Cost Benefit Analysis

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Abstract

This deliverable is a CBA of the deployment and operation of the Dynamic Capacity Management (DCM) Local Supporting Tool in a High Density Area for Step1. The scenario chosen was Barcelona ACC.

The Dynamic Capacity Management concept consists of a series of layered measures that can be taken to better match capacity to predicted demand and to reduce the complexity of traffic presentation to suit available capacity.

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Table of Contents

List of tables

List of figures

Executive summary

This document provides an economic study of the Dynamic Capacity Management Method addressed by P04.07.07 “Implementation of the Dynamic Capacity Management in a high density area”. With the Dynamic Capacity Management Method, the airspace capacity is adapted to the traffic load by grouping or de-grouping sectors and managing the associated staff resources.

This exercise aims to develop an analysis of the most relevant costs and benefits of the P04.07.07 Project thought the study of the DCM Local Supporting Tool and obtain some economic metrics which show the feasibility of the project. Taking into account this goal, the work is conducted in several stages: first, the analysis of the Project and the Baseline (alternative choice for continuing with the current way to operate and plans for investment, also known as the “Business As Usual” or “Do-Nothing” option), as a reference scenario. Then the analysis of the chosen scenario (Barcelona ACC). Lastly, an analysis of the Costs and Benefits was carried out.

After having all the information detailed above, economics metrics such as Net Present Value, Benefit/Cost Ratio and Sensitivity Analysis were calculated.

Economic and technical assumptions are described in the document in order to be consistent in the study.

The costs of the DCM Supporting Tool have been analysed but not included in the economic model. The tool is already developed. It is not a new cost for the ANSP.

The NPV obtained is 2.95 M€, taking into account that the Tool will operate from 2014 to 2019 (six years) and the implementation will be done in one year (2013). The study also shows that the analysed benefit: Reduction in delay is a variable with a big percentage into the NPV (55.6%). All results are for a single ACC (Barcelona ACC)

Costs were deeply analysed; the study showed that costs are not relevant for the NPV.

As a conclusion of this economic study, it can be confirmed: if it is compared the baseline (Daily Operation without the DCM Local Supporting Tool) versus the operation with the Tool (with the assumptions taken), it will obtain a positive NPV, meaning the project is feasible in economic terms.

1 Introduction

1.1 Purpose of the document

This document is the D27 “Cost Benefit Analysis for Dynamic Capacity Management Local Supporting Tool”. The aim of this document is to present the CBA for the DCM Tool based on the methodology explained in the section 2, and using the inputs from partners and from the D23 Validation Plan**Error! Reference source not found.** .

It was planned to base the CBA on the validation exercise results, however due to delays in exercises most of the CBA inputs come from Expert opinion

The cost benefit analysis is performed for an investment on the implementation of DCM Local Supporting Tool at Barcelona ACC.

Details on the DCM Local Supporting Tool and P4.7.7 project are included herein, for further details please see document references.

1.2 Intended readership

Intended audience of the document are:

- P04.07.07 Project Members (AENA, NATS, SELEX);
- Project Members of the same OFA (P04.03, P04.07.01, P07.05.03, P07.06.05 and P10.08.01);
- Project Members of the technical project P13.02.03;
- Federating Projects: 4.2, 5.2, 6.2 and 7.2 for Consolidation;

1.3 Structure of the document

This document is divided in twelve sections:

- Section 1 shows the purpose of the Economic Analysis of the DCM Local Supporting Tool;
- Section 2 explains the CBA Methodology used;
- Section 3 presents a short project description and analyses the DCM Local Supporting Tool;
- Section 4 shows the scenario and timeframe chosen to develop the CBA;
- Section 5 describes the baseline option against to operate with the DCM Local Supporting Tool;
- Section 6 describes the Stakeholders involved in the deployment and operation of the project;
- Section 7 summarises the technical and economical assumptions used to develop the CBA;
- Sections 8 and 9 give the necessary information to develop a CBA: They analyse the cost categories and an approach to the benefits. These sections also provide an estimation of those costs and benefits;
- Sections 10 and 11 provide the results of the economic analysis: NPV and cash flows, sensitivity analysis (through the tornado diagram) and benefit / cost ratio ;
- Section 12 makes an analysis of the results and provides some recommendations for future economical studies.

1.4 Glossary of terms

Term/Source	Definition
Airspace Configuration **SOURCE:** SWP 7.2	Is a pre-defined and coordinated organisation of ATS routes and/or terminal routes and their associated airspace structures, including airspace reservations/restrictions (ARES), if appropriate, and ATC sectorisation.
Dynamic Capacity Management **SOURCE:** 04.07.07	Concept proposed by P04.07.07 to adapt the capacity to the traffic load by grouping and de-grouping sectors and managing the staff resources.
Dynamic sectorisation **SOURCE:** SWP 4.2	The geographical and vertical limits of a control sector will be adapted to the traffic flow to optimise the capacity in real-time. Flexible sectorisation does not imply that ATC will be faced with sector configurations that are not known either to them or to the supporting FDP and RDP systems. Sector configurations will be part of the pre-determined scenarios of the ACC and will be simulated and training will be provided prior to usage.
Layered Planning **SOURCE:** 04.07.07	Concept proposed by P04.07.07 to support complexity reduction by a series of separate actions or 'layers' that cumulatively reduce complexity. The actions would be: A NATS-developed Oceanic Domestic Interface Manager (ODIM), High Level Direct Routing and an inbound longitudinal streaming concept.
PERSEO **SOURCE:** 04.07.07	Web-based local tool where the forecast demand is based on the processing of massive historical data obtained from multiple sources of information or a mix of real traffic data and these historical data. This tool includes an optimization algorithm to provide the most suitable airspace configuration.
Sector **SOURCE:** 04.07.01	A sector is the area of responsibility assigned to a Unit of Control. A sector is composed of one or several elementary sector.
Sector Cluster **SOURCE:** 04.07.07	A sector cluster represents a group of adjoining airspace blocks that are treated as a single ATM airspace. A sector cluster consists of several ATC sectors and multi-sectors.
Sector configuration **SOURCE:** 04.07.01	Airspace configuration in the Centre of Control (ACC)/ Sector Cluster i.e. the relation between the Units of Control and sectors.
Sector configuration schedule **SOURCE:** 04.07.01	List of planned sector configurations with their time of activation.
Target Sector Flow **SOURCE:** 04.07.07	It is a level below that the sector can safely handle to allow for the inefficiencies inherent to the CFMU process and the vagaries of the subsequent control process, providing some headroom /protection of overloads.

1.5 Acronyms and Terminology

Term	Definition
ACC	Area Control Centre
ADD	Architecture Definition Document
ANSP	Airspace Navigation Service Provider
ATC	Air traffic Control
ATFCM	Air Traffic Flow and Capacity Measures
ATM	Air Traffic Management
AU	Airspace Users
CBA	Cost Benefit Analysis
CHMI	CFMU Human Machine Interface
CFMU	Central Flow Management Unit
DCM	Dynamic Capacity Management
DOD	Detailed Operational Description
ECAC	European Civil Aviation Conference
E-OCVM	European Operational Concept Validation Methodology
HLDR	High Level Direct Routes
FDP	Flight Data Processing
FAB	Functional Airspace Block
FIR	Flight Information Region
FMP	Flow Management Position
NPV	Net Present Value
ODIM	Oceanic Domestic Interface Manager
OFA	Operational Focus Area

Term	Definition
OPS	Operations
OSED	Operational Service and Environment Definition
RDP	Radar Data Processing
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SPR	Safety and Performance Requirements
TMA	Terminal Manoeuvring Area
TSF	Target Sector Flow

2 Cost Benefit Methodology approach

A CBA is a well-known structured process that needs quantified costs and benefits as input data.

Once costs and benefits are available, the CBA process monetizes them and, by using standard metrics (i.e. NPV), analyzes if the Operational Concept (the implementation and operation of the DCM Local Supporting Tool in this case) is, in economic terms, worth implementing, or in what scenario, conditions, etc, it would be.

There are two steps to develop a successful CBA:

- To identify cost and benefit impact mechanisms of a given Operational Concept and quantify them.

  After identifying costs and benefits, it will be translated them as far as possible into quantified terms using inputs from other documents as the D24 "Validation Report" [3]**Error! Reference source not found.**, expert opinions and similar projects, to build the cost and impact benefit mechanisms.

- To translate the identified costs and benefits into monetary terms, to calculate outputs to analyze the Operational Concept in economic terms assessing the uncertainty and sensitivity of the results. The analysis takes into account the baseline scenario, standard inputs and deployment scenarios. In this step it will be calculated the NPV and the sensitivity analysis.

These two steps are shown in Figure below:

- Out of the grey figure: 1st step (Identification and quantification of costs and benefits: Cost and benefit impact mechanism)

- In the grey figure: 2nd step (Translation of costs and benefits in monetary terms taking into account the baseline scenario, standard values and the new scenario)

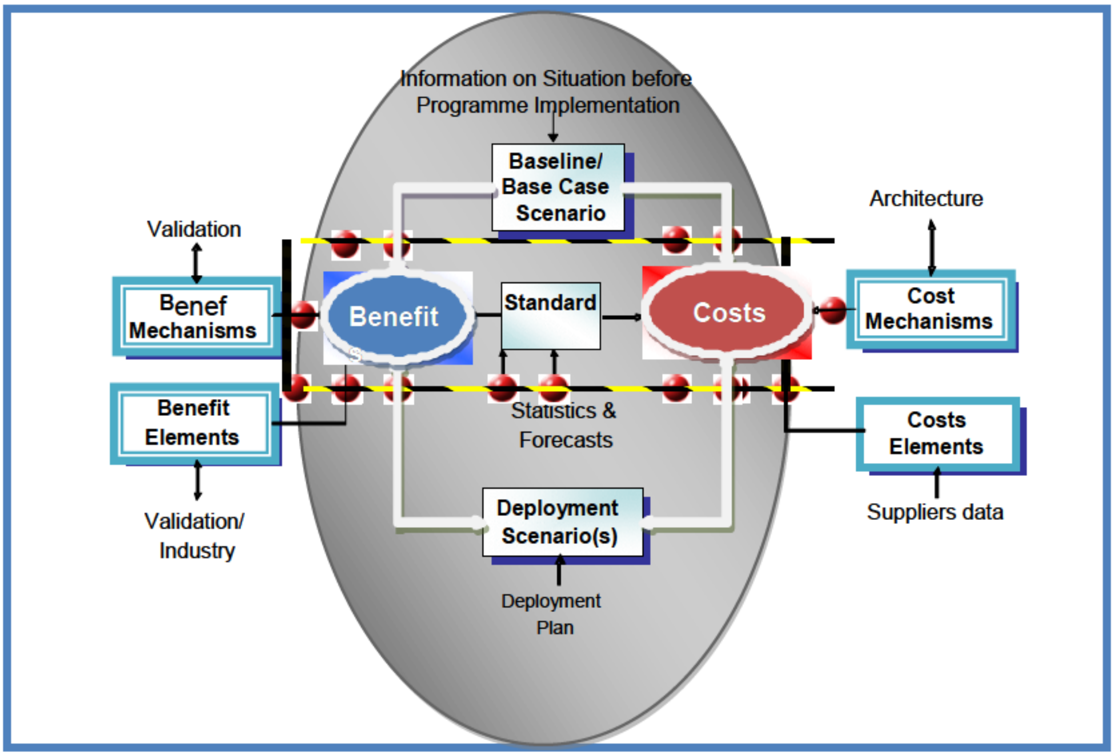


Figure 1: CBA Methodology Approach

3 Project description

3.1 The P 4.7.7 project in SESAR programme

The P04.07.07 is a primary project that set out the Operational Service and Environment Definition (OSED) and the Safety and Performance Requirements (SPR) for Implementation of the Dynamic Capacity Management in a High Density Area in the context of STEP 1 of the SESAR Verification and Validation (V&V) Storyboard.

At the beginning, this project was linked to the Complexity Assessment and Resolution Operational Focus Area within Package 5 (PAC05) of the SESAR V&V Roadmap "Integrated and Collaborative Network Management"[8]. Subsequently, it was integrated into OFA05.03.04 "Enhanced ATFCM Processes" according to the last OFA structure approved by the SJU. At the time of writing, both SWP4.2 DoD [4] and SWP7.2 DoD [5] were available and therefore have provided the top-down guidance to develop 04.07.07 FINAL OSED [7].

Within the **OFA 05.03.04 "Enhanced ATFCM Processes"**, several projects share the operational complexity assessment to balance demand and capacity. However, no gaps and **overlaps** are detected since they are covering different planning time horizons and environmental scope (local/network), as it shows in the following figure.

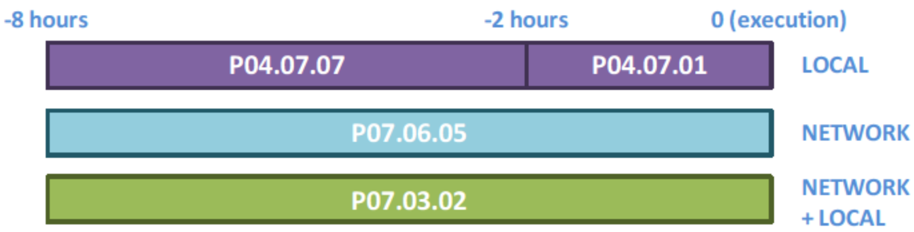


Figure 2: Links to other validation activities

On the other hand, P13.02.03 has been the responsible for developing a prototype according to the operational requirements defined by P04.07.07. This prototype, named DCM Local Supporting Tool, acts as a decision-making tool and allows an OPS Supervisor to detect and assess traffic imbalances on the day of operation from eight to two hours in advance.

3.2 P4.7.7 goal and scope

Airspace capacity is designed to meet projected demand patterns using fixed routes and sectors with controllers validated to these structures to handle the traffic. Different configurations of these structures could be used on the day of operation, but these are also limited to certain pre-defined options and procedures. As a result there is an inherent mismatch between the long lead times it takes to bring new ATM capacity into operation and the shorter time it takes for airlines to open new routes and services.

In order to adapt the demand and capacity in terms of numbers of aircraft and/or complexity, P04.07.07 addresses local airspace configuration measures framed during the tactical and execution phases (medium and short term planning). Airspace configurations are related to airspace volumes but also to routes and may combine both of them - e.g. routes to activate depending on sector configuration.

Current airspace issues to be addressed:

- Unused latent capacity which can occur in all Flow Management Positions (FMPs) during peak hour times every day. Currently, the tools to assist the FMPs have improved detection of the overload but do not offer better options to deal with it;

- Transatlantic flights which frequently cluster around an optimum North Atlantic (NAT) track. When such aircraft leave oceanic airspace eastbound, the traffic presentation can be highly complex, requiring high controller workload to resolve the issue. This issue of long haul traffic bunches requiring separating into new flows of over-flying and descending traffic is replicated in many other parts of the European Civil Aviation Conference (ECAC) area;

- Aircraft which are currently unable to fly their most efficient trajectories as they see fit. Aircraft trajectories are constrained in both time and space and are fragmented due to national boundaries.

The solutions proposed in P04.07.07 to address these problems are:

- **Dynamic Capacity Management Method (Step 1, V3):** with this method the airspace capacity would be adapted to the traffic load by grouping or de-grouping sectors and managing the associated staff resources. Opening additional sectors would use the optimal configuration based on progressive refinement during the tactical phase and take into account local constraints (e.g. Human resources allocation);

  In this context, the Dynamic Capacity Management concept has been supported in P04.07.07 by an Aena-developed decision-support tool which evaluates the most suitable ACC sector configuration during the day of operations in terms of capacity to match forecast demand. The prototype of this tool was validated in Barcelona ACC: DCM Local Supporting Tool.

- **Layered Planning Method (Step 1, V2):**

  - Oceanic Clearance Optimization: This will improve the allocation of oceanic clearances in order to facilitate improved delivery from the NAT organised track system at the UK/Ireland Functional Airspace Block (FAB) domestic interface;
  - High Level Direct Routes (HLDR): This will provide the most efficient and effective airspace structure best fitting the requirements of all stakeholders (some form of 'Free' or 'Tailored' routes) within UK/Ireland FAB Airspace. These measures are framed during the tactical phase.
  - Inbound Longitudinal Streaming: The early longitudinal streaming of aircraft departing oceanic airspace into arrival streams for individual UK Terminal Manoeuvring Areas (TMAs) will enable the adjusting of an aircraft's speed during the late cruise phase to

reduce domestic complexity. These measures are framed during the tactical and execution phases.

Taking into account the level of maturity of each method, the scope of this cost benefit analysis covers uniquely the dynamic capacity management concept. Therefore, hereafter P04.07.07 is referred exclusively to **Dynamic Capacity Management Method.**

Therefore, the scope of P04.07.07 includes validating the local processes that would allow detecting and assessing traffic imbalances on the day of operation up to two hours before the operation. This assessment identifies the impact of the imbalance at local level by analysing not only current metrics linked to performance areas such as capacity or efficiency but also local metrics such as impact on human resources distribution.

3.3 P4.7.7 description

P04.07.07 proposes a Dynamic Capacity Management concept in order to adapt the capacity to the traffic load by grouping and de-grouping sectors and managing the staff resources. The key aspects of this concept are:

- DCM allows the airspace structure to be dynamically adjusted to optimise the efficiency of Air Traffic Management (ATM) services;
- DCM can be applied in high traffic density airspace regions in which an environment (in terms of system capabilities) exists that enables the refinement of airspace sectorisation and traffic planning to be fully dynamic and used to adjust the traffic demand balance.
- DCM seeks to enable an increase in sectorisation efficiency by taking measures in advance that serve to detect, assess and resolve imbalances in traffic as well as to analyse local metrics such as the impact on human resources distribution.
- DCM is part of a layered planning process encompassing all ATM activities. Related SESAR Step 1 projects include: P07.06.03, P07.06.05, and P04.07.01 (see Fig 2)

In summary, the high level objective of dynamic capacity management concept is that en route controller complexity shall be reduced though better work/demand distribution within the Area Control Centre (ACC)/ Sector cluster.

In this context, the main objective of **P04.07.07** has been to validate the use of supporting tools in a high density area to evaluate the most suitable ACC sector configuration during the day of operations in terms of capacity to match forecast demand approximately eight hours before the operation, taking into account:

- the continuous refinement of the planning with the demand data along the planning phases (i.e. weeks, days and hours before the execution) and how the demand evolution has a direct impact on the capacity management;
- the local constraints such as the number of available controllers;
- the “what-if” scenarios designed at local level (e.g. impact in the capacity due to bad weather conditions, change of operational circumstanced in associated airports...).

In accordance with the results obtained from the validation exercises the Dynamic Capacity Management concept defined by P04.07.07 requires, to be applied in a multi-sector environment, new ground ATM system functionalities: i.e. implementing the DCM Local Supporting Tool.

4 Scenario and timeframe

4.1 Geographic scope

The airspace defined for the application of the DCM method is described below:

> An ATS Unit (ACC/Sector Cluster) which manages mainly aircraft in cruise-flight. These overflights are integrated with aircraft climbing and descending into and out of one or more TMAs. Its major jurisdiction of airspace is considered En-route and due to the high number of flights to be managed is defined as a high density operation. Although the operational scenario could be a medium or low density area, the high density is considered as a representative environment since this ACC/Sector Cluster handles the highest number of movements (150 movements/hour) within the its Area of Interest. The airspace will be both FIR and UIR and some sectors will cover that entire vertical range whereas others will cover only a range of levels within the overall FIR/UIR extent.
>
> The operational concept assumes full radar coverage, although, in reality, there may be extremities of some sectors that are outside radar cover (due to the distance from a radar head) or below radar cover as a result of high terrain.
>
> In order to be managed the ATS Unit must have predefined airspace configurations for the Area of Interest (ACC/Sector Cluster) where Sector Configuration planning can be planned/optimized.

Barcelona ACC fulfils those mentioned features and for this reason it was the scenario where the v3 validation activities were performed. The following figure depicts the Basic Traffic Volumes which are used to build these predefined sector configurations required for the DCM Method.

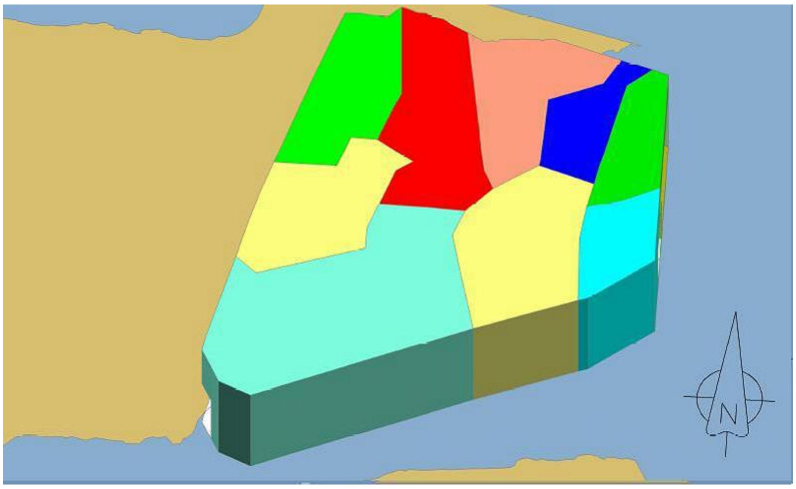


Figure 3: Geographic scope - Barcelona ACC

In order to settle the results of this analysis, the geographic scope of this one will be Barcelona ACC.

4.2 Timeframe scope

The P04.07.07 project started in 2012.The pre-implementation and implementation phase occurs during 2012-2013. The DCM Local Supporting Tool will be ready in 2014 in the geographic air space chosen (Barcelona ACC)

The first year getting benefits is 2014. Given the system is going to be completely operative in 2014; it will be expected 100% benefits on this year 2014. This study considers that the system is in operation nine years: from 2014 to 2019.

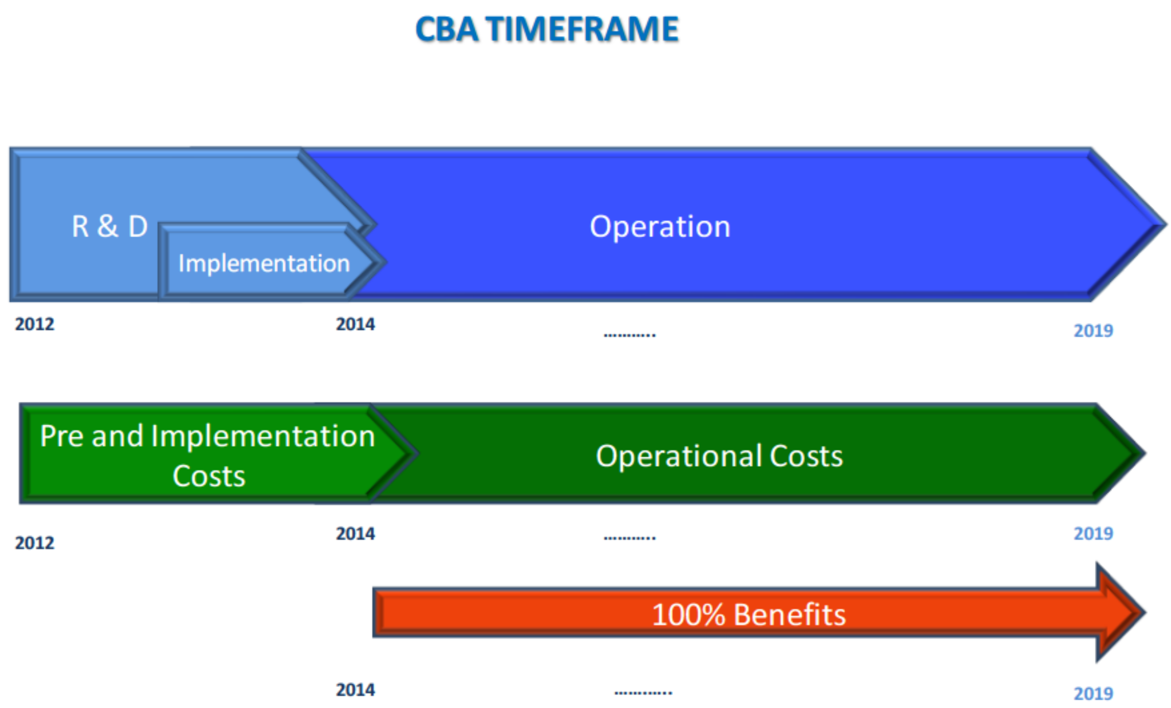


Figure 4: CBA Timeframe

Benefits are considered until 2019. The addressed OI (the DCM Local Supporting Tool) will be replaced by another one in this year.

5 Baseline-do nothing option vs Operation with P4.7.7

The Baseline Scenario is the alternative choice for continuing with the current approved plans for investment (also known as the "Business As Usual" or "do-nothing" option). In this exercise it is the reference case against which the project is appraised.

5.1 Reference Scenario - Previous Operating P04.07.07

Following P16.6.6 recommendations, Primary Projects can chose either B4.1/B5 (2005, 2008, 2010), or C2 (2010) or their own reference scenario as baseline.

This CBA study chooses its own reference scenario as Baseline (2012 in advance).

The baseline or do nothing option includes all activities which are necessary to maintain the existing level of service in the period of the study (2012-2022):

At present a Strategic Phase provides the first step in reducing traffic complexity up to one and a half years in advance of the day of operations. The Strategic Phase is focused on analysing major and significant events as well as anticipated capacity shortfalls for individual ACCs/airports. The result is a set of agreed ATFCM measures/solutions to be considered for implementation (partly or totally) in the Pre-tactical and Tactical phases. ATFCM solutions can be considered in three parts:

- Optimise capacity: a number of solutions are considered that should result in maximising capacity in line with profile of traffic demand such as sector management, civil/military coordination, reduction in traffic complexity, review monitoring value, balancing arrival/departure capacity and so on;

- Use other available capacity: this encompasses ATFCM solutions that aim to 'shift' traffic demand into areas where capacity is available, such as rerouting, Flight Level (FL) management and advancing traffic;

- Regulate the demand: constraints will be imposed on traffic by means of regulations.

A decision to implement and execute ATFCM measures within the Area of Responsibility of an FMP shall be preceded by coordination between the Central Flow Management Unit (CFMU) and that FMP. In this way, the FMP provides the CFMU with 'local knowledge', including any data or information which could be considered as necessary or useful in the effective and efficient execution of the ATFCM task. The CFMU advises the FMP of any events or information which will or may affect the service provided by its parent ACC(s).

However when aircraft become airborne, the traffic situation frequently evolves in a quite different way from the one planned by the CFMU and there are several reasons for this, including among others:

- Lack of accuracy of the CFMU traffic demand prediction process;

- Poor weather information and accuracy;

- Too coarse control of flights allocated with a departure slot;

- At local level – trajectory revisions due to ATC tactical open loop interventions.

The consequence of this deviation from the CFMU plan is that sectors experience peaks and troughs of demand that are not eliminated by the ATFCM/CFMU process. The less immediate consequence is that to prevent these demand peaks from overloading the sector, the Target Sector Flow (TSF) is set at a level that provides some 'headroom'. Essentially, the TSF is set below the level that the sector can safely handle to allow for the inefficiencies inherent to the CFMU process and the vagaries of the subsequent control process. This means that for much of the time capacity is available but remains unused because the sectors must be protected from overloads.

The CFMU Human Machine Interface (CHMI) is the existing and unique supporting tool which is used by pre-tactical and tactical decision makers (ATFCM solutions). CHMI data provision includes predicted sector occupancy and sector entries over the next few hours from the current time. However, experience has shown this information to be inaccurate to such an extent that it is used as a guide only.

Furthermore, CHMI:

- does not have a sector configuration optimization (in the current CHMI different sector configurations can be selected in advance to have a look at the different sectorisation option, however this process is not automatic and iterative taking into account local restrictions).
- does not take into account the human resources distribution (local restrictions);
- does not make a sector occupancy prediction the day before the period in question. If this were available, it would help with manning requirement planning for the next day (the period in question);
- does not take into account either the historical data and the preceding planning process;
- is based on the Initial Flight Plan, which does not take into account:
  - prevailing or planned tactical flight/flow constraint;
  - typical routing through ACC airspace;
  - other sources of information;
- is subject to CFMU change management.

Additionally, various other non-integrated tools and information and above all operational experience are used, primarily to interpret/enrich/correct the traffic predictions but also to test the feasibility of sector configuration schemes, allowing for better tactical decision making.

Therefore, OPS Supervisor /FMP Operators rely upon a mixture of unreliable data and experience to make and adapt short-term tactical plans.

5.2 Operating with P04.07.07 (DCM Local Supporting Tool)

The Dynamic Capacity Management Method aims to enable an increase in sectorisation efficiency by taking measures in advance that serve to detect, assess and resolve traffic imbalances as well as to analyse local metrics such as impact on human resources distribution.

The DCM Method is based on a supporting local tool that allows airspace structure to be dynamically adjusted to optimise the efficiency of the Air Traffic Management (ATM) services in an Area Control Centre / Cluster Sector. This method seeks to enable an increase in sectorisation efficiency by taking measures in advance that serve to detect, assess and resolve imbalances in traffic as well as to analyse local metrics such as impact on human resources distribution. With DCM Local supporting tool, the person responsible for operations (OPS Supervisor – Flow Manager) can:

- Select an optimum sector configuration and its distribution of human resources. Starting from sector families defined at the ATC Centre and applying the optimization algorithm, the tool provides the necessary output for the decision maker.

- Recalculate the sector configuration in accordance with local human restrictions, reduction of sector's capacity and so on.

- Plan the first shift the day before, when existing CHMI data is not reliable or realistic taking into account the expertise/ references of others similar analysis

- Compare several data resources, during the previous mentioned tasks (e.g. Select sector) , where the forecast demand is based on:
    - the processing of large volumes of historical data obtained from multiple sources of information or;
    - a mix of real traffic data and historical data;
    - uniquely real traffic data.

Therefore the DCM Method, based on the DCM Local Supporting Tool, complements the existing procedures to assess and applies the ATFCM measures/solutions (partly or totally) in the Pre-tactical and Tactical phases.

6 Stakeholders involved

This section presents a brief summary of the stakeholders to be considered in the Implementation of the Dynamic Capacity Management CBA study. It has been noted that each stakeholder can act either as contributor to cost, as beneficiary or as both.

In general, the list of the stakeholders is widely accepted to be segmented in the following classification:

- Airspace users
- Air Navigation Service Providers (ANSP)
- Airport Operators
- Aeronautical industry
- Passengers
- Ground Handlers
- Overall community

Specifically, this study will have into account ANSP's and Airspace Users. There will be others stakeholders affected, but they will not be included in the economic model.

6.1 ANSP's

ANSP's will incur the costs. They will buy and/or develop the tool: The Dynamic Capacity Management Tool and will be the stakeholder responsible for training.

After implementing the Dynamic Capacity Management ANSP's will obtain some benefits such us an optimisation of Human Resources Allocation.

6.2 Airlines

The CBA exercise only includes Airlines; it does not take into account other Airspace Users, such as General Aviation, Military Aviation, etc... It is not saying that these groups will not receive benefits, but the economic model will not take them into account.

Airlines will not incur any costs. They will only have benefits such as a reduction in delay.

6.3 Others

Further additional groups, which will be affected by the Project, can also be identified. These have not been included in the economic model.

- Industry: all manufacturers and other industries who develop tools such as the Dynamic Capacity Management Tool;
- Passengers: They will benefit from time savings due to reduced delays.

7 Assumptions

In order to carry out a clear and efficient study, the following assumptions have been made:

7.1 Economic assumptions

- The economic model uses the Real Discount rate: 4% (for constant price cash flows)[1];
- Initial figures are already in present value terms (2012);
- Inflation is not taken into account because that the model uses a Real Discount Rate;
- The economic units used in this study are Euros (€).

7.2 Technical assumptions

Assumptions on benefits

- The recalculation of sector configuration will be always better than the sector configuration without DCM Local Supporting Tool;
- After implementing the tool the optimum sector configuration obtained by the DCM Local Supporting Tool will be always used as the optimum configuration of the sector;
- Full benefits will be delivered in a year after implementation/integration phase completed (2013). The airlines will get 100% of the total benefits of DCM Local Supporting Tool a year after the first investments made in the DCM Local Supporting Tool;
- The traffic demand will increase by 3% following the Eurocontrol Medium-Term Forecast (2012) which confirms that traffic growth in the period of the study (2014-2019) is expected to remain stable at around 3%.

Assumptions on costs

- Costs of the DCM Local Supporting Tool are not included in the model. The prototype of the tool used in the validation exercises was developed by AENA under SESAR Programme.
- A company could develop the DCM Local Supporting Tool in the future, and will bear the development costs. These costs are not to be a separate cost position in the CBA but will be borne by the developer and incurred in the final selling price.
- Every ANSP that will subscribe to the DCM Local Supporting Tool services will bear the investment, maintenance and operational costs. There is an existing infrastructure where the information is located (middleware, common repository, information management system, interfaces, etc.). The tool will have access to this information. The existing infrastructure is not a cost considered in this CBA.

  There are no costs for Airlines. The use of the DCM Local Supporting Tool will be transparent for them.

[1] Standard Inputs for EUROCONTROL Cost Benefit Analyses (Edition number 5.0. Dic. 2011.: Please, note that the rate of 8% so far applied from 2006 is replaced by the European Commission's rate of 4% recommended in its Impact Assessment Guidelines, and also used by the European Aviation Safety Agency for its impact assessments

8 Approach to cost analysis

8.1 Cost descriptions

It can be considered four cost groups:

- **Pre-Implementation Costs (R&D Costs):** costs incurred during the pre-implementation phase under the form of research, prototyping, trials, and simulations.

  In this exercise it is identified costs incurred during the process of Research and Development. The CBA model will not take into account these costs. R&D Costs are part of the present study, which is co-financed by the SESAR Programme and ANSP's. Even so this study will give an approach to these costs for general interest and further studies.

  Besides, it is necessary to take into account that all these costs have already been done and are no longer necessary in a potential deployment. They all belong to the initial prototype. For deployment in new ACCs, the costs are included in the DCM Tool cost.

  Validation costs are the most relevant costs in this study. The validation was based on Shadow-Mode (see D24 Validation Report [3]). During the planned, the DCM Local Supporting Tool was used by the OPS Supervisor:

  - to plan the airspace sectorisation to be implemented during the next ATCo shift;
  - to monitor in real time the suitability of the selected airspace sectorisation;
  - to evaluate new airspace configurations at short time due to unexpected events (e.g. storms, unavailability of controllers,...)

  During the different simulation sessions, qualitative data were collected from the actors taking part in each run by different methods:

  - Individual questionnaires: specific questionnaires were developed to assess the operational concept;
  - Debriefing sessions: after each run the difficulties on the exercise was discussed among all the participants (operational and simulation staff);
  - Individual interviews: once all the runs are executed, the operational staff were interviewed to obtain a general impression on the functionalities of the new supporting tools.

- **One-Off Implementation Costs**: one-off implementation costs incurred during the implementation period, such as training, program management, etc.

  The SESAR concept envisages new air traffic controllers' roles and responsibilities. The Dynamic Capacity Management Local Supporting Tool has been developed to support the person responsible for determining the sectorisation in operation. In this way, OPS supervisor, Flow manager or new roles like Complexity Manager could be taking on these tasks.

  In this exercise, taking into account the current organization in Barcelona ACC, it is foreseen to give the training to OPS supervisors and Flow managers. Although the manpower has planned training every year (refresh of procedures, new systems, etc), this analysis will consider that the training associated to DCM Method will be additional to the standard one. This training would be imparted during one day to manpower involved.

- **Capital Cost Implementation:** Cost incurred to implement the project. Mainly these are costs of Hardware and Software; and the cost of the development of the DCM Local Supporting Tool.

- **Operating Cost**: maintenance, replacement and other costs incurred during the total period of the study.

8.2 Quantitative costs

Pre-Implementation Costs (R&D Costs):[2]

Name	Short Description	Total	Source
Prototype	1000 man-hours (initial phase and execution phase, including integration activities)	70000 €	Stakeholders judgment
Verification	60 man-hours (verification of the technical requirements)	4200 €	Stakeholders judgment
Validation	1900 man-hours of engineering 100 man-hours of controller	146000 €	Stakeholders judgment
Travels	12 National Trips carried out for seven different people in three times	7200 €	Stakeholders judgment

Table 1: Pre-Implementation Costs

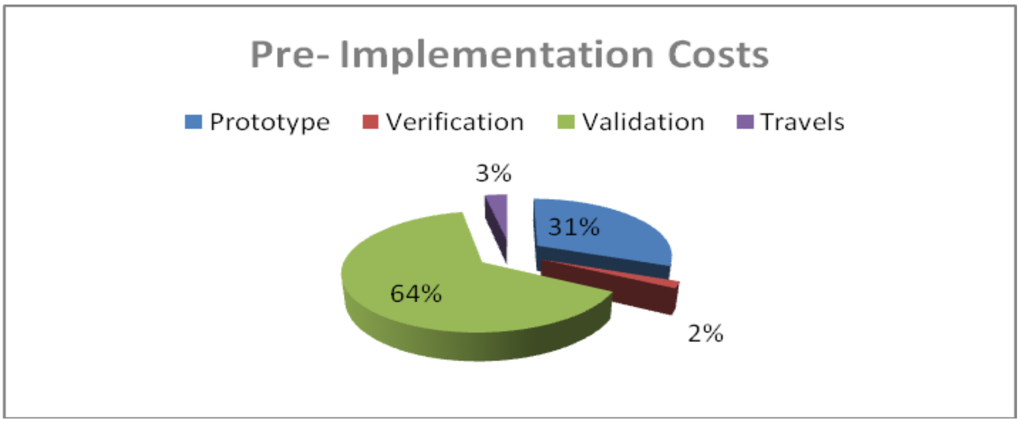


Figure 5: Pre Implementation Costs

[2] Please, note that these costs are not included in the model. The prototype of the tool used in the validation exercises was developed by AENA under SESAR Programme.

One-Off Implementation Costs

Name	Short Description	Total	Source
Training	Training imparted during one day to manpower involved (OPS supervisors and Flow Managers)	16000 €	Stakeholders judgment

Table 2: One off Pre-implementation Costs

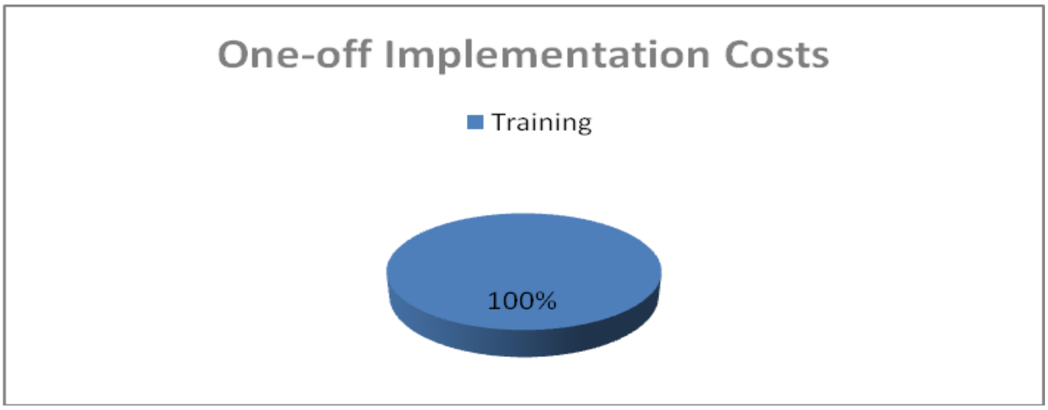


Figure 6: One-off Implementation Costs

Capital Costs Implementation: Investment Costs

Name	Short Description	Total	Source
Hardware/Software	Overall hardware and software needed including a medium-performance server + operative system license	5000 €	Stakeholders judgment
DCM Local Supporting Tool	3 man-months for software adaptation, covering inclusion of sector configurations for every considered ACC, data model enhancement, load testing, deployment and documentation	37800 €	Stakeholders judgment

Table 3: Investment Costs

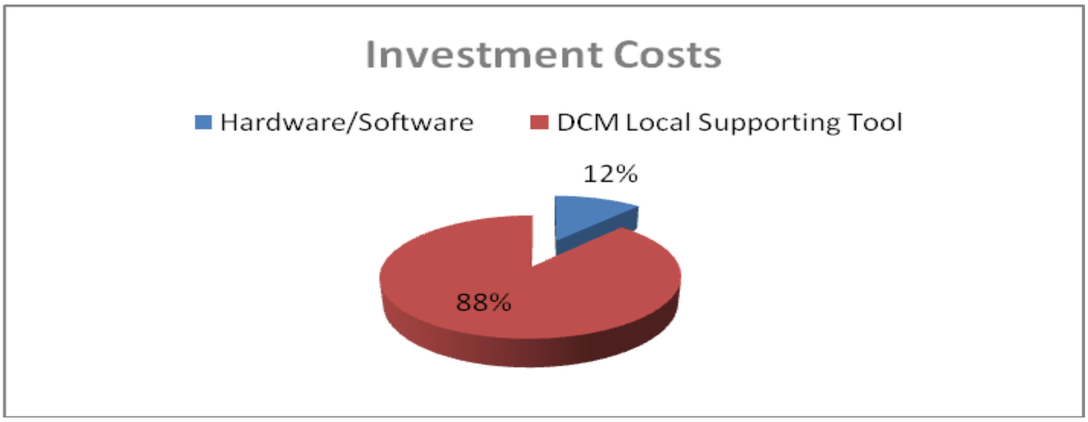


Figure 7: Investment Costs

Operational Costs

Name	Short Description	Total	Source
Maintenance Costs	20 man-days/year overall, not per-site. As the server is centralized, maintenance costs are shared and also centralized. The DCM Local Supporting Tool is a web tool, so no client software is required.	11200 €	Stakeholders judgment
Update of the Tool	20 man-days/year overall, not per-site. It includes adaptation to new configurations, system enhancements and improved functionalities.	11200 €	Stakeholders judgment

Table 4: Operational Costs

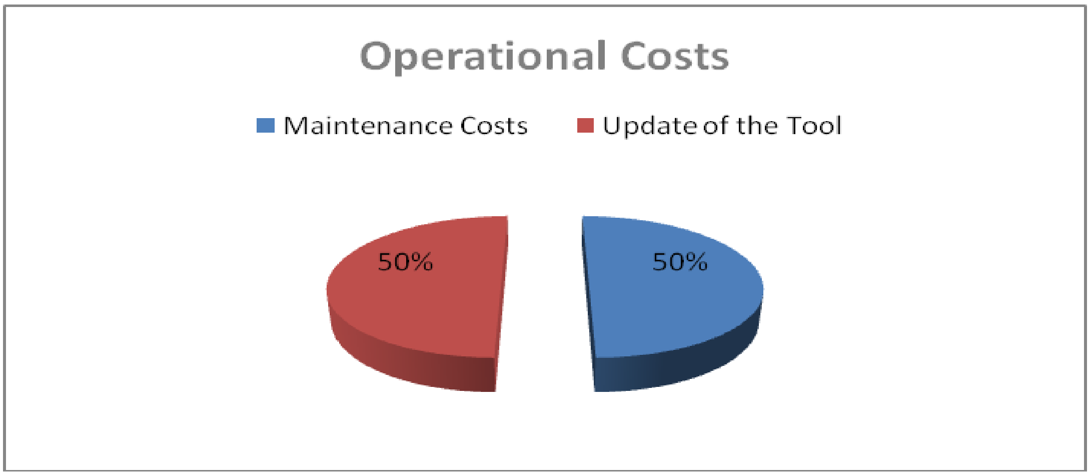


Figure 8: Operational Costs

Total Cost weight

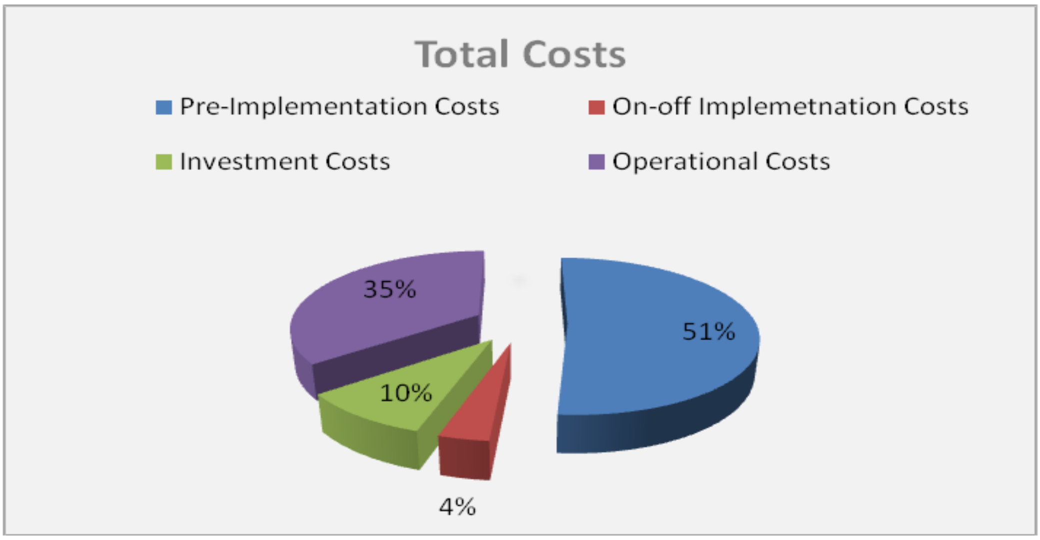


Figure 9: Total Cost weight

9 Approach to benefit analysis

The following table summarize the benefit and impact mechanisms (BIM) identified for the concept aspects that have been addressed by this exercise. More details about them can be found in the §3.5 and Appendix F of the P04.07.07 D23 – V3 Validation Plan [2].

KPA	Benefit Mechanisms
Safety	The assessment of the optimum sector configurations adapted to the forecast demand based on predefined scenarios will enable an increase in the controllers' situational awareness and thus increase Safety (+). In addition, the optimisation of sector configurations will contribute to the improvement of safety by avoiding or, at least, minimising controllers' overload.
Security	No direct benefit mechanism has been identified for the Security KPA.
Environmental Sustainability	No direct benefit mechanism has been identified for the Environmental Sustainability KPA.
Cost Effectiveness	The optimisation of sector configurations to adapt the capacity to the traffic load taking into account the available number of human resources will lead to an optimisation of Human Resources Allocation thus enabling an improvement in cost-effectiveness (+).
Capacity	The optimisation of the sector configurations usage will avoid unused latent capacity, thus potentially releasing Capacity (++) and/or enabling available capacity to be used more effectively, to avoid or, at least, minimise controllers' overload.
Efficiency	The adaptation of the capacity to the forecast traffic load will allow balancing the demand and capacity and thus reducing the regulations (+).
Flexibility	No direct benefit mechanism has been identified for the Flexibility KPA.
Predictability	No direct benefit mechanism has been identified for the Predictability KPA.
Access & Equity	No direct benefit mechanism has been identified for the Access & Equity KPA.
Participation	No direct benefit mechanism has been identified for the Participation KPA.
Interoperability	No direct benefit mechanism has been identified for the Interoperability KPA.

Table 5: Benefit Mechanisms

The following figure shows the BM diagram that was developed according to the P16.06.06 Guidelines for Producing Benefit and Impact Mechanisms

The main benefit of the DCM LOCAL Supporting Tool is the optimisation of sector configurations by means of supporting tools for OPS Supervisor to adapt the capacity to the traffic load by grouping and de-grouping sectors and managing the staff resources.

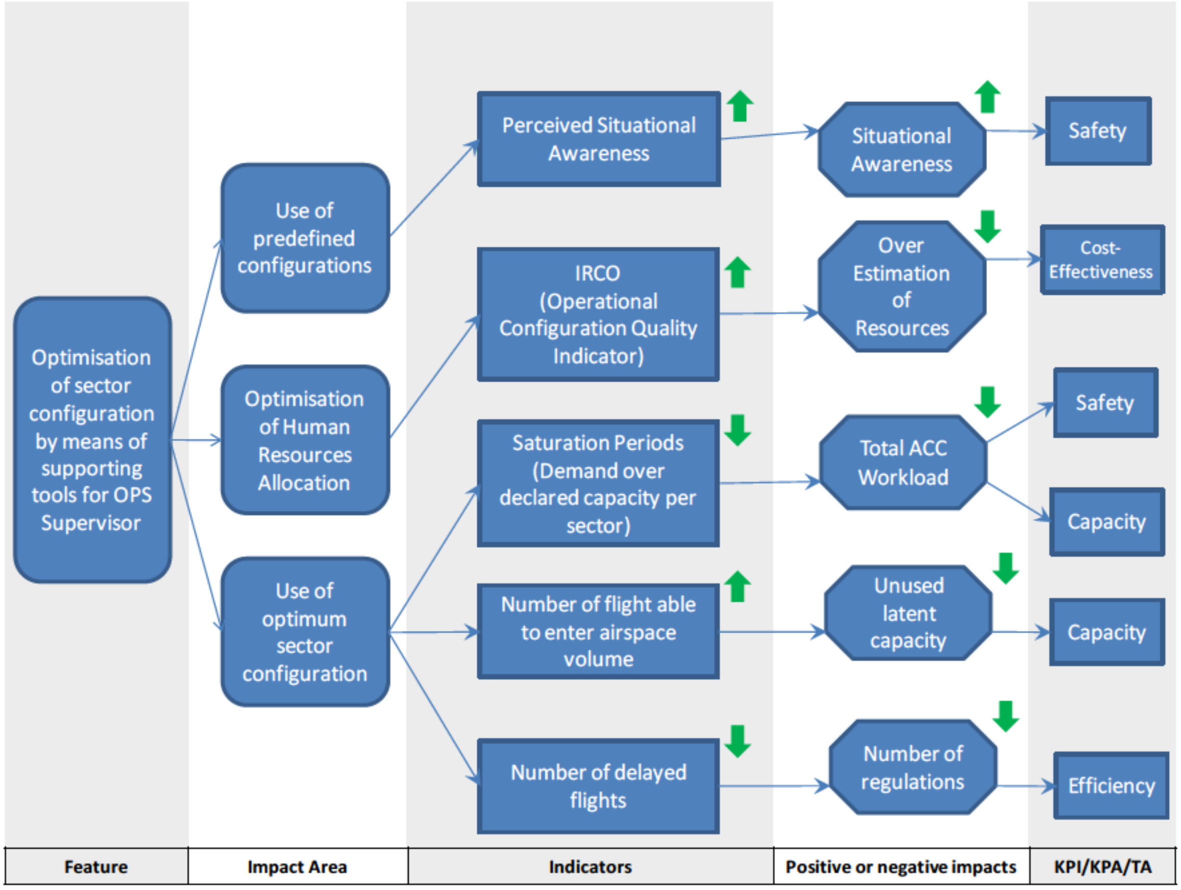


Figure 10: Benefit Mechanisms

9.1 Quantitative benefits

The approach to the benefits of the DCM Local Supporting Local Tool is through the Benefit Mechanism done by D23 Validation Plan [2].

As it can see in the Benefit Mechanism (Figure 10) four KPAs were analyzed: Safety, Cost-Effectiveness, Capacity and Efficiency.

However, involved experts, who gave the information necessary to develop the CBA, determined that only one KPA could be analyzed in terms of economics units: Efficiency (in terms of delay reduction).

DCM Local Supporting Tool reduces the number of regulations in the ACC Barcelona. This means a reduction in tactical delay in the airports where flights are departing.

At the beginning, the CBA would be based on validation benefits and data. In this line, the Shadow-Mode Validation Technique was planned to finish on October 2012. However, the number of delayed flights cannot be measured by means of this technique and since then further analytical modeling runs are being performed to cover it as planned in D23-V3 Validation Plan [2]. The results of this activity were expected to be delivered by the end of February 2013.

Therefore, initially Validation Exercises had finished too late to use its results as input for the CBA. In order to resolve this issue, experts[3] confirmed that due to the use of DCM Local Supporting Tool the airplanes before taking off could decrease its tactical delay by 0.015 minutes.

This estimation is aligned with the final results (see D24 Validation Report [3]):

	Average of Delay per flight		% Delayed Fligths	
ATCo's Shift	CHMI data	Supporting Tool	CHMI data	Supporting Tool
Morning	0:00:37	0:00:50	4,86%	5,63%
Afternoon	0:00:20	0:00:18	1,32%	1,25%

Table 6: KPIs for Efficiency – V3 Validation Report

It was appreciated that with the airspace configurations proposed by the supporting tool during the afternoon shift, the number of delayed flights and the average delay per flight were reduced. When the level of traffic increases (morning shift) the delays and delayed flights were increased but the average delay value per flight stays within the admissible values (less than 1 minute). Note that this reinforced the added value of reducing sectors without a negative impact on the quality of service.

Assuming an average delay of 0.6 minutes per aircraft, figure registered by Eurocontrol in Barcelona ACC during 2011, the DCM Local Supporting Tool reduces the delay due to regulations 0.03 minutes as maximum and 0.01 as minimum.

This tactical delay is the delay which occurs in ground, i.e. during the phase of flight before take-off.

For monetizing the ground delay it is used the recommended values of Eurocontrol, which present as a range from Low, to High, with a Base value. Low and high scenarios represent extreme scenarios where everything is systematically computed with respectively low/high values. Nevertheless, low and high values are useful to compute a sensitivity analysis.

Concepts included in the ground technical delay are: Fuel costs, maintenance costs, crew costs, ground and passenger handling, airport charges, aircraft ownership costs, passenger compensation, direct cost to an airline and passenger opportunity cost.

Name	High	Base	Low	Source
Reduction in tactical delay	0.03 min	0.015 min.	0.01 min.	Experts Estimation
Delay Cost per min.	70.2 €	47.9 €	13.2 €	Eurocontrol Standard Inputs Edition 5 [ref][4]

Table 7: Operational Benefits

[3] The reduction in delay as CBA Model input came from expert opinions after analysing the results of the validations (D24).

[4] Based on University of Westminster for the EUROCONTROL PRC, 'Evaluating the true cost to airlines of one minute of airborne or ground delay', May 2004

10 CBA Value Metrics

10.1 Net Present Value

The Expected Net Present Value of the DCM Local Supporting Tool investment is equal to 2.95M€, therefore the use of this tool will add this value to the airlines with the assumptions made.

10.2 Cash flows

Taking in consideration all assumptions and hypothesis made previously, the following net cash flow was obtained:

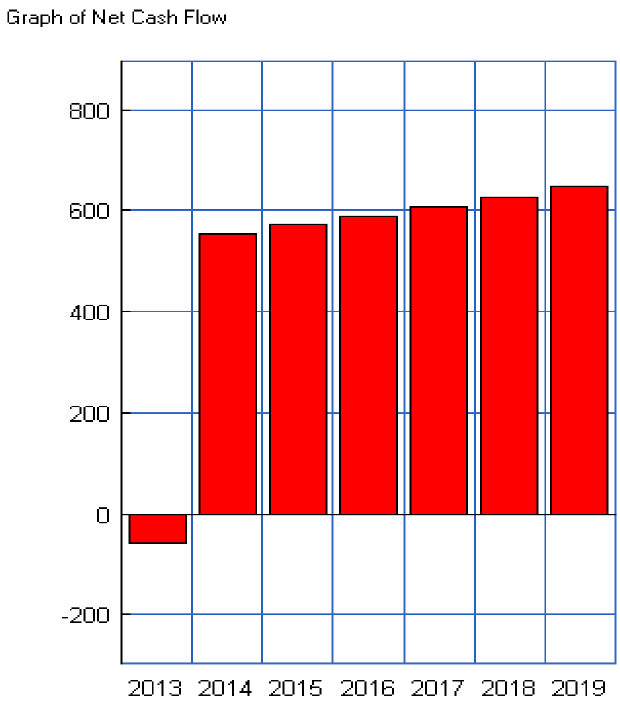


Figure 11: Net Cash Flows

As it can be seen in the figure above, the cash flows involve the 2013-2019 period.

In the first year of the study (2012) there were neither benefits nor costs due to R&D cost not being considered and also the implementation costs (one off and investment costs) starting in 2013. For this 2012 was not included in the cash flows.

The 2013 cash flow is very low because in this year only the cost of implementation exists. This cost is considerably smaller compared with the benefits in the following years.

The benefits will start in 2014 when the DCM Local Supporting Tool will be deployed and operating.

From 2013, it was considered that the Tool is totally in operation, so there are 100% of benefits from this year to the final period.

Benefits are increase year by year due to the increase of the demand which increase 3% as a average

10.3 Benefit- Cost (B/C) Ratio

The present value of the benefits is 3.73M€ over 7 years (from 2013 to 2019)

The overall Cost is 0.19M€.

A benefit cost ratio of 19.32 is shown graphically below; this means that the total benefits of implementing DCM Local Supporting Tool are 19.32 times higher than the total costs

Benefits	3733,84K€
Costs	193,2K€
B/C Ratio	19.32

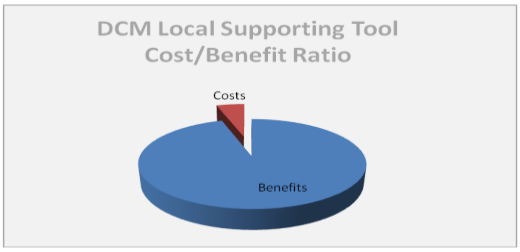


Figure 12: Cost / Benefit Ratio

11 Sensitivity Analysis

Sensitivity analysis examines the sensitivity of the project's economic performance – its costs and benefits – to the variation of individual parameters (NPV in this case) in order to identify the most critical issues and the degree of their impact.

The results of a sensitivity analysis are usually presented graphically. Tornado Graphs are the standard tool for this purpose.

Variables have been varied for the high and low scenarios in +/-10%.

The Tornado Diagram (fig below) shows clearly that there are two variables whose value has more influence in the NPV than the other ones. These variables are the Reduction in Delay due to the operation with the DCM Local Supporting Tool and the Delay Cost.

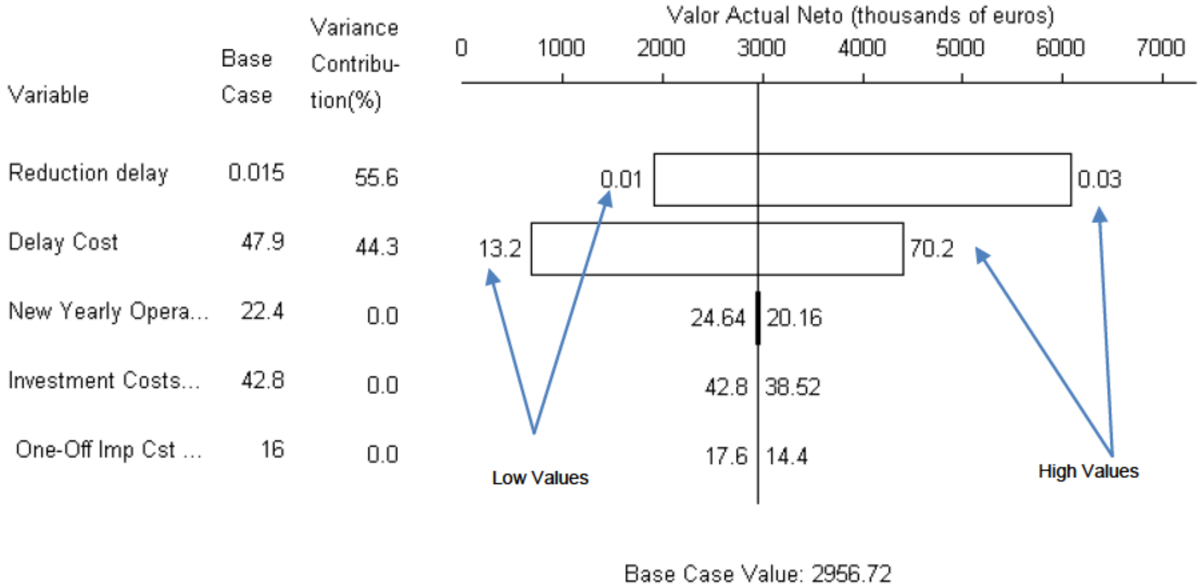


Figure 13: Tornado Diagram

The NPV for the base case is 2.95 Millions of Euros.

As it can be seen in the Tornado Diagram, the NPV fluctuates between 2 and 6 millions of Euros depending on the value of Reduction in Delay. Thus, if the estimation of the reduction in delay changes, the NPV is modified too: if the Reduction in Delay changes from 0.01 to 0.03 min per flight the NPV will be modified from 2 to 6 Millions of Euros as the NPV depends mainly on the value of that variable. In fact, the Reduction in Delay contributes at NPV value in 55.6%.

The Sensitivity Analysis also shows the cost of the delay has a great impact on the NPV. As it is difficult to influence in the future cost of the delay, it should be considered as a constant value, without any analysis of the NPV.

Other variables do not influence the total NPV. Mainly, because the One-Off Implementation costs and the Investment costs for ANSPs are low when compared with the benefits from the Reduction in Delay.

12 Conclusions

The economic study presented in this deliverable shows the economic analysis of the Deployment and Operation of DCM Local Supporting Tool in the geographic scenario described (Barcelona ACC).

The CBA Model has been developed taking into account Implementing and Operational Costs, along with Benefits; comparing the baseline (as reference scenario) with the Operation of the new system.

Several benefits were identified, but not all of them were quantified or monetized. Only one benefit was analysed in economic terms and introduced in the model to obtain economic metrics: Reduction in Delay.

Four kinds of costs were considered:

- Pre-Implementation Costs;
- One-Off Implementation Costs;
- Investment Costs;
- Operational Costs.

In spite of Pre-Implementation Costs has the biggest weight (51%), these costs were not included in the CBA Model, for two reasons:

- Following P16.6.6 recommendations, R&D Costs are not included in the CBA Model. Most of these costs will be covered by SESAR Programme and the ANSP's who are part of the Programme;
- All these costs have already been done and are no longer necessary in a potential deployment. They all belong to the initial prototype. For deployment in new ACCs, the costs are included in the DCM Tool cost.

But they were analysed and described for further studies (Section 8.1 and 8.2).

Operational Costs have a big portion as well (35%). It will be important to analyze Maintenance and Up-date of the Tool Cost to know if is possible to reduce them.

Investment Costs and One-Off Implementation Costs do not have a big influence on the NPV. With a percentage of 10% and 4% respectively, they are not relevant in the economic analysis.

Taking into account One-Off Implementation, Investment and Operational Costs and the Reduction in Delay as the only quantified benefit, the economic study shows a very positive results: If it is operated with the DCM Local Supporting Tool in the scenario described it will obtain a NPV of 2.95 M€.

There are two variables whose significance is very important in the results of this economic study:

- Reduction in Delay: This Operational Benefit has the higher value in the sensitive analysis. That is, its contribution to the NPV value is very high: 55.6 %
- Delay Cost: The contribution of this variable to the NPV value is 44.3%.

Both variables are part of the benefits. This means that if it is compared the baseline against the operation with the Tool and taking into account all the assumptions described in the document, it will obtain a positive NPV, meaning the project is feasible in economic terms.

This proves that the Deployment and Operation of the Tool is profitable in Barcelona ACC (even because the study was very conservative; it not included any more benefits)

Finally, as costs were extensively analysed, but not benefits; a further CBA is recommendable to know the contribution of the other variables which have not been considered, especially benefits which were not included in the model.

13 References

[1] SESAR. P16.6.6. D010-02. Guidelines for Producing Benefit Mechanisms. Version 00.01.02

[2] SESAR P04.07.07 D23 V3 Validation Plan, Version 00.02.00, 18th October 2012.

[3] SESAR P04.07.07D24 V3 Validation Report, Version 00.02.00,29th April 2013.

[4] SESAR WP04.02 D07 Detailed operational description, Version 00.05.00, 29th October 2012.

[5] SESAR WP07.02 D07 Detailed operational description, Version 00.01.00, 15th October 2011.

[6] SESAR, Operational Focus Area, Version 03.00.00, 4th May 2012.

[7] SESAR P04.07.07 D25 Final OSED, Version 00.02.00, 12th April 2013.

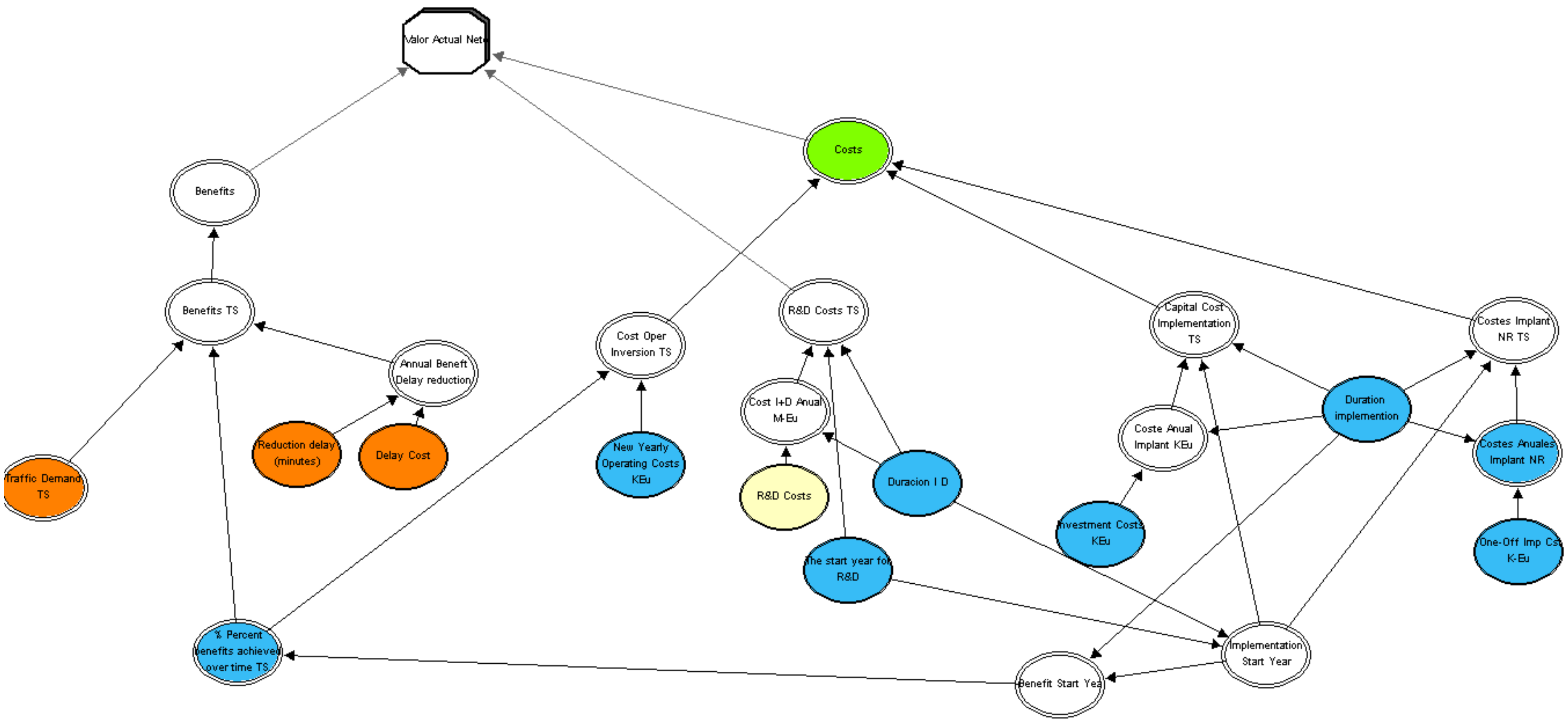
[8] SESAR, Operational Focus Area, Version 03.00.00, 4th May 2012.

Appendix A Summary of the CBA Model values

Input Parameter	Value	Low	Base Case	High	Units
This Year	2013				calendar year
Discount Rate	0,04				decimal fraction
Tax Rate	0				decimal fraction
The start year for R&D	2012	2012	2012	2012	calendar year
Duration R&D	1	1	1	1	years
R&D Costs	0	0	0	0	thousands of Euros
Yearly Operating Costs K-Euros	22,4	20,16	22,4	24,64	thousands of Euros
One-Off Imp Costs K-Euros	16	14,4	16	17,6	thousands of Euros
Investment Costs K-Eu	42,8	38,52	42,8	38,909	thousands of Euros
Delay Cost	47,9	13,2	47,9	70,2	units
Reduction delay (minutes)	0,015	0,01	0,015	0,03	minutes
Duration implementation	1	1	1	1	years
Annual Costs Impl. Non Recurring	16	14,4	16	17,6	thousands of Euros
Annual Costs Implant K-Euros	42,8	38,52	42,8	47,08	thousands of Euros
Annual Benefit Delay reduction	0,7185	0,64665	0,7185	0,79035	thousands of Euros
Implementation Start Year	2013				calendar year
Benefit Start Year	2014				calendar year

Table 8: CBA Model Values

Appendix B Model Diagram



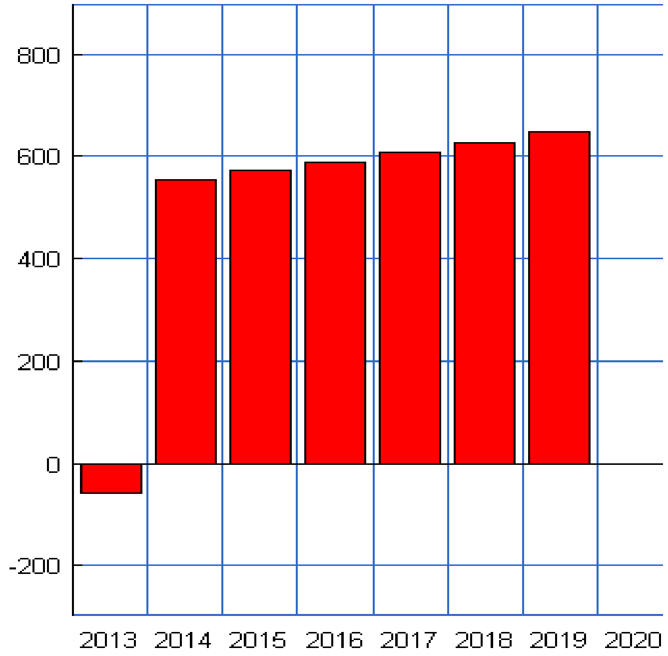
Appendix C "Summary of the results with a discount rate of 8%"

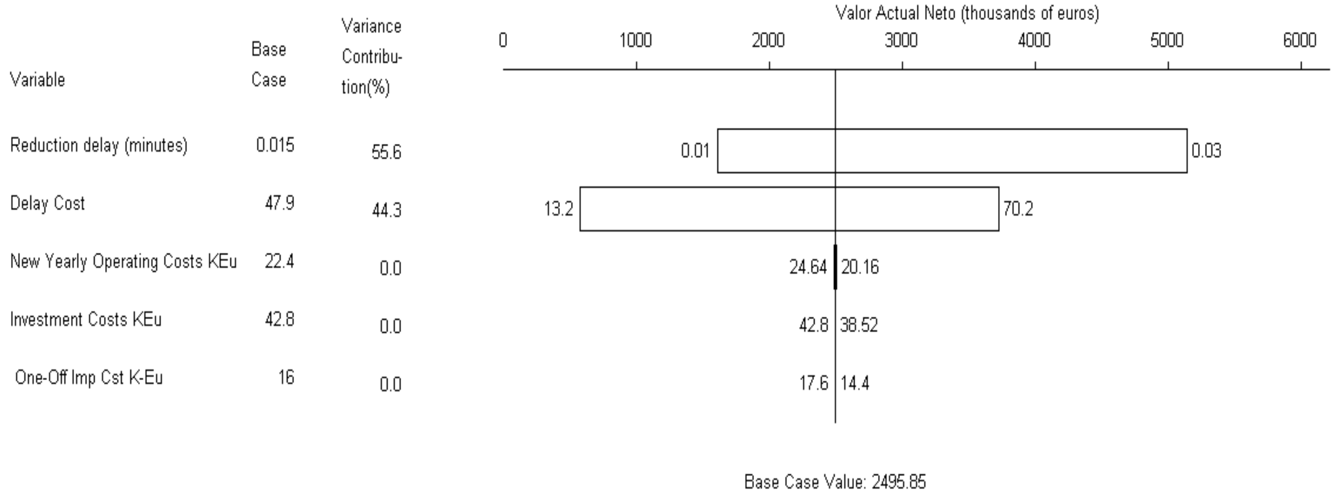
Following the assumptions, inputs and analytical model taken in this exercise, and using the rate of discount 8% (following P16.6.6 Guidance Material and recommendations), the results below were obtained:

Net Present Value

The Expected Net Present Value of the DCM Local Supporting Tool investment is equal to 2.49M€, therefore the use of this tool will add this value to the airlines with the assumptions made

Cash Flows





Sensitivity Analysis (Tornado Diagram)

The NPV for the base case is 2.49 Millions of Euros.

The sensitive analysis shows that the most relevant variables are Reduction in Delay and Delay Cost. Both variables have a great impact on the NPV

Other variables do not influence the total NPV. Mainly, because the One-Off Implementation costs and the Investment cost for ANSPs are low when compared with the benefits from the Reduction in Delay.

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