Simulations conducted by the Network Manager

Annex to workshop pre-read material

Status: Final
Classification: Public
## Annex A: Simulations conducted by the Network Manager

| A.1 | Context | 3 |
| A.2 | Simulation Assumptions | 4 |
| A.2.1 | Common Assumptions | 4 |
| A.2.2 | Specific assumptions for the AS-IS simulations | 4 |
| A.2.3 | Specific Assumptions for Run 1 | 5 |
| A.2.4 | Specific assumptions for Run 2 | 6 |
| A.3 | Methodology | 8 |
| A.3.1 | References for methodology | 8 |
| A.3.2 | Implementation of changes related to airspace structures | 8 |
| A.3.3 | Set up of airspace organisation used for Run 1 & 2 | 9 |
| A.4 | Simulation Results | 18 |
| A.4.1 | Results of AS-IS simulations | 18 |
| A.4.2 | Results from Run 1 and 2 | 19 |
Annex A: Simulations conducted by the Network Manager

A.1 Context

The simulations conducted by the Network Manager aim at providing a view on how the delays would evolve looking over the next 15–20 years (horizons 2030 and 2035).

They also intend to illustrate some of the possible benefits of the available solutions discussed in the scope of the two focus areas addressing the capacity issue, namely cross border ECAC wide Free Route Airspace (FRA), alignment of ACC productivity to observed best-practices, airspace reorganisation and a subset of automation solutions increasing ATCO productivity.

The NM has used its NEST\(^1\) and CAPAN\(^2\) tools, following the methodology commonly applied for airspace design studies\(^3\) including capacity planning and sector capacity assessments\(^4\) in support of the ANSPs of the European ATM network.

Details on the data tools and processes used by the Network Manager in can be found in the Network Operations Plan\(^5\), section 3.3.

The 3 different simulations conducted are the following:

- **AS-IS simulation**: Illustrates the expected evolution of capacity and delays taking into account short term planned changes
- **Run 1 simulation**: Simulates the effect of the generalisation of ECAC wide cross-border FRA, optimised airspace re-reconfiguration across ECAC, upward-alignment of ACC capacity to the level of currently well-performing ACCs (taking into account performant operating practices and local system support) and timely deployment of Pilot Common Project (PCP).
- **Run 2 simulation**: Includes the assumptions and changes included in Run 1 and in addition takes into account the benefits brought by a subset of SESAR 2020 solutions as well as datalink as primary mean for A/G communication (considering 90% of aircraft equipped).

---

1 NEST Fact Sheet, EUROCONTROL, November 2012 (https://www.eurocontrol.int/sites/default/files/publication/files/nest-factsheet.pdf)

2 Description of the CAPAN Method, Eurocontrol (https://www.eurocontrol.int/sites/default/files/field_tabs/content/documents/nm/airspace/airspace-capan.pdf)

3 European Route Network Improvement Plan – Part 1 – European Airspace Design Methodology – General principles and technical specifications for airspace design


A.2 Simulation Assumptions

A.2.1 Common Assumptions

The following assumptions apply to all simulations:

- Simulations cover the entire ECAC region
- Simulations have been made at horizon 2030 and 2035
- The simulations do not include military zones and activities
- **Air traffic** is predicted between all city-pairs based on the following assumptions:
  - Future Air traffic simulations are made starting from a busy summer day starting from actual traffic observed on September 9, 2016, with 34,594 flights in the NM reference area.
  - Traffic forecast uses the latest EUROCONTROL Network Manager Seven-Year Forecast\(^6\), covering the period 2018-2024.
  - After 2024, the traffic was calculated by extrapolating the high growth scenario traffic increase foreseen between 2023 and 2024. As such, a yearly traffic growth of 3.1% was considered for the entire period 2024-2035.
  - The calculation of the traffic demand follows the same procedure as for the Network Operations Plan and as described in the agreed capacity planning process.
  - Known airport capacity plans have been taken into consideration and the traffic distribution was based on the shortest routes scenario.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IFR Flight Movements (Thousands)</td>
<td></td>
<td></td>
<td></td>
<td>11,089</td>
<td>11,494</td>
<td>12,036</td>
<td>12,425</td>
<td>12,836</td>
<td>13,255</td>
<td>13,669</td>
<td></td>
<td>3.7%</td>
<td>3.3%</td>
<td>3.5%</td>
</tr>
<tr>
<td>H</td>
<td>9,770</td>
<td>9,923</td>
<td>10,197</td>
<td>10,604</td>
<td>10,957</td>
<td>11,245</td>
<td>11,524</td>
<td>11,738</td>
<td>11,969</td>
<td>12,176</td>
<td>12,405</td>
<td>2.3%</td>
<td>2.9%</td>
<td>2.0%</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td>10,826</td>
<td>10,995</td>
<td>11,058</td>
<td>11,095</td>
<td>11,176</td>
<td>11,226</td>
<td>11,300</td>
<td></td>
<td>0.9%</td>
<td>2.4%</td>
<td>0.5%</td>
</tr>
<tr>
<td>L</td>
<td></td>
<td></td>
<td></td>
<td>10,219</td>
<td>10,463</td>
<td>10,628</td>
<td>10,793</td>
<td>10,968</td>
<td>11,132</td>
<td>11,296</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Growth (compared to previous year unless otherwise mentioned)</td>
<td></td>
<td></td>
<td></td>
<td>4.6%</td>
<td>3.6%</td>
<td>4.7%</td>
<td>3.2%</td>
<td>3.3%</td>
<td>3.3%</td>
<td>3.1%</td>
<td></td>
<td>3.7%</td>
<td>3.3%</td>
<td>3.5%</td>
</tr>
<tr>
<td>H</td>
<td>1.7%</td>
<td>1.6%</td>
<td>2.8%</td>
<td>4.0%</td>
<td>3.3%</td>
<td>2.6%</td>
<td>2.5%</td>
<td>1.9%</td>
<td>2.0%</td>
<td>1.7%</td>
<td>1.9%</td>
<td></td>
<td>2.3%</td>
<td>2.9%</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td>2.1%</td>
<td>1.6%</td>
<td>0.6%</td>
<td>0.3%</td>
<td>0.7%</td>
<td>0.4%</td>
<td>0.7%</td>
<td>0.9%</td>
<td></td>
<td>2.4%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Table 1: Annual traffic growth values

The choice of the high traffic growth scenario was made to ensure that capacity delivery covers a demanding scenario and that, in the longer term, the capacity provision will be able to anticipate increasing traffic demand.

A.2.2 Specific assumptions for the AS-IS simulations

The following assumptions were used for the AS-IS simulation:

---

\(^6\) EUROCONTROL Seven-Year Forecast February 2018 (https://www.eurocontrol.int/publications/eurocontrol-seven-year-forecast-february-2018)
• All ACCs included in the April 2018 approved version of the NOP 2018-2019/2022 were considered as part of the simulations
• All evolutions related to PCP deployment and other major projects as covered by the local plans provided for the NOP by the ANSPs and as reflected in the April 2018 approved version of the NOP 20189-2019/2022 were included.
• For ACC capacity plan,
  ▪ Up to 2022, the latest NOP ACC capacity plans were taken into consideration, as per the April 2018 approved version of the NOP 2018-2019/22
  ▪ After 2022, ACC capacities were calculated from current ACC capacity with a +2% and +3% yearly growth for saturated and non-saturated ACCs respectively. As such,
    ➢ For the ACCs that have an annual delay forecast at 0.05 minutes/flight or lower for the year 2022, an yearly capacity increase of 3% was considered as being feasible;
    ➢ For the ACCs that have an annual delay forecast higher than 0.05 minutes/flight for the year 2022, an yearly capacity increase of 2% was considered as being feasible, due to the level of saturation starting to be reached in elementary sectors.
    ➢ As a result, for the period 2022-2030, a capacity increase of 3% per year was applied for 36 ACCs and a capacity increase of 2% per year was applied for 29 ACCs.
• No additional network-orientated implementation of operational and technical improvements was included.

In short, the AS-IS simulation considers the current airspace organisation and does not include impact of SESAR technology apart from those included in the PCP.

A.2.3 Specific Assumptions for Run 1

Run 1 simulation includes
• ECAC wide cross-border FRA as from 2025 and implementation down to TMA levels (as shown in Figure 1);
• optimised airspace re-configuration across ECAC;
• network-orientated implementation of operational and technical improvements;
• upward-alignment of ACC capacity to the level of currently well-performing ACCs (taking into account performant operating practices and local system support);
• timely deployment of Pilot Common Project (PCP).
A.2.4 Specific assumptions for Run 2

Additional improvements integrated in Run 2

Run 2 includes all improvements included in Run 1 plus additional benefits brought by a subset of SESAR 2020 solutions and the use of datalink as primary mean for A/G communication (assuming 90% equipage rate).

The table below indicates the SESAR 2020 solutions contributing to capacity through controller workload reduction that have been included in the simulation for Run 2.

<table>
<thead>
<tr>
<th>Solution ID</th>
<th>Solution Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJ-15-02</td>
<td>Delay Sharing Service</td>
</tr>
<tr>
<td>PJ-01-01</td>
<td>Extended AMAN with overlapping AMAN operations</td>
</tr>
<tr>
<td>PJ-15-08</td>
<td>Trajectory Prediction Service</td>
</tr>
<tr>
<td>PJ-18-01</td>
<td>Mission Trajectories in TBO</td>
</tr>
<tr>
<td>PJ-18-06a</td>
<td>ATC Planned Trajectory Performance Improvement</td>
</tr>
<tr>
<td>PJ18-06b</td>
<td>Tactical and NM Trajectory Performance Improvement</td>
</tr>
<tr>
<td>PJ-10-01c</td>
<td>Collaborative ATC</td>
</tr>
<tr>
<td>PJ-10-02</td>
<td>Improved Performance in the provision of separation</td>
</tr>
<tr>
<td>PJ-16-04</td>
<td>Workstation, Controller productivity</td>
</tr>
<tr>
<td>PJ-18-06</td>
<td>ATC Planned Trajectory Performance Improvement</td>
</tr>
<tr>
<td>PJ-10-01a</td>
<td>High Productivity controller team organisation</td>
</tr>
<tr>
<td>PJ-15-08</td>
<td>Trajectory Prediction Service</td>
</tr>
<tr>
<td>PJ-16-03</td>
<td>Workstation, service interface definition and virtual centre concept</td>
</tr>
<tr>
<td>Solution 49</td>
<td>Extended NOP in TBO</td>
</tr>
</tbody>
</table>
The following solutions were considered quantitatively in the run 2 as enablers supporting technical improvements and bringing benefits in support to controller productivity.

<table>
<thead>
<tr>
<th>Solution ID</th>
<th>Solution Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJ-11-G1</td>
<td>Enhanced Ground-based Safety Nets adapted to future operations ground safety nets</td>
</tr>
<tr>
<td>PJ 140401</td>
<td>Surveillance Performance Monitoring</td>
</tr>
<tr>
<td>PJ 140403</td>
<td>New use and evolution of cooperative and non-cooperative Surveillance</td>
</tr>
<tr>
<td>PJ 1701</td>
<td>SWIM Ti Purple Profile for Air/ground advisory information sharing</td>
</tr>
<tr>
<td>PJ 1703</td>
<td>SWIM Ti Green profile for G/G Civil Military information Sharing</td>
</tr>
<tr>
<td>PJ 1708</td>
<td>SWIM Ti Common runtime registry</td>
</tr>
<tr>
<td>Solution 76</td>
<td>Integrated and Performance based CNS (iCNS)</td>
</tr>
</tbody>
</table>

The following solutions were identified as bringing capacity improvement especially for scalability and resilience but were not included in the simulations due to maturity levels:

<table>
<thead>
<tr>
<th>Solution ID</th>
<th>Solution Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJ-01-03B</td>
<td>Dynamic E-TMA Advanced continuous climb and descent operations</td>
</tr>
<tr>
<td>PJ-10-01b</td>
<td>Flight Centred ATC</td>
</tr>
<tr>
<td>PJ-09-01</td>
<td>Network Prediction and Performance</td>
</tr>
<tr>
<td>PJ-09-02</td>
<td>Integrated Local DCB Process</td>
</tr>
<tr>
<td>PJ-15-01</td>
<td>Sub-regional DCB Services</td>
</tr>
<tr>
<td>PJ-09-03</td>
<td>Collaborative Network Management Functions</td>
</tr>
<tr>
<td>PJ-08-01</td>
<td>Management of Dynamic Airspace Configurations</td>
</tr>
<tr>
<td>PJ-10-06</td>
<td>Generic (non-geographical) Controller Validations</td>
</tr>
<tr>
<td>Solution 40</td>
<td>Mission Trajectories management and DAC</td>
</tr>
<tr>
<td>Solution 70</td>
<td>MSP in En-route</td>
</tr>
<tr>
<td>Solution 94</td>
<td>Advanced Virtual Centre</td>
</tr>
<tr>
<td>Solution 93</td>
<td>Delegation of airspace between ATSUs using Virtual Centre Concept</td>
</tr>
<tr>
<td>Solution 88</td>
<td>Trajectory based planning system</td>
</tr>
<tr>
<td>Solution 44</td>
<td>Digital Dynamic Airspace Configurations</td>
</tr>
<tr>
<td>Solution 42</td>
<td>Dynamic Mobile Areas Types 1 and 2</td>
</tr>
<tr>
<td>Solution 57</td>
<td>Reference Business Trajectory revision uplink supported by increased automation</td>
</tr>
<tr>
<td>Solution 96</td>
<td>Digital HMI Improvements for ATC centre</td>
</tr>
</tbody>
</table>

**ATCO workload model for Run 2**

The workload model applied for Run 2 is the same for all ECAC ACCs. It is based on a well performing European ACC an advanced ATM system and supporting tools, modern operational procedures and high complexity traffic.

This model has been adapted to incorporate the impact of the SESAR Solutions selected for the simulations. Indeed, NM and SESAR JU experts identified the group of tasks performed by the
controller that would be impacted by the SESAR solutions; then NM experts conducted an expert evaluation to assess the quantitative impact of these SESAR solutions on the tasks or group of tasks performed by the controllers. This exercise produced the capacities of each individual sector or in various configurations. The final sector capacities have been established only after several iterations.

A.3 Methodology

This section describes the process the NM used to conduct the simulations and in particular the definition of the airspace organisation used for the Run 1 & 2.

A.3.1 References for methodology

The en-route ATFM delay forecast was executed on the basis of the methodology described in the agreed capacity planning process provided in the Appendix 1 to the European Network Operations Plan 2013-2015 – Edition June 2013 - Capacity Assessment and Planning Guidance. The same methodology is used for performing en-route ATFM delay forecasts for each edition of the Network Operations Plan.

A.3.2 Implementation of changes related to airspace structures

The airspace structures are from AIRAC 1701 modified by available planned airspace improvements up to end of RP3 as per two editions of the ERNIP Part 2 - ARN Version 2017-2021 and ARN Version 2021-2022.

The airspace structures as included in the NEST layers were changed so as to simulate full cross border Free Route Airspace implemented (situation as of end of RP3).

Entry/exit points in/out of the FRA area were placed at the border of the study reference area. All intermediate points, inside the FRA area, were kept as they existed on AIRAC 1701. Arrival and departure points were kept to provide connectivity between en-route airspace and airports.

Airspace restrictions were not considered in the study and all evaluations were made with no military activity to preserve comparability of the results.

To arrive at the study reference area some 29,000 modifications were implemented to the airspace structure of AIRAC 1701. A snapshot of the layers of airspace changes introduced in the study is shown in the Figure 2 below:
A.3.3 Set up of airspace organisation used for Run 1 & 2

Methodology and Criteria

The methodology and criteria used are those described in the European Route Network Improvement Plan – Part 1 - European Airspace Design Methodology - General principles and technical specifications for airspace design.

Definition of Sector Groups

The principles for defining sector groups are described below and illustrated in Figures 3 and 4.
The General Criteria for determining Sector Groups are based on the notion of **areas of weak and strong interaction** that help in defining its boundaries. Areas of strong interaction are likely to occur in airspace where the ATC task is more complex due to one or more influencing factors including; high traffic density, nature of traffic, number of conflict or crossing points, airspace restrictions. Areas of weak interaction would occur in airspace where there are fewer conflicts, traffic is mainly stable and the ATCO tasks less complex.

The definition of Sector Groups must be based on an optimised airspace structure, integrating all the airspace components (FRA, route network, supporting sectorisation, multiple route options and associated, etc.). It must also take full account of military operational requirements. Particular emphasis should be given to the efficient connectivity with terminal airspace. Sector groups should contain elementary sectors with strong/complex interaction that necessitate close coordination between controllers.

The criteria to define Sector Groups are a combination of traffic density, nature of traffic (climbing/descending) and airspace topology (crossing flows, close crossing points). Within a Sector...
Group, several different combinations of sectors (sector configurations) are possible, depending on traffic flows. Weak interaction between sector groups are the zones of reduced complexity, where there are fewer conflicting flows and less evolving traffic. In areas of high traffic density and high complexity where there is no obvious area of weak interaction, it might be necessary to artificially create these zones to permit the definition of a Sector Group where appropriate (as is often done at the FIR borders, to facilitate inter-centre coordination). Such artificial creation has impact on operational performance.

The following Specific Criteria are applied for the establishment of Sector groups:

- The borders of sector groups should be based on operational requirements and do not to coincide vertically.
- Sector Groups should be designed to enable sufficient distance for conflict resolution in all routing options.
- Traffic profiles should be of a similar nature as far as possible. (evolving, in level flight etc)
- It is not an essential requirement to envelop segregated airspace within one Sector Group. However, the primary route and the alternate option should, in general, be contained within the same Sector Group to capitalise on the potential for flexible re-routing.
- The Sector Group should be configured to contain the traffic for sufficient time to be operationally practical.
- The Sector Group should be configured to allow for flexible sector configuration
- Conflict points situated in close proximity to each other should be contained in the same Sector Group but ideally not in the same sector.
- A Sector Group should have an operationally manageable number of sectors, likely to be 4/6 sectors in the congested areas and 6/8 sectors in the other areas.
- Similarly average time flown within a Sector Group should not be too excessive to fit the general criteria on optimal numbers of sectors.
- Vertical limits of the sector groups will vary according to their location and to the type of traffic contained within.

**Overall methodology**

The overall methodology is summarised in the Figures 5 and 6. For the purpose of this study, the Traffic Flow Families has been replaced by Operational Optimum areas and the sectors were designed within these optimum areas.

Targeted Studies aiming at operational implementation, would be more detailed and would require the proper definition of Traffic Flow Groups. They correspond to the sector groups as defined in the European Route Network Improvement Plan – Part 1 - European Airspace Design Methodology - General principles and technical specifications for airspace design.
Application of Methodology and Criteria

The traffic sample, assigned between the city pairs on the shortest distance and through the full cross border FRA, was analysed along the following criteria:

- All traffic flows were considered, within, to/from or overflying the NM area
- Traffic density – the traffic density was considered as one of the criteria in defining the next steps in the airspace design process, as described above. Traffic density is presented as a number of aircraft during the 24 hour period inside a quadrant of the following dimensions: 10x10NMx2FL.
Traffic conflicts – the potential traffic conflicts were considered as other criteria in defining the next steps in the airspace design process, as described above. A Traffic conflict is determined by a flight path intersecting with another flight path. The conflicts are not distinguished by type (crossing altitudes, crossing tracks, etc.); they are only depicted as point with the location of its occurrence. The airspace design solutions and the supporting procedures and systems are expected to safely address those potential conflict areas. The Figure 8 below shows the spots of high traffic conflicts.

Complexity areas – The areas of high complexity, depicted on the Figure 9 below, correspond to the high traffic density areas combined with the conflict areas. The combination of density and a number of conflicts is given per quadrant of the following dimensions: 10x10NMx2FL (flight levels), where every conflict is weighed two times the number of aircraft (C=d+2c; C=complexity; d=traffic density; c=traffic conflict).
Traffic demand and distribution

The overall traffic distribution based on seamless FRA implementation as described above and shown in the Figure 10 below:

Figure 10: Overall traffic distribution based on seamless FRA implementation
The assignment of raw traffic demand between the city pairs as shown in Figure 11 was based on the shortest distance within the seamless FRA to analyse the traffic distribution across the NM reference area.

Analysing traffic distribution resulted in identifying major entry/exit areas on the border interface of the FRA area (gateways), as well as within the area itself (connectivity to major TMA areas). Figure 12 below shows the gateways (red circles) and internal node areas (blue circles).

The Gateways correspond to the intersection of major traffic flows with the interface between the NM reference area and adjacent areas. The Gateways have a symbolic meaning since traffic is allowed to cross the interface at any entry/exit point on the border. A Gateway encompasses several entry/exit points used by majority of flights entering from or exiting to the same region.
The **internal node areas** are associated to areas where the prevailing traffic is that operating to/from major airports in the corresponding area. Those areas group several TMAs from major airports and are defined as Terminal Airspace Systems (TAS).

Indeed, to improve the design and management of terminal routes and ATC sectorisation servicing several airports in close proximity, the fusion of two or more terminal airspace structures has been envisaged and has been called Terminal Airspace System (TAS). TASs could extend across national borders if required by operational requirements. Operations within a TAS should be systemised and characterised by systems of entry (arrival) and exit gates that accommodate flows of arrivals and departures to and from various runways/airports. Generally, these entry and exit gates are to remain fixed even when the airspace configuration changes.

**Creation of Traffic Flow Areas**

Air Traffic flows are the consequence of the traffic distribution in relation to Gateways on the border interface of the FRA area, as well as within the FRA area (TAS). A traffic flow, in the context of this study, is a set of flights with similar elements with strong geographical connotation, e.g. orientation of flight trajectories and their proximity relative to their current geographical area, flights originating from the same area/region and proceeding in similar directions, or flights on the similar tracks proceeding to destinations in the same area/region. The major traffic flows are shown in Figure 13.

![Figure 13: Identification of major traffic flows](image)

It can be noticed that central TAS coincides with the central Traffic Flow Area (TAF), because the majority of traffic flows finish or start from the central TAS. Further to that, there is relatively intense traffic inside the central TAS not leaving the area.

**Creation of Optimum Operational Areas**

On the basis of the criteria for the creation of the sector groups, the Optimum Operational Areas (OOA) are including main traffic flows, but with the borders defined after being analysed along the following criteria:

- traffic density
- traffic conflicts,
- traffic complexity, and
• low interaction areas.

The analysis focused specifically on the traffic orientation, traffic loads, and most importantly, traffic interactions on the respective borders. The OOA definition and fine-tuning was done after multiple iterations by applying a mathematical model available in SAAM/NEST involving the application of the traffic density and complexity criteria defined above.

The OOAs are volumes of airspace with balanced traffic loads, which would allow for collaborative management of operational constraints in a manner to balance operational efficiency by defining the operational sectors. They correspond to a theoretical intermediate step leading to the design of operational sectors.

**Optimum sector design**

Sectors defined within each OOA presented in this study are the elementary sectors being the primary operational constituents of an airspace structure. This means that each of the defined sectors can act as the operational volume of airspace on its own or combined (collapsed) with other sectors. Each of the elementary, spatial sectors is represented by a dedicated technical sector suite (usually a pair of CWPs) while operational. It is assumed that each sector suite should be manned by two ATCOs while operational during at least twelve-hour period per day. By the application of the new technologies and advanced ATM system functionalities, it may be considered that, at average, less than two ATCOs will be manning an operational sector in the future. In particular, the move towards a flight or flow-centric air traffic control, and the application of trajectory based tools will inevitably allow the introduction of a multi-sector planner reducing a number of ATCOs required to generate maximum sector configuration for a given ATS unit.

**Sector capacities in the new airspace organisation**

The sectors defined as explained above have been subject to a CAPAN assessment by applying the same CAPAN parameters through the entire geographic scope of the study. The workload model applied was based on a well performing ACC in Europe an advanced ATM system, modern operational procedures and high complexity traffic. This exercise produced the capacities of each individual sector or in various configurations. The final sector capacities have been established only after several iterations. The result of these interactions provides the given number of sectors per OOA, i.e. maximum number of sectors needed to handle the daily traffic load. The sector elements with their respective calculated capacities have been run in NEST to determine the collapsed sectors and their capacities. The ICO model has been applied to produce the opening schemes.

The total number of sectors resulting from the re-design is slightly less than the number of sectors operated simultaneously today. With these sectors, the traffic increases up to 2025 can be handled at a delay per flight of approximately 0.45-0.5 minutes/flight. Further sectorisation actions are still possible to bring the number of sectors to the one or slightly above those handled today (approximately 700-750 sectors simultaneously opened) and to maintain a delay per flight at approximately 0.5 minutes.

The above total number of sectors includes the entire airspace, from SFC to FL660, excluding TMAs. The TMA’s dimensions and shapes, as well as their contents, have been kept unchanged.
A.4 Simulation Results

A.4.1 Results of AS-IS simulations

For 2030

As the delay forecast increased to significantly high levels for a number of ACCs, the delay forecast was frozen at 4 minutes/flight for the summer season for 24 ACCs. Indeed, exaggerated high delays would have resulted in significant traffic disruptions, network effects and major re-routing actions would have been taken to limit the operational disruptions. Based on the assumptions above, the delay forecast for the year 2030 indicates an annual delay per flight of 6.23 minutes/flight.

At European level, only 24 ACCs (most of them located at the edges of the European airspace) are still expected to have an operationally acceptable performance:

- 8 ACCs will record an en-route annual delay per flight of up to 1 minute/flight,
- 4 ACCs will record an en-route annual delay per flight between 1-2 minutes/flight,
- 24 ACCs will record an en-route annual delay per flight between 2-3 minutes/flight and
- 5 ACCs will record an en-route annual delay per flight between 3-4 minutes/flight.

The significant delay impact is also expected to have consequences on the flight efficiency. The evaluation of such consequences has been estimated on the basis of the actual route extension during a high delay day in the network with a low delay day in the network. Such a difference is estimated to be approximately 4 NM/flight.
For 2035

As the delay forecast increased to significantly high levels for a number of ACCs, the delay forecast was frozen at 5 minutes/flight for the summer season for 28 ACCs. Based on the assumptions above, the delay forecast for the year 2035 indicates an annual delay per flight of 8.47 minutes/flight.

At European level, only 20 ACCs (most of them located at the edges of the European airspace) are still expected to have an operationally acceptable performance:
- 6 ACCs will record an en-route annual delay per flight of up to 1 minute/flight,
- 4 ACCs will record an en-route annual delay per flight between 1-2 minutes/flight,
- 7 ACCs will record an en-route annual delay per flight between 2-3 minutes/flight,
- 21 ACCs will record an en-route annual delay per flight between 3-4 minutes/flight and
- 7 ACCs will record an en-route annual delay per flight between 4-5 minutes/flight.

The significant delay impact is also expected to have consequences on the flight efficiency. The evaluation of such consequences was estimated on the basis of the actual route extension during a high delay day in the network with the lowest delay day in the network. Such a difference is estimated to be approximately 7 NM/flight.

A.4.2 Results from Run 1 and 2

Flight Efficiency

The annual flight efficiency benefits are expected to generate a reduction of the routes flown by approximately 18NM per flight when comparing between the current airspace structures and a full FRA cross-border implementation scenario. This benefit is applicable to both Run 1 and Run 2.

<table>
<thead>
<tr>
<th>FE Benefits</th>
<th>Total impacted flights</th>
<th>Length (NM)</th>
<th>Time (min)</th>
<th>Fuel (kg)</th>
<th>CO2 (kg)</th>
<th>NOx (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26175</td>
<td>-471104,530</td>
<td>-78514,556</td>
<td>-3106624,730</td>
<td>-9816940,886</td>
<td>-40330,361</td>
</tr>
</tbody>
</table>

Capacity

The figures 15 and 16 below indicate the evolution of the air traffic controller workload in a comparative manner, between the AS-IS (Current), Run 1 (Scen. 1) and Run 2 (Scen. 2).
As the controller is able to manage more flights, there is an increase in the maximum capacity of sectors as shown in Figure 17 below.
Results on predicted delays

Figure 18 summarises the results on the predicted delays for the 3 simulations along with the number of flights per year.
The key results are:

a) AS-IS simulation demonstrates that the current plans are insufficient to cope with the high traffic growth scenario.

b) Run 1 demonstrates that a combination of airspace design and operational harmonisation and full implementation of the PCP could provide sufficient capacity until 2030.

c) Run 2 demonstrates that deployment of additional SESAR solutions could provide sufficient capacity until at least 2035.