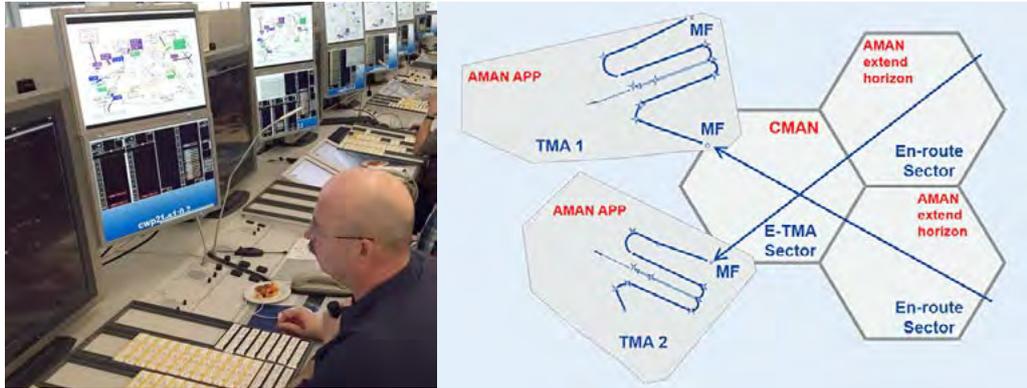
STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Enhanced predictability
- Improved fuel efficiency
- Better use of available capacity
- Enhanced safety

Some airports in Europe are located very close to one another, which means that they must share the surrounding airspace, or terminal manoeuvring area. However, in today's air traffic management, airports are considered as separate entities rather than integrated nodes in a wider network. As a result, aircraft cannot always access the most efficient routes in terminal airspace.

This SESAR solution coordinates traffic flows into multiple airports by means of a centre manager (CMAN). The solution operates in conjunction with the arrival management systems of the different airports to develop optimum arrival streams, based on balancing the demand and capacity. The CMAN uses airport data including predicted departure times and the extended arrival management horizon in order to calculate the most efficient arrival streams.

This solution looks at converging arrival streams, and spacing the aircraft to optimise traffic flow in order to reduce the need for tactical interventions by controllers. By imposing a time-to-lose (TTL) constraint, aircraft can be sequenced efficiently in the extended terminal area, reducing the need for subsequent radar-vectoring. The aim is to establish a new multi-airport arrivals concept that is expected to increase air navigation service efficiency, in particular the use of tactical voice communications, and deliver more fuel-efficient arrival streams.

The solution offers the most benefit in more complicated terminal airspace, where airports already use arrival management tools to smooth queues. A series of real-time simulations looked at converging arrival streams, spacing aircraft to optimise traffic flow in order to reduce the need for tactical interventions by controllers. The validation exercises also assess training and staffing requirements.

This solution is planned for implementation in Germany and Portugal.

More predictable arrival streams reduce the need for tactical interventions by controllers

CMAN helps to adjust capacity to match predicted demand in a complex terminal environment serving multiple airports



AIRBORNE SELF MANAGEMENT FOR MORE PRECISELY TIMED ARRIVALS

SJU references: #06/Release 5

Controlled time of arrival (CTA) in medium-density/medium-complexity environments



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

Building an arrival sequence in medium- and high-density environments calls on controller resources from an early phase in the approach procedure. The process is predominantly ground-based and can result in late vectoring and unnecessary holding rather than fuel-efficient strategies based on en-route speed management for efficient delay absorption. By combining time management capabilities on board aircraft with ground-based system support, the arrival management process can be more predictable and deliver more efficient operations.

BENEFITS

- Improved fuel efficiency per CTA flight
- Enhanced predictability
- Improved flight crew situational awareness

Controlled time of arrival (CTA) is a time constraint defined by air traffic control that allows an aircraft to self-manage its speed in order to arrive at a specific time at a defined point associated with an arrival runway. The controller calculates the CTA as part of the arrival management process and relays this information to aircraft equipped with this advanced navigation capability. While arrival management systems are not able to evaluate the most fuel-efficient strategy for each individual aircraft, each aircraft's flight management system will optimise the flight speed according to aircraft type and wind conditions.

More inclusive use of airborne technologies provides better investment return for airspace users on equipment that many have already installed in their aircraft

SESAR validated how CTA operations can be applied in medium-density and complex terminal airspace. Many aircraft are already equipped with flight management systems that support flying to a time constraint through the use of the required time of arrival (RTA) airborne function.

This solution is linked to EUROCAE standards ED-228A, ED-229A and ED-75D

This SESAR Solution is available for industrialisation.



SJU references:
#104/Release 1

SUPPORTING TEAM WORK

Sector team operations - en-route air traffic organiser

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Effective management of team operations**
- **Improved monitoring of traffic as well as information and task sharing**
- **Increased en-route airspace capacity**

The sustained traffic growth in the 1980s prompted the launch of the en-route air traffic organiser concept, to design electronic decision-making tools to help controllers. It recognised that there was a need to optimise service provision by assisting with detecting and monitoring tasks, freeing up mental resources to focus on resolving conflicts between flights.

In this framework, the SESAR solution is a medium-term conflict detection (MTCD) tool that allows controllers to filter aircraft and extrapolate their future positions. The tool is based on providing assistance to controllers particularly when faced with stress, fatigue or other disturbing agents. The solution does a number of things to help the controller. It shades out – according to pre-determined criteria – flights which are not relevant to a particular situation. It provides visual aids to help the controller schedule tasks. It also extrapolates the predicted trajectory of specific flights to aid the controller to identify potential conflicts well in advance. In addition, it provides geographical markers to provide the controller with task reminders at specific locations.

The solution allows controllers to perform control tasks more effectively using the support tools and working methods. The solution can bring benefits to any busy en-route environment.

This solution is ready for industrialisation.

The SESAR tool improves information and task sharing, and enhances cooperation between planner and executive controllers

SESAR validation results demonstrated a real potential for increasing the effectiveness of controllers in performing their tasks



HANDLING COMPLEXITY IN THE SKY THROUGH AUTOMATION

SJU references:
#118/Release 7

Basic extended ATC planning (bEAP)



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

Basic extended ATC planning is an automation tool and a set of procedures that support controllers in managing highly complex traffic. The solution aims to bridge the gap between air traffic flow and capacity management (ATFCM) and air traffic control. It provides real-time and fine-tuned measures to solve ATFCM hotspots, enabling early measures to be taken by ATC before traffic enters in overloaded sectors.

BENEFITS

- Improved operational and cost efficiency
- Enhanced levels of safety

The solution introduces an initial automated interface together with the related procedures that will facilitate the communication between local demand-capacity balancing (DCB) position and the controllers' working positions. The main benefits of the EAP function are better service provision to airspace users through reduced delays, better punctuality, less ATFCM regulations, and enhanced safety. The solution is seen as a potential enabler for the deployment of solutions, such as extended AMAN or free routing operations. Following validations in 2015/2016, the solution was approved by French national supervisory authority (NSA) in December 2016 and has since been deployed by DSN and has become operational at Reims, Bordeaux and Brest ACCs.

This SESAR solution is ready for industrialisation.



SJU references:
#63/Release 2

USING CONTROLLER RESOURCES EFFECTIVELY

Multi-sector planning

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Improved task sharing
- Better distribution of human resources
- Improved cost efficiency due to flexibility in sourcing and deployment of human resources

Advanced controller tools present an opportunity to look at managing the resources of the air traffic control workforce in new ways, especially when it comes to planning and pre-tactical tasks. With access to electronic flight data, decision-making tools such as what-if or look-see functions, the role of the planning controller has become more flexible. SESAR's multi-sector planning solution reconsiders the usual air traffic control team – composed of a planner for each tactical controller – and proposes a structure whereby a planner can support two tactical controllers, each responsible for a different sector.

The new operating procedures are a direct result of enhancements to the planning tools, such as the aforementioned solution, which improve the efficiency of the planning and decision-making process. They are not expected to be applicable to all sectors at all traffic levels, but a number of sectors can be combined in this way and operate efficiently at reasonably high traffic levels.

A further phase of solution development is extending the new team structure beyond one planner supporting two tactical controllers, to several tactical controllers under the responsibility of a single planner controller. This evolution will require developing the way in which boundaries are defined between planning and tactical control.

The solution is available for industrialisation.

Multi-sector planning improves efficiency and flexibility in manning air traffic control sectors while sectors are only split when required by the level of traffic

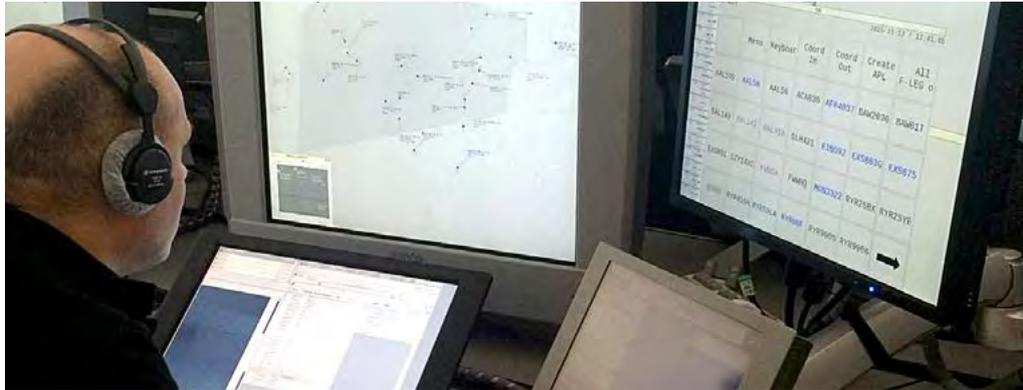
While the solution is not expected to be applicable to all sectors at all traffic levels, the SESAR validation exercises showed that a number of sectors can be combined in this way and operate efficiently at reasonably high traffic levels



KEEPING AHEAD OF TRAFFIC WITH ADVANCED CONTROLLER TOOLS

Enhanced tactical conflict detection & resolution (CD&R) services and conformance monitoring tools for en-route

SJU references:
#27/Release 5



Providing controllers with improved coordination tools is key to meeting Single European Sky performance targets, which aim to triple airspace capacity. SESAR is supporting development of functions to aid capacity and safety.

Reliable and accurate conflict detection and resolution services lead to better decision making and fewer tactical interventions by controllers. This SESAR Solution consists of innovative approaches that provide the en-route controller with two separation provision services:

First, an enhanced monitoring conformance service (MONA) for both tactical and planning controllers. Compared to the existing MONA, this SESAR Solution includes a new alert to take into account lateral deviation and the rate change monitoring in climbing and descending phase to minimize false alerts.

Second, a conflict detection and resolution service fully dedicated and designed for the tactical controller with a conflict detection service down to flight level 100. This service is based on effective clearances and specific ergonomics and use developed for the tactical controller, but also available and usable for the planning controller

Where existing tactical controller tools (FASTI baseline) do not fully match with the tactical controller's needs and do not cover all adherence deviations and present false alarms, this SESAR Solution can optimise air navigation service productivity, increases the benefits of such services, and increase the confidence of the en-route controllers in such coordination tools.

This Solution was validated through a series of exercises including several real-time simulations assessing the operational acceptability of automated tools in specific environments such as a free route environment.

Ultimately, the SESAR work focused on the distribution of tasks between planner and tactical controllers, and how the tools are integrated into the decision-making process.

This SESAR solution is available for industrialisation.

STAKEHOLDERS

- ANSP
- AO
- AU
- NM

BENEFITS

- Improved safety
- Optimised air navigation service provision
- Improved capacity
- Increased cost efficiency

New conflict detection tools allow controllers to assess possible conflicts much sooner

This solution is linked to Eurocontrol specifications (STD 61, STD 62)





SJU references:
#65/Release 2

ALLOWING USERS TO CHOOSE THEIR ROUTE

User-preferred routing

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Improved flight efficiency within one air traffic service unit
- Reduced average flown distance and reduced flight time
- Maintained air navigation service provision, despite capacity increase
- Reduced fuel burn and emissions
- Maintained levels of safety

Many aircraft currently follow fixed routes which are not always the most efficient in terms of time and fuel consumption. There are tactical refinements at an operational level, but SESAR is introducing far more radical change at a design level which ultimately aims to introduce free route airspace across Europe. This enables the operator's flight planning system to calculate the most efficient route taking into consideration wind speed and direction, turbulence, temperature, aircraft type and performance.

This solution is seen as an early iteration of the free route concept due to the potential for this option to mimic established direct route requests from operational airspace users. However, this solution does not take into account cross-border direct routing.

User-preferred routing validation is the result of a number of simulations and flight trials which thoroughly tested the procedures at night, on weekends and weekdays. The validation activities involved air traffic controllers, planners, and supervisors as well as aeronautical information services personnel. Several airlines also participated in the validation activities, learning how to operate the concept correctly, and how the routes are integrated into the wider network.

The results served to identify a list of direct routes within one air traffic service unit that could be implemented. They also showed the maturity of the solution which represents the first step towards the more advanced concept of free route operations. The Maastricht Upper Area Control centre now offers more than 250 user-preferred routes and has recorded an average 7 % reduction in flight distance flown – or two minutes less flight time - by participating aircraft, while lower fuel consumption has seen emissions fall between 6 and 12 %.

The solution is available for industrialisation and is part of synchronised deployment plans in accordance with the Pilot Common Project.

User-preferred routing takes Europe a step closer to the concept of European free route airspace concept

This solution is linked to Eurocontrol specifications (STD 61/STD 62/STD 63/STD 64)

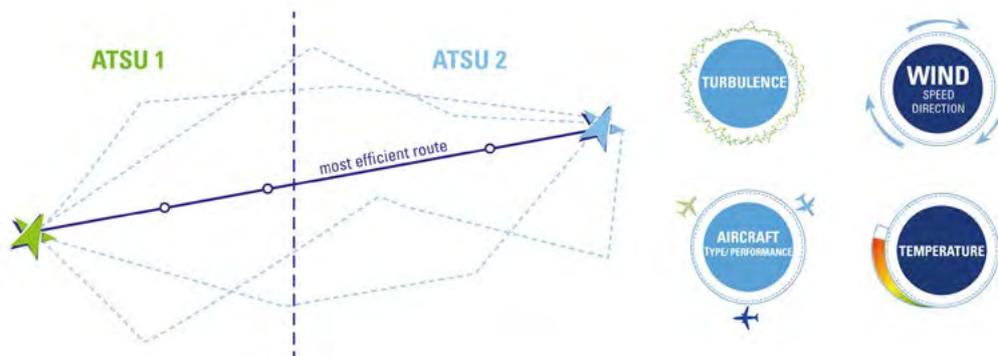




MORE DIRECT ROUTES FOR CROSS-BORDER OPERATIONS

SJU references:
#32/Release 5

Free route through the use of direct routing for flights both in cruise and vertically evolving in cross ACC/FIR borders and in high complexity environments



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

BENEFITS

- Increased airspace capacity
- Improved operational efficiency
- Reduced fuel burn and emissions

Under the current network structure, aircraft fly an average of 20 km further than the most direct route between two points. This SESAR Solution represents a step forward with respect to the user-preferred routing solution. It offers more direct flight planning route options on a large scale, crossing flight information regions and national borders.

Direct routing allows airspace users the possibility to plan a route close to their preferred flight path by selecting a direct route - connecting published waypoints - without the need for the intermediate points to be present in the current fixed-route network.

The extension of direct routes across flight information regions and national boundaries require appropriate airspace changes, as well as new flight data processing systems from airspace users. Advanced flexible use of airspace at the regional scale supports the use of direct routing operations.

Planned flight distances are reduced in comparison with the fixed route network and follow an optimised flight path

Published direct routes are established within local and regional documentation and then made available for flight planning. SESAR continues to support validation activities to assess the operational acceptability of cross-border direct routing operations.

Direct routing is particularly relevant for cross-border operations in high and very high complexity environments

The SESAR Solution is available for industrialisation and is being implemented across the whole of Europe's upper airspace in accordance with the Pilot Common Project.

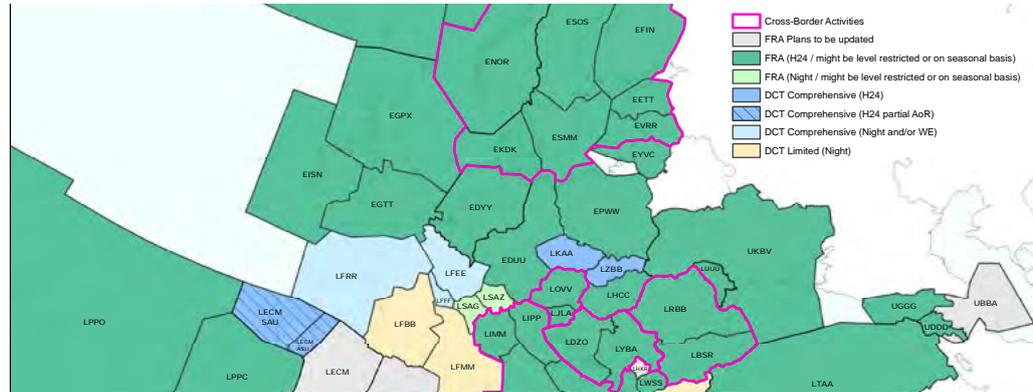




SJU references:
#33/Release 5

EUROPE-WIDE FREE ROUTING

Free route through the use of free routing for flights both in cruise and vertically evolving in cross ACC/FIR borders and within permanently low to medium complexity environments



BENEFITS

- Increased airspace capacity
- Improved operational efficiency
- Reduced fuel burn and emissions

Free routing corresponds to the ability of the airspace user to plan and re-plan a route according to the user-defined segments within free route airspace (FRA), where advanced flexible use of airspace (AFUA) principles provide the necessary airspace flexibility. This solution allows airspace users to plan flight trajectories without reference to a fixed route network or published direct routes within low- to medium-complexity environments.

The solution allows airspace users to plan trajectories, without reference to a fixed route or published direct route network. In doing so, it provides them with significant opportunities to optimise their respective flights in line with individual operator business needs and military requirements.

The validation activities for this solution included real-time simulations to assess the operational acceptability of free routing. The exercises compared service provision when dealing with free routing and direct routing traffic to assess what is required and acceptable and the likely benefits. The work also looked at airspace complexity and considered operational issues related to military airspace zones in a free routing environment.

The SESAR Solution is available for industrialisation.

Flights benefit from optimised flight paths when planning flights using free routes, but remain subject to air traffic control during execution

SESAR exercises are reviewing a range of different flight levels for the introduction of free route airspace implementation

This solution is linked to Eurocontrol specifications (STD 61/STD 62/STD63/STD64)

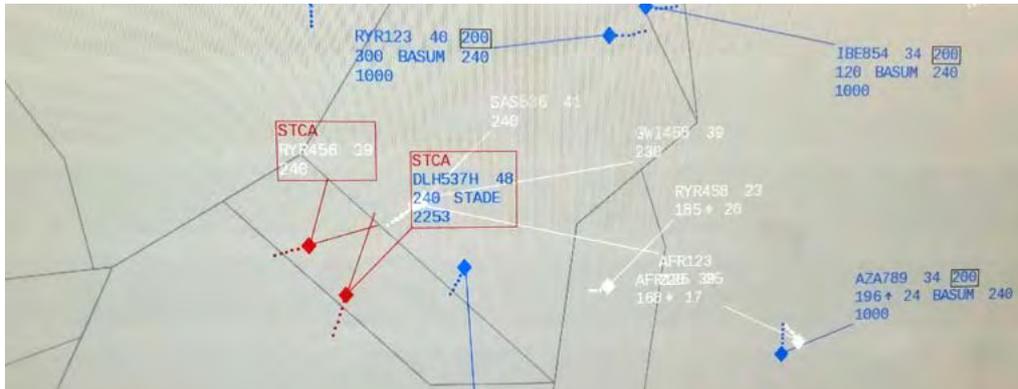




IMPROVING CONFLICT ALERT FOR CONTROLLERS

Enhanced short-term conflict alert (STCA) for terminal manoeuvring areas (TMAs)

SJU references:
#60/Release 1



Ground-based safety nets are an integral part of the ATM system. Using primarily ATS surveillance data, they provide warning times of up to two minutes. Upon receiving an alert, air traffic controllers are expected to immediately assess the situation and take appropriate action. A valuable safety net is the automated short-term conflict alert (STCA), a sophisticated algorithm which uses the track data to warn against possible short-term conflicts.

STCAs are challenging to develop since they must minimise false alerts, while at the same time making sure that real conflicts trigger an appropriate and timely warning. Specific tuning is necessary for STCA to be effective especially in the terminal airspace in order to account for lower separation minima, as well as increased frequency of turns, climbs and descents.

Validation exercises looked at enhanced STCA solutions to reduce the number of false and nuisance alerts compared to existing technologies, while maintaining the detection of genuine alerts. This is beneficial for flight safety, as it helps controllers focus on issues such as conflict risks or resolution advisories. The enhanced algorithms developed for the STCA prototype led to more precise warnings and fewer false and nuisance alerts when compared against existing STCA technology.

Tests using real traffic data demonstrated the operational and system feasibility of the prototype for the identification of conflicts between flights. For instance: the false alert rate of the new system was 15 % lower than the existing system. The likelihood of controllers receiving unnecessary resolution advisories during a level-off encounter between two trajectories was shown to be reduced by a factor of between 30 and 70 with the introduction of additional functionalities.

Human factors and local circumstances have a significant influence on determining what constitutes an operationally relevant conflict which must be alerted by STCA and what is an effective minimum level of nuisance/false alarms

The solution is available for industrialisation.

STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- Identification of conflicts, both en-route and in the terminal area
- Reduced false alert rate while maintained genuine alert rate and warning times are maintained
- Significant increase in safety of flight especially during complex operations



SJU references:
#69/Release 3

BETTER CONFLICT DETECTION TOOLS

Enhanced short-term conflict alerts (STCA) with downlinked parameters

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Enhanced safety through reduced false alert rates and improved warning times of conflicts between flights**
- **Improved operational efficiency**
- **Increase of controller's situational awareness**

Short-term conflict alerts (STCA) provide controllers with a short-term warning of potential conflicts between aircraft in the same airspace. Enhancing the STCA safety net with information down-linked from the aircraft provides more accurate data on which to base warning signals.

Aircraft already transmit enhanced surveillance data using Mode S. In this SESAR solution, two Mode-S derived parameters were incorporated into the STCA logic: selected flight level and track angle rate. The former prompts the system to check if the aircraft intends to climb or descend to a certain flight level even before it begins the manoeuvre. This can detect an unsafe clearance given in error by the controller, or controller-pilot misunderstandings in radio transmissions, such as read back errors or instructions copied by a different aircraft. The latter - track angle rate - gives a better anticipation of how an aircraft will turn, and applies particularly in terminal airspace.

STCA with downlinked parameters was tested for both en-route and terminal airspace environments. The validation results confirmed the benefits in terms of reduction of nuisance alerts, while relevant alert rate was maintained or increased. Thus, controllers' trust in the STCA system increased. There was also evidence of improvements in alert warning time within the en-route environment as well as terminal airspace, chiefly due to the anticipation of the vertical evolution based on the downlink of the selected altitude.

This solution is implemented by eight ANSPs (Austria, Germany Denmark, Ireland, Moldova, Malta, Maastricht Upper Area Control Centre and Poland) and planned by five ANSPs (Armenia, Spain, France, Lithuania and Portugal).

Controllers reported significant higher trust values with the support of downlinked parameters compared to the current version of short-term conflict alerts

Downlinked information confirming aircraft-selected flight level was the most relevant contribution to improved short-term conflict alerts



AUTOMATED AIRCRAFT COLLISION ALERTS

Enhanced airborne collision avoidance system (ACAS) operations using the autoflight system

SJU references:
#105/Release 1



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

Existing airborne collision avoidance systems (ACAS) triggers resolution advisories when a collision risk is predicted. Unnecessary alerts can be caused by aircraft correctly climbing or descending to a cleared flight level close to the level occupied by another aircraft. This can reduce the system's safety benefits and make air traffic control operations more complex. ICAO has recommended new altitude capture laws that automatically reduce the vertical rate at the approach to the selected flight level, reducing unnecessary resolution advisories.

SESAR partners conducted validation exercises that replicated the environment in which ACAS is being operated, and used different configurations to test the application of the new altitude capture rule compared with existing operations. The scenarios included testing aircraft in close encounters, where there is an actual risk of mid-air collision, and an in day-to-day encounters, in which the aircraft are not necessarily on a close-encounter course but where trajectories may trigger a conflict alert. The tests looked at safety, pilot acceptance, compatibility with air traffic control, and trajectory modification, to see if the new law improved the current situation.

The validation showed the new altitude capture law is very effective in reducing the number of resolution advisories triggered in 1,000 ft level-off encounters. The likelihood of receiving a resolution advisory was reduced by a factor of 30, and even 70 in one particular configuration. SESAR recommends implementing the altitude capture rule to reduce unnecessary ACAS alerts. It also recommends modifying the collision avoidance system to improve protection against multiple alerts.

The solution can bring significant operational benefits. By automatically reducing the vertical rate at the approach to the selected flight level, unnecessary alerts are reduced, increasing faith in the system, while reducing distraction on the flight deck. Compatibility with air traffic control operations has also been positively assessed.

The solution is available for industrialisation.

BENEFITS

- Safety levels are maintained
- ACAS operations are less disturbing for air traffic management and pilots
- Increased air navigation service provision
- Resolution advisories are more consistent
- Shorter response time for resolution advisories in general

The solution triggers a safe automated response by the aircraft itself, instead of the current manual response performed by pilots

The new altitude capture laws aim to reduce unnecessary alarms generated by airborne collision avoidance systems

This solution is linked to EUROCAE ED-224 (MASPS for Automatic Flight Guidance and Control System coupled to TCAS)

Optimised ATM network services

An optimised ATM network must be robust and resilient to a whole range of disruptions, including meteorological and unplanned events. An improved dynamic and collaborative mechanism will allow for a common, updated, consistent and accurate plan that provides reference information to all ATM actors involved in the planning and execution of flights. This feature includes activities in the areas of advanced airspace management, advanced dynamic capacity balancing (DCB) and optimised airspace user operations, as well as optimised ATM network management through a fully integrated network operations plan (NOP) and airport operations plans (AOPs), connected to the NOP via system-wide information management (SWIM).





SHARING INFORMATION IN REAL TIME

Initial collaborative network operations plan (NOP)

SJU references:
#20/Release 5



The network operations plan (NOP) is a single window showing information in real time about the air traffic situation across the whole of Europe. Through the NOP, air navigation service providers, airlines, ground handlers, meteorological experts and airports can view the current situation and can coordinate their activities. Importantly, it connects the airports with the rest of the system by including capacity and operational data and shows where any likely pinch points might occur.

The SESAR Solution extends the collaborative NOP information structure to enable more data exchanges between the Network Manager and other partners in order to deliver greater operational efficiency. Additional automation tools support the process, and assist decision making and performance monitoring. The concept also uses system-wide information management (SWIM) to allow shared operational real-time decision making. The SESAR solution addressed three main aspects: the airport operations plan (AOP)-NOP integration, the meteorological status monitoring and the network performance monitoring.

Live trials in different locations looked at the feasibility and benefits of expanding the collaborative aspects of NOP, and the integration AOP-NOP, specifically by assessing the safety and technical feasibility of automatically updating controller displays when airspace users activate temporary airspace reservations in military airspace. The exercises aimed to identify the interoperability requirements between air traffic control, airspace users and the Network Manager.

Meanwhile, a series of shadow-mode exercises evaluated the use of the information sharing environment for assessing the impact of advanced short-term air traffic flow capacity management (ATFCM) measures (STAMs) on network performance. The exercises are also validated the integration of weather information into the network - including meteorological forecasts - to improve tactical demand capacity balancing measures.

The SESAR Solution is available for industrialisation. The solution will be deployed across Europe in accordance with the Pilot Common Project.

STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- Increased ATC network capacity
- Enhanced predictability
- Improved planning allowing for optimised routes
- Enhanced safety

The solution enables the Network Manager and stakeholders to prepare and share information in real time and supports collaborative decision-making processes.

Data exchanges between the Network Manager, airports, airspace users and air traffic control carried out in real time contribute to greater operational efficiency





SJU references:
#66/Release 2

MORE EFFICIENT AIRSPACE MANAGEMENT

Automated support for dynamic sectorisation

STAKEHOLDERS
ANSP
AO
AU
NM



BENEFITS

- Improved safety due to increased situational awareness of supervisors
- Increased capacity due to better use of available resources, both human and airspace
- Reduced saturation periods and flight delays
- Increased cost efficiency

Spare airspace capacity can become available even at peak traffic times, but there are few tools available today to take advantage of this. Air traffic management systems can detect high traffic density, but do not – as yet – find alternative solutions to ease congestion. By adapting airspace configurations, this latent capacity can be used to help meet demand at peak times.

This SESAR automated solution considers the traffic needs, and groups or ungroups airspace sectors to match capacity with evolving demand. The support tool is used by the supervisor to determine sector planning on the day of operations and to manage staff resources accordingly. The result is better use of airspace and human resources, improved safety due to early management of constraints, and fewer delays.

During the validation activities, the automated support for dynamic sectorisation tool was used by the supervisor and flow manager to evaluate the most suitable en-route sector configuration and related staffing needs. The tool takes into account several information sources. These include demand data, including actual flight data as well as planned data; local constraints such as staff availability; and unplanned events such as bad weather or changes as a result of actions at other airports.

The validation of dynamic sectorisation showed that traffic capacity increased by 10 % during peak periods, while the number of delayed flights fell by 5 %. In addition, because the tools provided advanced warning, the air traffic management system was better prepared to manage these situations safely. The improved situational awareness avoided demand and capacity imbalances and enabled controllers to handle more flights per sector even during busy periods.

This solution is ready for industrialisation and is part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.

Shadow-mode trials using the tool for automated support for dynamic sectorisation resulted in better use of available airspace and staff resources

The concept provides support for decision making based on sector configuration in order to optimise use of the controller work force





ADVANCED FLEXIBLE USE OF AIRSPACE

Variable profile military reserved areas and enhanced civil-military collaboration

SJU references:
#31/Release 5



STAKEHOLDERS
ANSP
AO
AU
NM

Traditional airspace classification of certain areas for either ‘civil’ or ‘military’ use has been superseded by the concept of flexible airspace use which allows the airspace to be allocated according to user requirements. The concept is achieved through enhanced civil/military coordination and plays a major role in delivering additional airspace capacity. However, its application is still largely confined to national airspace use rather than cross-border implementation, a situation that SESAR is working hard to change.

BENEFITS

- Increased airspace capacity
- Optimised trajectories, thereby reducing track miles
- Improved safety

This solution offers greater flexibility by allowing dynamic airspace management in all phases of ATM operations, from initial planning through to the execution phase, taking into account local traffic characteristics. The solution includes support tools, operational procedures and processes for real-time airspace status data exchange and for managing variable profile areas (VPA). Planning operations can be enhanced by sharing airspace information in real time and supporting the collaborative decision-making process between the Network Manager, civil and military authorities, and airspace users. The aim is to achieve greater dynamic airspace management, accommodating local and network needs.

Live trials demonstrated the feasibility of automatically updating airspace status into the Network Manager system, and assessing the optimum technology solution that can put into an operational environment. The activities helped to refine the interoperability requirements so there is better exchange of data between the different parties. A series of shadow-mode trials validated the benefits of sharing and using aeronautical information for mission-planning purposes.

Flexible use of airspace allows users to have access on the basis of actual need

SESAR has validated the advanced flexible use of airspace in terms of connectivity using basic procedures and systems with limited functionality. SESAR’s work is now concentrating on refining those procedures and further developing the functionality of the systems space.

The solution is now available for industrialisation and is being deployed across Europe in accordance with the Pilot Common Project.





SJU references:
#19/Release 5

BETTER TOOLS FOR COMPLEXITY RESOLUTION

Automated support for traffic complexity detection and resolution

STAKEHOLDERS
ANSP
AO
AU
NM



BENEFITS

- Increased ATC capacity
- Improved punctuality
- Increased cost efficiency
- Enhanced safety
- Reduced fuel and emissions

Air traffic control uses flight plan data filed by airlines - indicating the routes they intend to fly - to safely and efficiently manage the airspace. Reality, however, can vary from planned operations, as aircraft encounter unexpected delays, weather disruption or can be re-routed to avoid bottlenecks. Providing local flow management positions (FMP) with more accurate information about traffic flow, as well as tools to predict complexity and traffic peaks, offers a more efficient way to reduce airspace complexity.

SESAR is replacing today's non-integrated tools with advanced software that can assess traffic demand and complexity based on continuously updated information from multiple sources. By applying predefined complexity metrics, FMPs at local level can take timely action to adjust capacity in collaboration with the Network Manager and airspace users. The result is more predictable traffic flow, fewer delays and enhanced safety.

The complexity assessment and resolution (CAR) tool operates in short-term and medium-term time horizons to balance workload across different sectors to maximise throughput without overloading or leaving airspace capacity unused. CAR is supported by automated tools which take into account the availability of airspace (due to weather, reservation, etc), sector capacity, operator preferences and overall network operations. Resolution of complexity problems requires the combination of automated detection tools and flexible deployment of human resources to ensure high levels of efficiency are sustained. It supports FMPs and supervisors in better tactical decision making, and delivers more predictable traffic flow.

Dynamic management of airspace structure helps to de-conflict traffic ahead of time, and optimises the use of controller resources

This solution enables flight management positions and supervisors to identify, assess and resolve local complexity situations, thereby reducing traffic peaks

Real-time simulations tested the automation tools in the en-route environment, and the extended arrival manager time horizon. Further real-time simulations assessed the concept of complexity measurement in a free route environment. The aim is to simplify the air traffic situation and enable controllers to optimise throughput with very little intervention.

This solution is available for industrialisation and is being deployed across Europe in accordance with the Pilot Common Project.





LESS WAITING AND FEWER DELAYS

Advanced short-term ATFCM measures (STAMs)

SJU references
#17/Release 5



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

To avoid traffic overload, flights are typically held on the ground rather than added to congested flight paths. These precautionary measures can be imposed hours in advance and are based on flight plans. Short-term air traffic flow capacity management (ATFCM) measures (STAMs) have more flexibility to handle traffic overload since control measures are applied at a later stage and align more closely with actual demand. They also allow additional measures, such as temporarily constraining a flight or group of flights at a lower altitude, or imposing minimum re-routings, to prevent sector overload.

SESAR has developed advanced STAMs through sharing information between the Network Manager and area control centres which only impose a wider range of measures as and when necessary.

Through close cooperation between different actors, it is possible to target individual flights with a STAM measure, such as a minor ground delay, flight level cap, or minor re-routing, to take into account local preferred solutions, rather than apply a regulation to a group of flights as a whole.

Advanced STAMs include a set of automated support tools at the network level which detect hotspots and disseminate the information to flow management positions in the area control centres. The toolset also includes 'what-if' functionalities to evaluate what the effect of STAMs will be before effectively applying them. The information takes account of an expanded information set including weather, airport operations, runway occupancy and traffic complexity. The data is shared electronically with the possibility to use business-to-business (B2B) system-wide information management (SWIM) in the future.

STAMs not only improve visibility and predictability during operations, but also allow detailed post-operations analysis

SESAR's automated STAM tools allow a shared situational awareness of the STAMs applied across the network for flow management staff, and makes all STAM-related data available for detailed post-operational analysis.

This solution is available for industrialisation and is part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.

BENEFITS

- Better use of airspace capacity in terminal and en-route airspace
- Increased cost efficiency
- Improved situational awareness of the European network





SJU references:
#18/Release 5

MOVING TO TIME-BASED OPERATIONS

Calculated take-off time (CTOT) and target time of arrival (TTA)

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Improved information sharing
- Enhanced predictability
- Improved situational awareness
- Increased capacity

As the airspace network and the airports become more connected, opportunities open up to smooth traffic flow and prevent imbalances between demand and capacity. This SESAR solution allows more intelligent demand and capacity balancing when traffic demand for landing into an airport exceeds the airport capacity (hotspot), by allowing the arrival airport to participate in the decision-making process of how to resolve the situation.

The solution aims at complementing departure regulations, such as the calculated take-off time (CTOT), with the dissemination of locally-generated target times, over the hotspot. Each airport collaborates with terminal area control to develop its own strategy to allocate the available landing capacity. Strategies are likely to take into account airspace users' input, the consistency of flight plans with seasonally-allocated airport slots, arrival route and runway allocation, or gate and connection management. This collaborative process contributes to a more coherent approach to demand regulation, which is expected to result in a reduced number of knock-on delays thereby benefitting passengers and airlines, as well as the network.

Another aspect of this SESAR solution is based on a greater level of information sharing between the Network Manager and flight operators. Whenever a flight is issued with a regulated take-off time, the airline also receives from the Network Manager the corresponding target time to arrive at the capacity-constrained area that motivated the regulation of its departure time. While target times are hard constraints, it is expected that the shared awareness will increase the effectiveness of air traffic flow management regulations. During the flight, any deviations between the agreed targets and the actual flight may be used by the different partners (flight crew, aircraft operator, local traffic managers) to support adherence to the time of entry in the congested area(s) and/or to assess and monitor the effects of deviations.

This solution involves the timely exchange of relevant airport and network information, resulting in common situational awareness which leads to improved network and airport planning activities, as well as improving operational performance

Live trials validated its feasibility with input from all actors involved. The trials included communicating planned measures (such as take-off and arrival time) as well as tactical measures imposed to maintain planned performance. The trials are also testing the use of sharing the same network view of the situation.

This solution is available for industrialisation and is part of synchronised deployment plans across Europe in accordance with the Pilot Common Project.





WORKING IN PARTNERSHIP WITH AIRLINES

Enhanced air traffic flow management (ATFM) slot swapping

SJU references:
#56/Release 4



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

Slot swapping is a means to reduce the impact of delays which may be caused by late inbound flights, weather conditions, airport congestion, among others. Slot exchanges within a single airline are agreed in a cooperative process with the Network Manager to smooth the traffic flow.

The SESAR solution enhances slot swapping functionalities by making it possible to swap pre-allocated slots with allocated slots or carry out multiple swaps for a single flight. These functionalities allow airlines to swap between long-haul and short-haul flights, or split the delay assigned to one flight between a maximum of three flights.

In current operations, when a flight is cancelled the Network Manager assigns its slot to another flight, usually operated by a different airline. This situation does not encourage flight cancellation, which results in the slots of cancelled flights being made available too late for them to be used by another flight. This solution allows airlines to promote one of their own flights in instances where they have to cancel a flight. This feature is expected to encourage cancellation of flights in the system, which would ultimately benefit all airspace users, particularly in capacity constrained situations.

Exercises simulating European city pairs validated this swapping tool which supported multiple swaps for a single flight, as well as substituting slots in case of cancellation. Over a seven-week time period, 199 swap requests were made using the tool with only 5 % rejected. The Network Manager reported that the response time to requests was not affected. Airspace users reported estimated savings of EUR 1 000 per flight.

It is not always easy to identify which flights would benefit from a swap. SESAR's enhanced slot swapping tool provides system support for the process, and makes it possible to carry out multiple swaps

The solution is available for industrialisation.

BENEFITS

- Improved network performance (management and capacity)
- Improved environmental performance



SJU references:
#57/Release 4

AIRLINE INPUT IMPROVES DEPARTURE OUTPUT

User-driven prioritisation process (UDPP) departure

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Reduced airline delay costs in case of disrupted situations, without jeopardising airport and network performance
- Increased flexibility for airlines
- Improved environmental performance

The user-driven prioritisation process allows airlines to change the priority order of unregulated flights among themselves and in collaboration with the airport authorities. Airlines are given this flexibility in the pre-departure sequence (PDS) for last-minute disruptions, which usually lead to departure delays or cancelled flights.

A full-scale demonstration at a major European hub introduced the SESAR tool as part of the airport's existing pre-departure sequencing process. The Departure Flexibility (DFlex) project allowed airlines to re-order departures based on their operational requirements while still early in the planning stages. It also included a 'ready-to-depart' functionality to support an immediate swap for a flight that is ready for start-up. Participating airlines were given the opportunity to agree to a new target start-up approval time (TSAT) with air traffic control to optimise their schedules. Among benefits, the tool helped to manage a runway closure which otherwise would have prevented passengers making flight connections, and delays were selectively kept to a minimum for long-haul flights.

Offers a local solution for airlines at a collaborative decision-making airport to identify slot swapping opportunities in an easy and user-friendly way

The solution creates more opportunities for departure flexibility within a group of airlines, with benefits increasing as more airlines join. It requires a pre-departure planning process to function, for example using information already shared between operators about planned push-back, start-up and target take-off times. It is especially beneficial in case of disruption with significant financial benefits for the airlines.

This solution is available for industrialisation and is now implemented at Paris Charles de Gaulle and Frankfurt airports, and is planned for implementation in Austria and Poland.

Enabling aviation infrastructure

The enhancements described in the first three key features will be underpinned by an advanced, integrated and rationalised aviation infrastructure, providing the required technical capabilities in a resource-efficient manner. This feature will rely on enhanced integration and interfacing between aircraft and ground systems, including ATC and other stakeholder systems, such as flight operations and military mission management systems. Communications, navigation and surveillance (CNS) systems, SWIM, trajectory management, common support services and the evolving role of the human will be considered in a coordinated way for application across the ATM system in a globally interoperable and harmonised manner.





SJU references:
#28/Release 5

SHARED DATA FOR IMPROVED FLIGHT EFFICIENCY

Initial ground-ground interoperability

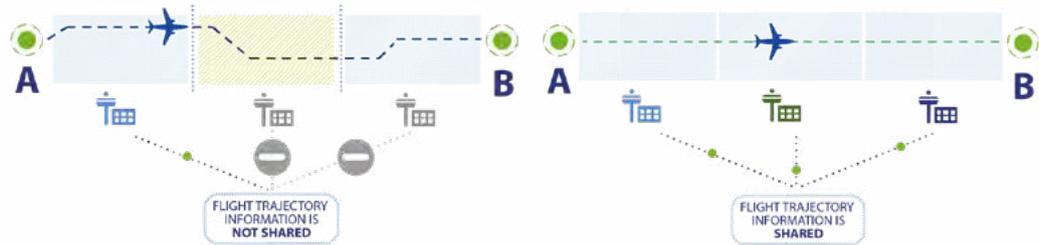
STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Increased and easier access to information sharing
- Support standards update in preparation for deployment

Today, when an aircraft leaves one national airspace and enters another, the adjacent centres exchange a basic or minimum set of flight information through an on-line data interchange mechanism known as OLDI. Centres further downstream however, do not get access to this information straight away and must rely on the originally filed flight plan in order to organise their airspace. To address this, SESAR is developing Europe's first system for continuous exchange of flight information between all actors managing an aircraft at all stages of its journey.

The solution is based on a secure system-wide information management (SWIM) technical infrastructure (known as the SWIM blue profile) supporting the concept of the 'flight object' which is a single entity holding the most up-to-date information about a flight. The system allows controllers to conduct silent coordination between adjacent units. In this way, all air traffic control facilities hold a consistent view of the flight at all times, which supports seamless cross-border operations, including cross-border free route operations.

This solution represents a key enabler to support all ATM solutions that require an interface between different ground control centres (e.g. Free route operations).

Requirements are being scoped for the technical feasibility of flight data trajectory sharing between air traffic service units through the use of flight object. The information is used for the coordination of tasks and controller assistance services between different ground control centers. Requirements and use cases specify how the flight object can be used by air traffic control to provide the optimum flight profile for an aircraft, also known as the reference business trajectory.

This solution has been consolidated with R&D activities in SESAR 2020 on the integration of trajectory management processes [See PJ.18-02].

Access to common flight data can result in more effective and better optimised coordination between adjacent ATC centres (or ANSPs)

Initial ground-ground interoperability represents a complete paradigm shift in how flight data information is shared between actors

This solution is linked to EUROCAE ED-133A



GETTING CONNECTED

Extended projected profile (EPP) availability on the ground

SJU references:
#115/Release 5



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

Modern aircraft feature advanced computerised flight management systems (FMS) to guide their navigation, which can exchange relevant data with the airline operations centres (AOC). Air traffic control centres, in turn, have sophisticated flight data processing systems (FDPS) to manage flight data on the ground, but there is limited data connection between the FMS and air traffic control ground systems.

BENEFITS

- Increased ground situational awareness resulting in increased predictability

The initial trajectory information sharing solution is based on the aircraft downlinking trajectory information directly from the FMS to the ground systems via an updated standard for the automatic dependent surveillance contract (ADS-C) that is used today exclusively for oceanic and remote operations. The newly developed standard is called ATN Baseline 2 and targets all operations. It allows the i4D FMS to downlink the extended projected profile (EPP), which contains an updated FMS route prediction. The data in the new standard is much more detailed than in the current ADS-C reports used in oceanic airspace; it includes, for example, the predicted aircraft weight, as well as the predicted horizontal and vertical speeds on up to 128 future waypoints along the route.

In this initial solution, the ground systems will enable controllers to display the downlinked route on the radar screen and will also automatically cross-check whether the downlinked route is consistent with what was expected on the ground; controllers will receive a warning in case a discrepancy is identified.

Increased data connectivity between on-board systems and ground air traffic control systems is a key enabler for the modernisation of the ATM system

This solution is ready for industrialisation. It is being deployed in a synchronised way across 22 air traffic control centres and 18 terminal manoeuvring areas and airports across Europe in accordance with the Pilot Common Project.

This solution is linked to EUROCAE standards ED-228A and ED-229A





SJU references:
#67/Release 2

PLANNING IMPROVES WITH ACCURATE FLIGHT DATA

AOC data increasing trajectory prediction accuracy

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Increased predictability
- Increased safety

Europe's vision to achieve high-performing aviation by 2035 builds on the idea of trajectory-based operations – meaning that aircraft can fly their preferred trajectory while minimising constraints due to airspace and service configurations. SESAR has introduced an early version which makes use of flight planning data sourced from airline operational control (AOC) to help controllers optimise aircraft flight paths. This solution represents an initial step towards the extended flight plan solution and flight and flow information for a collaborative environment (FF-ICE).

Access to flight planning data enables air traffic control to create more accurate trajectory predictors (TP) based on the intentions of the aircraft. The TP are used by advanced controller tools to detect potential conflicts and to develop efficient arrival and departure streams. Eventually, when new datalink communications are universally applied, trajectory information will be exchanged directly between the aircraft and the ground, anticipated from 2025 onwards.

The flight data provides information about aircraft climb and descent speed, and take-off mass, and can be used to help create trajectory profiles to meet five-minute up to two-hour time horizons. The data is particularly helpful when creating climbing and descending flight profiles, where current tools can encounter limited controller acceptance due to high false alerts and re-sequencing rates which result from the poor accuracy of trajectory predictions.

A real-time simulation in a complex terminal airspace resulted in a 10 % reduction in medium-term conflict-detection false alerts when the underlying technical profile is supported by AOC data. Air navigation service provision was improved since fewer false alerts meant controllers had to perform fewer unnecessary actions, and airlines consumed less fuel as a result of fewer level-offs.

This solution is planned for implementation in France.

Trajectory information provides air traffic control with the degree of accuracy it needs to build sequencing or conflict-detection and resolution tools which support controllers' tasks

Most of the benefits expected from this concept occur in flight segments with strong ascending and descending profiles such as terminal airspace

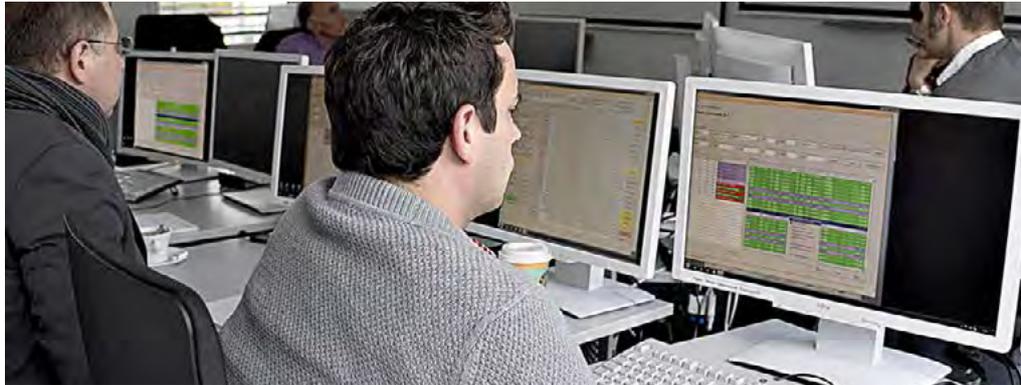
This solution is linked to the FIXM standard (v4) included in the ICAO Flight Plan 2012



IMPROVED PLANNING THANKS TO ENRICHED DATA

Extended flight plan

SJU references:
#37/Release 5



Air navigation service providers use aircraft flight plan data to plan and schedule air traffic in order to balance airspace supply and demand. In Europe's future trajectory-based flight environment, where aircraft can fly their preferred flight paths without being constrained by airspace configurations, flight plan data will include additional information, which will allow both the Network Manager and the air traffic control units to have a more precise plan of how the aircraft will fly.

The extended flight plan (EFPL) goes beyond the ICAO minimum requirements for aircraft flight plans, which were updated in 2012, with yet more operational data. In addition to trajectory data and aircraft performance data (compared to the ICAO flight plan), a key part of the concept allows for applied airspace management constraints and accepted trajectories to be sent from the Network Manager to the airspace users.

The EFPL includes further information relevant to each point of the aircraft's trajectory, for example speed and aircraft mass, as well as other performance data such as planned climb and descent profiles. This allows both air traffic control and the Network Manager to improve their prediction of the trajectory. This is especially relevant in complex airspace, because it allows better flow management, and also improves the performance of the conflict detection and resolution tools used by controllers.

The EFPL aims to reduce flight plan rejections by the Network Manager and increase traffic predictability. Concerning the flight plan rejections, the use of 15 data fields in the ICAO flight plan is open to different interpretations resulting in unwarranted flight plan rejections. The validation of this SESAR solution has included the refinement of the data exchange processes and shows that EFPL significantly reduces flight plan rejections compared to those associated with the ICAO 2012 flight plan validation process.

The solution is available for industrialisation. The extended flight plan is being deployed in Europe in accordance with the Pilot Common Project.

STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- Improved network predictability
- Enhanced safety
- Improved performance of conflict detection and resolution tools

The extended flight plan includes additional information in relation to an aircraft's planned four-dimensional trajectory which supports an airspace environment where aircraft can fly their preferred flight paths

This solution sees the integration of four-dimensional flight plan data into the Network Manager flight planning acceptance and distribution system





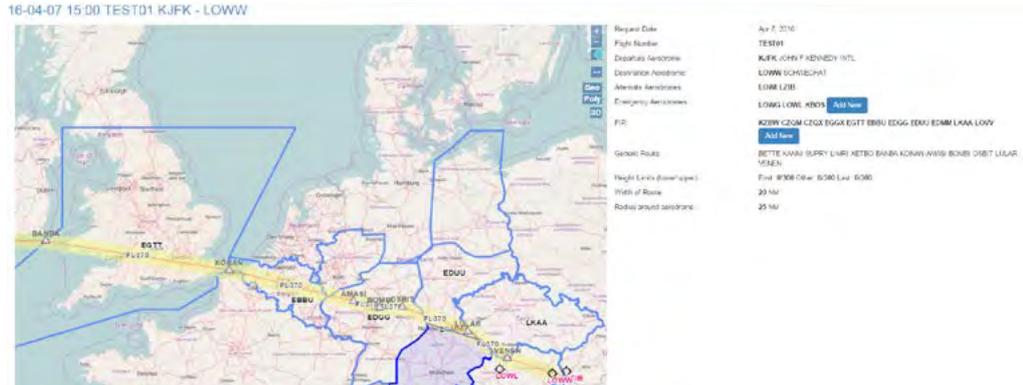
SJU references:
#34/Release 5

THE BENEFITS OF DIGITAL DATA

Digital integrated briefing

STAKEHOLDERS

- ANSP
- AO
- AU
- NM



BENEFITS

- Enhanced information sharing
- Increased cost efficiency through improved service provision
- Improved situational awareness

The current pre-flight briefing for the pilot includes pages of information, called notice to airmen (NOTAM), recent weather reports and forecasts (MET), which have to be integrated into a consolidated operational picture. The documents can be difficult for pilots to use, and no longer satisfy today's air traffic needs for timely and accurate aeronautical and meteorological information updates. By introducing digital NOTAM and MET data, the briefing could be radically improved.

Aircraft are increasingly equipped with electronic flight bag (EFB) devices which support pre-flight briefing to the pilot and on the ground through provision of flight documentation. The pre-flight briefing could take place directly on the EFB, receiving digital briefings from the ground and updated over a datalink during the flight. Retrieval of the digital aeronautical data, including NOTAM and MET data, is enabled by means of system-wide information management (SWIM) and digital NOTAM.

SWIM information exchange and digital NOTAMs can support the graphical representation of data such as meteorological charts, as well as increase the usability of briefing material by making it searchable and interactive. The digitised information can also be validated and cross-checked automatically (unlike today's pre-briefing documents) to ensure adherence to ICAO standards and to reduce risk of error. In addition, relevant information can be selected more easily from digital data compared with briefing notes which may include between 10 and 50 pages for a cross-European flight.

Real-time simulations assessed enhancements in pilot briefing applications based on digital NOTAMs, digital MET, and air traffic flow management data, with the aim of improving situational awareness for pilots and reducing briefing times.

In terms of benefits, the graphical presentation of digital information, better filtering automatic notification of relevant changes and a more logical organisation of the pre-flight information bulletins can improve pilot and dispatcher awareness, reduce briefing times and reduce the risk of information being misunderstood or missed.

This solution is available for industrialisation.

This solution aims to improve pre-flight information sharing between pilot, flight dispatchers and air traffic controllers through the exchange of easier to understand, better filtered digital aeronautical data

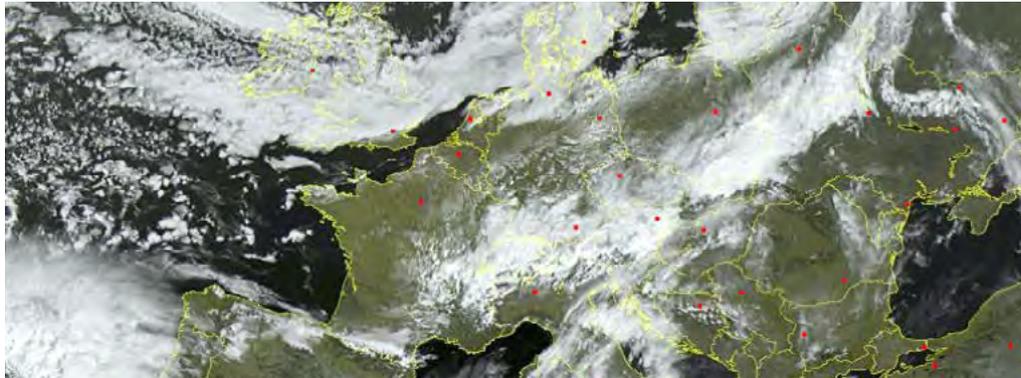
The SESAR solution is aligned with the ICAO roadmap for the provision of digital aeronautical information on a global scale and mirrors parallel development in the US



STAYING AHEAD OF THE WEATHER

Meteorological information exchange

SJU references:
#35/Release 5



Bad weather brings unwelcome disruption to flight schedules and is the cause of approximately 13 % of Europe’s primary delays. Yet the impact can be mitigated by the timely sharing of information so that effective recovery strategies can be put in place.

Meteorological information is currently available in several message formats and also in the form of maps or charts and plain text. Although end users are accustomed to these formats, they limit the opportunity to use the data effectively, for example to prioritise key information, or highlight relevant weather phenomena. Access to more precise weather data can assist decision making when it comes to flight planning, resource planning, and route planning, and can help to avoid unnecessary delay.

SESAR developed a mechanism by which meteorological data generated by European meteorological agencies can be seamlessly integrated into aeronautical information service provision; this is known as the four-dimensional (4D) weather cube. The 4DWxCube is a (virtual) repository of shared consistent and translated meteorological information, produced by multiple meteorological service providers (METSPs) and made available to airspace management stakeholders via its system-wide information management (SWIM) compliant MET-GATE.

Sharing this weather information and its integration within the air traffic management decision-making process enables airspace users, airports and air navigation service providers to stay up to date with the latest weather situation, and to plan accordingly and effectively. Weather conditions influence all aspects of air traffic operations, for example by increasing or decreasing tailwind, by changing pressure or temperature or by introducing low-visibility conditions.

The meteorological information exchange uses SWIM to enable seamless interchange of meteorological data with different partners, and involves SWIM-compliant services such as legacy forecasts (METAR/TAF/SIGMET) and new ones such as hazardous weather (convection, turbulence, icing) developed under the scope of this solution.

This solution is available for industrialisation. MET information exchange is being deployed as part of initial SWIM, in accordance with the Pilot Common Project.

STAKEHOLDERS

- ANSP
- AO
- AU
- NM

BENEFITS

- Improved safety
- Improved planning, leading to fuel reduction
- Increased cost efficiency through improved service provision

The SESAR 4D weather cube makes use of actual and forecast MET information from different air and ground sources for providing adverse weather alerts

This solution builds on ICAO Annex 3 standards and recommendations, and contributes to the definition of MET standards





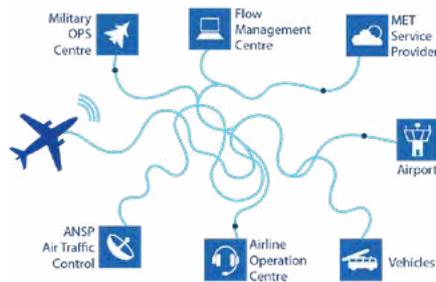
SJU references:
#46/Release 5

LEARNING TO SWIM

Initial system-wide information management (SWIM) technology solution

STAKEHOLDERS

- ANSP
- AO
- AU
- NM



BENEFITS

- Increased cost efficiency and easily accessible information sharing
- Improved contextual awareness
- Improved collaborative decision making

SESAR is introducing a new approach to sharing information, called system-wide information management (SWIM). SWIM enables seamless information data access and interchange between all providers and users of air traffic management data and services.

The aim of SWIM is to provide information users with relevant and commonly understandable information. It does not refer to a single solution or technology, but rather a global level of interoperability and standardisation that enables users and providers to exchange data without having to use different interfaces or protocols. It is based on service-oriented architecture and open and standard technologies. It introduces a totally new way of working that sits comfortably in a cloud environment.

This SWIM technological solution provides a coherent set of specifications to support standardisation in the context of SWIM deployment. These are the key elements in steering SWIM-enabled systems for ensuring interoperability are the following:

- ▶ Aeronautical information reference model (AIRM) to ensure semantic interoperability;
- ▶ Information service reference model (ISRM) to ensure organisational interoperability;
- ▶ SWIM technical infrastructure (SWIM TI) profiles and architecture to enable technical interoperability;
- ▶ SWIM registry to improve the visibility and accessibility of ATM information and services available through SWIM. It enables service providers, consumers, and the swim governance to share a common view on SWIM providing consolidated information on services that have been implemented based on SWIM standards.

SWIM represents a complete paradigm shift in how information is managed along its full lifecycle and across the whole European ATM system

The SWIM solution and services are developed in accordance with the ICAO SWIM manual

This solution is available for industrialisation and is part of synchronised deployment plans in accordance with the Pilot Common Project. The first SWIM-enabled solution was introduced in 2014 to support the exchange of data between neighbouring airspace sectors.





VISUALISING AIRBORNE ALERTS FROM THE GROUND

ACAS ground monitoring and presentation system

SJU references:
#100/Release 5



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

The airborne collision avoidance system (ACAS) provides resolution advisories (RAs) to pilots in order to avoid collisions. Controllers rely on pilots to report RAs by radio as they occur in accordance with ICAO regulations. However these reports can come late, incomplete or are absent in some instances. This solution consists of a set of monitoring stations and a server system, which enable the continuous monitoring and analysis of ACAS RAs and coordination messages between airborne units from the ground.

BENEFITS

- Enhanced safety

The system includes the potential to provide real-time airborne data to ground-based safety nets. For ACAS RA monitoring, the ground station is extended to be able to receive 1030 MHz messages exchanged between ACAS equipped aircraft and the RA broadcast that can provide information on the presence of an RA.

A test platform was used to monitor the entire upper airspace during a period of more than three years to collect data and evaluate the concept. The system was able to process and deliver valid resolution advisories within two seconds, and was able to filter out false advisories.

The SESAR validation work also showed that the fusion and the use of surveillance sensor data from Mode-S radar, wide area multilateration (WAM), multilateration (MLAT) and ADS-B, when combined with ACAS ground sensor RA data provide practical and beneficial safety enhancements.

SESAR exercises show that ACAS monitoring on the ground is feasible and can be integrated into an overall air traffic management system

This solution is available for industrialisation but further work is expected to address the operational use by controllers.



SJU references:
#101/Release 5

SPECTRUM EFFICIENT SURVEILLANCE

Extended hybrid surveillance

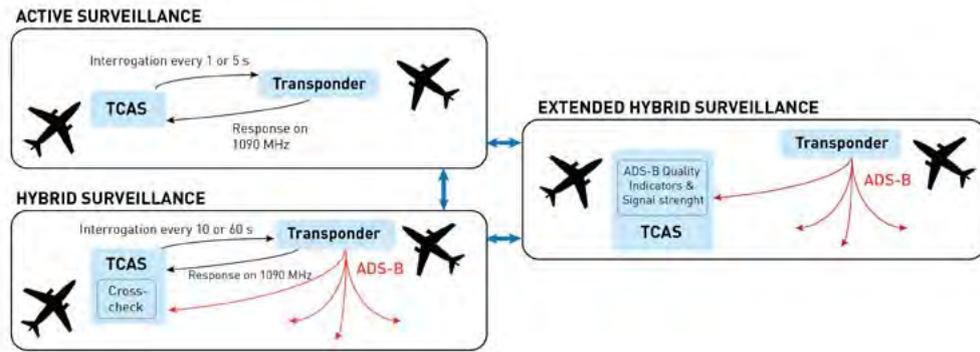
STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- Reduced risk of radar information loss due to overloaded frequency band

The traffic alert and collision avoidance system (TCAS) is an airborne collision avoidance system designed to reduce the incidence of mid-air collisions between aircraft. Currently, TCAS II is dependent upon 1090 MHz replies that are elicited by 1030 MHz interrogations. These provide the pilot with information about the relative distance, bearing and aircraft altitude and are used to build active tracks. However, the process uses precious frequency bandwidth that is also needed for surveillance purposes.

The technical solution consists of an enhanced TCAS capability, adding passive surveillance methods and reducing the need for active Mode-S interrogations. By making fewer active interrogations, this solution allows the aircraft to significantly reduce the usage of the 1090 MHz frequency.

Validations carried out using roof-top antennae in the proximity of an airport showed the basic functionality of the system. The concept was also flight-tested and this data was used in simulation activity to assess the results and overall impact on 1090 MHz load. The technology met the minimum operating requirements developed for the solution and resulted in no operational differences for pilots and controllers. When the 1090 MHz usage was compared with TCAS II, the assessment showed a reduction of Mode-S interrogations of at least 70 %.

This solution is available for industrialisation.

Minimum operational performance standards (MOPS) for improved hybrid surveillance has been already published both by EUROCAE (ED-221) and RTCA (DO-300A)

In addition to changes required for ADS-B-in capability, improved hybrid surveillance would also require a TCAS II unit software update



ENTERING THE NEW DIGITAL ENVIRONMENT

Aeronautical mobile airport communication system (AeroMACS)

SJU references:
#102/Release 5



STAKEHOLDERS

- ANSP
- AO
- AU
- NM

ATM communications capacity is reaching saturation in Europe due to increasing air traffic volumes and density. The situation is particularly acute on the airport surface where a large concentration of aircraft combined with pre-flight and post-flight operations increasingly rely on data communications.

The aeronautical mobile airport communication system (AeroMACS) offers a solution to offload the saturated VHF datalink communications in the airport environment and support new services. The technical solution AeroMACS is based on commercial 4G technology and uses the IEEE 802.16 (WiMAX) standard. Designed to operate in reserved (aeronautical) frequency bands, AeroMACS can be used for air navigation service providers (ANSPs), airspace users and airport authority communications, in compliance with SESAR's future communication infrastructure (FCI) concept. AeroMACS is an international standard and supports globally harmonised and available capabilities according to ICAO Global Air Navigation Plan (GANP).

SESAR validated the system concept and usage of the airport surface datalink system. This has been done through simulations, developing prototypes and testing in lab conditions as well as on-site at airports and on aircraft. In addition, SESAR led the development of standards in ICAO, EUROCAE/RTCA and the Airlines Electronic Engineering Committee (AEEC). Together with other FCI solutions, AeroMACS will support the multilink FCI concept, offering increased robustness of datalink operations and thereby supporting the move towards the use of datalink communications as the primary means of communications in airspace management.

This solution is linked to EUROCAE standards ED223 and ED227 and the AeroMACS Manual (ICAO Doc10044)

This solution is available for industrialisation. Implementation will be subject to the demonstration of a viable business case.

BENEFITS

- Increased capacity for information and communications exchanges
- More efficient airport surface operations with increased safety and security levels
- Increased cost efficiency, thanks to synergies and sharing of infrastructure between actors, thereby lowering costs



SJU references:
#109/Release 5

A NEW GENERATION OF SATELLITE-BASED DATALINK COMMUNICATIONS

Air traffic services (ATS) datalink using Iris Precursor

STAKEHOLDERS

ANSP

AO

AU

NM



BENEFITS

- **Enabler for initial i4D operations**

The Iris Precursor offers a viable option for air traffic services (ATS) datalink using existing satellite technology systems to support initial four-dimensional (i4D) datalink capability. The technology can be used to provide end-to-end air-ground communications for i4D operations, connecting aircraft and air traffic management ground systems.

The Iris Precursor is designed to exploit an opportunity to deploy an aviation communications service based on the existing SwiftBroadband (SBB) satellite network from Inmarsat. The aim is to augment the existing VHF datalink (VDL) capability in Europe in order to increase reliability and capacity, and help establish satellite communications as a key component in the future ATM communications landscape. This solution also offers an alternative datalink option for aircraft already equipped with SATCOM systems.

A SESAR flight trial demonstrated that the Iris Precursor service could provide the communication performance required for datalink exchanges to fly i4D operations. Specifically, it showed how i4D automatic dependent surveillance-contract (ADS-C) could be successfully maintained with two air traffic control centres for over two hours. During this time, i4D ADS-C reports were generated on events resulting in downlinking trajectory updates approximately every 20 seconds with 20 waypoints - an update rate which is well above the rate needed for i4D trajectory exchanges. In addition to the i4D trajectory exchanges, various controller-pilot datalink communications (CPDLC) messages were exchanged along the flight with a remarkable performance round trip time of below two seconds throughout the flight's duration.

This solution is available for industrialisation. The transition roadmap from Iris Precursor to the future communication infrastructure is currently being addressed by SESAR 2020 as well as by the European Space Agency (ESA) and Inmarsat (Iris Service Evolution).





IMPROVING SURVEILLANCE SECURITY AND INTEGRITY

ADS-B surveillance of aircraft in flight and on the surface

SJU References:
#110



Automatic dependent surveillance-broadcast (ADS-B) is a technique which allows the tracking of aircraft in flight and on the surface. Enhancements of the functionality and interfaces are required to the ground surveillance system, in order to make it compliant with the new applications of ADS-B in radar airspace, ADS-B for airport surveillance and other emerging requirements, such as security.

The SESAR solution consists of ADS-B ground station and surveillance data processing and distribution (SDPD) functionality. The solution also offers detection and mitigation techniques against deliberate spoofing of the ground system by outside agents. These techniques can also be used to cope with malfunctioning of avionics equipment. SESAR has contributed to the relevant standards, such as EUROCAE technical specifications, incorporating new functionalities developed for the ADS-B ground station, ASTERIX interface specifications as well as to the SDPD specifications.

Shadow-mode exercises showed how the solution can be used in different types of airspace (airports, TMA, en-route) under nominal and non-nominal conditions and can be used to improve flight conformance monitoring. The solution is seen as a key enabler for surveillance infrastructure rationalisation thanks to the efficiency gains it brings in terms of costs and spectrum usage. The solution is also fully interoperable with other surveillance means.

This solution is implemented in Germany, France and Hungary and planned in Austria, Estonia, Spain, Italy, Lithuania, Portugal and the Slovak Republic.

SESAR has contributed to the relevant standards, such as EUROCAE technical specifications, incorporating new functionalities developed for the ADS-B ground station, ASTERIX interface specifications as well as to the SDPD specifications

STAKEHOLDERS

ANSP

AO

AU

NM

BENEFITS

- Enabler for surveillance infrastructure rationalisation

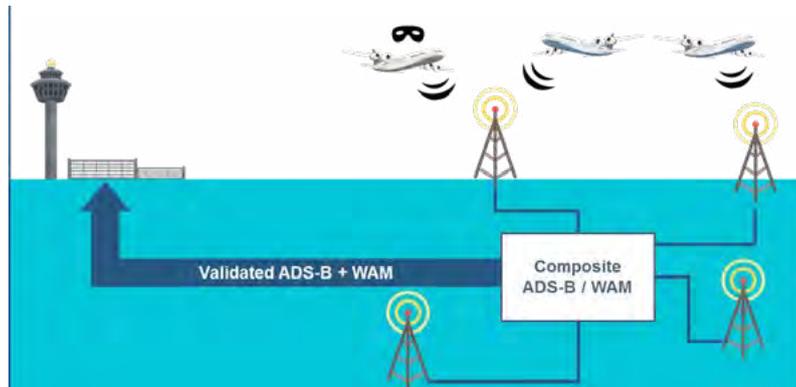


SJU References:
#114/Release 5

COMBINING SURVEILLANCE SYSTEMS FOR GREATER EFFICIENCY

Composite cooperative surveillance automatic dependent surveillance – broadcast/Wide area multilateration (ADS-B/WAM)

STAKEHOLDERS
ANSP
AO
AU
NM



BENEFITS

- Improved cost efficiency
- Improved security

Composite cooperative surveillance ADS-B/WAM is a system that exploits the similarities between the two surveillance techniques and combines them into a single system. ADS-B information received by WAM system is evaluated and if matching with WAM information extracted by others methods, then it is used in the WAM output. Information is then periodically re-evaluated.

By allowing the use of ADS-B data that has been validated against data derived in parallel by a WAM system, the system can help to reduce the number of interrogations and number of replies and therefore reduce the 1030/1090 MHz radio frequency (RF) load and improve spectrum efficiency. It achieves this through the integration of validated data items into the WAM channel, thereby preventing a need to re-interrogate the data item.

Since the two surveillance layers share hardware components, the system offers improved cost efficiency. Furthermore, the use of the system contributes to an improved security by successfully mitigating associated ADS-B threats.

SESAR has contributed to the relevant standards, such as EUROCAE technical specifications for WAM and ADS-B that are implementing this 'composite' concept

Shadow-mode exercises demonstrated that use of ADS-B data in the WAM output helps to reduce the RF pollution generated by the system. Platforms were used to collect a large dataset of overlapping CAT021 ADS-B and CAT020 WAM messages and assessed to compare WAM & ADS-B values.

This solution is implemented in Armenia, Austria and Latvia and planned in Denmark, France, Lithuania, Latvia, Former Yugoslav Republic of Macedonia, Poland and Romania.



2 Candidate solutions in the pipeline



High performing airport operations



Advanced air traffic services



Optimised network operations



Enabling aviation infrastructure

Building on SESAR 1, R&D is underway on a further 79 candidate solutions. A portion of these solutions are on track to be delivered in 2019 (referenced as Release 9), while further testing will continue on the remainder (as candidates for the second wave of R&D), in addition to initiating research on newly-identified candidate solutions.

It should be noted, however, that the contents of this section is subject to re-orientation in light of the next edition of the European ATM Master Plan. This section therefore is very much a look at work in progress, meaning that some of these candidate solutions may not reach maturity or the end of the innovation pipeline.

In addition to some already delivered, a number of candidate solutions have been identified as enablers for optimising the airspace organisation and capacity, as well as bringing scalability and resilience to the system

High-performing airport operations

The future European ATM system relies on the full integration of airports as nodes into the network. This implies enhanced airport operations, ensuring a seamless process through collaborative decision making (CDM), in both normal and adverse conditions. This feature addresses the enhancement of runway throughput, integrated surface management, airport safety nets and total airport management.



STAKEHOLDERS



SJU references:
PJ.#02-01/Release 9,
see delivered solution #64

RUNWAY THROUGHPUT BENEFITS FROM NEW WAKE TURBULENCE SEPARATIONS AND SEPARATION DELIVERY TOOL FOR CONTROLLERS

Wake turbulence separation optimisation

BENEFITS

[Increased airport capacity](#)

[Enhanced safety](#)

[Reduced fuel consumption and emissions](#)

[Improved predictability](#)

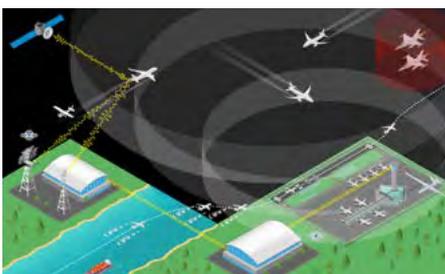
[Increased resilience](#)

Runway capacity is a limiting factor at many of the top 30 Europe's largest airports, especially during peak hours when demand cannot always be accommodated without inducing delay or increasing flying time. Aircraft are classified by ICAO by their wake generation characteristics - but these classifications can be further optimised when combined with additional separation classes introduced under Europe's Wake Vortex Re-Categorisation (RECAT-EU) scheme. First deployed at Paris-CDG in late 2015, RECAT-EU has increased runway throughput safely at the airport by more than 8% per hour during peak periods. Leipzig-Halle is also using this re-categorisation to optimise its freight movements and London Heathrow, Vienna and Toulouse have also begun using the new separation standards.

SESAR is developing more efficient wake turbulence separations consisting of time-

based minima between aircraft types, which take account of dynamic factors, such as current weather and static aircraft characteristics including wake generation and wake resistance. Those separations, when combined with the latest air traffic control separation delivery support tools, allow approach and tower controllers to deliver consistent and safe spacing between aircraft. The software features target distance indicators for aircraft approaching the runway landing threshold and time indicators for aircraft taking off. Software can be used in all mode of operations including mixed mode where the calculation of optimum separation on approach is a relevant factor for supporting predictable departures take-off times.

Furthermore, enhanced wake delay devices are developed in this candidate solution, which incorporate features designed specifically to reduce the risk of encountering wake vortices at low flight altitude, where there is limited opportunity for the pilot to recover from a vortex encounter.





SATELLITE APPROACH PROCEDURES MINIMISE NOISE AND ENHANCE RUNWAY THROUGHPUT

Enhanced approach procedures enabled by satellite technologies

Satellite constellations, such as Galileo, augmented by satellite-based augmentation systems (SBAS) and ground-based augmentation systems (GBAS), offer pilots greater flexibility to fly published enhanced GNSS approaches such as steeper glide slopes, second runway aiming points, or a combination of both, in addition to curved approaches.

These procedures enable the noise footprint to be moved, typically closer to the centre of the airport, or to reduce the amount of noise at ground level near the final approach segment. The operational combination of enhanced navigation capability provided by augmented satellite signals flown by equipped traffic, with a glide slope leading to a further runway-aiming point, also enhances runway capacity and throughput. This reduces the risk of encountering wake vortices as aircraft on approach to displaced runway thresholds can benefit from

reduced vortex separation minima for a specific combination of leader/follower aircraft pairs.

The candidate solution supports a number of options. Airports with closely spaced parallel runways (CSPR) can use enhanced arrival procedures to establish dual thresholds (DT), comprising a runway threshold staggered from the nominal threshold. Alternatively, a second runway-aiming point (SRAP) enables aircraft to land on one of two published runway-aiming points with corresponding glide slope, ground markers, lights, and visual aids. Airports can also publish approaches, which feature a glide slope between 3 degrees (current slope) anywhere up to 4.49 degrees (IGS). A more advanced version of this, enabled by an on-board flight management function, known as adaptive increased glide slope (A-IGS), features a glide slope that suits the aircraft weight, destination wind, temperature, pressure, and landing configuration chosen by the pilot.

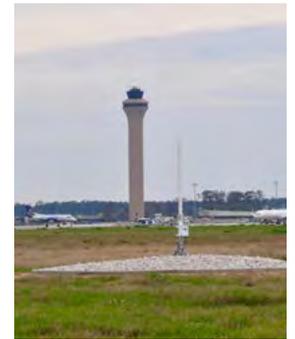
STAKEHOLDERS



SJU references: #PJ.02-02/Release 9, see delivered solution #55

BENEFITS

- Improved fuel efficiency and reduced noise
- Increased airport capacity
- Enhanced safety
- Increased operational and cost efficiency



HIGH ACCURACY SURVEILLANCE FREES UP CAPACITY ON APPROACH

Minimum-pair separations based on required surveillance performance (RSP)

The arrival and departure phases of flight are among the most safety-critical, but also where close spacing between aircraft can significantly increase capacity. The minimum separation distance between aircraft on final approach to the runway is currently typically 3 nm, or can be 2.5 nm under certain conditions depending upon international and local regulations.

This candidate solution is dependent upon the availability of accurate aircraft position data used by air traffic control and radar surveillance information that can satisfy the required surveillance and safety performance of 2 nm separation. The solution will demonstrate that the mid-air collision risk is acceptable, and that the new minima is compatible with the leader runway occupancy time (ROT) and pair-wise wake separations.

In reality, it is unlikely that there will be many pairs separated by 2 nm because of larger ROT and wake constraints. Mindful of this, the candidate solution proposes to deliver the



separation minima either through a category-based approach, where the new surveillance minima will only be allowed behind a leader aircraft category with a shorter ROT, or, through a separation tool (such as time-based separation), which will propose a minimum separation with a higher value of ROT, wake or the new surveillance minima.

STAKEHOLDERS



SJU references: #PJ.02-03/Release 9

BENEFITS

- Increased airport capacity
- Enhanced safety and increased resilience
- Improved fuel efficiency
- Increased operational and cost efficiency

STAKEHOLDERS



SJU references: #PJ.02-05/
Release 9, see #PJ.01-06
delivered solution #113



SAFER APPROACH PROCEDURES FOR ROTORCRAFT

Independent rotorcraft operations at airports

BENEFITS

- Improved fuel efficiency
- Increased predictability
- Ensured equitable access to airports and TMA

This candidate solution aims to improve access into all classes of airports in low-visibility conditions through the development and publication of specific approach and departure procedures for rotorcraft. If rotorcraft have to fly under instrument flight rules (IFR), either due to airspace class or to the weather conditions, ATC currently has to manage the flight in accordance with fixed-wing procedures, often causing delay in the overall throughput at busy airports.

By introducing an independent IFR procedure for rotorcraft on final approach and take-off, both aircraft types can fly simultaneous non-interfering (SNI) operations. The independent procedure relies on performance-based navigation - specifically required navigation performance (RNP) - to reach a point-in-space (PinS) to access the final approach and take-off area. GNSS-based procedures with vertical guidance provide a reliable and accurate means of navigation, which allows the development of dedicated and tailored routes, completely

decoupled from traditional navigation aids and from fixed-wing aircraft procedures.

Dedicated IFR procedures can also help small airports where the installation of traditional navigation aids is not financially viable, but where visual flight procedures and night operations are made safer. The peculiar rotorcraft capabilities of tight turns, steep climb and descent, combined with dedicated IFR procedures based on GNSS and the RNP navigation specification within low-level IFR routes, will not only avoid the interaction of rotorcraft with fixed-wing aircraft, but will also optimise operations in obstacle-rich urban environments and noise sensitive areas.



STAKEHOLDERS



SJU references: #PJ.02-06/
Wave 2 candidate



AFFORDABLE SURVEILLANCE AT SMALL AND MEDIUM-SIZED AIRPORTS

Improved access into secondary airports in low-visibility conditions

BENEFITS

- Increased predictability
- Improved fuel efficiency
- Ensured equitable access to airports

Small and medium-sized airports need cost-efficient solutions to perform operations in low-visibility conditions. While advanced equipment (e.g. A-SMGCS) and services are widely available, the cost of installation and maintenance may exceed the financial capability of secondary airports. Introducing low-cost solutions can bring direct benefits, and lead to increased capacity at primary airports by reducing the number of flight deviations. SESAR addresses both the ground and airborne aspects.

From the ground perspective, the candidate solution evaluates different options for aircraft and vehicle tracking using camera-based systems as an affordable alternative surveillance source, or in combination with other available surveillance sources such as multilateration and automatic dependent surveillance – broadcast (ADS-B) sensors.

All airport stakeholders can use the video data as a tool to enhance safety and operational performance.

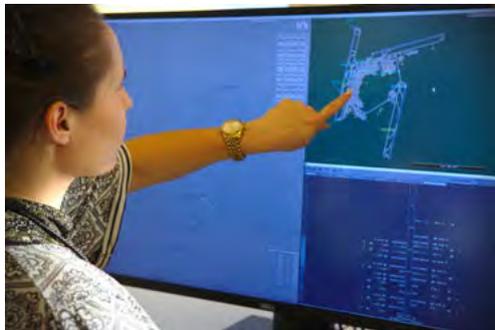
From the airborne perspective, the candidate solution aims to evaluate ATC requirements for precision approach procedures with vertical guidance down to Category II decision height, or no lower than 100 ft (60 m). This relies on satellite signals from GNSS (such as Galileo), either with use of satellite-based augmentation (SBAS) or ground-based augmentation (GBAS). The airborne perspective considers on-board equipment support to landing onto secondary airport. The candidate solution is assessing if a single GBAS ground station can enable approach operations during low-visibility conditions without other significant infrastructure.





MORE PRECISE PLANNING RAISES RUNWAY THROUGHPUT

Traffic optimisation on single and multiple runway airports



Ensuring the runway operates at optimum capacity contributes to the smooth running of an airport and increases the amount of traffic it can handle. This candidate solution focuses on an integrated runway sequence function to balance arrival flights and departure flights on single runway, dependent runways or parallel runways with the option to balance also flights between parallel runways. This solution enables efficient operations through early planning to support

predictability, continuous decent and enhanced runway throughput operations. The functionality of dynamic trajectory-based integrated runway sequence is designed to be combined with other SESAR Solutions, such as wake turbulence re-categorisation and time-based separation.

The improvements offered by the solution include the use of a runway manager (RMAN) for airports with more than one runway to plan the optimal runway configuration combined with the integrated runway sequence function for dependent runways and parallel runways. This dynamic assistance tool increases the predictability of runway capacity and results in a more efficient configuration of arrivals and departures.

Finally, this candidate solution is supported by improved prediction about runway occupancy times provided by ground-based systems, which measure the time taken to line up, take-off, land and vacate the runway.

STAKEHOLDERS



SJU references: #PJ.02-08/
Release 9

BENEFITS

- [Enhanced safety](#)
- [Improved fuel efficiency](#)
- [Enhanced airport and TMA capacity](#)
- [Increased operational and cost efficiency](#)
- [Improved predictability](#)
- [Enhanced security](#)



NAVIGATING MORE EFFICIENT CURVED APPROACHES

Enhanced terminal area for efficient curved operations

Following more precise arrival routes helps aircraft to reduce track miles and minimise noise over areas of habitation. Thanks to the use of GNSS (such as Galileo) geometric guidance, aircraft can fly RNP with accuracies of 0.3 nm or 0.1 nm, enabling airlines to fly more efficient routes and a wide variety of flexible approach paths. Starting a curved approach further from the runway allows easier segregation of traffic flows, for example according to wake category or preferred approach speed. Aircraft can also use different alignment points, some potentially very close to the runway, to optimise procedures in terms of fuel consumption or noise abatement.

This candidate solution aims to validate the use of GNSS geometric guidance from the initial approach fix or earlier, in order to make the transition easier in certain weather conditions - such as high temperatures - which might affect barometric vertical navigation. It requires developing and validating a concept that enables controllers to ensure that safe vertical



separation is maintained between all traffic that does not have lateral separation, whether they are using geometric or barometric vertical navigation. It also requires development of ground systems, synchronised with airborne data, to present altitude information to controllers. At a later stage the work extends to developing tools and procedures to support controllers when handling merging traffic - for example curved approaches and straight-in approaches - and the impact of weather on advanced curved operations.

STAKEHOLDERS



SJU references: #PJ.02-11/
Wave 2 candidate

BENEFITS

- [Improved fuel efficiency](#)
- [Enhanced TMA capacity](#)
- [Increased operational and cost efficiency](#)
- [Improved predictability](#)
- [Enhanced security](#)

STAKEHOLDERS



SJU references:
#PJ.03a-01/Wave 2
candidate, see delivered
solutions #47 & #48

SAFER, MORE EFFICIENT SURFACE MOVEMENT GUIDANCE

Enhanced guidance assistance to aircraft and vehicles on the airport surface combined with routing

BENEFITS

- [Improved fuel efficiency](#)
- [Enhanced airport capacity](#)
- [Increased operational and cost efficiency](#)
- [Improved predictability and punctuality](#)
- [Enhanced security](#)



Maintaining throughput rates in all weather conditions is a challenge at busy airports, but there are tools available, which can help to guide aircraft and vehicles safely around the airfield. The high-level objective for this candidate solution is to increase pilots' and vehicle drivers' situational awareness by providing them with supplementary guidance means in all weather conditions. Both pilots and vehicle drivers use an airport moving map, which shows the airport layout including taxiways, runways and fixed obstacles. It also displays the status of stop bars and virtual stop bars, tracks the position of the aircraft or vehicle, and shows the clearance to taxi as issued by air traffic control.

The candidate solution aims at optimising surface operations by providing controllers with advanced support tools for planning and

routing of aircraft and vehicles. By linking the display with virtual stop bars - first introduced for controllers in SESAR 1 - both drivers and controllers receive an alert if a vehicle inadvertently enters an area without clearance. The application of dynamic virtual block control contributes to smoother and more predictable traffic flow during low visibility conditions. The candidate solution also addresses the integration of airport sequencing tools such as arrival and departure management functions, and can be extended to include airfield ground lighting control to provide 'follow-the-greens' services.

Controllers are supported by an enhanced controller working position with centralised routing and planning optimisation algorithms, which provide better space representation, including satellite-based positioning with high integrity provided by mobiles, to return consistent plans to all stakeholders with minimised conflicts.

STAKEHOLDERS



SJU references:
#PJ.03a-03/Wave 2
candidate

MOVING SAFELY AROUND THE AIRPORT IN ALL VISIBILITY CONDITIONS

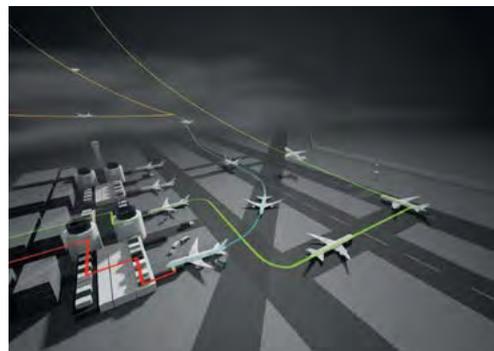
Enhanced navigation accuracy in low-visibility conditions on airport surfaces

BENEFITS

- [Improved fuel efficiency](#)
- [Enhanced airport capacity](#)
- [Increased operational and cost efficiency](#)
- [Improved predictability and punctuality](#)
- [Enhanced safety, resilience and security](#)

Low visibility is usually accompanied by increased spacing between aircraft to ensure safety while moving around the airfield. Currently the pilot relies almost entirely on a visual assessment of the aircraft's position on the ground by looking out of the window to ensure safe separation from obstacles in the absence of precision guidance equipment. The objective of this candidate solution is to take advantage of satellite navigation signals in conjunction with ground-based or satellite-based augmentation systems (GBAS or SBAS corrections) to provide accurate position information directly to the pilot.

Precise navigation information about the location of the aircraft on the airfield is especially important when using reference points such as wing tips, tail cone, nose and main landing gear for safe separation. The augmented aircraft position, shown on the on board navigation display, can be used to minimise the impact of bad weather on surface operations. The enhanced navigation capability provides more



accurate position information for integrated surface management operations, adding to ramp safety and efficiency in low visibility. The candidate solution looks first at manual taxi operations during the most severe weather landing conditions before developing the concept for autonomous taxi operations under zero visibility without direct pilot involvement.



SYNTHETIC VISION PROVIDES APPROACH AND TAXI GUIDANCES

Enhanced visual operations

Medium and small airfields have limited resources to invest in advanced ground infrastructure to support all weather operations. Emerging vision-based technologies offer an alternative, which is located on board the aircraft and can be used by all aircraft types.

Research continues on enhanced flight vision systems (EFVS) with the introduction of advanced active sensors that offer enhanced penetrability in adverse conditions. These additional capabilities will increase the performance and reliability of EFVS landing operations, making the solution an "all-weather operations". In doing so, the candidate solution will enable business aviation, regional and even commercial airspace users to access to all airports in all weather conditions, particularly secondary airports thereby avoiding cancellations, diversions and delays, provided the aerodrome has been declared suitable for EFVS operations.

Research will also continue on the use of EFVS and combined vision systems (CVS) in helmet-mounted display (HMD) for taxi and landing operations, including in low-visibility conditions. For taxiing, the candidate solution enhances the situational awareness of pilots, enabling them to detect and react promptly to evolving situations and in doing so improve their decision-making.

Vision systems will contribute to safety and efficiency in surface operations. For landing, the HMD is an alternative to existing HUD for EFVS operations. This candidate solution allows more aircraft, especially small and medium aircraft, to conduct low-visibility operations, which would not be possible otherwise.



STAKEHOLDERS



SJU references: #PJ.03a-04/Release 9, see delivered solution #117

BENEFITS

Increased operational and cost efficiency

Enhanced safety and resilience



EQUAL ACCESS FOR REMOTELY-PILOTED AIRCRAFT SYSTEMS ON THE AIRFIELD

Surface operations by remotely-piloted aircraft systems (RPAS)

Operators of remotely-piloted aircraft systems (RPAS) that can fly at higher altitudes and can remain airborne for many hours or even days at a time, are increasingly seeking access to airports. These RPAS are subject to the same rules, procedures and appropriate performance requirements as any other airport user. In order to ensure safe airport surface operations, they must interface with ground-based airport systems and be able to act and respond to ATC and other surface users just like conventional manned aircraft also in case of unexpected events.

SESAR is looking at the particular requirements of RPAS and aims to improve access and equity for this category of airspace user on the surface of the airport. Specifically, SESAR is examining the technical capabilities and procedural means needed to enable RPAS to comply with ATC instructions and to integrate with other manned traffic into surface operations. RPAS operations under instrument flight rules (IFR)

must be compliant with aviation regulations, not impact current airspace user operations, and be transparent to air traffic control. This candidate solution provides operational requirements for technological developments to support their safe integration on the airport surface.



STAKEHOLDERS



SJU references: #PJ.03a-09/Wave 2 candidate

BENEFITS

Enhanced safety and security

Ensured equitable access to airports

Improved usage of regional and third node airports

STAKEHOLDERS



SJU references:
#PJ.03b-01/Wave 2
candidate, see delivered
solution #02

ENHANCED CONTROLLER TOOLS BOOST AIRPORT SAFETY

Enhanced airport safety nets for controllers

BENEFITS

Enhanced safety

Safety is aviation's top priority. To ensure even safer airports, this candidate solution sets out to mitigate the risks of runway incursion, runway excursion and more generally the risk of incidents and accidents involving aircraft at the airport. Different, innovative types of controller alerts are being developed for the airport environment, targeting those equipped with advanced surface movement guidance and control systems (A-SMGCS) as well as those without A-SMGCS. New generation automation



tools at A-SMGCS airports offer improved conflicting ATC clearances (CATC) and conformance monitoring (CMAC) alerting functions for controllers, extended to cover the entire airport, some are already under deployment across Europe. Going beyond

these, where there is no alerting capability, for example at secondary airports where the operational and technical environment does not justify their implementation, the candidate solution takes account of new surveillance capabilities, such as video-based surveillance and ADS-B, to trigger controller alerts for conflicting situations and incursions on the runways, taxiways and apron areas.

Further alerts can be displayed when weather hazard situations occur in any airport environment, and can detect, calculate, and provide time-critical weather related alerts to tower controllers in reference to ATC clearances and the current weather. These indications serve to maximise situational awareness and to highlight areas where higher attention is needed. The candidate solution also addresses the challenges of integrating different safety nets - and controller alerts - including those delivered in earlier SESAR Solutions.

STAKEHOLDERS



SJU references:
#PJ.03b-03/Wave 2
candidate

TAILORED PILOT ALERTS REDUCE THE RISK OF RUNWAY INCURSIONS AND ATC VIOLATION

Conformance monitoring safety nets for pilots

BENEFITS

Enhanced safety

Failure to comply with ATC instructions while moving on the airport surface can lead to unintended runway incursions or incidents on taxiways or apron areas. Building on research undertaken in SESAR 1, the conformance monitoring alerts for pilots (CMAP) provides visual and audio alerts when a non-conformance to ATC clearances is detected by the on-board system. The alerts are generated by an aircraft autonomous capability on the basis of



discrepancies detected between the aircraft position and the airport map data base, and between the aircraft position and clearance instructions issued by air traffic control. The main benefits are realised when the aircraft and/or tower are not equipped with datalink or the aircraft is operating at an airport where the ATC is not equipped with suitable alerting systems.

The candidate solution addresses alerts for non-conformance to ATC instructions such as an aircraft deviating from its cleared route; non-conformance to ATC procedures; and non-compliance between the aircraft state and the airport configuration. For example, when an aircraft is cleared to roll on an airport area that is forbidden due to its size or there is an incompatibility between taxiway or runway and aircraft type. An additional advantage is the reduction in the reaction time for any non-conformance if both the flight crew and the controller receive appropriate alerts.



PILOT WARNINGS HELP TO AVOID AIRFIELD COLLISIONS

Traffic alerts for pilots for airport operations

Traditionally, pilots rely on their line of sight and instructions from air traffic control to avoid collisions. The candidate solution “traffic alerts for pilots for airport operations” - a software-based system - provides a very last warning to pilots of imminent collisions on runways or taxiways.

Specifically the system analyses aircraft position data and calculates factors, such as time to collision, through specialised algorithms to alert pilots of surrounding aircraft. In the case of business aircraft, the system provides timely surface traffic indications and warnings to the flight crew. These include visual awareness on the airport moving map display in the cockpit as well as an audio alarm.

The solution is designed to require minimal changes to existing avionics and make use of ADS-B, a globally mandated technology



upgrade due by 2020, to make the installation of the solution quick and simple. The solution is applicable to commercial aircraft and business aircraft with varying degrees of functionality. Its success depends on the performance and quality reception of broadcast ADS-B aircraft data and compliance with the relevant standards.

STAKEHOLDERS



SJU references:
#PJ.03b-05/Release 9

BENEFITS

Enhanced safety and security



ALERTING THE FLIGHT CREW TO CURRENT SURFACE CONDITIONS

Safety support tools for runway excursions

Runway excursions account for nearly a quarter of all runway safety accidents according to IATA's 2010-2014 Safety Report. This candidate solution aims to improve the assessment of runway surface contamination and global awareness in order to prevent runway excursions during take-off and landing. Providing the flight crew with information related to runway contamination status and braking efficiency will help them make the right decisions in the preparation and execution of take-off, approach and landing.

The candidate solution also proposes to use landing aircraft as a sensor to provide automatically to airport operations additional information, which can be used potentially for runway surface condition assessment by airport ground systems. The flight crew can also communicate the braking action through a pilot air report (PIREP) spontaneously or upon request to air traffic control. Runway surface conditions can be disseminated to other stakeholders, such as through the airport operations centre and



airline flight operations centre to enhance their situational awareness.

In addition, an on-board runway overrun awareness and alerting system (ROAAS) may alert the flight crew when a risk of runway overrun during final approach or landing run is detected, for it to decide a go-around if still possible or to apply maximum braking.

STAKEHOLDERS



SJU references:
#PJ.03b-06/Wave 2 candidate

BENEFITS

Enhanced safety

STAKEHOLDERS



SJU references:
#PJ.04-01/Wave 2
candidate, see delivered
solution #21 and #61

CONNECTING AIRPORTS WITH THE WIDER NETWORK

Enhanced collaborative airport performance planning and monitoring

BENEFITS

Optimised airport and TMA capacity

Improved fuel efficiency

Enhanced punctuality and predictability

Improved cost efficiency



Collaborative decision making by airport stakeholders promotes efficiency and predictability, as well as increased resilience through shorter recovery to normal operations. The airport operations plan (AOP) lies at the centre of airport operations decision support tools and collaborative decision making processes. SESAR 1 focused on integrating airport data - in particular the AOP - into the wider airspace network to support seamless traffic flow. This candidate solution enhances the planning and monitoring process by means of a number of operational improvements. These include the input of landside processes such as baggage and passenger flow, and sharing status updates to the AOP generated by target off-block times (TOBT) which can affect ATM performance. It also includes full and seamless interoperability with the airspace users' operational systems. The candidate solution also extends the monitoring processes of the airport operations centre (APOC), a facility which was also progressed during SESAR 1, in order to obtain early warnings

about infrastructure inefficiencies, issues, or failures that might result in possible delays.

The work is relevant to hubs as well as regional airports, where collaborative decision making allows for the generation of departure planning information (DPI) messages, which are shared with the Network Manager based on a reduced set of turnaround milestones compared to full airport-collaborative decision-making (A-CDM) implementation. It allows for the development of a decentralised or virtualised AOP for smaller airports or networks of airports.

In the longer term European standards are envisaged in order to share information within the network using SWIM, along with performance requirements and cybersecurity protection. The candidate solution is part of the move towards total airport management (TAM), a holistic monitoring and management of key airport processes, notably aircraft, passengers and baggage, which is key to increasing the performance of individual airports, as well as the network as a whole.

STAKEHOLDERS



SJU references:
#PJ.04-02/Wave 2
candidate, see #PJ.04-01
and delivered solution #21

A MORE PRO-ACTIVE APPROACH TO IMPROVING AIRPORT PERFORMANCE

Enhanced collaborative airport performance management

BENEFITS

Optimised airport and TMA capacity

Improved fuel efficiency

Enhanced punctuality and predictability

Increased cost efficiency

Efficient airport operations rely on users having up-to-date information about what is happening. This situational awareness can be enhanced to provide pro-active management of airport performance through DCB processes that aim to monitor, manage, and learn from operations. SESAR is developing a dashboard, which contains key performance indicators from landside and airside processes that impact the total airport. The dashboard allows different stakeholders to share the same vision and collaborate in root cause analyses.

The candidate solution also includes big data evaluation of historical and current data to improve continuously airport performance. The addition of integrated modules offers the ability to forecast future performance and provide what-if scenarios, while decision-support functionalities can help to assess factors such as meteorological conditions. The solution includes environmental parameters in the planning, execution, and post-operation phases by providing impact analysis



relating to key performance indicators contained within the EU performance reference period.

Total airport demand-capacity balancing (A-DCB) is achieved through the pro-active assessment of the available total airport capacity and the most up to date demand information, taking into account the prevailing and forecast weather and other relevant operational conditions. The candidate solution is part of the move towards total airport management (TAM), a holistic monitoring and management of key airport processes in order to increase the performance of individual airports as well as the network as a whole.



COST EFFECTIVE TOWER SERVICES AT SMALLER AIRPORTS

Remotely-provided air traffic services for multiple aerodromes

The costs of providing air traffic services are high and need to be reduced, especially at low and medium density airports. Control towers are relatively expensive to build and maintain, but the services they provide can be vital to rural and regional communities. Since the first remote tower services gained certification in 2015 in Sweden, several projects have been launched - including some which envisage a controller maintaining situational awareness for more than one airport at a time. SESAR has already delivered a solution enabling remote tower service provision to two low-density airports. Building on this, the latest SESAR research aims to test the feasibility of multi remote tower operations in airports with medium traffic volumes.

In order to enable more airports to be controlled simultaneously from a multiple remote tower module (MRTM), the work aims to validate advanced features of the visual information displayed to controllers and to integrate additional voice services in the module.

The candidate solution assumes that a controller can hold endorsements for up to three different airports, and addresses all types of airspace users including general aviation, rotorcraft, and RPAS. In addition to limiting the number of airports that can be operated in parallel, the controller can split one airport between different tower modules in case of traffic overload, or degraded mode. Furthermore, to meet the increased traffic, a planning tool for the controller is envisaged to help manage the increased complexity, tailored to suit different applications.



STAKEHOLDERS



SJU references: #PJ.05-02/Release 9, see delivered solution #52

BENEFITS

Maintained levels of safety
Operational and cost efficiency



REMOTE TOWER SERVICES FOR MULTIPLE AIRPORTS

Flexible and dynamic allocation of remote tower modules

Providing air traffic services to multiple airports from one location brings cost benefits in terms of shared resources, human resources and training costs. A remote tower centre (RTC) equipped with a number of remote tower modules can provide services to one or more airports from each module, such as those described in the previous candidate solution.

To achieve this goal of increasing the number of airports and traffic volume that can be safely controlled from an RTC, SESAR is examining the flexible and dynamic allocation of remote tower modules. The research looks at additional automation functionalities, which can be integrated into the module, such as conformance monitoring and task prioritisation, in order to allow more airports to be controlled simultaneously from one module by one controller. Planning complexity becomes more involved with an RTC compared to a single module, as any of the airports within the RTC can be grouped. The candidate solution

considers additional support tools for evaluating traffic volumes and workload planning to help the supervisor balance these aspects. This flexibility supports dynamic allocation of airports connected to different remote tower modules over time. In addition, the candidate solution addresses harmonised procedures across all the tower modules in the RTC to make it easier for controllers to hold endorsements for more than three airports.

The candidate solution addresses operations under visual and IFR, and applies to all types of airspace users.

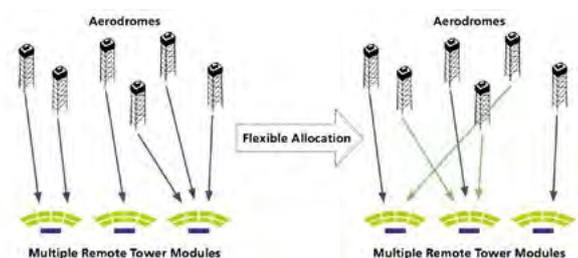
STAKEHOLDERS



SJU references: #PJ.05-03/Wave 2 candidate, see #PJ.05-02 and delivered solution #52

BENEFITS

Maintained levels of safety
Operational and cost efficiency
Improved access to weather information for airspace users



STAKEHOLDERS



IMPROVED ACCESS TO WEATHER INFORMATION FOR AIRSPACE USERS

SJU references: #PJ.05-05/
Wave 2 candidate

Automatic METAR at (manned or unmanned) airports

BENEFITS

Improved situational awareness/visibility

Increased cost efficiency

Airspace users rely on up-to-date weather information to take advantage of favourable wind conditions and avoid flight disruptions. Automatic weather stations provide useful information about conditions such as visibility, precipitation and convective weather, but this can be limited depending upon the location. Data from remote locations may be simplified, or omitted from automatic reports, especially where it is difficult or too expensive to implement, and staff, a conventional manned facility.

The candidate solution aims to deliver more consistent automated weather observations (AUTOMETAR), applicable to both manned and unmanned airports. The candidate solution aims to improve the monitoring of visibility, especially in inhomogeneous visibility conditions, and to track aeronautically significant weather phenomena and cloud types during different

cloud coverage conditions. The improved weather information can be integrated within air traffic management decision-making processes, delivered to airspace users and airport operators using SWIM standards.

The work covers two separate elements. The first is a fully automated meteorological system, which collects data from a number of sensors and cameras located at one or more remote airports. The data is then processed automatically and presented directly onto the controller's monitor. The second is a semi-automated system where a trained meteorological observer receives weather data from a number of remote sensors and cameras, and processes this information before presenting it on the controller's display. Both new sources of data, and existing standard meteorological sources of data, are included in the candidate solution.



Advanced air traffic services

The future European ATM system will be characterised by advanced service provision, underpinned by the development of automation tools to support controllers in routine tasks. The feature reflects this move towards further automation with activities addressing enhanced arrivals and departures, separation management, enhanced air and ground safety nets and trajectory and performance-based free routing. The increased use of digital connectivity enables increased virtualisation of service provision, opening up more options for ATM service delivery.



EXTENDED ARRIVAL MANAGEMENT TO BETTER MANAGE AIRPORT DELAYS

Extended arrival management with overlapping AMAN operations and interaction DCB and CTA

Air traffic is increasing in Europe, especially around major hub airports. Optimising airspace capacity in the terminal manoeuvring areas supports future growth along with improved flight efficiency and environmental performance. Planning arrival streams from an earlier stage enables delays to be absorbed in the en-route phases of flight, saving fuel and emissions compared with stack holding or long transitions in the terminal manoeuvring area. Research is underway to further extend the arrival planning distance, and to incorporate more complex and high-density environments where the en-route sector serves more than one airport or terminal manoeuvring area.

The candidate solution takes into account constraints applied for DCB/dDCB purposes, including those associated with solving DCB imbalances at an airport and preference information supplied in airport operations plans. To facilitate increased aircraft predictability, the candidate solution also addresses the advanced

ground support tools and automation needed to provide CTA in high complexity environments.

It is expected that further work is needed to further develop flight management system capabilities on board the aircraft in order to better respond to procedural constraints and those generated by air traffic control. The candidate solution also considers the wider context of balancing demand and capacity across the network, and methods for sharing data between systems.



STAKEHOLDERS



SJU references:
#PJ.01-01/Wave 2
candidate, see delivered
solution #05

BENEFITS

- Enhanced safety
- Reduced fuel consumption and emissions
- Optimised en-route and TMA capacity
- Enhanced predictability



STAKEHOLDERS



SJU references:
#PJ.01-02/Wave 2
candidate, see delivered
solution #08

FREEING UP CAPACITY AROUND AIRPORTS

Use of arrival and departure management information for traffic optimisation within the TMA

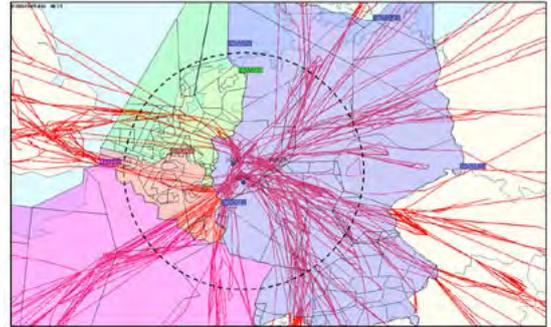
BENEFITS

- Enhanced safety
- Reduced fuel consumption and emissions
- Optimised TMA capacity
- Enhanced predictability
- Improved operational and cost-efficiency

Airports are important nodes in the ATM network. Providing more consistent delivery of arriving and departing traffic helps to optimise capacity at airports, especially where multiple airports are involved. This candidate solution investigates the use of information from departure management systems, and integrates this with information from arrival management systems to improve traffic flow within the extended TMA.

The traffic is managed in near real-time, taking advantage of predicted demand information provided by local arrival and departure management systems to identify sector overload or spare capacity, and to resolve complex interacting traffic flows in and around the airport. Sector load can be balanced by controlling sector entry times or waypoint times using instructions such as speed advisories, controlled time of arrival, ground delay or alternate routing.

Where multiple airports are included, the candidate solution addresses departure



synchronisation from more than one airport, for example through data sharing of specific events such as target take-off time (TTOT) or the flow of aircraft through a waypoint located a few minutes after take-off. Similar data sharing is used to optimise traffic flow when arrival and departure routes cross at similar altitudes.



STAKEHOLDERS



SJU references:
#PJ.01-03a/Wave 2
candidate, see delivered
solutions #10, #09

EXPANDING APPROACH PATHS TO PARALLEL RUNWAYS

Improved parallel operations

BENEFITS

- Enhanced safety
- Potential for reduced fuel consumption and emissions
- Optimised TMA capacity

PBN enables airspace users to fly more predictable flight paths, enhancing safety and capacity, and reduce environmental impact. PBN routes are available across much of European airspace, and are being increasingly introduced in busy terminal environments. SESAR is working on using the technology to provide simultaneous approaches to two parallel runways in high density and complex environments. The candidate solution includes developing PBN transitions, which connect to the final approaches, and PBN route structures, which facilitate path stretching or shortening. SESAR is also addressing the impact on flight crew tasks, controller workload, and overall feasibility.

The candidate solution covers independent parallel approaches where PBN is used to

increase segregation of arrival flows to the parallel runways, and to ensure a standard interception of the extended runway centreline. It relies on pre-defined trajectories with higher vertical profiles prior to final approach and the application of RNP navigation specifications. The candidate solution addresses two options to join the PBN transitions: merging to a point or merging to an axis.

The candidate solution is expected to result in safer approach paths and, once safety targets are met, support airspace capacity increase as a result of path stretching or shortening. It also reduces environmental impact by enabling aircraft to follow more optimal vertical profiles.





KEEPING NOISE TO A MINIMUM IN DENSE AND COMPLEX TERMINAL AIRSPACE

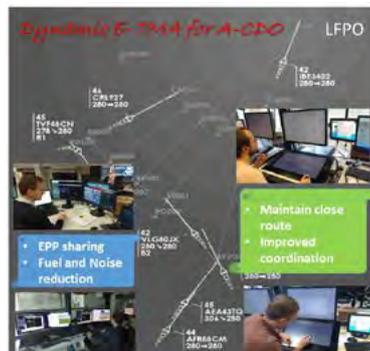
Dynamic extended TMA (E-TMA) for advanced continuous climb and descent operations

Widespread adoption of continuous descent approaches, rather than conventional stepped approach paths, is helping to reduce fuel consumption and noise during arrival and departure phases of flight. Efficiency can be further improved by support tools on the ground, which help to manage continuous trajectories, especially in dense and complex terminal environments. SESAR tools are designed to access relevant information such as speed advisories, which are calculated by the arrival sequencing manager, as well as a coordination tool, which facilitates the exchange of data between ATC sectors or ATC centres to share information about flight paths.

Further development includes improving the situational awareness of the controller when both continuous descent and continuous climb operations are taking place. A decision support tool can assist with conflict detection, while a departure manager (DMAN) can help to manage events such as start-up, taxiing, and take-off time. This contributes to more accurate trajectory prediction

and timing, and allows the controller to provide a conflict-free rate of climb or rate of descent rather than stepped flight paths.

The candidate solution is supported by standard arrival and departure routes, which comply with performance-based navigation principles. It addresses the dynamic use of lateral routes, but does not concern the management of the transition in and out of the terminal manoeuvring area, or with free route airspace.



STAKEHOLDERS



SJU references:
#PJ.01-03b/Wave 2 candidate, see delivered solution #11

BENEFITS

Reduced fuel consumption and emissions

Increased operational and cost-efficiency

Enhanced safety and security

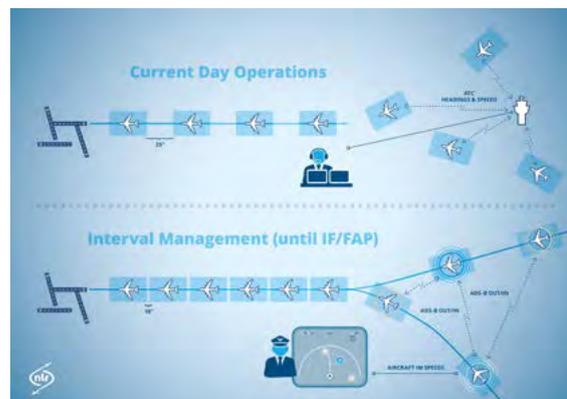


MORE PRECISE SPACING AND SEQUENCING SUPPORTS CAPACITY GROWTH

Airborne spacing flight deck interval management

Advanced navigation capability on board modern aircraft supports precise flight paths, which enhance safety and capacity. New technology can also help pilots to manage their spacing with other traffic while adhering to PBN procedures in the terminal manoeuvring area. The main challenge is to increase capacity and runway throughput while keeping the arriving and departing traffic streams on fixed routes. Today this is typically done through vectoring and merging traffic into a single stream as late as possible, for example at the beginning of final approach.

This candidate solution investigates the use of techniques available to the pilot, such as airborne spacing – flight deck interval management (ASPA-IM), to provide detailed traffic information in the cockpit. The technology addresses speed and energy control on previously assigned PBN routes. The routes can be dynamically adjusted and updated if necessary using 'what-if' capabilities. If traffic flows merge relatively early, the controller may use monitoring



tools, altitude separation, and spacing at the merge point. The advantage of ASPA-IM is that it provides more precise inter-aircraft spacing through closed-loop, precise guidance within the flight deck and it reduces the need for controllers to communicate multiple speed instructions. Both ground-based and airborne tools need to be coordinated and for information exchange to take place through ADS-B.

STAKEHOLDERS



SJU references:
#PJ.01-05/Wave 2 candidate

BENEFITS

Enhanced safety

Reduced fuel consumption and emissions

Optimised airport and TMA capacity

Enhanced predictability

Increased operational and cost efficiency

STAKEHOLDERS



SJU references:
#PJ.01-06 05/Release 9,
see #PJ.02-and delivered
solution #113

IMPROVING SAFETY FOR MIXED TRAFFIC IN THE TERMINAL AREA

Enhanced rotorcraft and general aviation operations in the TMA

BENEFITS

Ensured equitable access to TMA

Reduced fuel consumption and emissions

Increased operational and cost efficiency

Rotorcraft and general aviation fly at different speeds and altitude to commercial traffic. By introducing advanced approach and departure procedures for rotorcraft and general aviation in the TMA, SESAR is looking at improving safety at airports with mixed traffic modes, especially in adverse weather.

This candidate solution develops RNP approach and departure procedures specifically for rotorcraft and general aviation using PinS approaches based on augmented GNSS procedures. The procedures



introduce more flexible flight paths, including curved approach segments, and provide easier access to final approach and take-off points for these users while reducing the potential impact on other airspace users. The approach and departure paths can connect with the low-level IFR route network, if present, and can include initial, intermediate, and missed approach segments. The candidate solution also considers the use of a head-mounted display to provide 'eyes-out' information to the pilot, which can be used to facilitate safe-flying along the point-in-space procedure during the transition from visual flight conditions to IFR, and vice versa, thus increasing safety and reducing pilot workload.

The candidate solution also contributes to reduced noise footprint and improved access to final approach and take-off points with vertical guidance. This is in addition to the safety benefits of reducing the use of visual flight rules in marginal conditions, particularly in low-visibility conditions.

STAKEHOLDERS



SJU references:
#PJ.01-07/Wave 2 candidate

ASSISTED VISUAL SEPARATION TOOLS FOR THE PILOT ENHANCE SAFETY AND EFFICIENCY

Approach improvement through assisted visual separation

BENEFITS

Reduced fuel consumption and emissions

Enhanced safety

Maximised airport capacity

Safe aircraft separation for the most part relies on the reliability and accuracy of the position information displayed to the controller. By providing more detailed information to the pilot about aircraft immediately preceding and following during the descent and approach phases of flight, SESAR expects to improve flight safety and to address aspects of operational efficiency. For example, better traffic situational awareness enables the pilot to anticipate the behaviour of other traffic and to manage air traffic control constraints that could avoid go-arounds in high density traffic.

The candidate solution is looking at the possibility of delegating some air traffic control activity to the aircraft using a combination of visual operations. These include visual approach, combined with visual separation, which might enable an aircraft to fly a shorter approach - thanks to the possibility of ensuring its own safe separation from the preceding aircraft in the traffic sequence using traffic information

available on board. These kind of shorter approaches and reduced separations between aircraft on the same flight path lead to improved efficiency in the terminal manoeuvring area and help to maximise airport capacity.

The candidate solution goes on to address convergence between systems in Europe and the United States; such as cockpit display of traffic information (CDTI), cockpit assisted visual separation (CAVS), CDTI assisted pilot procedure (CAPP), and closely spaced parallel runway operations (CSPO).





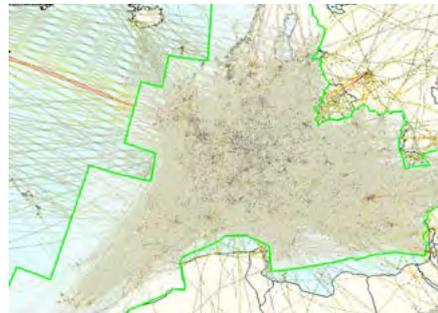
INTRODUCING FREE ROUTING IN HIGH COMPLEXITY AIRSPACE

Optimised traffic management to enable free routing in high and very high complexity environment

One of the objectives of the Single European Sky is to enable airspace users to plan flight trajectories without reference to a fixed route network in order to optimise flights in line with their business needs. Free routing allows airspace users to plan a route along segments of the great circle, which connect any combination of published waypoints and is due to become available above 31,000 feet from 2022 under European regulations. Free routing is already available in a number of low to medium complexity environments following validation work completed under SESAR 1, paving the way for the latest SESAR research, which is focused on high and very high complexity cross-border environments.

The free routing concept links a number of different operational areas and airspace management activities at regional, sub-regional and local level. The solution provides a description of high and very high complexity cross-border free routing environment in upper airspace (at the 2022 timeframe) and focuses on the improvement of separation provision.

While supporting the deployment of free routing operations beyond low and medium complexity environments, the candidate solution does not target unrestricted free routing operations, but aims to enable safe and efficient cross-border operations in free routing airspace with minimum structural constraints as far as practicable while maintaining the required level of safety and capacity in the airspace. The solution is part of synchronised deployment plans in full accordance with the Pilot Common Project.



STAKEHOLDERS



SJU references:
#PJ.06-01/Release 9, see delivered solutions #33

BENEFITS

- Reduced fuel consumption and emissions
- Enhanced predictability



STAKEHOLDERS



SJU references:
#PJ.06-02/Wave 2 candidate, see #PJ.06-01 and delivered solutions #33



EXTENDING FREE ROUTING TO THE LOWER AIRSPACE

Performance-based free routing in lower airspace

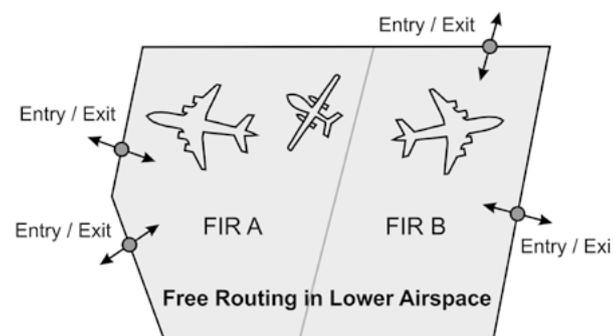
Flying more direct routes across Europe provides airspace users with the opportunity to improve fuel efficiency, optimise flight time between departure and arrival airports, and improve predictability and operational efficiency. Already available across large areas of Europe's upper airspace, SESAR is looking at ways of making free routing available in lower en-route airspace to extend the benefits beyond the Commission's mandated upper airspace. The candidate solution assumes that, even if below 31,000 feet there is a potentially higher variability of traffic demand, the implementation of free routing below 31,000 feet will not decrease the throughput at network level or lead to an increase in controller workload – and consequently to a reduction in capacity.

The candidate solution takes into consideration scheduled and unscheduled airline and cargo traffic climbing or descending, and further irregular but dense number of small piston or turbine aircrafts belonging to general and business aviation and rotorcraft. It relies on an

advanced planning functions that use information from the airspace user plan (AUP) and updated use plan (UUP) published daily; as well as other sources, and as a result of accessing aircraft performance data, produces the most direct and efficient flight profile. The candidate solution also covers the development and optimisation of flight planning algorithms concerning dynamic changes in AUPs.

BENEFITS

- Reduced fuel consumption and emissions
- Enhanced predictability



STAKEHOLDERS



SJU references:
#PJ.10-01a /Release 9

TEAMING UP FOR BETTER MANAGE TRAFFIC FLOW

High productivity controller team organisation

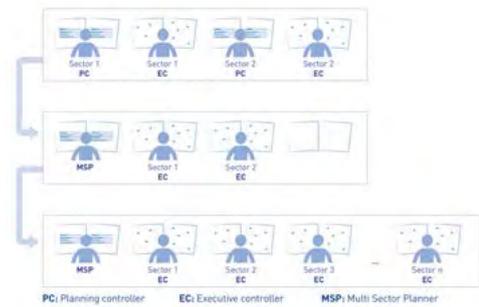
BENEFITS

- Improved operational and cost efficiency
- Maintained levels of safety

Demands on European airspace continue to grow as traffic rises and new entrants, such as unmanned and high altitude aerial vehicles, take to the skies. Air traffic control relies on highly trained controllers, who work with support tools to plan and manage traffic flow, where the combination of human intervention and automation tools is crucial to maintaining safe and efficient traffic flow. Among new team structures under review, a multi-sector planner position is proposed with the responsibility for the airspace controlled by more than one executive controller. The planner is able to adjust sector boundaries so that workload is balanced between controllers in order to distribute traffic and separation across the whole team. The concept applies to both the en-route and terminal area environment.

This candidate solution concentrates on the environment in which the planner operates, either the extended TMA or en-route. This includes how sectorisation interacts with broader

air traffic flow capacity management and how it relates to current and future route structures such as free route airspace. In particular, it considers the coordination support tools and harmonisation procedures needed to operate within the wider airspace. It also assumes the planner can access advanced trajectory prediction capability, conflict detection, conflict and intent monitoring, and flight conformance monitoring.



STAKEHOLDERS



SJU references:
#PJ.10-01b /Wave 2 candidate

REPLACING FRAGMENTED AIRSPACE WITH FLIGHT-CENTRIC AIR TRAFFIC CONTROL

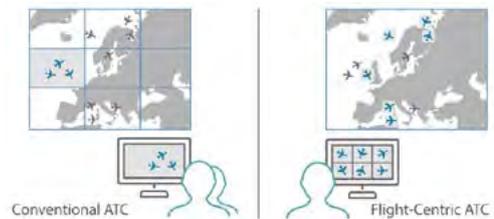
Flight-centric air traffic control

BENEFITS

- Reduced fuel consumption and emissions
- Enhanced predictability
- Improved operational and cost efficiency
- Maintained levels of safety

European airspace is divided into flight information regions, which are subdivided into sectors to provide safe separation services for aircraft travelling through the airspace. Changing this to a flight-centred structure without reference to geographical sectors opens up the opportunity to distribute the traffic more evenly, and to avoid lost productivity in under-loaded sectors. Aircraft may be under the responsibility of the same controller across two or more geographical sectors rather than handed over at sector boundaries. The new concept affects communications between controllers and pilots, as well as coordination procedures between controllers. In the terminal manoeuvring area, this alternative non-geographical allocation of airspace is based on assigning arrivals to one team of controllers and departures to another team of controllers.

The flight-centred solution requires new tools relating to traffic allocation and coordination. In the event of a conflict for example, it is important



to establish which controller is responsible for its resolution. For high traffic densities, advanced conflict detection and resolution tools are required which may have multiple functions in addition to flight-centric operations. These tools can provide long look-ahead time and help to allocate conflicts to controllers.

This candidate solution implies changed communication demands, and these are being studied within this project, including consideration of digital voice technologies.





SEAMLESS AIRSPACE MANAGEMENT THROUGH COLLABORATION

Collaborative control

The need for controllers to coordinate traffic at sector boundaries is not always necessary. Seamless airspace allows coordination between air traffic control sectors by exception rather than procedure, and introduces concepts such as sharing of airspace, flight intent and controller intent.

Two possible operating methods are addressed in this candidate solution. The first aims to remove constraints by applying sector boundaries only when a particular separation problem or traffic management demands. The controllers involved collaborate closely and may issue clearances into, and even operate traffic within, each other's sectors without prior co-ordination in order to fulfil the overall targets set by the planner. This method can lead to more efficient use of airspace in medium and less dense traffic conditions.

The second method uses planned sector boundaries and is applicable to very high-density airspace. In this case coordination is used only when required and relates to tactical



operations. It requires initial transfer criteria to be set to a default plan, although controllers can still operate collaboratively as they have access to planned and cleared profiles of flights outside their control. They may also issue clearances without prior coordination, or deviate from the default plan, should the traffic environment allow.

The solution makes use of advanced controller tools to reduce the need for co-ordination agreements, requires fewer boundary constraints, and enables constraints to be applied mid-sector rather than on the boundary. It also enhances work in the previous solution (#PJ.10-01a) where sectors are combined into multi-sector planning teams, for example during quieter traffic situation.

STAKEHOLDERS



SJU references:
#PJ.10-01c /Wave 2 candidate

BENEFITS

Reduced fuel consumption and emissions

Enhanced predictability

Improved operational and cost efficiency

Security



STAKEHOLDERS



SJU references:
#PJ.10-02a /Release 9

BENEFITS

Enhanced safety

Optimised en-route and TMA capacity

Increased operational and cost efficiency

Enhanced predictability



MORE ACCURATE TRAJECTORY PREDICTION AND FEWER NUISANCE ALERTS

Improved performance in the provision of separation

The latest controller decision support tools help to ensure safe separation between aircraft during en-route flight phases as well as in the terminal manoeuvring area. As a consequence, controllers rely on a high number of tactical interventions and use multiple radar vectors, stepped climbs and descents, in order to maintain separation between aircraft in high traffic situations. SESAR is looking at ways of delivering more accurate predictions of present and future aircraft positions through the use of aircraft-derived data, and reducing the need for so many tactical interventions. By enhancing the accuracy of conflict detection, SESAR aims to improve the provision of separation services in all phases of flight.

The enhanced ground-based tools being researched by SESAR include conflict detection and resolution featuring 'what-if' or 'what-else' scenarios; and flight conformance monitoring service, which can detect non-compliance with air traffic control instructions and issue alerts. Further data inputs include the use of aircraft enhanced flight plan data, improved weather



information such as wind data, enhanced surveillance data based on Mode S transmissions and aircraft-derived data (ADS-C). Research into the use of these advanced support tools is being carried out in the free route airspace environments and in conjunction with extended air traffic control planning activities such as collaborative control, described in the previous solution #PJ.10-01c, and the multi sector planning position and extended ATC planning role described in solution #PJ.10-01a and #PJ.09-02.

STAKEHOLDERS



SJU references: #PJ.10-02b / Wave 2 candidate

SEPARATION ASSURANCE IN ALL PHASES OF FLIGHT

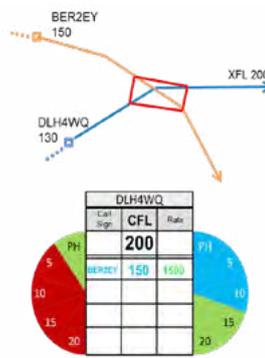
Advanced separation management

BENEFITS

- Enhanced safety and security
- Optimised en-route and TMA capacity
- Increased operational and cost efficiency
- Enhanced predictability
- Reduced fuel consumption and emissions

This candidate solution aims to increase the quality of separation management through the introduction of automation mechanisms while taking into account controller tasks and aircraft characteristics. SESAR is looking to reduce controller workload, reduce separation buffers, and facilitate new controller team organisation in the en-route and terminal manoeuvring areas of flight.

Controllers are assisted in their separation tasks by technical functionalities, which use advanced data to increase the quality of services provided. For example, ground trajectory prediction is improved when the ground system knows the complete flight profile through the full integration of ground trajectory constraints with the air trajectory. This includes predicted climb and descent speeds downlinked from the aircraft using automatic dependent surveillance – contract (ADS-C) and extended projected profile, as well as the integration of input data derived from meteorological services.



Uplink of altitude constraints allows the optimisation of climb and descent profiles that are compliant with ATC clearances while allowing the pilot to manage the flight in an economic and environmentally-friendly manner.

The candidate solution considers the impact of mixed-equipment fleet, comprising non-equipped and equipped aircraft, and enhanced conformance monitoring where the shared aircraft trajectory is checked against the calculated ground system trajectory.



STAKEHOLDERS



SJU references: #PJ.10-05 / Wave 2 candidate

SAFE INTEGRATION OF RPAS INTO CONTROLLED AIRSPACE

Integration of RPAS under IFR

BENEFITS

- Ensuring equitable access to the airspace
- Enhanced safety and security

RPAS have been used for many years by the military, but have been restricted to segregated airspace to protect their operations. With increasing demand for large civil RPAS, SESAR members are investigating how best to integrate these vehicles into non-segregated airspace alongside commercial manned traffic.

Managing RPAS traffic is challenging for controllers for a number of reasons. For a start, many RPAS fly significantly slower than conventional airliners. Added to that is the latency in communication that may occur between the operator on the ground and the platform in the air with the possibility of a command and control link loss.

RPAS may also require special mission patterns and could be impacted by weather such as strong winds, often far more significantly than other conventional aircraft.

SESAR research is investigating the technical capability required, and the procedural means to enable RPAS to comply with air traffic control instructions and operate safely in controlled airspace. The work includes looking at the impact of RPAS integration in specific areas, such as instances where RPAS might not be able to comply with all existing manned operational rules. This might include emergency situations such as the loss of the communications link between the remote pilot and vehicle. The candidate solution takes a number of factors into consideration including airworthiness standards, remote pilot and air traffic controller working methods, regulations, technical challenges and operational procedures.





TRAINING A MORE FLEXIBLE CONTROLLER WORK FORCE

Generic (non-geographical) controller validations



Air traffic controllers receive detailed and lengthy training to acquire a specific qualification to become for example, an area controller or aerodrome controller. In addition, they receive sector validations, which permit them to exercise their license in defined volumes of airspace. This contributes to inflexibility within the workforce, as controllers need to acquire additional validations to work in a different sector. It also makes it difficult to introduce concepts such as the flexible

movement of sector boundaries, or airspace changes, in response to shifts in traffic flow.

SESAR aims to develop and review advanced tools and concepts that can provide a more flexible validation regime that will allow tactical controllers to be endorsed to work in a larger number of sectors than they do today, and therefore broaden the controller-licensing scheme. The work is initially focused on concept definition and the identification of operational use cases. It intends to also identify the human, system and procedural enablers that are necessary to allow this to happen. The solution extends beyond just the sector and separation management training needs, and also includes looks at information needs, support in emergencies, fall-back modes of operation, and other considerations. Research to date indicates the solution can offer considerable operational efficiency gain and cost benefit to airspace users.

STAKEHOLDERS



SJU references:
#PJ.10-06

BENEFITS

- Improved operational and cost efficiency
- Enhanced security



TAPPING INTO NEW SURVEILLANCE SOURCES TO ENHANCE COLLISION AVOIDANCE

Enhanced airborne collision avoidance for commercial air transport normal operations - ACAS Xa

Airborne collision avoidance systems (ACAS) currently receive information only from Mode C/S interrogations, yet there are other surveillance sources available, such as the more accurate ADS-B, which could enhance this safety layer. In addition, the performance of collision avoidance can be improved by updating the mathematical processes and modelling used in today's traffic alert and collision avoidance system (TCAS).

Both these improvements form part of the ACAS Xa being designed for commercial aircraft with the aim of delivering the next generation TCAS beginning in the 2020-2023 timeframe. By introducing additional surveillance data and optimised resolution advisories, ACAS Xa is expected to improve on today's system without changing the cockpit interface, i.e using the same alerts and presentation. It forms part of ACAS X, a series of systems being developed for different users, described in the next five solutions.

ACAS Xa implements the surveillance improvement through the surveillance and



tracking module (STM) which processes the raw surveillance data coming from the surveillance sensors. Meanwhile the resolution advisory improvement is dealt with by the threat resolution module (TRM), which uses the estimated intruder parameters provided by the STM to choose an appropriate avoidance manoeuvre, if necessary.

ACAS systems need to be interoperable worldwide which is primarily ensured through the standardisation process. The European requirements identified by SESAR are being fed into the global standardisation process.

STAKEHOLDERS



SJU references:
#PJ.11-1/Release 9, see also #PJ.11-A2, 11-A3 and #PJ.11-A4 and delivered solution #105

BENEFITS

- Enhanced safety

STAKEHOLDERS



SJU references:

#PJ.11-A2 /Wave 2 candidate, see also #PJ.11-A1, #PJ.11-A3 and #PJ.11-A4 and delivered solution #105

IMPROVING COLLISION AVOIDANCE FOR LARGE DRONES

Airborne collision avoidance for remotely piloted aircraft systems – ACAS Xu

BENEFITS

Enhanced safety

Addressing the same objectives as the previous solution (#PJ.11-A1), this candidate solution aims to enhance ACAS, but is focused on the growing number of RPAS accessing the airspace. ACAS Xu is the therefore variant of the ACAS X concept dedicated to RPAS. Much like the ACAS Xa under development for commercial aircraft, the ACAS Xu includes ADS-B as an additional surveillance source to Mode S. However, it also includes other RPAS sensors such as electro-optical and infrared. It also looks at optimising resolution advisories (RAs) using advanced mathematical models with particular reference to RPAS. This includes adapting the strength and direction of RAs to the capabilities of the RPAS. For example, horizontal RAs could be introduced for RPAS unable of reaching the vertical acceleration/speeds required for vertical RAs.

SESAR is focused on determining the needs and requirements related to ACAS Xu usage in Europe, and the benefits, as well as



harmonisation with other world regions, including the US. It is also investigating if ACAS Xu helps the integration of RPAS in the European airspace. The solution covers any additional factors affecting collision avoidance with any unmanned platform, such as human factors and system latency.

The coordinated work will provide inputs to EUROCAE and RTCA and contribute to ACAS Xu global design and standardisation.

STAKEHOLDERS



SJU references:

#PJ.11-A3 /Wave 2 candidate, see also #PJ.11-A1, #PJ.11-A2 and #PJ.11-A4 and delivered solution #105

AIRBORNE COLLISION AVOIDANCE TAILORED TO SPECIFIC OPERATIONS

ACAS for commercial air transport specific operations – ACAS Xo

BENEFITS

Enhanced safety

ACAS provides a valuable layer of safety for all aerial vehicles, manned or unmanned. Research indicates that by adding an additional surveillance source, such as ADS-B, and by improving RAs using advanced mathematical modelling, safety can be enhanced. Among new systems under development, ACAS Xo offers a solution designed for particular operations not included in other ACAS X solutions – some of which are described previously (see #PJ.11-A1 and #PJ.11-A2). Typical ACAS Xo applications include procedures with reduced separation, such as closely spaced parallel approaches, which might generate an unacceptable number of nuisance alerts unless the system is able to recognise situations where new separation modes are being applied.

The candidate solution activities include the assessment of how potential cyber-threats could affect ACAS Xo, and the identification of adequate measures to mitigate effectively these threats. SESAR research aims to determine European needs and requirements related

to ACAS Xo usage in the Europe environment including its benefits in the European airspace, when necessary. The work on the SESAR solution also provides input to the European/US standardisation agencies EUROCAE and RTCA to contribute to ACAS Xo design and standardisation.





BETTER AIRBORNE COLLISION AVOIDANCE FOR GENERAL AVIATION AND ROTORCRAFT

Airborne collision avoidance for general aviation and rotorcraft – ACAS Xp

General aviation and rotorcraft have specific operational specificities and limited capability to carry equipment. They nevertheless operate in the same airspace as aircraft equipped with ACAS, and could benefit from collision avoidance advisories. SESAR aims to improve operational safety by mitigating the risk of mid-air collision between the aircraft in the same category, as well as between different aircraft categories and commercial or business jets equipped with ACAS, or with military aircraft flying through civil airspace.

To reduce the risk of mid-air collision between aircraft with mixed equipage, SESAR is looking at the functional enhancement of existing situation awareness systems such as ADS-B. For example, providing general aviation pilots, rotorcraft, or military jets with information about potential RAs included in ADS-B reports that affect them enables these pilots to determine what action is needed. The pilot is not provided with a resolution manoeuvre but is made aware of which manoeuvres to avoid in order to determine the

appropriate manoeuvre with general aviation or rotorcraft-adapted advisories.

ACAS Xp aims to provide this capability to general aviation and rotorcraft. The focus is on determining European needs and requirements related to ACAS Xp and providing inputs to European and US standards agencies EUROCAE and RTCA.



STAKEHOLDERS

ANSP	AD	AU	NM
------	----	----	----

SJU references:
#PJ.11-A4 /Wave 2 candidate, see also #PJ.11-A1, #PJ.11-A2 and #PJ.11-A3 and delivered solution #105

BENEFITS

Enhanced safety



EXPANDING GROUND-BASED SAFETY NETS IN BUSY AIRSPACE

Enhanced ground-based safety nets adapted to future operations

Safety is at the core of air traffic control. It also goes hand in hand with efficiency. Air and ground-based safety nets aim to increase safety levels while keeping up with ever increasing traffic density and complexity. By using new surveillance sources and wider information sharing, safety can be enhanced in the terminal manoeuvring area and en-route airspace. SESAR is developing a non-transgression zone (NTZ) safety net for controllers that uses downlinked aircraft parameters (DAPs) relayed from the cockpit via ADS-B or Mode S data transmissions. SESAR is also developing enhanced short-term conflict alerts (STCA) using the same source data.

The DAPS most relevant to developing the NTZ safety net include roll angle, true track angle and track angle rate. For STCA, the relevant DAPS include: final state selected altitude, vertical rate, roll angle, true track angle and track angle rate.

Thanks to the use of DAPS the candidate solution aims to avoid or minimise the number

of generated nuisance alerts. It also provides the controllers with an alerting system, which is more robust against information error or missing information and will improve the ground-based safety net performance e.g. identifying which separation mode has been compromised.

In addition, the candidate solution aims to ensure that ground-based safety nets maintain the level of performance under future operations introduced by other SESAR Solutions, which may modify the traffic patterns, the trajectory characteristics, the airspace design, the separation minima, among other factors.



STAKEHOLDERS

ANSP	AD	AU	NM
------	----	----	----

SJU references:
#PJ.11-G1 /Wave 2 candidate

BENEFITS

Enhanced safety and security

STAKEHOLDERS



A FUNDAMENTAL SHIFT AWAY FROM TACTICAL INTERVENTION

Trajectory-based operations

SJU references:
#PJ.18-02a /Wave 2
candidate,
see also #PJ.15-08

BENEFITS

Enhanced predictability

Enhanced safety and security

Reduced fuel consumption and emissions

Current air traffic management is based on a filed flight plan and tactical interventions by ATC as the flight progresses. The idea behind trajectory-based operations (TBO) is to enable the ATM system to know and, where appropriate, modify the flight's planned and actual trajectory, before or during flight, based on accurate information that has been shared by all stakeholders. This will lead to efficiency gains for both individual aircraft and for the network as a whole.

TBO calls for full integration of flight information in order to create a synchronised view of flight data by all actors involved. This shared information also includes any constraints imposed by the various ATM stakeholders. SESAR is addressing the operational and technical procedures needed to manage this shared information, and the scenarios where a stakeholder is allowed to update a trajectory, including any potential collaborative decision

making, ahead of any change in the reference business trajectory (RBT). The research covers air/ground exchanges for RBT management, task management by planning controllers, as well as cockpit display tools. Sharing a single flight data set amongst all actors will improve the performance of the network as a whole and enable user-specific needs to be accommodated.



Optimised ATM network services

An optimised ATM network must be robust and resilient to a whole range of disruptions, including meteorological and unplanned events. An improved dynamic and collaborative mechanism will allow for a common, updated, consistent and accurate plan that provides reference information to all ATM actors involved in the planning and execution of flights. This feature includes activities in the areas of advanced airspace management, advanced dynamic capacity balancing (DCB) and optimised airspace user operations, as well as optimised ATM network management through a fully integrated network operations plan (NOP) and airport operations plans (AOPs), connected to the NOP via system-wide information management (SWIM).



PUTTING BUSINESS NEEDS IN THE DRIVING SEAT

AU Processes for trajectory definition



Airspace users have varied business priorities, yet airspace management provides limited flexibility for users to incorporate specific aircraft or flight priorities into the requested trajectory. SESAR is researching ways to integrate processes within the flight operations centre (FOC), which help to manage and update the shared business trajectory with ATM network processes. This increases the FOC's role with regard to planning trajectory management, and investigates the impact of such integration on all stakeholders.

The aim is to fully integrate the FOC into the ATM network process through improved interaction tools, which will deliver improved collaborative decision making throughout the trajectory lifecycle. This includes defining and validating an iterative trajectory planning process for each

flight covering the creation of the trajectory, update, negotiation, and agreement. Once embedded inside the airspace users' FOC, this will enable airspace management, and in particular the network management function, to accommodate airspace users' requests to fly a specific trajectory. The process responds to the need to accommodate individual airspace users' business needs and priorities without compromising the performance of the overall ATM system.

The candidate solution is contributing to the development of flight and flow – information for a collaborative environment (FF-ICE) standards for trajectory exchange processes and FIXM information. This will also lead to achieving FF-ICE compatibility as well.

STAKEHOLDERS



SJU references:
#PJ.07-01 /Wave 2
candidate

BENEFITS

- Reduced fuel consumption and emissions
- Enhanced predictability and punctuality
- Increased operational and cost efficiency



STAKEHOLDERS



SJU references:
#PJ.07-02 /Wave 2
candidate, see delivered
solution #56 and #57

ADDING AIRLINE PRIORITIES TO COLLABORATIVE DECISION-MAKING IN CASE OF TRAFFIC CONGESTION

Airspace user fleet prioritisation (UDPP)

BENEFITS

Improved punctuality

When traffic is congested, airlines have little opportunity to propose alternative solutions to reduce the impact on their operations. SESAR 1 research initiated the user-driven prioritisation process (UDPP), which gives more flexibility to airspace users to reschedule their flights to keep their business-driven schedule priorities on track when facing capacity constraints and delays. For example, they can reorder the flights in the congested airspace or airports.

This candidate solution sees the extension of airspace user capabilities, through the UDPP, allowing them to recommend a priority order request to the Network Manager, with other ATM stakeholders and appropriate airport authorities, for flights affected by delays on departure, arrival and en-route in capacity-constrained situations. It goes beyond the enhanced slot-swapping and



departure flexibility introduced in SESAR 1 to provide a full set of prioritisation options and methods adapted to the different situations and types of airspace users.



STAKEHOLDERS



SJU references:
#PJ.07-03 /Wave 2
candidate

ADDRESSING MILITARY USER NEEDS WITHIN THE NETWORK

Mission trajectory driven processes

BENEFITS

Enhanced safety and security

Enhanced predictability and punctuality

Ensured equitable access to the airspace

Optimised en-route capacity

Enhanced civil-military cooperation and coordination

Europe's armed forces operate more than 150,000 flights per year. To accommodate these flights, the airspace is often closed, sometimes at short notice, to civil traffic. Given the growth of air traffic, SESAR is looking at technical systems and solutions that allow more flexible civil-military cooperation to maximise the use of airspace. Key to this cooperation is the ability of military planners to access flight plan and trajectory data provided by civil ATM systems, as well as the ability to feed these same systems with their own defined set of information.

SESAR research is seeking the full integration of processes from the military wing operations centre (WOC), within the ATM system, sharing military flight plan and trajectory information with local ATCs and the Network. The focus is on the creation and submission of military flight plans (iOAT FPL), the central management of these plans by the Network Manager, and their distribution to local air traffic control centres where these military flights are taking place.



The candidate solutions sees the harmonisation and consolidation of inputs coming from different military airspace users willing to use mission trajectories to conduct their flights. This includes continued development of a harmonised format for all military flight plans – which currently differ according to the state in which they are created - so they can be automatically validated and incorporated into the flight plan database of the Network Manager. Implementation of this improved iOAT FPL will be rolled out as legacy systems are replaced with financial and political consent.

This work is done in close cooperation between SESAR members and the European Defence Agency.





MAKING BETTER USE OF AIRSPACE CAPACITY

Management of dynamic airspace configurations

Managing airspace in a more dynamic way, for example by designing sectors based around predicted traffic flow, can increase capacity while reducing delays and emissions. SESAR research is making progress on the concept of dynamic airspace configuration (DAC), which allows ANSPs to organise, plan, and manage airspace configurations with enough flexibility to respond to changes in traffic demand. The aim is to harmonise airspace management, flow management, and air traffic control during planning phases to deliver a seamless and dynamic process enabled by Collaborative Decision Making (CDM) between stakeholders.

The candidate solution is composed of procedures and tools, which take account of 4D trajectory forecasts, fixed and flexible routing, and reserved or restricted airspace. It foresees dynamic sectorisation and airspace reservation/restriction (ARES) as part of the broader DCB process, where airspace configuration is a dynamic part of cross-border integrated capacity

management. The solution also integrates dynamic mobile areas (DMA) into the process. These include military reservations at a specific reference point agreed upon in a CDM process that satisfies airspace users' requirements, known as Type 1 DMA; and military needs at any geographical location along the trajectory, known as Type 2 DMA. Both types can be positioned with minimum impact on civil and military users within the dynamic environment. In this way, DCB allows for dynamic management of the airspace configurations and user trajectories.



STAKEHOLDERS



SJU references:
#PJ.08-01 /Wave 2
candidate

BENEFITS

- Optimised en-route capacity
- Enhanced predictability
- Increased operational and cost efficiency
- Enhanced safety and security
- Reduced fuel consumption and emissions
- Enhanced civil-military cooperation and coordination



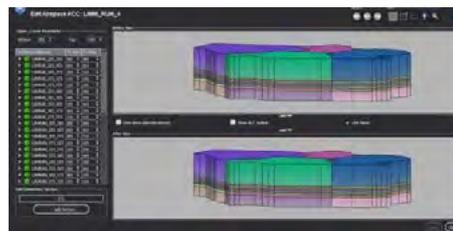
SAFE INTEGRATION OF MILITARY MISSIONS AND WEATHER PHENOMENA IN DYNAMIC AIRSPACE

Dynamic airspace configuration supporting moving areas

Introducing a more flexible and dynamic approach to sector configuration will help to match airspace capacity with traffic demand. DAC takes account of lateral and vertical dimensions, as well as time, to respond to performance objectives, which vary in time and space. In addition to the CDM activities addressed in the previous solution (#PJ.08-01), SESAR is developing processes, procedures and tools which support the management of a third type of dynamic mobile area. DMA Type 3 is described as a volume of airspace of defined dimensions, which forms an integral part of a mission trajectory and has been agreed upon in a CDM process which satisfies the airspace user's requirements. This volume of airspace is designed around moving aircraft and requires specific separation criteria based on the configuration of the aircraft and flight formation. Further research will address how the integration

of DMA Type 3 might impact the planning and/or execution phases, and potential impact on safety nets. DMA Type 3 could also be applied tactically to specific flights or formation flying.

This candidate solution also includes an impact assessment of the integration in the DAC process of areas that are potentially unsafe due to weather phenomena that can evolve in four dimensions. These moving hazard zones can be extended to other phenomena, such as volcanic ash.



STAKEHOLDERS



SJU references:
#PJ.08-02/Wave 2
candidate, see also
#PJ.08-01

BENEFITS

- Optimised en-route capacity
- Enhanced predictability
- Increased operational and cost efficiency
- Reduced fuel consumption and emissions
- Enhanced civil-military cooperation and coordination

STAKEHOLDERS



SJU references:
 #PJ.09-01 /Wave 2
 candidate, see also
 #PJ.09-02 and #PJ.09-03,
 and delivered solution #108

TRAFFIC DEMAND PLANNING BASED ON PERFORMANCE-DRIVEN CRITERIA

Network prediction and performance

BENEFITS

- Improved operational efficiency
- Improved predictability
- Enhanced safety

The purpose of DCB is to maintain a safe distribution of traffic to manage among controllers and avoid traffic overload. It is supported by traffic demand forecasts within a collaborative framework. Advanced DCB addresses the need to integrate network planning into this process and improve demand forecasts using shared business trajectory information and big data.



performance-driven network management culture, which shares constraints and agrees solutions among all stakeholders.

SESAR is looking to establish a performance driven network management culture as an evolution of the current process, which is mainly focussed on delay reduction. This requires a shared situational awareness and an agreed set of performance indicators to be used for real time performance monitoring, trade-off analysis, and what-if impact assessments. These indicators need to be dynamically selected according to network geographic interest scales and specific time horizons. The research identifies common local, regional, and sub-regional network performance indicators and their relationship to a selected set of network congestion mitigation strategies. The aim is to create a transparent

For example, network complexity prediction will enable both the identification of situations where the traffic complexity in a specific area is out of equilibrium or out of proportion compared to other directly related areas, as well as the assessment of impact on airspace capacity, predictability, flexibility and safety. The information can be used to implement dynamic airspace management and resource allocation measures, such as dynamic sector configuration and dynamic mobile areas, as well as traffic management measures such as re-routing and level capping, to help solve hotspots and complexity problems.



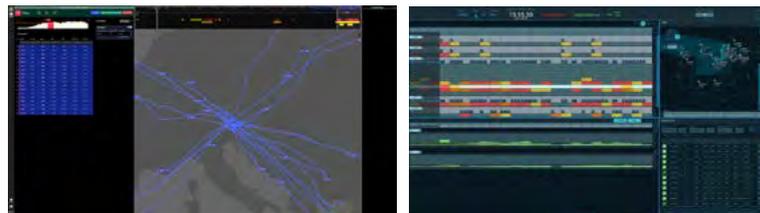
STAKEHOLDERS



SJU references:
 #PJ.09-02 /Wave 2
 candidate, see also
 #PJ.09-01 and #PJ.09-03

CLOSING THE GAP BETWEEN CAPACITY PLANNING AND DELIVERY

Integrated local DCB processes



BENEFITS

- Enhanced safety
- Reduced fuel consumption and emissions
- Optimised en-route, TMA and airport capacity
- Enhanced predictability and punctuality
- Improved operational and cost efficiency

DCB takes into account the needs of the network as a whole, as well as local factors, in order to avoid capacity overload in a seamless process. This solution looks in particular at the integration of local network management with extended planning and short-term arrival management activities. It builds upon basic extended ATC planning (bEAP) functionalities (see #118; an integrated network and ATC planning (INAP) working environment provides access to all capacity and flow/trajectory management options and enables local actors such as local flow managers to work with extended air traffic control planners to assess and resolve hotspots. They can identify and manage the best performing option between dynamic airspaces configuration measures, flow management measures and trajectory measures, for example

by de-conflicting, synchronising, or sequencing trajectories.

Short-term air traffic flow capacity measures (STAM) stand to benefit from closer integration as the time horizon for the application of a STAM is not dictated by the status of the flight, but rather by time horizon of extended air traffic planning activity. This solution takes into account those instances where there is a need to issue a STAM for a flight which has not yet taken off but is going to take off very soon and will enter a hotspot in less than 20-30 minutes.

Expected benefits include improved resource management efficiency, more effective conflict resolution, and seamless integration of airspace management functions such as dynamic airspace configurations.





WIDER COLLABORATION TO OPTIMISE NETWORK PERFORMANCE

Collaborative network management



The NOP developed during SESAR 1 is a powerful tool to DCB planning processes. It supports the collaborative ATM planning process by enabling stakeholders to develop a common view of the planned network situation. Further development of automated tools, for example to monitor and optimise operations, is underway in SESAR 2020 in order to identify and rectify constraints in the network. Network operations planning and execution follows an agreed set of rules and procedures, which guide DCB activities and user driven performance preferences.

In this context, SESAR is progressing the notion of collaborative constraint management in four dimensions (4D) – latitude, longitude, altitude and time. The aim is to consolidate DCB procedures

in order to minimise the adverse impact on airspace user operations and on overall network performance. For example, in place of the current slot allocation procedure based on first-planned, first-served; the solution supports a coordinated 4D constraints management process, which arbitrates between the owners of the constraint, the actors involved in the solution and the overall network performance needs. It allows airports, air traffic control, the Network Manager and airspace users to agree on reconciliation measures. In case of multiple conflicting constraints, a 'multiple constraints resolver' is designed to provide decision support to identify the optimum solution to satisfy all constraints.



STAKEHOLDERS



SJU references:
#PJ.09-03 /Wave 2
candidate, see delivered
solution #20

BENEFITS

- Enhanced safety
- Reduced fuel consumption and emissions
- Optimised airport, TMA and en-route capacity
- Enhanced predictability and punctuality
- Improved operational and cost efficiency

Enabling aviation infrastructure

The enhancements described in the first three key features will be underpinned by an advanced, integrated and rationalised aviation infrastructure, providing the required technical capabilities in a resource-efficient manner. This feature will rely on enhanced integration and interfacing between aircraft and ground systems, including ATC and other stakeholder systems, such as flight operations and military mission management systems. Communications, navigation and surveillance (CNS) systems, SWIM, trajectory management, Common Support Services and the evolving role of the human will be considered in a coordinated way for application across the ATM system in a globally interoperable and harmonised manner.



STAKEHOLDERS



SJU references:
#PJ.14-01-01 /Wave 2
candidate

A ROBUST FRAMEWORK FOR LOWER-COST INFRASTRUCTURE

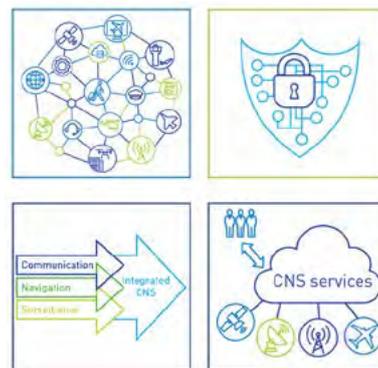
CNS environment evolution

BENEFITS

Enabler for solutions bringing greater cost-efficiency, safety, etc.

One of the objectives of the Single European Sky is to reduce airspace user costs whilst improving safety and efficiency. The SESAR communication, navigation and surveillance (CNS) roadmap sets out to do this by integrating these three domains to take advantage of cross-domain synergies. Integrated CNS brings interdependencies between previously separate activities and introduces new requirements in terms of robustness, spectrum use, interoperability and service quality for all airspace users, including military. SESAR is developing a performance-based approach to assess operational needs and to define a cross-domain robustness concept. This includes operating within the available spectrum and avoiding datalink saturation. It also includes a holistic approach on technology transfer opportunities, for example identifying what military can bring to civil, or what general aviation can bring to airport operations.

SESAR addresses the evolution from the current fragmented infrastructure, which is built around separate areas of functionality, towards a harmonised and cost-efficient infrastructure,



which features common performance criteria. The research pays special attention to cybersecurity and resilience considerations while still ensuring interoperability for civil-military CNS in current and future CNS infrastructure services and performance equivalence. In terms of performance expectations, a holistic analysis of the technical and safety requirements of the current and future CNS infrastructures and systems will highlight opportunities where the efficiency, safety, resilience and interoperability of the CNS infrastructure can be improved.



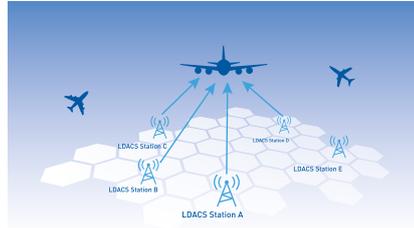


SECURE DATALINK UNLOCKS FUTURE CAPACITY

Future communication infrastructure (FCI) terrestrial datalink

Reliable datalink is an essential building block of the European vision for the future communication infrastructure (FCI). Establishing secure communication between the ground and the air is vital to support the growth in traffic volume and complexity. In particular, the future operational concept of trajectory management in 4D – latitude, longitude, altitude and time – needs to be supported by a reliable, scalable, modular and efficient datalink technology. The objective is to enable the widespread adoption of 4D trajectory management concepts for separation management, which will lead to more efficient flight paths, improved safety and fewer radio transmissions

SESAR is looking at both avionics and ground infrastructure requirements for robust digital voice and data services. Among solutions under review, SESAR is researching multi-link technology in order to deliver higher data capacity, improved communications performance, lower transaction time and higher continuity. Specifically, it is developing and standardising the candidate future terrestrial datalink system,



called LDACS (L-band-Digital Aeronautical Communication System). The goal is to progress on the development and standardisation of LDACS technology, including the analysis of security concepts and the development of a harmonized global standard. This solution will also address transversal topics and concepts, including the seamless transition from existing datalink technologies to LDACS and the inclusion of a ranging functionality.

The work is aligned with international standardisation activities at global level by agencies, such as ICAO, EUROCAE, RTCA and the Airlines Electronic Engineering Committee (AEEC), as well as ongoing research into future communications services capable of supporting a range of data link applications.

STAKEHOLDERS



SJU references:
#PJ.14-02-01 /Wave 2 candidate, see also #PJ.14-02-02 and #PJ.14-02-04

BENEFITS

Enhanced safety, security and resilience

Increased cost efficiency (technology cost)



SATELLITE COMMUNICATIONS PROVIDE FUTURE EYE-IN-THE-SKY

Future satellite communications datalink (FCI datalink)



Communication systems on board the most recent commercial satellite systems offer new capabilities to support airspace management communication needs. SESAR 1 successfully tested a secure satellite-based air traffic services datalink (SatCom Class B), using the Iris Precursor, which takes advantage of IP-

based broadband to provide secure and high-bandwidth cockpit communications to exchange flight information and trajectory data with the ground.

Complementary to this and as an element of the FCI, SESAR's is researching satellite datalink technology for the continental and oceanic regions including digital voice (long-term SatCom), to support the ATM concept in the 2020+ timeframe. In this respect, SESAR partners are working closely with European Space

Agency (ESA) to ensure that communications services evolve to accommodate future communications requirements.

STAKEHOLDERS



SJU references:
#PJ.14-02-02 /Release 9, see also delivered solution #109 and #PJ.14-02-01 and #PJ.14-02-04

BENEFITS

Increased cost-efficiency

Enhanced safety and security

Greater global interoperability





SATELLITE-BASED PRECISION APPROACHES IN ALL WEATHER **GBAS (for challenging environments)**

GBAS uses local augmentation to support precision approach operations for aircraft equipped with satellite navigation. The technology is used today in Category I precision approaches down to 200 ft decision height. In comparison to instrument landing systems (ILS), GBAS allows more flexible procedure design with less infrastructure. Additionally, GBAS can provide resilience in low visibility conditions (no significant impact in icy and snowy conditions), shorter routes, fuel-saving approaches, and precision approach on runways where ILS is not feasible.

Building on the SESAR 1 solution, this candidate solution addresses the development of GBAS CAT II/III based on multi-constellation and dual-frequency satellite services, including Galileo. This improves performance, especially where the impact of ionospheric gradients can be effectively reduced. The research extends to civil-military interoperability where use of MC/DF GBAS solutions by State aircraft and evaluation of potential technical interoperability between military differential GNSS and GBAS are assessed. Also, non-MMR avionics architecture

design for regional and business aircraft targeting CATII/III operations supported by xLS guidance is studied.

Further research includes enhancements to the first generation CAT II/ III GBAS to cope with adverse ionospheric conditions outside mid latitudes, thus enabling a globally deployable GAST D solution. Research is also focusing on devising GBAS ground station status data provision and developing cost efficient infrastructure for operations and maintenance on complex airports. Also, the new ICAO GBAS service volume definition that decouples the maximum use distance from approach service volume will be assessed from a ground-segment technical perspective.



STAKEHOLDERS



SJU reference:
#PJ.14-03-01 /Wave 2 candidate,
see delivered solution #55

BENEFITS

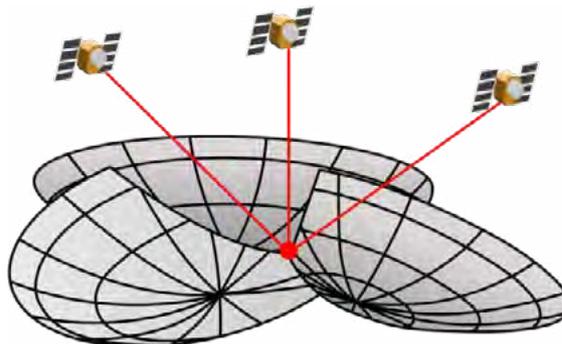
- Improved resilience by limiting the capacity reduction in degraded situations and by avoiding critical and sensitive areas
- No significant performance reduction and special maintenance during snow and ice conditions
- Reduced installation and maintenance costs compared to ILS
- Greater frequency efficiency in the VHF navigation band
- Improved environmental impact by approaching aircraft due to shorter routes and noise abatement



GLOBAL STANDARDS FOR SATELLITE-BASED PRECISION APPROACHES **Multi-constellation/Dual frequency (MC/DF) GNSS**

Standardisation developments for multi-constellation GNSS receivers have so far focused on the certain constellations, such as and Galileo. This includes the satellite-based augmentation systems, such as EGNOS in Europe. However, GNSS receivers also need to operate with other constellations and alternative augmentation systems. The impact of processing additional core constellations or new augmentation systems presents interoperability challenges in term of the avionics and receiver/antenna architecture and requires further evaluation. The SESAR research looks at the design and capability of antenna front-end design; out of band rejection characteristics and receiver architectures; and algorithms and transition between areas operated with distinct subsets of GNSS elements approved for operational use.

The SESAR solution aims to enable performance-based navigation procedures and allow for



the ground infrastructure to be rationalised. Navigation procedures include: precision approach with horizontal and vertical guidance, advanced approaches concepts, multiple runway aiming points, further runway aiming point, adaptive runway aiming point, adaptive increased glide slope, low-visibility procedures (LPV) or GLS-GAST-C below 200ft, vertical geometric navigation to support enhanced navigation in the terminal manoeuvring area, as well as ADS-B and 4D concepts.

STAKEHOLDERS



SJU references:
#PJ.14-03-02 /Wave 2 candidate

BENEFITS

- Greater resistance to interference through the use of independent constellation infrastructure and frequencies, and enhanced signal design
- Greater availability due to additional satellites and signals
- Robustness to the impact of control segment errors and failures
- Improved accuracy, integrity, availability and continuity through the exploitation of new satellites signals

STAKEHOLDERS



SJU references:
#PJ.14-03-04 /Wave 2
candidate



A BACKUP IN CASE OF GNSS OUTAGE

Alternative position, navigation and timing (A-PNT)



BENEFITS

- Enhanced safety, security resiliency
- Interoperability
- Increased cost efficiency

PBN procedures rely on the availability of GNSS constellations, such as Galileo, around the clock. The candidate solution alternative position, navigation and timing (A-PNT) pursues fallback capabilities in case of GNSS unavailability for the short, medium and long term.

The short-term alternative A-PNT only considers requirements related to the navigation domain due to the brief timeframe and unlikelihood of changes to airborne or ground systems. It aims to support RNP-1 operations in those terminal manoeuvring areas where RNP-1 has been implemented with limited or no impact on the continuity of essential operations, as mandated by an European Commission Implementing Rule. The backup is provided by current terrestrial navigational aids, mainly distance measuring equipment (DME), enhanced or complemented by VHF omni range (VOR), or VOR/DME minimum operational network (MON).

The medium-term alternative A-PNT is a standalone aircraft upgrade that supports RNP-based operations in the terminal manoeuvring

area. It operates with Standard Instrument Arrival (STARs) and standard instrument departure (SIDs) procedures.

To meet long-term outages, SESAR is researching a number of existing and new technologies capable of supporting more demanding operational positioning and navigation requirements. These include multi-DME coupled with receiver autonomous integrity monitoring (RAIM) algorithm, enhanced DME, the future LDACS for navigation, enhanced low frequency radio navigation (eLORAN), and Mode N. The long-term A-PNT airborne solution is expected to support RNP-1 arrivals and departures, RNP-defined routes, and RNP approach procedures with lateral and vertical guidance supposing appropriate ground infrastructure.

STAKEHOLDERS



SJU references:
#PJ.14-04-01 /Wave 2
candidate



NEW TEST AND EVALUATION PROCEDURES FOR NEW SURVEILLANCE SYSTEMS

Surveillance performance monitoring

BENEFITS

- Enhanced safety, security resiliency
- Interoperability
- Increased cost efficiency
- Optimised capacity

Surveillance plays a crucial role in ensuring airspace safety, security, capacity and efficiency. To ensure accuracy and reliability, each surveillance system needs to be tested at regular intervals to detect degradation trends early in the process. Performance assessment takes place at both individual sensor level and at data processing level in line with European safety requirements. New surveillance systems such as wide area multilateration (WAM), multi-static primary surveillance radar (MSPSR), multilateration (MLAT), and space-based ADS-B, are not all compatible with classical test methods and tools.

SESAR is working on new surveillance safety and performance requirements to establish baseline performance-based surveillance (PBS) criteria, in a similar way to performance- PBN requirements. This candidate solution will contribute to cost efficiency through harmonisation of common tools amongst a larger

user community, and will also enhance safety, capacity and security through the early detection of degradation trends as a result of real-time monitoring. The findings of the PBS research will be used to update existing standards and safety regulations for surveillance systems and surveillance evaluation tools in cooperation with European standards agency EUROCAE.



STAKEHOLDERS



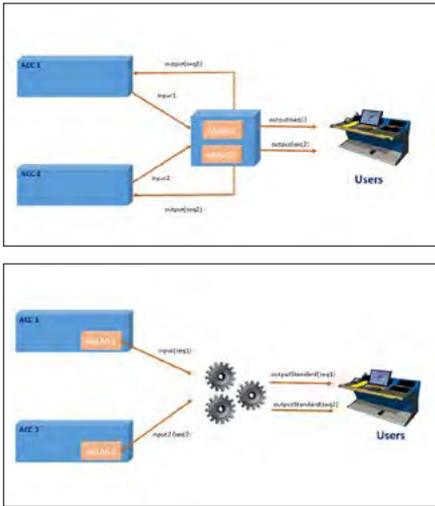
SJU references:
#PJ.15-02 /Release 9,
delivered solution #05

ARRIVAL SEQUENCING BENEFITS FROM A COMMON APPROACH

E-AMAN common service

BENEFITS

Increased cost efficiency



In accordance with SESAR cost-efficiency objectives, the extended arrival management (E-AMAN) common service aims to provide arrival sequences where multiple actors are involved; for example multiple airport operators, arrival management systems, area control centres, upper area airspace management, as well as the Network Manager. This common service supports the E-AMAN solution by providing the technical capability to extend the arrival management process, including arrival sequencing and planning functions, and distributing this information to all involved actors using SWIM capability.

This service provides E-AMAN information to different consumers and provides local arrival planning information according to their needs, for example indicating total delay to support queue management. This information can be used in planning and tactical operations, for example providing departure delay times or for speed advisories during flight. The service improves cost efficiency by reducing the number of system deployments and technical structures in operation. It also supports enhanced airspace capacity and runway throughput, optimised flight trajectories, reduced delays at network level, less holding time and less fuel consumption.

SESAR is addressing the technical and operational feasibility of two different implementation options: colocation of E-AMAN and federation of E-AMAN.

STAKEHOLDERS



SJU references:
#PJ.15-08 /Wave 2
candidate

SHARING ONE CONSISTENT FLIGHT TRAJECTORY

Trajectory prediction common service

BENEFITS

Cost efficient transition to TBO

Trajectory-based operations (TBO) is cornerstone of the SESAR vision paving the way for more predictable air traffic management. Many areas of the programme and solutions in the pipeline rely on trajectory information, which is captured in the SESAR architecture. In support of this transition, SESAR is researching a common service available to provide a single point of reference for a specific trajectory during all phases of the flight. The service covers the period from creation in long term pre-flight planning through to the flight execution phase, however it does not replace today's flight data processing systems as it provides inputs to traffic management rather than directly for control purposes. As an enabler for trajectory-based operations, the service provides a consistent flight trajectory and a common picture for all stakeholders, and is expected to result in a cost effective deployment of trajectory-based solutions.



The function of the service includes: the establishment of a single reference trajectory for a flight; provision of trajectory information to support planning activity; access to this data by authorised stakeholders; provision of trajectories related to operational needs of the military; and access of flight trajectory information to other consumers subject to appropriate access rights. It aims to cover the pan-European area and deliver high service availability, response time and data accuracy. SESAR work includes technical concept definition and service feasibility analysis, and required strong coordination with work on ground-ground interoperability activities underway in SESAR.



TOWARDS VIRTUALISATION

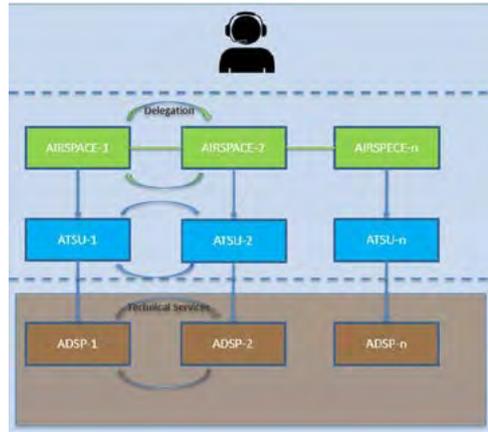
Delegation of air traffic services (ATS) and contingency

With virtual centres, Europe is breaking away from the conventional architecture for air traffic management. These centres aim to decouple the physical controller working position (CWP) from the remote provision of ATM data and technical services, such as flight data distribution and management.

The aim is to enable greater flexibility when it comes to organising ATC operations and, in doing so, seamless and more cost-efficient service provision to airlines and other airspace users.

SESAR is exploring different possible uses cases. These include the delegation of ATS among ATSU's based on traffic and organisation needs, either static on fix-time transfer scheduling (day/night) or dynamic when the traffic density

is below/over a certain level. The use cases also cover delegation to support contingency needs, allowing ATSU's to transfers responsibility in cases of service degradation or failure.



STAKEHOLDERS



SJU references:
#PJ.15-09 /Wave 2 candidate, see also #PJ.16-03

BENEFITS

- Increased operational and cost efficiency
- Enhanced security



FIRST STEP TOWARDS COMMON AERONAUTICAL DATA SERVICES

Static aeronautical data common service

Airspace users and navigation service providers use static aeronautical data to receive long term or permanent information such as PERM notice to airmen (PERM NOTAMs), as opposed to dynamic information such as the last operational status of airspace or route activation. SESAR is looking at the feasibility of providing static information in digital form at network level so that it becomes efficiently accessible as a common service to different ATM civil and military systems.

The network-consolidated output is an AIXM-compliant dataset whose subsets can be retrieved by individual requests demanding specific geographical areas, attributes or functional features. The service is foreseen to provide static information in a first step. Currently only static information is available in AIXM format, but the service is expected to evolve in the future to also provide dynamic information when this becomes available in the AIXM format, for example providing digital NOTAM.



The European Commission has mandated that Member States implement aeronautical information exchange among a number of ATM sub-functionalities based on initial SWIM (iSWIM) to support digital aeronautical data as an AIXM data set, as part of the PCP. This supports the business case for a static aeronautical data service and SESAR is addressing the technical and operational feasibility of the common service

STAKEHOLDERS



SJU references:
#PJ.15-10 /Release 9

BENEFITS

- Increased cost efficiency
- Enhanced security

STAKEHOLDERS



SJU references:
#PJ.15-11 /Release 9

MAP-READING USING A SHARED DIGITAL SOURCE

Aeronautical digital map common service

BENEFITS

Increased cost efficiency

Enhanced security

Aeronautical data provides essential information for ANSPs, airspace users and airport operators. Collecting aeronautical digital maps and providing them at network level in a highly customised format reduces the operating costs of using aeronautical maps and helps to establish a standard digital format. The aeronautical digital map common service is designed to deliver digital maps to multiple air traffic management systems which perform separation functions to meet a range of different consumer requirements.

The service aims to provide users with the capability to retrieve graphical representations of aeronautical data, which can be easily converted to different formats such as AIXM, GML and XML etc. The output is presented as standard, harmonised, graphic information that can be retrieved by individual requests demanding specific geographical areas using regular internet protocols or through SWIM services. Furthermore, users will only bear a cost consistent with the services they receive.

Research to date also indicates the benefits will continue to grow according to the spread of deployment of the common service, with most benefits arising from Europe-wide deployment.

The capabilities can be considered to be provided through standardisation, outsourcing, consolidation or partnerships. It can also be deployed at a single location (centralised service) or at multiple locations (distributed services).



STAKEHOLDERS



SJU references:
#PJ.16-03 /Release 9

TOWARDS VIRTUALISATION

Work station, service interface definition and virtual centre

BENEFITS

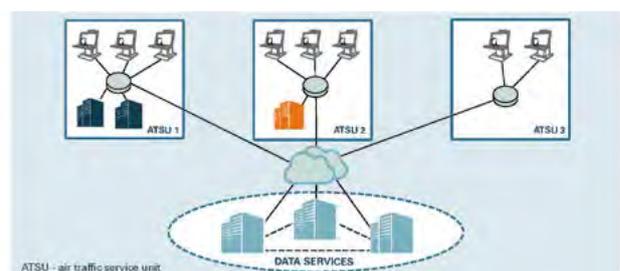
Increased cost efficiency

Enhanced security and resilience

Europe's air traffic management is in many cases composed of country-based systems and processes. This fragmentation or proliferation of systems results in a lack of interoperability and increases the cost of air navigation services. Virtual centres provide increased flexibility by sharing air traffic control operations between ATSU's and help to create a more seamless airspace.

A virtual centre decouples the service unit from the ATM data provider (ADSP) and enables data services - including flight data management, surveillance, and voice communications - to be supplied to multiple ATSU's. One ATSU may use data services from multiple ADSPs, just as an ADSP may serve multiple ATSU's. This flexibility leads to greater technical and operational agility, which in turn leads to improved performance.

SESAR is setting out the high-level system architecture, creating service definitions for ATM functions, and defining the interaction between data centres as well as local and contingency infrastructures. The candidate solution simulates and tests the provision of air traffic control and voice data initially in the route and approach control domains, with tower operations among future applications.





KITTING OUT CONTROLLER WORKSTATIONS WITH LATEST TECHNOLOGIES

Workstation, controller productivity

Kitting out the human machine interface (HMI) of the CWP with advanced technologies can help to minimise the workload and mental strain on controllers in air traffic control centres and towers. This is especially true when managing high traffic density or complex operations.

The candidate solution covers a number of new interaction technologies:

- Multi touch inputs (MTIs) are made possible thanks to a trackpad or touchscreen and a virtual keyboard. This new HMI interface allows controllers to make data inputs into the system more efficiently and without increasing the failure rate.
- An automatic speech recognition (ASR) system takes audio signals and transforms them into a sequence of words, i.e. "speech-to-text" following the recognition process. The resulting concepts can be used for further applications such as visualization on an HMI.
- With attention guidance, a controller's visual or mental focus is actively directed to a specific spot of the CWP HMI if necessary. The specific spot is an area where the controller

should look at to determine an assistance system (e.g. because of a potential conflict, long absence of attention, or demanded actions). The necessity to look at this spot is given if the controller did not look there for a certain amount of time (e.g. determined by an eye-tracking system).

- User profile management systems (UPMS) are a key enabler for automated HMI customisation through user authentication, application of ID cards or biometric technology. Once the controller is identified in a safe and secure manner, his/her predefined profile related to a particular role or a task on the CWP will be recognised and the HMI settings will be customised to this profile. This can happen during a shift change or whenever a controller's task or role on the CWP changes, for instance in the case of a change of sectorisation.
- CWP virtualisation will change the way controllers interact with the system. In doing so, this will require controller training and appropriate qualifications to handle the applications underpinning the CWP.

STAKEHOLDERS



SJU references:
#PJ.16-04 /Wave 2 candidate

BENEFITS

Increased operational and cost efficiency
Enhanced safety



ENHANCING INFORMATION SHARING BETWEEN PILOTS AND CONTROLLERS

Air-ground advisory information sharing (SWIM TI purple profile)

SWIM enables the management and exchange of air traffic management information between qualified parties using standard interfaces. It consists of standards, infrastructure and governance, all of which ensure interoperability between users of SWIM-enabled services. In addition to supporting information sharing on the ground, SWIM can support exchanges between the cockpit and air traffic control, which can lead to operational improvements.

Air traffic control and flight crews all benefit from more informed decision making as a result of this bi-directional near real-time information exchange. This SWIM application requires a set of aircraft and ground capabilities, which can interact and support collaborative decision making. In particular, it needs a set of interface standards, together with infrastructure architecture and configuration aspects, and it is intended to enable consumption and provision of ATM information between aircraft and ground applications.



Work underway for this candidate solution looks specifically at advisory (non-safety-critical) information exchange such as advisory weather, aeronautical data and better situational awareness. SESAR is testing the capabilities and robustness of the air/ground SWIM interface, as well as performance when multiple SWIM nodes are in use, and when several aircraft are communicating simultaneously. Research also includes security aspects such as authentication, authorisation and monitoring capabilities.

STAKEHOLDERS



SJU references:
#PJ.17-01 /Release 9, see delivered solution #46

BENEFITS

Increased cost efficiency
Enhanced safety and security

STAKEHOLDERS



SJU references:
#PJ.17-03 /Wave 2
candidate, see also
#PJ.17-01 and delivered
solution #46

BENEFITS

Enhanced civil-military
cooperation and
coordination

Enhanced security

Increased cost efficiency



CIVIL-MILITARY COOPERATION AT GROUND LEVEL IMPROVES WITH SWIM

SWIM TI green profile for ground-ground civil-military information sharing

Information exchange between civil and military operators based on SWIM was first tested during SWIM TI green profile SESAR 1. SESAR 2020 expands this bi-directional data flow to fully support SWIM-based coordination and cooperation between civil and military stakeholders, taking into account cyber-security. The SWIM technical infrastructure - or middleware - being developed for this application exclusively centres on SWIM-based exchanges between military systems, such as ATC, air defence (AD) or wing operations centres (WOC), and civil systems, such as ATC and Network Manager (NM) systems on the ground. Typical domains of interest include management of priority flights, military-specific requirements for air policing, sensitive data handling and resilience.

The candidate solution is relevant to any operational environment where civil-military cooperation takes place. It can apply to existing



SWIM services developed in SESAR 1, or future new services. To be relevant to all sectors, the military SWIM-enabled systems can be located in a military unclassified sub-domain, or in a military classified sub-domain - such as AD. In the second case, the bidirectional data

flow would go through an information exchange gateway (IEG) that connects both sub-domains in order to reach the military SWIM node located in the military unclassified sub-domain, which is connected to the civil infrastructure network.

STAKEHOLDERS



SJU references:
#PJ.17-07 /Wave 2
candidate

BENEFITS

Increased cost efficiency

Enhanced safety and
security



REPLACING LEGACY AIR/GROUND SERVICES WITH OPEN STANDARDS

SWIM TI purple profile for air-ground safety- critical information sharing

SWIM enables ATM information to be exchanged in a timely and accurate way. It operates in a network-centric environment by interconnecting multiple domain systems to provide accurate, accredited information to qualified parties. In the air/ground domain, SWIM allows the distribution of safety-critical information through the aeronautical telecommunications network/ Internet protocol suite (ATN/IPS) in place of legacy point-to-point contracted services. SESAR aims to replace legacy services - such as those in place to support controller pilot datalink communications (CPDLC) and ADS-C - with an information publication method over air-ground SWIM infrastructure. This enables several ANSPs and airline operators to subscribe to information over the ground-based SWIM network. Addressing the technical infrastructure of SWIM for air/ground services benefits many SESAR 2020 projects and provides a key building block for trajectory-based operations.



SESAR research is looking at safety critical requirements for air/ground information exchange and analysing service description documents (SDDs) for different ATM services. The work includes defining the SWIM technical infrastructure and identifying the functional and non-functional requirements of the air-ground service infrastructure. Key priorities include security, performance, safety, accessibility, maintainability and reliability. The research is based around the existing requirements for CPDLC and ADS-C services in use today.



DYNAMIC INFORMATION ABOUT SWIM SERVICES IN REAL-TIME

SWIM-TI common runtime registry



Registries are an essential building block of service-oriented architecture and provide a database of information related to services and their governance. A Runtime Registry provides a directory of available services, which can be updated dynamically by service providers, and accessed dynamically during runtime by service consumers. SESAR is extending the capability of the static registry for SWIM services developed under SESAR 1 to provide a runtime (or real-time) registry. This enables users to dynamically discover and connect to deployed SWIM services, which best suit their current operations.

A runtime registry holds dynamic information about all deployed SWIM services, and in particular the operational status of the service. The SWIM service provider periodically updates the status of its services in the registry, while the SWIM service consumers can, on request or by subscription, obtain the latest status of a SWIM service. This enables users to determine whether the service is currently operational or not and allows for quickly taking action, e.g. to switch to an alternative SWIM service in case of failure.

The registry improves ATM performance with respect to safety and security; a system becomes more resilient if it can quickly detect the failure of a service and switch to an alternate. In the long term the registry, through its provision of dynamic information about SWIM services, can introduce more dynamicity to the entire ATM system. It could for example open the door for market mechanisms into SWIM service provision by eliminating the need for formal SLAs; this would substantially lower market entry barriers for new service providers.

STAKEHOLDERS



SJU references:
#PJ.17-08 /Wave 2
candidate

BENEFITS

- Enhanced safety, security and resilience
- Increased cost efficiency



FLIGHT DATA LIES AT THE HEART OF EFFICIENT AIRSPACE MANAGEMENT

Flight object interoperability

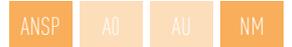
Today each ANSP relies on data contained in their respective systems to predict aircraft trajectory for their portion of airspace, with no synchronised view of the trajectory nor the factors that may constrain it. This is where SESAR's IOP or initial ground-ground interoperability comes in. The candidate solution allows controllers to conduct silent coordination between adjacent units. In this way, all concerned air traffic control units hold a consistent view of the flight at all times, which supports seamless cross-border operations, including cross-border free route operations.

(FDPS). It will allow truly seamless navigation across ANSP borders in Europe, allowing controllers to coordinate with their counterparts in neighbouring ACCs in the same way as they would with colleagues seated next to them. The solution is also part of the PCP, with synchronised deployment across Europe and entry into operation as of 1 January 2025.

Through continuous exchange of up-to-date and consistent trajectory information between all units, the solution enables more efficient operations, from tactical planning and complexity management, to early conflict detection and arrival management. Work is ongoing in SESAR to validate and update the EUROCAE's ED-133 flight object interoperability specification, the standard behind ground-ground interoperability (IOP), which defines the system-to-system interfaces between different flight data processing systems



STAKEHOLDERS



SJU references:
#PJ.18-02b /Release 9, and
delivered solution #28

BENEFITS

- Enhanced predictability
- Enhanced safety and security
- Increased cost efficiency
- Reduced fuel consumption and emissions



STAKEHOLDERS



SJU references:
#PJ.18-02c /Release 9



ENRICHED TRAJECTORY DATA LEADS TO BETTER FLIGHT PLANNING

EFPL supporting SBT transition to RBT

BENEFITS

- Enhanced safety and security
- Increased operational and cost efficiency
- Enhanced predictability and punctuality

Airspace users share their flight plans with stakeholders on the ground so flights can be managed as closely as possible to their ideal profile. This shared business trajectory (SBT) is progressively refined prior to departure to create a RBT agreed by air traffic control and the airspace user. This becomes the flight plan that is then filed. SESAR 1 introduced an extended flight plan (eFPL) to expand the information available for this collaborative decision making process in order to improve trajectory prediction. The enriched data set is reflected in ICAO's long-term vision of flight and fFlow information for a collaborative environment (FF-ICE).

Latest SESAR research aims to enhance further EFPL data to improve alignment of trajectories between air traffic control and airspace users. Included in this broader information exchange is the filed trajectory and agreed trajectory – with airport standard arrival and departure routes – as well as flight specific performance data, which allows air traffic control to recalculate,

when needed, a trajectory closer to the preferred trajectory as would be generated by the airspace user. The activity supports trajectory-based operations by helping to align and unify air traffic control and airspace users' trajectories in the pre-flight phase, and improves target time management for the network as a whole.

The solution is part of synchronised deployment, in accordance with the PCP.



STAKEHOLDERS



SJU references:
#PJ.18-04a /Release 9



ASSURED ACCESS TO THE BEST AERONAUTICAL INFORMATION

Improved AIM Information

BENEFITS

- Enhanced safety and security
- Enhanced predictability
- Reduced fuel consumption and emissions

Information about flight trajectories can be limited and inconsistent, with stakeholders lacking coherent aeronautical and meteorological information at European level. This reduces the accuracy of the predicted trajectory and makes it difficult for air traffic control and airspace users to detect incoming issues and design optimum solutions. This solution considers a number of operational areas that require better management of aeronautical information services so that trajectories can be planned using the most up-to-date knowledge about potential constraints. The quality, consistency and exchange of aeronautical information also needs to be of a high quality.

The candidate solution considers the technical and operational capabilities on board the aircraft and on the ground, as well as the development of an improved and harmonised operational air traffic flight plan. The work sets out to enhance the processes and systems that provide aeronautical information management (AIM) in



order to improve situational awareness of flight crew with respect to current and planned status of the available infrastructure. It also aims to develop a SWIM -based information exchange service to enable stakeholders to retrieve and input relevant data. Finally, the solution includes a validation exercise to show a developed AIM information exchange service in operation. The resulting concepts, prototypes and platforms are expected to be usable throughout Europe.



SHARING WEATHER DATA TO IMPROVE FLIGHT PLANNING

Improved MET Information

Weather conditions have a big impact on aviation: Strong headwinds can significantly extend travel time while sudden storms can affect departures and arrivals as aircraft avoid hazardous conditions. Advances in the understanding and prediction of local and global weather can increase flight safety and efficiency, especially when meteorological information can be integrated into decision-making processes.

Aircraft already have access to valuable weather information through atmospheric observations during flight, but this is not used to its full potential. The introduction of datalink communication methods, and specific SWIM protocols, will enable this data to be part of a

wider exchange service between the aircraft the ground.

SESAR research is looking at different types of weather information and how they can be used in flight planning. The candidate solution enables weather information to be part of an operational solution, which distributes enhanced meteorological information system-wide so that airspace users have more time to plan for changes in the weather. The solution also requires a good understanding of different types of weather-related information along with the capability to use it to improve the resilience of the airspace management system.



STAKEHOLDERS



SJU references:
#PJ.18-04b /Release 9

BENEFITS

- Enhanced safety and security
- Enhanced predictability
- Reduced fuel consumption and emissions



ACCURATE AERONAUTICAL DATA LEADS TO MORE EFFICIENT FLIGHTS

Improved use of MET and AIM in cockpit

The benefits associated with digital communications, such as fast delivery and accurate content, are accompanied by additional requirements relating to data quality and secure connectivity. SESAR is supporting technological developments as well as operational concerns - such as cyber threats and data quality - to comply with European aeronautical data quality (ADQ) standards. The work covers the aeronautical and meteorological data sources described in the previous two solutions, which are used to make strategic and tactical decisions relating to a particular flight.

By ensuring this data uses SWIM, or an advanced data link communications infrastructure, multiple stakeholders can be involved in the collaborative decision-making process. Information needs to be harmonised and consistent in quality to allow all actors to benefit from a common view of a flight trajectory. The candidate solution complies with the applicable regulation, standards and specifications, as well as emerging SWIM

specifications required to meet service level agreements and ADQ standards. It addresses cybersecurity and identifies measures to mitigate effectively any new or changed cyber threat. The objective is to improve the way airspace users make use of aeronautical and meteorological information during flight execution, and to support better trajectory planning based around reliable information exchange and collaborative decision making.



STAKEHOLDERS



SJU references:
#PJ.18-04c /Wave 2 candidate

BENEFITS

- Enhanced safety and security
- Enhanced predictability
- Reduced fuel consumption and emissions
- Security



STAKEHOLDERS



SJU references:
#PJ.18-06a/Release 9



SHARING GROUND-AIR DATA TO IMPROVE TRAJECTORY PERFORMANCE

ATC planned trajectory performance improvement

BENEFITS

- Enhanced safety and security
- Enhanced predictability
- Reduced fuel consumption and emissions

Flight planning takes account of multiple factors, ranging from aircraft status and operational requirements to traffic flow constraints and weather conditions. Using all possible data sources contributes to an improved prediction of the aircraft trajectory and to more efficient overall network operations. Trajectory prediction and management is a collaborative process that takes place between airspace users and air traffic control. New data link communications provide an opportunity for these actors to exchange more information in order to optimise the flight profile flown by each flight. Data extracted from the ADS-C application, provides an up-to-date and accurate information from flight management system (4D prediction and speed schedule), reflecting a user's preferred trajectory considering real time situation (e.g. effect from actual wind, weight and latest ATC instructions).

SESAR is addressing the technical requirements behind this data exchange so that different actors can benefit from the shared information. The research includes enhancing procedures



and tools on the ground so they take account of airspace user high-level preferences based on better data connections between the flight management system and air traffic control. The tools also take account of the aircraft's extended projected profile (EPP) developed under SESAR 1, which enables controllers to display the route downlinked from the aircraft on their radar screen and warn in case a discrepancy is identified between the flight management system and flight plan. This candidate solution is part of synchronised deployment plans in accordance with the PCP.



STAKEHOLDERS



SJU references:
#PJ.18-06b /Wave 2 candidate



A COMMON TRAJECTORY PREDICTION FOR ALL STAKEHOLDERS

Tactical and NM trajectory performance improvement

BENEFITS

- Enhanced safety and security
- Enhanced predictability
- Reduced fuel consumption and emissions
- Security

Optimising trajectory performance benefits the smooth operation of the ATM network as a whole. In addition to improving flight efficiency, predictable trajectories help to fulfil capacity demand and reduce emissions. SESAR is researching ways to achieve this by sharing trajectory information between the cockpit and air traffic control, in particular by using data downlinked from the aircraft to enhance the performance of systems on the ground. By using aircraft-derived data such as ADS reports, and predicted route data generated by the flight management system, SESAR is improving the trajectory prediction in the tactical phase. The aim is to support four dimensional trajectory-based operations which take into account user priorities and airspace constraints.

Among focus areas, SESAR is looking to better predict a change in the rate of descent, or changes in vertical profile, based on data generated by the flight management system (FMS). This may include speed changes or



continuous descent operations planned by the FMS. SESAR is also looking at how information from the flight management system can help air traffic control adjust uncertainty margins. The research is also expected to improve tactical trajectories, which are currently restricted by the lack of information available to air traffic control about aircraft preferences.

3 On the horizon



**High performing
airport operations**



**Advanced air traffic
services**



**Optimised network
operations**



**Enabling aviation
infrastructure**

SESAR looks beyond current research and development to investigate new ideas, concepts and technologies. By advancing promising research ideas and embedding them in a broader programme of work, SESAR is helping to future-proof Europe's aviation industry and to maintain its global competitive edge. This section gives a flavour of this work

Meteorological uncertainty management for trajectory-based operations – TBO-Met



BENEFITS

- **Reduction of airlines' buffer times**
- **Better-informed decision making**
- **Increase of declared sector capacities**
- **Better identification of demand-capacity balancing measures**

A better understanding of the factors that lead to uncertainty in air traffic is key when planning, executing, monitoring and synchronising trajectories between ground systems and aircraft. Having more accurate trajectories that factor in uncertainty can in turn increase the predictability of traffic, which has knock on benefits such as increased capacity, improved efficiency and reduced environmental impact.

To this end, the TBO-Met project focused on three research topics: trajectory planning, storm avoidance, and sector demand analysis, considering meteorological forecast uncertainties. The weather forecasts were obtained from ensemble prediction systems and nowcasts, which provide information about wind uncertainty and convective zones (including individual storm cells).

To address mid-term trajectory planning, the project developed a stochastic optimisation approach to plan the most efficient trajectories with low levels of uncertainty. The methodology is capable of trading-off predictability and cost efficiency (flight time or fuel consumption). To address storm avoidance, the project developed a probabilistic trajectory predictor, which proactively proposes possible deviations in order to avoid stormy conditions. As for addressing sector demand, the project defined a methodology to provide a probabilistic sector demand based on the uncertainty of the individual trajectories. The approach is able to quantify the impact of improved trajectory planning considering weather forecast uncertainty on sector demand. The overall conclusion of the project is that ATM efficiency can be enhanced by integrating weather forecast uncertainty.

► **More information:** <https://tbomet-h2020.com>

When meteorological uncertainty is taken into account, the results show that:

- **the predictability of aircraft trajectories can be increased**
- **storm avoidance can be better anticipated**
- **the prediction of sector demand can be improved**

WEATHERING THE WEATHER AT AIRPORTS

Probabilistic Nowcasting of Winter Weather for Airports -PNOWWA



Adverse weather conditions can play havoc with airport operations, limiting or putting a stop to aircraft movements, runway maintenance, de-icing, tower control and even luggage handling. Having accurate meteorological data and forecasts means that airport operators can prepare for the worst in advance. But weather can change in a matter of hours. That is why partners in the PNOWWA project are turning to nowcasting, very short-term (0-3h) probabilistic winter weather forecasts with a 15-minute-time resolution.

Focusing on snow, the partners extrapolated weather movements based on radar echoes and predictability of changes in snowfall intensity caused by underlying terrain (such as mountains and seas). Within these nowcasts, the projects provided information on the probability of a wide range of events, such as runways freezing over or decreased visibility. Over the course of the winter of 2017, the project partners demonstrated their model in Austria and Finland, allowing them to gather airport feedback on the applicability of the model and its scalability to other airports.

These results enable the quantification of the uncertainties related to delays in ground operations due to winter weather situations. When applied to ATM applications, the PNOWWA method will enhance timely operations in surface management and ATM decision making, thereby increasing airport capacity, reducing delays and promoting safety.

► **More information:** <http://pnowwa.fmi.fi>

The use of probabilistic forecasts in ATM are to support timely operations in surface management and ATM decision making, thereby increasing airport capacity, reducing delays and promoting safety

BENEFITS

- **Increased airport capacity (e.g. fewer delays, better ATM preparedness)**
- **Improved safety**
- **More efficient use of ATM resources**

Coordinated capacity ordering and trajectory pricing for better performing ATM - COCTA



BENEFITS

- **More efficient provision of air navigation services**
- **Increased choice for airspace users**
- **Incentives for reduced CO₂ emissions**

ANSPs have to decide on their capacity provision for a particular day of operation several weeks or even months in advance, whereas airspace users need flexibility in flight planning and prefer to make their route choice decisions at shorter notice. This contributes to a mismatch between planned capacity and actual demand in the European ATM system.

To tackle this problem, the COCTA project developed an innovative conceptual framework to improve efficiency of air navigation service provision in Europe by a better coordination of capacity and demand management:

On the capacity side, the Network Manager asks for airspace capacities in line with expected demand, employing a network-centred, demand-driven approach, as opposed to the current, largely supply-driven and piecemeal practice, with predominantly local (ANSP) perspectives.

On the demand side, the Network Manager offers different trajectory options to the airspace users, including novel concepts of flexible trajectories. One option is for an airspace user to pay less in exchange for granting the Network Manager some flexibility to move the flight with pre-determined spatial and temporal margins. Another option allows airspace users to decide on a flight trajectory within certain margins shortly prior to departure and for a premium. These trajectory options or products are tailored to capture the different business and operational needs of airspace users, thereby contributing to an optimised network performance.

The project studied the potential improvements achievable through the proposed framework, as well as trade-offs between the different key performance indicators (KPIs) in a large-scale case study. According to initial results, the framework could accommodate the same traffic volume with significantly reduced capacity and dramatically reduced cumulative delay in the network.

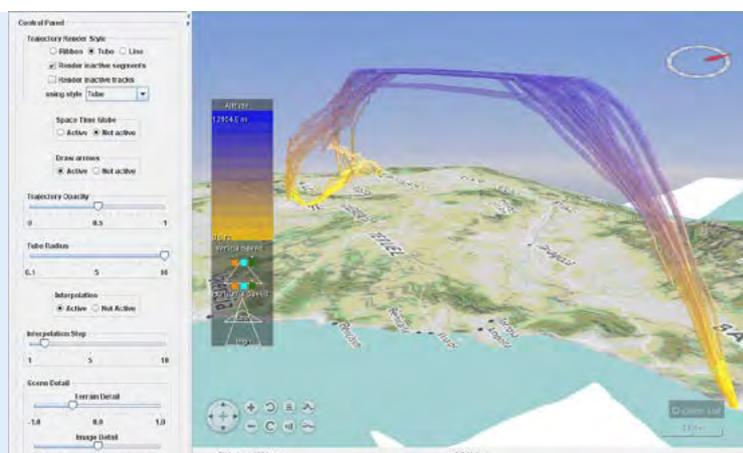
► **More information: www.cocta-project.eu**

Network-oriented capacity planning improves the overall cost efficiency of ATM in Europe

Innovative trajectory products/options enable airspace users to prioritise flights within the network in a fair and transparent manner

TRAJECTORY PREDICTION – LETTING THE MACHINE DO THE MATH

Data driven aircraft trajectory prediction research - DART



The complex ATM system worldwide has reached its limits in terms of predictability, efficiency and cost effectiveness. DART explored the potential of data-driven techniques for trajectory prediction, and agent-based modelling approaches for assessing the impact of traffic to individual trajectories, thus accounting for ATM complex phenomena. Improvements with consequent benefits in these emerging areas of research can support the trajectory-based operations (TBO) paradigm.

The project focused on providing answers to the following major questions:

- ▶ What are the supporting data required for accurate trajectory predictions?
- ▶ What is the potential of machine learning algorithms to support high-fidelity aircraft trajectory prediction?
- ▶ How does the complex nature of the ATM system impact trajectory predictions? How can this insight be used to optimise the ATM system?

DART delivered machine learning techniques to improve the accuracy of trajectory predictions, accounting for ATM network complexity effects

DART explored the potential of machine learning methods using historical data to increase the predictability for individual trajectories, and multi-agent collaborative reinforcement learning methods to resolve demand-capacity balancing (DCB) problems, supporting

the incorporation of stakeholders' preferences into the planning process.

Results suggest that data-driven methods, compared to model-based approaches, can enhance trajectory prediction capabilities by exploiting patterns derived from historical data. In addition to that, agent-based methods can regulate flights effectively, reducing imposed delays, while resolving DCB problems.

The DART developments pave the way towards advanced collaborative decision-making processes that support multi-objective optimisation taking the requirements of the different stakeholders in the ATM system into account at the planning phase.

▶ **More information:** <http://dart-research.eu>

BENEFITS

- **Increased predictability**
- **Reduced delays thanks to early resolution of DCB issues**
- **Advancing collaborative decision making and planning tools**

IMPROVING ATM EFFICIENCY THROUGH ARTIFICIAL INTELLIGENCE

Machine learning of speech recognition models for controller assistance – MALORCA



BENEFITS

- **Reduces command recognition error rates of the baseline system from 7.9% to under 0.6% for Prague approach and from 18.9% to 3.2% for Vienna approach**

Significant progress has been made in recent years in artificial intelligence (AI) and in particular in machine learning applications like automatic speech recognition (ASR). Thanks to these advances, new technologies are emerging in a variety of domains, including aviation.

Nowadays, instructions from ATC to pilots are usually given via voice communication. Automatic speech recognition can be used to convert the spoken words into text and extract the relevant information. It therefore offers the means to avoid the manual input of given ATC commands. The MALORCA project is a natural follow-up of the following speech recognition projects:

Combining ASR with a controller assistance system results in an assistant based speech recogniser (ABSR). Command recognition rates of 95% were achieved.

The system enables greater arrival throughput by reducing controllers' workload for manual system input. Tested for Dusseldorf approach, the system allowed up to two more landings per hour.

However, there is a snitch in that these systems require manual adaptation for their deployment in new environments. To overcome this, the project designed a low-cost solution that adapts the speech recognition tools for use at other airports or approach areas. The solution automatically learns local acoustic and semantic patterns and controller models from radar and speech data recordings which are then automatically introduced into the ASR software.

The MALORCA project proposed to overcome the need for significant expert knowledge by employing novel machine learning algorithms that allow a semi-automatic adaptation of the initial basic ABSR system to a target-domain (i.e. Prague and Vienna approach).

The performance of the trained ABSR system was successfully evaluated by air traffic controllers in Vienna and Prague in January 2018. The next logical step is to bring the ABSR technology, continuously learning from daily-recorded data, into the ops room.

► **More information: www.malorca-project.de**

Resilient synthetic vision for advanced control tower air navigation service provision - RETINA



Controllers in airport towers rely on being able to see aircraft taxiing, taking off and landing in order to manage them safely and efficiently. But when bad weather sets in, their visual situational awareness can be impaired, leading to a reduction in throughput. The results from the RETINA project are showing the promise that augmented reality holds for enhancing air traffic control operations, particularly in low-visibility conditions.

As trust in digital data grows RETINA's concept will allow the controller to have a heads-up view of the airport traffic even in low visibility conditions similar to the synthetic vision currently used in the cockpit

Using synthetic vision and augmented reality technologies, RETINA has developed a set of goggles through which controllers can see synthetic information overlaid on the actual "out-of-the-window" view. With these goggles, the controller can have a heads-up view of the airport traffic, call sign and aircraft type, supplemented by additional information, such as wind velocity and direction, airport layout and runway status, even during low-visibility procedures.

RETINA builds upon SESAR technologies, such as remote tower, safety nets, SWIM, to provide augmented reality tools for the tower controller

From a technological perspective, RETINA investigated two different augmented reality systems: conformal head-up displays (to coincide with the tower windows) and see-through head-mounted displays.

For each augmented reality system, a proof-of-concept was implemented and validated in a laboratory environment by means of human-in-the loop real-time simulations where the external view was provided to the user through a high fidelity 4D model in an immersive environment that replicated the out-of-the tower view.

During the validation, both subjective qualitative information and objective quantitative data were collected and analysed to assess the RETINA concept. The results showed that the RETINA concept is a promising solution to improve the human performance in the control tower, increasing resiliency at airports to low visibility and preserving safety.

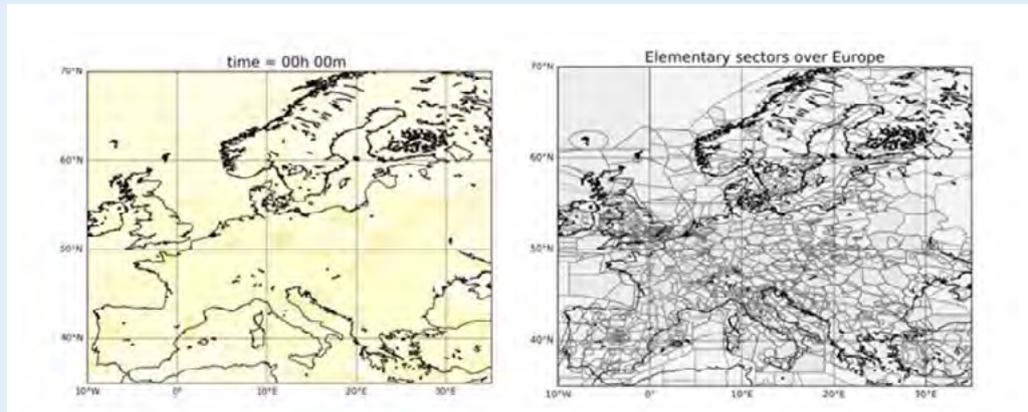
► **More information:** www.retina-atm.eu

BENEFITS

- **Improved situational awareness for controllers**
- **Increased airport capacity and throughput**
- **Improved flight punctuality and reduced emissions**

IMPROVING TRAJECTORY PREDICTION THROUGH UNDERSTANDING UNCERTAINTY

Combining probable trajectories – COPTRA



BENEFITS

- **Visualisation of uncertainty**
- **More accurate and stable demand prediction**
- **Quantitative understanding of delay propagation dynamics in space and time**

ATM is gradually moving towards the notion of allowing aircraft to fly their preferred trajectory, otherwise known as trajectory-based operations. One of the challenges related to the implementation of TBO is the ability to identify, model and manage the uncertainty associated to a trajectory.

The integration of the uncertainty models in the planning systems improves the trajectory predictions and supports the assessment of the feasibility of integrating the models into existing demand and capacity balancing (DCB) tools. The COPTRA project researched three areas related to uncertainty modelling:

- ▶ Defining and assessing probabilistic trajectories in a TBO environment;
- ▶ Combining probabilistic trajectories to build probabilistic traffic prediction;
- ▶ Applying probabilistic traffic prediction to air traffic control planning.

COPTRA showed that in addition to quantifying uncertainty through data analytics, it is possible to limit it through model-driven state estimation techniques. This enables not only to include flight intent or initial condition uncertainties but also to take into account model uncertainties.

COPTRA's models provide us with a clear quantitative understanding of delay propagation dynamics in space and time. The project results provide insight into how to achieve more efficient ATM operations in the future.

▶ **More information: www.coptra.eu**

The work performed in COPTRA to model uncertainty, allows us to be certain of our uncertainty

Key to enabling TBO is the ability to deal with the numerous sources of uncertainties inherent in ATM

Wake vortex simulation and analysis to enhance en-route separation management in Europe - R-WAKE



The R-WAKE project addressed the risk and safety study of the wake vortex encounter (WVE) hazards in en-route airspace, and the identification of potential enhancements to the current separation schemes. The aim is to enable traffic and trajectory management improvements, and expected benefits in safety, airspace capacity, and flight efficiency of the European ATM system. Applying a simulation-based approach, the project delivered five tangible results:

An ATM simulator that includes high-fidelity WVE dynamic risk models, referred to as R-WAKE System, tailored to support the project research approach.

A WVE hazard severity baseline, defined as a matrix of upset parameters thresholds per severity class, developed and assessed with contributions of experienced pilots and air traffic controllers.

A public database of simulation results, which constitutes an evidence body to support new separation scheme proposals, containing the upset and severity class computed for a large number of encounter scenarios, involving different aircraft types, geometries, separations, and weather conditions.

The R-WAKE-1 concept proposal, which consists of six new separation schemes designed to increase safety against WVE hazards and also airspace capacity, looking at the minimum wake separation in the three dimensions: lateral, vertical, longitudinal, and also combined lateral-vertical, and wind-dependent dynamic separations.

A feasibility and impact assessment of the concept, concluding that there is enough justification for proposing R-WAKE-1 as a new SESAR Solution, as a first step in a roadmap of identified incremental evolutions towards a long-term R-WAKE concept for optimising en-route separation minima provision.

► **More information:** www.rwake-sesar2020.eu

BENEFITS

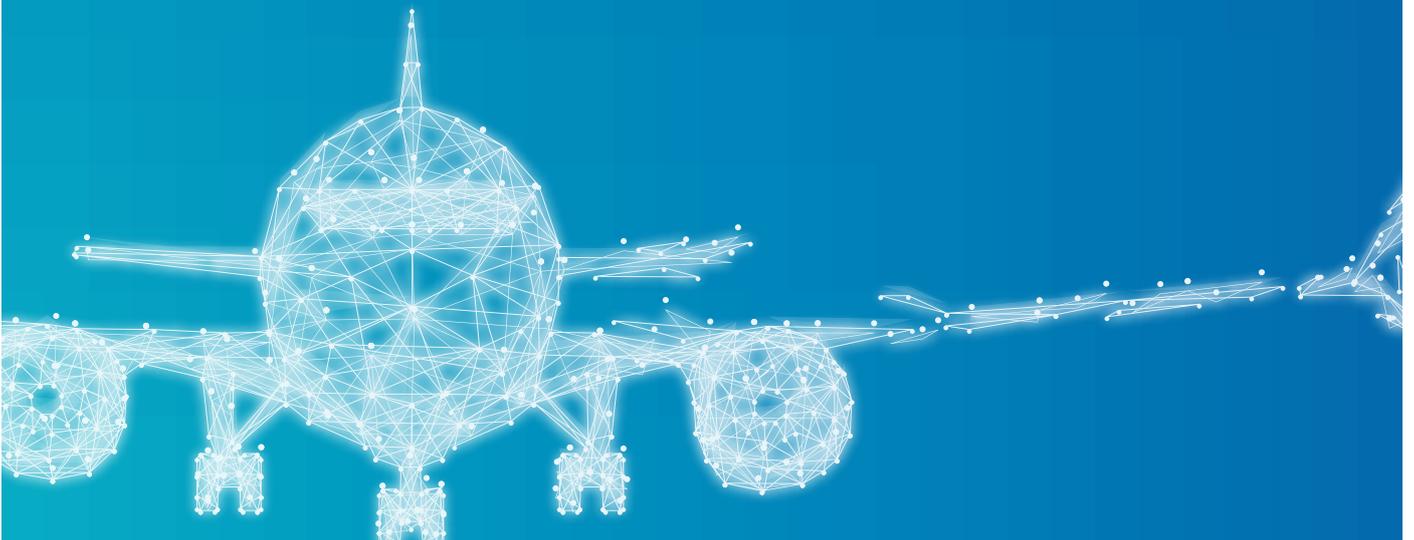
- **Increased safety**
- **Optimised airspace capacity**
- **Increased flight efficiency**

Conclusion

The SESAR JU will build on the content of this catalogue in the second wave of SESAR 2020 R&D, with the aim of moving more of the candidate solutions to the next level of maturity and ultimately deliver for market take up. In this respect, the next edition of this catalogue will detail further progress in the development, validation and delivery of solutions in line with the European ATM Master Plan and the objectives of SES and the EU Aviation Strategy.

The focus will be on the further integration of airports into the air traffic network; the implementation of advanced air traffic services such as satellite-based navigational aids; integrated arrival and departure management tools, and free route airspace; and optimising network services through increased dynamic data sharing between airlines and air traffic control.

Through this R&D work, SESAR JU members and partners will aim to bring benefits in key performance areas of safety, operational efficiency, security, capacity and the environment, fast-tracking solutions to meet individual stakeholder challenges or improvements to the overall network.



Reaching research maturity

SESAR researches and delivers solutions according to a set of agreed business needs and strict performance requirements and with a view to industrialisation readiness. During the course of developments and when assessing the results of SESAR validation, it may become apparent that these solutions do not fully match the completeness criteria for reaching the level of expected maturity and performance which in itself is the very purpose and value of R&D. This is the case for the solutions in this annex, for which further refinements in their development by stakeholders will be required if and when decisions for industrialisation are taken.



A COORDINATED DEPARTURE ROUTE

Departure management integrating surface management constraints

The departure manager (DMAN) takes inputs from a number of different sources to calculate the optimum sequence for aircraft to push back from the gate and taxi to the runway. The process may begin hours before a flight is due to depart, when flight plan data, flow management slots, and aircraft schedules provide a reasonable guide to departure time.

The calculation becomes a lot more precise if tactical information is added into the equation. For example, the taxi out time from the gate to the runway may change by several minutes depending upon the route available; arriving aircraft can slow down the rate of departure; and busy taxiways will also affect route planning by the tower controller. Taking account of these variables, the DMAN is able to estimate more precise departure times, and calculate a more accurate pre-departure sequence for aircraft at the gate.

The solution integrates surface planning and routing functions to build a very accurate departure sequence, taking the tactical changes into account. The solution includes procedures and technical specifications to support the addition of dynamic data from the control tower, in particular to take account of taxi-out times. Integrating surface management constraints with departure management delivers a more predictable departure sequence, and improving the use of available capacity on the airfield. Safety is also enhanced by reducing the risk of unplanned events.

While the solution reached operational and technical feasibility, the expected reduced fuel consumption and increased operational predictability could not be validated. SESAR 2020 PJ.02-08 builds on the valuable results to analyse the balance between sequence updates and planning stability.

STAKEHOLDERS



SJU references:
#14/Release 5

BENEFITS

- [Increased predictability](#)
- [Enhanced safety](#)
- [Reduces fuel burn and emissions](#)

The solution includes procedures and technical specifications supporting departure management that takes into account route planning and route monitoring information



STAKEHOLDERS



SJU references: #15/
Release 5



OPTIMISED ARRIVALS AND DEPARTURES

Integrated and throughput-optimised sequence of arrivals and departures

BENEFITS

Keeps delays to a minimum
More predictable arrival and departure times enhances safety

It is common for arriving aircraft to take priority at an airport, but with careful planning, traffic flow can be optimised for both arrivals and departures. By integrating the sequence of arrivals and departures, and adjusting the traffic flows to minimise delays, overall efficiency can be improved.

The solution requires the departure manager (DMAN) to be coupled with the arrival manager (AMAN). An algorithm ensures minimum separations are maintained, and up-to-date information regarding the pre-departure sequence and the arrival metering sequence is used to calculate the optimum traffic flow. Controllers play an important part in working towards establishing the plan, for example by following target take-off times and target landing times as closely as possible. Planners create gaps in the arrival sequence to allow for departure flights. The process is particularly

useful at busy single runway airports, or with dependent runways, where both capacity and efficiency can improve as a result of using integrated systems.

Real-time simulations assessed the feasibility of integrating AMAN-DMAN, and its impact on runway throughput, airport operations and service provision. Operational and human factor issues that can affect performance were also looked at. Controller tools such as route planning, surface conflict alerts, and flight data were included in the sequence planning.

While the solution reached operational and technical feasibility, the expected performance benefits could not be fully operationally validated. SESAR 2020 PJ.02-08 is focusing on the flow-based operations to enable optimised spacing of arrivals and departures reflecting benefits from reduced and predicted runway occupancy.

STAKEHOLDERS



SJU references: #16/
Release 5



AIRCRAFT SPACING TOOLS TO STABILISE ARRIVAL MANAGEMENT

ASAS spacing applications 'remain behind' and 'merge behind'

BENEFITS

Enhanced safety
Increased capacity in the TMA

The management of traffic flows in almost all European terminal manoeuvring areas (TMAs) requires complex traffic patterns and tactical intervention e.g. open-loop vectoring. This impacts the overall ATM system performance (capacity, predictability, efficiency).

By using the aircraft's on-board airborne separation assistance system (ASAS) to monitor distances between aircraft, the flight deck can maintain the spacing requested by air traffic control. Separation provision is still the controller's responsibility, but the pilot would only need one instruction – for example "remain 90 seconds behind" – rather than several speed commands by the controller. On-board

automation would automatically generate and execute the appropriate speed commands.

SESAR is assessing the application of airborne interval management sequencing and merging during the arrival phase for ADS-B-in-equipped aircraft.

While the solution was shown to be operationally and technically feasible, the expected operational benefits of decreased fuel consumption and efficient service provision could not be fully validated. SESAR 2020 PJ.01-05 is building from these results, but focusing on different environments and assessing various possibilities of communicating between aircraft.



LIGHTENING THE LOAD

Flexible communication avionics

Today, civil aircraft are typically fitted with several radios. This is standalone equipment, which is not only costly but also adds to the weight and the energy consumption of the aircraft. At the same time new technologies are expected to be implemented on board to meet the communication capacity and performance requirements of air traffic management in the future.

SESAR's flexible communication avionics aims to overcome this equipment challenge with the introduction of multi-purpose communications equipment capable of fulfilling conventional radio transceiver functions using generic computing platforms and software. The solution has the potential to reduce the cost, weight, size, and power penalties of multiple radio systems on board aircraft, and to provide flexibility for adding, removing, replacing, or upgrading these systems. In doing so, the solution facilitates the transition from current to future technologies and is a key enabler to realising efficiently multi-link operations.

Since not all aircraft radios are used simultaneously in all airspaces, the solution

brings the opportunity to build new dynamically reconfigurable radio systems to operate a specific radio link only when required. Such flexibility can allow a further reduction in the number of separate hardware components carried on board and can also improve availability of the aircraft communication functions and aircraft interactions with the ground.

The feasibility of the solution has been validated through the development of two prototypes and laboratory testing, as well as complementary assessments on the benefits and challenges, for instance, related to security and certification. The solution has the potential to reduce the cost, weight, size, and power penalties of multiple radio systems on board aircraft, and to provide flexibility for adding, removing, replacing, or upgrading these systems. In doing so, the solution facilitates the transition from current to future technologies and is a key enabler to realising efficiently multi-link operations.

Having reached V2/TRL4 maturity (technical feasibility), the technology is being demonstrated by industry within the Clean Sky II research programme.

STAKEHOLDERS

ANSP

AO

AU

NM

SJU references:
#112

BENEFITS

Enhanced safety

Increased capacity
in the TMA

ANNEX 2

Glossary

ABSR	Assistant based speech recogniser
ACAS	Airborne collision avoidance system
A-CDM	Airport collaborative decision making
ADDEP	Airport departure data entry panel
ADQ	Aeronautical data quality
ADS-B	Automatic dependent surveillance – broadcast
ADS-C	Automatic dependent surveillance – contract
ADSP	ATM data provider
AEEC	Airlines Electronic Engineering Committee
AeroMACS	Aeronautical mobile airport communication system
AFIS	Aerodrome flight information services
AFUA	Advanced flexible use of airspace
AI	Artificial Intelligence
A-IGS	Adaptive increased glide slope
AIM	Aeronautical information management
AIRM	Aeronautical information reference model
AIXM	Aeronautical information exchange model
AMAN	Arrival manager
ANSP	Airspace navigation service provider
AO	Airport operators
AOC	Airline operational control
AOP	Airport operations plan
A-PNT	Alternative position, navigation and timing
APOC	Airport operations centre
ARES	Airspace reservation/restriction
ASAS	Airborne separation assistance system
A-SMGCS	Advanced surface movement guidance and control systems
ASPA-IM	Airborne spacing – flight deck interval management
ASR	Automatic speech recognition
ATC	Air traffic control
ATFCM	Advanced short-term air traffic flow capacity management
ATM	Air traffic management
ATN/IPS	Aeronautical telecommunication network internet protocol suite
ATN/OSI	Aeronautical telecommunication network open systems interconnection
ATS	Air traffic services
ATSU	Air traffic control unit
ATV	Air transit view
AU	Airspace user
AUP	Airspace user plan
AUTOMETAR	Automated weather observations
BEAP	Basic extended ATC planning
CAPP CDTI	assisted pilot procedure
CAR	Complexity assessment and resolution
CATC	Conflicting ATC clearances
CAVS	Cockpit assisted visual separation
CBA	Cost-benefit analysis
CD&R	Conflict detection & resolution
CDA	Continuous descent approach
CDM	Collaborative decision making
CDO	Continuous descent operations
CDTI	Cockpit display of traffic information
CMAP	Conformance monitoring alerts
CNS	Communications, navigation and surveillance

CONOPS	Concept of Operations
COS	Conflict organiser and signaller
CPDLC	Controller-pilot datalink communications
CSP0	Closely spaced parallel runway operations
CSPR	Closely spaced parallel runways
CTA	Controlled time of arrival
CTOT	Calculated take-off times
CVS	Combined vision systems
CWP	Controller working position
DAC	Dynamic airspace configuration
DAPs	Downlinked aircraft parameters
DCB	Dynamic capacity balancing
DMAN	Departure manager
DME	Distance measuring equipment
DMIT	De-icing management tool
DPI	Departure planning information
DT	Dual thresholds
D-TAXI	Datalink taxi
E-AMAN	Extended AMAN
EASA	European Aviation Safety Agency
EATMA	European ATM architecture framework
EDIT	Estimated de-icing time
EEZT	Estimated end of de-icing time
EFB	Electronic flight bag
eFDP	Electronic flight data processing
EFPL	Extended flight plan
EFVS	Enhanced flight vision systems
EGNOS	European Geostationary Navigation Overlay Service
EPP	Extended projected profile
ERM	Environment reference material
ESA	European Space Agency
E-TMA	Extended TMA
EU	European Union
EVS	Enhanced vision systems
FAB	Functional Airspace Block
FABEC	Functional Airspace Block Europe Central
FASTI	First ATC support tools implementation
FCI	Future communication infrastructure
FDPS	Flight data processing systems
FF-ICE	Flight and flow information for the collaborative environment concept
FIS-B	Flight information system-broadcast
FMP	Flow management position
FOC	Flight operation centre
FRA	Free route airspace
FRT	Fixed radius transition
GANP	Global Air Navigation Plan
GBAS	Ground-based augmentation system
GLS GBAS	landing system
GNSS	Global navigation satellite system
GPS	Global positioning system
HMD	Helmet-mounted display
HMI	Human machine interface
HUD	Heads-up display
i4D	Initial four dimensional trajectory management
ICAO	International Civil Aviation Organization
ICT	Information and communications technology
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IEG	Information exchange gateway
IFR	Instrument flight rules
ILS	Instrument landing system
IRS	Inertial reference system
ISRM	Information service reference model
ITF	In-trail follow
ITM	In-trail merge
JU	Joint Undertaking

KPI	Key performance indicators
LDACS	L-band-digital aeronautical communication system
LPV	Localiser performance with vertical guidance
LTE	Long-term evolution
MC/MF	Multi-constellation/Multi-frequency
METSPs	Meteorological service providers
MLAT	Multilateration
MONA	Monitoring aids
MOPS	Minimum operational performance standards
MRTM	multiple remote tower module
MSPSR	Multi-static primary surveillance radar
MTCDD	Medium-term conflict detection
MTI	Multi touch input
NM	Nautical mile
NM	Network Manager
NOP	Network operations plan
NOTAM	Notice to airmen
NSA	National supervisory authority
NTZ	Non-transgression zone
OLDI	On-line data interchange
PBN	Performance-based navigation
PBS	Performance-based surveillance
PCP	Pilot Common Project
PinS	Point-in-space
PIREP	Pilot air report
P-RNAV	Precision area navigation
PWS	Pair wise separation
R&D	Research and development
RA	Resolution advisory
RAIM	Receiver autonomous integrity monitoring
RECAT	Europe's Wake Vortex Re-Categorisation scheme
REL	Runway entrance lights
RF	Radius-to-fix
RIL	Runway intersection lights
RMAN	Runway manager
RNP	Required navigation performance
ROAAS	Runway overrun awareness and alerting system
ROT	Runway occupancy time
RPAS	Remotely-piloted aircraft systems
RSP	Required surveillance performance
RTA	Required time of arrival
RTC	Remote tower centre
RTS	Remote tower services
RWSL	Runway status light
SATCOM	Satellite communications
SBAS	Satellite-based augmentation systems
SBT	Shared business trajectory
SDPD	Surveillance data processing and distribution
SecRAM	SESAR ATM security risk assessment methodology
SES	Single European Sky
SESAR	Single European Sky ATM Research
SID	Standard instrument departure
SIGMET	Significant meteorological information
SMGCS	Surface movement guidance and control system
SMR	Surface movement radar
SRAP	Second runway aiming point
SRM	Safety reference material
STAM	Short-term ATFM measures
STCA	Short-term conflict alert
STM	Surveillance and tracking module
SVS	Synthetic vision systems
SWIM	System-wide information management
SWIM TI	SWIM technical infrastructure
TAM	Total airport management
TBO	Trajectory-based operations

TBS	Time-based separation
TCAS	Traffic alert and collision avoidance system
THL	Take-off hold lights
TMA	Terminal manoeuvring area
TOBT	Target off-block time
TP	Trajectory predictors
TRM	Threat resolution module
TSAT	Target start-up approval time
TTL	Time-to-lose
TTOT	Target take-off time
UDPP	User-driven prioritisation process
UPMS	User profile management system
UUP	Updated use plan
VLL	Very low level
VoIP	Voice communications over Internet Protocol
VOR	VHF omni range
VPA	Variable profile areas
V-PAT	Vertical flight path analysis
WAM	Wide area multilateration
WeP	What-else probing
WiMAX	Aviation airport surface datalink system
WOC	Wing operations centre
WVE	Wake vortex encounter



founding members



AIRBUS



Honeywell

indra



NATS



skyguide

THALES



Publications Office