SESAR 1 Solutions Implementation

Key Feature - High Performing Airport Operations

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***Abstract*— Initial SESAR work programme (SESAR 1) delivered a number of mature and validated SESAR solutions that are ready to be deployed in Europe. SESAR 1 was followed by SESAR 2020 to address new challenges, changing markets and the need for continuous and coordinated investments, but the impact of SESAR 1 is recognized as a key factor of SESAR 2020's success. It is still too early to quantify SESAR 1's impact directly. As SESAR solutions are the tangible output of the R&D that is supposed to be used to achieve Operational /Technology Changes defined in the European ATM Master Plan, in this study we rely on planned solution implementations to indirectly indicate SESAR 1's success. This paper presents the preliminary results of the progress of the implementation of SESAR 1 solutions, focusing on solutions under High Performing Airport Operations. The analysis provides an overview by number of solution implementations, by performance area(s) possibly benefiting from implementation, and by number of airports involved and expected to be involved in the deployment process.**

Keywords - SESAR 1, SESAR solutions, airports, deployment, performance areas, implementation locations

I. Introduction

A performance-driven and technologically advanced air traffic management (ATM) system is a critical element for achieving greater connectivity and ensuring the sustainability of the aviation sector in Europe. In 2004, the SESAR (Single European Sky ATM Research) project was set up to modernise European ATM systems through the definition, development and deployment of innovative technological and operational solutions (SESAR Solutions).

The initial SESAR work programme (SESAR 1) delivered a number of mature and validated SESAR solutions that are ready to be deployed in Europe. In total, 67 SESAR Solutions were delivered as part of SESAR 1, classified by the SESAR Key Feature (Optimised ATM Network Services, Advanced Air Traffic Services, High Performing Airport Operations, Enabling Aviation Infrastructure). Direct and quantifiable benefits for European ATM and aviation are [1]:

- *ANS productivity*: reduced en-route and TMA costs per flight
- *Operational efficiency for airspace users*: reduced fuel burn and flight time
- *Capacity*: reduced delays, increased network throughput and throughput at congested airports
- *Environment*: reduced CO2 emissions
- *Safety and security*: high standards

SESAR 1 was followed by SESAR 2020 to address new challenges, changing markets and the need for continuous and coordinated investments. SESAR partners consider the success SESAR 1 as a key factor for the success of SESAR 2020. One of the requirements for the new European Master Plan Edition 2019 is to reflect the state of SESAR implementation and achievements, showing progress towards the Single European Sky (SES) vision and performance ambitions [2].

It is still early to quantify SESAR 1's impact directly, as many of the SESAR solutions are only started being implemented and stakeholders are still in the phase of planning the implementation. Therefore, the impact of SESAR 1 needs to be somehow quantified indirectly, e.g. by measuring the projected implementation rate, expected impact, implementation plans, and so forth. In this paper, implementation (current and planned) of delivered SESAR solutions, being a tangible output of SESAR R&D to achieve Operational/Technology Changes, is considered a good indicator of expected SESAR 1 impact in the future.

This paper addresses one of the key ATM stakeholders – Airports, i.e. the focus is on SESAR solutions that are contributing to High Performing Airport Operations SESAR key feature. The aim is to analyze deployment progress and to determine which SESAR solutions are the most "attractive" for airports. A similar exercise could be performed for the other ATM Stakeholders, analysing SESAR solutions that are more focused to that particular stakeholder or the area of implementation (for example CNS and its rationalisation).

This paper examines how airports perceive SESAR 1 implementation: where is the focus in terms of area of implementation, expected performance improvement, and

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locations having begun implementation or begun planning such implementation. It also discusses the relationship between airport utilisation level and the implemented solution(s).

Section II of this paper briefly explains the nature of a SESAR Solution and how such a solution is validated. Section III introduces the SESAR deployment process (plans and progress), distinguishing regulated deployment from voluntary deployment. Section IV addresses the scope of the analysis, performance classification of the SESAR solutions and data sources used. Section V presents the results of the analysis addressing different aspects: implementation trend (number of solution implementations – completed and planned), impact (expected effect on airport performance areas), coverage (number of airports implementing solutions), etc. Section VI sets out the conclusions.

II. SESAR SOLUTIONS

SESAR solution is a new improved procedure or technology, elaborated to modernise and improve the existing ATM system. Every solution is developed in a harmonised way and the solution pack usually includes: operational services and environment descriptions; safety, performance and interoperability requirements; technical specifications; regulatory recommendations; safety and security assessments; and contextual note.

SESAR solutions are delivered in a structured way through a release process. When a solution is released, it is validated in a real operating environment with the participation of all relevant stakeholders. The validation of concepts in SESAR is carried out in line with the European Operational Concept Validation Methodology, E-OCVM [3]. The E-OCVM was developed to help operational concepts move from R&D to operation. The method was born out of a need to demonstrate a 'business case' before the industry would invest in the necessary development process to turn a concept into reality. Figure 1 illustrates the phases of E-OCVM process as applied in SESAR [3].

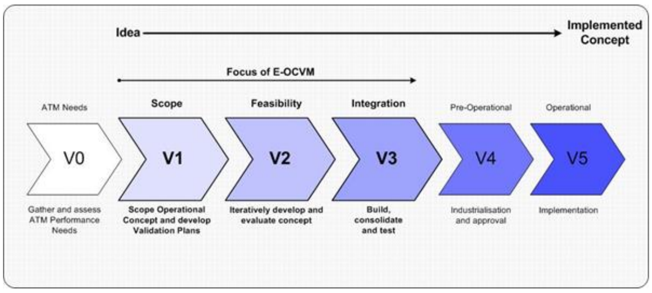


Figure 1. European Operational Concept Validation Methodology [3]

Additionally, for technological solutions, the SESAR Joint Undertaking (SJU) is now required to communicate achievements externally using Technology Readiness Levels (TRLs) [4]. TRLs ranges from pre-TRL1 to TRL7, that is possible complement of V0 to V3+ in E-OCVM terms. Industrialization (V4/TRL8) and Deployment (V5/TRL9) are beyond the scope of SJU. Deployment (one part) is in the domain of the SESAR Deployment Manager (DM). Some gaps exist at industrialization level.

The analysis performed and presented in this paper aims at capturing an expected deployment success of mature SESAR solutions that are ready for industrialization. Preliminary results of the analysis are limited to airport-related solutions.

III. SESAR DEPLOYMENT

In principle, SESAR solutions are deployed on a voluntary basis. They are selected by the ATM industry based on the business case and the level and type of improvement required by the stakeholders. The SESAR deployment process itself is defined mainly through the European ATM Master Plan (hereafter Master Plan) framework [1].

The Master Plan is the planning tool for defining European ATM modernisation priorities. Set within the framework of SES, the Master Plan provides a high-level view of what is necessary in order to deliver a high-performing aviation system for Europe. It also sets the framework for the related development and deployment activities, thereby ensuring that all phases of the SESAR lifecycle remain connected and SESAR Solutions become a reality [5].

The Master Plan allows stakeholders to view the information that is most relevant to them, whether they are executives, planners or those implementing the plan. Its content is structured in three levels, from the vision of future ATM (Level 1 - executive view that is endorsed by the European Council [6]), down to Level 2 that is planning view and ATM architecture, where different enablers and operational improvement steps are addressed as the solution matures through the R&D process. At the bottom is Level 3 - implementation view, which includes implementation plan and associated progress reporting.

A yearly Level 3 Implementation Plan is structured around a set of commonly agreed implementation objectives and actions (including those resulting from the SES legislation and ICAO) developed under the SESAR work programme, and with the participation of all ATM stakeholders. Level 3 Progress Report provides progress assessment for all implementation objectives at ECAC level.

Commission Regulation (EU) 716/2014 of 27 June 2014 [7] (on the establishment of the Pilot Common Project (PCP) supporting the implementation of the European Air Traffic Management Master Plan) introduces the first mandatory provisions for the implementation of SESAR. That Regulation addresses a number of ATM functionalities from SESAR and enables European operational stakeholders to apply for funding to support the implementation process. The PCP is managed by SESAR DM.

There is one purely airport-related ATM functionality included in the PCP - "Airport integration and throughput", and one functionality that addresses the airspace around the airport - "Extended arrival management and performance based navigation in high density terminal manoeuvring areas" that is also relevant for airports, but the main stakeholder is the Air

Navigation Service Provider (ANSP). The funding to implement projects related to these two functionalities is available for 26 major airports in Europe (including Istanbul airport and Swiss and Norwegian hubs). So far, 41 projects have been funded through this mechanism, addressing five SESAR solutions that are part of this analysis, namely solutions no. 02, 21, 22, 53 and 64. (see Table I) [8].

The assessment of SESAR implementation is performed today by assessing the implementation of the Master Plan Level 3 implementation objectives and, for PCP related items, the implementation of ATM functionalities defined in the PCP deployment programme. The link with the SESAR solutions is not directly visible, and currently there is no official SESAR solution centric reporting. This paper proposes how this could be achieved using the existing monitoring information.

IV. The Scope and the Data Sources Used

The Master Planning framework relies on the official ECAC-wide EUROCONTROL reporting process on Single European Sky ATM implementation - LSSIP (Local Single Sky ImPlementation). Data collected through LSSIP has a dual nature - some of the information is publically available to the whole ATM community (level 1 doc - implementation overview, high-level progress); and the more detailed information are restricted to authorized users (level 2 doc - detailed implementation status). Web tools supporting this monitoring and reporting process are: LSSIP Database, PRM (Planning, Reporting and Monitoring) website, LSSIP SharePoint and eATM Portal. The data used in this paper is from a publically available domain.

Based on LSSIP data and additional sources (Network Manager-NM, Stakeholders, PRISME), annual Level 3 Progress Report is produced. Some SESAR solutions are covered by the implementation objectives defined in the Level 3 Implementation Plan, and monitored on yearly basis through LSSIP. However, there are some SESAR solutions that are not covered by those implementation objectives (either because the solution is of a very local nature, the scope is very small, or it does not require a common and synchronised approach for deployment). Master Plan Level 3 Progress Report 2018 [9] tries to fill these gaps and makes the first steps towards SESAR Solution centric approach i.e. monitoring of implementation from a SESAR Solution perspective. The additional data was collected through a specifically designed survey performed between Dec 2017 and Feb 2018 (see in [9], Annex B) using the LSSIP process, contacts and infrastructure. Other data sources were also used where necessary, such as information from the NM, which was used for Advanced Tower (Solution 61).

Data related to 21 SESAR 1 solutions under the key feature High Performing Airport Operations - HPAO (set out in Table I) is collected and analysed here. The following assumptions are applied:

- *Timeframe of analysis*: 2017 to 2024. Solutions that are to be implemented beyond 2024 were disregarded from the analysis (very few).

TABLE I. SESAR 1 Solutions – High Performing Airport Operations [5]

Solution no.	Solution name
01	Runway status lights
02	Airport safety nets for controllers: conformance monitoring alerts and detection of conflicting ATC clearances
04	Enhanced traffic situational awareness and airport safety nets for vehicle drivers
12	Single remote tower operations for medium traffic volumes
13	Remotely provided air traffic service for contingency situations at aerodromes
21	Airport operations plan (AOP) and its seamless integration with the network operations plan (NOP)
22	Automated assistance to controllers for surface movement planning and routing
23	D-TAXI service for controller-pilot data-link communications (CPDLC) application
26	Manual taxi routing function
47	Guidance assistance through airfield ground lighting
48	Virtual block control in low visibility procedures (LVPs)
52	Remote tower for two low density aerodromes
53	Pre-departure sequencing supported by route planning
54	Flow based integration of arrival and departure management
55	Precision approaches using GBAS Category II/III
61	A low-cost and simple departure data entry panel for the airport controller working position
64	Time-based separation
70	Enhanced ground controller situational awareness in all weather conditions
71	ATC and AFIS service in a single low-density aerodrome from a remote controller working position (CWP)
106	DMAN Baseline for integrated AMAN DMAN
116	De-icing management tool

- *If one solution assumes the integration of two components, and the monitoring data is available per individual components only, not for that particular solution directly*: as, for example, is the case with solutions 21 and 53. Solution 21 deals with AOP and its seamless integration into the NOP. Monitoring data are available for AOP and for its integration into the NOP separately. Therefore, the later implementation date of two individual components is set/chosen as the planned implementation date of the whole integrated solution.

- *Grouping when data obtained covers more than one solution*: remote tower services fall within this category (solutions 12, 52, 71). The granularity of data does not allow for the precise identification of which solution is addressed, but rather covers more than 1 solution (in this case 3). In that case, the solutions are grouped together and the data aggregated.

- *Some solutions are reported as implemented, yet the airport is not open for operation*: Istanbul's new airport, which will open in October 2018. Solutions reported for this airport are considered as having been implemented in 2018.

V. ANALYSIS OF SESAR 1 DEPLOYMENT AT AIRPORTS

The analysis performed addresses SESAR 1 solutions and their deployment (completed or planned) across airports in Europe during the period 2017-2024. First, the solution implementation trend is provided – overall and by category with respect to area of implementation. Then, an analysis of the expected performance impact is provided. Furthermore, solution deployment per airports is analysed (number of solutions implemented by airports, number of airports implementing solutions) with the aim of detecting the most successful/needed solutions. Also, solutions are classified by the type of airport they are targeting with respect to traffic volume and utilisation level.

A. *Implementation trend by categories*

All airport-related solutions analysed can be categorised in four groups, based on scope/area of implementation:

1. Safety nets and visual aids (Safety): 01, 02, 04, 26, 47, 48, 70
2. Integration in the network (Network): 21, 53, 61, 116
3. Arrival, departure and surface operations (ARR/DEP/SO): 22, 23, 54, 55, 64, 106
4. Remote tower services (RTS): 12, 13, 52, 71

It is expected that, by 2040, as many as 16 more airports will experience congestion to the degree experienced by Heathrow today. More capacity will be needed at airports in 17 different states [10]. Based on how the industry has responded in the past, EUROCONTROL [10] has modelled six different capacity gap mitigations (SESAR, local alternative, consensus benchmark, schedule smoothing, larger aircraft and high speed train investment), apart from new runways. It found that "of these mitigations, the most promising are the developments under SESAR 1 which target busy airports at peak hours", if they can be successfully deployed.

Closing the capacity gap is not only a task for airports, but also for other stakeholders. Accordingly, apart from (6) solutions directly related to ARR/DEP/SO operations, there are (4) solutions which put airports in the context of the network. That way, airports can benefit from earlier planning and, together with other stakeholders, can contribute to achieving better utilisation of existing resources and overall (network) performance. Safety solutions (7) ensure that safety is maintained as a top priority. RTS solutions (4) are not capacity-related, but offer improvements for small regional airports and their own (different) concerns.

Figure 2 shows the planned implementation of solutions by category and total numbers. Cumulative numbers are used to depict implementation trends between 2017 and 2024. The numbers include cases where solutions officially started with implementation (1-100% progress) and cases with explicit plans to implement solutions (but currently at 0% progress). In 2017, 83 implementation plans were initiated, while as many as 258 are planned for 2024. A similar deployment trend is observed among Network and ARR/DEP/SO solutions. Safety solutions deployment is planned at a somewhat lower rate, while RTS solutions participate with lower numbers in overall deployment, which is due to the/a specific (narrow) field of impact with a local (not global) value.

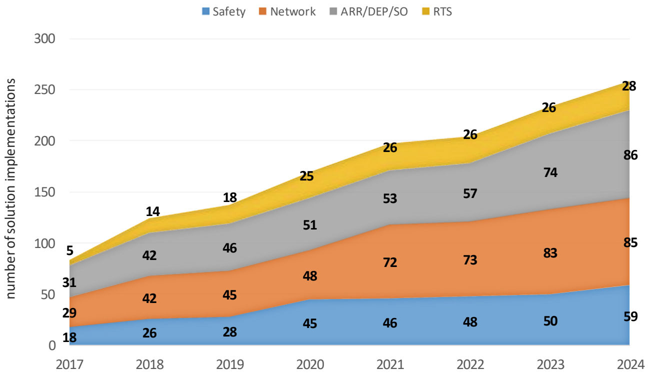
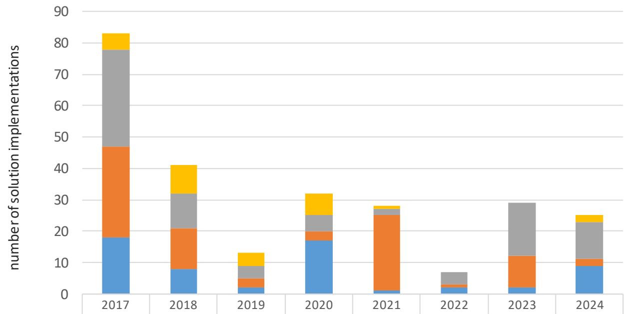


Figure 2. Cumulative number of solution implementations by categories

Figure 3 shows the planned number of implementation cases per year. Year 2017 is used as a base year and includes all implementations started before and during 2017. As many as 40 solution implementations are expected by the end of 2018, while in the following six year period, approximately 30 implementations are planned each year, except for the years 2019 and 2022 with project pessimistic plans (approx. 10 implementations per year). Safety solutions will be in focus in 2020 with a particular focus on integration in the network in 2021 and ARR/DEP/SO in 2023 and 2024.



	2017	2018	2019	2020	2021	2022	2023	2024
RTS	5	9	4	7	1	0	0	2
ARR/DEP/SO	31	11	4	5	2	4	17	12
Network	29	13	3	3	24	1	10	2
Safety	18	8	2	17	1	2	2	9

Figure 3. Number of implementation cases planned for the period 2017-2024

In this analysis, a single implementation of a solution is counted as one implementation case (regardless of the solution). But, it should be noted that solutions may vary greatly in their size/coverage (e.g. "Precision approaches using GBAS Category II/III" and "De-icing management tool"). As a result, the introduction of weights to emphasize this difference is advisable for further analysis.

A total of 258 implementation cases by 2024 involve 92 airports. Network solutions are implemented or planned at 62 airports, ARR/DEP/SO solutions at 45 airports, safety solutions at 37 airports and RTS solutions at 26 airports (number of towers controlled remotely is counted). A more thorough analysis by implementation locations (airports) is set out later in this paper.

B. *Performance view*

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 (PA), notably: safety, cost efficiency, operational efficiency, capacity, environment, security and human performance [11]. For each solution considered, the attribution of the primary/dominant and (if applicable) contributing key PA(s) are defined.

Table II shows the planned deployment effects of particular solutions to one or more PAs. The primary PA affected is presented in the darker shade, and other PAs which are also affected are presented in the lighter shade. Out of 21 solutions, 12 solutions influence only one PA, while 9 solutions have a contributing effect to one or more additional PAs, apart from the primary PA under their impact.

TABLE II. SOLUTION EXPECTED EFFECT ON PERFORMANCE AREA(S)

Solut. no.	**Performance Area**				
	Safety	***Operation. efficiency***	***Capacity***	***Cost efficiency***	***Environ.***
01	■				
02	■				
04	■				
12				■	
13				■	
21		■	▒		
22	▒	■	▒		▒
23		■			
26	■	▒			▒
47	■	▒	▒		▒
48	■	▒			▒
52				■	
53		■			
54		■	▒		▒
55			▒	■	▒
61		■			
64			■		
70	■				
71				■	
106		■			▒
116	▒	■			

Figure 4 shows the planned number of solutions per year contributing to each PA. Those numbers include the primary and additional effect on every PA, which means that the number of contributors (*) is larger (or at least equal to) the number of solution implementations each year. For example, for capacity PA - not only solution 64 counts, but also solutions 21, 22, 47, 54 and 55 are included. Solution 47 contributes safety, but also all other PAs except cost efficiency. In this chart, Environment PA also appears. Among the solutions analysed, there is no solution with primary effect on environment, but as many as 7 solutions (see Table II) are expected to benefit this PA.

In 2019, 2022, 2023 and 2024, planned effects are rather evenly distributed among PAs, with the exception of cost-efficiency, which is related to RTS solutions and applied in fewer numbers. Safety PA appears to be in focus in 2020, while in 2021 operational efficiency and capacity are in focus. The impact on operational efficiency is also significant in 2018 and 2023 – each with more than 20 solutions contributing to a single PA. The improvement of airport performance through solution implementation is somewhat lower in 2019 and 2022, with around 20 contributing solutions in all PAs. The year with the greatest effect on airport performance is expected to be 2023.

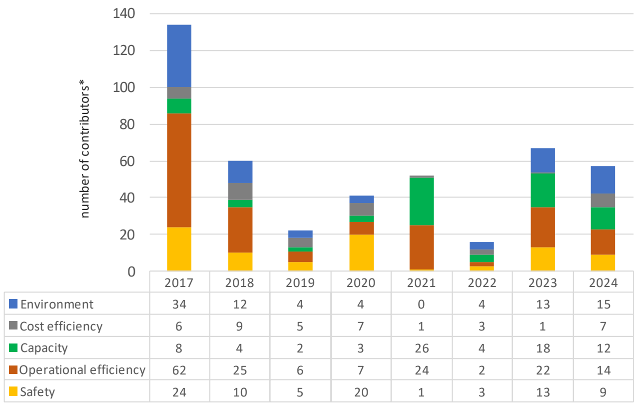


Figure 4. Number of contributors by performance area, period 2017-2024

Figures 5-9 provide an overview of solution implementation for each PA separately – number of solutions with primary impact on that PA and additional contributors, by year.

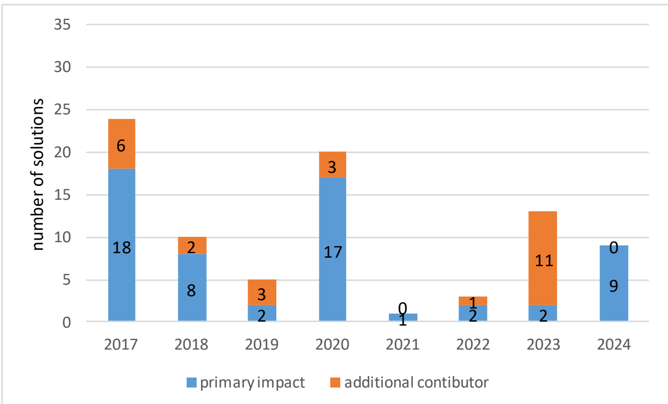


Figure 5. Number of primary and additional solutions contributing safety

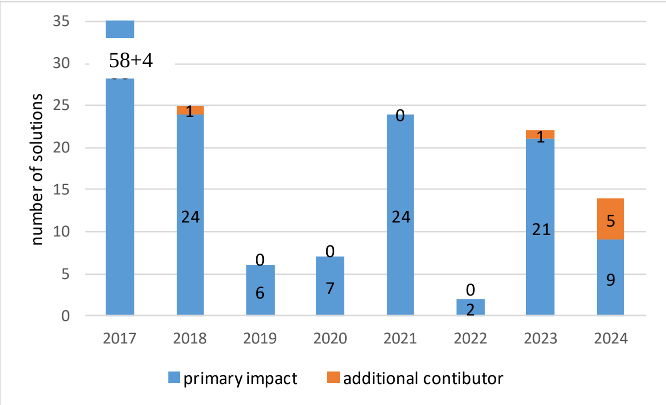


Figure 6. Number of primary and additional solutions contributing operational efficiency

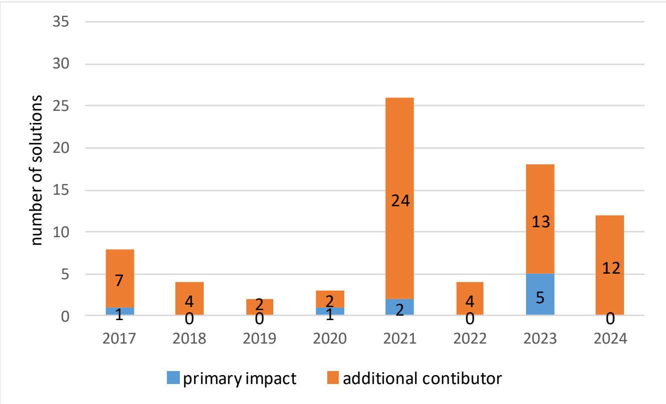


Figure 7. Number of primary and additional solutions contributing capacity

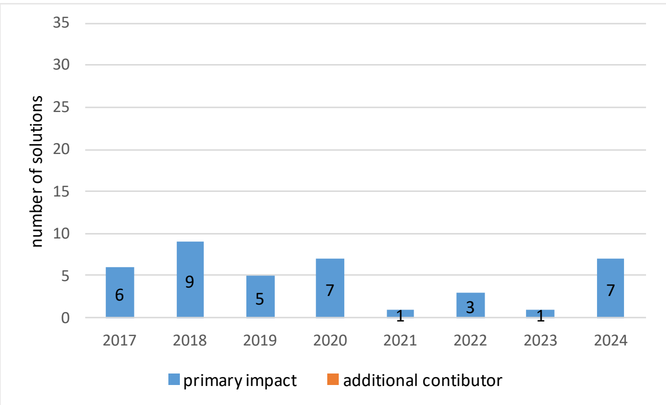


Figure 8. Number of primary and additional solutions contributing cost efficiency

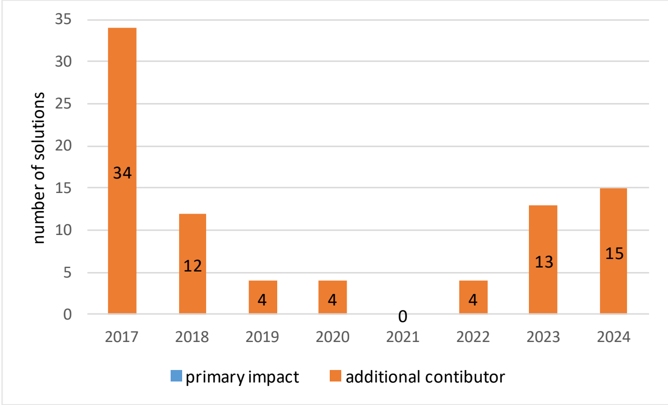


Figure 9. Number of primary and additional solutions contributing environment

C. Implementation locations

All solutions are implemented or planned to be implemented at 92 airports across Europe. More than half (48) of the airports will implement only one solution, see Table III.

Approximately 30% of airports (29) are planning to implement 2-5 solutions and 13% (12) of airports are planning to implement 6-9 solutions. Airport EKCH (Copenhagen) plans to implement 10 solutions and a maximum number of 12 solutions is expected to be implemented at LFPG (Paris CDG) and LOWW (Vienna).

TABLE III. SOLUTIONS BY AIRPORTS

no. SOLs	no. APTs	%	
1	48		**0,52**
2	11	0,12	
3	6	0,07	
4	4	0,04	
5	8	0,09	**0,32**
6	8	0,09	
7	2	0,02	
8	0	0,00	
9	2	0,02	**0,13**
10	1	0,01	
11	0	0,00	
12	2	0,02	
13	0	0,00	**0,03**

Figures 10 and 11 show the deployment charts by airport. Figure 10 contains only airports that implement a single solution. Different colours are used to designate those airports that have already started to implement solutions (green) from those airports that are planning to implement a solution (orange).

In Figure 11, airports with 2 or more solutions are depicted. Different colours depict the different number of solutions by airports: 2-3, 3-4, 4-5, 6-7, 8-9, 10 and more. The numbers include both planned and implemented solutions.

It should be noted that 77 airports are currently implementing at least one solution. At the remaining 15 airports, the implementation of solution(s) has not yet started, but is expected by 2024.

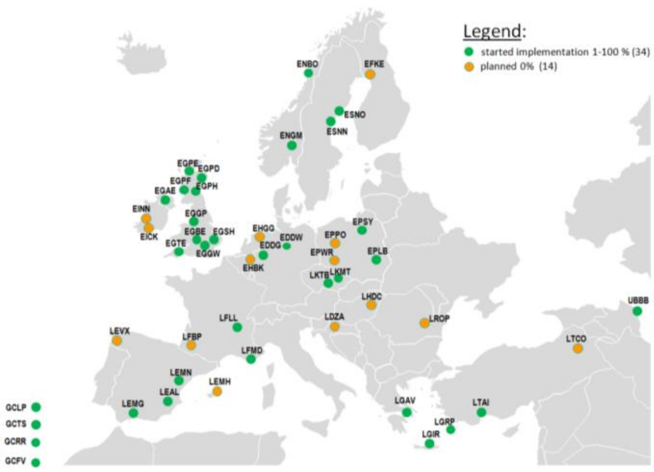


Figure 10. Airports implementing or planning to implement one solution

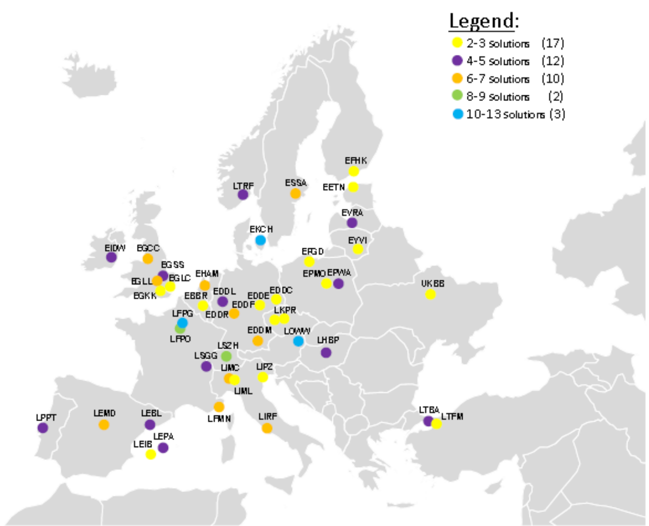


Figure 11. Airports implemented or planning to implement two or more solutions

If we observe only solutions that are currently being implemented (1-100% progress), only 5 airports are implementing more than 5 solutions, namely: EGLL and EKCH - 6, LFPG – 7 and LOWW and LSZH - 8. Nine airports are implementing 4 solutions, 14 airports are implementing 3 solutions and 11 airports are implementing 2 solutions, while the vast majority (38) of airports are implementing only one solution. As mentioned above, the remaining 15 airports have no solutions in progress of implementation to date.

To date, 14 (out of 21) solutions have been fully implemented at one or more airports. An overview of fully implemented solutions is provided in Table IV. One solution has been fully implemented at 41 airports, while 11 airports have two or more fully implemented solutions. The maximum amount of implemented solutions is at Paris CDG – 4 solutions.

Different colours indicate levels with respect to slot coordination (level 1-green, level 2-orange and level 3-red) [12] which is considered here as a proxy for airport utilisation/congestion levels. As expected, most of the solutions are currently being implemented at medium and highly utilised airports, where improvement in airport performance is more important. However, some solutions ("Virtual block control in low visibility procedures" or "Precision approaches using GBAS Category II/III") are also implemented at airports with low utilisation, perhaps as convenient "trial" cases, before their wider implementation.

TABLE IV. FULLY IMPLEMENTED SOLUTIONS

Solution no.	Airports completed the implementation (100%)
01	LFPG, ESSA
02	EGKK, EGLL, EBBR
13	EKCH, LHBP, EYVI
47	EVRA, EPWA
48	EVRA
55	EETN
61	LEMG, LEAL, LEIB, LEMN*, LFMN, EDDR, EDDE, EDDG, EDDC, EDDW, EGLC, EGSS, EGGW, EGGP, EGCC, EGPH, EGPD, UKBB
64	EGLL
70	EFHK, LFPG, LHBP,EVRA
106	EFHK, ESSA, ENGM, EKCH, EIDW, EGSS, EGLL, EGLC, EGKK, EBBR, EDDL, EDDF, LKPR, LFPG, LFPO, EDDM, LOWW, LSZH, LSGG, LFLL, LIMC, LIML, LIPZ, LIRF, LTBA, LEBL, LEPA, LEMD, LPPT
116	EFHK, LFPG
12,52,71	ESNO, ESNN

**heliport*

Table V shows the authors' views on the distribution of the solutions by airports with respect to their size (traffic volume) and performance areas (primary effect). Bold numbers indicate that a solution has an additional effect to one or more PAs, apart from the effect indicated (see Table II for details).

The majority of solutions are designed to increase the performance of large, highly utilised airports, although not limited to them (especially when it comes to safety). However, a few solutions target airports with low-to-medium traffic (12, 52, 71 and 61). Solution 13 is rather general, as it relates to contingency procedures. It is similar to solutions 48 and 55, which are related to GBAS precision approach and Low Visibility procedures, respectively. Although these solutions have been implemented at only two small, non-congested airports to date, solutions 48 and 55 are generally suitable for any airport with respect to traffic volume and density. Solution 116 primarily targets airports with long winter seasons, as it is related to de-icing procedures. According to long term plans to better utilise existing capacity [13], 6 solutions (21, 22, 23, 53, 54 and 106) are designed to improve operational efficiency (hence airport throughput) at very busy airports. Solution 106 has (to date) achieved the greatest implementation success. It is fully implemented at 29 airports (see Table IV), all highly utilised and, for the vast majority, large in terms of traffic volume (more than 20 million pax a year). This is closely related to A-CDM implementation, so all the airports that have implemented A-CDM have reported full completion of this solution. It is also interesting to notice that solution 61 has been implemented at 18 airports to date, all small-to-medium size airports (but medium-to-high utilization), which is the main target group for this solution in operational efficiency PA.

For airports with high traffic, there are solutions that target each PA, but the majority are in operational efficiency and safety PA. For airports with medium to high traffic, there are no solutions primarily designed for capacity improvements, while the majority of solutions contribute to safety PA. In the case of low to medium traffic, the focus is on cost efficiency. Environment PA is also expected to be improved in each airport category, as an additional benefit of 7 solutions. All 7 solutions are expected to contribute to the improvement of environmental issues at airports with high traffic volume, 4 solutions apply to airports with medium to high traffic, and 3 solutions apply to airports with low to medium traffic.

TABLE V. SOLUTIONS BY PERFORMANCE AREA AND AIRPORT TRAFFIC

Performance Area	**Traffic volume**		
	High	*Medium to high*	*Low to medium*
Safety	01,02,04,**26,47, 48**,70	01,04,**26,47,48**,70	01,**26,48**
Operational efficiency	**21,22**,23,53,**54, 106,116***	**116***	61
Capacity	64		
Cost efficiency	13,**55**	13,**55**	13,**55,**12,52,71

**winter operations*

VI. CONCLUSIONS

Based on the analysis presented in section V, the following conclusions can be drawn.

By 2017 (inclusive), there were 83 solution implementations at airports in the ECAC area. By 2024, this number will climb to a total of 258 implementations, which clearly demonstrates the interest and the buy-in for airport related SESAR solutions by the airport community.

In quantitative terms, the most successful solutions with the biggest population of airports, which are already implementing or planning to implement those solutions, relate to integration into the network and ARR/DEP and surface operations.

Analysis of the performance of current and planned SESAR solutions implementation shows that for some years, there is a rather even distribution among different PAs (2019, 2022, 2023 and 2024), and for others, certain focus areas can be identified. Capacity and operational efficiency-related solutions will be in focus in 2021. Safety will be in focus in 2020. Overall, the greatest planned effect on airport performance will be in 2023.

Quite a large population of airports in the ECAC area are involved in the implementation of SESAR solutions. A total of 92 airports are either implementing or planning to implement one or more SESAR solutions. This is yet further proof of the significant buy-in and commitment of airport community towards the SESAR implementation.

Distribution of solutions by airport traffic level shows a limited amount of solutions available for low to medium traffic, which is reasonable given that the SESAR work programme is more focused on delivering performances at major, very busy airports. However, a more balanced approach should be established to cover other airport groups as well, or at least to indicate which existing solutions could be scalable for those other airport groups, especially in the area of capacity utilisation. This would be line with the European Commission's Aviation Strategy for Europe [13] and the work of Airport Observatory, which highlights the need to making best use of existing latent capacity.

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