Flow CONOPS

Edition: 1.0
Edition date: 24-04-2024
Classification: White
Reference nr: 24/08/05/47

DOCUMENT CONTROL

Document Title	Flow CONOPS
Document Subtitle	-
Document Reference	24/08/05/47
Edition Number	1.0
Edition Validity Date	24-04-2024
Classification	White
Status	Released Issue
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EDITION HISTORY

Edition No.	Validity Date	Author(s)	Reason
Ed.0.01		Flow ConOps Drafting Groups	First version
Ed.0.02		Flow ConOps Drafting Groups	General revision
Ed.0.03		Flow ConOps Drafting Groups	Fine-tuning Revision
Ed.0.04		Flow ConOps Drafting Groups	Fine-tuning Revision
Ed.0.05		Flow ConOps Drafting Groups	DG comments received
Ed.0.06		Flow ConOps Drafting Groups	Fine-tuning Revision as part of first review cycle
Ed.0.07		Flow ConOps Drafting Groups	Fine-tuning Revision as part of first review cycle
Ed.0.08		Flow ConOps Drafting Groups	Second review by DG
Ed.0.09		Flow ConOps Drafting Groups	Fine-tuning Revision as part of second review cycle
Ed.0.10		Flow ConOps Drafting Groups	Final Draft
Ed. 0.11		Flow ConOps Drafting Groups	Revision of executive summary and AS-IS performance monitoring – Final draft
Ed.0.12		Flow ConOps Drafting Groups	Update of Chapter 9 and Chapter 10
Ed.0.13		Flow ConOps Drafting Groups	Final draft
Ed.1.0		Flow ConOps Drafting Groups	Approved edition by NMB/39

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Executive Summary

One of the aims of the “High Level Network CONOPS 2029” concerns the need to provide sufficient, scalable capacity to safely accommodate forecasted air traffic demand without imposing significant operational, economic, or environmental penalties on airspace users, airport operators and ANSPs. This Flow CONOPS document highlights how the ATFM service (ATFCM) will extend its collaboration and integration with partner processes, extend information exchange, and evolve digital tools to support capacity optimisation through efficient traffic flows.

The Flow CONOPS, in the ECAC area, targets to dynamically balance the twin imperatives of demand and capacity in the gate-to-gate perspective with due regard to the aerodrome turnaround processes. Within this scope, the goal of the CONOPS is to enable flight punctuality, efficiency and flexibility having regard to the available aerodrome and airspace resources with the emphasis on optimising the network capacity through robust, comprehensive and equitable collaborative decision-making (CDM) processes. These processes will be supported by widespread dissemination of relevant and punctual information to all stakeholders: airspace users, aerodromes, ANSPs and NM; and will take full account of the required ATM performance targets and needs of all stakeholders, including military, general aviation and the anticipated new entrants.

The NM/NMOC will continue to function as the facilitator of the CDM processes and as a central repository of an expanded set of relevant information, while hosting digital platforms and tools to support the processes. These will provide NM with an overview of the network impact assessment of any particular constraint or un/planned event. Then to collaborate with the other actors (FMPs, AMCs, AUs, aerodromes, etc.) for determining an optimal ATFM solution (capacity optimisation, ATFM measure or combination) to any given set of circumstances.

The key ATFM solution improvements will derive from the progressive integration of the ATFM phases and ATFM service with other processes, including aerodrome, ASM, ATC planning, flight planning and post operations analysis/ performance monitoring.

Integration of the ATFM service phases will introduce common datasets, tools and comprehensive information exchange to smooth the transitions and feedback between the ATFM phases. Key technology enablers will be provided by the iNM programme e.g., the integrated Data Layer’s (iDL) harmonised restriction and traffic volume models, support to near-live operational performance monitoring, scenario and traffic demand management.

The further integration of aerodrome operations planning into the ATFM service will support exchange, mapping and use of new information including airport-corner, real-time airport slot and curfew information. This will facilitate: monitoring of on-time performance, addressing reactionary delays, airport demand capacity balancing functions and critical event management.

Integration with ASM will evolve the airspace capacity management through dynamic airspace configuration that is fully cohesive with the demand capacity balance process to be able to dynamically accommodate civil, military and new-entrant airspace users’ requirements. The emphasis on the network approach will facilitate the exploitation of

any ATM capacity and to minimise need of penalisation to the airspace users e.g., comprehensive reduction of ATM constraints/ route availability document (RAD) restrictions.

Network information sharing and coordination with the integrated network ATC planning (INAP) will improve the extended look-ahead time-horizon and the efficiency of local traffic management, ATC planning actions, complexity assessment & resolution, and ATFM solutions. This will support planning actors to identify the best solution to cope with both demand capacity balancing and ATC execution phase requirements.

Integration of NM's Flight and ATFM services will deliver: a consolidated flight status indicating the operational events affecting a flight; and the consolidated 4D-trajectory that is gate-to-gate optimised using the best-known: meteorological conditions, coordinated airports data, and consolidated data from all sources of information from any involved stakeholder at any phase of the flight, from early planning until the end of the execution of the trajectory.

The range of ATFM measures will be extended to exploit local traffic counting methods, targeted measures, complexity resolution measures and methods of prioritisation. These measures require the network consolidated 4D-trajectory to provide stable, reliable predictions of traffic demand. Extensive use of enhanced, shared simulation tools will facilitate network impact assessment and CDM of ATFM measures to determine the best, combination of ATFM solutions (what-if) and subsequent optimisations (what-else). It is anticipated that harnessing the most significant artificial intelligence and machine learning techniques will support these enhancements.

Operational performance monitoring will evolve to incorporate timely, near-live monitoring of network performance and targets that will inform wider network performance management actions. Comprehensive feedback gathering tools combined with simulations incorporated into replay tools will support performance analysis, investigation and prompt reporting.

All of these new capabilities will require extensive coordinated planning and training facilities to ensure smooth transition to operational deployment.

In summary, the enhancements provided in this Flow CONOPS are designed to support airspace users, airport operators, ANSPs and NM in safely meeting their business, environmental and societal objectives through improved network performance, notably capacity, flight efficiency, punctuality and flexibility.

1. Introduction

1.1 ATFM Objectives and principles

Air Traffic Flow Management is a service established with the objective of contributing to a safe, orderly, and expeditious flow of air traffic by ensuring that ATC capacity is utilized to the maximum extent possible, and that the traffic volume is compatible with the capacities declared by the appropriate ATS authority. Source: ICAO Doc 4444 PANS-ATM.

Note: the definition used in Commission Regulation 255/2010 (art.2 Definition) reflects the ICAO description (*air traffic flow management (ATFM) measure' means the actions taken to perform air traffic flow management and capacity management*).

The term Air Traffic Flow and Capacity Management used by EUROCONTROL (Definition ATFCM Operations Manual), includes process that ensures better realisation of the ATM capacity towards the traffic demand, minimising the need of applying ATFCM measures.

Given the evolution of concepts and technology, the ATFCM definition has moved towards a Collaborative Decision-Making process to allow all relevant ATM operational stakeholders to participate in FLOW management decisions that affect them. In this respect, the document by convention is named FLOW CONOPS, to highlight the wider scope of the processes described hereafter.

The objectives of ATFM consist of:

a) enhancing the safety of the ATM system by ensuring the delivery of safe traffic densities and minimizing traffic surges;

b) ensuring an optimum flow of air traffic throughout all phases of the operation of a flight by balancing demand and capacity;

c) facilitating collaboration among operational stakeholders to achieve an efficient flow of air traffic that supports the achievement of the business objectives of airspace users (AUs) and provides optimum operational choices (punctuality, cost management of operations and others);

d) balancing the legitimate and sometimes conflicting requirements of all AUs, thus promoting equitable treatment;

e) reconciling ATM system resource constraints with Air Navigation Service Provider (ANSP's) cost-efficiency and environmental priorities;

f) Facilitating the management of disruptive operational conditions negatively impacting capacity, in order to minimize negative impact to all operational stakeholders;

g) facilitating the achievement of global interoperability of systems, i.e. a seamless and harmonized ATM system, while ensuring compatibility with international developments.

h) Reconcile Airspace Management process (ASM) and ATFCM processes in order to minimise the impact of Airspace unavailability on ATM operations.

The principles of ATFM are:

a) optimizing available airport and airspace capacity without compromising safety;

b) maximizing operational benefits and global efficiency while maintaining agreed safety levels;

c) promoting timely and effective coordination and collaboration with all affected stakeholders;

d) fostering international collaboration leading to an optimal, seamless ATM environment;

e) recognizing that airspace is a common resource for all users by ensuring equity and transparency, while taking into account security and defence needs;

f) supporting the introduction of new technologies and procedures that enhance system capacity and efficiency;

g) enhancing predictability, for ANSPs as well as AUs;

h) helping to maximize aviation economic efficiencies and returns, and support other economic sectors such as business, tourism and cargo;

i) helping to maximize aviation environmental efficiencies;

j) constantly evolving to support the ever-changing aviation environment.

1.2 ATFM Benefits

The benefits of ATFM cover various domains of the ATM system:

a) operational:

   1) enhanced ATM system safety;
   2) increased system operational efficiency and predictability;
   3) effective management of capacity and demand;
   4) increased situational awareness among stakeholders and a coordinated, collaborative development and execution of operational plans;
   5) improved punctuality, reduced fuel burn and reduction of AU operating costs;
   6) monitor and consider environmental impact in all decision making mechanisms
   7) effective management of operations during disruptive operating conditions and effective mitigation of constraints and consequences;
   8) analysis of post-operational data to draw lessons learnt;
   9) increase of ATCO productivity: and
   10) reduction of supporting costs related to operations.

b) societal:

   1) improved quality of air travel, including improved information provided to the travelling public;
   2) increased economic development through efficient services to the projected increased levels of air traffic;
   3) reduction of harmful gas emissions;

4) mitigation of the effects of unforeseen events and situations of reduced capacity, through the coordination of effective and rapid solutions to recovery;
5) provide information to stakeholders and passengers in case of disruptive events.

1.3 Purpose

The purpose of the Network FLOW concept of operations is to prepare the European ATM Network to be ready to process 50,000 flight per day in 2029 and beyond by:

- Enhancing rolling FLOW processes;
- Optimize the available airspace capacity;
- Integration of ASM and ATFCM processes;
- Enhancing flight efficiency and aircraft fleet rotations while improving safety level;
- Integration of airports into the Network;
- Integration of flight and flow processes;
- Meeting societal needs for an environmentally performant route network;
- Through network resilience, meeting the challenges of daily traffic demand waves.

Contributing to achieve the Single European Sky (SES) Performance Targets for Reference Period (RP) 3 and 4 (when defined, agreed and published by the European Commission) which addresses the period 2025-2029.

This CONOPS will also help to identify the elements to be subject to R&D prior to deployment, with possible special influence in the SESAR 3 Programme when suitable for the time frame of this CONOPS.

The target frame of the document is the forthcoming years up to the 2029, in line with the time-scope of the Network Strategy Plan (NSP).

1.4 Scope

This scope of this document is described in the following dimensions:

- The ATFM process
- The geographical dimension of ATFM

1.4.1 The ATFM process

The document addresses the entire ATFM process through the Strategic, Pre-tactical, Tactical, and the Post OPS analysis phases.

The ATFM includes the ATFCM, the ASM and their interactive rolling processes, aiming to exploit ATM capacity at European level and minimising the utilisation of ATM constraints to balance demand and capacity through an enhanced CDM process involving all relevant stakeholders.

1.4.2 Geographical area

For implementing the network functions related to the content of this document, the geographical area of applicability is defined in the Regulation 123/2019 art. 1 (point 3 and 4).

1.5 Intended audience

The intended audience includes:

a) EUROCONTROL concerning the
   i. management of strategic projects related to the ASM/ATFCM developments;
   ii. Network Manager Operations Centre (NMOC) management and OPS Staff as guidance for the implementation of centralised FLOW operations and data sharing information;
   iii. SESAR 3 areas of research.

b) ANSPs for guidance for the implementation of FLOW Management.

c) Airports for guidance for the implementation of process and provision of relevant data (e.g. DPIs, APIs) supporting FLOW management.

d) Computerised flight plan service provider (CFSPs) concerning the Flight Operations Control (FOC) systems developments to receive and process flow information to support the flight plans process.

e) Airspace Users (FOC and flying aircraft) as final beneficiary of the flow process for the optimization of the flight trajectory.

f) Military authorities (who could be also ANSPs, Airports, AUs, but also Air Defence Units) for guidance for the implementation of ATM operations compatible with the flow processes and procedures.

g) SJU and related solutions partners for validation activities related to FLOW management evolutions.

h) SDM for planning, monitoring and supporting the deployment of implemented improvements among the relevant stakeholders, especially in relation of AF5 ATM functionality.

i) EASA concerning the certification of system handling FLOW management processes as relevant.

j) Manufacturing industry for information for systems developments supporting ASM/ATFCM operations as relevant.

k) Standardization initiatives (EUROCAE, RTCA).

2. Current Flow Management processes

The aim of this chapter is to provide a quick summary of the relevant processes supporting FLOW management, focusing on the key deficiencies/limitations of the processes and related NM systems support. The structure of the chapter contains identified common processes, supporting different NM activities, and specific elements for each phase of the ATFCM process (Strategic, pre-tactical, tactical (including execution) and Post-OPS).

The following provides a general outline of the steps involved in the ATFCM process during strategic planning, pre-tactical planning, tactical and post operations phases:

a) determine capacity: review/assess airport/airspace sector configuration & capacity;

b) assess demand: determine forecasted traffic demand;

c) determine events impacting capacity: assess forecasted weather, infrastructure/service availability, airspace availability, planned/special events, etc.;

d) analyse and compare demand and capacity levels: focus on the periods in which demand exceeds available capacity.

e) apply the Collaborative Decision Making (CDM) model: communicate the situation to the facilities and stakeholders involved through the means available, using the CDM processes;

f) determine, using CDM, the action required for mitigating a demand/capacity imbalance: after requesting and collecting information, determine the most appropriate ATFCM solutions (e.g., capacity optimization or ATFM measure) for the situation;

g) disseminate information: using the means of communication established to that end, inform, in a timely manner, the parties involved about the common situational awareness and ATFM solutions to be applied or of the cancellation thereof;

h) monitor the situation: examine the situation periodically, as necessary, to ensure that the ATFCM solutions mitigate the consequences of the imbalance. If necessary, re-assess and adjust accordingly; and

i) conduct a post-operations analysis: evaluate the effectiveness of the ATFCM solutions and catalogue the best work practices. This analysis should review the weekly or monthly reports of the NMOC/flow management positions (FMPs). An ATM performance-based assessment should be conducted to ensure that the ATFCM service has measurable benefits on ATM performance.

Note: The ATFCM process is greatly enhanced by automated information exchange and digital tools that support the CDM processes.

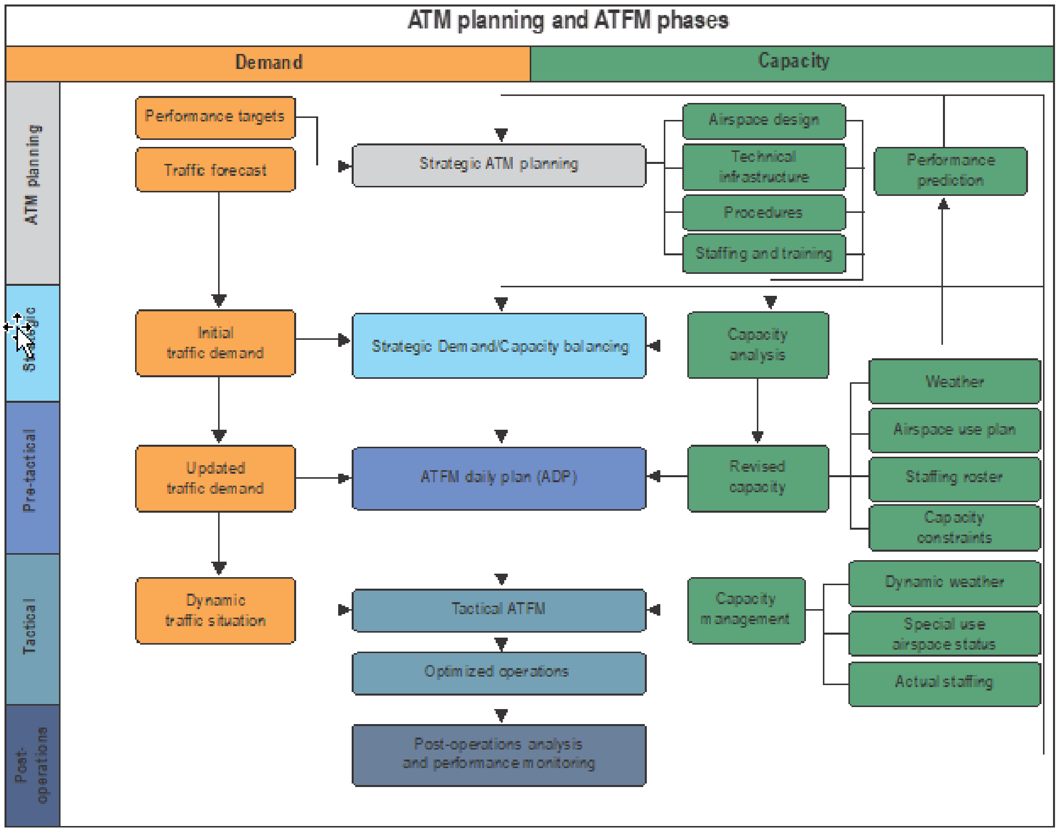

Figure 1 - ATM planning and ATFM phases

2.1 Common Processes

2.1.1 Acquisition of traffic demand

The ATFCM service runs over four "linked" phases that should represent a continuous planning, action and review cycle. The performance of the service is reliant upon the quality of its inputs of which a stable traffic demand assessment is key.

The reality is that independent traffic demand databases have been developed to support the different ATM planning and ATFCM phases and often without due consideration of the local FMP, airport and AU perspectives. The result is a discontinuity in the traffic demand knowledge between phases that requires independent re-establishment between the phases – similarly, the opportunity for constructive feedback between phases is lost. This adds to volatility.

The aim is to reduce the symptoms of traffic demand volatility to a level that will increase stakeholder confidence and permit a management of uncertainty applied to the ATFCM planning and solutions; without affecting the necessary stakeholder flexibility used to mitigate short-term operational situations and events that cannot be foreseen.

Note: The knowledge gap between the ATFCM tactical operations and the ATS execution phase is specifically addressed in the Network 4DT CONOPS.

2.1.2 Load/Capacity monitoring

FMPs and NM perform Load monitoring to identify geographical areas subject to Demand Capacity Balancing (DCB) imbalances in the network. Within NM, NMOC and NM Strategic perform such activity within the time horizon of the various ATFM phases (e.g. NM Strategic as part of the Rolling Seasonal NOP Capacity Assessment).

Today, the supporting tools allowing for this task to be performed remain 2-dimensional, whereby: the airspace is represented by rows in a table with time represented by the x-axis. This means that important elements of such airspaces, such as shape, flight levels and other contextual information are oversimplified before they are displayed to the Flow Manager. This, combined with the complexity of the current systems, leaves room for improvement in the load monitoring system of the future.

The current Load Monitoring already alerts FMPs when situations of imbalance occur for the sector configurations selected. However, due to the above-mentioned constraint – of showing a 3-dimenstional system with time, in 2-dimensions – combined with displaying options that are safety-centric, false imbalances are routinely identified when monitoring load (e.g., when a traffic volume (TV) has distinct monitoring values for 1 selected period, the smaller one is always the one displayed). This is done to make sure that no imbalance is left unchecked, but it also leads to false alerts.

2.1.3 ASM management

Air traffic flow management (ATFM) service manages congested airspace with the best possible match between available capacity and demand. Optimisation can increase available airspace capacity by increasing the number of controllers working at the same time (splitting sectors) and/or matching sector configurations to the traffic demand.

Airspace management (ASM) manages airspace as efficiently as possible in order to satisfy its many users, both civil and military. This service concerns both the way airspace is allocated to its various users (by means of routes, zones, flight levels, etc.) and the way in which it is structured in order to provide air traffic services.

These two services should come together to optimise available capacity to meet the airspace user demands.

The ASM service runs over all ATFM phases (strategic, pre-tactical, tactical and post-operational) that should represent a continuous planning, action and review cycle. Ideally, it should be fully integrated with the ATFCM function to exploit the network opportunity vs capacity optimization and flight efficiency, identifying the best airspace organisation (Area Control Centre (ACC) sector configuration), dynamic management of airspace/route restrictions and adequate ATFCM measures.

Currently, ASM and ATFCM processes are managed independently with some degree of coordination, especially at local level, but not supported at network level by a systematic integrated process.

This is more evident with the Airspace Use Plan/ Updated (Airspace) Use Plan (AUP/UUP) management where the interaction with ATFCM is poor, meaning that AUP and ATFCM Daily Plan (ADP)/Initial Network Plan (INP) processes are not synchronised.

For the UUP process, limited coordination is granted for the ad-hoc request while any other change in the airspace status is not evaluated in terms of possible network effect. Manual workarounds are used for defined cases such as ad hoc requests (P3), as far as the number of requests is sporadic. Even in this case, there is no possibility to evaluate possible domino effects for simultaneous P3 requests.

In addition, the processes are impacted by the lack of a consistent evaluation of the traffic demand vs military events along the entire process.

Despite the efforts to improve the process to inform AUs that routing opportunities are available, the uptake by AUs is rather low and varies a lot from company to company. This depends on the AU capability to react to the routeing opportunity offered, that is how fast they are in changing the Flight Plan (FPL) accordingly and communicate the change to cockpits.

The current rolling AUP and UUP already provide a good degree of dynamicity but is not yet achieving the full rolling process required to manage real time airspace status data, so negatively influencing traffic predictability.

ASM scenarios have been recently introduced from a technical perspective but applied few times and just at national level.

The need to perform an efficient network impact assessment (NIA) is a key task, both at local and network level. The lack of system capabilities de facto undermines the possibility to perform an efficient NIA, as well as any automated CDM process between local FMP/AMC and NM. The current simulation systems (PREDICT, SIMEX) don't allow the automatic download of DRAFT AUP/UUP, limiting the possibility to properly assess the impact on traffic and sector loads.

The utilisation of pre-defined scenarios, including the combination of airspace structures and restrictions, is rather limited and the current systems are not efficient enough (intensive manual work is required) to facilitate such analysis, including the utilisation of historical AUP/UUP data to evaluate possible trends. Further evolution with extension to cross border solutions should be exploited, looking at the combination of ASM scenarios and cluster of restrictions, so moving towards effective ASM/ATFCM integrated processes.

Same evolution could be investigated to combine existing or new ATFCM scenarios with ASM scenarios.

Another element not addressed is the effect of actual take-off time variations vs Estimated Take-Off Time (ETOT)/Calculated Take-Off Time (CTOT) when the trajectory of the flight implies the crossing of active military areas. Any actual take off time variation could imply a potential risk of crossing the areas when activated, issue well known but not solved yet, except for the utilisation of buffer time extending the activation of the areas. This technique is more frequently used by States to “prevent” possible infringements. Although reducing the risks, it doesn't offer a full guarantee of covering all cases. On top, it implies a default loss of airspace availability for more efficient trajectories.

2.1.4 Network Impact Assessment and Simulations

The Network Impact Assessment process evaluates the impact of a specific measure/set of measures on the overall Network aiming at resolving the DCB bottlenecks.

The weaknesses of the current processes are the following:

a) Lack of robustness and ease in the tools to evaluate the optimal combination of ATFM measures for the network (including the effect of removing existing measures such as active Route Availability Document (RAD)). Currently, finding an optimum set of measures based on the traffic, capacity and constraint assumptions is driven by an iterative and time-consuming “try and see” approach, facilitated by expert judgment. Notwithstanding the high value of the latter, tool limitations do not necessarily guarantee the best outcome for the network.

b) Lack of ease to perform analyses based on different operational goals, e.g., reducing delays, reducing complexity, limiting re-routing or total airspace user cost.

c) Lack of robustness in the tools to effectively estimate close to real-life ATFM delay. Current practises require complex and cumbersome data mining to assess expected delay.

d) The simulations used for strategic and pre-tactical phases are separate and cannot be accessed from each other. This means that, for instance, the assumptions made during strategic phase simulations about airspace, airways, RAD, and traffic demand are not clearly visible during the pre-tactical phase, and vice versa. There is a lack of a simple way to transfer the impact assessment, simulations, and scenarios between the different ATFM phases, which will need to be addressed to improve future impact assessments.

e) Lack of consistency of the environment data through the various ATFM phases simulation tools.

f) Lack of actual data on sector openings to feed possible predictive models.

g) Lack of information on airline business models to better replicate airline behaviour and preferences (e.g., way to flight plan and preference between delay and re-routing/extra-mileage)

Simulations

<u>Gaps and issues</u>

The current system supports the rolling network planning processes using a variety of simulation tools (e.g. PREDICT/SIMEX, ETFMS/SIMEX, NEST/SAAM), datasets and HMIs. This leads to inefficiencies, ineffectiveness and issues related to accessibility, integration, scalability and coordination that should all be addressed when further developing the service evolutions and functionalities, in line with the foreseen operating contexts and stakeholder needs.

<u>Accessibility</u>

NM simulations are not archived and are not accessible to external users, including post operations.

Integration

a) The simulation tools are not integrated into the ATFCM process workflows with limited capability to compare different solutions.

b) Network impact assessments do not consider IATA or other data sources and therefore, it is not possible to simulate or assess Network solutions versus the balanced performance approach of the new operational performance targets as punctuality, fuel burn and cost.

c) The tool interactions are cumbersome, requiring high manual workload and workarounds to overcome tool limitations. During busy periods this heavily limits the actual use of the tools.

d) Simulation of ATFCM solution combinations (measure and restriction) are time consuming, resulting in difficulties in providing relevant assessments. E.g., the assessments do not warn of conflicts between existing constraints and application/modification/removal of new constraints. This limits the analysis of cross-impacts between different measures: ASM, restrictions, airspace configurations, flight level capping and horizontal rerouting and ATFCM regulations.

e) The current system has limited weather information. For certain procedures flow data must be visually compared against paper-based weather forecast in order to assess the weather-related capacity reductions.

f) The overall result is a poor traffic demand trajectory predictability prediction. This has in turn a significant impact on capacity optimizations. The current traffic demand predictability predictions have room for improvement.

Coordination

The current simulation tools do not directly support the necessary CDM and coordination required by ATFCM process workflows.

Scalability

Within the tools available at pre-tactical and tactical level:

- What-If functionality is limited to single flight re-route manipulations. During busy traffic days or during major disruptions this causes significant inefficiencies.
- The availability period for archive data is too limited and this restricts the time scope of replays.

2.1.5 Scenario management

Scenarios are ATFCM delay mitigation measures aimed at resolving Network capacity bottlenecks or asked by an ANSP for specific operational needs.

Linked to ATFCM scenarios and their management, there are several areas of possible improvements:

a) Scenario creation/modification is a very long and complex process due to the contribution of many operational stakeholders (FMPs) and NM parties (NM Strategic staff, NM Pre-tactical Team, etc.), each with specific roles and responsibilities.

b) Scenario creation/update request is a manual process, not supported by automation (e.g., via B2B).

c) For the creation/ modification and traceability of scenarios, each involved party uses a different tool (FMPs are submitting paper requests, NM Strategic assesses with NEST, Data Modification Request (DMR) creation is done using Remedy, Scenario management tool is used for traceability and CDM, NM Pre-tactical Team creates scenarios in PREDICT, etc.)

d) Current scenario definition is limited in terms of number and type of criteria, e.g. aircraft type cannot be used.

e) Impossibility to assess multiple scenario/RAD interactions, e.g., when creating a new scenario, the system does not check whether captured flows - or any other applicable constraint - is conflicting or interacting with another existing scenario or RAD restriction.

f) The use of different tools for the impact assessment (NM Strategic use NEST, while NM Pre-tactical Team uses PREDICT). Often there are different results, leading to different conclusions (sometimes because of this reason scenarios are not created).

g) Scenarios require to be traced throughout their entire lifecycle from creation to use in operations and potential deletion or archiving. This can span over several years.

h) The maintenance and archiving of scenarios (highlighting invalid scenarios, rarely used ones, etc.) is a manual process, not supported by any automation for their regular review and validation.

i) The current system offers several re-routing assistance capabilities (Flight Plan Validation System - IFPUV, AO What-If Reroute (AOWIR), Group Rerouting Tool (GRRT), Centralised What-If Reroute - CWIR). Although based on the same rerouting sources and algorithm, these tools are independent and are providing a different subset of features and parameters to the users.

2.1.6 Flight Status

The NM systems (ETFMS / PREDICT, IFPS and external interfaces) have different ways to sort and organise flights according to the situation which the flight finds itself into. These are referred as flight "status". This status usually depends on the system that handles the flight at the time. For example, during flight planning, the IFPS will manage the flight and provide information on the status of the FPL. Later, once in the ETFMS, the flight will have a status depending on its flow management status. The status of a flight is often closely related to the trajectories held by the respective systems.

These different statuses do not always correspond to the same status in the different systems i.e. a FPL can be suspended in ETFMS but not in the IFPS. Lack of a common naming convention and criteria to organise the status of a flight leads to inconsistencies amongst the NM systems.

After successful processing of the FPL in IFPS, the flight will have a Filed status in IFPS. Flights that do not pass IFPS validation are in a Rejected status and those being modified are Invalid. IFPS does not receive airborne updates on the progress of a flight like ETFMS, so a minimum exchange between IFPS and ETFMS has been established for very basic consistency regarding flight status. This will trigger status changes in IFPS.

During the IFPS revalidation against any possible environment modifications that may impact flights, where errors are found, the flight will be suspended or will receive an advisory status message. The latter applies for flights that may not be suspended because they originate out of area, are ATFM exempted or the EOBT is 30 min in the future. The suspension triggered by IFPS is communicated to ETFMS through a FUM message.

The advisory status message informs the AU that the operation of the flight remains, but a significant operational penalty should be expected on the flight (e.g., entering a now closed route). It gives a last chance to the AU to amend the FPL to prevent it. Advisory messages are not generated by ETFMS in case a flight is at risk.

Once in the ETFMS, the flight will be in the status Filed (with or without a slot) and later TACT activated (when the ETOT has been reached or there is an accurate TTOT). There is no suspended status as such in the ETFMS processing, those flights are considered Filed in the internal processing. There are some other statuses that will apply to the flight. These are related to other ETFMS functionalities, and they are linked to the aforementioned ETFMS statuses, but represented separately. These are, amongst others: the readiness status, the CDM status and the FAM status. For example, FAM statuses are linked to a flight reaching the TACT activated status in the ETFMS processing.

The ETFMS also generates FUMs for a flight when important changes of the status take place in the ETFMS causing that the flight may no longer have its FPL amended in IFPS. This information is used by the IFPS for updating the flight status. When processed by the IFPS, FUMs produced by the ETFMS modify the status of the flight in the IFPS in case of: A-DPI processing (Off-block status), suspension (Suspended status) and de-suspension (Filed status).

The different NM interfaces will also display a status or provide one in the message exchange, although the same scenario may be represented differently. For example, the flight status displayed in CHMI and the NOP Portal will show a set of statuses depending on the source of the flight data and whether the flight is activated in ETFMS, airborne data has been received or it is terminated. On the other hand, FUMs will provide a status indicating, for example, if a slot has been allocated or if the flight is suspended.

2.1.7 Traffic volumes and restrictions

Both traffic volumes (TV) and restrictions (RS) are used to capture traffic: in some cases, both models respond to the same operational goal. The two models have grown in different directions over the years since their creation. The result is two different sets of processes and procedures taking place at different phases and systems.

The coexistence of the two models creates complexity and higher technical and operational costs. Operational units at the NMOC and ANSPs have to follow different processes and procedures to design traffic volumes and restrictions. However, both are implemented in the NM environment layer. Traffic volumes and restrictions are then managed operationally by different teams in the NMOC, thus requiring coordination between flow, flight plan and environment personnel.

The purpose of the traffic volume model is to monitor and regulate a volume of air traffic during pre-tactical and tactical operations. Traffic volumes have a structure defined by a Reference Location (RL) and flows. The RL is based on a geographical entity: Aerodrome (AD), Aerodrome Set (AZ), Airspace (AS), (AUA, Cluster, RSA, CS, ES) and Significant Point (SP). Each TV belongs to a traffic volume set, which links it to a FMP.

Depending on the RL, TVs have different qualities. For example, TVs can be activated linked to a sector configuration if the RL is an airspace (type ES or CS). Any TV can be activated outside a sector configuration and with pre-defined periods.

A TV can capture all flights over the RL or a subset of those, depending on flow definition and role. Flows have the purpose of specifying the flights which are captured or not in order to be counted and subject to ATFCM measures. A flow consists of upstream element(s), downstream element(s) or both. The elements in a flow can be: AD, AZ, AS and SP. A flow may be defined by a maximum of three upstream and three downstream elements. Each flow may be defined as: Included (IN) (subject to counts and measures), excluded (EX) (neither subject to counts nor measures), exempted (EM) (subject to counts but not measures) and included / exempted (IE) (an extra flow not yet captured by other flows and subject to counts but not measures).

In order to monitor traffic captured in a TV, capacities may be defined, both entry Monitoring Values (MV) and Occupancy Traffic Monitoring Values (OTMV).

It is possible to create flows that capture flights based on flight data (this includes information from the FPL, such as CNS, and dynamic data like DPI processing). This it relies on the specific use of syntax in the flow note, which is a free text filed not intended for this purpose.

On the other hand, the purpose of the restriction model varies with the type of restriction, but the most common case is to impose a restrictive measure on a flow during flight planning. Normally it is developed strategically and published in the RAD, but it may be modified during pre-tactical and tactical operations.

Flow conditions are defined to capture flights with the aid of logical operands. For most type of restrictions, an included location conditions group allows to define a sequence of locations that include departing and arriving aerodromes (AD), sets of aerodrome (AZ) and airspace (AS); with up to four crossings in-between (only 'AND THEN' operands may be used between departing, crossing and arriving conditions), defined by significant points (SP), airspace (AS), airspace borders, routes (SID/STAR, en-route portion), DCT segments and sets of points. More than one location may be defined at each departing, crossing and arriving condition and level bands are possible at crossing conditions. Therefore, restrictions may be built using more elements than TVs.

One of the departing, crossing or arriving conditions must serve as the reference location (RL) for the applicability of the restriction.

A second location conditions group can be combined with the included location conditions group by an 'OR', 'AND' or 'AND NOT' operand. Between the departing, crossing and arriving Location Conditions within this group a global logical operand has to be inserted if necessary. The operands 'AND THEN' and 'OR' are allowed in this case between the departing, crossing and arriving conditions within the second location conditions group.

Flight property conditions like aircraft type/classification (e.g., 'propellers only' or 'jets only'), Flight type (e.g., military), aircraft equipment (CNS), operator and other elements may be used in combination with the above-described flow conditions to further fine-tune the selection with FPL information. Unlike the aforementioned case for flows, this type of filtering is done in a structured way.

DCT and FRA DCT RSs have a reduced definition of flow conditions, with the possibility of defining DCT limits.

The basic applicability is defined based on days of the week and time intervals. It can also contain special dates, such as holidays, that are derived from the country unit where the RL is. A dependent applicability triggers the period(s) of time and possible vertical limits with or without vertical definitions, normally linked to FUA activation periods.

Restrictions may be grouped, so they can be enabled / disabled as one.

There are different types of restrictions: Traffic Flow RS, Profile Tuning Restriction, Aerodrome Flight Rule RS, Flight property RS on Terminal Procedure, DCT Limitation RS, SSR Code Allocation RS, FRA DCT RS, DCT Limitation RS and Error Management RS. Due to the different purpose of each type, the actions on the flights matched by the flow conditions greatly differ; including forbidden or allowed routings, vertical profile modifications, CCAMS code assignments, etc.

2.1.8 RAD

The current management of the RAD is based on permanent daily applications of time, geographical and vertical restrictions in Central Airspace and Capacity Database (CACD) (as published in AIP and RAD) as requested by civil/military ANSPs or Airports, having the same impact on FPL flight profiles as those applied temporarily for ATFM purposes (ATFM standard measures, Airport Cherry Picking (ACP)/ Mandatory Cherry Pick (MCP), Re-routeing (RR)/ Flight Level Capping (FL) scenarios).

Such restrictions can be then considered as always ON (enabled in CACD and mandatory for AU) and act at FPL level: if RAD is not respected, the FPL becomes invalid (suspended or rejected) in IFPS and shall be refiled by the AU respecting the restrictions, being this a necessary condition to receive an ACK message by IFPS.

Currently the published RAD restrictions can be disabled by NMOC through a cumbersome coordination with relevant ANSP(s) and made available to CFSP/AU for FPL purposes and it is rarely applied (Flexible RAD procedure in Pre-tactical, ATC strikes). In the past years, the enhancement of this process was slow because of the current system limitations and because the management of the ATFM measures and RAD restrictions are operated by two different systems/personnel within NMOC, respectively in ETFMS/Flow Management staff and CACD/Airspace Data staff.

Currently, it is not also possible to quickly simulate the impact of tactically disabling a restriction in CACD vs sector and airport counts in ETFMS, that is why RAD restrictions are always ON (published in AIP, RAD and enabled in CACD).

Recently the concept of dynamic RAD has been introduced through trials for its validation via AUP process (also supporting a possible integration with ASM). However, such trials highlighted several limitations (no impact assessment tool, cumbersome procedures to enable/disable RAD restrictions in the Pre-tactical/Tactical phase, lack of specific coordination and communication tools with ANSPs/AUs, etc) that prevent an effective application of a ‘dynamic RAD’ procedure.

2.1.9 Network CDM

The CDM process is a key enabler for ATFCM and network management, allowing for the sharing of all relevant information among decision makers and supporting an ongoing dialogue between the various stakeholders (e.g. Airlines, Military airspace users, civil and military ANSPs, Airports) throughout all ATFM phases.

This process enables the various organizations to keep each other continuously updated on events resulting from the strategic to tactical phases. Applying CDM principles to ATFCM facilitates the ability to make better decisions and provides the stakeholders with enhanced situational awareness. This awareness generates an environment where such stakeholders share a better understanding of the overall network situation.

Current CDM deficiencies

Although the ATFCM CDM processes are mature, there are several CDM improvement areas to be addressed: internal to ATFCM and to the external interfaces with related concepts such as ATM planning, ASM (Advanced Flexible Use of Airspace (AFUA), Dynamic Airspace Configuration (DAC), Dynamic Mobile Area (DMA)), airports and airlines (User-Driven Prioritisation Process (UDPP) and trajectory management), crises management. These improvements can consist of information exchanges and to coordination associated to common process milestones.

NM’s disparate CDM processes and weak interfaces affect performance for various reasons such as inconsistent objectives, obtaining optima piecewise, different decision times, and lack of visibility into each other’s processes.

Different layers of decision-making can lead to inconsistencies. For example, agreement can be reached on broad performance objectives through CDM for strategic decisions. Operational decisions reached collaboratively may seek different operational performance objectives based upon circumstances, effectively working at odds with the strategic decisions. Processes should consider potential inconsistencies and guidelines for mitigating these inconsistencies.

CDM processes can be misused for individualistic advantage. CDM processes are based upon information provided by multiple participants with differing objectives; the provision of false information to “game” the system in their favour is a potential concern. Lack of harmonisation may make it difficult to detect or be too robust against the impact of these behaviours across disparate processes.

There is need to provide the mechanisms to share CDM processes and information to the users, in all phases of operation and between those phases.

NM (NMOC), ANSPs (FMP, TWR, airports), airspace users (AOCC, others), military (AMCs, others) often rely on fragmented and sometimes non-digitalised information and applications running in different views or based on different technologies.

With the increase of air traffic demand and operational workload associated, the integration of all the ATFCM phases, applications and operational information within a unified, closer & more harmonised set of NM CDM processes and to support new concepts has emerged. This should be treated as a priority.

Internal ATFCM processes

- The Strategic phase CDM process outputs are captured on a different platform than that used by pre-tactical and tactical ATFCM (and post ops). These outcomes are then re-implemented into the NMOC tool set using the CACD (DMR), NOP portal and the scenario repository.
- During strategic and pre-tactical phases, NM uses historical flight plan trajectories to determine future traffic demand and as an input to adapt ATC capacity and configuration planning in the strategic phase. The quality of the assessment of the planned the ACC configurations has a dependency on the quality of NM selection of the selected 4D trajectories. Other sources of reliable 4D trajectories should be considered to improve capacity planning.
- During the pre-tactical and tactical phases, the decision making is not consistently recorded in the provided standalone tool. This makes it cumbersome for post ops phase to analyse what contributed to decision to either apply or not apply an ATFCM solution to overcome a demand and capacity imbalance.
- There is a need to evolve the (equity/fairness) priority rule sets and to use non-ICAO information sources (IATA) to benefit the EATMN.

Coordination Platform (iDAP - integrated Digital ATFCM platform) is the digital coordination tool for:

- FMPs to propose to NM, ATFCM regulations and cherry pick measures;
- FMPs and ATC Towers to propose to NM, proposals to mitigate constrained flight impacts;
- AUs to request mitigations to NM, for their ATFCM constrained flights and critical flights (tactical phase).

Coordination Platform has evolved since its 2010 inception from a simple standalone web application that mitigated telephone call waiting times to now performing tactical coordination digitally and enable ATFCM measure proposals to NMOC and for NMOC to accept or reject them. Telephone coordination is now limited to critical situations only.

Coordination Platform's development is ongoing through stakeholder workshops seeking improvements to mitigate upcoming network issues and to address known tool deficiencies:

- **Lack of simulations input when making proposals**. Coordination Platform introduced an immediate workload and time saving by not having to wait for telephone calls to be answered and to exchange coordination information. The ability for Coordination Platform to exchange information very quickly led FMPs to start sending immature proposals, without full assessment of the outcome, and these were quickly followed by corrective proposals to tune the measures that caused network instability.
- **Proposals management is 'simplistic'**. NM is able to accept or reject received proposals but there is no capability for optimisation/adjustments. Instead, any counter proposals or adjustment must first be coordinated by telephone for agreement. Telephone coordination might not always be possible during periods of high workload and therefore limits the extent NMOC can optimise operations. Ideally, when receiving the proposal.
- **One-way proposals**. In the current CDM setup, it is only NM who may accept proposals and perform system actions. However, it may happen that NM needs the

approval of a local unit before performing the action in the system – today NM achieves this via the telephone.

- **Automatic acceptance.** NM today has a set of business rules used in the automatic treatment of certain requests. Up to now, this is limited to automatic rejection of requests when they do not meet basic requirements. The automatic treatment should be extended to acceptance of some types of proposal where all the information is integrated in one system, E.g., Slot Extensions and Slot Swap requests.
- **Critical flight requests**. AUs may flag flight requests for slot improvement as critical. Such Coordination Platform requests are highlighted to NMOC and then treated in priority over other similar Coordination Platform requests. NMOC will exploit all means to reduce the ATFM delay of the critical flights, in coordination with relevant ANSP/Airport responsible for the ATFM measure. However, other ATFCM processes are not aware of the flight criticality.
- **Telephone integration.** The received Coordination Platform proposals are stored together with system actions in NM archive systems for later analysis and retrieval. The telephone coordination is not reflected in the same system archives as the resultant actions. This creates a big gap for post ops processes because the system actions are not traceable to a telephone coordination (e.g., phone coordination is stored in the telephone tapes, but not in the NM systems).

2.1.10 Local Traffic Complexity tools

The local traffic management process that considers the predicted complexity coupled with traffic demand, enables the ANSPs to take timely action to better address demand and capacity balancing or request trajectory changes, in coordination with NM and Airspace Users. Several variants of local traffic complexity management processes/tools are implemented across ANSPs with different level of capabilities and exchanges for data reception/provision. Additionally, in NM27.0, NM deployed its first ever functionality for monitoring and managing local complexity.

The rigid application of ATFCM measures, based on standard capacity thresholds as the pre-dominant tactical capacity measure is replaced by a process that foster a close cooperation between ANSPs and NM, aiming to monitor the traffic demand, versus the effective capacity of sectors and the complexity of expected traffic situation in a specific area or airport.

Few ANSPs provide feedback on local Traffic Complexity Manager (TCM) process to NM, mainly via the NM B2B service.

Not all the TCM tools support the management of entry and occupancy counts, permitting users to switch the view from one to another.

2.1.11 Airport Slots

The identification of DCB imbalance, i.e., imbalance between the number of requested airport slots and capacity, starts at D-6 weeks and is currently done independently by Airport Function office in NMOC. Airports with identified DCB issue are contacted directly to explore potential solutions. This direct communication continues until D-2 days.

Non-coordinated airports can also have capacity issues from time to time. They are currently not able to easily share a list of flights for the affected period by e.g., uploading it via a standard interface. Currently the demand is shared with Airport Function office by email.

Airport slot coordination is a local process that does not guarantee consistency and resilience across the network. This lack of Network view during the planning phase can increase network inefficiencies and tactical problems.

Normally, major demand/capacity imbalances are addressed during the pre-tactical phase, however, there is still a potential for significant airport traffic peak demand. Thus, the Airport Function will support the resolution of unplanned issues if they arise.

Airport Function tactically monitors slot usage at some airports. This requires comparison of issued airport slots with filed flight plans, and where the filed flight plan does not correspond to the existing airport slot, the operator is contacted to rectify the situation. The current process is inefficient for two reasons:

- There is no access to the latest slot database within EUROCONTROL, as DDR data is updated only once a day and therefore external system must be used.
- There is no mapping of IATA and ICAO data fields in NM systems and therefore this check must be performed manually by Airport Function staff.

Once a flight is airborne, MIRROR tool is used to assess landings at destination and whether those will make their next departure on time, since the next departure may be affected by weather en-route or inbound holding. The tool is not integrated with NMOC systems (ETFMS does not use Scheduled Off-Block Time (SOBT) and IATA codes).

Moreover, there is no systematic analysis of adherence to airport slots in the post-operational phase.

2.2 Strategic phase

2.2.1 Acquisition of traffic demand

The acquisition of traffic demand is key for Strategic ATFCM and for the NM to provide operational services to stakeholders according to the NF IR 123/2019. Within a strategic time horizon, the following weaknesses can be highlighted for acquisition of traffic demand:

- Sources of traffic data are not directly connected to strategic tools. A heavy data maintenance process is required to guarantee traffic demand is available in the proper format.
- Traffic demand not easily shareable between different ATFM phases e.g., Strategic to Pre-tact.
- Flight trajectories are based on historical types, such as Filed Tactical Flight Model (FTFM), Regulated Tactical Flight Model (RTFM), Current Tactical Flight Model (CTFM) and thus inherit the limitations of these flight models. Moreover, current trajectory simulation capabilities only partially reproduce actual business models.

2.2.2 Strategic simulations (NEST)

NEST is the main strategic phase simulation tool. NEST is a scenario-based modelling tool developed by EUROCONTROL. It is used by the ANSPs and NM to:

- Optimise the available resources and improve performance at network level;

- Design and develop the airspace structure;
- Plan the capacity and perform related post operations analyses;
- Organise the traffic flows in the air traffic flow and capacity management (ATFCM) strategic phase;
- Prepare scenarios to support fast and real-time simulations;
- Ad-hoc studies at local and network level.

NEST is dependent on the quality and content of the datasets with respect to:

- Possibility to include official future environment in any ATFM or trajectory simulation;
- Environment data formats and easy transfer process through all ATFM phases while allowing flexible data manipulation for simulation purposes;
- Alignment of the various calculation modules in the ATFM simulation tools, in order to make sure algorithms and associated results are the same.

2.2.3 Special Events

There is a lack of archived past events impact information and ATFM-related data in a swiftly retrievable format. This could be useful to support the impact assessment and the evaluation of expected traffic demand. Currently data can be retrieved from various sources, but they have to be manually manipulated and tailored in order to model future event circumstances.

There is a lack of common event management flow, allowing a seamless process from event notification to carry-on in operations. Relevant information, including simulation data or operations critical information, cannot be easily shared or made available between the different ATFM phases and NM Teams. A lot of the information and data flow still heavily relies on e-mails.

2.3 Pre-tactical phase

2.3.1 Acquisition of traffic demand

Within the pre-tactical time horizon (from D-6 to D-1 before operations), the acquisition of traffic demand is mainly based on the use of historical flight data (by default, flight data of the week before, the same day of week). Selected historical flight data is further adjusted with flight intentions collected in the NM DDR (Demand Data repository), to anticipate the future changes in the volume of traffic compared to the selected historical reference day.

Flight intentions reflect future planned flights derived from airport slots allocated at around 170 coordinated airports in Europe and complemented with commercial flight schedules from airlines for flights not liaising coordinated airports.

Important to note that flight intentions contain limited information about individual flight (liaised airports, aircraft type, flight id and schedule departure and arrival time), but no information about the planned route. Information about planned routes becomes only available to NM when the first flight plan is received: currently most of the flight plans are sent to NM by airspace users in the last twenty hours before departure (off-block time).

This is an important limitation in the traffic demand acquisition process used in PREDICT to support the pre-tactical planning, considering that resulting traffic demand forecast mainly reflects historical filed routes derived from past operations and not the future planned routes and the underlying future conditions impacting the planned routes like wind directions, airspace and route availability, future restrictions, etc.

The adjustment process of historical flight data with flight intentions used in PREDICT intends to anticipate the variation of the volume of traffic at the airports from one week to another. However, not all airports are covered, nor all types of traffic (mainly commercial flights, but limited information about future General Aviation/Business Aviation (GA/BA) traffic and cargo /ad hoc flights). Late changes to the planned traffic at airports (e.g., late traffic reduction resulting from special events and specific meteo conditions like snow and fog) are not reflected in PREDICT if changes to the flight programmes of the impacted airports are made in the last 30 hours before operations. Indeed, the latest flight adjustment done in PREDICT is done with flight intentions updates received in DDR at D-2 mid-afternoon.

Another adjustment process available in PREDICT is the North Atlantic Traffic (NAT) replacement. It consists in replacing the historical tracks of the North Atlantic traffic to better reflect the variation of the entry and exit points of NAT to/from the NM area (eastbound and westbound traffic over the Atlantic Ocean) resulting from variations of the Jet stream position (also designated as forecast NAT tracks).

Consequently, traffic demand acquisition during the pre-tactical phase may present a non negligeable variation, compared to the forecast traffic demand derived from flight plans which will be eventually submitted to NM and used in the ETFMS system to derive the filed demand during the day of operations.

2.3.2 Simulations (PREDICT)

PREDICT and SIMEX are the pre-tactical phase simulation tools developed to support the procedures set out in the ATFCM operations manual, specifically:

- Evaluation studies of ATFCM measures for special events and to support crises management;
- Pre-tactical preparation of the ATFCM daily plan;
- Maintenance of Scenarios (RR and FL) between AIRAC datasets.

Integration

The AIRAC switches often introduce cross-border airspace and flexible RAD procedure changes directly into the pre-tactical and tactical operational systems. This limits the pre-tactical phase time to assess the impacts and to revise previously prepared special events scenarios stored in the scenario (RR, FL) repository. This adversely affects the support for airspace, RAD change, and special events.

During the pre-tactical ASM (FUA) phase, MILO/AMC perform impact assessments using the CHMI tool. This information is not directly transferred to the current pre-tactical system, hence requiring effort duplication when performing impact assessments (group rerouting, etc.).

The current system is not connected to conferencing/sharing software: meaning NMOC manually produces static snapshots of their HMIs and share these in conferences or via e-mail or other tools.

The NM rerouting tools limitations, mainly linked with the tool performance, execution time and algorithm assumptions need to be continuously addressed and aligned with operational requirements (e.g. evolution of FRA, RAD).

The pre-tactical traffic demand predictability needs improvement. When the traffic demand is predicted into specific sector groups, ANSPs configure capacity to meet that demand; rosters are set and configurations input into the system. On the day of operation, when the traffic demand varies significantly from that predicted, the ANSPs may provide capacity that is under-used and at the same time insufficient capacity in the sector groups actually occupied by flights. ATCOs specific local sector group validation hampers the flexibility to choose any available sector configuration by the FMP. The same traffic demand is used in pre-tactical simulations to analyse, assess and select ATFCM measures as part of the ADP preparation. Improved AU accessibility to predict and simulations could help to identify poor demand predictions.

<u>Scalability</u>

The simulations are limited to a single day and restrict the ability to manage multi-day events and exercises.

2.3.3 Initial Network Plan

The communication and coordination of the ATFCM Network daily plan to ANSPs, Military authorities, Airports and Airspace Users is paramount for the NM to execute the Network Function, as committed in the NF IR 123/2019.

The Initial Network Plan (INP) is a document (replacing the former Network News distributed via AFTN) produced at D-1 by the NMOC Pre-tactical team and published in the NOP portal.

The INP details the Pre-tactical ATFCM Network Plan, aimed at providing stakeholders information on events that are foreseen to impact flight operations and/or ATC on the following day.

The input of INP is mostly manual because of a limited data exchange with the NMOC systems.

After the publication in NOP portal the INP can be modified by the Pre-tactical Team in case of a significant change in the ATFCM Network Plan. The INP is not modified during the day of operations.

The INP should become a dynamic document (DNP – Dynamic Network Plan), modifiable any time and entailing more automation with info/data retrieved directly from ETFMS vs all ATFCM updates of the above listed items during the day of operations.

As described in the ASM management, there is no alignment if the process for the publication of ASM and ATFCM information. Moreover EAUP/EUUP are published separately on the NOP Portal, providing no visibility of any possible interaction.

2.3.4 Integration of airports into the Network

Airports and Airlines tend to plan their operations well in advance compared to ANSPs. ATC and ATFM services are provided on a very short notice when compared to them.

This shared plan is mostly founded on flight schedules following the EU Regulation 95/93 for coordinated airports. Europe hosts half of the Level 3 coordinated airports (104 out of 204 as per 2019 data) with several of these 'Level 3' airports highly saturated with over 85% of the slots occupied in the busiest period of the day. Therefore, building a resilient plan during the strategic and pre-tactical phases becomes paramount to execute the plan as smoothly as possible minimizing the impact on the air transportation system users.

Advanced ATC Towers and Airport Collaborative Decision Making (A-CDM) airports don't provide any information during the pre-tactical phase. The lack of pre-tactical information limits the pre-tactical DCB assessment.

Advanced Network Integrated (ANI) Airports are airports that have implemented the Collaborative Decision-Making process. In addition to the A-CDM DPI messages, ANI airports also provide the Predicted Departure Planning Information (P-DPI) messages as an output of their Demand Capacity Balancing (DCB) process.

P-DPI provides NM with relevant data from the airport operations plan as soon as this data becomes available and a FPL is available in ETFMS (since EOBT – 48 hours). The main weakness resides in ETFMS, because a FPL is always needed for receiving the P-DPI message. Airports have relevant commercial information about their flight in their systems several days in advance and their demand is constantly updated (e.g. with IATA flight cancellations). This demand is typically exchanged between Airports and their Stakeholders with IATA format. On ETFMS side we can start to receive those updates¸ only when a FPL is filed or we can react to a cancellation only when the expected flight plan is not received, thus not having always the most updated picture as the Airport systems have.

The number of IATA attributes in the DPI messages is limited, ETFMS does not support the exchange of all the IATA attributes used by Airports and their Stakeholders.

ANI airports also share the General Arrival Planning Information (G-API) message which can be used by ANSPs and Airports for providing more accurate data on inbound flight, in particular to share general flight data attributes such as STAR, landing Time, arrival Runway with the ATM Network. The same weaknesses on the need for a FPL for receiving the messages and IATA format compatibility apply.

Another issue for ANI airports is that there is not always full visibility and timely exchange with ANSPs on data in all the phases (e.g., planned runway usage, STAR). This is then reflected in the message exchange with ETFMS and the calculated flight trajectories which are sub-optimal.

In case of a crisis or severe disruption (following an NMOC decision), the dedicated information services are activated via NM System (e.g. Airport Corner). All information related to the severe disruption provided by an airport is shared in real time with the NMOC, Airlines, ANSPs and other Airports (the Network). The aim is having situational awareness on the situation at airports (airside and landside constraints and capabilities) in support to the Network situational awareness and collaborative decision making at each phase of the crisis or severe disruption.

In case of mass diversion, there is no centralised tool/approach in NM systems to provide all Stakeholders with the necessary awareness (available apron capacity, ground services available, etc) and optimise actions on flights that need to land at alternate aerodromes.

2.4 Tactical phase – Pre-departure

2.4.1 Simulations (Tact SIMEX)

SIMEX is the tactical phase simulation tool developed to support the procedures set out in the ATFCM operations manual, for:

- Evaluation of ATFCM solutions before application in tactical operations.

Accessibility

Accessibility to simulations is a key gap. An FMP with a DCB issue initiates a solution but cannot simply simulate that solution or share/coordinate it with the adjacent FMPs for analysis and impact assessment. Instead of performing cumbersome simulations and coordination, the FMP calls NMOC and a regulation is applied to solve the DCB imbalance, the regulation may be tuned and possibly replaced by an overarching network measure. This experimentation on the live system directly results in large quantities of revision messages and possible reactive mitigations from AUs. At a network level this contributes to volatility.

AUs use IFPUV and cannot test their Flight Plans against tactical simulations.

NMOC staff can find valid routes in IFPS, but not in the tactical ATFCM tools. This often leads to extra complexity and additional workload.

MILO/AMC perform impact assessments using the CHMI tool. This information is not directly transferred to the current ATFCM tactical system, hence requiring effort duplication when performing ATFCM impact assessment (group rerouting, etc.).

Coordination

The current simulation tools do not directly support the necessary CDM and coordination required by ATFCM process workflows. FMP initiated simulations cannot be viewed by NMOC and any resultant measures have to be coordinated independently of the simulation – duplicating workload and delaying application of the ATFCM solutions.

2.4.2 STAM measures

Short-Term ATFCM Measures (STAM) are specific and dedicated measures for demand capacity balancing (DCB) applied to a limited number of targeted pre-departure and/or airborne flights or flows reducing the complexity and/or demand of anticipated/identified local traffic peaks on the day of operation, through close cooperation between different actors. This means that flights that meet certain conditions could be subject to these measures. The implementation of these measures could avoid the implementation of Regulations.

STAMs are implemented across ECAC area by local Flow Management Positions (FMPs) with various level of sophistication, but sometimes have an impact on the network, and therefore require that an overall Network Impact Assessment (including what-if capabilities) is made by FMPs or NM in coordination with each other.

Types of STAMs:

- **Minimum departure interval (MDI)**

Sequential departures from certain aerodromes need to be spaced by X minutes if they proceed in a specific direction. The restrictions are similar to assigning CTOTs, the difference being that the application of the measure is temporary.

MDIs are coordinated nowadays with Airports and adjacent ACCs if needed, not with NM. This is subject to improvement in the future.

- **Successive aircraft separation**

Traffic is regulated by requiring minimum miles-in-trail separation is maintained between a series of successive aircraft on specific routes.

Successive A/c separation are coordinated nowadays with Airports and adjacent ACCs if needed, not with NM. This is subject to improvement in the future.

- **STAM Re-routing Proposal (RRP)**

In the past years, local rerouting/level capping proposals from FMPs to AOs have been integrated in NM systems. Currently FMP can only do STAM RRP measures coordinated via NM in the Flight Planning phase (until 2h before EOBT).

The current STAM RRP operative has been designed as optional for the FMPs but it is now part of the FMP DCB toolbox in NM systems and has the main goal to reduce the delay of the Network. This is considered an advanced tool and as such it has been enabled in NM B2B Web services only for advanced NM B2B FMP users, however those system capabilities will be available via B2C interface too.

NM is in charge of receiving from FMPs the STAM RRPs and sending them to the FOC. On top of that, in cross-border situations, NM has the role to assess the impact of the measure and to establish the coordination with the impacted ANSPs. Nowadays there is a limitation, in the system, NM can process a maximum number of 15 STAM RRPs that require NMOC approval (impact beyond adjacent FMPs) per day per FMP. There is subsequently some room for automation especially in the coordination.

Please note that MCP/ACP regulations can be also applied as STAM.

2.4.3 ATFM Slot allocation

The principles of allocation of ATFM departure slots are defined in the IR 2019/123. The NM complies with such principles.

CASA builds and manages a list of slots. To calculate the slot, FMPs provide the hourly entry rate that traffic demand shall adhere to (which can be zero in case of some scenarios and crisis management). It is not possible to regulate a TV using an occupancy rate, despite many FMPs do monitor using occupancy counts.

A regulation may be divided in sub-periods, each sub-period being assigned a different entry hourly rate. CASA uses the rates to build the slot allocation list.

When the regulation is activated (before the regulation start time) CASA will give each flight a pre-allocated slot. Flights are prioritised according to the order of their planned entry into this location ("first planned, first served"), but possibly delayed ensuring that the hourly entry rate will not be exceeded at the location where the measure is applied. This initial reservation is internal to the NM systems and is subject to amendment if new flight data arrives.

The general principle to be used to search a slot in a regulation is first to find the worse delay in all concerned regulations. The regulation providing the biggest contribution is declared the most penalising regulation for this flight. The flight will be forced with the delay provided by the most penalising regulation in all other regulations. The new sequence position imposed by the MPR typically has an impact (either positive or negative) on other flights in the sequences of other regulations.

A Calculated Time Over (CTO) the reference location will be computed for the flight for the selected slot. The CTO will be propagated upstream following the trajectory of the flight to find the Calculated Take-Off Time (CTOT). The difference between the CTOT and the ETOT will provide the ground delay that the flight will have to respect the given rate at the reference location of the regulated TV.

Nowadays conventional ATFCM regulations already coexist with some local originated measures. Yet, the problem of reconciling multiple constraints continues to grow as local measures from different actors originating in more sophisticated systems, increasingly spread over an earlier planning horizon, are overlapping with each other. Moreover, attempts by local DCB systems to refine measures and AU to preserve their priorities often result in additional constraints.

2.4.4 Integration of airports into the Network

The main issues impacting flow management processes related to airport integration are:

- Lack of departure predictability caused by not assessing the impact of the inbound flight on the departure flight (turnaround process).
- Lack of schedule data that impacts airports, AUs and Network performance.
- In general, for all the Airports integrated in the Network a continuous monitoring service is missing, to guarantee that the quality of the data provided is up to standard for flow management.
- The issue on the timely and availability of data exchange between Airports and ANPS is still present in the tactical phase as in the pre-tactical.

2.5 Tactical phase – Post-departure

2.5.1 Post take-off ATFCM measures

In the tactical post-departure phase, there is no DCB tool available to the NM as currently no ATFCM measures can be applied to a flight after its take-off. The majority of operations in this phase are performed only by ATC through tactical interventions, such as airborne STAMs (Miles-In-Trail, tactical horizontal or vertical re-routings, etc.) in order to balance traffic in ACC sectors or for any other ATC need.

The applicability of post-take-off ATFCM measures will be quite limited in future because any action entails a complex coordination between NM, FMP/ATC, AO and pilots. Any planned deviation from the agreed trajectory shall consider aircraft capability vs fuel on board.

It would be anyway possible to create a repository for post-take-off ATFCM measures, based on existing RR and FL scenarios, entailing limited re-routeing or level capping, with little impact on additional fuel burn, supported by what-if network impact tool.

There is no STAM RRP allowed to be sent nowadays after the Airborne phase (after ATC has activated it).

All STAM measures applied by ATC shall be anyway notified to the NM systems in real time to enhance traffic predictability downstream.

2.6 Post OPS phase

2.6.1 Attribution of delay

The current system of delay attribution derives from regulation reasons applied when regulations are applied. There are 15 reasons which are not flexible enough to reflect the real causes of ATFM delay (i.e., ATC capacity and Staffing). There are no rules for application of regulation reasons: although agreed guidelines are documented in the NM operations manual. These are open to interpretation and can be manipulated by ANSP's to suit circumstances.

Furthermore, the current performance scheme does not encourage cooperation across different ATC units or ANSP's, preventing the Network Manager from implementing or optimizing the best ATFM solutions for the Network.

It is currently not always clear which entity has generated a given delay and for what reason- future systems need to better reflect the true generator of delay.

In case of circumstances establishing delay re-attribution mechanisms, it is currently very cumbersome and lengthy to determine the delay to be re-attributed at the level of entity, regulation and worse single flights.

2.6.2 Network Performance – Analysis and Investigation

Current post operations are significantly restricted for several reasons:

Lack of data: Not all data is stored and what is stored is spread across several different and incompatible databases. Full data are not stored for long time. Even where data is stored it is not always parsed or stored in easy-to-understand format. Current data services and support are limited, slow and expensive.

Poor simulation and replay facility: The current simulation tools are not able to fully replicate any traffic situation. It is possible to load a day's data but once modified (What if) the tool cannot replicate airline behaviour reducing any simulation to a guess work.

Additionally, the current replay facilities are extremely slow, this causes a high workload and time consuming. As a result, replays are only rarely used.

Feedback:
Feedback from operational staff is of vital importance (as a complement to accurate data storage) as it helps to build the operational or situational history.

The current available system for NMOC staff to giving feedback is very basic- writing in a word document on a particular subject – some work has been done to structure the feedback, allowing it to be categorised and therefore better catalogued for trend analysis. Although this is improving it remains rudimentary.

Obtaining feedback from operational staff remains difficult and often relies on labour intensive meetings and interviews. This may give an inconsistent picture of operational issues.

Reporting:
The NMIR is not suitable for operational data reporting. Dashboards have been developed for various purposes and whilst this eased to reporting on operational issues, it remains limited and not available to external customers. This remains a significant weakness in post ops reporting.

2.6.3 Network Performance – Monitoring & Reporting

NM reports annually the results of the key performance indicators (KPIs) monitoring and related targets to the EC and NM governing bodies, usually as part of the NM Annual Report. In addition, NM reports its performance and the results of KPIs monitoring to each NMB meeting.

NM has developed several dashboards that allow the daily, weekly, monthly, seasonal and annual monitoring of several network, AFTM and NPP indicators. This allows a more flexible monitoring of those indicators.

In addition, NM produces reports showing the status of the KPIs and, where appropriate, other objectives. NM internal procedures set the monitoring frequency of the individual indicators (Performance SC six times p.a.).

Despite the efforts to improve the effectiveness of the performance monitoring activities, there are still several limitations:

- Data availability and accessibility is challenging.
- Infrastructure readiness is the biggest challenge so far and also moving forward
- Valuable data from operational systems is not archived for further usages or to generate insights/analytics
- Not all data is made available outside Ops system/s or sometime not available at a granular level. For example:
  - Fuel burn data, after several attempts only total fuel burn data is available
  - For 4D trajectories, only final and actual trajectory is available but not how it changes over time
- Two distinct data environments (on-prem and cloud) and integration between them is not efficient
- Changes in source data are not always shared with the stakeholders in a timely

manner.

- Operating model needs improvements to meet the stakeholders needs, and processes should be made more defined & lean.
- TEC deliveries are not always in time and needs to made more efficient.
- Data ownership/roles & responsibility is not well defined and agreed
- No single source of truth agreed for key data assets, that leads to ambiguous definitions and incorrect/contracting results.

2.6.4 Post OPS Simulations/Replay

NEST, SIMEX and REPLAY are the post OPS phase simulation tools developed to:

- evaluate the performance of specific ATFCM solutions of interest to learn for future events;
  - What could have been done better?
  - What other options were available?
- scrutinize operational incidents related to overloads and over deliveries;
- feed into the strategic phase (input into the next planning cycle).

Integration

Current replay facilities are extremely time-consuming to prepare (+12 hours) and require a high workload to use. They are limited to a single day.

Replay does not offer the ability to simulate other alternative options.

Further, a rewind facility is not supported, instead users must start the replay process again.

The availability period for archive data is too limited and this restricts the time scope of replays.

3 Drivers for change

3.1 High Level drivers

The evolution of the FLOW management intends to put into operations the Network Strategy Plan (NSP) 2020-2029 approved through European Commission Decision (EU) No 2019/2167 of 17 December 2019, and supports the implementation of improvements as defined in the ATM Master Plan and the Common Project One (CP1) Implementing Regulation No 2021/116.

Through alignment with the NSP and CP1 IR, this FLOW CONOPS is in line with the SESAR ATM Master Plan Essential Operational Changes and ICAO ASBUs.

The objective of this FLOW CONOPS is to serve as a common high-level view for all operational actors on the target for operating the network in 2029. Further, it provides a basis to ensure all improvement activities are in place to achieve the required performance over and above what can be achieved using current and new ATM network methods, processes and enabling system supporting **SES regulations.**

The Single European Sky initiative was launched with a view to improving the overall performance of air traffic management (ATM) amongst others by moving several competences to the framework of the European Union, as part of the Common Transport Policy. The following regulations provide requirements supporting the evolution of FLOW Management.

- **Commission Regulation (EC) No 255/2010 of 25 March 2010**

This Regulation lays down common rules on air traffic flow management. This Regulation lays down the requirements for ATFCM to optimize the available capacity of the European air traffic management network (hereinafter EATMN) and enhance ATFM processes (art.1).

The regulation describes several generic obligations for the member States (art. 4), such as the availability of the 24 hours service, the definition of common processes and procedures, to be described in available documentation, as well as the definition of common procedures for requesting exemption from an ATFM departure slot shall be drawn up in accordance with the ICAO provisions. Those procedures shall be coordinated with the central unit for ATFM and published in national aeronautical information publications. In this respect, the central unit for ATFM notifies a Member State which grants exemptions in excess of 0,6 % of that Member State’s (art.11) annual departures.

This Regulation is applicable to all flights intended to operate or operating as general air traffic in accordance with instrument flight rules within the airspace defined in Article 1(3) of Regulation (EC) No 551/2004 as well as to all the ATM parties specified in art. 1.

- **Flexible Use of Airspace Regulation 2150/2005**

Although dated (2005), the regulation remains still valid in defying the main objectives of FUA Concept (art.2), such as any segregation/restriction shall be of temporary nature and integration of ASM/ATFCM/ATC processes, the main responsibility of the three ASM levels (art. 3, 4 and 5). Emphasis across the regulation is provided to promote cross border operations to achieve a more efficient use of the airspace not bounded by national borders.

- **CP1(R116/2021)**

The Common Project One ('CP1') is established to support the implementation of the European Air Traffic Management ('ATM') Master Plan (art.1).

"Implementation" means, in reference to ATM functionalities, the procurement, installation, testing, training and putting into service of equipment and systems, including associated operational procedures, carried out by operational stakeholders.

The ATM functionalities in the scope of CP1 are:

- AF1: extended arrival management and integrated AMAN/DMAN in the high-density terminal manoeuvring areas;
- AF2: airport integration and throughput;
- AF3: flexible airspace management and free route airspace;
- AF4: network collaborative management;
- AF5: system wide information management;
- AF6: initial trajectory information sharing.

- **Network Function implementing rule 123/2019**

The art. 1 of the implementing regulation describes which are the functions of the Network Manager. One of them refers to "the Air Traffic Flow Management (ATFM) as referred to in Article 6(7) of Regulation (EC) No 551/2004 and in Regulation (EU) No 255/2010;".

Annex II provides more details on this function.

- **Network Strategy Plan**

The NSP approach builds on the alignment between operational and technical transformations for which the Network Manager will ensure appropriate coordination:

- From an operational perspective, a continuous effort towards Network Optimization, to be collaboratively achieved with all operational actors, while addressing military requirements.
- To implement the operational perspective, a progressive integration of mature SESAR solutions including ATM/CNS infrastructure optimization and rationalization related to the execution of network functions, paving the way towards the new Flight and Flow centric operations, supported by trajectory data exchanges.

The NSP Strategic Objectives accelerate the transformation of Network Operations while adapting the related ATM services to maximize their societal benefits. They address all network Components including resources and capabilities that together serve the civil and military airspace users to meet their needs and requirements as well as the defined level of performance.

- **Network High level CONOPS**

Through alignment with the NSP and CP1 IR, the High-Level Network Concept of Operations is in line with the SESAR ATM Master Plan Essential Operational Changes and ICAO ASBUs.

The High-level Network CONOPS addresses the major directions for changes, as described in the following picture.

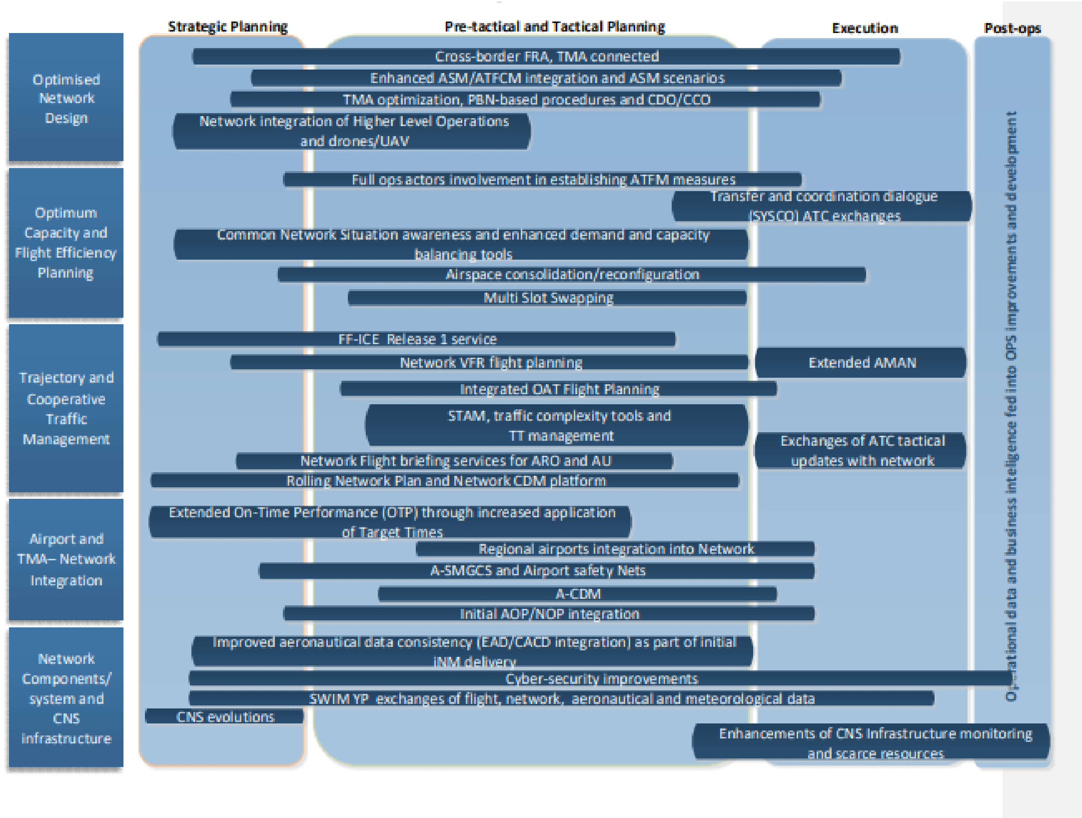

Figure 2 -Major directions for changes – Network CONOPS

The document describes at high level the existing gaps in each area and then provides a high-level description of foreseen changes, addressing them through distinct timely steps, namely 2025 and 2029.

- **Network performance targets for RP4**

Being the time horizon of the CONOPS covering the NSP evolutions until 2029, the objective is to contribute to the expected new performance targets for the RP4 (2024-2029), with attention to environment and capacity KPAs at local and network level.

Performance ambitions are categorized in accordance with SES KPAs of safety, environment, capacity, cost efficiency and include two additional KPAs; operational efficiency and security, which have been identified as key within the SESAR performance framework.

- **ATM Master Plan**

The European ATM Master Plan (hereafter referred to as “the Master Plan”) is fundamentally a planning tool for setting ATM priorities and ensuring that the SESAR Target Concept becomes a reality. The Master Plan is an evolving roadmap built in collaboration with, and for the benefit of all ATM stakeholders. The purpose of this document is to outline the vision and performance ambitions for future ATM systems within a timeframe of up to 2035 and beyond a perspective towards 2040 and up to 2050, and to prioritize R & D activities and subsequent solutions required to achieve these objectives.

- **ICAO context**

The International Civil Aviation Organization's (ICAO) Global Air Navigation Plan (GANP) presents a framework for harmonizing avionics capabilities and the required air traffic management (ATM) ground infrastructure as well as automation.

The framework is the Aviation System Block Upgrades (ASBUs). An ASBU is a package of capabilities (modules) which has essential qualities of:

- Clearly defined measurable operational improvements with appropriate metrics to determine success.
- Necessary equipment and/or systems in aircraft and on the ground along with an operational approved or certification plan
- Standards and procedures for airborne and ground systems
- Positive business case over a clearly defined time period.

The ASBUs provide a roadmap to assist air navigation service providers in the development of their individual strategic plans and investment decisions with a goal of global aviation system interoperability.

The ASBU framework includes different components. For the CONOPS, the operational thread of interest is Network Operations, addressing the major flow related improvements. Without entering in detail, the expected improvements of interest for the FLOW CONOPS are addressed in Block 2 and 3 and 4 and are focused on dynamic evolutions of the ATM processes, fully aligned with the evolutions identified in the NSP strategic objectives,

3.2 Technical and Operational Drivers

The new Network Manager system (iNM) needs conceptual and operational requirements for the ATFCM components. The Flow CONOPS needs to be seen as a vehicle to identify the required process/system changes from NM perspective, as well as the process/system changes for other Stakeholders that support the objectives of CONOPS with their components and relevant flow data exchanges. To produce a consistent and reliable ATFCM during all phases of flight, the Network Manager needs to receive/provide a variety of different inputs/outputs concerning the different Flow components.

The iNM, and especially the ATFCM part, needs to address the legacy debt and weaknesses as:

- EAD and CACD data misalignment;
- No connection between the systems used in strategic, pre-tactical and tactical phases.
- Creation of airspaces, points, flows (all static data) in CACD system is only possible monthly (AIRAC);
- Update of sector configurations, capacity, RWY in use, taxi-time still relying on manual input by ANSPs/TWRs;
- Access to list of flights subject to RAD measure is a cumbersome procedure;
- Flight future trajectory still based on NM system calculation;
- Flight profiles in flight planning system not updated by data coming from A-CDM or Advanced TWR vs en-route constraints;

- Lack of flight planning system back-up;
- FPL errors still subject to manual input/corrections by NMOC staff;
- Traffic capture for ATFM purposes only limited to entry times in locations;
- ATFM measures still based on rolling hours;
- Total lack of multiple ATFM measures optimization;
- Simulations (SIMEX Pre-tactical/Tactical) and Network impact assessment available tools (ATFM measures/scenarios, slot list manipulation) are static (no Network wide system solutions);
- What-if reroute tools (AOWIR etc) not exploiting all available possibilities vs FRA and RAD constraints;
- No integration of ASM with Pre-tactical/Tactical systems
- No record of ATFM delay savings in the Pre-tactical/Tactical systems other than manual slot manipulation or (accepted) rerouting proposals;

The Network Flow Concept is also needed to support future ATM concepts like:

- Flight/Flow Centric operations;
- virtual centres;
- the flow exchanges with the ATM data service providers;
- capacity on demand service;
- dynamic cross-border airspace configurations with dynamic delegation of ATS service between concerned ATS units.

4. Future Flow Management processes

This chapter addresses the expected improvements in terms of new processes and system capabilities iNM should provide. The structure reflects the chapter 2 organisation, starting with common processes and then addressing the specific improvements for each phase (Strategic, Pre-tactical, Tactical and Post-ops). The target date for the improvements is 2029. The evolution will require extensive use of prototyping, business architecture study and technical studies.

4.1 Common processes

4.1.1 Acquisition of traffic demand

Note: The traffic demand gap between ATFCM tactical operations and the ATS execution phases is specifically addressed in the Network 4DT CONOPS.

Common traffic demand assessment processes are required to link strategic with pre-tactical planning phases; and pre-tactical planning with tactical operations phases that allow constructive feedback between phases.

A common Traffic Demand Store (TDS) and process should be established to oversee acquisition and analysis of traffic demand to be used across ATFCM planning phases and simulation tools until replaced by received ICAO PFP/e/FPL data.

The strategic planning phase's traffic demand is established against incomplete information and assumptions. Later, during the pre-tactical phase, more information becomes available that revises the traffic demand. The TDS would detect these revisions and feed them back into the strategic phase to validate assumptions and to enrich later traffic demand forecast iterations alongside any impacted ATFCM solutions.

GA, BA and Military traffic is challenging to forecast. TDS would analyse this traffic and associate it with any corresponding events or trends e.g., military exercises, cultural events etc. This knowledge can then be fed back to the strategic phase (and to ASM) for subsequent planning and into the pre-tactical phase for similar shorter term detected trends.

The pre-tactical planning phase traffic demand, named Predict Flight Data (PFD), is loaded into the tactical operations traffic demand and then it is either replaced by an ICAO e/FPL or timed-out and deleted. Firstly, the pre-tactical traffic demand should be revised/replaced with accepted Preliminary Flight Plan (PFP) data or received e/FPL information. Secondly, the TDS should analyse PFD / e/FPL route differences and associate these to detected causal factors e.g., ASM, continental jet streams, unusual weather patterns, etc. The TDS should apply the detected route differences to near term future PFDs (D-6 to D-0) affected by similar detected factors.

4.1.2 Load/Capacity monitoring

As first improvement, it should be ensured that NMOC and FMPs are able to monitor the same traffic picture, to grant proper coordination and avoid any ambiguity when discussing any relevant parameters.

Load Monitoring:

A rationalization of the airspace entities available (e.g., AUAs, clusters, traffic volume sets, sectors, traffic volumes) should take place, to confirm their role and the "raison d'être" of each one, depending on the real needs of the FMPs.

A complete and continuous maintenance cycle should be foreseen by FMPs to confirm the configurations that are to be used in operations. This task can leverage on new technologies whereby, the Load Monitoring application could regularly suggest to FMPs which entities, in which configurations (or which configurations themselves), are not used by any FMP/ATC and identified as obsolete or unusable because of ATCO cross-sector or cross-border validations to ensure the best possible picture of the load in their Area of Responsibility.

The Load Monitoring application of the future should identify and resolve current areas of incertitude, or at least, provide the FMP with the necessary tools and information for immediate decision-making in those situations.

For the accurately identified imbalances in the Load Monitoring view, the application will be able to proactively apply any pre-defined solutions designed by the FMP for a particular issue, and, display their expected outcomes while indicating the best available scenario for a resolution – according to the rules, parameters and metrics set by each FMP in their preferences (e.g. maximum delay generated, maximum delay generated per traffic, traffic complexity, etc…) . The counts would henceforth be used for more in-depth analyses, to confirm the details of the proposed scenarios, showing the overall impact of a measure or the exact impact expected on each airspace user affected. The system should leverage harnessed Machine Learning (ML) technologies to generate other possible solutions based on similar traffic demand and airspace configuration patterns in other places of the network. These AI-generated solutions would be proposed to the Network and local flow managers when they favourably compare with the pre-defined scenarios foreseen.

The future monitoring techniques will need to integrate traffic complexity aspect.

One possibility is to define a common complexity model that will serve as the reference for all ANSP. This complexity model would be integrated in the iNM and deliver counts modulated according to the calculated complexity of the traffic.

The complexity information can be reflected in the usage multiple monitoring values reflecting better the nuances of traffic load monitoring than a single value that is used today. A dynamic/flexible monitoring scheme may be a first step toward traffic complexity. Traffic complexity can also be shared with the ATFCM community through a standardized colour scheme providing clear guidance to other stakeholders on the available capacity of a TV and the impact of an action on the complexity level.

Counts:

The counts will develop from today's relatively static feature displaying demand, regulated demand and load situation, into a truly interactive functionality. To build on the load monitoring tasks of the future, the counts application will utilize new technologies to identify specific airspace users and flights that are appropriate candidates for the measures proposed to minimize impact – while they will allow the FMP to easily undertake direct coordination with NMOC, ATC and concerned airspace users, if needed. The counts of the future will focus to confront real flight intentions of airspace users with the true airspace and flow management situations of the network. Conditions derived from Letters of Agreement between ANSPs should be included to better replicate actual operational conditions.

Counts will need to support the transition from reactive to proactive DCB management by including predictive information. Predictive count information shall be presented to the users along with its level of reliability/accuracy to enable users both at local and network level to anticipate possible bottle necks. Count prediction mechanism may evolve and get more sophisticated with the use of machine learning and AI to learn from the Post ops and grow in the strategic phase (current implementation for example is PFD injected in TACT with a replacement algorithm).

4.1.3 Evolution towards DAC/DCB integration

DAC/DCB integration will be the natural evolution by 2029 of the ASM/ATFCM integration, based on more dynamic features and a continuous CDM process among the relevant stakeholders. The ATM environment will define the level of dynamic solutions available. Certainly, Free route environment, especially through its regional applications, will offer much better opportunities to exploit the DAC/DCB improvements.

The evolution towards more dynamic solutions is consistent with the needs of all stakeholders, i.e., aiming for a more dynamic trajectory management and capable of handling greater complexity, with enriched data content managed in real time to provide opportunities for the optimisation of entire ATM network operations.

The full application of Dynamic Airspace Configurations (DAC) will be used to accommodate civil and military demand.

The Dynamic Airspace Configuration concept will introduce the following new elements:

- New approach: i.e., Initial performance-based operations
- New processes: i.e., move from collaborative processes to ASM merged with DCB into fully integrated ASM/ATFCM/ATS CDM layered process
- New Airspace solutions (new Airspace REServation (ARES) types, evolutions of dynamic sector configurations)
- New operational means: i.e., Dynamic Sector Configuration becoming fully dynamic and is the tool of integrated capacity management process
- Automated Support for Dynamic Airspace Configurations
- Iterative process to balance DAC solutions vs DCB solutions to optimise performance outputs.

With all these new elements in place, it will be possible to play dynamically with all capacity elements and constraints in one single, seamless process. Such a fully integrated ASM/ATFCM/ATS CDM layered process will provide the possibility to deploy the most optimum set of airspace configurations at all levels, more dynamically and efficiently updatable, ensuring best possible balance of the different performance targets.

At any moment, a Dynamic Airspace Configuration will be composed of any of the following components:

- Controlled Airspace Block (formerly referred to as sectors) configurations (built from airspace building blocks). Controlled Airspace Blocks are delineated through a dynamic sectorisation process supported by automated tool.
- Airspace Volumes created by (organised around) significant traffic flows (e.g., SE or SW axes, big city pairs), major events (e.g., Olympic Games, international military exercises or operations)
- Dynamic TMAs boundaries
- ARES including two types of Dynamic Mobile Areas (DMA), complementary to the extended utilisation of modular areas and different options for flexible management (e.g. VPAs).

The cohabitation of DMAs with high modular static areas and utilisation of flexible parameters (e.g., Variable Profile Area - VPA) will promote the definition of ASM scenarios, dynamically managed through an enhanced CDM process. Different types of DMAs are envisaged (type 1, 2 and 3) to better accommodate the military requirements with the most suitable airspace structure. For military AUs, the new generations of military manned and unmanned aircraft with their innovative technologies and new tactical capabilities will require more flexibility and adaptability from the ATM network to accommodate mission-specific requirements. The implementation of DAC process in FRA environments will facilitate the utilisation of the DMA concept.

The definition of flexible parameters, subject to the planned mission requirements and defined priority criteria, will facilitate the CDM process to identify the best combination of areas and sector configurations/ restrictions to satisfy civil and military demands. The flexible parameters will depend on the type of areas selected to accomplish the mission; for DMAs the flexible parameters could include the horizontal/vertical and time dimensions, while for the static areas the vertical and time dimensions will be relevant; in this case the advanced modularity will offer the horizontal flexibility (vertically as well if no flexible parameters are offered).

DAC will provide the possibility to “assemble” the airspace solutions (ARES activations time and place, sector organisations, ATS route or Free route organisation, etc.) throughout national, FAB or Europe in seamless continuum and according to various performance targets.

One size does not fit all, but different airspace configurations pursuing different performance objectives will be dynamically deployed and adapted across Europe at the same time. Those airspace configurations will respond to different operational needs and will focus on different performance targets that vary across the European ATM Network in time and space.

DAC will be achieved through a continuous CDM process, consistent from local to sub-regional and regional levels, which is triggered either by local or network performance requirements, depending on a specific situation in time and place. Although covering entirely the ATM planning phases, DAC processes are not bounded by time, thus the design, configuration, optimisation and execution often overlap.

Automated Support for Dynamic Airspace Configuration, including a “What If/What Else Tool” for decision making process, will be used. The “What If/What Else Tool” functionalities, exploiting potentiality offered by the usage of AI/ML capabilities, will enable dynamic airspace configuration management and dynamic updates, especially in the pre-tactical and Tactical (pre-departure) phases. Such Automated Support functionalities will enable rapid assessment of different airspace configurations options and elements, including Network and local impact assessment, identification of optimum configurations, and rapid sharing of the assessment results between respective CDM actors. It will be based on the forecast workload/complexity level (trajectories and trajectories/ARES) and ATCO availability (vs sector configurations) in respect of defined performance target to be achieved or focus on (e.g. airspace configuration aiming to improve flight efficiency or capacity).

Dynamic Sectorisation aims to identify the Optimum Sector based on the Shared Airspace Module (SAM) and Sector Building Block (SBB) concept. The following picture provides an example of the sector configuration evolutions according to the level of dynamicity introduced in the dynamic sectorisation process. Different models will coexist, depending on the required dynamicity according to the traffic demand and its complexity. The distribution of the traffic at European level will define the kind of dynamicity required by different ACCs.

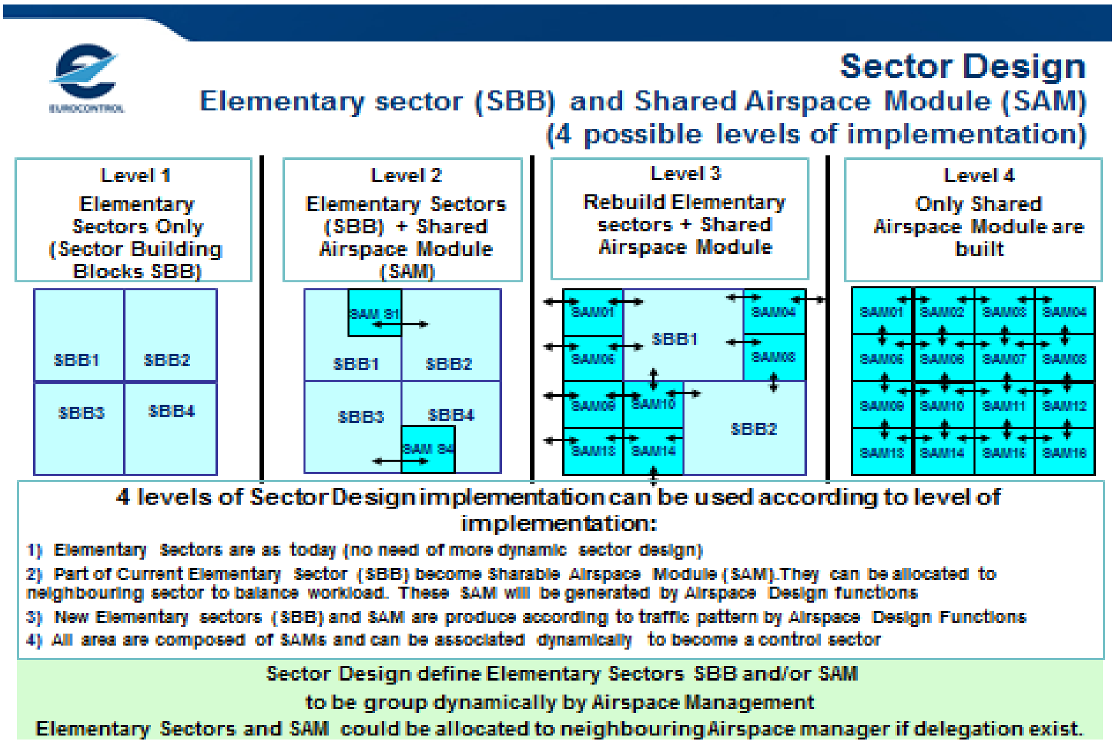

Figure 3 - Sector Design

The process will provide a configuration that is in line with defined local KPIs and local operational strategy and targets, and is optimum from both Local and Network point of view (at least with the minimum number of ATCOs without hotspots or, a configuration with the minimum number of hotspots considering the number of ATCOs available.

The Dynamic Airspace Configuration will be fully integrated with the DCB processes for planning and execution phases at local, sub-regional and regional levels. This means that the processes of elaborating airspace configurations include DCB assessment and vice versa, in case of any DCB issue, airspace (re)configuration is amongst the possible means to solve the problem. It will be initiated by the DCB function.

The application of DCB measures in a DAC environment, will be characterised by the following operational concepts:

- Demand and Capacity Balancing (DCB), a process that tries to adjust demand and capacity, mitigating the negative impact of this adjustment on AUs flight profiles while also applying Dynamic Airspace Configurations concept.
- Collaborative Decision-Making process between ASM, ATFM and ATS, to guarantee the application of the best consensual solution possible and the integration of different methods to achieve it.
- Network performance enhancement, another criterion for sector configuration where the base to create a configurations plan is a series of performance indicators.
- Forecasted traffic demand, a result of predicted trajectories through which a configurations plan can be created accordingly.
- NOP, an enabler of DCB as it shares the relevant information among the involved actors.
- Performance-based operations environment, where a KPI performance framework is continuously monitored and assessed to support the dynamic airspace configuration process
- Complexity management – an enabler for DAC, via improved estimates of controller workload – derived from the improved predictions of traffic demand.

The Operational Stakeholders will ensure the management of an enhanced Demand DCB process to support capacity on-demand ATS service. The DCB process will be supported by Scenario Management and what if/ Network Impact Assessment of airborne rerouting in support to any DCB measures. Coordination of defined restrictions group scenarios or traffic volumes regulations as well as STAM measures will ensure the identification of the most efficient solution to balance the demand not satisfied by the DAC exploitation of available ATM capacity.

4.1.3.1 DAC/DCB in ATM Timeline

Dynamic Airspace Configuration is employed throughout the ATM timeline through to post operational analysis phase.

Dynamic sectorisation and constraint management starts within Network operations in the early planning phase and continues throughout the execution phase. Smooth and coherent interfaces between Network operations and ATS operations in that area are required: tools, algorithms, processes and procedures shall be worked out accordingly.

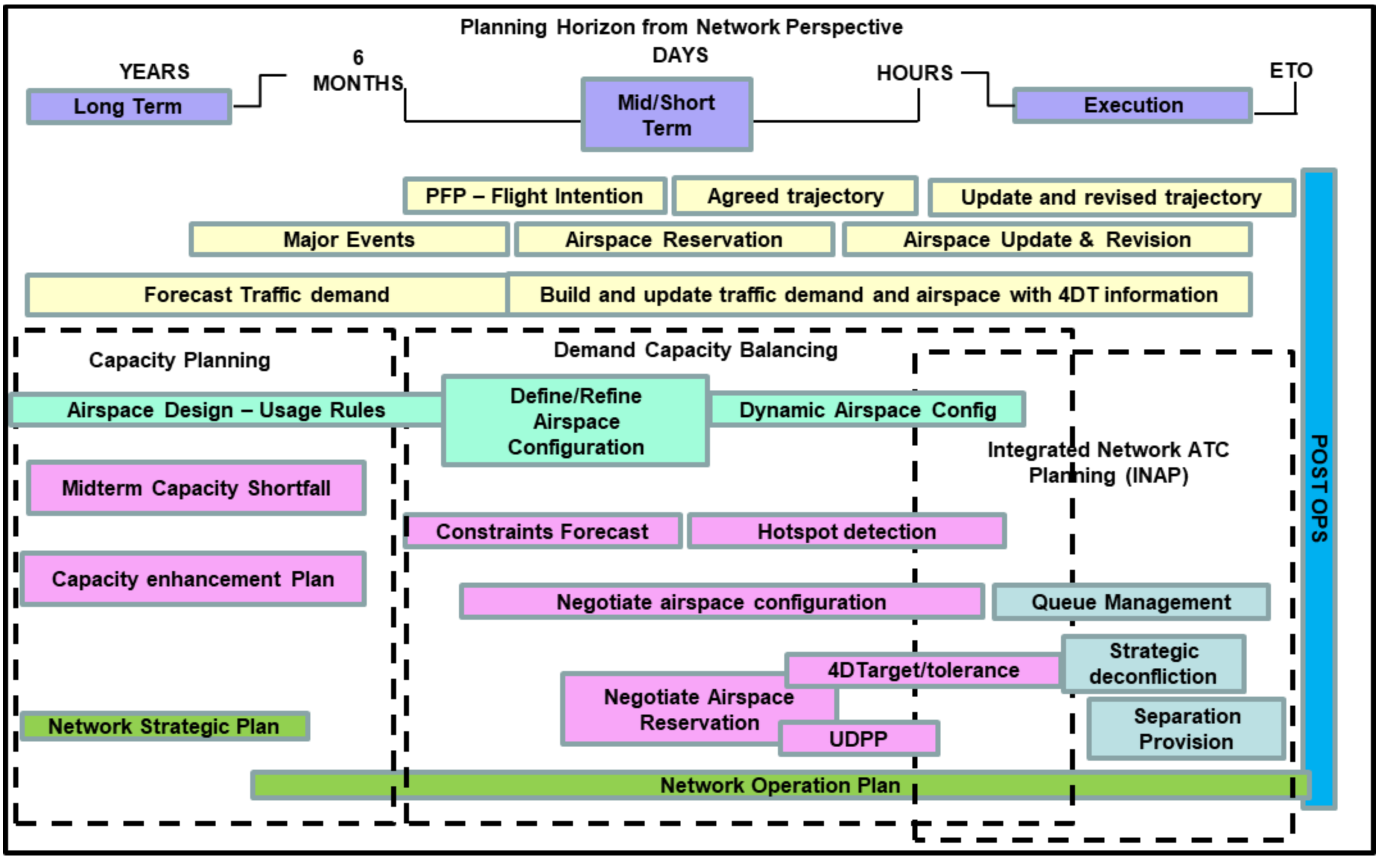

Figure 4 - Dynamic Airspace Configuration throughout the ATM timeline

The process is dealing with a layered process from Planning to Execution with three parallel activities: Demand Management, Capacity Management and Demand and Capacity Balancing. Three main streams are identified:

- Airspace demand forecast (yellow),
- Airspace design and configuration (green),
- Demand and Capacity Planning and Balancing (magenta).

At strategic level, the definition of ATFCM scenarios in combination with ASM scenarios and restriction groups, will provide a set of solutions to support the CDM at pre-tactical level.

It will also include the definition of dynamic RAD restrictions to be managed through the CDM process, aiming at providing opportunities to improve environmental performance without penalising capacity.

Focusing the pre-tactical phase, the analysis of the forecasted air traffic flows will offer to the Airspace Planners (both civil and military) the key element to consider when deciding the geographical location of the airspace that satisfies the AU's requirements when booking specific areas, whilst trying to keep to the possible minimum the reservation impact on these flows. Traffic Complexity Management tools will take in account the quantitative and qualitative assessments of complexity, the uncertainty of the trajectory prediction over time, aiming to capture the relationship with workload.

The local complexity tools will be enhanced by the integration of what-if scenario management and Network Impact Assessment capabilities provided by NM via SWIM services.

The complexity measurements will provide a key input into the DAC processes, supporting the local and network planners to calculate and implement the optimum configuration of airspace reservations, ATC sectors and TMA boundaries, which provide the required capacity across the Network.

The ATFCM measures will evolve as well into complex sets of measures, which will comprise not only the flow and capacity elements within the new dynamic DCB processes, but also the ASM and ATS elements, everything enhanced by accurate meteorological data. Utilization of STAM measures and alternatives regulation solutions (e.g. occupancy regulations) will be extensively used if residual DCB imbalances remain, following capacity optimization.

(DCB) processes iteratively evaluate traffic demand against the capacity thresholds using statistical methods and margins of flexibility commensurate with uncertainty. When imbalances are detected, the CDM processes are enhanced to determine and activate ATFCM solutions. It will be an iterative process with DAC until optimum solutions are identified.

Evolution of EAUP/EUUP and ADP like publications will notify to the AUs the agreed ATM solutions, allowing AUs to finalize the agreed 4D trajectories to be shared with NM and local relevant stakeholders.

The Dynamic Airspace Management will be enhanced by additional real time sharing of the latest updates in terms of airspace configurations, airspace reservations and airspace releases.

The tactical elements of the DAC processes will continue to support the fine-tuning of the local and network measures, providing in a continuous flow of information the most up-to-date data concerning airspace reservations, airspace configurations as well as real time airspace updates to all involved operational stakeholders.

4.1.3.2 DAC/DCB ATM actors

The actors and the functions performed in the various phases are described in following Table.

	Regional	Sub regional (FAB)	Local
Long-term before M-6	Airspace Designer European Network Manager	High Level Sub-regional policy body Airspace Designer Sub-regional Capacity Manager Sub-regional level 1 coordination	Airspace Policy Body (HLAPB) Airspace Designer Local Capacity Manager Local ASM level 1
Mid/Short Term	European Network Manager	Sub regional Flow Manager	Local Traffic Manager

M-6 -> D		Sub-regional Airspace Manager coordinator (Civil Airspace Manager and Military Airspace Manager)	Flow manager Local Flow manager Local Airspace Manager (Civil Airspace Manager and Military Airspace Manager)
	Step2 Military/Airspace Users involvements in imbalance resolution		
Execution **D day**	European Network Manager	Sub regional Flow Manager Sub-regional Airspace Manager coordinator	Local Traffic and Flow Manager Local Airspace manager
		Integrated Network management and ATC Planning function roles (INAP) The area of responsibility of INAP is established to provide a volume of airspace which is sufficiently large to enable INAP function activities to be performed.	
	Step2 Military/Airspace Users involvements in imbalance resolution		
Post Ops Analysis			

Table 1 - DAC/DCB ATM Actors

The sub-regional roles and functions are subject to agreements among the different States. Bilateral agreements would likely be more frequent to facilitate cross border operations (e.g. Lead AMCs) Their involvement in the timeline process is synthesised in the following picture.

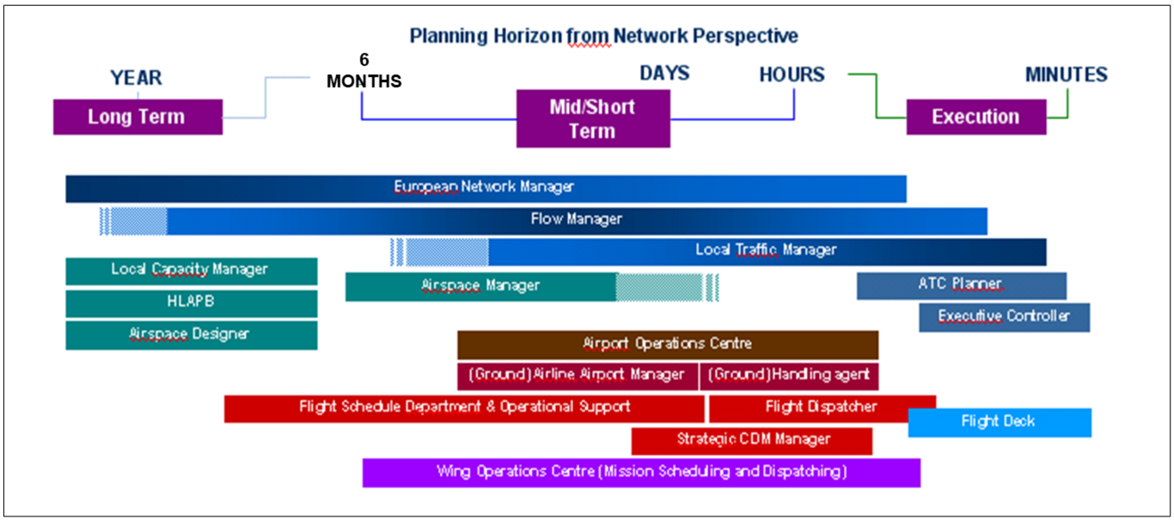

Figure 5 - DAC Planning Horizon from Network Perspective

More details about roles and responsibilities are provided in chapter 5.

4.1.4 Network Impact Assessment and Simulations

The Network Impact Assessment (NIA) will continue to be a key enabler for the provision of flow management services, guiding the operations when their effects are visible in the traffic and the overall Network.

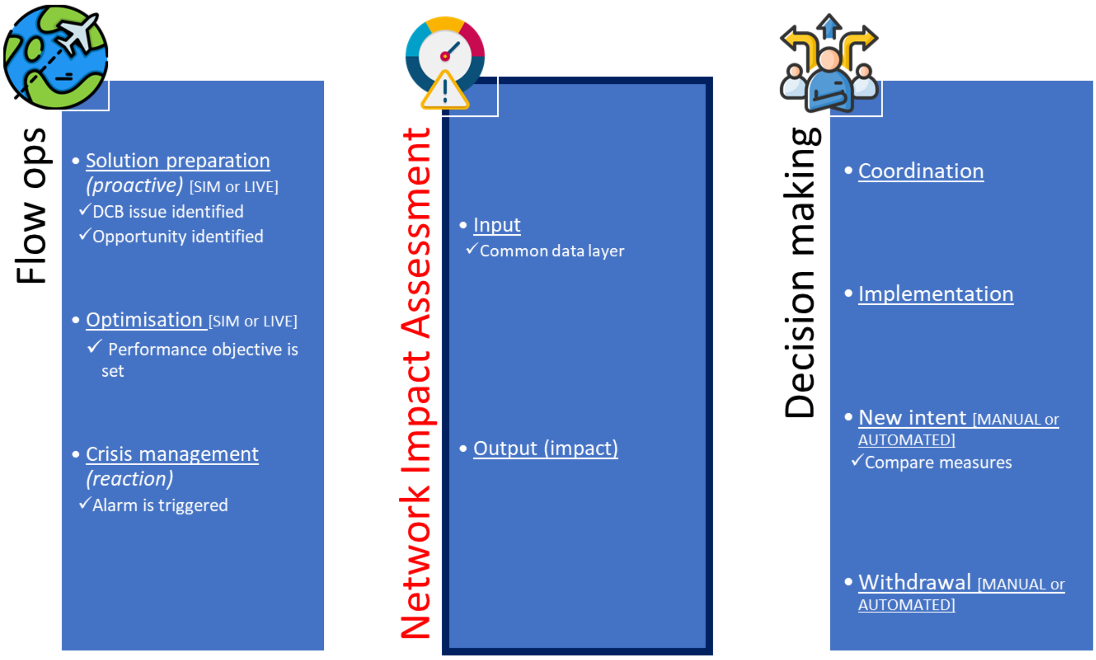

Figure 6 - NIA as a flow enabler

The NIA is one of the main future functions aimed at supporting NMOC and stakeholders in assessing how the traffic is impacted by the mentioned variables and which are the mitigation measures to optimise the use of the available capacity vs AUs need to fly efficient and sustainable flight profiles.

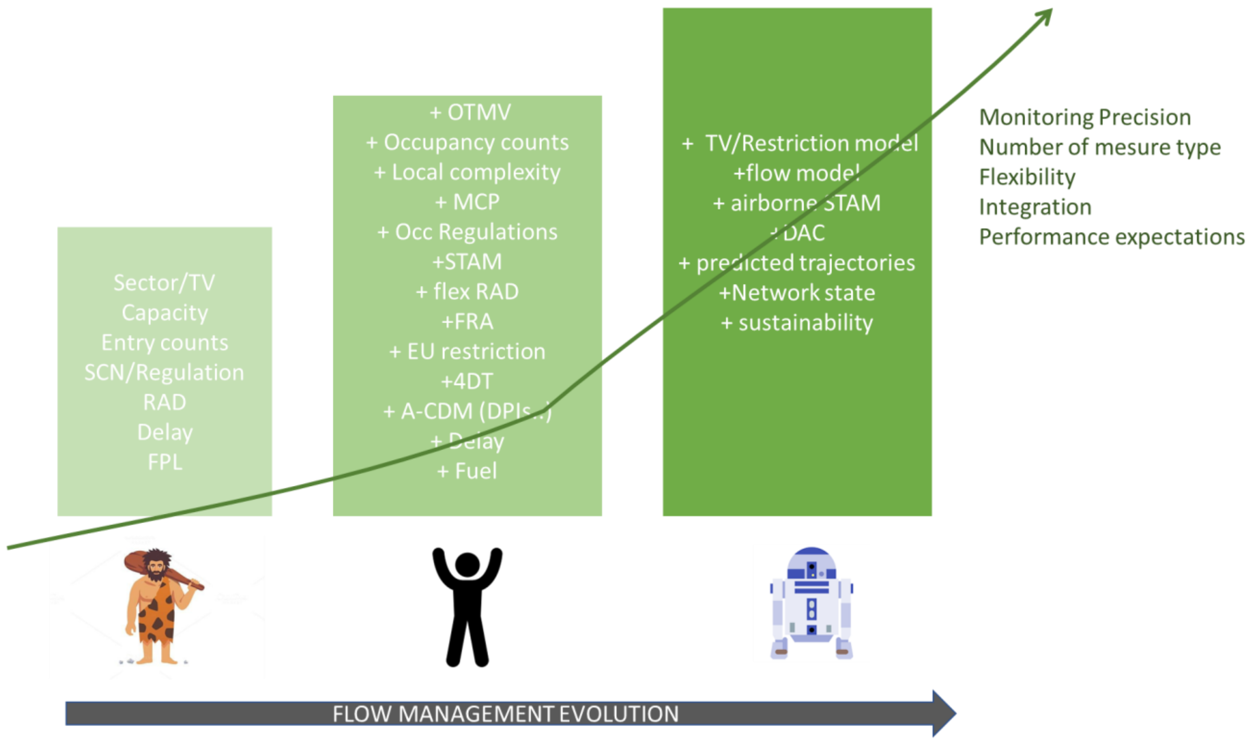

Figure 7 - Flow management evolution

With the evolution trend toward more flexibility, smarter data, more objectives and more tools, it gets more and more complicated to anticipate any impact on the network traffic without referring to **an advanced impact assessment tool.** The stakes are high for the current Network Impact assessment process.

Traffic demand monitoring is the basis for Flow Management. As the methods and techniques to monitor the traffic evolves, the impact assessment tool will need to follow and align to deliver impact results in line with those monitoring references. Depending on the user, the output requirement shall also be adapted.

The impact results shall integrate the following new monitoring elements of Flow Management actors:

- Complexity information
- Merged TV/Restriction model
- New monitoring values (advanced capacity model, additional monitoring values for FMPs depending on KPIs...)
- Hotspot/Netspot information: impact to be computed on hotspot, netspot etc. (see below content provided by NM Dashboard team)
- ASM data information

As we foresee transparency between all ATFCM actors, the computing NIA algorithm should be common to all actors. Nevertheless, the NIA functionalities and output should be customized and managed via access control.

As ATFM and ASM move toward a seamless planning from the Strategic to the Tactical phase, the NIA should do the same: one single NIA for all the phases, with functionalities available in relevant phases using the data available in the common Data Layer, with the maturity it has.

Computing the impact assessment of an Event scenario and requesting impact in terms of occupancy is not realistic, however the computing algorithm should be the same and only the source and the available output should be adapted.

ATFM evolution foresees the development and usage of multiple prediction algorithms (like AI Capacity reduction for example) that will help anticipate DCB situations.

To ensure a seamless usage, the NIA shall:

- be fed by latest information, i.e., from the common data source;
- be able to use predictive information: you can evaluate a solution today for a problem anticipated, for instance, 1h, 1 day, 1 month or 1 year in advance.

The impact assessment that is computed should be able:

- to consider the target date: integrate predictive intelligence (weather, traffic trend, etc.);
- to be refreshed regularly (link with simulation save and refresh).

The future NIA shall:

- support the comparison of individual measure/combination of measure (both demand and capacity measures);
- consider the RAD constraints at the projected date of the assessment, the a/c performance at the projected date of the assessment, trajectories of a/c at the projected date of the assessment
- shall support Hotspot prediction AI;
- be shared easily to support coordination.
- be easily retrievable in the post ops phase

To fill the current gaps and to pave the way to future evolutions, the NIA will need to support the latest environment information. However, in order to have the full picture of the ATFCM situation, the NIA will need to have access to all measures applied and support the assessment of all measures available in the NM system (current and new).

Simulations.

The role of simulations will continue to be crucial in all phases of ATFCM/ASM and more generally in those rolling planning processes and systems supporting, collaborating, or interfacing with ATFCM and ASM. This will be achieved through common datasets, functions and tools that support integrated rolling planning processes. It is assumed that a dedicated simulator room will be established.

ATFCM simulations will be enhanced as described below:

- Simulations will be available to all authenticated stakeholders and integrated into the CDM coordinated workflows and will permit ATFCM units to assess, modify, share and coordinate ATFCM solutions, relieving NMOC of duplicated tasking.

- *Note: Provided that is not in contrast with Regulation 123/2019 vs the sharing of ATFCM function between NM and ANSPs*
- Simulations will support NMOC to assess network effect of ASM planning to provide advice on possible adaptations to optimise airspace organisation (balance areas allocation vs sector configurations) and minimise the need of ATFM measures.
- By default, the simulation function will run ***always-on*** and will be kept consistent with operational datasets inputs and updates.
- Simulations will therefore be the norm. All user inputs will be swifty simulated prior to their application to the operational system and will ensure that the operational system delivers outputs very close to those assessed during simulation.
- Simulations will continue to be used for the assessment of candidate ***what-if*** ATFCM/ASM solutions for special event planning, ATFCM and ASM daily planning and to solve DCB imbalances in the pre-tactical and tactical phases. These assessments will provide two network impact views: operational view and the balanced performance view.
    - The operational view assessments will provide a comparative assessment of the strength of candidate ATFCM/ASM solutions in terms of effectiveness and efficiency, e.g., ATFCM delay, route extension, airspaces/aerodrome on and off loads. This will allow comparison between the candidate ATFCM/ASM solutions and for counter proposals to be generated by the simulation ***solver*** tool that identify optimal ATFCM/ASM solutions.
    - The balanced performance view assesses the candidate solutions contribution towards the daily balanced performance targets set in terms of punctuality, fuel burn and other costs.
- Simulation will need to include a ML/AI fed rerouting tool, (learning from post ops and strategic) to be able to support efficiently the impact assessment of lateral/vertical rerouting scenarios, restriction activation/deactivation.
- The concept of ***always-on*** simulations additionally allows the network to run autonomously ***what-else*** solver protocols to determine and coordinate alternate Network ATFCM/ASM solutions, in order to better address complexity and to optimize the set of measures versus the balanced performance daily targets.
- Once a simulation solution is applied, the simulation dataset/meta data will be archived as a simulation snapshot for possible re-use and post operations performance analysis and assessment against real outcomes.
- In support of post ops analysis - archived simulation data sets require derived meta data to outline the purpose of the user inputs (solve hotspot, avoid weather, fuel economy) and will include capability to add situational awareness via user narrative and clarification.
- A specific simulation warehouse will be used to manage simulation snapshot storage, custom simulations, and replays.
- Tactical simulations will support the future concept of INAP to support ATS planning functions.

It will be also essential to enhance training, testing and validation capabilities of Flow services, including additional emulation functionalities vs the current one with the possibility to mimic the outputs of likely flight execution phase reactions to ATFCM inputs e.g., delayed departures and reroutes.

Note: these enhancements should be considered relevant for other NM services (addressed by other ConOps).

4.1.5 Scenario management

The future operations will have to consider new components that automatically propose measures (or set of measures) and provide advice to users about measures (including rerouting), given the current or predicted situation (considering traffic, but also weather/natural hazards, network events, etc.).

The purpose is to give advice to operational staff, not to take decisions on their behalf. The users can then trial the proposed measures/scenarios by using the workspaces feature and assessing the qualities of the proposed measures. If/when fit, those measures can be applied on the live system. The proposed solutions will consider different KPIs, user priorities and advanced cost model algorithms.

The future operations should automatically prepare rerouting proposals based on the latest network situation (route availability, ATFM delay etc). This information will also be used to produce Network impact assessments.

When the NM system receives information about the new flight intention, or any other update, this should be evaluated with regards to the known network status, known constraints as a part of rolling/continuous network impact assessment process.

Main features should be the following:

- Guarantee continuity of and further enhance the functionalities of the newly created scenario management tool to trace scenarios throughout their entire lifecycle from request, initial assessment, network CDM, creation, publication on relevant communication channels, use in operations, operational re-validation, maintenance, amendment, potential deletion or archiving. This should include easy interaction between all involved parties (external and internal stakeholders, different NM areas).
- Totally flexible scenario definition, not limited in terms of number and type of criteria, e.g., aircraft type or flight level (this links to Traffic Volume definition options). Link between the assessment tools at strategic and pre-tactical level, so strategic scenario-related data and simulations can be made readily available to the other ATFM phases' functions and vice-versa.
- Automatic capability to assess multiple scenario interactions, e.g., when creating a new scenario, the system should automatically check whether captured flows or any applicable condition is conflicting or interacting with another existing scenario or RAD. The same should apply for scenarios already existing in the database.
- Automated maintenance and revalidation of the scenario repository.

Additional future solutions will be exploited as:

- Combination of solutions, incl. scenarios, stored in NM systems for tactical usage.
- Scenarios based on the Network KPIs
- Correlation between D-1/D-0 predicted demand and the historical data (most delayed sectors) with NM systems taking into account the network view (network delays,

demand/load/weather/ MIL activities) and sending RRPs well in advance to avoid these sectors/hotspots.

- Strategic and pre-tactical/tactical shall use the same tools when creating scenarios, or as a minimum interoperability to be ensured (connected via B2B) leading to the same end-result.

4.1.6 Multi constraint resolution (CASA evolutions)

Multi constraint resolution deals with the integration of the various stakeholder constraints in the DCB processes, such as departure and arrival airports, INAP actors, TMAs, and the AU, in order to provide network-wide solutions that ensure safety, respect their constraints and priorities as far as possible to address a demand/capacity imbalance problem.

Although multi-constraint resolution is mostly managed in the tactical period, it should be noted that the resolution of constraints is a gradual process that can take place as soon as constraints start to appear. In the strategic phase, due to limited stakeholder' requests and the inaccuracy of DCB process we can only speak about an embryonic multi constraint resolution as the demand and capacity assessment is managed at macroscopic level by considering axis and other flows. It is in the week preceding the day of operations when flight demand gradually gets confirmed, user constraints start to arrive, imbalances can be detected so the multi-constraint resolution process starts taking shape.

Quality and quantity of information will clearly increase as the tactical phase approaches, but rules and process for constraint resolution should be consistent throughout every phase of the ATFCM process.

The application of ATFCM "regulations" by air navigation service providers (ANSPs) and the consequent use of the CASA system by the NM to calculate departure delays for the regulated flights, has been and still is a pragmatic DCB solution to resolve network imbalances. However, the situation is evolving rapidly, and the different stakeholders want their needs and constraints to be considered in the resolution of the DCB imbalances and are asking for more flexibility and the use of local own strategies to allocate available capacity.

This leads to the following:

- A multiplication of the sources for DCB decisions (en-route, airport, airspace users),
- A combination of DCB measures, some time-based, some with vertical and lateral trajectory adjustments, or both. (STAM, Target times, UDPP)
- A combination of DCB measures addressing different severity problems, from safety issues to pure optimization issues,
- The need for powerful what-if functionality to check impact on overall network performance and propose potential alternatives.

In order to set up the best possible multi-constraint resolution tool in the new Flow system, input priorities should be established vs slot allocation (i.e., AU/critical flights, AMAN/DMAN, ANI etc), but always respecting safety (declared ATC capacity not exceeded).

Multi constraint resolution principles

Moving away from the simple approach of equalizing the largest delay to the most relevant operational problem, the *most important constraint* should be determined according to a ranking based on the actors and their constraints, for each of the distinct phases of the timeline, providing a different weight depending on the actor's role, location of the constraint and other factors. The new CASA algorithm for resolving constraints will take the *most important constraint* at a given time to provide the delay. Currently there are ranking rules implemented (DPI/CTOT, DPI/API, force-slot /Target time of Arrivals (TTA)-target time over (TTO) etc …) but they need to be reviewed to consider the increasing new type of measures and constraints. These rules shall be clear and agreed to by all actors up-front before being implemented.

As today, for a given flight affected by several DCB measures, the above-mentioned prioritization and ranking rules will be continuously recalculated to assess the most important constraint until the agreed freeze time, that will normally coincide with Slot Issue Time 1, aside other freeze times like Time to Insert the Sequence (TIS) and Time to Remove from Sequence (TRS) for CTOT/DPI interaction, with strict conditions applying after the freeze times.

To increase the chances of resolving multiple constraints satisfactorily, meaning addressing the maximum of stakeholder preferences, priorities and constraints, while guaranteeing safety and minimizing delay, it is recommended that, as much as possible, such constraints, priorities and preferences are provided – with a buffer defining time-not before/time-not-after for arrival. These constraints blend in the network dynamicity much better and help to find solutions. Today there are measures like force-slot that could evolve into buffers when operationally feasible, similarly to the slot and departure tolerances available at airports.

Key points:

- Clear and agreed set of priority rules to apply when constraints are in conflict.
- Most important constraint is determined by applying priority rules based on ranking.
- When resolving, the most important constraint will provide the delay, if any.
- NM systems should be able to treat user's constraints one by one or in a bulk. For instance, users could submit Target times TTO/TTA, issued by any actor Airport Impact Assessment (AIMA), UDPP or INAP individually or in bulk.
- Constraints/Priorities and preferences should be provided with a buffer, when applicable and as much as operationally feasible

UDPP and AU prioritisation and preferences

The concept of UDPP (user-driven prioritization process) and inter-airline slot swapping, referred to in this document as UDPP+, are partially supported in current ETFMS. UDPP+ provides airlines with additional flexibility in planning phases, beyond the current slot swapping process which imposes strict rules like swapping within the same MPR, and maximum of three swaps in order to limit traffic volatility in the CASA slot lists.

UDPP+ enables AU to recommend a priority order request to the NM for flights affected by arrival constraints. By prioritizing and reordering their flights, the impact of delays on airline operations can be significantly reduced as the cost of delay depends on the specific events and nature of the flight. When the reordered/ prioritized flight list is made among different airlines, the potential cost reduction is higher. This airlines prioritization will be achieved by airlines submitting priorities for their flights - multi-swaps, selected flight protection, fleet delay assignment and/or margins of manoeuvre (take off not before/after) – and cost structures to an intermediate UDPP client regional system that will optimize the result and provide the reordered UDPP+ flight list to NM. NM will provide the so-called UDPP server, a set of functionalities including what-if and submit in the form of B2B services that will allow the UDPP client to assess different combinations of UDPP inputs, check their network impact (NIA) and finally to submit to NM.

There are basically two ATFCM measures on which UDPP+ can be implemented: on an ATFM regulation and on a TTA measure. Either of the measures will be triggered, as today, by the FMP or an airport and for both AUs should coordinate their re-ordered flight list with the corresponding FMP or airport.

On an ATFM regulation, the initial slot list is created by CASA using the FPFS principle, then it is updated with the UDPP+ re-ordered flight list provided by the UDPP client, after a final NIA check performed on NM.

On a TTA measure, the UDPP+ re-ordered flight list is sent to NM using API (Arrival Planning Information) Target time messages. The TTA includes the time buffer of manoeuvre of the flight. NM in return will confirm the proposed flight arrival time or provide a different time within the AU wished time brackets or provide a different time altogether, if the AU wished time would have a negative impact on the network based on Network Impact Display assessment). The NM UDPP service should be able to process the full re-ordered flight list provided by TTAs in one single submit, as well as incrementally-one submit at a time. Note that TTAs are converted into departure times (CTOT) by ETFMS.

Arrival Target Times for Airports

In the concept of target time of arrival each airport collaborates with Terminal control area and Arrival Management (AMAN) to develop its own strategy for the allocation of the available landing capacity in peak traffic hours. The strategies consider arrival route and runway allocation or gate and flight connection. The algorithms that integrate these strategies are called AIMA (Airport Impact Assessment) and reside in the AOP. This collaborative process helps to manage airport arrivals more efficiently than traditional CASA, and to reduce the number of knock-on delays, thus benefiting passengers and airlines as well as the network.

In addition, airlines can and are expected to contribute to this process by sending their constraints in the form of priority flights and preferences to the airport (arrival or departure). Once received, AU priorities and preferences will be integrated in the AIMA algorithm that will create a list of proposed target time of arrival for the required/chosen flights and send it to NM, via the API message request.

However, this collaboration AU/Airport DCB may not be guaranteed at several airports. It depends on different factors, such as the nature of airlines operating at the airport (hub airlines or point-to-point and charter) and the airline's capacity to interact with the various airports linked to their flights. There are several reasons for this:

1. the AUs prefer to organize and negotiate their priorities with the other airlines up-front in a purposed UDPP client that can better address their needs, or

2. they do not wish to communicate information on ‘preferences’, considered confidential.

Whatever the reason, TTA from an airport do not necessarily include AU preferences aside the knock-on delay reduction that AIMA can calculate thanks to AOP/NOP integration.

CASA evolutions

CASA Occupancy

In the last years, a shift from conventional management of traffic through the monitoring of entry counts towards occupancy has been taking place. A growing number of FMPs are using this monitoring technique either by itself or in combination with entry counts. Occupancy counts allow INAP to better analyse the traffic composition, to be able to pinpoint flight specificity, assess complexity and apply STAM 90 min before the traffic enters the sector.

Occupancy regulations bring a major shift in how CASA accommodates user preferences. As opposed to conventional ATFM regulations which spread traffic according to a given hourly rate, occupancy regulations expedite ATFM slots i.e., entry times into a regulated sector, according to the available capacity of said sector at a given moment in terms of occupancy load. Note that since each FMP can tailor occupancy counts parameters as they better characterize their airspace, occupancy CASA must be compatible with any duration defined.

Occupancy based regulations do not aim to substitute the Entry based regulations but to complement them it will be possible to combine them whenever traffic situation requires a better protection.

Target CASA

Conventional ATFM regulations regulate entire traffic volumes, which are usually composed by multiple traffic flows. However, it is known that in circumstances where regulations are requested due to e.g., traffic complexity, not all the flows captured by the traffic volume contribute to the problem to solve with the same weight.

This means that regulating one single flow, or multiple but not all the flows within the TV, could solve the DCB issues identified by INAP, with reduced impact to the rest of the traffic. Moreover, past SESAR exercises seem to indicate that in some circumstances, applying a regulation on a single flow rather than on the full set of flows within a TV, can be beneficial in terms of delay even for that traffic which ends up being regulated.

The current CASA algorithm regulates and spreads all the traffic captured by the regulated traffic volume. The new CASA functionalities should be able to apply ATFM regulations to specific flows within a traffic volume if the user requests it, or even enable users to provide different rates to the different flows targeted by the regulation.

Resourceful Overloading of Slots

The other potential evolution could be Resourceful Overloading of Slots mechanism (RCO) which assumes that due to the dynamicity of the network, such as manually forced slots, slots forced by CASA applying MPR rule, exempted flights or SRM thresholds amongst others, CTO overloads occur and are accepted in the CASA slot allocation.

Hence, using the safety principle of the compensation mechanism, RCO overloads some slots under certain conditions.

Basically, the traffic around the new CTO cannot exceed the rate by a certain configurable threshold which often implies free slots in the vicinity of the slot to be overloaded. This safety compensation mechanism also assumes that the few CTOs overlapping will not increase the probability of bunching. RCO is highly configurable allowing the user to decide the compactness of the allocated CTOs. It can also be applied in a regulation basis, meaning that not all regulations have to make use of the RCO mechanism, and can be reserved just for FMPs willing to accept an overload slot.

Solvers

ATFCM Demand and Capacity Solver is a software system that helps Air Traffic Flow and Capacity Management (ATFCM) professionals optimize their operations by providing them with the tools to analyse their current capacity and demand situation, and to identify potential solutions.

Among the solvers, there are those that propose to resolve the delays using various techniques beside CASA FPFS as an alternative or complement to CASA. There are the pure cherry pick (CP) solvers and hybrid solvers that combine CP and FPFS algorithms.

<u>DCB toolset evolutions</u>

Regulation Plan Optimizer

In addition to the conventional DCB Toolset, the NM operators can optimize the ATFM regulation plan to improve their day-to-day operations. Especially during busy days where the number of regulations to coordinate with the FMPs is high.

The interactions between regulations, which depend on the flights that have in common, are extremely complex and difficult to predict. Consequently, these interactions increase the overall network delay and the average delay per flight. The regulation plan/cleaning tool (a.k.a Sequence 12) is expected to optimize existing regulations. It evaluates a limited set of solutions for optimization and suggesting the optimal (or high-quality) solution by either cancelling, modifying or existing regulations or creating new ones. The optimization has to be performed in pre-tactical and tactical phase, early enough to be effective vs ATFM delay reduction, but late enough to prevent AU from refilling new flight plans. The process will be continuous: any new event that contributes to modify the Pre-tact or Tact plan will be re-assessed by the Regulation Plan Optimiser.

Remark: further options aimed at reducing ATFM delays, such as Resourceful Overloading of Slots (RCO) or Solvers (cherry picking solver, ISOBAR) need further tests and assessment before putting them in operations.

Weather impact capacity predictors

Network traffic prediction and performance are very dependent from the local airport or en-route weather quality of forecasts, and they represent the main weakness for the predictability. ISOBAR addresses this challenge through the contribution to an Artificial Intelligence (AI)-based Network Operations Plan, by integrating enhanced weather forecasts for predicting imbalances between capacity and demand.

The weather impact on DCB prediction tools reinforces CDM processes at pre-tactical and tactical level into the Local Traffic Manager (LTM) and Network Management (network) roles integrating dynamic weather cells. It highlights demand and capacity imbalances at pre-tactical level depending on the input of probabilistic weather cells by using applied AI methods and ATM and weather data integration.

This could allow the earlier implementation of ATFM measures caused by weather and allow AU to plan and respond to them in anticipation thus increasing traffic predictability and reducing the need for reactive measures.

4.1.7 Consolidated Flight status

The consolidation of the flight status within the different NM services will bring clarity to both internal and external users and avoid duplications and inconsistencies between flight planning and flow management services. FUMs[1] will not be necessary anymore to update the flight status on each side, as the status will be unique. Moreover, AUs will have one consolidated view of the status of the flight, that provides them with the information of what options are possible, both at flight planning and flow management levels. The consolidated status will consider Flight & Flow Information for a Collaborative Environment (FF-ICE) deployed services.

For this purpose, the NM will provide a consolidated flight status (e.g., suspension) with a series of possible “conditions” (e.g., origin of the suspension - restriction / XCD regulation etc.) that may apply to it. The conditions help to understand the operational events affecting the flight. These events may require the application of specific operational procedures. The status will be the result of the most restrictive condition affecting the flight, either in flight planning or flow management (in other words, the status field will be an aggregation of the flight conditions). The flight conditions will be the NM response to the agreed trajectory of a flight. This response will contain feedback on more static restrictions (e.g., permanent RAD) and more dynamic ones (e.g., regulations, dynamic RAD, FUA restrictions, etc.). The flight status guides and supports the relevant actors on the possible actions that may be performed on a flight.

As part of the new arrangement, the advisory mechanism would be understood as a new condition that will be applied to flow management level for the cases where the execution of a flight is at risk, to warn NM external stakeholders.

It is important to note that some of those conditions may coexist. Likewise, a Suspended flight may have conditions such as RVR unknown or airport suspension (following a C-DPI).

The FF-ICE filing statuses will be integrated in the conditions of flights. The FF-ICE planning statuses will also be integrated to support the Trial service.

The advisory condition will be triggered in all cases when the execution of a planned flight is at risk. The AU and ATS (where applicable) receive a structured message with information that a specific flight is subject to an advisory condition. This would apply for flights close to suspension (e.g., due to FAM), where updates in regulations or restrictions restrict the route initially filed, etc. This way, AUs are made aware of an incoming situation that might heavily impact the initial operation of the plan and allows them to react.

[1] According to the Transition to SWIM policy that consists in set of principles to be applied by NM to guide the transition from current technologies into SWIM, for Airports and ANSPs, DPI and FUM exchange via AFTN will be decommissioned by 31/12/2027.

The update in the NM systems as the traffic becomes airborne will remain reflected in the future NM data, ensuring it remains aligned. Therefore, Airborne (like the current ATC activated status) and Terminated status will continue to be triggered following ATC updates.

In this context, an advisory condition will continue to warn about evolving circumstances. For example, an aerodrome closure or ASM updates should prompt this condition and its associated message for affected airborne flights. The AU or a downstream ATS unit may then propose route revisions using the CDM platform. It is expected that conditions will evolve to cover for the CDM process following the same concept as the needs arise.

Note: as minimum requirement, The potential airspace restriction infringements due to DPI should be identified and highlighted to the right stakeholders who are in a position to take action to solve the inconsistencies before the flight is given start-up approval

A Terminated status would be followed by a Closed status, as it happens today in IFPS.

The deployment of further FF-ICE services will require the necessary adaptations to ensure seamless information about a flight.

4.1.8 Traffic capturing tool

Currently, two different concepts are used to capture traffic in flows: restriction and traffic volume, mostly applicable respectively for flight planning and for flow management. Given the move for trajectory-based operations, the split between flight planning and flow management will disappear, requiring a harmonized approach versus the way of capturing traffic, by combining the advantages of both models and expanding them where required.

The operational processes followed by the NM, ANSP, AU and CFSP Stakeholders in the strategic and tactical phases would be improved by evolving the existing restriction and traffic volume models to close the gap between the two. The alignment of both models should:

- Reduce technical and operational costs by having one traffic selection model throughout strategic, pre-tactical and tactical phases.
- Facilitate working arrangements locally and at the NMOC (better cross domain understanding);
- Better adapt to a wider use of Free Route Airspace across Europe (empowering both models with more advanced options);
- Release capacity thanks to a more accurate model, where the selected traffic can be better fine-tuned and avoid unnecessary overall penalization;
- Support best ATFM measures at network level;
- Facilitate the connection with DAC processes and management in the context of integrated DCB operations.

More dynamicity in traffic selection will require capturing traffic based on any physical entity as reference location, like set of points, DCT segments and airspace borders, including the selection of a FL band to bring further vertical flexibility. More than one element may be marked as reference location, like already available in restrictions. This reference location may need to be adapted tactically directly on the interface to support the network evolution.

The flow conditions used to capture traffic will need to develop in flexibility and granularity just as the reference location. It will be possible to define a complex sequence of (different) downstream and upstream flow elements (not limited to three elements), with FL bands and logic rules to connect them.

Flight data will need to be further used to filter flights more selectively. The single model for capturing traffic will be able to consider information available for a flight. From all filed flight planning data (e.g., aircraft CNS equipment) to evolving flight data (e.g., API / DPI messages, airborne information...). This will also include profile information such as time elapsed in reference locations during climb/cruise/descent phases. This would facilitate selecting traffic in a structured way (also for flow management purposes) based on, amongst others: Aircraft equipment (CNS), aircraft type (anticipating parking constraints at small airports), departure and arrival information (monitoring using API and DPI messages), aircraft identification and operator, last validity and time closeness to AURA (Airspace Utilization Rules and Availability), etc.

The complexity of a traffic flow cannot easily be indicated at the moment in the NM systems, but it should be allowed to define the weight of a flow in the TV, in order to account for ATC workload. Although this is already possible from a technical point of view, future NM system evolutions should improve access to this functionality by external users. A possible approach to this issue would be to alter the time that traffic in a flow remains in a TV.

Following on the previous paragraph regarding flow complexity, the option to monitor / regulate a TV in a sector configuration with a global capacity / rate and different capacities / rates per flow that respect the global TV value will be enabled. The different values would be based on routeing (sequence of environment elements crossed, entry point in a sector…) or flight data (e.g., PBN, departing from a CDM airport having an A-DPI, aircraft type...).

These new capabilities will particularly support flow management in a FRA environment and, in general, adapt the traffic capture to specific conditions thus, reducing the amount of data to maintain and allowing the release of capacity due to the current high capture of traffic.

Where agreed, a TV could report the delay generated if regulated (totally or partially) by an FMP different from the one where the reference location is. The decision on the “ownership” of the delay should remain flexible, allowing for pre-tactical and tactical decisions. Eventually, this will allow the NM to suggest the best traffic volume to regulate based on Network impact and ensure delay is distributed accordingly.

It is envisaged to extend the dependent applicability between scenarios and restrictions automatically, which would be eased by using the same model. In current operations, horizontal and vertical rerouting may be limited by AURA, such as RAD restrictions and profile tuning restrictions respectively. The dependent applicability with AURA is extensible to sector configuration and runway changes.

4.1.9 RAD

Because of FF-ICE and the future merge of the Traffic Volumes and Restrictions models in iDL/iNM, the management of ATFM standard measures and restrictions will be a unique process, managed by a single system/operator in NMOC, so becoming a flexible

CDM tactical process, as it happens today for standard ATFM regulations (via Coordination Platform).

The current RAD process should be reviewed such that restrictions are implemented permanently active only for specific reasons (e.g., because of military areas or to comply with cross-border Letter of Agreement), leaving the rest of the RAD restrictions disabled but in stand-by status.

Disabled RAD restrictions would remain in a non-active status, until they are activated following the pre-tactical/tactical Demand and Capacity Balancing (DCB) process, supported by the Network impact assessment of relevant ATFCM measures.

The selection of eligible RAD restrictions to be used in a flexible manner (dynamic management), taking into account identified permanent TFR, will be subject to an assessment done at strategic level in CDM among NM, ANSPs and AUs. Specific procedure will identify the responsibilities of each relevant stakeholder involved in the CDM process. The aim is to determine which RAD measures will be left on non-active status, as well as the possible impact on other parent RADs.

The relevant restrictions applied for an individual flight, group of flights or specific flow(s), should be communicated to AUs at least 3 hours prior the FPL filing by CFSP/AU, in order to allow AU to comply with the agreed ATFM/restrictions, (update the FPL, time necessary to send info/data to cockpit, refuelling).

Some adjustments in sectors at risk of overload, as deemed necessary (dynamic network demand, unexpected events) should be done through STAM, possibly not impacting flights already with an FPL acknowledged in iNM, except when unusual circumstances or Network disruptions trigger closure of sectors, airports or other events occur causing route unavailability.

The paradigm shift from RAD restriction *always ON* to *always OFF/stand by* represents a major challenge and a revolution in the European ATFM, so it is a mid/long-term objective, requiring high level agreements on the new principle and the subsequent definition of the relevant operational procedures as well as the necessary Network and stakeholders' system changes.

4.1.10 Integration of airports into the Network

Airports shall be able to send to NM Systems DPI and API information as soon as the information is available in their systems, without the need for an associated FPL in NM system.

The exchange of information between the network and integrated airports should be event-driven and no longer based on specific time triggers. The future NM system will support a seamless DPI exchange vehicle used to provide information depending on the progress of the flight as opposed to today's fixed time-based triggers (send Early DPI (E-DPI) at EOBT - 3 hours; send Target DPI (T-DPI-t) at EOBT - 2 hours, etc.). Instead, DPI will be transmitted when there is a relevant change in the content, i.e. data element update. As a natural consequence, a rationalization of the DPI message types will be done.

Data exchange shall be supported using modern interfaces as NM B2B services.

NM Systems do not support the exchange of all the IATA attributes used by Airports and their Stakeholders. A full IATA/ICAO values mapping would provide better compatibility and common unique reference of the flight's statuses, improving all the ATFM phases up to the post-ops.

NM systems shall have a comprehensive picture of the curfew periods and rules related to each airport, each flight and provide automated alerts for airports/airlines if prediction algorithms indicate that a flight is in danger of violating local airport curfew. Other alerting services and data (e.g. on ATFCM Regulation prediction or Regulation Impact on flights and expected delay) shall be available from the NOP to AOP for allowing proper mitigation action.

Apart from the proposed changes described above, future NM Systems could also look at opportunities for allowing a direct connection and flight data exchange with other NM internal systems and external user systems. This could allow NM systems to pull data from externals only when necessary and derive the necessary information for Flow Management in a transparent manner.

The future system will allow integrated airports to inform the Network through DPI about the REA status of the flight, processed accordingly in the flow process.

NM Systems should build airport predictive models for those airports that are not able to assess the impact of the arrival flight on the departure flight. Also, turn-around should be monitored by NM to improve and refine the departure times provided for the predictive models when the aircraft is on the ground for those airports not able to provide this kind of information.

<u>For ANI airports:</u>

An additional issue is that there is not always full visibility and timely exchange with ANSPs on data. A more collaborative approach and better visibility on the situation in all phases (including a transparent data exchange) will improve the DCB awareness and allow for better flow management. For example, a tighter link between Airport Operators and ANSPs on expected runway configuration, together with the reasons for changes would allow to improve the awareness of the network and improve the performances at the AOP. DCB with predicted departure/arrival flow at pre-tactical and tactical level, together with mismatch information between current flow and schedule, would allow NM to know when there is less or more predicted departure/arrival flow than originally planned by schedule, for prediction of traffic levels in Network.

The local DCB processes will be improved via enhanced Airport Operating Plan (AOP)/Network Operating Plan (NOP) integration. The improved integration of local airport DCB with the network DCB will allow the overall network to react in an optimum way to all the possible changes and deviations from the agreed AOPs.

Through the API exchange, airports could provide definition of specific traffic volumes (e.g. certain ground handling agent(s), certain pier of an airport, Schengen / Non-Schengen stands, …) that describe the bottlenecks capacity issues the local airport experiences. Applying regulations only to flights which are concerned in the identified bottleneck instead of all arrival flights would prevent unnecessary/unfair delay minutes allocation (evolution of the current 'Terminal regulations' fed by G-API).

For all integrated airports, the take-off time estimations provided to NM systems should consider the linking between inbound and outbound flights as well as any knock-on reactionary delay.

In case of Mass diversions, NM systems shall be able to receive all the inputs from Airports, Airlines, FMPs and share the relevant information across the Network.

The dedicated information services provided by the NM system (e.g. Airport Corner) in case of crisis or severe disruption will be extended and enriched to better support the NMOC, Airlines, ANSPs and Airports, enhancing the Network situational awareness and collaborative decision making at each phase of the crisis or severe disruption.

4.1.11 Extended AMAN and TT reconciliation

As more ATS units and the Network Manager are involved in extending the range of eAMAN, there is a resultant complexity within the collaborative decision-making process for “stabilising” the arrival sequence.

The earlier actions require a clear and consistent process, fully transparent to all the participating actors, to be agreed and implemented.

In this context, the role of ATFCM is to ensure that the arriving traffic demand is planned to not exceed the operational capacity set by ATS, in line with ATC and aerodrome capability, and otherwise to apply ATFCM regulations in the pre-departure phase to address any arrival imbalance. In addition, the ATFCM processes may act upon other network constraints affecting the flights arrival flights.

These ATFCM measures smooth traffic in excess to solve the identified peaks. This action shifts in time the planned individual flight trajectories. These time updates are communicated by NM B2B (or EFD) to eAMAN.

Within ATFCM pre-departure processes, there is provision for the arrival flow stakeholders, including eAMAN, to influence and prioritise the planned order of the shifted flights entering the constraint. This is considered to be regulation tuning.

NM communicates the ATC departure slots to the airlines and aerodrome TWRs of departure for each affected flight. Each slot allocation message contains the calculated take off time (CTOT) set within a tolerance of [-5, +10 minutes] and the corresponding target time at the arrival aerodrome (or agreed waypoint) to be passed to flight crew (CP1) for contextual awareness of the downstream constraint and the expected flight arrival time.

It is assumed that the flights progress after take-off along their planned trajectory and, without deviation from their flight plan, will arrive at the target fix as planned within the tolerance of [-5, +10 minutes]. The flight progress of airborne flights is communicated by NM B2B (or EFD) to eAMAN.

As the flight progresses, it enters the eAMAN horizon where it is managed under ATS LoAs.

4.1.12 Local Traffic complexity tools and interfaces with iNM

The Local Traffic Complexity tools need to evolve in several directions as:

- Established more accurate prediction of expected traffic demand;
- Improve “what if” capabilities and traffic complexity resolutions;

- Support interoperability and sharing of essential proposals and resolutions with NM and adjacent FMP/ATS units;
- Integration of local Traffic Complexity tools within the INAP process;
- Identification of hotspots and multiple imbalances.

The traffic complexity resolution shall be used in the layered ATFCM/ATM planning process encompassing many ATFCM/ATC activities and ensuring that all these planning processes are interoperable supported by required data exchanges.

The Network Manager is the main source of provision of accurate demand data for the local traffic complete tool via EFD distribution. NM Intends to implement the Network Trajectory service which shall be capable of providing more robust, accurate and consistent trajectory to all Stakeholders during all flight phases. The local traffic complexity tools should exploit the better prediction of Network Trajectory Service and develop the appropriate interfaces to its reception. However, there are currently no plans to phase out the EFD distribution, therefore each Stakeholder should identify the most appropriate means of receiving the traffic demand from NM.

When the traffic situation involves an unacceptable level of complexity, it is necessary to identify a potential solution to reduce it. This can be done by using "What-if" facilities to assess several pre-defined scenarios for complexity resolution before their actual implementation. The applicable measures are based on either Dynamic re-sectorization or trajectory management modifications.

Local FMP in coordination with NM will make a full evaluation of the solution with a positive network performance impact, with an emphasis on A/C performance and AU needs, this process needs to be heavily supported by automation and strive to enable informed decision making through real time NM impact assessment of proposed resolutions. The complexity resolution shall be mainly applied in high traffic density airspace regions, enabling the refinement of airspace sectorization and traffic planning in order to be fully dynamic and to adjust ATCO workload balance. The complexity resolution measures shall address the dynamic ATC sectorization changes and individual flight and traffic flow optimizations in terms of traffic complexity. The complexity resolution shall enable processes which contribute to - and increase - controller productivity by taking measures in advance aiming at balancing traffic complexity, workload of the controller and efficiency of the flight profiles.

The local complexity shall be capable to support the CDM process for complexity resolution with Network effect (mostly via NM B2B services) and notify NM of agreed complexity resolution (dynamic sectorisation, STAM measures, trajectory revision) via NM B2B services.

Even if the methodology and parameters used to identify high traffic complexity situations may be tailored to the specifics of each airspace and computed using local tools, there should be a network-wide agreed common output to the local complexity process. E.g.: adapted capacities (monitoring values (MV) and Occupancy Traffic Monitoring Values (OTMV)), increased or reduced traffic counts according to the complexity… NM systems will make use of this common output in the different CDM processes, for guaranteeing that actions taken for solving high complexity situations for one user, do not generate issues in another point of the network. While many stakeholders will develop their own local complexity tools, NM should provide an alternative functionality, based on a set of rules agreed by network stakeholders.

Traffic complexity reduction measure includes multi-sector planning within an ACC and STAM measures across several ACCs.

Complexity Assessment and Resolution (CAR) is a service that allows traffic and airspace structure to be dynamically adjusted to optimize the efficiency of the Air Traffic Control (ATC) / Air Traffic Management (ATM) services concerned with its airspace of application called - ATC Centre.

CAR is applied mainly in high traffic density airspace regions (ATC Centres) in which an environment (in terms of system capabilities) exists that enables the refinement of airspace sectorization and traffic planning to be fully dynamic and used to adjust the controller workload balance. It will be applied as well as in the ATC Centre where dynamic sectorization is in place, and where individual flight and traffic flow optimizations in terms of traffic complexity are performed. This addresses the need to define a future time window for which traffic complexity prediction is practical. Key to the success of CAR is the development of a mathematical description that serves to predict future controller workload.

CAR is used in the layered planning process encompassing all ATM activities. Ensuring that all these planning and control processes interoperate in a beneficial manner is one of the SESAR objectives. In this case it relates to bridging the gap between ATFCM local function and extended ATC planning function, that is INAP function.

The Local Traffic Manager (LTM) will be responsible for keeping the complexity of the traffic within a large area with multiple ATC sectors (ATC Centre) to a level which is manageable by Air Traffic Controllers. The principal tasks are to monitor the level of traffic complexity, forecast traffic patterns, assure the provision of information on upcoming congestions, initiate CDM processes to find solutions to reduce traffic complexity when needed and verify the applicability of proposed solutions of airspace users etc.

4.1.13 Network CDM

Broadly speaking, NM should adapt its role and become the Network interface for stakeholders, able to integrate and optimise their local plans through standardised CDM to reach the performance targets.

Standardising internal/external CDM processes will increase efficiency. More efficient processes improve agility/scalability and requires fewer NM and stakeholder resources.

Common network CDM will enhance cooperation between all the relevant actors (NM, AOC, AU, ATC, FMP, etc) involved in network activities. This includes continuous information sharing and provision of timely updates regarding the status of planning and execution.
The common CDM will provide a strong basis for extending international cooperation and for solving wider critical issues that historically affect both aviation and non-aviation sectors over extended periods and that have a wider impact on society.

The ATFCM service will, accordingly, enhance internal/external CDM interfaces and digitalise their workflows:

- Externally, need for strong CDM interactions with related concepts such as ATM planning, critical weather, crises management, airspace data management ASM

(AFUA, DAC/DMA), airports (AOP-NOP), ANSPs (INAP) and airlines (trajectory management and UDPP);

- Internally, apply the CDM to all layers of decision making between ATFCM phases and stakeholders to reduce inconsistencies and duplications. This will smooth the transition of the services from strategic, pre-tactical, tactical to post-operational phases. Effective information management and sharing enables each participant to be aware of information of relevance to other participants' decisions; and
- Internally, evolve coordination and data exchange capabilities within tools to facilitate an effective and efficient way to coordinate ATFCM solutions and delay mitigations across the network (integrate local and network solutions) either actively or, through collaboratively agreed procedures, passively.

Internal ATFCM processes

- NM operations will evolve towards proactive performance management through the introduction of the balanced performance approach. This features a focus on airline and airport stakeholders by monitoring specific indicators against daily targets that are set in the context of the foreseen daily Network evolution. Analysing the anticipated network situation (ADP) and setting daily performance targets will require additional pre-tactical stakeholder CDM coordination. Agreed daily targets will be exchanged with the network stakeholders. Flights at risk will be presented in a watch list that will be monitored and prioritised for mitigating actions aimed at achieving the agreed daily performance targets.
- During the tactical phase, further enhance ATFCM coordination/CDM:

NOTE: some tactical ATFCM measures may be implemented outside of a CDM process if the time is not enough to allow for a coordination to take place. In this case the AU and NMOC should be included in the information flow.

- Before sending a proposal though Coordination Platform to NM, the FMP will be presented with a simulated view of their proposed action. Any fine tuning of the measure will be achieved by the initiator FMP before sending the proposal to NMOC. Please refer to simulation section 4.3 for **simulation impact assessment** prior to proposal.
- Coordination Platform will support measure **counter proposals** from NM and other stakeholders to the proposal initiator for additional review.
- Coordination Platform will support **multi-stakeholder coordination**: whereby impacted FMP(s) consider the proposal for acceptance/rejection/counter proposal; and other stakeholders are informed of the ongoing coordination. This includes FMP initiating flight mitigation requests with downstream impact e.g., to exclude a flight from a measure – the impacted FMP will ensure that the proposal is digitally accepted/rejected.
- Coordination Platform will support rules based on automated treatment of proposals and counter proposals. These will include rules for **automated acceptance,** automated rejection and to generate an automated counter proposal. Additionally, these rules can determine responses to event(s) when time (or workload) does not permit further collaboration in response to the event(s).
- A central database will be used to administer the Coordination Platform rules, criteria of NM and FMPs for acceptance, rejection, or the need for manual intervention of proposals.

- **Flight criticality** will be applied to flight information and exchanged with stakeholders to be used in ATFCM solution optimization before or after measure activation.
- System actions resulting from telephone coordination shall be tagged / logged with decision rationales and will be archived to improve traceability of **telephone coordination calls.**

There is an imminent operational need to address the integration of ATFCM and ATC planning functions, especially within the high/very high complex environments via the INAP.

The INAP processes are mainly applicable in regions of high traffic loads where the ATC sectorisation and conventional flow control measures are insufficient to support the capacity demand. Such airspaces could be regarded as those in which the traffic demand, in terms of aircraft occupancy, might exceed the declared sector capacity.

The figure below represents INAP interaction with different Stakeholders.

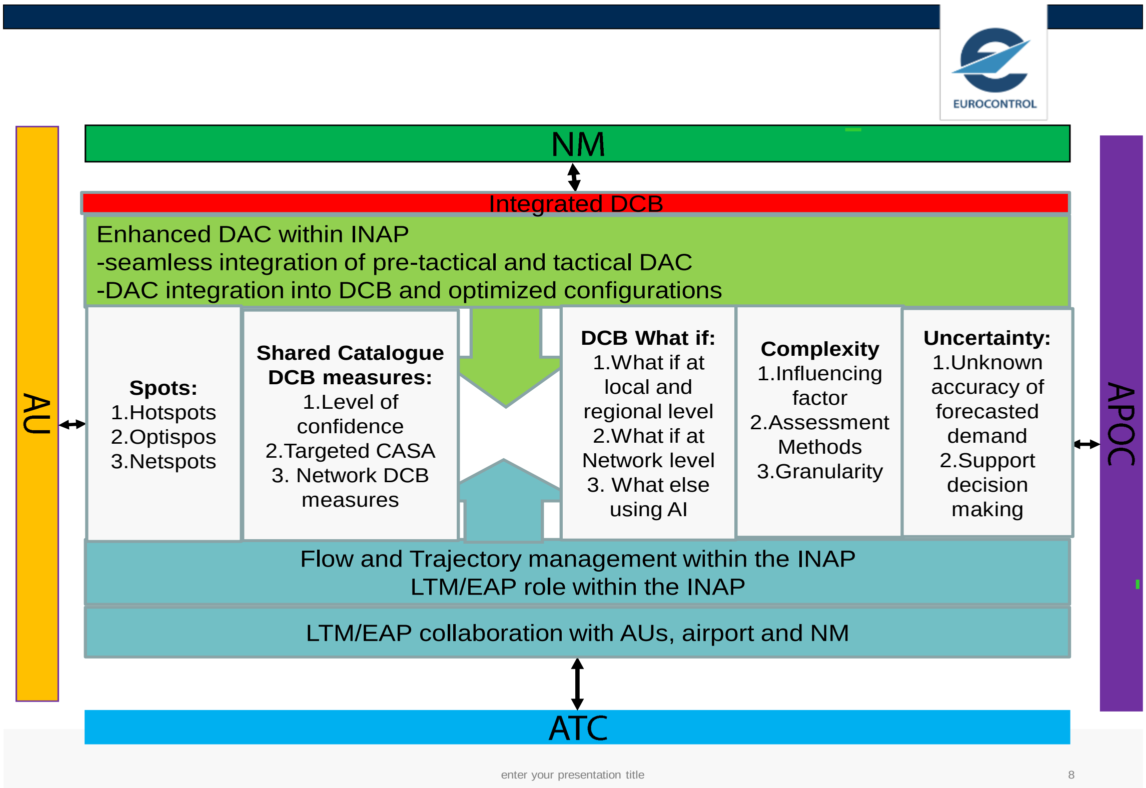

Figure 8 - INAP Interactions

When the aircraft becomes airborne, the traffic situation may evolve quite differently from the one planned prior to the ATM Execution phase. This can cause sector overloads, capacity restrictions and/or the inability to use available capacity in a productive and efficient manner. In these situations, there is a need to apply tactical measures. This situation drives the need for development and implementation of a real time integrated process for managing the complexity of the traffic with capability to reduce traffic peaks, through early implementation of measures for workload balancing. Depending on the available timeframe, these measures will be taken either by NM and/or by the ATC Planning roles. Nevertheless, an overlapping area between these two functions / roles for traffic complexity assessment, resolution and implementation of measures exists. As a result of extended ATC planning horizons and more dynamic approach on the ATFCM side, an overlap within the ATM layered planning shall occur.

The INAP objective is to enable a seamless ATM layered planning from the early phases of planning undertaken by NM until the ATC planning performed some minutes before the assumption of control by the concerned ATC unit.

The INAP process shall be supported by automation tools that plan and organise traffic within an area of operation, such that situations of excessive complexity and high air traffic controller workload can be avoided. The scope of the INAP shall be the overlapping period of NM ATFCM with the local complexity measures, that is when the extended ATC planning process starts by identifying early traffic imbalances within the strategic CDM process and the appropriate future time horizon.

The INAP process shall link the Network Management Function with ATC planning.

The INAP process includes the following sub-processes/activities:

- Monitor and manage workload distribution within AoR;
  - Implement ATFCM measures agreed within the CDM process;
  - Monitor the execution of the measures and the situation at the extended ATC planner level;
- Identify early deconfliction and implement resolution;
- Integrate the NM measures, traffic synchronisation and strategic conflict management measures;
- Feedback the proposed measures to NM.

Several hours before the flight entry into the respective AOR, the Network Manager ATFCM tools, Local Complexity tools and the Extended ATC Planner shall monitor the balance between demand and capacity by assessing traffic demand the associated uncertainty the consequent complexity and ATC workload.

In case of a detected traffic imbalance, the ATC in cooperation with NM shall analyse the different parameters to identify the cause of imbalance and evaluate different options to resolve it.

The detected capacity/demand imbalances shall be addressed via different Network or local measures, intended to enable transitions during the flight phases, keeping planning constraints to a minimum. Those fine-tuned ATFCM measures (e.g., level capping, rerouting, shall apply to flights still on the ground as well as airborne flights. The relevant ATC actors would implement the ATFCM measures on airborne flights and share the proposed resolution with NM via NM B2B services.

During the tactical phase, the AUs could request NM a change of flight details via UDPP for flights affected by delay at departure, arrival and En-Route or provide any other preference. In this case, a CDM process shall be triggered between the concerned Stakeholders (NM, AU, ATC, local FMP) to identify and elaborate an optimum solution at the Network level and commonly decide on the best measures to be deployed. The agreed measure needs to communicate back to NM.

The INAP actors shall need to deploy adequate system improvements to monitor the effectiveness of implemented measures and adjust them if required.

Within the INAP process, extended ATC planning shall benefit from better knowledge of the flight profile (increased precision and larger geographical scope), through the trajectory data provided by the NM trajectory services, as well as sharing them through NM B2B exchanges. The INAP actors shall, as far as practicable, be able to better plan flights sector throughput. All INAP actor shall implement the medium-term workload management process and conflict detection/resolution tools (only for ATC actors).

During the flight execution, the trajectories agreed during the CDM process shall be distributed by NM. Those calculated locally shall be shared with NM and used by different systems/actors to optimise the traffic distribution at congested areas, with an overall objective to increase predictability and accommodate the expected AUs' demand.

The INAP process shall be applied to group of ATC sectors within a contiguous volume of airspace, which is sufficiently large to enable INAP process activities (NM and ATC) to be performed.

The INAP process shall try to re-balance the air traffic situations within a defined future time of application. System supported facilities (Network and/or local traffic complexity tools) shall provide an indication of the predicted traffic complexity levels and associated traffic complexity characteristics. The list of factors contributing to the traffic complexity shall also made available. The decision concerning which type of workload balancing measures shall be applied locally or within a CDM process (if the identified resolution has wider Network impact) and afterwards shared with all concerned actors.

The manual support to INAP is the simplest approach, where a human decides on which strategy to apply for solving traffic complexity overloads. However, this approach shall be avoided as the there is no possibility to share the outcome of the decision taken.

The INAP shall be supported by semi-automated "What-If" capabilities, mainly aiming to use:

- A predefined "What-if" set of scenarios, where the different airspace configurations or sectorization are continuously evaluated and the human actor will decide which scenario to apply and when. •
- On request "What-if" where the human actor needs to generate an alternative scenario, aiming at ensuring that the applied measure solves the identified problems. For this purpose, a toolbox of "generic scenarios", based on the predefined ones, which can be selected and customised for the specific traffic complexity situation identified. This type of scenarios encompasses the airspace organisation, cherry-picking and flow measures.

The automated INAP support shall rely on the huge number of variables which need to be considered when developing a strategy for the management of traffic complexity. An automated INAP process shall assess the measures which may be extremely complex for the human to manage. These measures shall address the specific complex situation to tackle and need to incorporate the impact and interaction with the Network tools and local support tools, that may be affected by the selected measures. Such measures could mix local re-sectorisation, interaction with the extended Arrival Manager (AMAN) and changes of certain traffic flow due to the changing Network situation.

Although the focus of INAP shall be to arrange the planning, well balancing ATCO workload and avoiding overloads, these measures shall not be implemented at the expense of Network goal. The trajectory revisions aiming to reduce traffic complexity need to consider the AU needs for flight efficiency. This is the main reasons that these measures need to be part of CDM process, if the timing for actions permits. There might be occasions when actions may be taken that serve to significantly improve trajectory adherence to these other goals whilst having little impact on traffic complexity.

4.1.14 Airport Slots

To ensure network view on airport issues and their impacts, it is necessary to establish a collaborative decision-making process to identify and resolve DCB imbalances at airports. This process will involve all impacted stakeholders – NMOC, airports and Airport Function. The collaborative decision-making process will be supported by an information sharing platform that would allow all actors to have a common view and understanding of the situation.

For temporarily coordinated airports, it is necessary to provide a standardised interface to provide their slots and list of flights so that they can be considered during the planning.

NM systems shall have a comprehensive picture of the capacity and airport slots available related to each airport and provide automated alerts for the Airport Function if prediction algorithms indicate there will be a demand versus capacity imbalance.

Tactical monitoring of airport slots shall be done automatically using the filed flight plans and airport slots data. The Airport Function shall be informed when a discrepancy is identified to take necessary actions. To enable this, it is necessary to implement:

- real-time data feed with airport slot information
- mapping of IATA and ICAO data fields in NM systems

NM systems shall have a comprehensive picture of the curfew periods related to each airport and provide automated alerts for the Airport Function if prediction algorithms indicate that a flight is in danger of violating local airport curfews.

A dedicated monitoring tool will be used to determine which aircraft operators are adhering to their airports slots and which are deviating and by how much.

4.2 Strategic phase

4.2.1 Acquisition of traffic demand

The future system should be capable to seamlessly retrieve and share historical and future traffic data, including comprehensive 4D profile calculation, between all ATFM phases and between different stakeholders including airlines (e.g., airline anticipated flight 4D trajectories).

The system should include enriched flight trajectories based on AI processing of past data, wind models, current and future environment, so to reproduce as close to reality as possible the route choices for military and their missions, route choices/business models of the various airspace users.

4.2.2 Strategic simulations

- Possibility to include additional environmental information (e.g. NOX emission) in any ATFM or trajectory simulation.
- Alignment of environment data formats and easy transfer process through all ATFM phases while allowing flexible data manipulation for simulation purposes.
- Alignment of the various calculation modules in the ATFM simulation tools, in order to make sure algorithms and associated results are the same.
- Tools should keep guaranteeing flexibility in the setting up of any simulation scenario. The user should be able to keep a "fully creative" approach and thus be able to mix and match whatever elements necessary for the simulation.

4.2.3 Special Events

The following features were identified as an improvement to special events preparation and management:

- Possibility to simulate future events based on similar archived past events independently of the location (e.g. Champions League, Davos WEF), with AI support
- Support systems should be able to channel the flow of relevant information through the different ATFM phases and this should include simulation data, environment data and any operations critical information.

4.3 Pre-tactical phase

4.3.1 Acquisition of traffic demand

The proposed enhancement is to offer a smoother transition between the pre-tactical and tactical traffic demand acquisition processes by merging them into a common, iterative and continuous process.

This would imply the following enhancements:

The update cycle of the pre-tactical traffic demand acquisition will evolve from a daily update which is frozen at D-1 in the morning towards a more continuous update cycle allowing to inject late received flight intentions and early flight plans data as soon as becoming available:

- Flight intentions (mainly derived from airport slots updates) will continue to be injected to reflect airport slots newly allocated by airports in the last 30 hours (in particular to reflect the late allocated airport slots for ad-hoc flights and GA/BA aviation). Similarly, late cancellation of airport slots received in the last 36 hours will be processed (to reflect special conditions at airports like fog, snow, strikes resulting into a significant program reduction at specific airports).
- Flight plans will be processed and injected in the pre-tactical traffic acquisition process as soon becoming available in the NM system. This will allow to reflect the planned route selected by airspace users and replace the historical planned route currently used by default to build the pre-tactical traffic demand.

The FF-ICE/1 planning service will support airspace users to share initial planned trajectory earlier with NM. This would allow the airspace users' systems to receive early feed-back of dynamic restrictions and proposals for more efficient route opportunity through what if services.

Historical flights (possibly adjusted with flight intentions) used to build the initial iterations of the traffic demand will be removed if not confirmed by a flight plan when getting close to its planned departure time (i.e, if not confirmed by a flight plan at least three hours before initial planned off-block time). This to avoid historical ghost flights remaining in the late iterations of the traffic demand of the tactical phase.

Confidence index will be associated to the traffic demand, in order to inform its users of the mix of flight data sources used in the traffic demand (i.e., proportion of historical flights, confirmed or not by flight intentions, proportion of planned trajectories derived from flight plans). HMI filtering capabilities would help to visualize the proportion of each source to illustrate the confidence index associated to the generated traffic demand.

4.3.2 Dynamic Network Plan

The NM/NMOC prepare and coordinate the strategic/pre-tactical/tactical ATFCM plans with military authorities, ANSPs, airspace users and airports. It is paramount to run real time communication and coordination tools during the plan preparation, its implementation and subsequent modifications.

The DNP main features should be:

- Self-populated with predefined data set (tbd) i.e.
    - Pre-tactical/tactical active ATFM measures
    - RAD applied due special events
    - Network situation map, showing airspaces/routes/airports constrained by RAD or subject to ATFM delays and future bottlenecks
- It shall be possible to attach any relevant operational document and images;
- To enable the dissemination of dynamic planning, it is expected that DNP can be published with frequent updates as defined by the user;
- A section shall be available to IFPS/Flight Efficiency Team;
- Links should be available to access e-RAD, AUP/UUP, Airport Corner etc (tbd);
- A section should be dedicated to future events (from D-7 tbd);
- A section shall be dedicated to entries input by stakeholders (tbd);
- It shall be archived and available to NMOC after the end of its lifecycle of 48 hours.

Stakeholders should be able to access the plan at any time and expect updates in real or near real time.

Output should be visually easy to interpret and available on all devices (including mobile) and elements should also be printable.

The NOP Headline News could be also integrated in the DNP.

4.4 Tactical phase – pre-departure

4.4.1 STAM measures

STAM will remain a subset of measures **targeted to a flight or a flow**, in the day of operation. In terms of timeline, the application of STAM measures will be **brought forward** in the operation even to the flight execution at a later stage. The coordination will be more **agile** and the possibility to **negotiate will increase,** however with **some** expected **degree of automation.**

STAM future requirements

- STAM adaptable to cope with different objectives:
  - Proactive STAM:
    - For evolution on the upcoming DCB issues (current use and improved) – MDIs, STAM RRP, TONB/TONA and Miles-in-Trail.
    - Dynamic RAD - It is expected that dynamic RAD will bring the advantage to rerouting by exempting a flight or flow from a RAD restriction, improving the alternative rerouting toolbox.
  - Reactive:
    - Optimization of regulation - NM system will allow to target with STAM measures the regulated flights if their PTOT improves with the RRP.
- Full integration of STAM measures in NM systems:
  - Contributing to a robust Network view, all STAM measures (locally implemented or through a CDM process) will have to be communicated to NM systems, this is key for full situational awareness.
  - Having agile and automated coordination will allow an increased number of measures to be handled across the network. This is the result of the expected dynamicity in the Network.
  - As some STAM measures are expected to continue to be proposals from FMP, to be accepted (or not) by FOCs, the concept will continue to encourage FMPs and NM to provide a what-if delay per flight, if possible, for allowing FOC to assess whether to accept or reject the proposed measure for the individual flight(s).
- Reconciliation of measures:
  - Because of the expected expansion in the number of measures, a correct process of measures/restrictions reconciliation will be essential.
  - This reconciliation process will be defined during the strategic phase.

4.4.2 Extended AMAN and TT reconciliation

Extended AMAN concept shows the need to plan and organise the inbound traffic to reduce the risk of bottlenecks and improve efficiency of the use of the airport/TMA resources. With the extension of the AMAN horizon, eAMAN requirements may be applied to ATFCM regulations through the generation and communication of flight target time requests.

The eAMAN can request the spread of traffic at a metering point associated with an arrival flow. Either a network cherry pick regulation or a conventional regulation may be requested by the FMP and activated by NM. The eAMAN sends NM its requests of target times at the metering fix for specific flights. These are automatically network impact assessed and then processed accordingly by CASA to update the slot lists. Departure slots (CTOTs and target times) are then issued.

Note: the eAMAN may also support AFLEX procedures, whereby airlines may communicate their priority flight order as an eAMAN input.

The same ATFCM process can be utilised to meet the AOP needs in coordination with airlines, based upon a locally agreed priority scheme that requests target times at the ADEP for specific flights. E.g., aerodrome mitigates knock-on-effect of late inbound flights by requesting earlier target times.

A third DCB option is for the FMP to use the STAM ACP procedure that results in the issuance of departure slots and target times.

There is a necessity to ensure consolidation between the different process needs between eAMAN/AOP/airlines, through a robust local CDM process ensuring that NM receives target times for a flight from a single arrival source.

4.5 Tactical phase – Post departure

4.5.1 Extended AMAN and TT reconciliation

The eAMAN will receive updated arrival times flight trajectory information from NM B2B. This can be for unregulated and regulated traffic.

With the extension of arrival management into en-route sectors there is an increased likelihood that a flight already in receipt of a CTOT and target time for DCB measures also receives ATC instructions related to queue management for the destination airport. The conflict between a CTOT/target time and queue management arrangements for a flight should normally be avoided by eAMAN having the target time information from NM B2B.

The ATC sector will deliver the necessary ATC clearances received from the eAMAN as per the LoA between adjacent units and the flight crew will comply with the ATC instruction, thus superseding any NM target times.

eAMAN should also communicate any resultant time estimate updates to NM using the NM B2B services, so that NM may maintain a consistent set of flight trajectories.

4.6 Post OPS phase

4.6.1 Attribution of delay

A future concept of delay attribution should allow for more delay reasons than the current 15 delay reasons although it should also be restricted to maintain a manageable level. This should be augmented with an agreed but strict set of rules of application rather than the current guidelines.

It should be possible to attribute delay to several reasons across any given restriction. These should be flexible enough to apply to time bands and possibly individual flights.

Mechanisms shall be established to ensure that delay can be attributed to originators of the delay rather than the geographical entity where delay is generated: this will need to be developed with strict procedures and clear rules of application to ensure transparency.

To futureproof against changes to current or foreseen performance scheme requirements, a provision should be made for attributing delay to non ATFM reasons and for delay to be calculated when generated by restrictions other than ATFM regulations of their derivatives.

This will allow for a fuller picture of the delay experienced by a flight. Reporting on such delay will require careful management.

Subject to the performance scheme a network delay budget could be established, and future systems need to be developed to enable, optimize and measure this.

In case of circumstances establishing delay re-attribution mechanisms, the system should allow a direct determination of the delay to be re-attributed at the level of single flights.

4.6.2 Network Performance - Analysis and Investigation

Analysis and investigation of network performance (as well as airport local performance that impacts it) will continue to take place in the post operational phase however analysis should commence sooner.

Both will continue to be data led and the future concept outlined below is based on the need to obtain data in real or near real time: **What happened?**

Whilst data is of paramount importance, the non-tangible information from operational staff will remain crucial to understanding the data: **Why did it happen?**

The combination of the above, whilst fully leveraging AI and machine learning techniques, will provide the analysis to help us learn and improve over time: **What could we have done better?**

Finally, the analysis should be reported quickly, clearly and accurately.

Future post operations will consist of four basic enablers:

(a) Data gathering and access

(b) Simulation and Replay

(c) Feedback and information gathering

(d) Rapid reporting

Feedback

Whilst simulation and replay tools will be fundamental in future operations of equal importance is the development of comprehensive feedback gathering tools: the current tools allow operational staff to write feedback after or during an event in a separate word type document that can be updated as needed.

Future feedback tools will enable staff to add verbal or written feedback in context-integrated and retrievable from the system being worked on: i.e. when a measure is applied in ETFMS (or its successor), a timestamped written or verbal note can be added at the same time. Verbal recordings will be fully transcribable.

These tools will support a fully transparent, straightforward approach to feedback and investigation.

Future systems also need to support analysis of the decision-making process followed by operational staff, especially in the pre-tactical phase. Use cases:

- what contributed to a decision to apply a pre-tactical ATFM measure (archiving of data, together with the operational perspective).
- what contributed to a decision **not** to apply a pre-tactical ATFM measure (archiving of data, together with the operational perspective).

Both use cases can be extended to tactical operations.

Reporting

Post operational reporting will be supported by all tools able to output clear text (or visualizations) of all data via dashboards and any other relevant technology to enable staff to quickly, easily and accurately report data to the appropriate audiences. This concept relies on all data being archived and parsed.

4.6.3 Network Performance - Monitoring & Reporting

The current operational performance monitoring approach will continue, but with several improvements based on a data science strategy and new technical capabilities. The monitoring will become timelier with the use of B2B data to produce on-the-day/near-live performance metrics, representing an improvement from the current D+1 monitoring.

To improve the accuracy and efficiency of operational performance investigations, data science techniques will be used. For example, traffic count prediction can be used to validate the key factors influencing traffic volume volatility.

The process will require three different capabilities: enterprise-wide business intelligence, advanced analytics, and data science, all of which should be supported by a big data infrastructure. For enterprise reporting and drill-down, dashboard tools will continue to be needed, with access to richer data due to big data capabilities. Data science tools will also be used, with the data science study lifecycle and processes stabilized, though these tools tend to develop rapidly.

To ensure the effective implementation of the data science strategy, NM will adopt Machine Learning Operations (MLOps) practices such as model version control, testing, deployment, and monitoring. By doing so, NM can ensure that ML models used for operational performance are reliable, scalable, and can adapt to changing data environments.

One crucial component of MLOps is the implementation of a continuous delivery pipeline, which enables the automated deployment of ML models into production. NM plans to build and test ML models in a development environment before deploying them into production. NM will monitor the performance of the models to ensure accuracy and reliability.

To support MLOps, NM will need to develop data pipelines that enable the efficient and scalable flow of data between systems. NM will also invest in monitoring and alerting tools that enable proactive monitoring of deployed models and alerting when issues arise. These investments will enable NM to build an end-to-end data science platform capable of delivering insights that drive operational performance improvements.

In summary, the future of operational performance monitoring will incorporate timely on-the-day/near-live monitoring, improved accuracy and efficiency through data science techniques, and technical improvements to support these capabilities. A big data infrastructure will support enterprise-wide business intelligence, advanced analytics, and data science, with the Cloudera (Corporate data management tool) stack of tools converted to policy and data science tools used in a stabilized manner. MLOps practices will ensure effective implementation of ML models for operational performance.

4.6.4 Post OPS Simulations/Replay

Post OPS simulations facilitate the evaluation of ATFCM situations and solutions to learn for future events.

The post ops assessment of simulations will include evaluation of solution reuse and accordingly to feedback recommendations to the strategic and pre-tactical phases.

The post ops capability will require replay of the historic events and the capability to interact with them by simulating alternate ATFCM solutions and comparing and contrasting them.

The simulation tool will provide the capabilities to:

- quickly select and replay any day or set of days of operation in fast time
- pause the simulation
- process user inputs to simulate alternate (what-if) ATFCM solutions/ scenarios or to generate network optimizations (what-else)

5. Roles and responsibilities

Introduction

Current roles and responsibilities are going to evolve in line with the expected improvements, namely:

- Optimised Network design;
- Optimum Capacity and flight efficiency planning;
- Trajectory and Collaborative traffic management;
- Airport and TMA - Network integration;
- Network components/systems and CNS infrastructure evolutions

Hereafter are described the changes for the main actors, relevant for the scope of this document.

ATC roles

Several changes are foreseen in the ATM layered planning. With relevance for the CONOPS, the following are the main roles of ATM layered planning.

The INAP function can be related to several roles from Network Operations and ATC Operations. It includes the Local Traffic Manager role and appropriate ATC operational roles.

Performing this function requires actors to have thorough local expertise and the way it will be implemented (procedures, detailed activities, actors involved) will vary depending upon local drivers. The extended look-ahead time horizon of the ATC Tools will enable the INAP function to better assess and anticipate the complex situations for ATCOs.

Depending on local procedures, the INAP-related-tasks could be performed by different actors, not only limited to local Traffic Management but also encompassing the ATC scope of action. The deployment of specific system, the involvement of human actors and the granularity of the processes are based on the ATM layered planning principles and the complexity of the operations. These actors will allow the identification of the best local solutions to cope with both Dynamic DCB and ATC requirements in the execution phase.

The roles in the ATM Layered Planning could overlap. Actors endorsing these roles would depend on local ATS or ANSP procedures, operating methods and traffic environment. A given actor could assume a given role, part of the tasks of a given role, several roles or part of the tasks of several roles.

For example, the Multi-sector Planner could perform solely the task of sector planning extended to two or more sectors (group of sectors Planners responsibilities) and could also perform elements of the complexity management role.

Similarly, the Extended ATC planner task might be emulated within the Complexity Manager role or Multi-sector Planner role.

The OPS Supervisor role will be responsible for the general management of all activities in the Operations Room. It decides on staffing and manning of controller working positions in accordance with expected traffic demand. Supported by simulations of traffic load and of traffic complexity and assisted by local traffic management, the OPS Supervisor takes decisions concerning the adaptation of sector configurations to balance capacity versus the forecasted demand. Based on the results of simulations, the required flow control measures may be implemented by ATFCM through a CDM process. In addition, OPS Supervisor will be responsible for the task related to the delegation of ATS provision.

The role of Sequence Manager will be extended to the remaining high and medium complex TMAs and this role will be further enhanced by automated impact assessment of manual traffic sequence (what-if task and functionality).

NMOC and Local FMP roles

The Network Manager Operating Centre (NMOC) provides Network services and facilitates efficient network operations by and for all ATM stakeholders.

- During the medium to short term phases the NMOC works towards identifying and mitigating significant DCB issues strategically, both at network and local levels.
- NMOC will take DCB initiatives, in accordance with NM IR, for seasonal traffic variations, large scale military activity, significant events (such as Olympic games) and reductions in normal capacity, due to weather, major infrastructure implementation, industrial action, etc.
- During the execution phase, the NMOC will assure the stability of the NOP (Network Operations Plan), reacting to unexpected events, which impact the overall network performance, such as unusual meteorological conditions or loss of significant assets (e.g., runways, airports). Among other means, activation of pre-agreed scenarios will enable the NMOC to restore Network stability.

The relationship between central (NMOC) and local ATFM Units is ruled by the current EC Implementing Regulation No 2019/123. The ATFM function is a shared function between the central and local ATFM units, through the CDM process. Sharing the responsibility for the ATFM service provision in a CDM context entails the availability of the same information/data to all the actors/decision makers. This is a continuous process that will be improved through the iNM programme: traffic demand, simulations, Network impacts, cross-border STAM RRP, MET info, as well as local ATC decisions, will be available to all the ATFM actors/decision makers in real time. This is a crucial point in the preparation of the best possible pre-tactical plan or in taking the best possible agreed tactical decision in a coordinated manner.

Additionally, iNM will bring further process automation and improved collaboration facilities in support of the ATFM function.

Having access locally to the network tools and data allows local ATFM units to assess the network impact of any possible measure, relieving NMOC from that task. Many more simulations can be done, as the task is distributed, allowing to achieve much better solutions.

NMOC has then more time to dedicate to the overall coordination of measures implementation with all actors and check their effectiveness.

iNM will open the door to post-departure ATFM, provided that on board systems/avionics will be fully integrated with NM and ANSPs. This makes possible to perform tactical

STAM rerouting in response to last minute capacity bottlenecks en-route, weather or any other unexpected event, causing a capacity reduction in the Network. This entails that ATC systems shall be able to display info/data on radar screens in real time coming from the NMOC.

NMOC staff profiles, currently split in the three operational domains (Airspace Data, Flight Planning, Flow Management) will be completely reviewed, adapting their roles and responsibilities to the cross-domain integrated functionalities that will be introduced gradually with the iNM programme. New recruits and current NMOC staff will be progressively trained for the new processes and tools, as the new capabilities are made available through iNM. All the NMOC operations manuals (as well for the local ATFM Units) shall be changed accordingly.

FMPs/TWR/Airports personnel will also need to be trained on new procedures and interfaces. The current Airport Function Trial in NMOC will become a permanent position, and the scope will be enlarged to assist all Airports in the European Network versus capacity optimisation, weather impact, curfew management and airport slot adherence.

The initial EAD/CACD integration with new digital workflow processes involving AIS, ENV Coord, RAD Coord and NMOC will require some additional training and competence acquisition of the different stakeholders involved and their roles and tasks will need to adapted to new requirements.

ASM/DAC roles

Major changes are expected with the implementation of DAC and DCB concepts. With the DAC concept, the local civil/military will focus on the definition of parameters, performance driven, to allow operational actors to define and manage the dynamic airspace structures (sector configuration and DMAs) at pre-tactical and tactical levels. These dynamic structures, especially DMAs, will coexist with current structures, as well as the utilisation of predefined airspace organisation, whenever deemed easier to manage and more appropriate to solve problems.

Local DAC actor fulfils a joint civil-military function at national level which integrates ASM, ATFCM and ATS functionalities, so that their processes can be performed in a combined manner allowing for a cooperative management of Airspace Configurations. This function is expected to manage civil/military airspace allocation, flow and capacity management, including sector configuration management at local/sub-regional level with following responsibilities:

- Plan and develop Dynamic Airspace Configurations that meet defined Network and local operational performance targets for the referred period;
- Monitor Airspace Configuration deployed during the strategic phase, considering Network and local performance;
- Retrieve and process MIL\Special AUs SMTs (Shared Mission Trajectory)/requests;
- When and if the problem detected - using “What if” tool to find new sectorisation, matching the demand with acceptable level of performance;
- If there are no airspace sectorisation options matching the demand within an acceptable level of performance, a negotiation with military\special AUs or other DMA/TSA/TRA activation parameters (that satisfy required level of performance) shall be pursued.

- As a result of such new DMA/TSA/TRA activation parameters, identify SBTs /RBTs (Shared Business Trajectory/Reference Business trajectory) that are not compliant anymore with new DAC and pass them to DCB actor for further coordination with AOs;
- Coordinate with other DAC actors/FAB and NM;
- Take final decision on the DAC;
- Promulgate new/latest DAC configuration on the NOP.
- When DAC process reaches its limit in terms of exploiting airspace capacity to accommodate civil and military demands, the actions pass to DCB for demand balancing:
- either when the problems are solved, or
- outstanding problems cannot be solved by further DAC modifications/improvement.
- DCB actor is the responsible for hotspot declaration and provision of this info to AO;
- DCB actor interact with AOs;
- DCB actor may come back to DAC process if time permits.

Civil and military Airspace users' roles

WOC (Wing Operations Centre) is a generic term designating a local military airspace user function which gathers the operational processes and services, directly related to the airspace users, linked to Mission Trajectories and other aerial activities and is involved in DAC as owner of ARES:

- Defines ARES (fix ARES, VPAs, and DMAs) to be processed by DAC function in accordance with AUs mission request;
- Supports integration of ASM with ATFM by sharing trajectory requests with embedded ARES (where suitable) or independent ARES requests; sharing of trajectories and ARES requests triggers the CDM process for DAC;
- Provide to DAC actors the indication of flexible parameters used to facilitate the CDM process;
- Share and update trajectories (via NOP/NM) and ARES in accordance with the rules and procedures established by national authorities;
- Participates to CDM for ARES location, volume and activation parameters and holds the end responsibility for their agreement.

FOC is a generic term designating a local civil airspace user function which gathers the operational processes and services directly related to the airspace users and linked to Business Trajectories. Different are the activities supporting the FLOW process:

- Provide NM the preliminary FPL to inform the ATM actors of the desired trajectory, responding to AUs business requirements;
- Capture latest airspace status information to update the 4D trajectory, both in terms of FPL (for flights on the ground) and to evaluate possible improvements of the trajectory for airborne flights (downstream trajectory);
- Be involved in the CDM process to coordinate STAM measures to modify the trajectory (STAM RRP).

6. Required system changes (NM, FOC, ATC, Aerodrome, aircraft, MET)

In order support the processes listed above in Section 5, the Operational Stakeholder will need to envisage the system changes as depicted in the table below:

Operational Stakeholder	Required system changes
Airspace Users-Flight Operation Centres	• AOP/NOP departure information integrated in EFPL • Enhanced air traffic flow management (ATFM) slot swapping • User-driven prioritisation process (UDPP) departure • ENV performance management • Dynamic airspace configurations (DAC) • Collaborative framework managing delay constraints on arrivals • B2B evolution
Network Manager	• CCAMS • Implement IATA / ICAO data fields mapping to enable exchange of airport information with NM and improve awareness on flight status • Integration of airport operational information into NM systems • Allow DPI and API provision without filled FPL • Implement Curfew monitoring and alerting service • Implement continuous monitoring of data exchange (with alerting service in case data quality is not sufficient for flow management activities) • Enhanced planning systems for the management of DMAs • Enhanced air traffic flow management (ATFM) slot swapping • User-driven prioritisation process (UDPP) departure • ENV performance management • Dynamic airspace configurations (DAC) • Collaborative framework managing delay constraints on arrivals • B2B evolution
ANSPs (all ATS units including local FMPs)	• Enhanced local traffic complexity tools • Enhanced planning systems for the management of DMAs • STAYING HEAD OF THE WEATHER Meteorological information exchange • Enhanced air traffic flow management (ATFM) slot swapping • User-driven prioritisation process (UDPP) departure • ENV performance management • Delegation of ATM services provision among ATSUs • Dynamic airspace configurations (DAC) • Collaborative framework managing delay constraints on arrivals • B2B evolution

Airports	• Provision of DPIs and APIs exchanges via NM B2B • Exchange of airport operational information with NM • Enhanced air traffic flow management (ATFM) slot swapping • User-driven prioritisation process (UDPP) departure

Table 2 - Required System Changes

The list of system changes described in the table shall be considered in conjunction with those described in the 4DT and iDL CONOPS. In case of redundancy, the system changes are mentioned in relation to their specific need for supporting the processes described in chapter 5.

7 Contingency

Current systems have been developed in the beginning of the 90s based on the user consultation made at that time. Because the users have said that they could do 24 hours without TACT system (today's ETFMS), it was designed and developed in a way that limits its recoverability today following a major outage.

Since then, without changing the design, we have tried to improve the recoverability of ETFMS (and other NMOC systems) but there may still be an ETFMS outage period following a major incident. That is why it is very important to keep the current procedural contingency to bridge the gap.

Below are today's requirements for the mission critical systems (they reflect the reality of the current design, not necessarily what is operationally needed):

System	Current Contingency Requirements	Committed in System Specification (reg. 373)
CCAMS	immediately, max 30 mins	30 mins
ETFMS	within 2 hours after the decision to activate Disaster Recovery Plan	ess than 2 hours for 80% of the time, max 4 hours
IFPS	immediately	ess than 2 hours for 80% of the time, max 4 hours
CACD	immediately	ess than 4 hours for 80% of the time, max 8 hours

Future NM Disaster recovery and contingency requirements in the iNM context:

Considering that we are now drafting the ideas and concepts of operations that would be part of future NM services/systems for many years to come, we have to be as unrestricted and open as possible. Especially, after experiencing the limitations caused by the design made in the 90s.

There are also points that require better recoverability strategies which are valid today, for example:

- Today's external users access ETFMS via B2B and download continuously data for their business: if ETFMS is not accessible/down or loses data, this will impact the business of the airlines and ANSPs.
- The time that the 'procedural contingency' is applied will cause business impact in terms of delays and cancellations.

- EUROCONTROL CRCO (Central Route Charges Office) uses NM operational data coming from ETFMS logs for billing purposes. Today's setup will cause data loss around the time of the disaster (max 2 days), this will have a direct impact on CRCO's ability to make correct billing to airspace users.
- After ETFMS (switch to fallback) recovery, it is a long and painful task to correct the DWH DB (Data Warehouse database) for duplicates, missing records and correlating the 2 different TACT IDs.
- IFPS does not have a reduced-service equivalent like the procedural contingency of ETFMS; if IFPS and its backup are unusable no flight can take place in the NM area.

About future services:

- iNM's vision is to have an integrated service environment including the end user systems → if this is true, we must cater for an immediate recovery without affecting this vision.
- If we consider the possibility of NM having a central role in the high-altitude operations, we will have a much safety-critical role in service provision; this will even require some of the iNM components to be truly fault tolerant.

<u>Assumption</u>: For the future (iNM), NM's secondary site must be located in a closer geographical area (not far from Haren premises), this will allow synchronous data replication.

<u>Note:</u> The requirements listed below are for the FUTURE flow management and flight planning systems, not for those that will be copied AS IS to the new digital platform.

<u>So, here are the high-level, future disaster recovery and contingency requirements:</u>

- RTO (tolerated downtime) → 15 minutes (for both internal AND external users) → some functions may tolerate less down time if we are entrusted the role of managing the space launches
- RPO (how much data can be lost) → 0 hours (i.e. no data loss is tolerated), including archived data (current DWH)
- No single point of failure
- Redundancy → for all mission critical systems including HMI, web portal and their storage; switch-over without losing data (Stateful design), i.e after switch-over, the fallback system shall 'remember' the last transactions
- Connectivity to fallback systems → should be automatic, as much as possible (today's users of CHMI and NOP need to re-connect to the fall-back equivalents, also DNS mapping update takes time, so until then the contingency NOP must be accessed with its previous URL)
- Minimum service provision → in case contingency fails (cyber-attack; people-related; …) a minimum-service equivalent to kick-in (using different technology, no dependency to existing infrastructure)
- Off-site backups (data and executables) → protection from cyber-attacks like ransomware (backups must be inaccessible to networks)
- Messages via ANg1 (AN1 New Generation System)→ as today, double reception (at main and fallback sites)

Why not 30 minutes or 1 hour of RTO:

- Today's IFPS for example, can be switched to EUROCONTROL Bretigny site within minutes, the same is true for CACD and ANg1. The mentioned 30 minutes in the table cover the time for human intervention. For the future, if we adopt automatic switch-over solution, 15 minutes can be set. So, the question should be why not 15 minutes?
- There will be more and more dependency on NM systems by the ATC (and perhaps the STC); since technically it is possible to switch within 15 minutes, why to limit the future? How much money would we save from the total cost by saying 1 hour outage is OK? How can we justify to users who pay for the iNM that after spending 300 million, they will still suffer an hour of outage?

8. Transition Principles

The Network Manager was committed by EU to perform 4 Network Functions as per NF IR 123/2019:

- ATFCM
- Airspace Design
- Scarce resources
- Support to crisis management

The NMOC provides data and services to all the ANSPs of 44 State Members of EUROCONTROL, civil and military airspace users, Airports and CFSPs.

The nature and the importance of such functions entail the principle of service continuity, as the service discontinuity would cause a major disruption or a crisis to the Network.

The iNM is meant to replace completely the whole of the current NMOC systems and add state-of-the-art new functionalities, aimed at facing future challenges as significant traffic increase and complexity, the need to reduce emissions and the new entrants, to avoid conflicting issues with civil aviation, using the same parts of the European airspace.

The NMOC current legacy systems shall be kept up and running until the iNM is tested, validated and delivered in full service. As a direct consequence, there is no possibility to dismantle any part of the NMOC current legacy systems during the transition to iNM.

Moreover, after the iNM is completed, a back-up system should be in place as, once again, the importance of the NMOC systems for the European ATM necessitates a redundance of each system for the sake of service continuity.

9. Initial roadmap

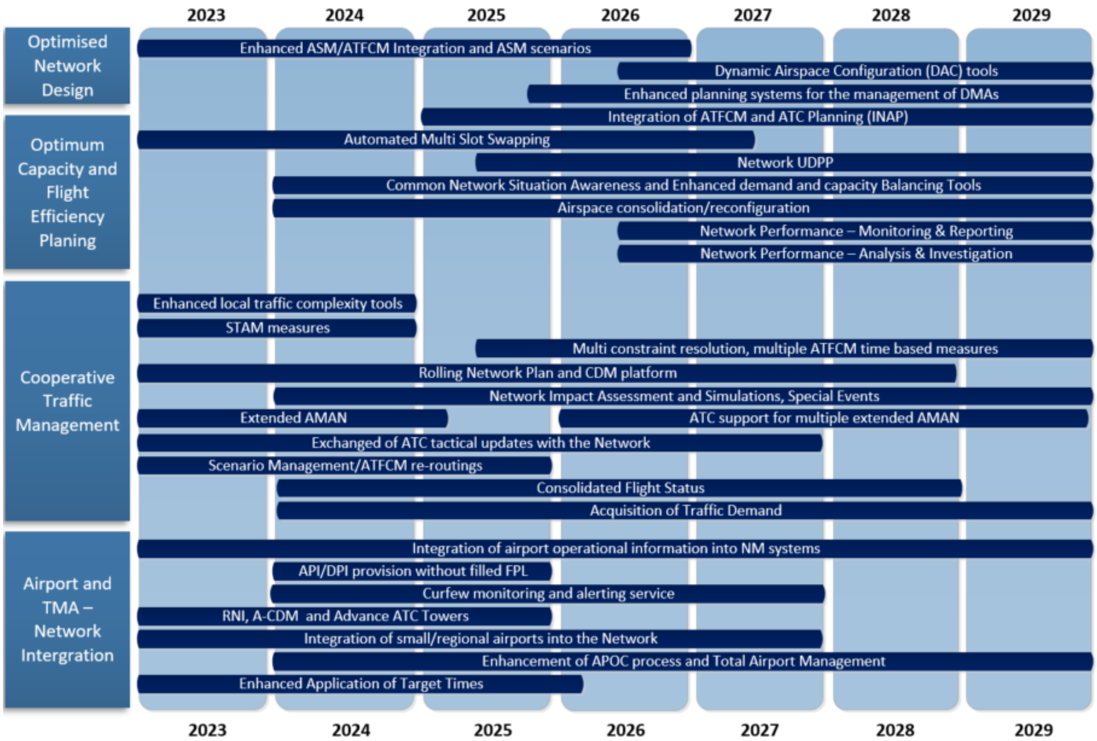

Figure 9 - Initial Roadmap

10. Improvement of the performance parameters

The Flow concept of operations is integral part of the High Level CONOPS (Network Concept of Operations) 2029 [5th July 2022] approved by the Network Manager Board. The overall costs and benefits are explained in Chapter 4 of the High Level CONOPS.

Overall, the High Level CONOPS Provides for a cost estimate of € 5,4 Billion until 2029 and correspondent benefits' estimate for € 9.5 Billion in 2029, benefits in comparison to the baseline performance in 2018. If the CONOPS enablers and components are delayed, going beyond 2029, then correspondently benefits are delayed.

Considering the High Level CONOPS, in this paragraph f we will provide a first estimation of costs to implement the Flow CONOPS and an estimation of benefits in comparison to 2018 baseline.

We will not count in this paragraph:

- The costs and benefits already indicated in the 4DT CONOPS and IdL CONOPS
- Military OAT benefits such as mission effectiveness or mission efficiency.

10.1 Estimated costs of Flow CONOPS

The cost estimation aims at identifying the order of magnitude of the cost range of the overall costs to implement the Flow CONOPS.

The Flow CONOPS relies both on technology already described in 4DT and iDL CONOPS and in technical changes directly related to Flow CONOPS which are complementing the 4DT and iDL technology.

Hereunder we only describe the costs of technology directly related to Flow CONOPS
A stepped approach was applied:

- Step 1: Define the scope for the cost computation which is the one indicated in Chapter 6 "Required system changes".
- Step 2: Review of available documentation (SESAR R&D (Research & Development) business cases, cost projects awarded for CEF funds, and support to ANSPs (Air Navigation Service Providers) made by EUROCONTROL)
- Step 3: Review of feedbacks from operational stakeholders during the forthcoming consultation process for the Flow CONOPS
- Step 4: Determine the order of magnitude of the cost range for each category of operational stakeholder
- The cost estimation is provided as a range of value given that costs could widely vary depending on:
    - The technical and architecture set up
    - The price of system purchases
    - The internal required effort for system development and deployment
    - The organisation of training programmes and plans.

Type of costs included in the cost estimation

The cost estimation is based on

- The cost of internal system developments or system purchase from suppliers
- The cost of system deployment
- The cost of training

Scope and cost range of Airspace User systems (FOCs)

The cost is estimated for the top 30 airlines in terms of flights which cover more than 60% of flights. This amount of traffic represents the critical mass to enable the Flow CONOPS Small airlines with a simple FOC may not need complex system changes to support the flow CONOPS.

The main cost for Flight Management System in FOC is related to the implementation of algorithms and HMI modifications inherent to:

- ATFM slot swapping and airport slot swapping (UDPP) for those airlines which have not yet implemented such technical features.
- Management of airspace data related to the availability of Dynamic Mobile Areas (DMAs) and to the status of airspace following Dynamic Airspace Configuration (DAC) or Re-configuration.

The estimated range of costs is between 2 and 4 million € for each airline, for a total between 60 and 120 Million.

Scope and cost range of ANSPs systems

Same as in 4DT CONOPS, we assume that 50 FDPs or other systems need to be modified.

The main cost for FDP or other system evolution is related to the implementation of systems, algorithms and HMI modifications inherent to:

- The consumption of MET information received via SWIM in WXXM or GRIB format. This may be a new decision support system or module which integrates MET and ATC data in order to provide options in term of ATC capacity reductions and/or ATC sector configuration to cope with adverse weather conditions.
- Systems or modules for the management of airspace data related to the availability of Dynamic Mobile Areas (DMAs) and to the status of airspace following Dynamic Airspace Configuration (DAC) or Re-configuration. Reinforcement of data exchange with the civil-military unit (AMC Level 2 and 3) responsible for configuring the DMAs.
- A traffic complexity tool if not yet implemented and/or the B2B connection with NM systems to receive traffic complexity data.

The estimated range of costs is between 5 and 15 million € for each ANSP for a total between 250 and 750 Million.

Scope and cost range of NM (Network Manager)

The main cost for FDP or other system evolution is related to the implementation of systems, algorithms and HMI modifications inherent to:

- The consumption of MET information received via SWIM in WXXM or GRIB format. This may be a new decision support system or module which integrates MET and ATFCM data in order to provide options in term of ATFCM scenarios to cope with adverse weather conditions.
- Implement Curfew monitoring and alerting service
- Enhanced planning systems for the management of DMAs
- CDM tools for exchanging options of Dynamic airspace configurations (DAC) with ACCs and AMCs.

The estimated range of costs is between 15 and 25 million €.

Scope and cost range for airport operators

Same as in 4DT CONOPS, we assume that 15 airport operators may need to implement a new system which is about airport slot allocation swapping (UDPP).

The estimated range of costs is betwee3 and 5 million € for each airport operator for a total between 45 and 75.

There is no further costs directly related to the Flow CONOPS. The modification “Allow DPI and API provision without filled FPL” is part pf the AOP/NOP integration described in the 4DT CONOPS

Scope and cost range for MET providers

We assume that 50 MET providers need to provide for the evolution of systems and MET services. The main cost is related to the implementation of systems, algorithms and HMI modifications inherent to:

- The deployment of the SWIM Yellow profile.
- The distribution of MET information via SWIM in WXXM and GRIB format.
- The delivery of MET services to Airspace Users, ANSPs and Network Manager in accordance with their MET requirements.

The estimated range of costs is between 2 and 4 million € for each MET provider for a total between100 and 200 Million.

Scope and cost range for Military entities as ANSPs and as Airspace Users

There is no costs directly related to the Flow CONOPS.

Overall Cost Estimation

The overall cost estimation for deploying the Flow CONOPS is between 520 and 1 245 €.

10.2 Benefits of Flow CONOPS

The benefit estimation aims at identifying the order of magnitude of the benefits produced by the Flow CONOPS. A stepped approach was applied:

a. Step 1: Bearing in mind the scope of changes review of available documentation (SESAR R&D business cases, benefits estimated by SESAR Deployment Manager, benefits estimated in ERNIP (European Route Network Improvement Plan) and NOP (Network Operations Plan) publications.

b. Step 2: Review the partition of the performance benefits between all major enablers (FRA (Free Route Airspace), 4DT, Flow CONOPS, etc.)

c. Step 3: Review expected date of implementation of required changes and consider the benefit profile (start-up profile and date of full benefits).

d. Step 4: Review of feedbacks from operational stakeholders during the consultation process

e. Step 5: Determine the order of magnitude of the benefits

The expected total benefits from the Flow CONOPS are in the region of € 1,9 Billions (rounded)

Industry Sector	**Key Performance Area**	**KPI**	**2018 baseline**	**Benefit gain from FLOW CONOPS**	**Monetisation of gain in million € (difference between 2029 do nothing scenario and 2029 with NET CONOPS**
Air Transport Operations	**Departure Delay (non ATM).**	Minutes of dep delay per flight (reference to schedule)	14,4	1 min per flight	€250
Air Transport Operations	**Predictability**	Traffic ahead of schedule in minutes Million minutes(AIBT-SIBT)	9	0,5	€8
Air Transport Operations	**Predictability**	Operational Cancellations (number of events)	31.000	1.000	€15
Air Transport Operations	**User Prioritisation**	Number of ATFM and UDPP slot swapping	15000	35000	€92
				TOTAL	**€365**

Table 3 - Air Transport Performance Contribution of FLOW CONOPS

In term of environmental benefits, the FLOW CONOPS will provide approximately 150 million Nautical Miles savings, i.e., the equivalent of 1.000 million tons of fuel saved, or reduced emissions of 3.200 million tons, or 0.850 billion Euros.

Key Performance Area	KPI	Baseline	2029 expected performance enabled by FLOW CONOPS	Benefit gain from FLOW CONOPS	Monetisation of gain in million € (difference between 2029 do nothing scenario and 2029 with FLOW CONOPS
ATM En-route capacity	Minutes of ATFM En-route delays per flight	5	0,5	1 min per flight	€400
ATM airport capacity	Arrival airport ATFM delay	1,13	0,5	0,2 min per flight	€100
Cost-Effiency	ATCO productivity	0,94	1,04	0,1	€50
				TOTAL	€550

Table 4 - ATM Operational Performance Contribution of FLOW CONOPS

Comparing the performance in the year 2018 (baseline) with the year 2029, the net value of the Flow CONOPS in term of benefits is estimated to be 1,9 billion € (rounded).

A. Annex A - Mapping with ATMMP enablers

Flow CONOPS Future processes and capabilities	ATMMMP enablers supporting the relevant processes and capabilities
Load/Capacity monitoring including DAC (traffic counts & configurations)	NIMS-37-Basic Complexity assessment tools NIMS-04 ATFCM capacity planning sub-system enhanced to take into account dynamic sector shapes NIMS-13a Capacity planning and scenario management equipped with tools to identify the possible re-routed flights/flows providing the best benefits NIMS-23 Capacity planning and scenario management equipped with tools integrating SB/MT information, to assist ATS in optimising the use of airport and airspace usable capacity NIMS-77 Enhanced local DCB traffic monitoring functions
Evolution towards DAC/DCB integration	AAMS-02- Dynamic Airspace Configuration tools for the Integrated Network Working Position AAMS-11 — ASM support systems enhanced to exchange real-time airspace status updates AAMS-18-Airspace management system enhanced to support the European-wide use of Military Training Area as part of the integrated European airspace planning process AIMS-15-Aeronautical Information sub-system enhanced to be able to handle Dynamic Mobile Areas
ASM/ATFCM data integration	AAMS-13-ASM scenario management sub-system equipped with tools for assessing the impact of airspace changes on capacity AAMS-15-Scenario management sub-system equipped with tools to support pre-tactical CDM NIMS-32- B2B (Business to Business) Web Service eRAD and eAMI
	NIMS-42 — NM systems enhanced to receive, process and display real-time tactical (ASM level III) airspace usage information
Scenario management/ATFCM re-routings	NIMS-02- Provision, reception and processing of collaborative flight plan updates NIMS-30 ATFCM scenario management equipped with tools for assessing the impact of capacity changes on trajectory efficiency
Consolidated Flight status	NIMS-46 Integrated local DCB working position NIMS-46b Interface to the integrated local DCB working position

AOP/NOP Evolution	AERODROME-ATC-20 Enhanced ADDEP (Airport Departure Data Entry Panel) AERODROME-ATC-114 Update of the Aerodrome ATC system to align with RNI airport operations NIMS-41- NM interface capable to integrate Airport impact assessment REG-0536-Community Specifications for A-CDM AOC-ATM-13 Participating of the FOC/ WOC in the airport triggered CDM process AIRPORT-38- Airport/ATFCM Extended data interface AIRPORT-02-TTA Airport Impact Assessment Tool Airport-02b TTA Airport Impact Assessment Tool (rolling AOP-NOP environment) AIRPORT-02c Airport Airside/Landside Impact Assessment Tool AIRPORT-03-Airports Operation Plan (AOP) tool AIRPORT-03b-Enhanced Airport Operation Plan (AOP) Tool for ANI airports AIRPORT-03c-Light Airport Operational Plan (AOP) Management Tool (for RNI airports) AIRPORT-07 Decision support tools for airport airside/landside performance management (what-if) AIRPORT-41 Airport Operations Centre Support Tools (Performance airside/landside dashboard) AIRPORT-42 Tactical Capacity Planning Tools (Airside/Landside) AIRPORT-40b Enhanced Airport Performance Monitoring System (Airside/Landside dashboard) AIRPORT-035a Airport CDM (level 4 - CDM integrated with passenger process) AIRPORT-035b Airport CDM (level 4 - CDM integrated with landside process) AIRPORT-33-Provision of departure and arrival constraints to the Aerodrome ATC surface management AIRPORT-54 Artificial Intelligent system to monitor airport processes AIRPORT-64 AODB adaptation for Centralised Lite APOC system AIRPORT-65 Lite APOC GUI (using Centralised Lite APOC web services) SVC-052 Centralised Lite APOC web services (for GUI) SVC-066 Update of DPI service (to remove time-restrictions on reception by NM) NIMS-03- Reception of DPI messages NIMS-03b- Adaptation of ETFMS for removing time restrictions on DPI reception NIMS-25- Integration of Airport CDM data into Network DCB sub-system

	NIMS-52 ETFMS adaptation for an inclusion of airport constraints NIMS-70 Centralised Lite APOC system NIMS-75- Updated Airport Network Digital Data Centre to feed the airport function dashboard (airport capacities & events) NIMS-76- Updated Airport Function Dashboard with DCB views (drilled down to any specific airport)
Extended AMAN and TT reconciliation	NIMS-38-Calculation and dissemination of the TTO & TTA AERODROME-ATC-113 TTOT processing APP ATC 162-AMAN Sequence build with integration of constraints applied for DCB/dDCB purposes AOC-ATM-22-TT data integration in the FOC trajectory FOC-010 Upgrade of FOC system for TTA management for long-haul flights AOC-ATM-22 TT data integration in the FOC trajectory APP ATC 200-TTOT computation for flights departing from nearby airports ER APP ATC 213-Enhanced AMAN/XMAN to calculate target times at key locations throughout systemised airspace for the purposes of de-bunching and delay absorption.
Crisis Management	None
Local Traffic complexity tools and interfaces with iNM	ER APP ATC 15-Flight Data Processing: support Dynamic Sectorisation and Dynamic Constraint Management. ER APP ATC 93-Enhance Resource Management and Planning Tools to use Traffic Complexity Assessment. ER APP ATC 17-Enhance Traffic and Flow Management sub-systems to support dynamic flow management in co-ordination with local, regional, and European levels. ER ATC 92-ATC tools to re-organize traffic flows to reduce complexity in the planning phase ER ATC 164-ATC tools to re-organize traffic flows to reduce complexity in the execution phase APP ATC 62 Demand and Capacity system enhanced to better handle departure flows out of the TMA APP ATC 63 Demand and Capacity system enhanced to better handle approach sectors/flow load in real-time
Acquisition of traffic demand	NIMS-57 -Integration of PFP processing into Traffic Demand Management AOC-ATM-25- Integration of PFP submission in the flight planning NIMS-14c Demand Data Repository Phase III
Network Impact Assessment	NIMS-09-Capacity planning and scenario management equipped with tool to assess the impact of requested flight level changes NIMS-10 Capacity planning and scenario management equipped with sector management tool to assist ATCCs in defining sector configurations NIMS-48 Integrated Network Working Position (iNWP)

Strategic simulations	NIMS-06 Network information management system equipped with post-analysis tools for airport traffic NIMS-08 Strategic and pre-tactical demand-capacity balancing evaluation, simulation and display tools
Special Events	PRO032- FCM Procedures to respond to predictable but non-nominal events
Airport Slots	NIMS-33 Dedicated tools supporting Airport Slot Monitoring (e.g. Stanly, AMON)
Multi constraint resolution (CASA evolutions)	NIMS-36-Enhanced Complexity assessment tools NIMS-12 Demand Capacity Balancing equipped with a tool to identify and arbitrate multiple imbalance and hotspots NIMS-48 Integrated Network Working Position (iNWP) NIMS-49 Multiple Constraint Resolver
Simulations and what-if	NIMS-08 — Strategic and pre-tactical demand-capacity balancing evaluation, simulation and display tools NIMS-27 Network DCB sub-system enhanced with improved accuracy of processing real-time data
Dynamic Network Plan	None
ATC/ATFCM integration (INAP)	ER APP ATC 17- Enhance Traffic and Flow Management sub-systems to support dynamic flow management in co-ordination with local, regional, and European levels.
Attribution of delay	NIMS-72 Enhance NM flight planning and DCB functions to integrate the proactive flight criticality data NIMS-78 Enhance local ATFCM system to integrate the proactive flight criticality data.
STAM measures	NIMS-13b Enhanced short term ATFM measures (STAM) NIMS-13c Full regional support of dDCB
Network CDM (Coordination Platform, UDPP and slot manipulation)	AIRPORT-06 UDPP Departure on A-CDM Airport system AIRPORT-48 Advanced Airport UDPP integrated with AOP Monitoring AOC-ATM-17 UDPP Departure system for FOC AOC-ATM-18 FOC adaptation to support UDPP FOC-005 -FOC capabilities to participate in UDPP NIMS-39a Enhancement of ETFMS for slot swapping NIMS-39b Enhancement of FOC HMI for slot swapping NIMS-44 Evolution of NIMS to support management of UDPP, inclusion of user preferences and priority as part of SBT NIMS-65 Enhance the eHelpdesk function to support FDCI
Application of DAC	AAMS-19 Dynamic Airspace Configuration tools for the Integrated local DCB working position
Network Performance - Monitoring & Reporting	NIMS-06 Network information management system equipped with post-analysis tools for airport traffic
Network Performance - Analysis and Investigation	NIMS-22 Enhanced performance management sub-system
Post OPS Simulations/Replay	None

Table 5 - Mapping with ATMMP enablers

B. Annex B - Relevant Documentation

[1] Network Strategy Plan 2020-2029 (NSP), approved through Commission Implementing Decision (EU) 2019/2167 of 17 December 2019

[2] High Level Network CONOPS 2029, approved by NMB on 5 July 2022

[3] COMMISSION IMPLEMENTING REGULATION (EU) No 2021/116 of 1 February 2021 on the establishment of the Common Project one supporting the implementation of the European Air Traffic Management Master Plan

[4] COMMISSION IMPLEMENTING REGULATION (EU) No 2019/123 of 24 January 2019 laying down detailed rules for the implementation of air traffic management (ATM) network functions and repealing Commission Regulation (EU) No 2021/677

[5] COMMISSION IMPLEMENTING REGULATION (EU) No 2019/317 of 11 February 2019 laying down a performance and charging scheme in the single European sky and repealing Implementing Regulations (EU) No 2013/390 and (EU) No 2013/391

[6] SESAR, European Air Traffic Management Master Plan, Edition 2020

[7] SESAR Concept of Operations (CONOPS 2019) edition 1, May 2019

[8] SESAR Operational Concept Document 2021

[9] Trajectory Management Document, SESAR PJ18W2 4DSkyways, 15 Mar 2023

[10] ICAO, (draft) Performance Improvement Areas and Improvements for Block 0 (-2013), 1 (- 2018), 2 (- 2023) and 3 (- Long Term)

[11] ICAO, 2016-2030 Global Air Navigation Plan, Doc 9750-AN/963, Edition 5 –2016

[12] EUROCONTROL Airspace Architecture Study Transition Plan, 2019

[13] EUROCONTROL Network High level Concept of Operations (as approved by NMB/34, July 2022)

[14] EUROCONTROL Specification for On-Line Data Interchange (OLDI) - Ed. 5.0

[15] ICAO Manual on Flight and Flow – Information for a Collaborative Environment (FF-ICE) doc. 9965

[16] EUROCONTROL FPFDE NFPM Implementation Guidelines Volume 1 (for FF-ICE R1) and Volume II

[17] Advanced Flexible Use of Airspace (AFUA) concept

[18] EUROCONTROL Implementation Strategy FPFDE-NFPM

C. Annex C – Abbreviations

Term	Definition
ACC	Area Control Centre
A-CDM	Airport Collaborative Decision Making
ACP	Airport Cherry Picking
ADP	ATFCM Daily Plan
AFUA	Advanced Flexible Use of Airspace
AIMA	Airport Impact Assessment
AMAN	Arrival Management
Ang1	Access Node 1 New Generation System
ANI	Advanced Network Integrated
ANSP	Air Navigation Service Provider
ANSP	Air Navigation Service Provider
AOP	Airport Operating Plan
AOWIR	AO What-If Reroute
API	Arrival Planning Information
ARES	Airspace REServation
ASM	Airspace Management
ATCO	Air Traffic Controller
ATFCM	Air Traffic Flow and Capacity Management
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
AU	Airspace User
AUP	Airspace Use Plan
AURA	Airspace Utilization Rules and Availability
CACD	Central Airspace and Capacity Database
CAR	Complexity Assessment and Resolution
CASA	Computer Aided Slot Allocation
CDM	Collaborative Decision Making
CFSP	Computerised flight plan service provider
CRCO	Central Route Charges Office
CTFM	Current Tactical Flight Model
CTOT	Calculated Take-Off Time
CWIR	Centralised What-If Reroute
DAC	Dynamic Airspace Configuration
DCB	Demand Capacity Balancing
DDR	Demand Data repository
DLA	Delay
DMA	Dynamic Mobile Area
DMR	Data Modification Request
DNP	Dynamic Network Plan
DPI	Departure Planning Information
DWH	Data Warehouse

eAMAN	extended arrival management
E-DPI	Early DPI
ETOT	Estimated Take-Off Time
FF-ICE	Flight & Flow Information for a Collaborative Environment
FF-ICE R1	Flight & Flow Information for a Collaborative Environment Release 1
FF-ICE R2	Flight & Flow Information for a Collaborative Environment Release 2
FL	Flight Level Capping
FOC	Flight Operations Control
FPL	Flight Plan
FTFM	Filed Tactical Flight Model
GA/BA	General Aviation/Business Aviation
G-API	General Arrival Planning Information
GRRT	Group Rerouting Tool
iDAP	integrated Digital ATFCM platform
IFPUV	Flight Plan Validation System
INAP	Integrated Network Management and ATC Planning
INP	Initial Network Plan
LoA	Letter of Agreement
LTM	Local Traffic Manager
MCP	Mandatory Cherry Pick
MLOps	Machine Learning Operations
MV	Monitoring Values
NAT	North Atlantic Traffic
NIA	network impact assessment
NMOC	Network Manager Operations Centre
NOP	Network Operations Plan
NSP	Network Strategy Plan
OTMV	Occupancy Traffic Monitoring Values
P-DPI	Predicted Departure Planning Information
PFD	Predict Flight Data
R&D	Research and Development
RAD	Route Availability Document
RCO	Resourceful Overloading of Slots
RNI	Regional Network Integrated
RP	Reference Period
RR	Re-routeing
RS	Restrictions
RTFM	Regulated Tactical Flight Model
SAM	Shared Airspace Module
SBB	Sector Building Block
SBT	Shared Business Trajectory
SES	Single European Sky
SESAR	SES ATM Research
SMT	Shared Mission Trajectory
SOBT	Scheduled Off-Block Time

SRT	Shared Reference Trajectory
STAM	Short-Term ATFCM Measures
TCM	Traffic Complexity Manager
T-DPI	Target DPI
TDS	Traffic Demand Store
TIS	Time to Insert the Sequence
TRS	Time to Remove from Sequence
TTA	Target time of arrival
TTO	Target time over
TV	Traffic Volume
UDPP	User-Driven Prioritisation Process
UUP	Updated (Airspace) Use Plan
VPA	Variable Profile Area

Table 6 - Abbreviations table

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