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Abstract

This Functional Requirements Document (FRD) outlines the functional and non-functional requirements for SESAR Solution 0408 – Green Route Charging (GRC). Developed in two stages —Initial and Full Solution—GRC aims to reduce horizontal flight inefficiencies caused by unit rate differences and promote climate-friendly trajectories by accounting for both CO_2 and non-CO_2 emissions. The goal is to reach TRL 2 for the Initial Solution and TRL 1 for the Full Solution.

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Green-GEAR

GREEN OPERATIONS WITH GEOMETRIC ALTITUDE, ADVANCED SEPARATION & ROUTE CHARGING SOLUTIONS

Green-GEAR

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1 Executive summary

This Functional Requirements Document (FRD) describes SESAR Solution 0408, Green Route Charging (GRC), which aims to incentivise optimal green trajectories and more efficient use of airspace through a novel route charging mechanism. The Initial Solution primarily focuses on reducing CO_2 emissions and improving horizontal flight efficiency. The Full GRC Solution extends the concept to address aviation's overall climate impact, considering both CO_2 and non-CO_2 effects. This includes the strategic avoidance of airspace volumes forecast to have a high radiative forcing impact—so-called *climate hotspots*.

The functional architecture of the GRC Solution involves a Central Planner, which aggregates traffic forecasts, capacity forecasts, and unit rate data. Based on these inputs, the Central Planner calculates modulation factors for route charges. These are then provided to airline flight planning systems to support optimised trajectory selection and to States for annual unit rate calculations. In the Full Solution, the Central Planner additionally integrates atmospheric data from meteorological providers.

A key assumption underlying the solution is the principle of revenue neutrality for Air Navigation Service Providers (ANSPs). Airspace Users are assumed to optimise flight planning with the goal of maximising utility, in most cases by minimising their direct operating costs (DOC).

The concepts on which the GRC Solution is based were validated through modelling and submitted for stakeholder consultation, with the objective of reaching TRL 2 for the Initial Solution and TRL 1 for the Full Solution. This document serves as the corresponding Functional Requirements Document (FRD). Further development, validation activities, and stakeholder engagement will be required to progress towards higher TRL levels.

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2 Introduction

2.1 Purpose of the document

This document defines the functional requirements (FRD) for Green Route Charging (GRC) Solution 0408 at TRL 2. The goal of this document is to present the functional requirements that have been identified through the concept development, validation exercises, and workshops. These functional requirements serve as further input for the design process, to be included in the Final OSED, and serve as a starting point in further efforts to mature the concept.

This FRD provides a high-level description of the GRC SESAR Solution target architecture, together with the functional requirements specification covering the functions and interfaces to be implemented.

This document describes the 'what' is needed for the Green Route Charging solution to achieve its objectives, and not the 'how' it should be implemented.

2.2 Scope

The present FRD addresses the Green Route Charging SESAR Solution (0408), targeting TRL 2 maturity. The Solution proposes a route charging mechanism that incentivises airspace users (AUs) to choose flight trajectories with the minimum climate impact, while addressing and reducing airspace congestion. The Solution focuses on the strategic phase of flight, providing a price signal to airspace users that enables more efficient flight planning, environment, and capacity-wise.

The scope of this FRD includes the functional requirements for two options focussed on minimising the CO_2 emissions and one option that is focussed on minimising the climate impact taking both CO_2 and non-CO_2 emissions into account. The first two are called Initial Solutions, and the last is called the Full Solution.

The Initial Solutions are:

1. Introducing a 'Modulation of Route Charges' (MRC) mechanism, applied to the current trajectory-based route charges. The objective of the MRC mechanism is to reduce the CO_2 emissions, while aiming not to exceed the declared capacity of airports and sectors.

2. Introducing an MRC mechanism, applied to the 'Origin-Destination Charging' (ODC) mechanism. The same objective applies to reduce the CO_2 emissions, while aiming not to exceed the declared capacity of airports and sectors. The ODC mechanism calculates the route charge to be paid by the AU along the Great Circle (GC) path between the origin and destination airport. The total revenue is shared between the servicing ANSPs. The shares are based on the traditional trajectory-based route charge.

The Full Solution aims to incentivise the use of climate-friendly trajectories, considering both CO_2 and non-CO_2 emissions, while aiming not to exceed the declared capacity of airports and sectors.

This FRD will focus on the operational and technical aspects of the Green Route Charging Solution, as described in the Operational Service and Environment Definition (OSED), and will not cover tactical phases, as the setting of unit rates for route charging is a strategic process that needs to be stable for at least a year of operations, as per current applicable regulations.

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2.3 Intended readership

This document is aimed at the following stakeholders:

- All Green GEAR consortium members who are contributing directly to the solution research or contributing to related solutions or work packages in the project (DLR, EUROCONTROL, NATS, NLR, UNITS, UoW).
- Relevant SESAR R&I projects.
- SJU Program representatives, as the owner and final approver of this document.
- The relevant stakeholders.

2.4 Background

This section presents the background on which the Solution 0408 is building, focusing on previous work and existing systems that have influenced the project's direction.

2.4.1 EUROCONTROL Route Charging System

The Green-GEAR project builds upon the existing EUROCONTROL route charging system, a regional cost-recovery mechanism adhering to ICAO's charging policies [ICAO Doc 9082 10th Ed] and the Single European Sky regulations [EU No 2019/317]. EUROCONTROL contracting States apply a regional common route charging system specifically for en-route charges. Initially based on historical costs, the system moved to forecast costs in 1983, introducing the concept of under and over recovery of costs. The establishment of the Single European Sky in 2004 emphasised transparency and economic regulation, leading to the adoption of the determined costs method alongside the existing full cost recovery method. In 2013 the first EU regulations regarding Modulation of Charges were introduced in Commission Implementing Regulation (EU) No 391/2013, but until now no use was made of this regulation. In 2020, the calculation method transitioned from charging on filed route to charging on actual route flown, improving the cost-relatedness of revenue for ANSPs and enhancing airspace efficiency by eliminating incentives for filing optimised flight plans that are not always adhered to, which sometimes led to less efficient use of airspace.

2.4.2 Origin-Destination charging

The project also incorporates the Origin-destination Charging (ODC) mechanism as an alternative to the current "charging-on-filed-route" charging mechanism. The aim of ODC is to eliminate detouring incentives from unit rate differences [Verbeek, 2016]. This is possible when the total route charge for a flight becomes independent of the trajectory taken. Then the flight plan optimisation process will only minimise for fuel and flight time, and will therefore not try to sacrifice fuel for lowering the overall route charges.

ODC makes this possible by basing the route charge for a flight on the great circle path between the origin and destination. This is an invariant path. Therefore each possible trajectory for this flight between origin and destination has the same route charge. Only the fuel consumption and flight time will vary for each possible trajectory.

The ANSPs that provide the service to the flight operating along the actual trajectory must be paid for their services. The total amount of revenue generated is already fixed. Therefore, the revenue of the

servicing ANSPs is set to be a share of this fixed route charge using the trajectory-based route charge as a bases.

2.4.3 Previous Research Projects

This project builds on a foundation of prior exploratory research activities both within and outside SESAR and falls within the scope of the effort made by the European Green Deal, the overarching policy framework striving for climate neutrality by 2050, which emphasises reducing emissions across various sectors, including aviation. Notably, several significant past projects have laid the groundwork:

- **SATURN (Strategic Allocation of Traffic Using Redistribution in the Network)**: Focused on the modulation of en-route charges to redistribute traffic across Europe, providing initial insights into how pricing strategies can influence traffic flow.
- **ADAPT (Advanced Prediction Models for Flexible Trajectory-Based Operations)**: Explored advanced prediction models aimed at enhancing flexible, trajectory-based operations, providing a basis for adaptive decision-making in air traffic management.
- **Pilot3 (from Clean Sky 2)**: Contributed by integrating environmentally focused initiatives under the Clean Sky 2 umbrella, emphasising sustainability in aviation through innovative approaches and technologies.
- **COCTA (Coordinated Capacity Ordering and Trajectory Pricing for Better-Performing ATM)**: Provided an in-depth examination of coordinated capacity ordering and trajectory pricing, aiming to improve air traffic management (ATM) performance through strategic pricing and capacity management.
- **CADENZA (Advanced Capacity and Demand Management for European Network Performance Optimization)**: Focused on reducing air traffic emissions and improving overall network performance through enhanced demand-capacity balancing strategies.
- **ATM4E**: Explored the feasibility of a concept for environmental assessment of ATM operations, working towards environmental optimisation of air traffic operations in the European airspace, considering climate, air quality, and noise impacts.
- **CONCERTO**: Currently running, aims to make eco-friendly flight trajectories an everyday occurrence, reducing both CO_2 and non-CO_2 emissions from aviation by integrating green Air Traffic Control (ATC) capacities with appropriate automation.
- **GEESE**: Currently running, aims to develop an initial concept of operations for enabling Weather-Efficient Routing (WER) from Europe to the North Atlantic, analysing safety aspects and impacts on legacy systems.
- **CICONIA**: Currently running, focuses on reducing aviation's climate effects through innovative CONOPS, closely examining non-CO_2 effects and exploring methods to measure them.

These preceding and currently ongoing projects contribute valuable insights and methodologies that inform the development of this project's route charging mechanisms. They illustrate the use of pricing mechanisms to effectively manage air traffic and foster environmentally sustainable operations.

2.4.4 CLIMaCCF / FlyATM 4E and ALARM Projects

The consortium has used the CLIMaCCF V1.0 Python library for defining climate hotspots, which is a product of the FlyATM 4E and ALARM projects [27]. This library computes individual and merged non-CO_2 algorithmic climate change functions (aCCFs) and is still under development and validation. These projects provide advanced climate science tools that allow the Green-GEAR project to address both CO_2 and non-CO_2 emissions in its route charging mechanisms. By leveraging these models, the project aimed to enhance the accuracy and effectiveness of its environmental impact assessments.

Note, however, that the solution 0408 is not defining the actual method to be used for defining climate hotspots. CLIMaCCF is used for defining climate hotspots in the present proof-of-concept. Other methods for defining climate hotspots, like Direct Radiative Forcing (RF), Effective Radiative Forcing (ERF), etc. may also work in the context of solution 0408. This would need to be validated.

2.5 Structure of the document

This Functional Requirements Document is structured as follows:

- Section 1 gives an executive summary of the FRD and provides a summary of the key information and elements contained in the document.
- Section 2 describes the purpose, scope, intended readership, background and structure of the document. It also contains a glossary of terms and a list of acronyms used in the FRD.
- Section 3 describes the functional architecture.
- Section 4 describes the functional requirements both for the airline and ATM systems.
- Section 5 describes the key assumptions taken while developing the Solution at TRL2.
- Section 6 includes the list of references used in developing the FRD.

2.6 Glossary of terms

Term	Definition	Source of the definition
Strategic	The Air Traffic Flow Management phase between Day -12 months to Day -7 days prior to the day of operation.	EUROCONTROL Network Manager Glossary
Pre-tactical	The Air Traffic Flow Management phase between Day -6 and Day -1 prior to the day of operation.	EUROCONTROL Network Manager Glossary
Tactical	The Air Traffic Flow Management phase on the day of operation.	EUROCONTROL Network Manager Glossary

Table 1: glossary of terms

2.7 List of acronyms

Term	Definition
A*<no.>*	Assumption *<no.>*
aCCF	algorithmic climate change function
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
AU	airspace user
CBA	cost-benefit analysis
CLIMaCCF	[Python library for computing individual and merged non-CO_2 algorithmic climate change functions]
CONOPS	concept of operations
CORDIS	Community Research and Development Information Service
CP	Central Planner
CRCO	Central Route Charges Office
D*<no.>*	Deliverable *<no.>*
DDR	Demand Data Repository
DES	Digital European Sky
EC	European Commission
ECO-EVAL	economic evaluation
ENV	environment [performance indicator]
ER	Exploratory Research
ERP	Exploratory Research Plan
EU	European Union
FL	Flight Level

Term	Definition
GA	Grant Agreement
GRC	Green Route Charging
Green-GEAR	Green operations with Geometric altitude, Advanced separation & Route charging Solutions
Green RC	Green Route Charging
HE	Horizon Europe
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ID*<no.>*	Identifier *<no.>*
IR	Industrial Research
JU	Joint Undertaking
KPA	Key Performance Area
KPI	Key Performance Indicator
M*<no.>*	project month *<no.>*
MRC	Modulation of Route Charges
MRV	EU Monitoring, Reporting, and Verification system for air traffic
MTOW	maximum take-off mass
NM	Network Manager
OBJ*<no.>*	objective *<no.>*
OD	origin-destination
ODC	Origin Destination Charging
OPS	operational efficiency [performance indicator]
OSED	Operational Service and Environment Description
PI	Performance Indicator
R&I	research & innovation
RP	Reference Period
RQ*<no.>*	research question *<no.>*

Term	Definition
SES	Single European Sky
SESAR	Single European Sky ATM Research
S3JU	SESAR 3 Joint Undertaking
SJU	SESAR Joint Undertaking
STELLAR	SESAR Tool Enabling collaborative ATM Research
T*<no.>*	task *<no.>*
TRL	Technology Readiness Level
UK	United Kingdom [of Great Britain and Northern Ireland]
UKRI	UK Research and Innovation
UTC	coordinated universal time
V*<no.>*	version *<no.>*
VA*<no.>*	Validation assumption *<no.>*
WER	weather-efficient routing

Table 2: list of acronyms

3 Functional architecture view

3.1 SESAR solution overview

SESAR solution ID	SESAR solution title	SESAR solution definition	Justification (why the solution matters?)
0408	Green route charging	Charging mechanism that incentivises trajectories with minimum climate impact, while reducing airspace congestion.	The enabler for the European airspace to become the most environmentally friendly in the world, as set in the SRIA and the ambitions of the European Green Deal, and enables aviation to become more environmentally efficient [31][32]

Three variants of the GRC solution are considered. Two of which are focused on minimising the climate impact by focussing only on CO_2 (initial solution), and one solution that also takes the non-CO2 impact on the climate into account (full solution).

1. The 'Modulation of Route Charges' (MRC) mechanism uses the EUROCONTROL route charging system as a basis. In addition, a modulation factor is determined for each candidate route of a given origin-destination traffic flow, with the objective to reduce the environmental impact (e.g. CO_2 emissions) of flying, while addressing the expected airspace congestion.

2. The MRC mechanism uses the Origin-Destination Charging (ODC) system as a basis. A modulation factor is determined for each candidate route of a given origin-destination traffic flow, with the objective to reduce the environmental impact (e.g. CO_2 emissions) of flying, while addressing the expected airspace congestion. The ODC route charge is determined using the great circle path between the origin and destination. The servicing ANSPs get a share of this ODC route charge based on the route charge along the planned or actual trajectory.

3. The third mechanism uses the EUROCONTROL route charging system as a basis. The modulation factor is used to address the reduction of the climate impact from both CO_2 and non-CO_2 emissions, while addressing the expected airspace congestion. This is the full solution.

The GRC solution implies a central planner that determines the modulation factors associated with the traffic forecasts between origins and destinations, and the charges of the various ANSPs along the prospected route. The modulation factors of all prospected routes are provided to the airlines for use in their flight planning tools, and to the process that determines the yearly route charging unit rates.

The GRC solution impacts various systems, including but not limited to:

- The GRC central planner has inputs from:

- The member states regarding the performance plans and related information (i.e. traffic forecast, costs). See the Performance Review Body website[2] for published performance plans, charging schemes,
- The NOP (Network Operations Plan) published by the Network Manager that consolidates airport and ACC capacity forecasts
- The EU MRV (Monitoring, Reporting, and Verification) system regarding the climate hotspot predictions for use in the full solution.

- The GRC central planner provides the following information:
  - modulation factors on different routes that are distributed to states, airlines, ANSPs and CRCO

The top-level benefits of the GRC solution are:

- reduced climate impact from air traffic,
- improved horizontal flight efficiency,
- reduced airspace congestion.

The GRC Solution does not impact any of the ATM systems directly, as its aim is to provide appropriate information and incentivise airlines to plan climate friendly trajectories, as much as possible, under the operational constraints.

3.1.1 Supporting reasons for this SESAR solution

The current route charging system somewhat incentivises airspace users towards behaviour that may result in longer routes. This results in higher CO_2 emissions than necessary. The initial GRC Solution aims to reduce the CO_2 impact of air traffic, and the full GRC Solution aims to reduce the climate impact of air traffic. By incentivising airlines to choose more climate-friendly routes, GRC contributes to the overall reduction of CO_2 and non-CO_2 emissions. This aligns with the European Union's climate goals and the performance ambitions outlined in the European ATM Master Plan.

Without a coordinated approach, alterations of flight trajectories when avoiding contrail-sensitive areas could lead to undesirable airspace congestion in specific sectors. Therefore, solution 0408 aims to mitigate resulting airspace congestion through the use of a centralised planner that takes the dependencies between flight trajectories into account. Solution 0408 aims to minimise the overall impact on the AU and climate from the mitigation.

[2] https://eu-single-sky.transport.ec.europa.eu/ses-performance-and-charging-scheme/published-performance-plans_en

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3.1.2 ATM capabilities addressed by the SESAR solution

This section identifies the ATM capabilities from the SESAR architecture baseline addressed by the SESAR Solution, and describes the associated updates.

SESAR solution capabilities	Comments on potential updates required at capability level
Trajectory Optimisation considering climate impact	The solution 0408 allows airlines to take the climate impact of a flight into account through the route charging process. Trajectories with a higher impact on climate are relatively more expensive than trajectories with a lower impact on climate.
Trajectory Optimisation considering congested airspace	The solution 0408 allows airlines to take congested airspaces into account through the route charging process. Trajectories with a higher impact on congestion are relatively more expensive then trajectories with a lower impact on congestion.
Strategic Demand Capacity Balancing	The solution 0408 allows to take into account expected imbalances between demand and capacity of sectors and airports through the route charging process (Initial Solution) during the strategic planning phase.
Pre-tactical Demand Capacity Balancing	The solution 0408 allows to take into account expected imbalances between demand and capacity of sectors and airports through the route charging process (Full Solution) during the pre-tactical planning phase.

Table 3: SESAR Solution 0408 capabilities

3.1.3 Stakeholders impacted by the SESAR solution

This section identifies the operational stakeholders as defined in the SESAR architecture baseline impacted by the Solution and describes their expectations:

Stakeholder	Why it matters to the stakeholder
Airspace Users (AUs)	The AUs are directly impacted by the GRC solution as their flight planning optimisation process is influenced by the changes in the route charging mechanism. The primary objective for AUs is to reduce operating costs, which include route charges. Therefore, any alteration to the route charging system is scrutinised due to potential cost increases, the expectation of improvements in ANS performance, and the necessity to avoid double charging.

Stakeholder	Why it matters to the stakeholder
	The GRC solution will affect their direct operating costs, encompassing fuel consumption and route charges, as well as flight time. It also aims to reduce ATFM delays through charge modulation in the Initial Solution. For the Full GRC Solution, the impact addresses the overall climate impact of flight trajectories, considering both CO_2 and non-CO_2 emissions, with the aim of incentivising environmentally friendly flight paths.
Air Navigation Service Providers (ANSPs)	ANSPs are impacted by the GRC solution. ANSPs generate revenue through the collection of route charges, which are essential to cover the costs associated with staff and investments aimed at providing ANS. Therefore, any route charging scheme, including GRC, must provide sufficient revenue to cover planned costs for each year of the Reference Period (RP). Due to changes in the routes taken by airspace users, the generated service units may fluctuate. Furthermore, the application of modulation factors will alter the revenues for flights receiving ANS. A key objective for ANSPs is to ensure a revenue-neutral implementation of the GRC Solution, meaning they aim to receive the same income for the same amount of workload. The Initial Solution's MRCs has the potential to reduce congestion in specific sectors and airports. However, the Full GRC Solution, which involves avoiding climate hotspots, could introduce additional workload to ANS operations by the need to divert traffic flows tactically.
Central Route Charges Office (CRCO)	The CRCO will continue collecting the route charges after solution 0408 has been implemented. Therefore, the CRCO needs to be able to access the modulation factor data applicable to each trajectory. CRCO wants to prevent increases in claims on charges. The addition of modulation factors introduces an additional element that may be contested.
Network Manager (NM)	The NM is involved in the strategic demand capacity balancing process. Solution 0408 needs input from the NM regarding the available capacity of sectors and airports. The NM wants to limit the need for flow management measures determined during the pre-tactical phase. MRC and ODC+MRC are designed to take the capacity into account when setting the modulation factors, which could diminish capacity related ATFM regulations. The Full GRC also needs the information on airspace capacity. The new route charging mechanism might impact the ATFM processes, as re-routing to avoid hotspots might saturate capacities under certain conditions. The ATFM processes also need to understand the impact of hotspots on capacities.

Stakeholder	Why it matters to the stakeholder
Central Planner	The Central Planner function could be assigned to one of the existing stakeholders. The Central Planner does not need to be a separate stakeholder. The Central Planner will collect the traffic and capacity forecasts, and unit rates and run the GRC model/s to determine the modulation factors M. The Full GRC Solution will require the Central Planner to also share/collect climate hotspot forecasts.
States	The States, through their National Supervisory Authorities (NSAs) will need to use modulation factors when calculating the yearly unit rates for their national performance plans. The objective of the States is to have a revenue neutral implementation of the solution 0408. The performance and charging schemes are regulated and the States are actors in this process.
Member States' National Supervisory Authorities (NSA)	NSAs prepare the performance plans for each Reference Period (RP) including the yearly updates of traffic forecasts, based on EUROCONTROL's forecast. The traffic forecasts are used as input for the centralised planner.
European Commission	Solution 0408 influences the total climate impact of air traffic. The European Commission wants to limit the climate impact of individual flights. It therefore wants to have validated that the GRC will result in the reduction of the total climate impact of air traffic. The European Commission will need to revise the Single European Sky (SES) performance and charging scheme to incorporate the MRC mechanism.
Flight Planning System Providers	Solution 0408 influences the process of calculating route charges. Therefore, the flight planning systems need to be adapted to be able to handle modulation factors when optimising flight trajectories. The Flight Planning Systems need also to get access to the modulation factor data applicable to each trajectory.
MET	Solution 0408 uses climate hotspot predictions from MET providers. For the MET this is a service that will be provided in accordance with the EU MRV.
Society	The society creates the environmental impact through the societies travel behaviours. The reduced CO_2 and non-CO_2 emissions from aviation helps society to reduce societies climate impact.

Table 4: SESAR Solution 0408 stakeholders

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3.2 SESAR solution functional view

3.2.1 Interaction(s) identification

This section discusses the interactions between capability configurations and technical systems. Most of them are new interactions. The interactions are taking place between the CP, and the NM, and AUs. An overview of the interactions is given in Figure 1 and Figure 2 for the Initial Solution and Figure 3 for the Full Solution.

For the Initial Solution it can be seen from Figure 1 that a CP is the new role needed for the solution. As input for the CP are traffic forecasts, capacity forecasts regarding sectors and airports, and finally unit rates applicable for each state. The output of the centralised planner are the modulation factors that are provided to the AU, and the states. The AUs use the modulation factors inside their flight planning processes.

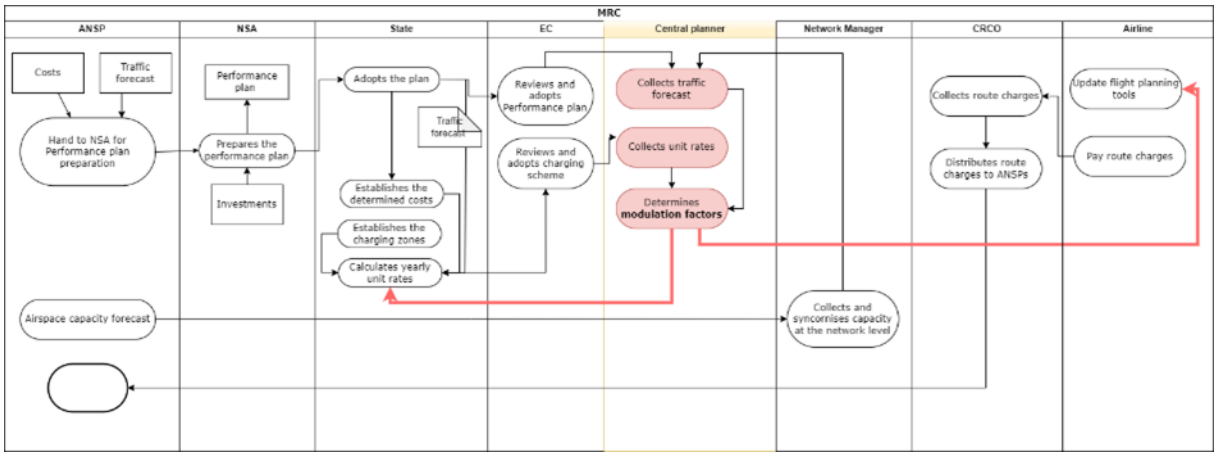

Figure 1: Schematic overview of interactions in solution 0408 (Initial Solution MRC)

To make ODC work together with MRC only one additional function is necessary from the MRC overview. There needs to be a centralised process that determines the unit rates when applying ODC.

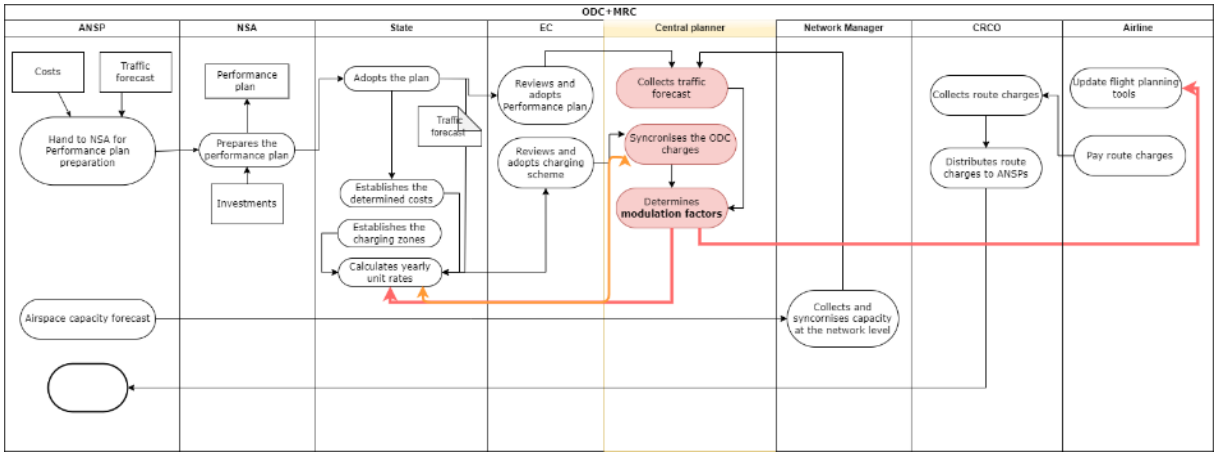

Figure 2: Schematic overview of interactions in solution 0408 (Initial Solution ODC+MRC)

For the full solution there are some additions. The MET provides weather forecasts that can be used by AUs to ascertain the climate hotspot locations, and the CRCO for monitor of accurate hotspot determination. These weather forecasts are provided to the CP as input for the climate hotspot forecasting. Next, it is expected that the climate hotspot forecasts are provided to the AUs, ANSPs, and NM.

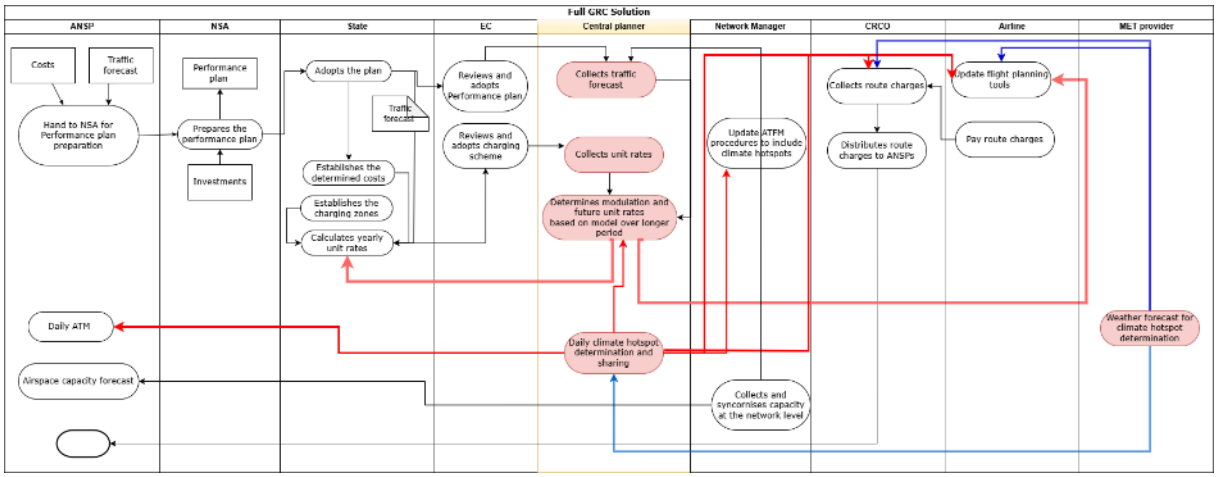

Figure 3: Schematic overview [VR1] of interactions in solution 0408 (Full Solutions)

3.2.2 Functional decomposition

This section identifies the functional decomposition relevant to the solution, only depicting the technical systems and roles that have been identified as impacted by the solution at this R&I stage (TRL 2 target).

The description of the updates introduced by the solution 0408 into these technical systems and roles is provided in the following section. Orange systems are new, orange-blue systems need to be updated, blue systems are already present. There will also be a need for a new role for the Central Planner, and an updated role for the Flight Planner.

The schematic overview of the functional decomposition of Solution 0408 is divided into a version for the Initial Solution in Figure 4, and a version for the Full Solution in Figure 5.

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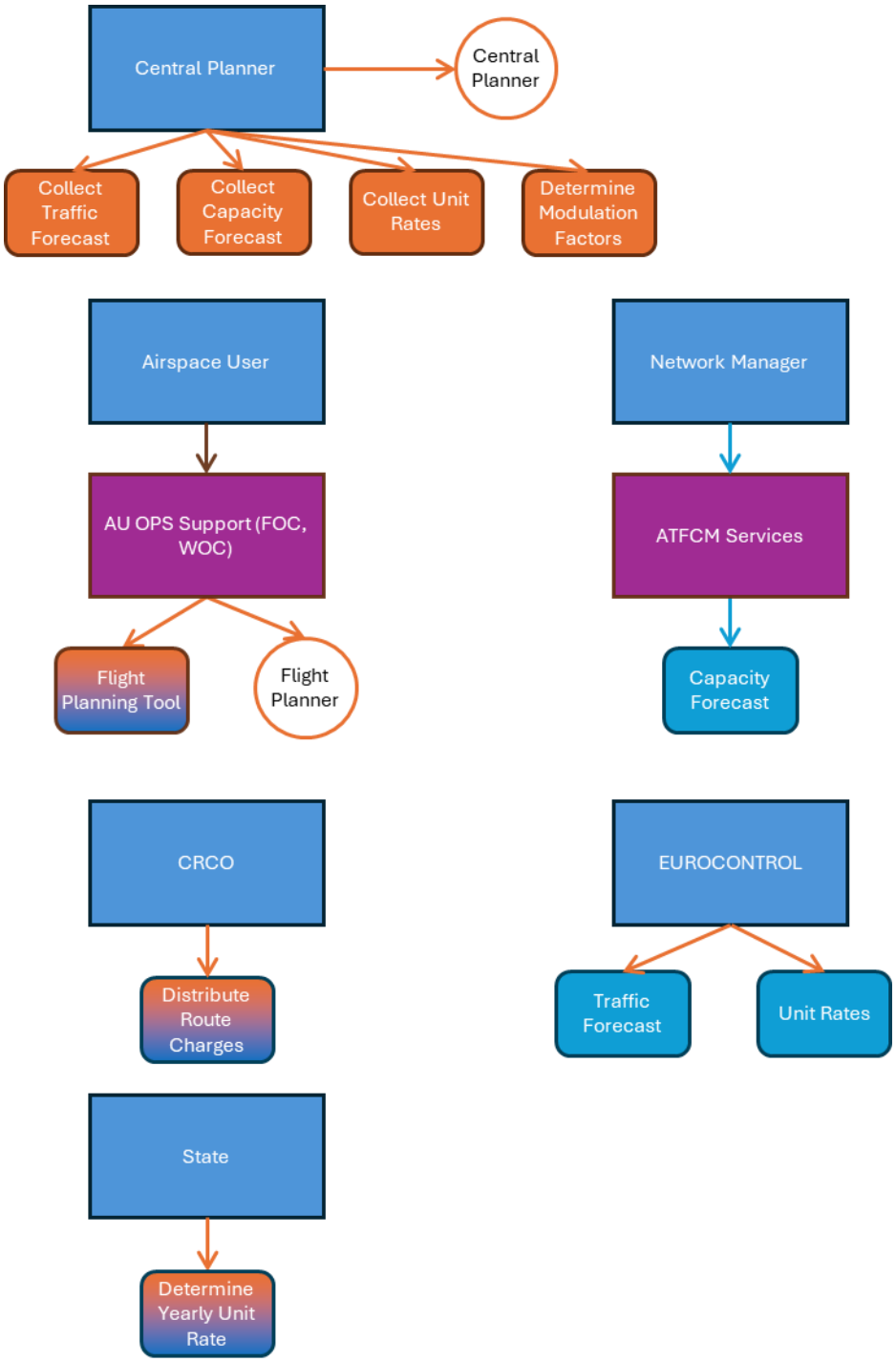

Figure 4: Schematic overview of functional decomposition of solution 0408 (Initial Solution).

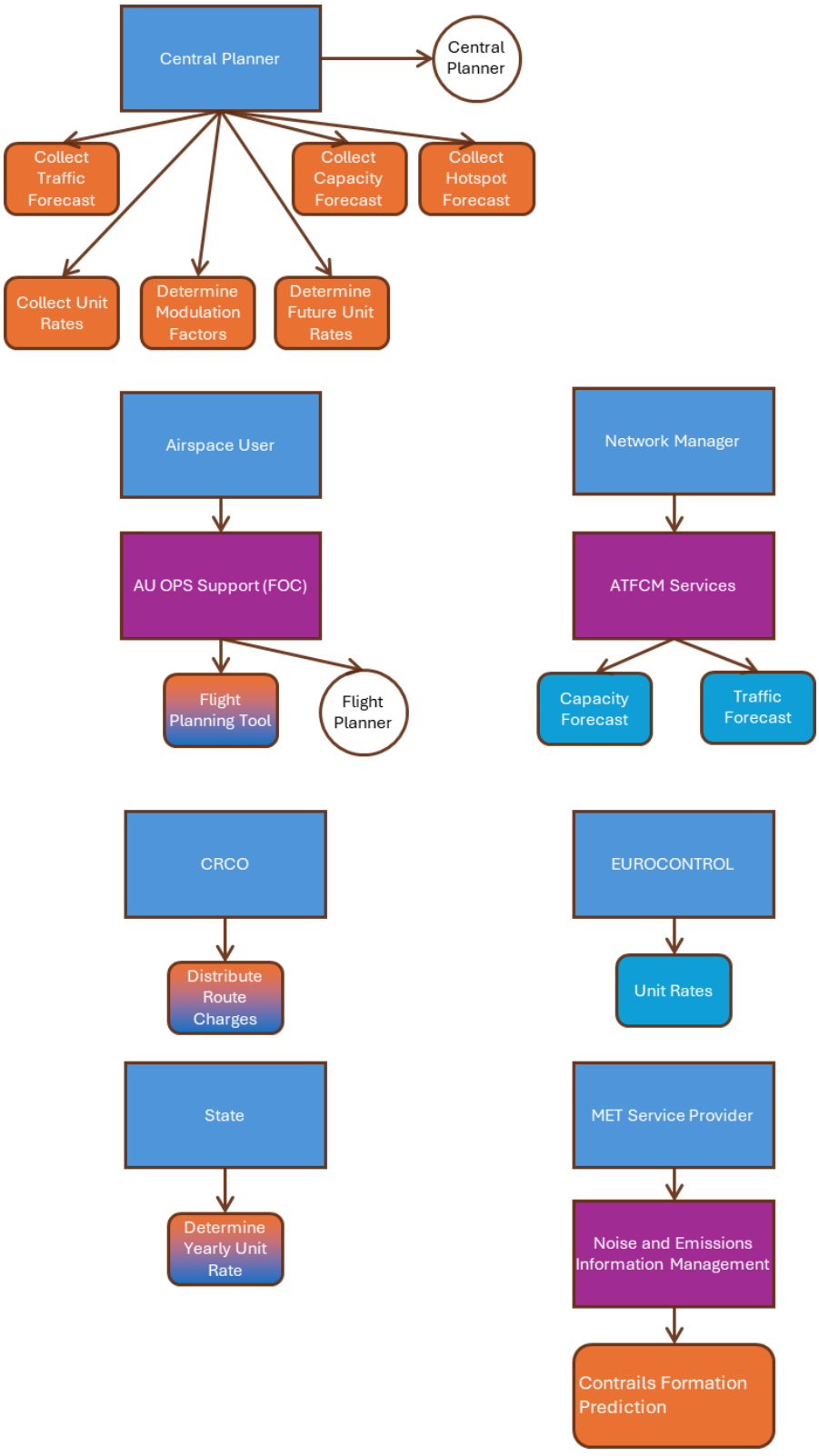

Figure 5: Schematic overview of functional decomposition of solution 0408 (Full Solution).

3.3 High level impact of the SESAR solution on the baseline SESAR architecture

This section described the updates introduced by solution 0408 into the technical systems and roles from the SESAR architecture baseline identified in the functional decomposition above.

A complete impact assessment is not yet available at this maturity level, but the outcomes of the preliminary assessment are summarised in the following two tables for the Initial and Full Solutions.

Initial Solution

Technical systems impacted by the SESAR solution	Functions / roles impacted by the SESAR solution	Comments on required updates
Collect Traffic Forecast		Solution 0408 introduces the following technical systems as part of the Central Planner: - The ability to collect the traffic forecast for the applicable charging period based on the performance plan. The forecast is provided by EUROCONTROL.
Collect Capacity Forecast		Solution 0408 introduces the following technical systems as part of the Central Planner: - The ability to collect the sector and airport capacity forecasts from the Network Manager. The forecasts are for the applicable charging period.
Collect Unit Rates		Solution 0408 introduces the following technical system as part of the Central Planner: - The ability to collect the applicable unit rates for the applicable charging period. The unit rates are provided by EUROCONTROL.
Determine Modulation Factors		Solution 0408 introduces the following technical system as part of the Central Planner: - The ability to generate Modulation Factors for route charges of a specific route. - The ability to take traffic forecasts into account when optimising the Modulation Factors. - The ability to take the base unit rates (EUROCONTROL RCS or ODC) into account when optimising the Modulation Factors.

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Technical systems impacted by the SESAR solution	Functions / roles impacted by the SESAR solution	Comments on required updates
		- The ability to take sector/airport capacity forecasts into account when optimising the Modulation Factors. - The ability to take the CO_2 emission forecast into account when optimising the Modulation Factors
	Central Planner Role	In Solution 0408 the Central Planner, supported by the Central Planner System, is able to: - Generate the Modulation Factors applicable to all forecasts traffic in the applicable charging period.
Flight Planner Tool		Solution 0408 introduces the following modification to Flight Planning Tools: - The ability to take into account the applicable Modulation Factors when calculating the route charges for the specific route. The Modulation Factors are applied to the base route charge (EUROCONTROL RCS or ODC) applicable to the route. - The ability to optimise the flight trajectory in respect to costs including the costs from the modulated route charges.
	AU OPS Support (FOC)	In Solution 0408 the Flight Planner, supported by the Flight Planner Tool, is able to: - Deal with Flight Plan generation that includes modulated route charges.
Capacity Forecast		In Solution 0408 CP makes use of the Strategic Capacity Forecast from the NM: - The ability to generate a Strategic Capacity Forecast for the sector and airport capacity. No change is expected to this functionality.
Distribute Route Charges		Solution 0408 introduces the following modification to the Distribution of Route Charges:

Technical systems impacted by the SESAR solution	Functions / roles impacted by the SESAR solution	Comments on required updates
		- The ability to take into account the applicable Modulation Factors when calculating the route charge for the specific flight. The Modulation Factors are applied to the base route charge applicable to the actual trajectory.
Traffic Forecast		Solution 0408 makes use of the Traffic Forecasts from the Performance Plan: - The ability to generate a Traffic Forecast for the next charging period
Unit Rates		Solution 0408 makes use of the Unit Rate estimates for the next charging period. - The ability to generate Unit Rate estimates for the next charging period.
Determine Yearly Unit Rates		Solution 0408 introduces the following modification to the Determination of Yearly Unit Rates: - The ability to determine the yearly unit rates - The ability to take into account the applicable Modulation Factors
	Shared eco-friendly trajectory	Solution 0408 supports the Trajectory Management process by improvement of the AUs flight planning and network management.

Table 5: Systems impacted by SESAR Solution 0408 (Initial Solution)

Full Solution

Technical systems impacted by the SESAR solution	Functions / roles impacted by the SESAR solution	Comments on required updates
Collect Traffic Forecast		Solution 0408 introduces the following technical systems as part of the Central Planner: - The ability to collect the traffic forecast during the pre-tactical phase.
Collect Capacity Forecast		Solution 0408 introduces the following technical systems as part of the Central Planner:

Technical systems impacted by the SESAR solution	Functions / roles impacted by the SESAR solution	Comments on required updates
		- The ability to collect the sector and airport capacity forecasts from the Network Manager.
Collect Unit Rates		Solution 0408 introduces the following technical system as part of the Central Planner: - The ability to collect the applicable unit rates. The unit rates are provided by EUROCONTROL.
Collect Hotspot Forecasts		Solution 0408 introduces the following technical system as part of the Central Planner: - The ability to collect the climate hotspot forecasts.
Determine Modulation Factors		Solution 0408 introduces the following technical system as part of the Central Planner: - The ability to generate Modulation Factors for route charges of a specific route. - The ability to take traffic forecasts into account when optimising the Modulation Factors. - The ability to take the base unit rates into account when optimising the Modulation Factors. - The ability to take sector/airport capacity forecasts into account when optimising the Modulation Factors. - The ability to take the CO_2 emission forecast into account when optimising the Modulation Factors. - The ability to take climate hotspot forecast into account when optimising the Modulation Factors.
Determine future unit rates		Solution 0408 introduces the following technical system as part of the Central Planner: - The ability to adjust for future unit rates to take into account the revenue excess from applying Modulation Factors to past traffic.

Technical systems impacted by the SESAR solution	Functions / roles impacted by the SESAR solution	Comments on required updates
	Central Planner Role	In Solution 0408 the Central Planner, supported by the Central Planner System, is able to: - Generate the Modulation Factors applicable to all forecasted traffic in the pre-tactical phase.
Flight Planner Tool		Solution 0408 introduces the following modification to Flight Planning Tools: - The ability to take into account the applicable Modulation Factors when calculating the route charges for the specific route. The Modulation Factors are applied to the base route charge applicable to the route. - The ability to optimise the flight trajectory in respect to costs including the costs from the modulated route charges. - The ability to optimise the flight trajectory taking the climate hotspot forecasts into account.
	AU OPS Support (FOC)	In Solution 0408 the Flight Planner, supported by the Flight Planner Tool, is able to: - Deal with Flight Plan generation that includes modulated route charges. - Deal with Flight Plan generation that includes climate hotspot forecasts.
Capacity Forecast		In Solution 0408 CP makes use of the Capacity Forecast from the NM: - The ability to generate a Capacity Forecast during the pre-tactical phase for the sector and airport capacity. No change is expected to this functionality.
Distribute Route Charges		Solution 0408 introduces the following modification to the Distribution of Route Charges:

Technical systems impacted by the SESAR solution	Functions / roles impacted by the SESAR solution	Comments on required updates
		- The ability to take into account the applicable unit rates when calculating the route charge for the specific flight. - The ability to take into account the applicable Modulation Factors when calculating the route charge for the specific flight. The Modulation Factors are applied to the base route charge applicable to the actual trajectory.
Traffic Forecast		Solution 0408 makes use of the Traffic Forecasts from the Network Manager: - The ability to generate a Traffic Forecast during the pre-tactical phase
Unit Rates		Solution 0408 makes use of the Unit Rate estimates. - The ability to provide Unit Rate that are applicable during the pre-tactical phase.
Determine Yearly Unit Rates		Solution 0408 introduces the following modification to the Determination of Yearly Unit Rates: - The ability to update the future unit rates - The ability to take into account the applicable Modulation Factors
Contrail Hotspot Forecast	Meteorological and Climatological Information Management	Solution 0408 introduces the following technical system as part of the MET Service Provider – Emissions Information Management: - The ability to provide contrail hotspot forecasts for use by the AUs and Central Planner.
	Network Cooperative Traffic Management	Solution 0408 improves the flow management process to reduce the climate impact.
	Shared eco-friendly trajectory	Solution 0408 supports the Trajectory Management process by improvement of the AUs flight planning and network management.

Table 6: Systems impacted by SESAR Solution 0408 (Full Solution)

4 Functional requirements

This section provides the functional requirements for Solution 0408 Green Route Charging.

The requirements identifiers are structured as follows:

“REQ-XXXX-FRD-OPxx.Yyyy”, referring to:

- REQ is the object type (requirement);
- XXXX is the Solution ID, so always 0408 in this document;
- FRD because defined in the FRD
- OPx is the applicable Concept method, with three possible reference codes:
  - OP1: applicable to Initial Solution: MRC (only CO_2)
  - OP2: applicable to Initial Solution: ODC+MRC (only CO_2)
  - OP3: applicable to Full Solution: MRC (CO_2 and climate hotspots)
- Yyyy reference number (four digits e.g., to indicate a sequence number), distinguished as follows:
  - 0yyy , starting from 0001, for AU System requirements
  - 1yyy , starting from 1001, for Central Planner System requirements
  - 2yyy, starting from 2001, for MET provider requirements

4.1 Airspace User System requirements

Initial Solution

Identifier	REQ-0408-FRD-OP1.0001 REQ-0408-FRD-OP2.0001
Title	Optimal flight planning incorporating modulation factors
Requirement	The FOC flight planning system shall be capable of optimising the flight trajectory taking into account a cost model that incorporates modulation factors. The modulation factors are specific to route options and departure times.
Status	<in progress>
Rationale	The modulation factors are necessary for usage in the flight planning system to be able to optimise the trajectory of the flight in respect to minimum direct operating costs.
Category	<Functional>

Full Solution

Identifier	REQ-0408-FRD-OP3.0001
Title	Optimal flight planning incorporating modulation factors

Requirement	The FOC flight planning system shall be capable of optimising the flight trajectory taking into account a cost model that incorporates modulation factors. The modulation factors are specific to optional routes and departure times.
Status	<in progress>
Rationale	The modulation factors are necessary for usage in the flight planning system to be able to optimise the trajectory of the flight in respect to minimum direct operating costs.
Category	<Functional>

Identifier	REQ-0408-FRD-OP3.0002
Title	Incorporate MET forecasts regarding climate hotspots
Requirement	The FOC flight planning system shall be capable of optimising the flight trajectory taking into account airspace blocks representing climate hotspots. For these hotspots modulation factors apply.
Status	<in progress>
Rationale	The climate hotspot forecasts are necessary for usage in the flight planning system to be able to optimise the trajectory of the flight in respect to the minimum direct operating costs, including the costs of flying through climate hotspots.
Category	<Functional>

4.2 Central Planner System Requirements

Initial Solutions

Identifier	REQ-0408-FRD-OP1.1001 REQ-0408-FRD-OP2.1001
Title	Collect Traffic Forecast
Requirement	The Central Planner shall be capable to collecting the strategic traffic forecasts from the EUROCONTROL Performance Plan
Status	<in progress>
Rationale	The Central Planner needs a traffic forecast to be able to balance the forecasted demand with the forecasted capacity of the sectors and airports.
Category	<Functional>

Identifier	REQ-0408-FRD-OP1.1002 REQ-0408-FRD-OP2.1002
Title	Collect Capacity Forecast
Requirement	The Central Planner shall be capable to collecting the strategic capacity forecast (sectors/airports) from the Network Manager
Status	<in progress>
Rationale	The Central Planner needs capacity forecasts to be able to balance the forecasted demand with the forecasted capacity of the sectors and airports

Category	<Functional>

Identifier	REQ-0408-FRD-OP1.1003 REQ-0408-FRD-OP2.1003
Title	Collect Unit Rates
Requirement	The Central Planner shall be capable to collecting the forecasted unit rates from EUROCONTROL
Status	<in progress>
Rationale	The Central Planner needs unit rates when determining modulation factors for the forecasted traffic.
Category	<Functional>

Identifier	REQ-0408-FRD-OP1.1004 REQ-0408-FRD-OP2.1004
Title	Identify most common routes for each origin destination pair
Requirement	The Central Planner shall be capable to determine the most common routes operated for each origin destination pair
Status	<in progress>
Rationale	The Central Planner needs trajectory options when balancing demand and capacity. For each trajectory option a specific modulation factor is set.
Category	<Functional>

Identifier	REQ-0408-FRD-OP1.1005 REQ-0408-FRD-OP2.1005
Title	Estimate the CO_2 emissions of each trajectory option
Requirement	The Central Planner shall be capable to estimate the CO_2 emissions of each trajectory option
Status	<in progress>
Rationale	The Central Planner needs to be able to estimate the direct operating costs of each trajectory option. This includes the cost of fuel consumption, which is linked to the CO_2 emissions.
Category	<Functional>

Identifier	REQ-0408-FRD-OP1.1006
Title	Estimate the Route Charge of each trajectory option
Requirement	The Central Planner shall be capable to estimate the Route Charge (EUROCONTROL RCS) of each trajectory option
Status	<in progress>
Rationale	The Central Planner needs to be able to estimate the direct operating costs of each trajectory option. This includes the cost of the route charge multiplied with the modulation factor.
Category	<Functional>

Identifier	REQ-0408-FRD-OP2.1006
Title	Estimate the Route Charge of each trajectory option
Requirement	The Central Planner shall be capable to estimate the ODC Route Charge of each trajectory option
Status	<in progress>
Rationale	The Central Planner needs to be able to estimate the direct operating costs of each trajectory option. This includes the cost of the route charge multiplied with the modulation factor.
Category	<Functional>

Identifier	REQ-0408-FRD-OP1.1007 REQ-0408-FRD-OP2.1007
Title	Calculate the Modulation Factor for each trajectory option
Requirement	The Central Planner shall be capable to calculate the modulation factor of each trajectory option (includes departure delays)
Status	<in progress>
Rationale	It is assumed that flights will choose the route with the lowest direct operating cost including the modulated route charges. The modulation factors are chosen such that the ANSPs have a net zero effect on their revenue assuming the same service level (a combination of factors >1 and <1). Furthermore, the modulation factors are chosen such that demand will not exceed sector and airport capacity. This includes considerations for time displacement. Also, the modulation factors are chosen such that when possible the minimum cost route candidate is the one with the lowest CO_2 emissions.
Category	<Functional>

Identifier	REQ-0408-FRD-OP1.1008
Title	Estimate the Route Charge of the actual trajectory
Requirement	The CRCO shall be capable to calculate the route charge (EUROCONTROL RCS) of the actual trajectory given the applicable modulation factors
Status	<in progress>
Rationale	The CRCO needs to be able to calculate the applicable route charge. With this the revenues of each ANSP can be estimated. Once the applicable route charge is collected it can be provided to the applicable ANSPs.
Category	<Functional>

Identifier	REQ-0408-FRD-OP2.1008
Title	Estimate the Route Charge of the actual trajectory
Requirement	The CRCO shall be capable to calculate the route charge (ODC) of the actual trajectory given the applicable modulation factors
Status	<in progress>

Rationale	The CRCO needs to be able to calculate the applicable route charge. With this the revenues of each ANSP can be estimated. Once the applicable route charge is collected it can be provided to the applicable ANSPs.
Category	<Functional>

Identifier	REQ-0408-FRD-OP1.1009 REQ-0408-FRD-OP2.1009
Title	Calculate the yearly unit rates given the applicable modulation factors
Requirement	The states shall be capable to estimate the unit rates that would apply in their airspace given the applicable modulation factors.
Status	<in progress>
Rationale	The modulation factors have influence on the traffic flow inside states. This means that a higher or lower service level can be expected then without modulation. Given the expected cost of their operation they may need to update the unit rate in their state to have a net zero effect on their revenue.
Category	<Functional>

Full Solution

Identifier	REQ-0408-FRD-OP3.1001
Title	Collect Pre-Tactical Traffic Data
Requirement	The Central Planner shall be capable to collecting the pre-tactical traffic data from the Network Manager
Status	<in progress>
Rationale	The Central Planner needs pre-tactical traffic data to be able to balance the forecasted demand with the expected capacity of the sectors and airports.
Category	<Functional>

Identifier	REQ-0408-FRD-OP3.1002
Title	Collect Capacity Forecast
Requirement	The Central Planner shall be capable to collecting the pre-tactical capacity forecast (sectors/airports) from the Network Manager
Status	<in progress>
Rationale	The Central Planner needs capacity forecasts to be able to balance the forecasted demand with the expected capacity of the sectors and airports
Category	<Functional>

Identifier	REQ-0408-FRD-OP3.1003
Title	Collect Unit Rates
Requirement	The Central Planner shall be capable to collecting the current unit rates from EUROCONTROL
Status	<in progress>

Rationale	The Central Planner needs unit rates when determining modulation factors for the expected traffic.
Category	<Functional>

Identifier	REQ-0408-FRD-OP3.1004
Title	Identify most common routes for each origin destination pair
Requirement	The Central Planner shall be capable to determine the most common routes operated for each origin destination pair
Status	<in progress>
Rationale	The Central Planner needs trajectory options when balancing demand and capacity. For each trajectory option a specific modulation factor is set.
Category	<Functional>

Identifier	REQ-0408-FRD-OP3.1005
Title	Estimate the CO_2 emissions of each trajectory option
Requirement	The Central Planner shall be capable to estimate the CO_2 emissions of each trajectory option
Status	<in progress>
Rationale	The Central Planner needs to be able to estimate the direct operating costs of each trajectory option. This includes the cost of fuel consumption, which is linked to the CO_2 emissions.
Category	<Functional>

Identifier	REQ-0408-FRD-OP3.1006
Title	Estimate the climate hotspot impact of each trajectory option
Requirement	The Central Planner shall be capable to estimate the climate hotspot impact of each trajectory option
Status	<in progress>
Rationale	The Central Planner needs to be able to estimate the direct operating costs of each trajectory option. This includes the cost that is assigned to operating in climate hotspots areas.
Category	<Functional>

Identifier	REQ-0408-FRD-OP3.1007
Title	Estimate the Route Charge of each trajectory option
Requirement	The Central Planner shall be capable to estimate the Route Charge (EUROCONTROL RCS) of each trajectory option
Status	<in progress>
Rationale	The Central Planner needs to be able to estimate the direct operating costs of each trajectory option. This includes the cost of the route charge multiplied with the modulation factor.
Category	<Functional>

Identifier	REQ-0408-FRD-OP3.1008
Title	Calculate the Modulation Factor for each trajectory option
Requirement	The Central Planner shall be capable to calculate the modulation factor of each trajectory option (includes associated departure delays)
Status	<in progress>
Rationale	It is assumed that flights will choose the route with the lowest direct operating cost including the modulated route charges. The modulation factors are chosen such that the ANSPs have a net zero effect on their revenue assuming the same service level. Furthermore, the modulation factors are chosen such that demand will not exceed sector and airport capacity. Also, the modulation factors are chosen such that when possible the minimum cost route candidate is the one with the lowest overall climate impact.
Category	<Functional>

Identifier	REQ-0408-FRD-OP3.1009
Title	Estimate the Route Charge of the actual trajectory
Requirement	The CRCO shall be capable to calculate the route charge (EUROCONTROL RCS) of the actual trajectory given the applicable modulation factors. This takes into account the impact of flight level changes based on charge modulations.
Status	<in progress>
Rationale	The CRCO needs to be able to calculate the applicable route charge. With this the revenues of each ANSP can be estimated. Once the applicable route charge is collected it can be provided to the applicable ANSPs.
Category	<Functional>

4.3 CRCO System Requirements

Full Solution

Identifier	REQ-0408-FRD-OP3.2001
Title	Monitor accurate hotspot determination
Requirement	The CRCO will monitor for accurate hotspot determination
Status	<in progress>
Rationale	The CRCO will monitor for accurate hotspot determination in case the CP function is not subsumed into it. The CRCO has a monitoring role.
Category	<Functional>

5 Assumptions

This chapter lists the assumptions that are applicable to the Green Route Charging Solution, and that have an impact on the functional requirements that were defined in Chapter 4.

5.1 Common assumptions for SESAR Solution 0408

This section covers assumptions that are common to the different functions across the Solution 0408.

5.1.1 Operational

Initial Solutions

- SESAR Solution 0408 assumes that the Green Route Charging is only applied to the CRCO members for which the EU regulations regarding Modulation of Charges apply.
- SESAR Solution 0408 only applies to flights for which route charges are applicable. This therefore not includes flights with a maximum take-off weight (MTOW) below 2000 kg, military flights, flights operating in visual flight rules (VFR) airspace, and circular flights.
- SESAR Solution 0408 aims to comply with the revenue neutrality principle applicable to ANSPs. It is assumed that ANSPs receive on average a similar revenue for the same amount of service provided. While the average unit rate of the service is preserved with this approach, it does not guarantee that the total revenue of each ANSP remains the same upon introduction of MRC.
- SESAR Solution 0408 assumes that airspace users optimise their flights in respect to minimising the direct operating costs. The direct operating costs include the cost of fuel, time, and route charges.
- SESAR Solution 0408 assumes that the calculation of the modulation factors is done during the strategic phase several months to a year before the actual day of operation.

Full Solution

- SESAR Solution 04080 complies with the existing EU and ICAO rules and regulations in respect to route charges. This includes the EU regulations regarding the modulation of charges.
- SESAR Solution 0408 assumes that the Green Route Charging is only applied to the CRCO members for which the EU regulations regarding Modulation of Charges apply.
- SESAR Solution 0408 only applies to flights for which route charges are applicable. This therefore not includes flights with a maximum take-off weight (MTOW) below 2000 kg, military flights, flights operating in visual flight rules (VFR) airspace, and circular flights.
- SESAR Solution 0408 aims to comply with the revenue neutrality principle applicable to ANSPs. It is assumed that ANSPs receive on average a similar revenue for the same amount of service provided. While the average unit rate of the service is preserved with this approach, it does

not guarantee that the total revenue of each ANSP remains the same upon introduction of MRC.

- SESAR Solution 0408 assumes that airspace users optimise their flights in respect to minimising the direct operating costs. The direct operating costs include the cost of fuel, time, route charges, and charges for passing through climate hotspots.

5.2 Specific assumptions for Solution 0408

This section covers assumptions that are particular to given functions.

5.2.1 Airspace User System

Initial Solutions

- The Flight Planning System providers are assumed to implement the modulation factor functionality for the airspace users.

Full Solution

- The Flight Planning System providers are assumed to implement the modulation factor functionality for the airspace users.

5.2.2 Central Planner System

Initial Solutions

- The Central Planner assumes that the impact of wind on the aircraft performance is not taken into account.
- The Central Planner assumes that the fuel costs of a specific route are estimated and not provided by the AU.
- The Central Planner assumes that the delay costs of a specific route are estimated and not provided by the AU.
- The Central Planner assumes that the unit rates are fixed over the applicable charging period when estimating the Modulation Factors.
- The Central Planner is assumed to be able to provide the modulation factors for routes that are not in the traffic forecast set and therefore have no modulation factors of their own.

Full Solution

- The Central Planner assumes that the fuel costs of a specific route are estimated and not provided by the AU.
- The Central Planner assumes that the delay costs of a specific route are estimated and not provided by the AU.

- The Central Planner assumes that the unit rates are fixed over the applicable charging period when estimating the Modulation Factors.
- The Central Planner is assumed to be able to provide the modulation factors for routes that are not in the traffic forecast set and therefore have no modulation factors of their own.

5.2.3 MET Service System

Initial Solutions

- Not applicable

Full Solution

- The MET Service System providers are assumed to provide climate hotspot forecasts.with an accuracy that is enough to get an overall climate benefit when optimizing flight plans. This is considered as an Enabler required for the Full Solution.

6 References

6.1 Applicable documents

This FRD complies with the requirements set out in the following documents:

SESAR solution pack

[1] 'SESAR DES Solutions Green-GEAR V2.0', May 2024.

Content integration

[2] Content Integration – Executive Overview, Edition 00.01, 16th February 2023.

[3] DES Common Assumptions, Edition 00.02.01, 29th June 2023.

[4] DES Performance Framework, Edition 00.01.04, 29th June 2023.

[5] DES Performance Framework – U-space Companion Document, Edition 00.01.02, 3rd April 2023.

Content development

[6] SESAR 3 Joint Undertaking – Communication Guidelines 2022-2027, Edition 0.03, 23rd November 2022.

System and service development

Performance management

[7] Performance Assessment and Gap Analysis Report (PAGAR) 2019 – updated version, Edition 00.01.00, 20th May 2021.

[8] SESAR Solution Cost Benefit Analysis (CBA) Quick Start Guide (1_0).docx

[9] SESAR ECO-EVAL Quick Start Guide (1_0).docx

[10] Performance Assessment and Gap Analysis Report (2019), Edition 00.01.02, 13th December 2019.

Validation

[11] DES HE requirements and validation /demonstration guidelines, Edition 3.00, 15th September 2023.

[12] DES SESAR Maturity Criteria and sub-Criteria_01_01 (1_1).xls

Safety

[13] DES expanded safety reference material (E-SRM), Edition 1.2, 17th November 2023.

[14] Guideline to Applying the Extended Safety Reference Material (E-SRM), Edition 1.1, 17th November 2023.

Human performance

[15] SESAR DES Human Performance Assessment Process TRL0-TRL8, Edition 00.03.01, November 2022.

Environment assessment

[16] SESAR Environment Assessment Process, Edition 05.00.00, 23rd July 2024.

Security

Project and programme management

[17] Green-GEAR Grant Agreement No. 101114789, version 1, signed 11th May 2023.

[18] SESAR 3 JU Project Handbook – Programme Execution Framework, Ed. 01.00, 11th April 2022.

6.2 Reference documents

[19] SESAR 3 ER 1 Green-GEAR – D5.1 – Initial OSED – Green RC, Ed 01.00, 29nd June 2024.

[20] SESAR 3 ER 1 Green-GEAR – D5.2 – ERP – Green Route Charging, Ed 01.00, 31st July 2024.

[21] SESAR 3 ER 1 Green-GEAR – D5.3 – Intermediate ERR – Green Route Charging, Ed 01.00, 12th February 2025.

[22] SESAR 3 ER 1 Green-GEAR – D5.4 – Final OSED – Green RC, Ed 01.00, submitted 17th September 2025.

[23] SESAR 3 ER 1 Green-GEAR – D5.6 – ECO-EVAL – Green RC, Ed 01.00, 9th July 2025.

[24] SESAR 3 ER 1 Green-GEAR – D5.7 – Final ERR – Green RC, Ed 01.00, submitted 16th September 2025.

[25] SESAR 3 ER 1 Green-GEAR – 2nd Green Route Charging Solution Workshop, 29th April 2025.

[26] ICAO Doc 9082 10th Edition, ICAO's Policies on Charges for Airports and Air Navigation Services, 2024.

[27] Commission Implementing Regulation (EU) 2019/317 of 11th February 2019 laying down a performance and charging scheme in the single European sky.

[28] Verbeek, R., & Visser, H. G. (2016). Why aircraft will fly more fuel-efficiently on FRIDAY: The FRIDAY route charges method. In D. Lovell, & H. Fricke (Eds.), 7th International Conference on Research in Air Transportation: Philadelphia, USA

[29] 'Strategic Allocation of Traffic Using Redistribution in the Network (SATURN) report', 2015.

[30] S. Dietmüller et al., 'A Python library for computing individual and merged non-CO_2 algorithmic climate change functions: CLIMaCCF V1.0', Geosci. Model Dev., vol. 16, no. 15, pp. 4405–4425, 2023

[31] SESAR JU, 'Strategic research and innovation agenda (SRIA)'

[32] 'Green Deal' Available: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

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