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Vista

MARKET FORCES TRADE-OFFS IMPACTING EUROPEAN ATM PERFORMANCE

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Abstract

Vista examines the effects of conflicting market forces on European performance in ATM, through the evaluation of impact metrics on four key stakeholders, and the environment. The review of regulatory and business factors is presented. Vista will model the current and future (2035, 2050) framework based on the impact of regulatory and business factors. These factors are obtained from a literature review of regulations, projects and technological and operational changes. The current value of those factors and their possible evolution are captured in this deliverable.

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Executive summary

Vista examines the effects of conflicting market forces on European performance in ATM, through the evaluation of impact metrics on four key stakeholders, and the environment. The project comprises a systematic, impact trade-off analysis using classical and complexity metrics, encompassing both fully monetised and quasi-cost impact measures. To achieve these objectives, Vista models the current, 2035 and 2050 timeframes based on various factors and their potential evolution. These factors influence the choices of the actors in the ATM system: prices of commodities and services, regulations from national and supranational entities, and new technologies are all part of a complex socio-economic system that results in evolving business models, passenger choices, etc.

This deliverable reports the work done on the review of the business and regulatory factors which could potentially be included in Vista's model for the current, 2035 and 2050 scenarios. It presents an inclusive review of potential regulations, technologies, services and operational changes which could impact the ATM system. The factors have been divided into two categories: regulations and business factors. Note that these are *scoped* in this deliverable, to be evaluated in subsequent work.

Concerning regulations, the different areas of the ATM network and regulations applying to them have been reviewed. Some of the regulations act as enablers of the technological and operational changes, for example, the Single European Sky regulatory framework. In other cases, the regulation directly affects the performance of some stakeholders, such as regarding air passenger rights. For each of these regulations, their possible evolution is also described. These modifications are based on communications and strategies laid down by, or foreseen by, regulatory trends.

The main source for the business factors are the SESAR-related projects. In particular, this deliverable compiles the high-level goals of SESAR found in its Master Plan (Ed. 2015), as well as more precise information related to the SESAR workpackages. This deliverable suggests that the operational sub-packages offer the right level of description for the factor, and indeed identifies each of them as a factor. This has the additional benefit of enabling the direct computation of some expected impacts in terms of KPIs for each of the factors through the use of the targets and the validation exercises defined at the sub-package level. Some more long term R&D research activities are also considered, in particular to be used in the 2050 scenarios.

Other business factors include the price of fuel, the business models of the airlines, and changes in demand linked to the socio-economic development of Europe. Regarding the latter, many factors will be considered as closely linked and the diverse possibilities of development will be significantly influenced from works such as the STATFOR forecasts.

1 Introduction

1.1 Objectives of Vista and of this deliverable

Vista examines the effects of conflicting market forces on European performance in ATM, through the evaluation of impact metrics on four key stakeholders, and the environment. The project comprises a systematic, impact trade-off analysis using classical and complexity metrics, encompassing both fully monetised and quasi-cost impact measures. To achieve these objectives, Vista models the current, 2035 and 2050 timeframes based on various factors and their potential evolution. These factors influence the choices of the actors in the ATM system: prices of commodities and services, regulations from national and supranational entities, and new technologies are all part of a complex socio-economic system that results in evolving business models, passenger choices, etc.

Some of these factors, foreground factors, will be analysed in detail in order to understand their impact on the system's metrics. The others, background factors, will be grouped giving them predefined possible values to generate future background scenarios onto which to test the foreground factors. This approach allows us to model possible future evolution of the system while understanding the impact of individual parameters.

The International Civil Aviation Organization (ICAO) has contributed significantly to ATM system performance measurement and its international harmonisation. In its manual (ICAO, 2009) on global performance of the air navigation system, ICAO identifies eleven key performance areas (KPAs): safety; security; environmental impact; cost effectiveness; capacity; flight efficiency; flexibility; predictability; access and equity; participation and collaboration; interoperability. In this deliverable, the data required to generate the scenarios is presented: an exhaustive list of all the factors which could influence the behaviours of the actors within the system and the performance within these KPAs – although only a *selection* of these KPAs will be explicitly modelled.

The factors are classified as 'regulatory' or 'business' (as defined in Section 1.3). A literature review and consultation with the members of the consortium has been carried out to identify these factors, their possible evolution and their high-level impact on stakeholders and their behaviour.

1.2 Background and literature sources

An extensive review of sources to identify regulatory and business factors has been carried out. As mentioned above, the factors considered in Vista have an impact on the KPAs monitored in the system.

In this context, European Regulation 390/2103 defines the performance scheme for air navigation services (European Commission, 2013b). This regulation lays out the requirements to create the performance plans and their implementation and monitoring. Four KPAs are defined (safety, environment, capacity and cost-efficiency) with a set of KPIs. Whilst some are currently (only) monitored, others have specific associated targets for the reference period (Performance Review Body, 2013).

Union-wide targets are set following a one-year process. The first part of the process is the development of evidence on the possible level of Union-wide targets which are usually based on historical analysis, latest available forecasts, benchmarking between ANSPs and continental benchmarking (comparison between Europe and the US). Depending on the KPIs, this process may also include inputs from the Network Manager, results from simulations, or even inputs from econometric studies. This work is done by the PRB and submitted to a written open consultation. The second phase is a more political phase where the European Commission considers this PRB input and proposes a Commission Regulation to the Single Sky Committee. Several meetings are required to get a majority in favour of a certain proposal. This is usually achieved through modification of assumptions or proposals made by states and input from airspace users outside the Single Sky Committee. Local targets (be it at FAB or national levels) are proposed by states in their Performance Plans taking into account the adopted Union-wide targets and knowing against which criteria their proposed targets will be assessed by the European Commission. These assessment criteria are known in advance as they are listed in the performance scheme Regulation.

The current reference period (RP2) set targets until 2019. RP3, which will cover the reference period 2020-2024, is under preparation. Depending on the decisions made by states, it is most likely that the methodology for deriving targets will be very similar to that of RP2, if the KPIs remain the same. A White Paper was presented at the Single Sky Committee (SSC) (Performance Review Body, 2016a). In this White Paper, an analysis is performed for the four KPAs in the context of the risks and evolution of the system.

Both the White Paper and comments received after a first consultation with stakeholders (Performance Review Body, 2016b) emphasise the importance of better understanding the interdependencies between the KPAs and KPIs (even KPIs within KPAs), on which further work is required. This is strongly expressed by many stakeholders (*ibid.*). Some view that the trade-offs need to be explored at the state, not EU, level, due to heterogeneity. Indicators in the ATM Master Plan and the SES Performance Scheme differ. Several major stakeholders would like to see (*ibid.*) a clearer mapping between SESAR Master Plan objectives and the (binding) SES PS targets. SESAR defines “aspirational” performance ambitions (ATM Master Plan, SESAR JU (2012)), grouped into six KPAs (safety, environment, capacity, cost efficiency, operational efficiency and security), and sets out supporting binding changes in the PCP (which does not include targets, but refers (SESAR JU, 2013) to “modest” contributions to the SES PS targets). These ambitions are focused on 2035. Hence, a better understanding and integration between the ATM Master Plan (and SESAR Common Projects) impacts and expectations and the Performance Scheme indicators and targets should be considered. Finally, the outcome of the consultation proves that different views and compromises among states are still required during RP3. For this reason, changes are still expected regarding the final objectives of RP3.

The European Commission has defined high level goals for 2050. In Flightpath 2050, goals are defined for transport efficiency, environment, safety and security (European Commission, 2011e). These goals are complemented with emissions targets defined by the Roadmap to Single European Transport Area (European Commission, 2011d). See Annex I, for more information regarding the Performance Scheme, SESAR performance ambitions, and the Commission vision for 2050.

For regulatory factors, key areas of regulation have been identified, with their potential evolution, drawing on the expertise of the consortium. This review includes mainly European Commission regulation affecting ATM as a whole. National regulation, other international regulatory bodies and industry organisations have also been reviewed where relevant, e.g. use of unmanned vehicles or standardisation of processes at the airport.

For business factors, technological and operational changes are based on the evolution of the system defined on the SESAR programme. In this context, the main sources reviewed during the production of this deliverable are, in no implied order of importance:

- European ATM Master Plan (SESAR JU, 2015);
- European ATM Master Plan Level 3 - Implementation View (SESAR JU, 2016a);
- SESAR Solutions Catalogue (SESAR JU, 2016b);
- European ATM Portal (https://eatmportal.eu/).

As we have noted, Vista models the current, 2035 and 2050 timeframes. By the 2050 period, more disruptive technology and operational changes might be expected. For this reason, when specifically considering the 2050 timeframe, research activities outlined in the SESAR ATM Master Plan have been identified.

A wider literature review has been carried out while identifying the factors in Vista. This review includes research publications in specific conferences (e.g. SESAR Innovation Days, ICRAT, USA/Europe ATM R&D Seminar) and journals. In general, these publications are too specific as they tackle individual technologies and evolutions which are already aligned with SESAR and the Flightpath 2050 vision.

The ACCHANGE (Accelerating Change of Air Traffic Management by Regional forerunners) project analysed potential paths for change in air traffic management in Europe. In this context, different future scenarios were defined (SESAR JU, 2014; Adler *et al.*, 2014; Adler *et al.*, 2015). To outline the scenarios considered in ACCHANGE, focus was given to four building blocks and their possible evolution: actors (ANSPs, airports, airlines, etc.), organisations (fragmented airspace, functional airspace blocks and centralised services), price regulation for ANSPs (ANS charges in SES II, financing new technologies and alternative proposal for modulation of charges) and enabling technologies (common projects, pilot common project and virtual centres). This project focused on the outcome obtained from an economic game between the different stakeholders under different conditions. The factors that might affect the evolution of the system are captured in Vista at a lower level by considering the regulatory and business factors affecting these evolutions.

One of the objectives of the Compair (Competition for Air Traffic Management) project is to propose market designs for the introduction of competition in the European ATM sector. The project will model different possibilities to introduce competition into ATM, quantifying the outcome of each option (Delhaye and Blondiau, 2016). Vista will monitor the outcome of this project as it might help to identify the possible evolution of some of regulatory and business factors considered.

The APACHE (Assessment of Performance in current ATM operations and of new Concepts of operations for its Holistic Enhancement) project proposes a new framework to assess European air traffic management performance-based on simulation, optimisation and performance assessment tools that will be able to capture the complex interdependencies between KPAs at different modelling scales (micro, meso and macro). At higher maturity levels, APACHE aims to be a technological enabler for performance-based operations (PBO). The APACHE project was presented at the Sixth SESAR Innovation Days (Prats, 2016). In D3.1 of the APACHE project, a review of current KPIs and a proposal for new ones are presented. The deliverable reviews the KPAs and KPIs defined by ICAO, CANSO, SES Performance Scheme, performance monitoring at EUROCONTROL and SESAR performance framework.

Finally, while carrying out the review of the literature sources and the consultation within the member of the consortium, an identification of experts has been carried out. This expert panel will be used during the following phases of Vista to validate the scenarios, factors and their impact on the model.

1.3 Approach in Vista

As introduced above, in Vista, we identify factors likely to affect the evolution and performance of the system with their impact on the system and potential evolution. These factors are differentiated between regulatory and business factors. The former include all the legal requirements emanating from national and supranational entities in order to regulate a certain part of the system. These factors are by nature known (for the current situation), and their immediate effects are relatively unambiguous. However, indirect effects due to changes of business models can be present in the medium- to long-term, which could decrease the efficiency of the regulation, have an opposite effect to the expected one, or simply have another effect in another part of the system. Some of these regulatory factors can be seen as enablers of operational and technology modifications in the system while others have a direct impact on the behaviour of the actors in the system. The regulatory factors have been grouped based on the phase of the operations (primarily) affected by them.

Business factors are more generic and their effects are sometimes less clear. In essence, a business factor is a **service, technology, operational concept or commodity** which may impact a stakeholder's business model, or the behaviour / customer satisfaction of a passenger, when it is available or changes its price. Obviously, there are a great number of business factors, especially if one considers the heterogeneity of the actors implied. As a consequence, Vista tries to group them into common areas.

Vista first addresses new services and technologies that are likely to be introduced in the future, affecting gate-to-gate performance. For this, Vista looks specifically at major R&D initiatives, and in the first place, SESAR. SESAR has a very clear structure in terms of workpackages and the targets which are likely to be achieved by different dates. These clearly-defined new solutions can be directly used in the Vista model, either using some heuristic impacting one part of the model (e.g. factor X decreases the airport access time by Y%) or directly modelling the new mechanism. Since Vista also deals with the door-to-gate and gate-to-door travel legs, changes related to airport access and airport processes are also considered. The third kind of business factors reviewed is related to socio-economic changes within Europe. Several non-independent factors are gathered under the same umbrella to avoid unwanted complexity within the model and inconsistent values of the different factors. Most of the forecast for these factors are based on economic and social prediction studies like STATFOR. Finally, with respect to commodities, Vista will consider fuel as an independent variable from the global economic development of Europe.

This deliverable is organised as follows: Section 2 presents the regulatory factors; Section 3 presents the business factors; and, Section 4 outlines the next steps to be taken for the next deliverables.

2 Review of regulatory factors

2.1 Review of regulatory factors

Different regulations affect the technology and operations that are deployed and implemented in Europe. There are different levels of regulations from global organisations, e.g. ICAO, to European regulation and national level requirements. Some of these regulations define the operational constraints in the system while others are required to develop, in a synchronised manner, the technological changes expected and captured in the business factors. Note that in some cases, there are standards pushed by industry that affect the efficiency of the processes.

Other legislation has been obtained from reviewing the implementation of solutions as described in the consolidated list of 'engineering views' of all active Implementation Objectives for the European ATM Master Plan which contains a relationship of the legislation that applies to these different solutions (EUROCONTROL, 2016). Finally, the European portal for legislation (EUR-Lex; http://eur-lex.europa.eu/homepage.html) provides access to European legislation categorised by sector, e.g. air transport.

2.2 Summary of regulatory factors

The regulatory factors with their possible evolution have been identified and classified depending on the phase they affect. Each factor is identified with an ID to facilitate its traceability through the different deliverables in the Vista project. These IDs are linked to the factors' regulatory areas:

- **Table 2** presents the regulatory factors that affect operational and technological changes impacting gate-to-gate operations. These factors are grouped into the following regulatory areas:
    - SES development and integration (factor ID: Regulatory SES Integration (RSIx[1])): Regulation that enables the definition of the Single European Sky, the ATM Master plan and the Common Projects;
    - Performance-based regulation (factor ID: Regulatory Performance Regulation (RPRx)): Regulatory factors affecting the definition of the performance scheme and its monitoring;

[1] "x" is a value placeholder, as also in the examples that follow.

  - ANSP requirements (factor ID: Regulatory ANSP Requirements (RARx)): Common requirements applied to ANSP entities.

- **Table 3** groups the regulatory factors that affect airport demand, operations and access. These factors are grouped by:
  - Airport demand (factor ID: Regulatory Airport Demand (RADx)): Factors that affect capacity management at airports, the development of regional infrastructures and the charges at airport;
  - Airport processes (factor ID: Regulatory Airport Processes (RAPx)): From an aircraft operator (handling processes) and from a passenger perspective;
  - Airport access / egress (factor ID: Regulatory Airport Access (RAAx)): Regulatory factors affecting the access and egress of the airport.
- **Table 4** groups other regulatory factors that do not correspond to the previous categories:
  - Other regulatory factors (factor ID: Regulatory Other Regulatory (RORx)): These other regulatory factors cover the passengers' rights regulation, development of common charging scheme, environmental regulation (emission trading scheme), labour agreements, drone operations and the Commission vision for air transport in 2050.

Table 1 summarises the regulatory factors grouped by regulatory area.

Table 1. Summary of regulatory factors

Regulatory area	Regulatory factor	Factor ID
SES development and integration	Single European Sky integration	RSI1
	Common projects	RSI2
	Network Manager	RSI3
Performance-based regulation	Performance Scheme	RPB1
	Performance Review Body	RPB2
ANSP requirements	Common requirements	RAR1
Airport demand	Airport slots	RAD1
	Regional airport development	RAD2
	Airport charges	RAD3
Airport processes	Ground handling market	RAP1

Regulatory area	Regulatory factor	Factor ID
	Industry standardisation of airport procedures	RAP2
Airport access/egress	Airport access	RAA1
Other regulatory factors	Passenger provision schemes	ROR1
	Common charging scheme	ROR2
	Emission schemes	ROR3
	Noise pollution	ROR4
	ANSP labour agreements	ROR5
	Drone	ROR6
	ATCO interoperability	ROR7
	Safety	ROR8
	Operation of air services	ROR9
	2050 vision	ROR10

Table 2. Operational and technological regulatory factors affecting gate-to-gate phase

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
SES development and integration	Single European Sky integration	Current	The regulatory framework for the creation of the Single European Sky is laid out in the SES Framework regulation (Regulation 549/2004) (European Commission, 2004a). The SES Service provision regulation (Regulation 550/2004) sets the common requirements for the provision of air navigation services allowing Member States to choose a service provider (European Commission, 2004b). This regulation also sets the framework of collaboration between service providers, e.g. data exchange for operational purposes. This regulation has been amended by SES II (Regulation 1070/2009) which identifies the use of performance scheme for air navigation services and network functions and the need of cooperation to develop the functional airspace blocks. The creation of common projects to assist on the development of the ATM Master Plan is also laid out on this regulation (European Commission, 2009a). Operational concepts such as the flexible use of airspace are regulated on specific legislation, e.g. Regulation 2150/2005 (European Commission, 2005a). The Single European Sky integration requires the interoperability of services and their regulation, e.g. aeronautical data and information (European Commission, 2010a) or interoperability of surveillance (European Commission, 2014c). Regulation 255/2010 lays down the common rules on air traffic flow management to be used under the Single European Sky (European Commission, 2010b).	All stakeholders	Enabler to the Single European Sky and development and deployment of SESAR projects and operational concept. Higher international collaboration allowing the development of FABs, wide-spread free-routing implementation. Overall this collaboration and SESAR deployment leads to a decrease of gate-to-gate time, increases economic efficiency of ANSPs. The regulation allows also Member States to designate a certified service provider for provision of air navigation services in its area of responsibility.	RSI1

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
		Evolution	As the Single European Sky develops, regulation setting up the framework and defining the operational environment will be laid out. Further integration is expected developing the concepts of FABs. Based on an audit of the functioning of the nine FABs in Europe, commissioned by the EC, new requirements on FABs are expected.		Further development of cross-border collaboration and operational framework development. Different degrees of integration can be considered. Further liberalisation of air navigation services is expected.	
	Common projects	Current	The Pilot Common Project (European Commission, 2014b) set up the first common project to implement the first set of ATM functionalities (AFs) identified in the ATM Master Plan. These AFs are logical groupings of essential operational / technical changes. The project seeks to deploy and synchronise the technologies and projects, leading to the modernisation of the infrastructure of European ATM.	All stakeholders	Mandatory timely implementation of six ATM functionalities defined in the ATM Master plan.	RSI2
		Evolution	Second Common Project (and subsequent CPs). The Second Common Project is expected to be launched: 1) Corresponding required investments in combination with pressure on costs might affect the financial viability of individual ANSPs, thus potentially reshaping the ANSP landscape in Europe. 2) The resulting technological harmonisation is equally expected to change the ANSP landscape, as ANSPs will less and less behave as stand-alone organisations. (Cf. ANSP alliances such as those identified in **Table 11**.)		Further mandatory technological improvements enabling to achieve the operational changes stemming from the European ATM Master Plan.	

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
	Network Manager	Current	The functions to be carried out by the body designated as Network Manager (NM) are laid out in Regulation 677/2011 and Regulation 970/2014 (European Commission, 2011b; European Commission, 2014a). The NM shall perform the functions of design the European Route Network, the coordination of scarce resources, e.g. radio frequencies, SSR transponder codes and of performing the ATFM function. The Network Strategy Plan (NSP) is detailed through the Network Operations Plan (NOP) and the NM contributes to the implementation of the performance scheme. The NSP is aligned with the reference period and developed, maintained and implemented by the NM. The NSP at operational level is translated into the NOP. Currently EUROCONTROL is designated as Network Manager. Network Management Board composed of all stakeholder groups.	All stakeholders	The Network Manager is to play a vitally important role for the competitiveness of Europe's aviation industry. It is a key actor for the operational network performance in the areas of capacity and flight efficiency.	RSI3
		Evolution	Audit carried out in 2016 led to recommendations such as more autonomy for the NM (with respect to EUROCONTROL), envisaging the set-up of a dedicated NM unit rate, etc. Tendencies are observed to designate an industry-led consortium as NM (cf. SESAR Deployment Manager), though presumably only in the mid-to-long term future (Network Manager Audit report and position papers (among others Industry Consultation Body)).		Industrial partnerships becoming increasingly important in European ATM	

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
Performance-based regulation	Performance Scheme	Current	Regulation 390/2013 defines the performance scheme framework. It lays out the requirements to create the performance plans and their implementation and monitoring. This performance monitoring should be applied to air navigation services. The key performance areas and indicators are established and the reference periods defined (first reference period 2012-2014 and second reference period 2015-2019, subsequent reference period should be of five calendar years) (European Commission, 2013b). Incentive schemes can be applied as part of the performance plans defined by the Member States.	ANSPs	This performance approach allows us to monitor the different KPIs defined for the ANSPs operations. The expected impact is a more efficient operation with a reduction on costs and delay.	RPB1
		Evolution	Follow up reference period to be developed. Targets for the different KPIs to be adjusted based on previous experience. The general expectation is that Reference Period 3 will reflect a thorough revision of the performance and charging scheme, while keeping the basic SES regulation (especially Art. 15 of the SES Framework Regulation (European Commission, 2004a) and Art. 11 of the SES Service Provision Regulation (European Commission, 2004b)) unchanged. Performance plans at FAB level may disappear. Lack of understanding of interdependencies between KPAs and between KPIs identified as a shortcoming of the performance scheme.		Higher importance of performance results on operational decisions.	

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
	Performance Review Body	Current	Commission Implementing Decision (EU) 2016/2296 Describes the setting up of an independent group of experts designated as Performance Review Body (PRB) of the Single European Sky (European Commission, 2016a). The PRB shall assist the Commission in the implementation of the performance scheme.	All stakeholders	The PRB is to achieve a high level of independence and impartiality	RPB2
		Evolution	Tendency to establish an Independent Performance and Economic Regulator (IPER), potentially empowered to set targets, while this decision power is currently within the remit of the NSAs of the Member States. Counterbalanced by a tendency to reject a 'one size fits all' regulatory approach by proposing to shift more decision power to the NSAs in order to better capture local circumstances and local interdependencies.		More top-down performance target setting process, leading to more ambitious performance targets versus more bottom-up process, with ranges of values determined at EU-wide level and final values within these ranges by the NSAs.	

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
ANSP requirements	Common requirements	Current	Regulation 1035/2011 lays down the common requirements for the provision of air navigation services in a safe and efficient manner. These requirements cover the granting of certificates. These requirements cover the different services provided: air navigation services, air traffic services, meteorological services, aeronautical information services and CNS services (European Commission, 2011a).	ANSPs	Assessment of the means of compliance against these common requirements is the basis for the competent authorities to certify an organisation to provide ANS in Europe.	RAR1
		Evolution	Adjust the regulation to align the requirements to the new operational concepts developed under SESAR.		The implementation of common requirements facilitates the separation between Member States and service providers allowing the implementation of advanced cross-border solutions and decoupling between service provider and airspace.	

Table 3. Airport-related regulatory factors

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
Airport demand	Airport slots	Current	Common rules for the allocation of slots at EU airports were defined in Regulation 95/93 applying principles of neutrality, transparency and non-discrimination. Slots are allocated by independent coordinators and airlines must use 80 per cent of their allocated slots to not lose them on the following year (European Commission, 1993). The regulation has been amended in 2004 and 2009 (European Commission, 2004d; European Commission, 2009d). These modifications added more flexibility and strengthened the coordinator's role and the monitoring of compliance. Guidelines have been laid out for the exchange of slots.	Airports, Airlines	Limited possibility of accessing airports where slots are scarce.	RAD1
Airport demand	Airport slots	Evolution	Proposed amendment to regulation to: allow airlines to trade slots allowing a secondary market encouraging competition with market based mechanism; help new entrants to access the market; tighten the rules to demonstrate the use of slots during the season; increase the level of transparency on slots transactions; and, improve the information flow between slot coordinators, airports, airlines and national authorities (European Commission, 2011c).	Airports, Airlines	Possibility of market based mechanism for the trading of slots. Increased competitiveness at airports.	RAD1

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
	Regional airport development	Current	As described in (European Commission, 2005b), regional airports often face a less favourable situation when developing their services than major hubs. This might be due to the fact that they have not reached the critical size. The guidelines defined by the Commission try to overcome this situation for the developing of regional airports. The framework defined in the guidelines specifies to what extent and how public financing of airports and State aid for starting up air routes is assessed by the Commission. For airport financing the guidelines cover aspects related to financing the construction of infrastructure, aid for operation of the infrastructure and aid for airport services. For aids related to the start-up of new routes, the guidelines allow public aid to be paid temporarily to airlines under certain conditions and special arrangements are accepted for the outermost regions.	Airports Airlines	Development of regional airports and particularly on the outermost regions which are penalised with poor accessibility.	RAD2
		Evolution	The European Commission acknowledges that regional airports are important to the development of an integrated European air transport network and that it would be desirable to use the latent capacity of regional airports (European Commission, 2006b). This can be achieved by developing the community guidelines on financing of airports and start-up aid to airlines departing from regional airports (European Commission, 2005b).			

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
	Airport charges	Current	Directive 2009/12 sets the common principles for the levying of airport charges at Community airports (European Commission, 2009e). This directive applies to all airports open to commercial traffic with an annual traffic over five million passenger movements and to the airport with the highest passenger movement in each Member State. It states that there should be no discrimination between airport users but does not prevent the modulation of airport charges for issues such as environment. It allows airport managing bodies to vary the quality and scope of particular airport services, terminals or parts of terminals, adjusting the airport charges accordingly.	Airports Airlines	Possibility of modulate charges as a function of parameters such as environmental impact. It also allows airports to adjust charges according to infrastructure usage.	RAD3
		Future	The Commission's view is that when airports are subject to effective competition, the market should determine the levels of airport charges and there is no need for regulations. However, when this competition is not effective a specific regulatory framework may still be necessary. The Commission is planning on assessing how Directive 2009/12 may need to be reviewed to keep this principle (European Commission, 2015a).			

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
Airport processes	Ground handling market	Current	Directive 96/67 liberalised the ground handling market in Europe ensuring free access by suppliers for ground handling services to the market for the provision of ground handling services to third parties. It also ensures the freedom to self-handle (European Commission, 1996).	Airports	Allows the entry of competition in the ground handling market.	RAP1
		Future	The Commission will undertake an evaluation of Directive 96/97 and decide if it needs to be reviewed (European Commission, 2015a). Airport processes should be enhanced with new technology, e.g. deployment of A-CDM or A-SMGCS (European Commission, 2006b).			
	Industry standardisation at airport procedures	Current	There are standard procedures applied through the different stakeholders that facilitate the processes and the interoperability of systems. In this context IATA standardisation manuals are produced (e.g. airport handling manual, ground operations manual or baggage reference manual (IATA, 2016a; IATA, 2016b, IATA, 2016c)).	Airports Airlines	Increased interoperability and simplification of procedures. Higher efficiency and reduction of processes within airport operations.	RAP2
		Evolution	Increased standardisation is expected simplifying and enhancing processes.		Higher reduction of airport processes. E.g. reduction of baggage mishandling with the introduction of resolution 753 in 2018 (IATA, 2016d)	

Regulatory area	Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
Airport access / egress	Airport access	Current	The regulatory context regarding airport access is complex because it can involve regulations related to airport development, surface transport operations and planning controls. In countries where there is more of an integrated approach to transport provision, or when all transport modes are the responsibility of the same government body, this may simplify the situation. Often airports will be required to provide detailed information (and possibly targets) about future surface access proposals in their airport master plans or equivalent planning documents, whilst the individual surface modes will normally be subject to the regulations specific to that mode. European air quality policies affect the development of public national, regional and local policies to promote the use of public transport for accessing the airport (European Commission, 2008a; European Commission, 2013c).	Airports	Policies related to air quality lead to integration of airport with other means of transport.	RAA1

Regulatory area	Regulatory factor	Description		Primary stakeholder	Expected effect	Factor ID
		Evolution	There is no indication that a policy or regulation at EU level relating to airport surface access to be developed in the future. Where national policies exist to improve surface access at airports they are being driven primarily due to forecast growth in air transport; the desire for more efficient, convenient and quicker accessibility with a better passenger experience; and a need to reduce harmful emissions. One of the objectives of the EU transport policy is to link the core network airports with the rail network, preferably high-speed by 2050 (European Commission, 2011d). In general, national infrastructure plans aim to provide a higher share of public transport to access the airport and higher integration with other means of transport, and rail in particular. The European Commission view is that airports should improve their multimodal connectivity (European Commission, 2015a; European Commission, 2006b).		Higher intermodality, link with rail and increased use of public transport for accessing the airport.	

Table 4. Other regulatory factors

Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
Passenger provision schemes	Current	Regulation 261/2004 establishes the minimum rights for passengers when they are denied boarding, their flight is cancelled or delayed. This includes right of care and right to compensation (European Commission, 2004c).	Airlines	Impact on airlines' costs and operational decisions to deal with delay and passengers' connections.	ROR1
	Evolution	The European Commission will adopt interpretative guidelines in order to provide guidance to the citizens and the airlines on current passengers' rights (Regulation 261/2004) until amendments become available. It will also evaluate how to promote cooperation between National Enforcement Bodies and authorities (European Commission, 2015a). In March 2013, a memo was released by the Commission (European Commission, 2013d) detailing the key proposed changes to clarify legal grey areas and introducing new rights. In February 2014, the following proposed strengthening (*inter alia*) of air passenger rights passed its first reading in the European Parliament (European Commission, 2014h): • Right to care: introduction of a right to care for passengers after a delay of two hours, for all flights irrespective of distance (thereby removing the current dependency on flight distance); • Re-routing: ensuring passengers have a right to be re-routed by another airline or transport mode in case of cancellation when the carrier cannot re-route on its own services; **(cont'd …)**			

<table>
<tr><th>Regulatory factor</th><th>Description</th><th>Primary stakeholder</th><th>Expected effect</th><th>Factor ID</th></tr>
<tr><td></td><td>Connecting flights: clarifying that rights to assistance and compensation apply if connecting flights are missed because the previous flight was delayed by at least 90 minutes.
The European Parliament’s proposals also go further than those proposed by the Commission in strengthening air passenger rights (European Commission, 2014h):
Compensation for delays (short and medium flights): the Parliament proposes a three hour delay threshold for compensation. In contrast, the Commission considers a five hour threshold to be in passengers’ best interests, with a longer delay threshold reducing the financial incentive on airlines to cancel delayed flights to avoid paying compensation, and instead make every effort to repair technical problems and operate flights;
Extraordinary circumstances: the Parliament backs the Commission’s proposal to clearly define extraordinary circumstances (e.g. strikes, storms and operational problems) which are outside an airline’s control, so excluding any compensation obligation. However, unlike the Commission’s proposal, the Parliament proposes that technical faults can almost never be exempt.
Other possible evolutions of passenger provision regulations include:
Passengers entitled to compensation being automatically compensated;
Load factors maintained significantly below 100% on key/connecting/trunk routes to reserve some capacity for rebooking passengers who miss flights/connections - a ‘social’ capacity and resilience provision supporting Flightpath 2050 ambitions through new regulatory paradigms;
Enhanced identification of primary delay reasons to adjust airline liability.</td><td></td><td>Further development of cross-border collaboration and operational framework development. Different degrees of integration can be considered.

Further liberalisation of air navigation services is expected.</td><td></td></tr>
</table>

Common charging scheme	Current	The SES Service provision regulation (Regulation 550/2004) and its amendment (Regulation 1070/2009) define the principles for charging scheme. This scheme shall be based on the account of costs for air navigation services incurred by service providers. The full cost shall be shared among airspace users. However, the regulation allows us to produce sufficient revenues to exceed all direct and indirect operating costs and to provide for a reasonable return on assets to contribute towards capital improvements. Moreover, the charges system may be used to provide mechanism, such as incentives that provide financial advantages and disadvantages, to encourage ANSPs and/or airspace users to support improvements in ATFM such as increased capacity and reduction of delay (European Commission, 2004b; European Commission, 2009a). Regulation 391/2013 lays down the measures for the development of a common charging scheme for air navigation services. It determines that the en-route air navigation services shall be financed by en-route charges while terminal air navigation services shall be financed by terminal charges. The Member States shall establish charging zones and the charges shall cover the operating costs, allowing the possibility of funding common projects for network-related functions. The regulation specifies how the costs shall be estimated. It allows the Member States to apply a financial incentive scheme for air navigation service providers in relation to the objectives achieved on the different key performance areas identified on the Performance scheme (European Commission, 2013b). Regulation 391/2013 also allows Member States to apply modulation of air navigation charges to incentivise the adoption of equipment on aircraft or to optimise the use of air navigation services, reduce the environmental impact of flights and reduce the overall cost by modulating charges according to the level of congestion of the network in a specific area or route.	ANSPs	Airlines	Uniform application of charging scheme through the Single European Sky. Charges based on operating cost but allows the application of modulation to the charges to incentivise the adoption of technology and according to the level of congestion of the network during a specific period of time.	ROR2

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Regulatory factor	Description	Primary stakeholder	Expected effect	Factor ID
Evolution	Five evolutions with a potentially high impact on ANSP behaviour can be expected to take place: 1) Development of modulation of charges The capacity issue is two-fold: both overcapacity and congestion have a cost. A system of congestion pricing, imposing higher unit rates in congested airspace and lower in non-congested ones may be introduced. 2) New definition of service units On current regulation, the service unit are based on entry and exit point on the charging zone according to the last-filed flight plan. A possible evolution includes its modification to charge based on the actually flown route. 3) Substantial incentivisation The very limited financial bonuses and penalties linked to the incentive scheme on the capacity target compared to the gains and losses with respect to the cost efficiency target achievement only weakly incentivise ANSPs to optimise both at the same time. An incentive scheme for capacity with higher financial stakes may alter ANSP behaviour. 4) Reshaping of charging zones ANSPs' vulnerability to traffic volatility (whether caused by diverging unit rates, geopolitical events or airspace redesign) may encourage States to redefine charging zones by establishing regional common en-route unit rates. This could in turn initiate a process of integration between the involved ANSPs, as sharing a unit rate would lead to a common cost management. **(cont'd …)**		The possible modifications of the charging scheme might lead to different behaviours from the aircraft operators' perspective as the charges costs are considered when submitting and operating a particular flight. From an ANSP point of view, being an infrastructure provider with high fixed costs, it is more important to be protected against risk shocks than to have more freedom to maximise profits. This position is reinforced by the substantial difference in RP1 and RP2 between the actual traffic levels and the forecasted volumes underpinning the performance plans.	

Regulatory factor	Description	Primary stakeholder	Expected effect	Factor ID
	5) Pure price cap model The current model, labelled "hybrid price cap", is perceived as inconsistent by airspace users. It contains features of a price cap model, but at the same time includes several protection measures for ANSPs by allowing traffic risk sharing, cost risk sharing and cost elements exempt from cost sharing. In a pure or genuine price cap model, a more direct link between actual price and agreed quality of service would be established.			

Regulatory factor		Description	Primary stakeholder		Expected effect	Factor ID
Emission schemes	Current	Directive 2008/101 added aviation into the European scheme for greenhouse gas emission allowance trading (European Commission, 2003a, European Commission, 2009b). The directive describes the current implementation of the European Trading Scheme (EU-ETS). Directive 2009/12 sets common principles for the levying of airport charges. In that directive, it is indicated that airport charges should not discriminate among users but allows us to modulate the charges for issues of public and general interest including environmental issues. In this respect, noise and NO_x emissions-related charges can be introduced (European Commission, 2009c). ICAO's policies on charges for airports and air navigation services allow the use of emission-related aircraft charges to address local air quality problems around airports (ICAO, 2012). Directive 2003/96 allows for a fuel tax to be levied on domestic flights within Member States (European Commission, 2003b).	Airlines	Environment	The current directive is translated into an extra cost linked to the fuel consumption. The current levels of cost for carbon allowance significantly limit the impact of the regulation. The effect of NO_x on local air quality around airports lead to some airports already charging in relationship to the emissions. For example, EGLL has an emission charge of £7.76 per kg/NO_x in 2013/14 (Civil Aviation Authority, 2013).	ROR3

Evolution	The ICAO Assembly on their 39th session Resolution 22/2 consolidated the ICAO policies and practices related to the environmental protection defining a Global Market-based Measure (MBM) scheme (CORSIA) (ICAO, 2016a). Resolution A39-3 and A38-18 of 2013 define this MBM scheme (ICAO, 2016b; ICAO, 2016c; ATAG, 2016). Until the end of 2016, a temporarily reduced scope legislation applied in the EU. The EU has not considered the ICAO agreement, CORSIA, yet: a decision is expected in 2017. Considering that ICAO resolution A39-3 states recognises that MBM should not be duplicative and international aviation CO_2 emissions should be accounted for only once and that the aviation industry supports a single global carbon offsetting scheme, as opposed to a patchwork of State and regional MBMs, it might be expected that EU-ETS would be replaced (at least for international flights) by the ICAO MBM mechanism while the European regulation might still be applied to EU flights excluded from the ICAO agreement (e.g. national flights within EU countries) (ETS Aero, 2016). The trend in airport charges due to NO_x emissions is to increase the cost per kg of NO_x, e.g. in the period 2007 to 2013 NO_x charges increased by 448% considering inflation for EGLL (from GBP1.00 to GBP6.69/kg NO_x) (Civil Aviation Authority, 2013). Other possible evolutions in terms of airport charges for emissions include cap and trade systems such as the EU-ETS scheme. Initiatives such as Clean Sky, a joint undertaking for the development of clean technology (European Commission, 2014f), are developed and further research and development is expected in this field to reduce the impact of individual flights.	The introduction of ICAO CORSIA MBM mechanism affects to the number of flights affected by the allowance scheme. There shall be a transition period between EU-ETS and CORSIA to avoid double taxation on the emissions. ICAO regulation applies to international flights while the European regulation might still be applied to national flights. A higher pressure on the number of flights required to offset their emissions might lead to higher costs of carbon allowances impacting the extra costs linked to fuel consumption. Higher cost due to NO_x might incentivise airlines towards the usage of less polluting aircraft. However, the impact on their operating cost is limited.

Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
Noise pollution	Current	Besides the application of airport charges linked to noise (Civil Aviation Authority, 2013), the European Commission has laid down rules to facilitate the introduction of operating restrictions to limit or reduce the people affected by noise while safeguarding internal market requirements (European Commission, 2002a). It also develops a common framework for measuring the impact of noise and implementing mitigation strategies (European Commission, 2002b). Finally, the use of specific noise abatement objectives and the use of operating restriction are considered by Regulation 598/2014 (European Commission, 2014d). That Regulation aims to improve the noise environment around EU airports in particular in the case of night flights. The rules are based on the principles of the balanced approach to noise management agreed by the ICAO. Regulation 598/2014 repeals Directive 2002/30/EC with effect from 13 June 2016.	Airports Environment	Airports might apply restrictions to traffic to limit or reduce the number of people affected by noise. Other possibilities such as charging schemes or development of abatement procedures can be used.	ROR4
	Evolution	Directive 2002/30 (European Commission, 2002a) has only been used in the case of a limited number of airports and according to (European Commission, 2008e), some stakeholders are of the opinion that it is not sufficiently clear and some Member States already had similar provisions under national law prior to the entry into force of the Directive. It is expected that noise problems will increase as more population is affected by the impact of noise. This is due to incrementing traffic (European Commission, 2008e); for this reason the Commission intends to examine ways of clarifying the provisions of Directive 2002/30 and its scope (European Commission, 2008e).		This might lead to more restrictions in terms of operations, e.g. night restrictions.	

Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
ANSP labour agreements	Evolution	Three tendencies are observed: 1) Flexible rostering ANSP rostering gets increasingly adapted to the traffic variation, e.g. with shifts starting every 15 or 30 minutes. 2) Establishment of minimum service levels (thus alleviating the effect of industrial action) 3) ATCO (air traffic controller) mobility (European Commission, 2015b) The latter is linked to the establishment of a common licensing system for air traffic controllers in Europe.	ANSPs	The labour agreements at ANSP level that are expected in the future might reduce the effect of industrial action and increase the efficiency by allowing the mobility of ATCOs and virtualisation of ACCs. Mobility of ATCOs would unleash the potential to substantially increase productivity. The corresponding harmonisation of working conditions could lead to an increase in the cost per ATCO.	ROR5

Regulatory factor		Description	Primary stakeholder		Expected effect	Factor ID
Drones	Current	Experimental or amateur built RPAS, military and non-military governmental RPAS flights, civil RPAS below 150 kg are regulated at national level. The responsible regulatory body for platforms with a mass greater than 150 kg is EASA (European Commission, 2008b). Operational approval and pilot competence are carried out at national level (Civil Aviation Authority, 2015). Joint authorities for rulemaking on unmanned systems (JARUS) are currently developing recommended requirements for pilot licensing, process for airworthiness, certification, etc. (JARUS, 2015).	ANSPs	Airports	Current use of drones is limited. Commercial operations limited to aerial work with small platform or use in segregated airspace.	ROR6

Regulatory factor	Description	Primary stakeholder	Expected effect	Factor ID
Evolution	The Commission proposes a basic legal framework for the development of drone operations as part of a new aviation safety regulation replacing Regulation 216/2008 and request from EASA to prepare more detailed rules for drone operations and development of industry standards (European Commission, 2015a). In order to ensure that the airspace in which the growing number of unmanned aerial vehicles (UAV) operate is safe and orderly, procedures need to be put in place. This calls for a dedicated UAV Traffic Management (UTM). UTM complements the Air Traffic Management (ATM) provided today for aircraft that operate in controlled airspace.		Forward unification of regulation across Europe will facilitate the development of drones' operations. Regulation evolving to enable technical operations of drones in a wider context. Once the regulatory framework is up and running, a network of UTM system providers is expected to emerge, potentially either leading to alliances between UTM and ATM providers or to a disruption of the monopolistic provision of air navigation services.	

Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
ATCO interoperability	Current	Regulation 1032/2006 establishes the mechanism for the notification, coordination and transfer of flights between ATC units (European Commission, 2006a), this is required to develop a seamless coordination between the different control centres.	ANSPs	Allows standardisation on the coordination of flights between ATC units. It is required to develop a seamless coordination between the different control centres.	ROR7
	Evolution	With the development of the Single European Sky, interoperability becomes crucial, particularly with the development of FABs, virtual control centre, etc. (European Commission, 2009a). Further regulations might be required to ensure the seamless development of these concepts of operation.		Required to maintain the development of single Euro.	
Safety	Current	Regulation 216/2008 set out the principles to establish and maintain a high uniform level of civil aviation safety in Europe, including the creation of a European Aviation Safety Agency (EASA). Common safety rules offer a uniform level of requirements for operators, manufacturers and aviation personnel (European Commission, 2008d). Regulation 139/2014 lays down rules on the conditions for the certification and operation of aerodromes (European Commission, 2014e). Regulation 3922/91 applies to the harmonisation of technical requirements and administrative procedures in civil aviation safety, concerning the operation and maintenance of aircraft and to persons and organisations involved in those tasks. (European Commission, 2009f). Regulation No 390/2013 defining the performance scheme identifies safety as a KPA (European Commission, 2013b). During RP2 targets have been set to achieve high levels of effectiveness of safety management and full application of the severity classification based on the Risk Analysis Tool methodology by 2019 (European Commission, 2014g).	Airports Airlines	Unified and harmonised safety requirements through the Member States.	ROR8

Regulatory factor	Description		Primary stakeholder	Expected effect	Factor ID
	Evolution	Safety regulation developed in combination with the deployment of technology and operational concepts under Single European Sky. The increment in traffic means that safety requirements and standards must increase to keep the targeted level of safety (European Commission, 2009a; European Commission, 2011e). For RP3 new indicators are considered for monitoring, e.g. separation minima infringements, while it is considered that high-severity outcomes and data-driven performance indicators should not be targeted to avoid under-reporting (Performance Review Body, 2016b; EASA, 2016). Focus will be given to key risks and interdependency issues. The performance objectives that are currently considered for safety include: reduction of loss of separation incidents both horizontally and vertically by focusing on system risk, elimination of runway incursions and improved management of ATM system security and business continuity (Performance Review Body, 2016a).		Higher requirements as traffic increases to maintain level of safety.	

Regulatory factor		Description	Primary stakeholder	Expected effect	Factor ID
Operation of air services	Current	Regulation 1008/2008 lays down common rules for the operation of air transport services in the EU, including the licensing of EU air carriers and price transparency (European Commission, 2008c). The regulation harmonises the criteria for awarding airlines' operating licenses and their validity. It states that airlines are free to set the price for their intra-EU air services and the requirements in terms of indicating the final price and supplement services. Public service obligation may be imposed for a scheduled air route between an EU airport and an airport serving a peripheral or development region in its territory, if ensuring minimum services on that route is considered vital for the economic and social development of the region which the airport serves. The legislation also allows EU countries to regulate the distribution of air traffic between airports if they serve the same city or conurbation and are served with adequate public transport infrastructure.	Airlines	Airlines are allowed to set their price based on market demands. States can incentivise the development of public services in some particular cases.	ROR9
	Evolution	Besides air carriers, the European Commission considers that the general and business aviation sector should be incorporated within the European Union's air transport policy (European Commission, 2007). In 2006, almost 10% of aircraft movements registered by EUROCONTROL were attributable to this sector and it is expected to develop as a result of the need for more mobility, flexibility and point-to-point services, increased congestion at main airports, security constraints and the development of new technologies. These services increase people's mobility, business productivity and regional cohesion (European Commission, 2007).		Besides scheduled aviation, business aviation might increase in the forthcoming years. Higher competition might be observed, there is an incentivisation toward regionalisation and intermodality development.	
2050 vision	-	Flightpath 2050 (European Commission, 2011e) provides a view of the challenges and vision for air mobility in the 2050 framework. It defines high level goals for societal and market needs, industrial development, the environment and energy supply, safety and security and research.	All stakeholders	Define research topics and operational concepts and targets for 2050 operations.	ROR10

3 Review of business factors

3.1 Review of business factors

3.1.1 Technology and operational changes

3.1.1.1 SESAR technology and operational changes

The technological and operational changes expected in the 2035 and 2050 frameworks within Europe are mainly driven by SESAR, its evolution and deployment. This is particularly true for the 2035 framework, for which several changes are defined by regulatory factors, as described in Section 2. This includes the SES Framework Regulation, SES Service Provision Regulation, SES II Regulation and Pilot Common Project, and the SESAR Master Plan (European Commission, 2004a; European Commission, 2004b; European Commission, 2009a; European Commission, 2014b; SESAR JU, 2012). For 2050, more disruptive technology and operational changes might be expected.

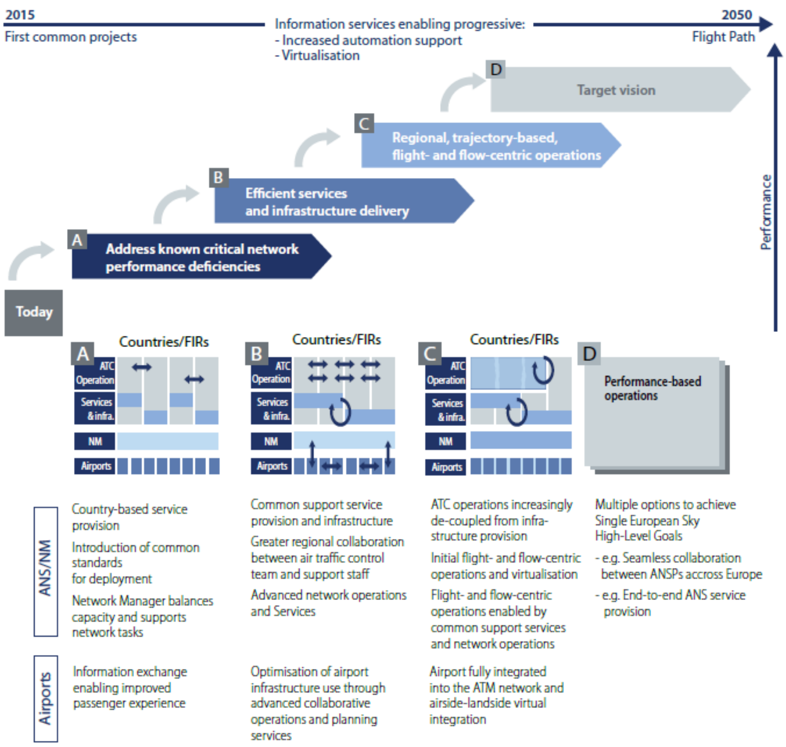

Figure 1. SESAR four-phases approach (SESAR JU, 2015)

SESAR initially based its development around three time steps, called ‘Step 1’, ‘Step 2’, and ‘Step 3’. They were intended to guide SESAR innovation towards more advanced research initiatives as time progressed. However, these steps have been effectively disregarded as it became clear that different fields of innovation were advanced more slowly or more rapidly than initially thought. Planned progress had thus been associated with *capabilities* rather than a timeframe *per se*, but this approach will be phased out. Indeed, from the deployment baseline, the system will now evolve towards a time-based operation scheme (corresponding to Step 1), then to trajectory-based operations (Step 2) and finally reaching performance-based operations (Step 3).

Even though the Steps themselves are being disregarded, the underlying concepts will still apply. In particular, there were some targets initially planned for each Step in terms of the different KPIs defined by SESAR. These targets are important to the present deliverable and the model itself, since they give at least a rough estimation of how much the system could evolve based on a preliminary expert-based assessment of the benefits of several technological and managerial advancements. As a consequence, we consider these targets as the best estimates regarding future changes in the system and we use them in the scenario definition phase.

In **Figure 1** the development phases for the operational concept evolution are presented. There are four defined phases, as defined in (SESAR JU, 2015):

- Address known critical network performance deficiencies: This phase includes the gradual adoption of a service-oriented architecture (SOA). This approach allows increased information sharing and exchange between ATM stakeholders, including the Network Manager (NM), airlines and airports across national borders. This phase has already started with the delivery of mature solutions by SESAR 1 and the implementation of the PCP and will continue with the next common projects, the content and timeframe of which will be decided by the European Commission.
- Efficient services and infrastructure delivery: By developing open standards for the ATM systems, stakeholders will be allowed to find commonalities in their operation and service needs allowing the development of common services. This enables the stakeholders to optimise resources and services moving from a physical to a virtual infrastructure where automation and information management can be exploited. This phase is reliant on solutions from SESAR 2020 R&D activities and performance gains obtained from Europe-wide and/or local deployment of technologies.
- Regional, trajectory-based, flight- and flow-centric operations: Trajectory-based and flight-centric operations within a network context, i.e. without being limited by airspace configurations, can be operated due to the increased levels of automation and interoperable systems. This implementation might be gradual from the regional level, limited to a part of the airspace, or limited to some moments in time. A decoupling between the system infrastructure and air traffic control operations allows ANSPs to provide services beyond national borders, adapting to demand. In this phase airports are also fully integrated into the ATM at the network level. As with the previous phase, these improvements are reliant on solutions from SESAR 2020 R&D activities and performance gains obtained from Europe-wide and/or local deployments.
- Target vision - performance-based operations: By this phase, the ATM system is characterised by a high degree of automation. This phase allows for multiple options to be envisaged, for example collaboration between ANSPs across Europe and/or end-to-end ANS service

provision. This phase extends beyond 2035 towards 2050 with continued R&D activities to enable performance-based operations and demonstrating how SESAR Solutions can be deployed in complex environments. The deployment of solutions will be based on the maturity of SESAR solutions built on SESAR 1, common projects and R&D developed under SESAR 2020.

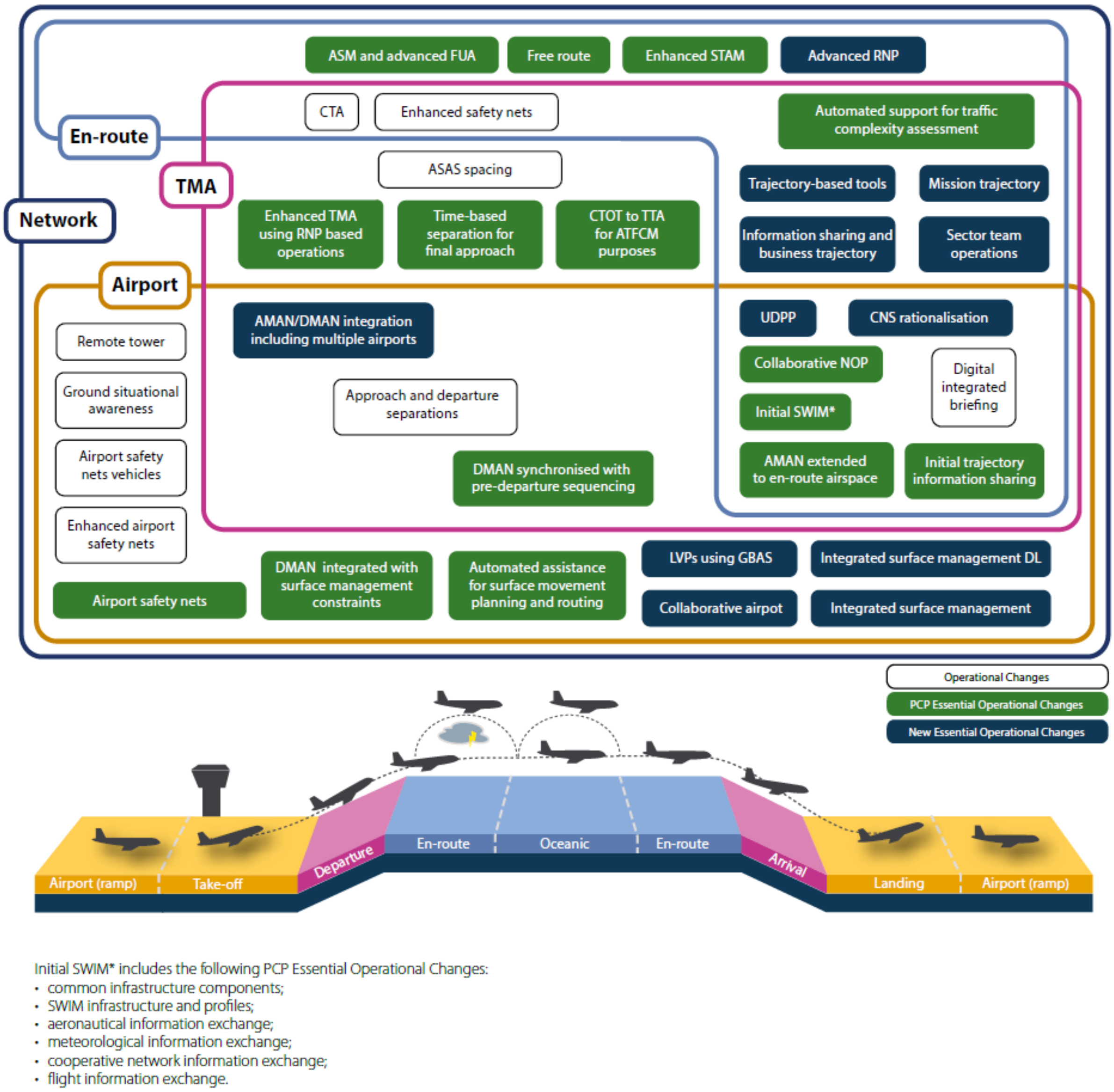

Figure 2. Operating environments changes (SESAR JU, 2015)

The development and deployment of solutions within the 2035 framework are defined in the ATM Master Plan (SESAR JU, 2015; SESAR JU, 2016a; SESAR JU, 2016b; EUROCONTROL, 2016). These solutions extend the ATM Functionalities defined in the PCP adding New Essential Operational Changes. **Figure 2** presents these operational changes and **Table 5** summarises the different changes with the timeframe for their deployment and the expected effect on the ATM system. The definition and evolution of the ATM Master Plan and SESAR implementation and deployment are maintained and updated in the European ATM Portal[2] (https://eatmportal.eu/) (SESAR JU, 2017a). The Operational Changes defined in the ATM Master Plan are related to Operational Improvements which are grouped into Operational Focus Areas (OFAs), as shown in **Table 5**. These OFAs are composed of a number of Operational Improvement Steps (OISs), each subjected to a validation process which estimates its impact on the performance of the system (Project B.05, 2015). The implementation and deployment of the Operational Changes are managed by defining Operational Packages and Sub-Packages (a list of which is presented in **Table 6**).

[2] Public version of the European ATM Portal: https://www.atmmasterplan.eu/

Table 5. SESAR Operational Changes

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
Extended AMAN and PBN in high density TMA	AMAN extended to en-route airspace	OFA04.01.02 Enhanced Arrival & Departure Management in TMA and En-Route	AMAN extended to en-route phase to 180-200 NM from the airport. Traffic sequencing during en-route phase.	Reduction of congestion in TMA and arrival holding delay	EGLL, LFPG, EGKK LFPO, EGSS, LIMC, EDDF, LEMD, EHAM, EDDM, LIRF, LEBL, LSZH, EDDL, EBBR, ENGM, ESSA, EDDB, EGCC, LEPA, EKCH, LOWW, EIDW, LFMN, LTBA PBN in high density TMAs	2023
	Enhanced TMA using RNP-based operations	Not directly aligned with an OFA	PBN arrival/departure procedures			2023
Airport integration and throughput	Airport safety nets	OFA01.02.01 Airport safety nets	Detection and alert of conflicting ATC clearances and deviation of vehicles from instructions	Increased capacity	EGLL, LFPG, EGKK LFPO, EGSS, LIMC, EDDF, LEMD, EHAM, EDDM, LIRF, LEBL, LSZH, EDDL, EBBR, ENGM, ESSA, EDDB,	2020

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ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	Automated assistance to controller for surface movement planning and routing	OFA04.02.01 Integrated Surface Management	A-SMGCS providing automatic taxi routes with estimated taxi times and managing conflicts	Reduced taxi times Increased predictability	EGCC, LEPA, EKCH, LOWW, EIDW, LFMN, LTBA	2023
	DMAN integrating surface management constraints	OFA04.01.01 Integrated Arrival/Departure Management at Airports	Integration with surface management constraints to determine optimal surface movement. A-SMGCS.	Reduced taxi times Increased predictability		2020
	DMAN synchronised with pre-departure sequencing	OFA04.01.01 Integrated Arrival/Departure Management at Airports	Calculating target take off times (TTOT) and target start approval time (TSAT). In combination with A-CDM.	Reduced taxi time Increased ATFM-Slot adherence		2020
	Time-based separation (TBS) for final approach	OFA01.03.01 Enhanced Runway Throughput	Separation using time instead of distance.	Increased capacity	EGLL, EGKK, LFPO, LIMC, EDDF, LEMD, EHAM, EDDM, LIRF, LSZH, EDDL, ENGM, EGCC, EKCH, LOWW, EIDW, LTBA	2023

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
Flexible airspace management and free route	ASM and advanced-FUA	Not directly aligned with an OFA	Airspace managed dynamically with coordination with military activities. No fixed routes network. Manage airspace reservations more flexibly in response to airspace user requirements.	Reduction of ATFM regulations due to military activities. Enabling FRA, DCT and CDR.	Airspace above FL310	2021

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	Free route	OFA03.01.03 Free Routing	Using Direct Routing Airspace (DRA) and Free routing airspace (FRA). DRA: Entry and exit points with published direct routing. FRA: Entry and exit points with no fixed airspace structures or route networks.	Shorter (direct) routes within NAS		2021
Network collaborative management	Automated support for traffic complexity assessment	OFA03.01.04 Business and Mission Trajectory OFA05.03.04 Enhanced ATFCM processes	Predicting traffic complexity and overloads with planned trajectory and network information. This will allow us to apply mitigation strategies at local and network levels.	Increased predictability	EATMN	2021

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	Collaborative NOP	OFA05.01.01 Airport Operations Management OFA03.01.04 Business and Mission Trajectory OFA05.03.07 Network Operations Planning	Increased integration of NOP and Airport Operations Plan information. Shared operational planning and real-time data.	Increased predictability		2021
	CTOT to TTA for ATFCM purposes	OFA05.03.04 Enhanced ATFCM processes	Target Times shall be applied to selected flights for ATFCM purposes to manage ATFCM at congestion and not only at departure. Target Times of Arrival (TTA) derived from Airport Operations Plan (AOP).	Increased predictability		2021

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	Enhanced Short Term ATFCM Measures (STAM)	OFA05.03.04 Enhanced ATFCM processes	STAM using cooperative decision-making.	Increased predictability Reduction of re-routing and delay		2021
iSWIM	Aeronautical information exchange Common infrastructure components: SWIM registry, PKI Cooperative network information exchange Flight information exchange	ENB02.01.01 SWIM	Information exchanges built on standards and delivered though an IP-based network.	Increased cooperation Enabler of other functional-ities	ACC: London ACC Central, Karlsruhe UAC, UAC Maastricht, Marseille East + West, Paris East, Roma ACC, Langen ACC, Ankara ACC, Muenchen ACC, Prestwick ACC, ACC Wien, Madrid ACC (LECMACN + LEC), Bordeaux U/ACC, Brest U/ACC, Padova ACC, Beograde ACC, Reims U/ACC, Bucuresti ACC, Barcelona ACC, Budapest ACC, Zuerich ACC, Amsterdam TMAs and Towers: London TMA TC, Langen ACC, Paris TMA/ZDAP, Muenchen ACC, Bremen ACC, Roma TMA, **(cont'd …)**	2024

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	MET information exchange				Milano TMA, Madrid TMA, Palma TMA, Arlanda Approach, Oslo TMA, Barcelona TMA, APP Wien, Canarias TMA, Copenhagen APP, Zuerich APP, APP Brussels, Padova TMA, Helsinki APP, Manchester APP, Dublin TMA Airports: EGLL, LFPG, EGKK LFPO, EGSS, LIMC, EDDF, LEMD, EHAM, EDDM, LIRF, LEBL, LSZH, EDDL, EBBR, ENGM, ESSA, EDDB, EGCC, LEPA, EKCH, LOWW, EIDW, LFMN, LTBA Civil-military coordination: All centres in Member States that have non-integrated civil/military service provision: **(cont'd …)**	

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	SWIM infrastructure and profiles				Austria, Belgium, Bulgaria, Czech Republic, France, Ireland, Italy, Portugal, Romania, Slovakia and Spain AOC system providers All Met providers Network Manager	
Initial trajectory information sharing	Initial trajectory information sharing (i4D)	ENB03.01.01 TMF Trajectory Management Framework and System Interoperability with air and ground data sharing	Improved use of target times and trajectory information, when available using 4D trajectory data.	Increased predictability	All ATS units providing ATS.	2024 (ATS and Network Manager enable i4D) 2025 (at least 20% aircraft operating corresponding to at least 45% of traffic)

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
New essential operational changes	UDPP	OFA05.03.06 UDPP OFA05.03.04 Enhanced ATFCM processes	Exchange departure order of flights from different airlines penetrating the same constraint.	Airspace users within commercial agreements can reduce the delay of higher cost sensitive flights Facilitate ATFCM planning and departing sequencing	All airports Network	2025
	Advanced RNP	OFA02.01.01 Optimised 2D/3D Routes	Enhancements on route structures allowing spacing between routes to be reduced.	Increased predictable behaviour Higher capacity	En-route: medium, high Network	2024

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	AMAN/DMAN integration including multiple airports	OFA04.01.01 Integrated Arrival/Departure Management at Airports OFA04.01.02 Enhanced Arrival & Departure Management in TMA and En-Route	Support coordination of departure and arrival traffic flows for multiple airports in the same vicinity.	Increased TMAs throughput Reduction of delay	Airports: LUCL, HUSL, HUCL TMA: medium, high	2026
	Trajectory-based tools	Not directly aligned with an OFA	ATC separation management through the deployment of different ATC tools and procedures, advanced tactical controllers' tools and 'what-if' capabilities using enhanced trajectory data.	Increased tactical coordination Increased capacity	All TMAs All en-route Network	2029

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	Sector team operations	OFA03.03.01 Ground Based Separation Provision in En-Route OFA03.03.02 Ground Based Separation Provision in the TMA	New roles and operational procedures for controllers.	Increased capacity	All TMAs En-route: medium, high	2023
	LVP using GBAS	OFA01.01.01 LVPs using GBAS	Improve low visibility operations using GBAS CAT II/III	Increased capacity	All airports	2024

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	Collaborative airport	OFA05.01.01 Airport Operations Management OFA05.03.04 Enhanced ATFCM processes	Interface the landslide with the ATM network. AOP and A-CDM for normal, adverse and/or exceptional operating conditions derived from planning, monitoring, management and post-operations analysis. TTA derived from the AOP used by NM to balance arrival demand and capacity.	Increased predictability	All airports Network	2027
	Integrated surface management	OFA04.02.01 Integrated Surface Management	Assistance to vehicles and flight crews with taxiway lighting.	Increased predictability Reduction of taxi times	Airports: LUCL, HUCL	2028
	Integrated surface management datalink	OFA04.02.01 Integrated Surface Management	Datalink information exchange between flights, ATCo and vehicles and ATCo.	Reduction of taxi times	Airports: LUCL, HUSL, HUCL	2026

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	CNS rational-isation	Not directly aligned with an OFA but linked with: • ENB01.01.03 Communication • ENB01.01.04 Navigation • ENB01.01.05 Surveillance	New optimisation with new functionalities and/or technologies that support higher performance and efficiency.	Reduced costs	All	2024
	Information sharing and business trajectory	ENB03.01.01 TMF Trajectory Management Framework and System Interoperability with air and ground data sharing OFA03.01.04 Business and Mission Trajectory	Initial reference business trajectory (iRBT) which includes the initial shared business trajectory (iSBT) containing target times over/arrival (TTO/TTA).	Increased predictability Increased capacity	All	2026

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	Mission trajectory	OFA03.01.04 Business and Mission Trajectory	Reference trajectory used by ATM partners during flight execution. Same information as SBT.	Increased predictability Increased capacity	All	2028
Operational changes that are not considered essential	Airborne separation assistance system (ASAS) spacing	OFA03.02.01 ASAS Spacing	Maintenance required spacing with a designated target aircraft.	Increased capacity	Maybe considered for deployment at local level	<2035
	Controlled time of arrival (CTA)	OFA04.01.02 Enhanced Arrival & Departure Management in TMA and En-Route	Report and maintain controlled time of arrival	Increased predictability Increased TMA capacity		
	Enhanced safety nets	OFA03.04.01 Enhanced Ground Based Safety Nets	Enhance STCA with aircraft-derived data (ADD).	Increased TMA capacity		
	Airport safety nets for vehicles	OFA01.02.01 Airport safety nets	Increase situational awareness for vehicles.	Increased safety		

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	Approach and departure separations	OFA01.03.01 Enhanced Runway Throughput	Improve wake turbulence separation during take-off and final approach based on weather conditions, aircraft characteristics and required surveillance performance. It can also detect wake-turbulence suing direct measurements from the ground or on-board.	Increased capacity		
	Enhanced airport safety nets for flight crew	OFA01.02.01 Airport safety nets OFA04.02.01 Integrated Surface Management	On-board systems enhanced to detect risk of collisions during runway operations.	Increased safety Increased capacity		
	Ground situational awareness in all weather conditions	OFA01.02.01 Airport safety nets	Situational awareness enhanced with ADS-B.	Increased safety Increased capacity		

ATM Functionality / Operational Changes	Operational Change	Related Operational Focus Area (OFA)	Description	Effect	Scope*	Timescale Implemented by the end of
	Remote tower	OFA06.03.01 Remote Tower	Provision of remotely-provided ATS for one/multiple aerodromes.	Increased capacity		
	Digital integrated briefing	ENB02.01.02 AIM/MET	Improvements on pilot briefing information.	Increased safety		

* Definitions for the scope of New Essential Operational Changes:

LUSL: low utilisation (<90% utilisation during 1 or 2 peak periods a day) simple layout

LUCL: low utilisation (<90% utilisation during 1 or 2 peak periods a day) complex layout

HUSL: high utilisation (>90% utilisation during 3 or more peak periods a day) simple layout

HUCL: high utilisation (>90% utilisation during 3 or more peak periods a day) complex layout

TMA low: low complexity handle less than 30 movements in peak hour

TMA medium: medium complexity handle between 30 and 60 movements in peak hour

TMA high: high complexity handle more than 60 movements in peak hour

En-route low: low complexity en-route has a complexity score of less than 2

En-route medium: medium complexity en-route has a complexity score between 2 and 6

En-route high: high complexity en-route has a complexity score of more than 6

Complexity score: composite measure combining traffic density (concentration of traffic in space and time) with structural complexity (structure of traffic flows) as described in PRR 2013 Report.

Table 6. Operational Packages and Sub-Packages

Operational Package	Operational Sub-Package	Operational Focus Area
PAC01 - Increased Runway and Airport Throughput	SPC01.02 - Airport Safety	OFA01.02.01 - Airport safety nets OFA01.01.02 - Pilot enhanced vision
PAC02 - Efficient and Green Terminal Airspace Operations	SPC02.01 - Enhanced Route Structures	OFA02.01.01 - Optimised 2D/3D Routes
PAC03 - Moving from Airspace to Trajectory Management	SPC03.01 - 4D Trajectory Management	ENB03.01.01 TMF - Trajectory Management Framework and System Interoperability with air and ground data sharing OFA03.01.03 - Free Routing OFA03.01.04 - Business and Mission Trajectory
	SPC03.02 - Airborne Spacing and Separation	OFA03.02.03 - ATSA-ITP OFA03.02.04 - ASEP
	SPC03.03 - Ground Based Conflict Management	OFA03.03.01 - Ground Based Separation Provision in En-Route OFA03.03.02 - Ground Based Separation Provision in the TMA
	SPC03.04 - Air Safety Nets	OFA03.04.01 - Enhanced Ground Based Safety Nets OFA03.04.02 - Enhanced ACAS Operations
PAC04 - End to End Traffic Synchronization	SPC04.01 - Traffic Synchronization	OFA03.02.01 - ASAS Spacing OFA04.01.01 - Integrated Arrival/Departure Management at Airports OFA04.01.02 - Enhanced Arrival & Departure Management in TMA and En-Route
	SPC04.02 - Integrated Surface Management	OFA04.02.01 - Integrated Surface Management
PAC05 - Integrated and Collaborative Network Management	SPC05.01 - Demand and Capacity Balancing Airports	OFA05.01.01 - Airport Operations Management

Operational Package	Operational Sub-Package	Operational Focus Area
	SPC05.03 - Demand and Capacity Balancing En-Route	OFA05.03.01 - Airspace Management and AFUA OFA05.03.03 - Dynamic Airspace Configurations OFA05.03.04 - Enhanced ATFCM processes OFA05.03.06 - UDPP OFA05.03.07 - Network Operations Planning
PAC06 - Cooperative Asset Management	SPC06.03 - Remotely provided Air Traffic Services for aerodromes	OFA06.03.01 - Remote Tower
ENB01 - CNS	ENB01.01 - CNS	ENB01.01.03 - Communication ENB01.01.04 - Navigation ENB01.01.05 - Surveillance
ENB02 - Information Management - ENB02.01	ENB02.01 - SWIM	ENB02.01.01 - SWIM ENB02.01.02 - AIM/MET

SESAR identifies four Key Features (SESAR JU, 2015):

- Optimised ATM network services: evolving from airspace centric vision to a full 4D trajectory management where free routing is provided between TMAs, A-FUA, automated support for traffic complexity assessment, collaborative NOP, the use of CTTOO to TTA for ATFCM purposes, enhanced STAM and UDPP.
- Advanced air traffic services: extending AMAN to the en-route phase, enhanced TMA using RNP-based and advanced RNP operations, free route, AMAN/DMAN integration including multiple airports, trajectory based tools and sector team operations.
- High-performing airport operations: TBS for final approach, automated assistance to controllers for surface movement planning and routing, airport safety nets, DMAN synchronised with pre-departure sequencing and with surface management constraints, airport operations plan, LVPs using GBAS, collaborative airport, integrated surface management.
- Enabling aviation infrastructure: SWIM to provide communication services for the interchange of information for the ATM system. This includes meteorological information exchange, cooperative network information exchange, flight information exchange, CNS rationalisation, information sharing and business trajectory.

Note that even if the technology is ready and deployed by 2035 there are factors beyond the technological capabilities that might affect the operational context. For example, by 2035 the virtual centre concept might be defined and the technology ready and deployed but its implementation will require political determination for closer integration and changes to ANSPs' business models that are beyond the technical changes.

Besides the operational changes described in **Table 5**, the SESAR ATM Master Plan (SESAR JU, 2015) identifies key R&D activities to enable those changes to be implemented and for their further development. Research activities that are considered to provide significant changes to the ATM system in the 2035 - 2050 framework include those described in **Table 7**, grouped by the features that will be impacted by the research.

Table 7. Research and Development activities

Key Feature	R&D Activities
Optimised ATM network services	• Management of dynamic airspace configurations • Integrated local DCB processes • Network prediction and performance • Collaborative network management functions • Mission trajectory driven processes • AU processes for trajectory definition • AU trajectory execution from FOC perspective • AU fleet prioritisation and preferences
Advanced air traffic services	• Flight- and flow-centric ATC • High productivity controller team organisation • Collaborative control • Improved performance in the provision of separation • Advanced separation management • IFR RPAS integration • Dynamic and enhanced routes and airspace • Enhanced rotorcraft and GA operations in the TMA • Ad hoc delegation of separation to flight deck • Enhanced airborne collision avoidance for commercial air transport normal operations - ACAS Xa • Use of arrival and departure management Information for traffic optimisation within the TMA • Generic (non-geographical) controller validations
High-performing airport operations	• Wake turbulence separations optimisation • Enhanced arrival procedures • Independent rotorcraft operations at the airport • Traffic optimisation on single and multiple runway airports • Traffic alerts for pilots for airport operations • Enhanced airport safety nets for controllers • Surface operations by RPAS • Enhanced collaborative airport performance management

Key Feature	R&D Activities
Enabling aviation infrastructure	• Integration of trajectory management processes in planning and execution • Performance-based trajectory prediction • Enhanced mission trajectory • Management and sharing of data used in trajectory (AIM, meteo) • Work station, service interface definition and virtual centre concept • SWIM TI purple profile for A/G advisory information sharing • Airborne D&A systems supporting integrated RPAS operations • FCI terrestrial datalink • Future satellite communications datalink • GA/RC specific CNS systems • GBAS • Multi-constellation/multi frequency GNSS • Alternative position, navigation and timing

According to (SESAR JU, 2015), beyond 2035 and towards 2050, R&D activities will focus on enabling performance-based operations and demonstrating how SESAR solutions can be deployed in complex environments.

Finally, SESAR defined several Key Performance Areas (KPAs), each having at least one Key Performance Indicator (KPI). These KPIs have some very specific targets to be reached, broken down by Sub-Packages (and even OFAs). These KPIs are defined as follows:

- Airport Capacity: Change in maximum declared runway throughput per hour at Best in Class (BIC) airport;
- Airspace Capacity (En-Route): Change in IFR Movements per airspace volume per unit time (most challenging En-Route environment);
- Airspace Capacity (TMA): Change in IFR Movements per airspace volume per unit time (most challenging TMA environment);
- CMCC1: Measure of the impact on the military in terms of the distance and flight time to an exercise area;
- CMCC2: Measure of the offered fuel and distance saved by GAT operations from changes to military operations;
- Cost Effectiveness (ATCO): Change in Flights per ATCO-Hour on duty;
- Cost Effectiveness (TECH): Change in Technology Cost per Flight;
- Environment / Fuel Efficiency: Change in Average Fuel Burn per Flight;

- Predictability / Flight Duration Variability: Change in Variance of differences between Actual and Planned RBT duration;
- Punctuality: Measure of the flights departing within +/- 3min of their scheduled departure time, after accounting for ATM and weather-related delay causes;
- Resilience: Measure of the avoided loss of airport and airspace capacity;
- Safety: Change in Fatal accidents per year with ATM contribution.

All of these KPIs have targets for the three Steps defined by SESAR, reflecting the incremental improvement of the ATM system over time. Note, however, that some relatively new KPIs, such as "Resilience", lack a target for Step 1. In Vista, we will use these KPIs as a basis for the impact of the different business factors within the model, as shown in **Table 9**.

Note that most of these KPIs are defined relative to a baseline, and are thus expressed as a percentage. Moreover, it is important to bear in mind that if most of these KPIs represent an improvement when they are positive, it is not the case for all of them. In particular, "Environment / Fuel Efficiency", "Predictability / Flight Duration Variability", "Safety", and "Cost Effectiveness (TECH)" represent improvements when they are negative.

As mentioned above, the OISs are regularly being assessed as to their potential effects on the whole system, in particular in terms of the KPIs cited above. This is performed by Project B.05 and the results can be found in the various Performance Assessments Reports (Project B.05, 2015) produced by this project. These results are also compared to the target fixed by SESAR. These results are important to Vista, because they give quantitative assessments of the effect of the technologies, and could thus be directly used within the model. Even if the results are not available, the targets themselves can give a good estimation of the effects of the technologies. Also, since these effects and targets have been derived *independently*, there may be dependency conflicts that will need to be resolved at the Vista modelling stage.

3.1.1.2 Non-SESAR technology and operational changes

Besides SESAR operational and technology changes, there are foreseen evolutions for some of the stakeholders' internal operations. For instance, the use of automatic learning techniques combined with artificial intelligence and big data may provide real-time responses to airline operational needs. The integration of systems is paramount to achieve these changes. In general, it is expected that airlines will improve their management of on-time performance, turnaround and passenger information.

3.1.2 Fuel

Fuel represents a significant part of airlines' direct operating costs. Moreover, it has an impact on many different technical solutions, e.g. the effectiveness of delay recovery strategies is closely linked with the cost of using extra fuel to recover delay. Finally, the environmental impact of aviation is related to fuel consumption and therefore fuel cost might play an important role on the impact on environmental policies such as emission charges. For these reasons, in Vista, fuel is considered as an important business factor that should be modelled.

3.1.3 Demand

Demand evolution will drive the changes in supply. The economic development of the EU - EFTA region will drive modifications on demography and set up the macro-economic context where traffic will operate. This will have a major impact on passengers' demand. Evolution of competing means of transport, e.g. high-speed train, or technology that might affect demand, e.g. virtual reality, should be considered as they might have an impact on the demand.

3.1.4 Stakeholder business models

As previously mentioned, the business models implemented through the different stakeholders might have an impact on the solutions implemented. Significant changes can be expected in the 2035, and especially in the 2050, framework.

Broadly speaking, ANSP business models fall into one of the following categories:

1. ANSPs within a government department or as a separate branch of government;
2. Corporatised ANSPs fully owned by government;
3. Corporatised ANSPs partially owned by government;
4. Fully privatised ANSPs.

There is no simple criterion to decide whether (and if so, which) there is a single model which is best suited to cope with the changing environment.

Nevertheless, it is clear that a number of on-going or expected developments will substantially influence the way ANSPs will run their business.

One can think about the liberalisation of tower services, the development of virtual area control centres, the System-Wide Information Management, the shift from ground-based infrastructure to satellite communication, increased automation, collaborative information-based services and the growth of Unmanned Aerial Vehicles (UAV) presumably leading to the emergence of providers of UTM (UAV Traffic Management).

3.2 Summary of business factors

The business factors considered are defined from the analysis of the previous sections. In Vista, the factors have been classified depending on the phase they are affecting and by business areas, each factor is identified with an ID to facilitate its traceability through the different deliverables of the project. These IDs are linked to the factors' business areas.

- **Table 9** presents the operational and technological business factors that affect the gate-to-gate phase. These factors are grouped into the following business areas:

- SESAR Operational Changes Packages (factor ID: Business Technology SESAR (BTSx)): In this case, the business factors correspond to the Operational Sub-Packages defined in SESAR (European ATM Portal as in December 2016). These Operational Packages are related with OFAs and operational and technological changes;
- Other operational and technology changes (factor ID: Business Technology Others (BTOx)): Operational Changes and technology updates that are derived from research and development activities or changes identified by SESAR ATM Master plan but not captured in the different Operational Packages or included directly within the SESAR descriptions.

- **Table 10** groups the factors that affect the pre-/post-gate phases business factors, i.e. access and egress to the airport, and airport processes. These factors will affect the door-to-door experience of the passengers. These business factors are grouped by:
  - Airport access / egress (factor ID: Business Airport Access (BAAx)): factors that will affect the time required to access/egress the airport;
  - Airport processes (factor ID: Business Airport Processes (BAPx)): which might affect the total time at the airport from a passengers' perspective;
- **Table 11** groups the factors that impact demand along with other economic factors.
  - Demand evolution (factor ID: (BEDx)): factors that affect the demand and hence affecting the demand and supply of passengers' itineraries and flights;
  - Other economic factors (factor ID: (BEOx)): other economic factors affecting operations, such as fuel or airspace charges.

Table 8 summarises the business factors grouped by business area.

Table 8. Summary of business factors

Business area	Business factor	Factor ID
SESAR Operational Changes packages	Weather Resilience (SPC01.01)	BTS1
	Airport Safety (SPC01.02)	BTS2
	Enhanced Runway Throughput (SPC01.03)	BTS3
	Enhanced Route Structures (SPC02.01)	BTS4
	4D Trajectory Management (SPC03.01)	BTS5
	Airborne Spacing and Separation (SPC03.02)	BTS6
	Ground Based Conflict Management (SPC03.03)	BTS7
	Air Safety Nets (SPC03.04)	BTS8
	Traffic Synchronisation (SPC04.01)	BTS9

Business area	Business factor	Factor ID
	Integrated Surface Management (SPC04.02)	BTS10
	Demand and Capacity Balancing Airports (SPC05.01)	BTS11
	Demand and Capacity Balancing En-Route (SPC05.03)	BTS12
	Remotely provided Air Traffic Services for aerodromes (SPC06.03)	BTS13
	CNS (ENB01.01)	BTS14
	SWIM (ENB02.01)	BTS15
Other operational changes and technology changes	Drones / RPAS	BTO1
	Performance-based operations	BTO2
	Virtual control centre	BTO3
	Passenger reaccommodation tools	BTO4
	Machine learning and deep learning	BTO5
	OTP monitoring	BTO6
	Integrated turnaround/hub operations control	BTO7
	Cybersecurity	BTO8
	Development of carbon-neutral fuels	BTO9
Airport access/egress	Airport multi-modal connectivity	BAA1
Airport processes	Self-processing at airport	BAP1
	Resource allocation at airport	BAP2
Demand evolution	Economic development of EU – EFTA	BED1
	Development of high-speed trains	BED2
	Societal travel characteristics changes	BED3
	Travel substitutes	BED4
	Air traffic predictability	BED5
	Modal competition *versus* cooperation	BED6
Other economic factors	Fuel prices	BEO1
	Airspace charges	BEO2
	Airline business models	BEO3
	Smart, integrated ticketing	BEO4

Table 9. Operational and technological business factors affecting gate-to-gate

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
SESAR Operational Changes packages	Weather Resilience (SPC01.01)	Include OFAs: • OFA01.01.01 LVPs using GBAS	• Improve low visibility operations using GBAS CAT II/III	Airlines Airports	• Safety: o Tr-BO: N/A / -0.87% • Resilience: o Ti-BO: +9.52% / N/A	BTS1

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Airport Safety (SPC01.02)	Includes OFAs: • OFA01.02.01 Airport safety nets • OFA01.01.02 Pilot enhanced vision Detection and alert of conflicting ATC clearances and deviation of vehicles from instructions. Increase situational awareness for vehicles. On-board systems enhanced to detect risk of collisions during runway operations. Situational awareness enhanced with ADS-B.	• Enhanced airport safety nets for flight crew • Ground situational awareness in all weather conditions • Airport safety nets for vehicles • Airport safety nets • Traffic optimisation on single and multiple runway airports • Traffic alerts for pilots for airport operations • Enhanced airport safety nets for controllers • Independent rotorcraft operations at the airport	Airlines Airports	• Safety: o Ti-BO: N/A / -8.5% o Tr-BO: N/A / -1.61%	BTS2

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Enhanced Runway Throughput (SPC01.03)	Includes OFA: • OFA01.03.01 Enhanced Runway Throughput Improve wake turbulence separation during take-off and final approach based on weather conditions, aircraft characteristics and required surveillance performance. It can also detect wake-turbulence suing direct measurements from the ground or on-board. Separation using time instead of distance.	• Approach and departure separations • Enhanced arrival procedures • Time-based separation (TBS) for final approach • Wake turbulence separations optimisation • Traffic optimisation on single and multiple runway airports	Airports	• Airport Capacity: o Ti-BO: +5.62% / +7% o Tr-BO: N/A / +2.14% • Airspace Capacity (TMA): o Tr-BO: N/A / +4.31% • Environment/fuel efficiency: o Ti-BO: -0.07 / -0.25% o Tr-BO: N/A / -0.37% • Predictability/Flight Duration Variability: o Ti-BO: -0.76% / -3% • Resilience: o Ti-BO: +83.33% / N/A • Safety: o Ti-BO: N/A / 0.06%	BTS3

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Enhanced Route Structures (SPC02.01)	Includes OFA: • OFA02.01.01 Optimised 2D/3D Routes Enhancements on route structures allowing spacing between routes to be reduced.	• Advanced RNP • Enhanced TMA using RNP-based operations • Dynamic and enhanced routes and airspace	ANSPs Airlines	• Airport Capacity: o Ti-BO:+1% / N/A • Airspace Capacity (en-route): o Ti-BO: +10% / +5% • Airspace Capacity (TMA): o Ti-BO: +4.35% / +5% • Cost effectiveness: o Ti-BO: +1.41% / +3.33% • Environment/fuel efficiency: o Ti-BO: -0.78% / -0.5% o Tr-BO: N/A / -0.69% • Predictability/Flight Duration Variability: o Ti-BO: -1.14% / -2% • Safety: o Ti-BO: N/A / -8.16% • Safety: o Tr-BO: N/A / -4.06%	BTS4

4D Trajectory Management (SPC03.01)	Includes OFAs: • OFA03.01.03 Free Routing • OFA03.01.04 Business and Mission Trajectory Initial reference business trajectory (iRBT) which includes the initial shared business trajectory (iSBT) containing target times over/arrival (TTO/TTA). Increased integration of NOP and Airport Operations Plan information. Shared operational planning and real-time data. Predicting traffic complexity and overloads with planned trajectory and network information. This will allow us to apply mitigation strategies at local and network levels. Using Direct Routing Airspace (DRA) and Free routing airspace (FRA). DRA: Entry and exit points with published direct routing. FRA: Entry and exit points with no fixed airspace structures or route networks. Reference trajectory used by ATM partners during flight execution. Same information as SBT.	• Information sharing and business trajectory • Collaborative NOP • Automated support for traffic complexity assessment • Free route • Mission trajectory and enhanced mission trajectory	All stakeholders	• Airport Capacity: o Tr-BO: N/A / +0.32% • Airspace Capacity (en-route): o Ti-BO: +0.5% / +2% • Airspace Capacity (TMA): o Ti-BO: +0.5% / +2% o Tr-BO: N/A / +3.62% • Cost Effectiveness: o Ti-BO: +0.05% / +0.5% • Environment/fuel efficiency: o Ti-BO: -0.4406% / -0.65% o Tr-BO: N/A / -0.57% • Predictability/Flight Duration Variability: o Ti-BO: -3.64% / -4% • Safety: o Ti-BO: N/A / -0.09%	BTS5

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Airborne Spacing and Separation (SPC03.02)	Includes OFAs: • OFA03.02.03 ATSA-ITP • OFA03.02.04 ASEP	• Airborne separation assistance system (ASAS) spacing • Ad hoc delegation of separation to flight deck • Enhanced airborne collision avoidance for commercial air transport normal operations - ACAS Xa • Collaborative control	ANSPs Airlines	• Airport Capacity: o Ti-BO: +2% / +1% o Tr-BO: N/A / +1.07% • Airspace Capacity (TMA): o Ti-BO: +6.45% / +5% • Cost Effectiveness: o Ti-BO: +0.48% / +0.73% • Environment/fuel efficiency: o Ti-BO: -0.11% / -0.3% • Predictability / Flight Duration Variability: o Ti-BO: -5.78% / -5.5% • Safety: o Ti-BO: N/A / -0.14%	BTS6

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Ground Based Conflict Management (SPC03.03)	Includes OFAs: • OFA03.03.01 Ground Based Separation Provision in En-Route • OFA03.03.02 Ground Based Separation Provision in the TMA New roles and operational procedures for controllers.	• Sector team operations • Trajectory-based tools • High productivity controller team organisation • Generic (non-geographical) controller validations • Improved performance in the provision of separation • Advanced separation management • Flight- and flow-centric ATC	ANSPs	• Airspace Capacity (TMA): o Ti-BO: +13.64% / +5% o Tr-BO: N/A / +21.8% • Airspace Capacity (en-route): o Ti-BO: +9.89% / +8.5% • Cost Effectiveness: o Ti-BO: +8.76% / +5.83% • Environment/fuel efficiency: o Ti-BO: -0.07% / -0.21% o Tr-BO: N/A / -0.85% • Predictability / Flight Duration Variability: o Ti-BO: -4.08% / -3.2% • Safety: o Ti-BO: N/A / -1.18% o Tr-BO: N/A / -5.74%	BTS7

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Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Air Safety Nets (SPC03.04)	Includes OFAs: • OFA03.04.01 Enhanced Ground Based Safety Nets • OFA03.04.02 Enhanced ACAS Operations Enhance STCA, enhanced ACAS with aircraft-derived data (ADD).	• Enhanced safety nets • Traffic alerts for pilots for airport operations	ANSPs Airlines	• Safety: o Ti-BO: N/A / -6.93% o Tr-BO: N/A / -9.24%	BTS8

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Traffic Synchronisation (SPC04.01)	Includes OFAs: • OFA03.02.01 ASAS Spacing • OFA04.01.01 Integrated Arrival/Departure Management at Airports • OFA04.01.02 Enhanced Arrival & Departure Management in TMA and En-Route Report and maintain controlled time of arrival. Support coordination of departure and arrival traffic flows for multiple airports in the same vicinity. Calculating target take off times (TTOT) and target start approval time (TSAT). In combination with A-CDM. Integration with surface management constraints to determine optimal surface movement. A-SMGCS. AMAN extended to en-route phase to 180-200 NM from the airport. Traffic sequencing during en-route phase.	• Controlled time of arrival (CTA) • AMAN/DMAN integration including multiple airports • DMAN synchronised with pre-departure sequencing • DMAN integrating surface management constraints • AMAN extended to en-route airspace • Use of arrival and departure management Information for traffic optimisation within the TMA	All stakeholders	• Airport Capacity: o Ti-BO: +2% / +1% o Tr-BO: N/A / +1.07% • Airspace Capacity (en-route): o Ti-BO: -4.28% / 0% • Airspace Capacity (TMA): o Ti-BO: +6.45% / +5% o Tr-BO: N/A / +6.74% • Cost Effectiveness: o Ti-BO: +0.48% / +0.73% • Environment/fuel efficiency: o Ti-BO: -0.11% / -0.3% • Predictability / Flight Duration Variability: o Ti-BO: -5.78% / -5.5% • Resilience: o Ti-BO: +24.42% / N/A • Safety: o Ti-BO: N/A / -0.14% o Tr-BO: N/A / -0.31%	BTS9

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Integrated Surface Management (SPC04.02)	Includes OFAs: • OFA04.02.01 Integrated Surface Management A-SMGCS providing automatic taxi routes with estimated taxi times and managing conflicts Datalink information exchange between flights, ATCo and vehicles and ATCo. Assistance to vehicles and flight crews with taxiway lighting.	• Automated assistance to controller for surface movement planning and routing • Integrated surface management datalink • Integrated surface management	Airports	• Airport Capacity: o Tr-BO: N/A / +0.12% • Environment/fuel efficiency: o Ti-BO: -0.17% / -0.25% o Tr-BO: N/A / +0.09% • Predictability / Flight Duration Variability: o Ti-BO: -10.8% / -7% • Resilience: o Ti-BO: +25% / N/A • Safety: o Ti-BO: N/A / -1.37% o Tr-BO: N/A / -0.06%	BTS10

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Demand and Capacity Balancing Airports (SPC05.01)	Includes OFAs: • OFA05.01.01 Airport Operations Management Increased integration of NOP and Airport Operations Plan information. Shared operational planning and real-time data. Interface the landslide with the ATM network. AOP and A-CDM from normal, adverse and/or exceptional operating conditions derived from planning, monitoring, management and post-operations analysis. TTA derived from the AOP used by NM to balance arrival demand and capacity.	• Collaborative NOP • Collaborative airport • Enhanced collaborative airport performance management	Airlines Airports	• Airspace Capacity (TMA): o Ti-BO: +0% / +0.25% • Environment/fuel efficiency: o Ti-BO: -0.22% / -0.02% • Predictability / Flight Duration Variability: o Ti-BO: -9.23% / -5% • Punctuality: o Tr-BO: +4.85% / N/A • Safety: o Ti-BO: N/A / -0.16%	BTS11

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Demand and Capacity Balancing En-Route (SPC05.03)	Includes OFAs: • OFA05.03.01 Airspace Management and AFUA • OFA05.03.03 Dynamic Airspace Configurations • OFA05.03.04 Enhanced ATFCM processes • OFA05.03.06 UDPP • OFA05.03.07 Network Operations Planning Increased integration of NOP and Airport Operations Plan information. Shared operational planning and real-time data. Predicting traffic complexity and overloads with planned trajectory and network information. This will allow to apply mitigation strategies at local and network levels **(cont'd …)**	• ASM and advanced-FUA • Dynamic airspace configurations • Collaborative NOP • Automated support for traffic complexity assessment • Collaborative airport • UDPP • Enhanced Short Term ATFCM Measures (STAM) • CTOT to TTA for ATFCM purposes • Development of trajectory-based tools • Dynamic and enhanced routes and airspace • Flight- and flow-centric ATC	ANSPs Airlines	• Airspace Capacity (en-route): o Ti-BO:+8.8% / +10% • Airspace Capacity (TMA): o Ti-BO:+5% / +4.65% o Tr-BO: N/A / +4.4% • CMCC (CMC2): o Ti-BO: +0.07% / N/A • Cost Effectiveness: o Ti-BO: +2.91% / +4.17% • Environment/fuel efficiency: o Ti-BO: -0.19% / -0.27% o Tr-BO: N/A / -0.22% • Predictability / Flight Duration Variability: o Ti-BO: -0.27% / N/A • Safety: o Ti-BO: N/A / -2.21% o Tr-BO: N/A / -1.32%	BTS12

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
		Interface the landside with the ATM network. AOP and A-CDM from normal, adverse and/or exceptional operating conditions derived from planning, monitoring, management and post-operations analysis. TTA derived from the AOP used by NM to balance arrival demand and capacity. Exchange departure order of flights from different airlines penetrating the same constraint. STAM using cooperative decision-making. Target Times shall be applied to selected flights for ATFCM purposes to manage ATFCM at congestion and not only at departure. Target Times of Arrival (TTA) derived from Airport Operations Plan (AOP).				

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Remotely provided Air Traffic Services for aerodromes (SPC06.03)	Includes OFA: • OFA06.03.01 Remote Tower Provision of remotely-provided ATS for one/multiple aerodromes.	• Remote tower	ANSPs Airports	• Cost Effectiveness (ATCO): o Ti-BO: +1.06% / 0% • Cost Effectiveness (TECH): o Ti-BO: N/A / -1.55%	BTS13
	CNS (ENB01.01)	Includes OFAs: • ENB01.01.03 Communication • ENB01.01.04 Navigation • ENB01.01.05 Surveillance New optimisation with new functionalities and/or technologies that support higher performance and efficiency.	• CNS rationalisation • Future satellite communications datalink • GBAS • Multi-constellation/multi frequency GNSS • Future Communication Infrastructure (FCI) terrestrial datalink	All stakeholders	• Cost Effectiveness: o Ti-BO: N/A / -2%	BTS14
	SWIM (ENB02.01)	Includes OFAs: • ENB02.01.01 SWIM • ENB02.01.02 AIM/MET Improvements on pilot briefing information. Information exchanges built on standards and delivered though an IP-based network.	• Digital integrated briefing • Aeronautical information exchange • A/G advisory information sharing	All stakeholders	• Environment/fuel efficiency: o Ti-BO: N/A / -0.05% • Predictability / Flight Duration Variability: o Ti-BO: N/A / -0.5%	BTS15

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
Other operational changes and technology changes	Drones / RPAS	Integration of remotely piloted aircraft systems in the airspace and into the ATM system. Applications such as goods transportation might be expected as early as RP3. Un-crewed passenger platforms are less likely to be deployed in RP3 timeframe (Performance Review Body, 2016a).	• Segregation of airspace for the use of RPAs • Use of RPAs in non-segregated airspace in low-complexity airspace • Use of RPAs in non-segregated airspace in complex airspace. • Surface operations by RPAS • Airborne detect and avoid systems supporting integrated RPAS operations	ANSPs Airlines	Potential disruption with new entrants in the ANSP market. Increased pressure on airspaces (more traffic).	BTO1
	Performance-based operations	Development of performance-based navigation with the management of trajectory planning and execution.	• Integration of trajectory management processes in planning and execution • Management and sharing of data used in trajectory (AIM, meteo) • Performance-based trajectory prediction	ANSPs Airlines	Operations based on performance targets Increased cost efficiency for airlines and ANSPs Increased capacity for airspaces Increased predictability Increased resilience	BTO2

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Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Virtual control centre	Provision of remotely-provided ATS for airspace	• Work station, service interface definition and virtual centre concept	ANSPs	Reduction of cost for ANSPs Flexibility and efficiency gain to allocate resources.	BTO3
	Passenger reaccommod-ation tools	Use of technology to identify passenger reaccommodation for disruption.	• Reaccommodation capabilities • Advanced arrival-departure coordination.	Airlines	Reduction of operational costs and delay management. Reduction of passenger delay.	BTO4
	Machine learning and deep learning	Machine learning and deep learning in real time. Requires infrastructure required (e.g., satellite communications, equipment in aircraft, integrated EFB), systems' integration, maintenance and knowledge extraction.	• Real time applications to predict and fine tuning operations.	Airlines	Optimisation of operations under disruption. Increased cost efficiency, higher predictability, higher resilience of operations	BTO5
	OTP monitoring	Enhanced OTP monitoring and tracking of disruptions.	• Enhanced OTP monitoring • Enhanced tracking of disruptions in the airline operations' network	Airlines	Higher reactivity to disruptions and enhanced disruption management.	BTO6

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect*	Factor ID
	Integrated turnaround/hub operations control	Integrated turnaround and hub management tools considering passengers' connections and flights' turnarounds.	• Integration of turnaround and passengers' connections at hubs	Airlines	Enhanced A-CDM, resources allocation and reduction of passengers' disruptions due to missed connections.	BTO7
	Cybersecurity	Increasing reliance on inter-connected ATM systems, services and technologies increases the risk of cyber-attacks. Cybersecurity and its impacts on safety are considered within the safety KPA for its inclusion in RP3 (Performance Review Body, 2016a).	———	All stakeholders	Safety and security at risk Increased investment on cybersecurity	BTO8
	Development of carbon-neutral fuels	Neutral-carbon fuels uptake by different airlines (IATA, 2015)	———	Airlines Environment	Reduction of penalties from ecological regulations.	BTO9

* For SESAR-related business factors, for each Step, two values are quoted, separated by a "/". The first value is the expected impact, as determined in the validation exercises (described above), the second is the target value for the corresponding SESAR Sub-Package (often abbreviated as "SPC" for "Sub-Package Code"). For the corresponding units associated with these values, see Section 3.1.1.1.

Terminology: Ti-BO and Tr-BO refer to time-based operations and trajectory-based operations, respectively, as used in the European ATM Portal under the terms "Step 1" and "Step 2" (accessed February 2017).

Table 10. Pre/post-gate phases business factors

Business area	Business factor	Description	Operational and technological changes	Expected effect	Factor ID
Airport access / egress	Airport multi-modal connectivity	Connection of the airport with other means of transport: train, road. Factors affecting the preference of means of transport to access / egress the airport	• Intermodality • High-speed train connections at the airport • Regional train development • Environmental awareness • Ticket integration • Autonomous vehicles	Airport connectivity will affect the catchment area and the times to access / egress the airport. Increases demand for big airports, decreases demand for short routes. The means of transport selected to access / egress the airport affects the total time. Increases passenger satisfaction, decreases travelling time.	BAA1
Airport processes	Self-processing at airport	Development of technologies allowing self-processing at the airport, reducing airport process times.	• Self check-in • Self bag drop • Self boarding • Self passport check	Increases passenger satisfaction, decreases processing time.	BAP1
	Resource allocation at airport	Development of technologies allowing the tracking of flows of passengers in order to redistribute resources to manage fluctuations in real time	• predictive based on machine learning and big data • real time passenger tracking thanks to Wi-Fi, RFIDs • beacons • facial recognition	Increased predictability of the processing time, increased resilience.	BAP2

Table 11. Demand and other economic business factors

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect	Factor ID
Demand evolution	Economic development of EU - EFTA	Modification of demographic and macro-economic environment of the EU	• Middle class development in Europe • Supply chain costs • Regionalisation • Energy demand • Transport demand	Airlines	Modification on the passenger and flight demand	BED1
	Development of high-speed trains	Increment of high-speed train share in the travel market.	• Continuing increase of high-speed rail network • Next generation of high-speed trains	Airlines Airports	High-speed trains have a dual effect: • direct competition with airlines for some routes (decreased local demand), • increased catchment areas for some airports.	BED2

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect	Factor ID
	Societal travel characteristics changes	Evolution of current passengers' profiles leading to changes in demand.	• Passengers' profile evolution (cultural seeker, family and holiday traveller, single traveller, best agers, eco-responsible passenger profile, digital native business traveller (SESAR JU, 2017b)) • Environmental awareness	Airlines	Changes of passengers' distribution between the different profiles considered in Vista	BED3
	Travel substitutes	New technology which reduces travel demand.	• Development of virtual reality meetings and tourism	Airlines	Decrease demand for business (VR meetings) and leisure (VR tourism) travel. I.e. reduction of passenger demand	BED4
	Traffic predictability	Some ANSPs are reporting that traffic volatility is increasing, i.e. traffic predictability is decreasing, and will continue to remain high, even though at least some of the causes could quickly change (e.g. low fuel price driving airlines to circumnavigate charging zones with high unit rates or congested airspace).	———	ANSPs	If traffic predictability decreases, there will be an increase in traffic volatility and financial instability for ANSPs	BED5

Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect	Factor ID
	Modal competition *versus* cooperation	Tendencies to liberalise air navigation services (e.g. tower services) bring more competition into the system. In parallel, FABs and other alliances (Borealis, B4, Gate one, A6, COOPANS, ...) show increased cooperation	———	ANSPs	May lead to more cost effective service provision, but also to the establishment of super-monopolies	BED6
Other economic factors	Fuel prices	Fuel price evolution	———	Airlines	Impact on operational costs and efficiency of some mechanisms (e.g. delay management and recovery)	BEO1
	Airspace charges	Airspace charges and heterogeneity through Europe	• ANSP level CRCO charges • FAB CRCO charges • Unified CRCO charges	ASNPs Airlines	Possible trade-offs on route selection considering direct operating costs.	BEO2
	Airline models	Changes in airlines business models, including the degree of customer focus by the airline Note: could be an endogenous variable in the model	• cost-driven, passenger satisfaction-driven etc.	Airlines	Changes market shares of the different types of airlines considered in Vista. An increased customer focus may increase customer satisfaction leading to higher market share.	BEO3

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Business area	Business factor	Description	Operational and technological changes	Primary stakeholder	Expected effect	Factor ID
	Smart, integrated ticketing	Automatic multi-modal passenger reaccommodation	• agreements between different types of stakeholders (airlines, train companies, etc.)	Airlines Airports	Increased predictability, decreased travelling times through reduction of buffer times.	BEO4

4 Next steps and look ahead

In this deliverable, the regulatory and business factors considered in Vista have been identified by looking at the main effort in R&D in the ATM world as well as reports on current and future regulations. The lists of the factors are purposefully highly inclusive. However, it is clear that some factors are more important than others regarding their quantitative impacts and some factors cannot be captured by the model envisioned by Vista. Moreover, not all the factors are equally pertinent with respect to Vista's objectives. As a consequence, some of them will be only considered at a high-level during the modelling process, whereas others will be more central.

In particular, it is important to make a distinction between the factors for which we want to assess the impact as opposed to factors which are likely to be implemented anyway within a certain timeframe. This distinction is important as not all factors can be tested independently from each other, due to purely combinatorial effects and the fact that some factors are correlated in their values due to their close relationship.

The next steps are planned as follows:

- **Business and Regulatory Scenarios Report (Deliverable 3.1, FEB 2017):** this will define two types of factors: 'background factors', which will form the backbone of the scenarios, and the 'foreground factors', which will be explicitly modelled with their different possible values in the model in order to assess their specific effects. In this deliverable, the possible values that are considered for the different factors will also be presented. Each of the factors needs to be studied in detail to see how it could be reflected in the model. There are two main ways each of them can be implemented:
    - with a heuristic approach, based on quantitative assessment of the impact of the factor on one part of the system. For instance, the impact of free-routing can decrease the overall gate-to-gate time by X%;
    - with a dedicated model, i.e. changing some rules within the model. For instance, the mechanism of UDPP could actually be explicitly implemented within the model.

  Clearly, not all the factors have a well-defined output in terms of their impact on the metrics, so some of the factors modelled with a heuristic approach will be estimated approximately with input from the stakeholders.

- **Stakeholder Consultation on Business and Regulatory Scenarios (Deliverable 6.2, APR 2017):** The factors identified in this deliverable (D2.1) and classified in D3.1, will be the subject of a consultation with the stakeholders. This consultation will allow us to adjust the impact of the factors in the model and to identify which scenarios should be prioritised.
- **Airline site visits (APR/MAY 2017):** Once the modelling phase starts, site visits to the airlines will allow us to improve how the different factors impact the parameters of the model and to validate

the modelling approach considered for each factor. It will also help us to identify the level of detail required for the different factors considered in Vista.

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Annex I – KPAs, KPIs, targets and ambitions

This Annex summarises the information regarding KPAs, KPIs, targets and ambitions defined for them for the Single European Sky (SES) framework, SESAR, Flightpath 2050 and the roadmap to Single European Transport Area.

Single European Sky (SES) Framework Regulation

During RP2, defined in Regulation 390/2013 for the period 2015-2019 (European Commission, 2013b), different indicators are monitored within four KPAs (safety, capacity, environment and cost-efficiency). **Table 12** shows the ANS performance indicators within the KPAs and the type of monitoring performed. Whilst some are currently (only) monitored, others have specific associated targets for the reference period (Performance Review Body, 2013). Union-wide targets are set following a one-year process. The first part of the process is the development of evidences on the possible level of Union-wide targets which are usually based on historical analysis, latest available forecasts, benchmarking between ANSPs, continental benchmarking (comparison between Europe and US). Depending on the KPIs, this process may also include inputs from the Network Manager, results from simulations or even inputs from econometric studies. This work is done by the PRB and submitted to an open written consultation. The second phase is a more political phase where the European Commission considers this PRB input and proposes a Commission Regulation to the Single Sky Committee. A few meetings are required to get a majority in favour of a certain proposal. This is usually achieved through modification of assumptions or proposals made by States and input from airspace users outside the Single Sky Committee.

Local targets (be it at FAB or national levels) are proposed by States in their Performance Plans taking into account the adopted Union-wide targets and knowing against which criteria their proposed targets will be assessed by the European Commission. These assessment criteria are known in advance as they are listed in the performance scheme Regulation.

Table 12. KPAS and ANS performance indicators for RP2

KPA	ANS performance indicators	Regions where indicator applies on RP2		
		EU wide	FAB	National
Safety	Effectiveness of safety management (EoSM)	✓	✓	!

KPA	ANS performance indicators	Regions where indicator applies on RP2		
		EU wide	FAB	National
	Application of severity classification scheme (RAT methodology)	✓	✓	!
	Application of Just Culture (JC)	×	✓	!
	Separation infringements	×	!	!
	Runway incursion	×	!	!
	ATM-specific occurrences at ATS units	×	!	!
	Airspace infringements	×	!	!
	Level of occurrence reporting	×	!	!
	Application of automatic data recording for separation minima infringement monitoring	×	!	!
	Application of automatic data recording for runway incursion monitoring	×	!	!
Environment	Horizontal flight efficiency of last filed flight plan (KEP)	✓	×	×
	Horizontal flight efficiency of actual trajectory (KEA)	✓	✓	×
	Effectiveness of booking procedures for FUA	!	×	!
	Rate of planning of CDRs	!	×	!
	Effective use of CDRs	!	×	!
	Additional time in taxi-out phase	×	×	!*
	Additional time in terminal airspace	×	×	!*
Capacity	En-route ATFM delay	✓	✓	!**
	Arrival ATFM delay	!	×	✓*
	ATFM slot adherence	×	×	!*
	ATC pre-departure delay	×	×	!*

KPA	ANS performance indicators	Regions where indicator applies on RP2		
		EU wide	FAB	National
Cost-efficiency	Determined Unit Cost (DUC) for en-route-ANS	✓	×	✓***
	Determined Unit Costs (DUC) for terminal ANS	✓	×	✓***
	Costs of EUROCONTROL	!	×	×

✓ Targets

! Monitored

× Not considered

* Includes National and Airport

**Local

*** Charging zones

Commission Implementing Decision 2014/132 sets the Union-wide targets for the KPAs that render them mandatory in RP2 (European Commission, 2014g), as presented in **Table 13**. These targets have been determined with traffic assumptions at the Union-wide level in en-route service units of 114 305 000 for 2019 and with a cost for en-route air navigation services forecast at the Union-wide level of EUR2009 5 612 769 000.

Table 13. Union-wide targets

KPA	Target
Safety	Union-wide targets are set at achieving high levels of effectiveness of safety management and full application of the severity classification based on the Risk Analysis Tool methodology by 2019.
Capacity	Reduction of the en-route air traffic management delay to 0.5 minutes per flight for each year.
Environment	Reduction of the average horizontal en-route flight inefficiency for the last filed flight plan trajectory (KEP) to 4.1% and for the actual trajectory (KEA) to 2.6%.
Cost-efficiency	Setting the average Union-wide determined unit cost for en-route air navigation services as defined in point 4.1 (a) of Section 1 of Annex I to Implementing Regulation (EU) No 390/2013, expressed in real terms EUR2009, of EUR 56.64 for 2015, EUR 54.95 for 2016, EUR 52.98 for 2017, EUR 51.00 for 2018, and EUR 49.10 for 2019. This corresponds to an annual reduction of 3.3% in the determined unit cost of en-route ANS.

The targets in **Table 13** are detailed by FAB and charging zone as laid out by Commission Implementing Decision 2015/347 and Commission Implementing Decision 2015/348, for which values have been updated by Commission Implementing Decision 2016/599 (European Commission, 2015c; European Commission, 2015d; European Commission, 2016b). These detailed targets, for 2019, are presented in **Table 14** for capacity, environment and cost-efficiency KPAs.

Table 14. FAB and charging zone targets RP2 for 2019

FAB	Charging zone	Capacity	Environment	Cost-efficiency		
		En-route ATFM delay min/flight	KEA	Total en-route determined costs (2009 values)	Total en-route service units	En-route determined costs (2009 values)
FAB-CE	Austria	0.29 (0.27*)	1.81	EUR 168 977 503	2 882 000	EUR 58.63
	Croatia			HRK 573 017 597	1 926 787	HRK 297.40
	Czech Republic			CZK 2 570 401 338	2 881 000	CZK 892.19
	Hungary			HUF 23 350 067 982	2 512 526	HUF 9 293.46
	Slovakia			EUR 61 041 573	1 330 604	EUR 45.88
	Slovenia			EUR 28 906 876	546 470	EUR 52.90
UK-IR	Ireland	0.26	2.99	EUR 118 798 780	4 262 135	EUR 27.87
	United Kingdom			GBP 526 523 219	10 940 000	GBP 48.13
FABEC	Belgium - Luxembourg	0.43	2.96	EUR 156 223 161	2 501 309	EUR 62.46
	France			EUR 1 154 043 494	19 064 000	EUR 60.54
	Germany			EUR 892 382 909	13 004 000	EUR 68.62
	The Netherlands			EUR 170 296 296	2 902 813	EUR 58.67
	Switzerland			CHF 153 393 253 **	1 470 383 **	CHF 104.32 **
Baltic	Poland	0.22	1.36	PLN 585 822 496	5 039 000	PLN 116.26
	Lithuania			EUR 20 814 037	559 548	EUR 37.20
	Cyprus	0.38	2.45	EUR 48 952 987	1 521 959	EUR 32.16

FAB	Charging zone	Capacity	Environment	Cost-efficiency		
		En-route ATFM delay min/flight	KEA	Total en-route determined costs (2009 values)	Total en-route service units	En-route determined costs (2009 values)
Blue Med	Greece			EUR 144 936 752	4 599 834	EUR 31.51
	Italy			EUR 651 586 847 (EUR* 604 216 765)	10 630 000 (9 897 521*)	EUR 61.30 (EUR* 61.05)
	Malta			EUR 18 982 242	672 000	EUR 28.25
Danube	Bulgaria	0.09 (0.04*)	1.37	BGN 154 176 130	3 090 000	BGN 49.90
	Romania			RON 530 795 951	4 441 542	RON 119.51
DK-SE	Denmark	0.09	1.19	DKK 616 095 213	1 628 000	DKK 378.44
	Sweden			SEK 1 698 130 296	3 425 000	SEK 495.80
NEFAB	Estonia	0.13	1.22	EUR 20 295 459	885 643	EUR 22.92
	Finland			EUR 37 662 953	861 000	EUR 43.74
	Latvia			EUR 21 256 247	890 000	EUR 23.88
	Norway			NOK 897 883 922 **	2 549 966 **	NOK 352.12 **
SW	Portugal	0.52 (0.30*)	3.28	EUR 109 037 112	3 171 128	EUR 34.38
	Spain (Continental)			EUR 545 563 910	9 238 000	EUR 59.06
	Spain (Canarias)			EUR 85 450 091	1 543 000	EUR 55.38

* values amended by Commission Implementing Decision 2016/599 (European Commission, 2016b)

** values as presented on their initial plans

RP3, which will (very probably) cover the reference period 2020-2024, is under preparation. Depending on the decisions made by States, it is most likely that the methodology for deriving targets will be very similar to that of RP2 if the KPIs remain the same. A White Paper was presented at the Single Sky Committee (SSC) (Performance Review Body, 2016a). In this White Paper, an analysis is performed for four KPAs in the context of the risks and evolution of the system:

- Regarding safety, the White Paper considers that there is scope to refocus attention on key risks which show interdependency issues. Security threads that could affect safety are also identified, e.g. cyber security. EASA has reviewed the safety performance indicators that should be considered (EASA, 2016). Some indicators currently considered in PR2 are advised to be discontinued, e.g. JC, while others should be modified, e.g. EoSM. One of the issues with safety indicators is that setting targets might be counterproductive as it might undermine reporting, having a negative impact the safety performance of the system. For this reason, the indicators that are Tier 1 and most of Tier 2 (high severity outcomes with ATM contribution and data-driven performance indicators) should only be indicators and monitored without assigned targets; Tier 3 indicators (safety risk management processes) are more suitable for target setting. EASA suggests the use of new Tier 2 indicators: runway incursions, separation minima infringements, over-deliveries of traffic by the network manager, i.e. the period of time when actual traffic is higher than 10% of the slot rate in an ATFM regulation, and ATM specific (technical) occurrences which could be monitored via EASA safety risk management and the European plan for aviation safety. Tier 3 would include effectiveness of safety management at ANSP and National Supervisory Authority levels, and Risk Assessment Tool (RAT) severity application. It has been suggested that with automated reporting, which would avoid under-reporting, additional targets could be included within the safety KPA relating to safety occurrences, such as runway infringements and separation minima infringements (European Commission, 2016c).

- Regarding the environment, RP3 should examine the interaction between the shortest route available and most cost efficient, as airlines might not select the one that provides a lower KEP. Other indicators are suggested such as vertical efficiency and the complex interaction between CO_2/NO_x and noise which might make it difficult to be targeted at an EU level. Noise is considered as an important factor that might require monitoring. The use of FUA should also be considered when selecting the routes available and hence when setting the targets for environment.

- Regarding capacity, RP3 might focus on the main European bottlenecks that create most of the delays with respect to the management of the airspace. Due to the high impact of industrial action, options should be considered in the development of RP3 to help minimise their frequency and impact (European Commission, 2016c). The importance of fully understanding the barriers to matching capacity to demand is also considered as an important factor which might lead to the need of a more precise KPI than just the average minutes of en-route ATFM delay per flight and of arrival ATFM delay per flight (European Commission, 2016c).

- Regarding cost efficiency, the White Paper shows the aspiration of the PRB to identify the boundaries between the different phases of flight and allocate cost accordingly. More competition might be encouraged. It has been suggested that the KPI capturing cost efficiency could be subdivided into services (e.g. staff costs and other operating costs), each with an associated and transparent charge (European Commission, 2016c). There are costs that are out of the control of ANSPs that might be removed from the KPIs and a mechanism needs to be created to avoid undesirable gaming behaviours when considering traffic forecasts, cost exemptions, costs postponement and cost allocation (en-route and terminal). In RP2 targets are set on inputs to unit rates, not outcomes, which leads to plans to be set on very conservative levels to the risk in favour of the ANSP, e.g. assumptions of low traffic scenarios to increase unit rates reducing traffic risk or some FABs designing incentives that are easy to meet or ineffective (Performance Review Body, 2016a).

Table 15 presents the performance objectives per KPA defined in the White Paper (Performance Review Body, 2016a).

Table 15 Performance objectives for PR3 (Performance Review Body, 2016a)

KPA	Target
Safety	• Reduction of loss of separation incidents both horizontally and vertically by focusing on system risk • Elimination of runway incursions • Improved management of ATM system security and business continuity
Environment	• Maintenance of contribution towards global emission by maintaining, or improving ATM contribution to fuel burn. (CO_2 emissions) • Improving the assessment of noise contribution and route design at a local level • Improving the delay caused by holding and en-route delay management to reduce CO_2 and NO_x effects at airports • Improving the management of fragmentation through better through standards management and facilitating competition in ATM
Capacity	• Maintaining delay measures to facilitate 98% of aircraft on time performance • Improving the use of Special Use airspace released to the community by special use airspace manager • Improving the resilience of the South East Quadrant with particular focus on Balkan State inclusion and improvements of Greece and Cyprus performance • Improving the level of airport capacity during RP3 and onwards, on the largest coordinated European airports, with an increase of airport slots at the same rate as the traffic increase

KPA	Target
Cost-efficiency	• Incentivising the deployment of technological developments to improve cost efficiency targets • Improving the effectiveness of the charging mechanisms to improve cost efficiency • Increasing the view of gate-to-gate to match cost and operational performance • Improve the effectiveness of the fifth pillar of SES by improving communication and change management dialogues • Improving the institutional arrangements to reduce duplication, improve harmonisation of common rule sets, and reduction of 'red tape'

Both the White Paper and comments received after a first consultation with stakeholders (Performance Review Body, 2016b) emphasise the importance of better understanding the interdependencies between the KPAs and KPIs (even KPIs within KPAs), on which further work is required. This is strongly expressed by many stakeholders (*ibid.*). Some view that the trade-offs need to be explored at the State, not EU, level, due to heterogeneity. Indicators in the ATM Master Plan and the SES Performance Scheme differ. Several major stakeholders would like to see (*ibid.*) a clearer mapping between SESAR Master Plan objectives and the (binding) SES PS targets. SESAR defines "aspirational" performance ambitions (ATM Master Plan, SESAR JU (2012)) and sets out supporting binding changes in the PCP (which does not include targets, but refers (SESAR JU, 2013) to "modest" contributions to the SES PS targets). Hence, a better understanding and integration between the ATM Master Plan (and SESAR Common Projects) impacts and expectations and the Performance Scheme indicators and targets should be considered. Finally, the outcome of the consultation proves that there are different views and compromises among States are still required during RP3. For this reason, changes are still expected regarding the final objectives of RP3.

SESAR ambitions

As noted above, the performance ambitions supported by SESAR are "aspirational" (SESAR JU, 2012). They refer to the performance capabilities that may be achieved if SESAR Solutions are made available. **Table 16** presents these performance ambitions per KPA.

Table 16. SESAR performance ambitions for 2035 (based on (SESAR JU, 2012))

KPA	SES High-level goals vs. 2005	KPI	SESAR ambitions vs. baseline 2012		Other information
			Absolute saving	Relative saving	
Safety	——	Accidents with ATM contribution	No increase in accidents	Improvement by a factor 3-4	——

KPA	SES High-level goals vs. 2005	KPI	SESAR ambitions vs. baseline 2012		Other information
			Absolute saving	Relative saving	
Environment	Enable 10% reduction in the effects flights have on the environment Positive impact on noise and air quality	CO_2 emissions (tonne/flight) • Horizontal flight efficiency (actual trajectory)* • Vertical efficiency • Taxi-out phase	0.79-1.6 tonne	5-10%	———
		Noise and local air quality*****	———	———	SESAR 2020 aims to provide specific indicators and metrics to assess solutions to improve performance
Capacity	Enable 3-fold increase in ATM capacity	Departure delay (min/dep) • En-route air traffic flow management delay* • Primary and reactionary delays all causes	1-3 min	10-30%	———
		Additional flights at congested airports (million)	0.2-0.4 (million)**	5-10%***	
		Network throughput additional flights (million)	7.6-9.5 (million)**	80-100%****	

KPA	SES High-level goals vs. 2005	KPI	SESAR ambitions vs. baseline 2012		Other information
			Absolute saving	Relative saving	
Cost efficiency (ANS productivity)	Reduce ATM services unit cost by 50% or more	Gate-to-gate direct ANS cost per flight • Determined unit cost for en-route ANS* • Determined unit cost for terminal ANS*	EUR 290-380	30-40%	———
Operational efficiency	———	Fuel burn per flight (tonne/flight)	0.25-0.5 tonne	5-10%	Airport surface operations: 38-75 kg/flight (30% reduction in average taxi fuel burn) TMA climb/descent operations: 163-325 kg/flight (10% reduction in average climb/descent fuel burn) En-route operations: 50-100 kg/flight (2.5% reduction in average cruise fuel burn)
		Flight time per flight (min/flight)	4-8 min	3-6%	———

KPA	SES High-level goals vs. 2005	KPI	SESAR ambitions vs. baseline 2012		Other information
			Absolute saving	Relative saving	
		Predictability*****	———	———	Increase arrival predictability according to RBT prior to push-back Ambition to reduce size of arrival at the gate time window for 70% of flights from 5 min to 2 min (60% reduction) 80% of the improvement expected from improvements on taxi-out and TMA arrivals.
Security	———	ATM related security incidents resulting in traffic disruptions	No increase in incidents	———	———

* Targeted by SES

** Additional flights, not saving

*** Additional flights that can be accommodated at congested airports, representing 5-10% of flights at congested airports (≈31% of 14.4 (million) flights in 2035)

**** Additional traffic accommodated in 2035 in comparison with 2012 and associated with ANSP productivity gains, enabled by SESAR

***** Not directly KPI but indicator/area to which aims have been defined

Flightpath 2050

Flightpath 2050 defines goals for the 2050 period (European Commission, 2011e) for:

Transport efficiency:

- 90% of travellers within Europe are able to complete their journey, door-to-door within 4 hours;
- Flights arrive within 1 minute of the planned arrival time regardless of weather conditions;
- Air traffic management system handle at least 25 million flights a year (fixed-wing, rotorcraft, manned, unmanned and autonomous);
- 24-hour efficient operation of airports;
- Ground infrastructure allowing connection to other modes.

Environment:

- 75% reduction in CO_2 emissions per passenger kilometre and 90% reduction in NO_x emissions with respect to 2000 aircraft capabilities;
- perceived noise emissions reduced by 65% with respect to 2000 aircraft capabilities;
- Emission-free while taxiing;
- Europe as a centre of excellence on sustainable alternative fuel.

Safety and security:

- Less than one accident per ten million commercial flights;
- Integration of unmanned air vehicles in same airspace as manned vehicles safely;
- Seamless security with minimum passenger impact.

Roadmap to Single European Transport Area

The Roadmap to Single European Transport Area covers all transport within Europe, i.e. not only air transport (European Commission, 2011d). However, ANS contribution should be considered when analysing the emission targets set for all transports (ANS contribution represent 0.2%). The roadmap to Single European Transport Area defines a target of:

- A reduction of at least 60% of GHGs with respect to 1990 by 2050 (corresponding to a reduction of around 70% below 2008 levels);
- A reduction of GHGs of around 20% below 2008 levels by 2030.

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