Economic assessment of STCA standardisation

Document information

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1 Introduction and background

1.1 General

1.1.1 This document is an economic assessment for the design, implementation and operation of standardised STCA (Short Term Conflict Alert) throughout the ECAC area.

1.2 Objective of the economic assessment

1.2.1 STCA is a ground-based safety net intended to assist the controller in maintaining separation between controlled flights by generating, in a timely manner, an alert of an infringement or potential infringement of separation minima.

1.2.2 The ECIP (European Convergence and Implementation Plan) is a plan of agreed actions for improving European Air Traffic Management (ATM) in which objectives and stakeholder lines of action define what has to be done, why, how, when, where and by whom.

1.2.3 The ECIP 2006-2010 contains an agreed objective (ATC02.1) for the harmonisation of STCA in accordance with the Operational Requirements Document for EATCHIP Phase III ATM Added Functions Volume 2 – Safety Nets. This is referred to as Level 1 STCA.

1.2.4 The ECIP 2006-2010 also contains an agreed objective (ATC02.2) for ECAC-wide standardisation of STCA in accordance with the EUROCONTROL Specification for STCA (raised from tentative in Summer 2006). The specification contains the minimum requirements for development, configuration and use of STCA. It also serves as a reference for the detailed safety work that is needed for safety assurance of STCA and for ESARR4 compliance (Ref: 4); and is fully aligned with the EUROCONTROL ATC Domain Roadmap.

1.2.5 The agreed ATC02.2 objective for STCA standardisation supersedes the corresponding ATC02.1 objective for STCA harmonisation. Moving from harmonisation to standardisation addresses issues related to cross-border and FUA (Flexible Use of Airspace) aspects as well as ensuring consistency between airborne and ground-based safety nets.

1.2.6 This economic assessment identifies the economic implications of raising the status of objective ATC02.2 from tentative to agreed.

1.3 Benefit summary

1.3.1 The over-riding driver for standardising STCA is to increase the level of safety in European airspace. This economic assessment has not attempted to ‘put a price on safety’, but instead provides evidence that there are economic benefits from adopting a standardisation approach.

1.3.2 Our results show that standardising STCA within ECAC (inline with ECIP objective ATC02.2) is at a minimum not cost prohibitive, but may in fact bring financial benefits. Particularly to ANSPs that collaborate to learn from each others’ experiences.

1.4 Contents of this assessment

1.4.1 The contents of this assessment are:

- Section 2 – Short Term Conflict Alert – provides some background information regarding STCA and the differences between Level 1 and Level 2 STCA.
- Section 3 – Approach – describes our approach to the study.
- Section 4 – Cost framework for STCA implementation – details the cost assumptions we have made in the economic assessment.
- Section 5 – STCA geographic coverage – discusses the current coverage of STCA throughout ECAC.
- Section 6 – Data analysis – shows the results of the economic assessment.
- Section 7 – Sensitivity analysis – shows the sensitivity of the economic assessment to some key input parameters.
- Section 8 – Conclusions – draws conclusions from the results and sensitivity analyses.

2 Short Term Conflict Alert

2.1 Introduction

Level 1 STCA

2.1.1 The Operational Requirements Document (ORD) for EATCHIP Phase III Volume 2 provides, among other things, details on the requirements for implementing an STCA. An implementation that complies with the ORD in accordance with ECIP objective ATC02.1 is referred to as a 'Level 1 STCA' in this assessment.

Level 2 STCA

2.1.2 The EUROCONTROL Specification for Standardised STCA specifies in more detail the minimum requirements for the development, configuration and use of Short Term Conflict Alert (STCA) in the ECAC area. An STCA that complies with these requirements in accordance with ECIP objective ATC02.2, is referred to as a 'Level 2 STCA'.

2.1.3 The EUROCONTROL Specification for STCA is complemented by guidance material. This guidance material will enable the presentation of examples and recommendations for such elements as STCA implementation planning, safety assurance, training and optimisation.

2.2 Level 2 STCA compared to Level 1

2.2.1 Level 2 STCA requirements supersede those for Level 1. The standards developed for Level 2 STCA include additional requirements to cover areas that are outside the performance of the STCA itself such as policy, training and ATC procedures.

2.2.2 The performance requirements for a Level 2 STCA have also undergone re-drafting from the Level 1 specification. The new standard for Level 2 contains additional information compared to the previous requirements, especially in the areas of data recording, STCA capabilities and safety requirements. However, any ANSP that complies with the Level 1 specification will also comply with the technical performance components of the Level 2 specification.

2.2.3 The Level 2 specification has also raised the Human Machine Interface components to the 'requirement' level, rather than the 'guidance' approach taken in the Level 1 specification.

2.3 STCA status

2.3.1 Many ANSPs have already implemented STCA in the ECAC region (see STCA geographic coverage discussion, Section 5).

2.3.2 Results from the survey of practices in safety nets conducted in 2004/5 (Ref: 2) highlighted a number of areas of concern in regards to the variability across ECAC in STCA implementation, including warning times, validation/optimisation practices and national regulatory role in STCA implementation. An example of this variability is in the parameters set for STCA operation (Table 2-1), which illustrates the variations encountered. These variations support the move towards standardisation of STCA (Level 2).

Parameter	Min	Max
STCA update period (secs)	4	8
Lowest speed for track eligibility (kts)	20	60
Horizontal separation (NM)	1.25	3
Vertical separation (feet)	375	900
Look-ahead time (secs)	20	90
Warning time (secs)	20	70

Table 2-1 STCA Parameter ranges across ECAC(Ref: 2)

2.3.3 The safety nets survey highlighted concerns regarding the context in which some ANSPs implement STCA. The introduction of STCA by some ANSPs does not seem to be a deliberate safety management choice, but rather through general technical improvements. Thus, STCA may be implemented as part of a new system without a policy view of the role and use of STCA.

2.3.4 The survey also highlighted harmonisation within and between different countries as an area of concern. This concern included the lack of uniform implementation policy, similar concepts for HMI, similar definitions and related procedures and policies in areas where there is a fragmented approach within and between countries. It is not known whether differences occur due to differing practices and procedures, or are only due to historical reasons and a lack of knowledge about the solutions adopted by other ANSPs. These local differences, when not due to specific local requirements, are potentially problematic and complicate the exchange of information and practices between ANSPs.

2.4 Standardised STCA

2.4.1 STCA Level 2 standards, developed for ECIP, will provide ANSPs with awareness of:

- the important areas to focus on during the design phase;
- a set of priorities which assist in defining and prioritising implementation activities;
- any local discrepancies in implementation policies that may affect system developments or upgrades.

2.4.2 The benefit of the EUROCONTROL Specification for STCA, with the additional guidance material, is seen to be related to both improved effectiveness of STCA, as developed during the design phase, and a reduction in implementation costs.

3 Approach

3.1 Overview

3.1.1 We performed the economic assessment in a number of steps, as follows:

- prepared an initial economic assessment;
- validated the initial economic assessment with ANSPs and EUROCONTROL;
- prepared a final economic assessment for publication, incorporating the feedback and comments from ANSPs and industry.

3.1.2 Figure 3-1 illustrates this approach.

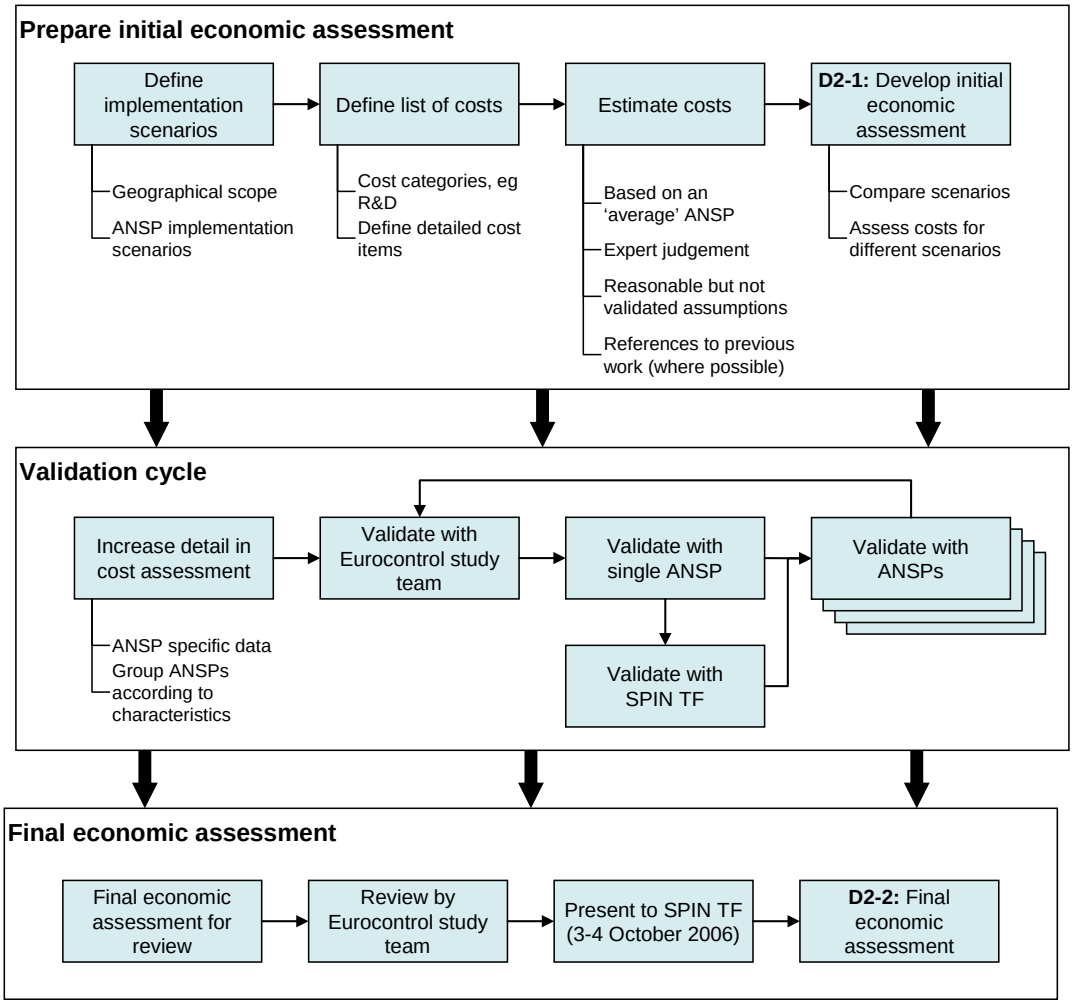

Figure 3-1 Economic assessment flow diagram

3.1.3 Firstly, we defined the geographical scope of the economic assessment and then developed a number of scenarios in order to assess:

- The economic impact of implementing Level 2 STCA.
- How the costs incurred in order to comply with the Level 2 STCA standards vary depending on the maturity of current STCA systems.

3.2 Geographic scope

3.2.1 The economic assessment investigates the financial impact of the ECAC-wide implementation of Level 2 STCA. It is restricted to the unit level and is not split between enroute airspace and TMA (Terminal Manoeuvring Area). This is due to the difficulties in obtaining data specifically related to TMA implementations and usage of STCA.

3.2.2 The use of an STCA function in a tower environment is not assessed or discussed in this assessment.

3.3 STCA deployment cases

3.3.1 The EUROCONTROL Safety Survey (Ref: 2) found that STCA deployment status varies across the ECAC region. As such, many units are at different stages in their STCA development and deployment. To recognise this variability, we have described several cases to ensure that costs of STCA reflect this diversity.

3.3.2 We identified four STCA status groups (referred to as 'cases') so that any unit within ECAC can, at a high level, be represented by one of these cases. The four cases are:

- **Case A** – Units that have not implemented an STCA, but have the opportunity to include it as part of a new ATC system design.
- **Case B** – Units that have not implemented an STCA, but will implement one as part of an existing ATC system.
- **Case C** – Units that have deployed an STCA that is not in full operational use throughout all their ATC sectors and/or does not comply with Level 2 STCA specifications.
- **Case D** – Units that have deployed an STCA that is in operational use in all of their sectors and complies with STCA Level 1 specifications.

3.3.3 The cost of implementing STCA is different for each of these cases.

3.4 ECAC-wide implementation scenarios

3.4.1 ECIP objective ATC02.1 states that units should 'Implement and make operational use of the Short Term Conflict Alert (STCA) ground based safety tool compliant with the Operational Requirements Document for EATCHIP Phase III ATM Added Functions - vol.2' and that this should be completed by September 2006. Therefore, the cost of meeting objective ATC02.1 is the **Baseline Scenario**. This represents the expenditure if all ECAC units had implemented an STCA that complies with the Level 1 specifications.

3.4.2 Figure 3-2 presents a simplified graphical view of this Baseline Scenario. Chapter 6 will expand on this method to present the results of the assessment.

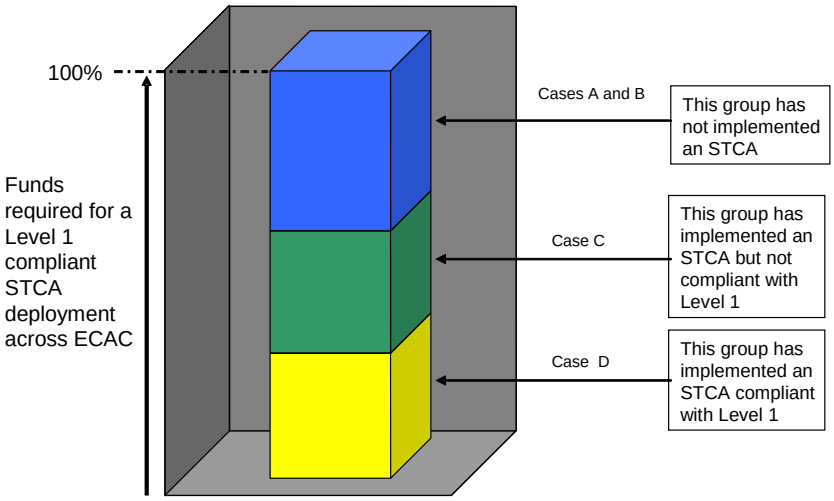

Figure 3-2 Cases referenced to total cost for ECAC wide Level 1 STCA implementation

3.4.3 To provide the comparison with the Baseline Scenario, we estimated the costs associated with moving each case towards compliance with the Level 2 specification. This is termed the '**Level 2 Scenario**'.

3.4.4 In addition to the 'Level 2 Scenario' we evaluated the impact on cost of a collaborative approach to the deployment of STCA, which is fostered and maintained by EUROCONTROL, between ANSPs willing to participate. This is termed the '**Collaboration Scenario**'.

3.5 Other considerations

3.5.1 In addition to the financial considerations introduced above, we assess the impact that an agreed ECIP objective (ATC02.2) could have on the coverage of STCA throughout ECAC.

3.5.2 The discussion is based on an estimate of flight hours that are currently controlled without the support of STCA as compared to total flight hours within ECAC. A qualitative assessment of the potential safety benefits of implementing STCA ECAC-wide is discussed in Section 5.

4 Cost framework for STCA implementation

4.1 Introduction

4.1.1 This section describes the different phases through which an individual ANSP will progress to implement an STCA. These phases are:

- Project administration.
- Research and development.
- Procurement.
- Deployment.
- Ongoing maintenance and support.

4.1.2 Each of these phases has been broken down into individual cost items. These individual items have been assessed as to whether they depend on the ECAC-wide scenario (Baseline, Level 2 or Collaboration), the deployment case (A, B, C or D), or both.

4.1.3 The cost breakdowns are summarised in Annex B.

Cost estimates

4.1.4 The cost estimates of all cases are based on the development and implementation of the STCA. The estimates quoted below are based on expert judgement and have been validated by ANSPs and industry.

4.1.5 In many of the costs elements, Case D has no cost for the Baseline Scenario. The Baseline Scenario assumes that units continue on the path to harmonisation (in accordance with objective ATC02.1 for Level1 STCA) rather than standardisation (ATC02.2), and those units in Case D already comply with Level 1 STCA specifications.

4.2 Project administration

Project management

4.2.1 We estimated project management to be 10% of the overall effort of implementation. As expected, this means that an implementation requiring more staff effort will also take more project management effort.

	Benefit assumptions
Case A–STCA to be included in new ATM system	10% of overall effort for all Baseline, Level 2 and Collaboration Scenarios
Case B–STCA to be implemented in existing ATM system	10% of overall effort for all Baseline, Level 2 and Collaboration Scenarios
Case C-STCA in system but not in operational use	10% of overall effort for all Baseline, Level 2 and Collaboration Scenarios
Case D-STCA complies with EUROCONTROL standards	10% of overall effort for all Baseline, Level 2 and Collaboration Scenarios

Table 4-1 Project management summary

4.3 Research and development

Requirements analysis

Baseline Scenario

4.3.1 The cost of requirements analysis will not vary between the cases A to C. For these cases we assume that even if the STCA functionality is present in the system, as for Case C, effort will still be required to determine the concept of operations and then define a set of operational requirements from that concept to bring the STCA into compliance with a Level 1 requirements.

4.3.2 Determination of the concept of operations and operational requirements may be more complicated where the STCA covers both enroute and terminal airspace environments due the variability of aircraft types and profiles. However, as stated in Section 3.2 'Geographic scope', this assessment focuses at the unit level and not ATC functional level, and as such the cost estimation assumes that STCA will apply generically to both environments.

Level 2 Scenario

4.3.3 The development of an agreed set of principles in the Level 2 STCA documentation will reduce expenditure on requirements analysis compared to the Baseline Scenario. Based on the current level of documentation for a Level 2 STCA this could be in the order of a 50% saving in the concept development work, however validation activities will still be required to fine tune the concept to the local environment. As Case D does not require changes to the technical performance of the STCA (only changes to policy and training) there is essentially no effort needed for requirements analysis.

Collaboration Scenario

4.3.4 As this scenario assumes a collaborative approach with other implementers there will be a reduction in the effort, of the order of 30% from the Level 2 Scenario that would otherwise be needed during requirements derivation activities.

4.3.5 We assume that for all scenarios, validation work will be conducted on the concept of operations and on the requirements. Usually this will be in the form of fast and real time simulations, however, other forms may be used where these systems are not available, such as desktop scenarios involving operational staff.

4.3.6 Note that the requirements analysis figures assume that the analyses will be carried out locally by the ANSPs. If the work is carried out centrally by the ATM manufacturers (Indra, Thales, etc), then the analysis figures could be significantly lower. This depends on the similarities between different ATM implementations.

	Assumptions
Case A–STCA to be included in new ATM system	50% cost reduction for Level 2 Scenario and 65% for Collaboration Scenario compared to Baseline Scenario
Case B–STCA to be implemented in existing ATM system	50% cost reduction for Level 2 Scenario and 65% for Collaboration Scenario compared to Baseline Scenario
Case C-STCA in system but not in operational use	50% cost reduction for Level 2 Scenario and 65% for Collaboration Scenario compared to Baseline Scenario
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios

Table 4-2 Requirements analysis summary

4.3.7 An example of a collaborative approach is the recently-launched Thales COOPANS agreement which will allow joint procurement of ATM system upgrades, reducing the risks of new systems through an incremental approach and encompassing the Single European Sky initiative. This agreement aims at increasing the commonality and interoperability of systems and benefiting from economies of scale.

Safety Case development

Design

Baseline Scenario

4.3.8 The effort for the creation of a safety case during the design phase is dependent on the case in question. As Case A will already contain resources for safety case development (for the whole ATC system), the addition of an STCA will be negligible in its impact on the effort required. In Cases B and C this activity will be required for the ATC system upgrade, with no discernable differences in the effort between the two since the upgrade is adding new functionality with direct impact on ATC performance.

4.3.9 There is no effort required for Case D, as the system complies with the EUROCONTROL standards.

Level 2 and Collaboration Scenarios

4.3.10 The safety case effort during the design phase will differ from the Baseline Scenario. We have estimated a reduction in effort for designing the safety case at 50%. This is due to the guidance material developed by EUROCONTROL that provides ANSPs with:

- A Generic Safety Argument for STCA. The document contains a generic argument intended to be used by ANSPs in developing safety assurance for STCA applications. The aim is to aid ANSPs in reasoning about what is necessary by way of assurance in claiming that the STCA system will benefit safety and to reveal the logic behind such reasoning.
- A Generic Safety Plan for STCA. This plan identifies the safety activities that should be undertaken in the definition, development and deployment of an STCA system. The scope of this document encompasses all phases of a system lifecycle and all system elements (people, procedures and equipment.)

- An Outline Safety Case for STCA. Its purpose is to provide guidance material for ANSPs to assure their own implementations of STCA in accordance with the EUROCONTROL Specification.

	Assumptions
Case A–STCA to be included in new ATM system	50% cost reduction for Level 2 Scenario and Collaboration Scenario compared to Baseline Scenario
Case B–STCA to be implemented in existing ATM system	50% cost reduction for Level 2 Scenario and Collaboration Scenario compared to Baseline Scenario
Case C-STCA in system but not in operational use	50% cost reduction for Level 2 Scenario and Collaboration Scenario compared to Baseline Scenario
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios

Table 4-3 Safety case summary

Safety case discussion

There is the potential for ANSPs utilising the EUROCONTROL safety case outline (Ref: 10) to reduce their expenditure when creating a safety case. The outline safety case has the added benefit that it is designed to match EUROCONTROL standards and guidelines to ensure the safety case is of a high standard.

A system safety case in this context is:

"A formal document that provides the evidence, arguments and assumptions to support the claim that the system is safe enough for operational use.

"This should describe the 'system' and its functions, identify the hazards, assess the risks, identify the measures in place to control the risks, and define the safety management arrangements for the operational system.

"This provides an assurance that any risks introduced by the change have been minimised as far as is reasonably practicable." (Ref: 6)

Safety cases, as part of formal Safety Management Systems (see ESARR3, Ref: 3) are increasingly seen as 'Best Practice' for air traffic control. An example is the EUROCONTROL work for the Maastricht ATC Operations Control Room (see Ref: 7).

However, safety cases obviously need to be fit for purpose. The development of safety cases in technical areas can be very demanding, particularly if there is limited knowledge within the ANSP of the technology concerned. This is where the EUROCONTROL Outline Safety Case for STCA could add significant value, both in terms of ensuring high standards and from the resource savings generated by not duplicating work already done elsewhere.

The creation of the safety case first requires analyses of the nature of the Complexity and Challenges faced by the different units covered by an ANSP, and of the STCA Functionality Levels of potential STCA software builds. Some explanation of these terms is appropriate:

Complexity and Challenges (C & C): Complexity of the unit airspace is a topic that has been the subject of much work in EUROCONTROL. For example, highly complex airspace has dense traffic frequently engaged in manoeuvres, while less dense airspace has comparatively light levels of traffic flying mainly in cruise mode. Challenges include such things as intricate airspace boundaries with other States and high levels of military activity.

STCA Functionality Levels (SFL): STCA software can range from 'Manufacturer-supplied' parameters to 'tailored to meet specific unit/ANSP needs'. The latter would require quite large-scale evaluation studies to optimise parameters and/or restrict STCA operation in particular parts of the airspace. The tailoring would mainly be carried out to reduce various kinds of nuisance alerts, which might otherwise distract the controller from real problems.

The SFL modules are largely required to minimise 'false' alerts, rather than being needed to ensure the production of necessary alerts, with sufficient warning time. In other words, these software modules 'clean up' the information received by controllers to minimise distraction. It is crucial to raise alerts for genuine potential airspace infractions – *true positives* – but important too, to minimise the number of *false positives,* so as not to 'cry wolf' too often. (For an example of this, see Ref: 8).

In terms of safety benefits and cost reductions the EUROCONTROL Outline Safety Case:

1) Ensures that Level 2 STCA safety performance standards are met across Europe, in a formally documented fashion. It uses European-level expertise to do this – and hence meets Best Practice safety requirements – rather than expecting ANSPs to re-invent safety cases.

2) Saves money because producing a European-level outline safety case saves ANSPs from having to duplicate data collections, analyses and testing.

Procedure Development

Description

4.3.11 For Cases A to C effort is required to develop and/or create ATC procedures for the use of STCA. Case D is an exception as it assumes that the existing STCA system and procedures are not impacted by the Level 2 standards.

4.3.12 The procedure development work will normally begin after concept development so that by the time deployment occurs local procedures will have been developed, agreed and promulgated.

Impact

Baseline Scenario

4.3.13 There is no discernable difference between Cases A to C in the effort required for procedure development. Each of these cases assumes there is no current operational use of the STCA and hence the effort for procedure development will not change between each case.

Level 2 Scenario

4.3.14 Currently Level 2 documentation does not provide for procedures and hence the effort required for procedure development will not vary significantly from the Baseline Scenario for Cases A to C. However, it is feasible that as the concept in STCA Level 2 is refined and more mature, fewer procedures local to each ATC sector (which are relatively costly to develop and publish) will be required. Therefore, at this stage, we assume no reduction in effort for procedure development.

4.3.15 Case D assumes that the current Level 1 STCA is operational and complies with Level 2 standards. Therefore, we assume that there is no cost associated with procedure development for Case D.

Collaboration Scenario

4.3.16 Through the collaboration between ANSPs, savings in effort required for procedure development are likely. Through the assistance of mature implementers and the use of guidance material, an ANSP implementing Level 2 STCA will realise significant effort savings through the sharing of lessons learnt. Therefore, we estimate a reduction in the order of 30% during procedure development.

	Assumptions
Case A–STCA to be included in new ATM system	No cost reduction for Level 2 Scenario and 30% for Collaboration Scenario compared to Baseline Scenario
Case B–STCA to be implemented in existing ATM system	No cost reduction for Level 2 Scenario and 30% for Collaboration Scenario compared to Baseline Scenario
Case C-STCA in system but not in operational use	No cost reduction for Level 2 Scenario and 30% for Collaboration Scenario compared to Baseline Scenario
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios

Table 4-4 Procedure development summary

4.4 Procurement

4.4.1 The commercial confidentiality associated with procuring ATM systems meant that obtaining the cost of an STCA system was very difficult. Therefore, we estimated the cost of procuring STCA through the amount of software code that would be required for each of the STCA functions. We estimated the overall cost of the STCA to be the sum of the costs to develop each of these STCA functions.

Code

4.4.2 The figures for software code development (by the ANSPs) include the implementation of the STCA requirements, the adaptation of the existing FDP and HMI code to include the new STCA functionality, and the addition of functions to underlying data handling routines for the additional data which STCA functionality requires. The STCA implementation and HMI adaptation will require most of the effort, with some additional work needed to expand the data capture facilities for “black-box” recording (RECAP).

4.4.3 The estimates are based on the assumption that approximately fifteen lines of code will be written per day and on the relative amounts of code required for each ATC component, derived from existing ATC systems.

4.4.4 It is also assumed that the addition of STCA functionality will complement existing FDP and HMI functions and will not require any significant redesign work, and that STCA functionality will complement any existing conflict detection functionality (such as MTCD) through effective demarcation of requirements.

4.4.5 Cases A and B are expected to take identical amounts of effort, as the source of the design plan preceding the requirements will not alter the time taken for their implementation. Case C will take less effort than Cases A and B because, since an STCA component already exists, the interfaces between it and other components will already be defined.

4.4.6 For Case D, we assume that there will be no additional procurement costs as the STCA implemented is compliant with Level 1 and is therefore technically compliant with Level 2 standards.

4.4.7 For each case, we estimate that the same amount of effort is required for each scenario, as the time taken for the implementation of the requirements will not be affected by the underlying ECIP objective – it is assumed that the number of lines of code required will be the same.

4.4.8 Note that the code development figures assume that the implementations will be carried out locally by each ANSP. Therefore, the status of the STCA will not alter these figures, because the amounts of work required locally will be identical.

	Assumptions
Case A–STCA to be included in new ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case B–STCA to be implemented in existing ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case C-STCA in system but not in operational use	No cost reduction for Level 2 or Collaboration Scenarios
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios

Table 4-5 Software code summary

4.5 Hardware and technical maintenance

4.5.1 The cost of the hardware and the maintenance of the system by the supplier is estimated to be the same for Cases A to C for all scenarios. There is no cost associated with Case D as the system already complies with EUROCONTROL standards.

	Assumptions
Case A–STCA to be included in new ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case B–STCA to be implemented in existing ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case C-STCA in system but not in operational use	No cost reduction for Level 2 or Collaboration Scenarios
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios.

Table 4-6 Hardware and technical maintenance summary

Site adaptation

4.5.2 The adaptation of the STCA system to site-specific implementation relates to any local modifications required for data handling. ANSPs believe that this is a major cost element. The local adaptation of the STCA and the setting of parameters can prove to be a vast exercise that also depends on the complexity of airspace.

4.5.3 The costs for the Level 2 and Collaboration Scenarios are the same as for the Baseline Scenario.

4.5.4 There will be no cost for Case D as the STCA is already in full operation and complies with Level 2 Standards.

	Assumptions
Case A–STCA to be included in new ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case B–STCA to be implemented in existing ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case C-STCA in system but not in operational use	No cost reduction for Level 2 or Collaboration Scenarios
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios

Table 4-7 Site adaptation summary

Testing

4.5.5 The amount of testing is the same for all the cases in all three scenarios, in that the new or altered STCA functionality will have to be thoroughly tested both in itself and in its impact on other ATC components. The amount of effort required for the definition and performance of test procedures will be the same regardless of circumstance. The testing will take place over several weeks.

4.5.6 If the development and implementation (but not activation) of testing is carried out centrally by the ATM manufacturer(s), instead of locally by ANSPs, then the testing costs will be lower for the Level 2 and Collaboration Scenarios (because the same testing will be used for many ATM systems). However, this reduction is not estimated in this economic assessment.

	Assumptions
Case A–STCA to be included in new ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case B–STCA to be implemented in existing ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case C-STCA in system but not in operational use	No cost reduction for Level 2 or Collaboration Scenarios
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios

Table 4-8 Testing summary

Implementation

Baseline Scenario

4.5.7 The effort for the creation of a safety case during the implementation phase will change depending on the case in question (as for the design safety case). As Case A will already contain resources for safety case development for the whole ATC system, the addition of STCA functionality will be negligible in its impact on the effort required. In comparison, for Cases B and C the creation of a new safety case will be required for the ATC system upgrade, with no discernable difference in the effort between them.

Level 2 and Collaboration Scenarios

4.5.8 There will be benefits from the provision of standards and guidelines provided by EUROCONTROL for completing the safety cases. This is described in more detail in paragraph 4.3.8. We estimate a reduction of effort of the order of 50% due to the guidance material provided by EUROCONTROL, but this is dependent on the ANSPs using the guidelines to assist in the completion of the safety case.

	Assumptions
Case A–STCA to be included in new ATM system	50% cost reduction for Level 2 Scenario and Collaboration Scenario compared to Baseline Scenario
Case B–STCA to be implemented in existing ATM system	50% cost reduction for Level 2 Scenario and Collaboration Scenario compared to Baseline Scenario
Case C-STCA in system but not in operational use	50% cost reduction for Level 2 Scenario and Collaboration Scenario compared to Baseline Scenario
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios

Table 4-9 Implementation safety case summary

4.6 Deployment

Operational Validation

4.6.1 This cost element excludes the validation activities that have been included during the concept development phase (e.g. Fast Time Simulation).

4.6.2 This validation includes all the activities associated with real time simulations and desktop reviews by operational staff. We expect that some revisions and amendments will be made to the procedures and STCA functions after this process. The process of making the amendments has not been included in the costs of operational validation, as they are included in 'STCA Tuning'. However, we have factored in 10% extra effort to account for the re-validation work conducted after this fine-tuning has taken place.

4.6.3 As this element includes a high number of extra personnel to run the simulations the following assumptions have been made for the number of day's effort:

- 3 measured sectors in the simulation;
- 1 feeder sector;
- 2 ATCOs per sector (executive and planner);
- 1 day training and 2 days simulation;
- plus support staff, measurement and report writing activities.

Baseline Scenario

4.6.4 The cost of effort for operational validation for Cases B and C will not differ as the activity will be solely focussed on the STCA. However, the effort for Case A will be reduced due to the general operational validation of the new system.

Level 2 Scenario

4.6.5 For Cases A to C some reduction in effort as compared to the Baseline Scenario is expected, as the operational concept and requirements will be more mature and validation will be easier to plan and will contain fewer risks to completion.

4.6.6 The cost for Case D is negligible as the functionality is already present and is operational. Validation work is only required where changes to STCA have been made to bring it into line with the Level 2 standards.

Collaboration Scenario

4.6.7 The cost for Case D is negligible. However, where validation work is required due to changes in the STCA some effort savings are possible compared to the Level 2 Scenario. This will be due to the collaborative environment and the positive impact that this will have on validation work. Joint validation will also be possible through sharing simulation facilities. Guidance from mature implementers may also assist in the provision of valuable lessons in the analysis of validation objective development, simulation set-up and results analysis.

	Assumptions
Case A–STCA to be included in new ATM system	10% cost reduction for Level 2 Scenario and 20% for Collaboration Scenario compared to Baseline Scenario
Case B–STCA to be implemented in existing ATM system	10% cost reduction for Level 2 Scenario and 20% for Collaboration Scenario compared to Baseline Scenario
Case C-STCA in system but not in operational use	10% cost reduction for Level 2 Scenario and 20% for Collaboration Scenario compared to Baseline Scenario
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios

Table 4-10 Operational validation summary

STCA Tuning

4.6.8 The variability of airspace complexity will influence the cost of STCA tuning. The higher the variability, the more difficult the task will be to optimise (through tuning activities) to attain operational acceptance and approval for the STCA. An important aspect is the level of granularity of the specifications, such that an ANSP is able to derive a large number of the parameters without having to conduct a similarly large number of tuning activities.

Baseline and Level 2 Scenarios

4.6.9 Based on the current draft Level 2 STCA specifications, the Baseline and Level 2 Scenarios will not achieve a benefit in regards to tuning activities. The granularity in the standard is not sufficient to justify a reduction in costs as actual parameters are not specified.

Collaboration Scenario

4.6.10 We assume that EUROCONTROL will continue to facilitate a collaborative approach to implementation of the Level 2 STCA — so through this approach more detailed case studies of tuning activities and parameter setting will be made available within ECAC.

4.6.11 Additionally, through the involvement of several ANSPs that have already implemented successful STCAs that comply with the Level 2 standard, the collaboration will show how an STCA can work within varied airspace complexities.

4.6.12 Hence, cost reductions for STCA tuning are justifiable for the Collaboration Scenario and are estimated to reduce effort required by 20%.

4.6.13 There will be no STCA tuning costs associated with Case D as this case assumes that the STCA implementation already technically complies with Level 2 standards.

	Assumptions
Case A–STCA to be included in new ATM system	No cost reduction for Level 2 Scenario and 20% for Collaboration Scenario compared to Baseline Scenario
Case B–STCA to be implemented in existing ATM system	No cost reduction for Level 2 Scenario and 20% for Collaboration Scenario compared to Baseline Scenario
Case C-STCA in system but not in operational use	No cost reduction for Level 2 Scenario and 20% for Collaboration Scenario compared to Baseline Scenario
Case D-STCA complies with EUROCONTROL standards	No cost for all scenarios

Table 4-11 STCA tuning summary

Training

4.6.14 Operational training will constitute a large portion of the costs for the deployment of an STCA tool as it involves all of the ATCOs who will be exposed to the STCA.

Baseline Scenario

4.6.15 It is not anticipated that there will be any significant difference between the effort required for the Baseline and Level 2 Scenarios for Cases A through C. This is because the ATCOs will have no experience of operating with an STCA.

Level 2 and Collaboration Scenarios

4.6.16 For Case D, we assume that any changes made will require ATCO training as a minimum to ensure ATCO adherence to changes in policy and procedures. Hence, the training effort will still be required. However, it will be less than for Cases A to C as ATCOs will not need as much instruction or simulation in the basics of the STCA as they are familiar with using STCA. We estimate the effort will be reduced by 90% compared to the other cases.

4.6.17 As each unit has varying numbers of ATCOs and training support staff, a number of assumptions are required to estimate effort. The 'generic' unit modelled for the training component is as follows:

- 420 ATCOs that require the training;
- each ATCO to complete 1 day of training including both classroom and simulation;
- access to additional support and training staff.

	Assumptions
Case A–STCA to be included in new ATM system	No cost reduction for Level 2 Scenario or Collaboration Scenario compared to Baseline Scenario
Case B–STCA to be implemented in existing ATM system	No cost reduction for Level 2 Scenario or Collaboration Scenario compared to Baseline Scenario
Case C-STCA in system but not in operational use	No cost reduction for Level 2 Scenario or Collaboration Scenario compared to Baseline Scenario
Case D-STCA complies with EUROCONTROL standards	No cost for the Baseline Scenario. Cost is 10% of other cases for the Level 2 and Collaboration Scenarios

Table 4-12 Training summary

4.7 Ongoing maintenance and support

4.7.1 We have also taken the ongoing cost of maintaining and analysing the performance of the STCA into account. We assume that the unit will have one member of staff working full-time (250 days) to ensure that correct functioning of the system and to ensure that any problems with the system performance are reviewed at an early stage.

4.7.2 We consider this figure equal for Cases A and B. For Cases C and D the ANSPs should have support focussed on the operation and analysis of the existing STCA. Therefore, we assume that there is no additional cost for these units. However, for Case D there is the potential for some effort saving if the analysis of the STCA performance and the ongoing STCA support is carried in collaboration with other ANSPs in terms of sharing lessons learnt. In this case, there might be some additional benefit, however we have not estimated it at this stage.

	Assumptions
Case A–STCA to be included in new ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case B–STCA to be implemented in existing ATM system	No cost reduction for Level 2 or Collaboration Scenarios
Case C-STCA in system but not in operational use	No cost reduction for Level 2 or Collaboration Scenarios
Case D-STCA complies with EUROCONTROL standards	No cost reduction for Level 2 or Collaboration Scenarios

Table 4-13 Ongoing maintenance and support summary

4.8 Project risk

4.8.1 The estimates quoted above are estimates that have been validated by ANSPs and industry, however there is also a level of risk associated when implementing a new system.

4.8.2 Risk can have a number of effects, including:

- The project over-running in terms of timescale and effort. This can be through unforeseen complications or underestimations of effort;
- A reduction in the effectiveness of a system through a poorly planned and executed implementation.

4.8.3 The Level 2 Standards for STCA will potentially reduce both of these risk factors. The EUROCONTROL guidelines provide further information to assist with the implementation and tuning of the STCA to ensure that it works effectively. These guidelines will help to reduce the amount of effort required to plan and implement an effective STCA.

4.8.4 The standards produced by EUROCONTROL provide the specification for the Level 2 STCA, ensuring that the system is an effective safety net.

4.8.5 The estimated risk factors associated with the cost items defined in Table 8-1 to Table 8-3 are shown in the annexes with reduced uncertainty in cost for the Level 2 Scenario and the Collaboration Scenario.

4.8.6 The research and development phase of STCA implementation is a key to its success. Time lost at this stage of STCA implementation can have major implications for the overall outcome of the project, both in terms of quality of the project and overall cost of the project. It is at this stage of Level 2 STCA implementation that the EUROCONTROL standards and guidelines will provide the greatest benefits in terms of reducing the risk of project over-run and ensuring the STCA is highly effective.

4.8.7 Full details of the estimation of project risks are included in Annex C to this report.

5 STCA geographic coverage

5.1 Introduction

5.1.1 A major qualitative benefit of achieving ECAC-wide implementation of STCA is a potential increase in safety. The sole purpose of STCA is to enhance the safety of the ATM system by alerting air traffic controllers to infringements or potential infringements of specified separation minima.

5.2 Flight hours controlled supported by STCA

5.2.1 Figure 5-1 shows the percentage of flight hours controlled with and without the support of STCA. In 2003, between 10 and 20 percent of flight hours in the region analysed were controlled without the support of STCA. This figure does not account for those units that have an STCA implemented but are not using it operationally, or are not using it in accordance with EUROCONTROL specifications. Therefore, this figure of 10-20% is likely to be a minimum.

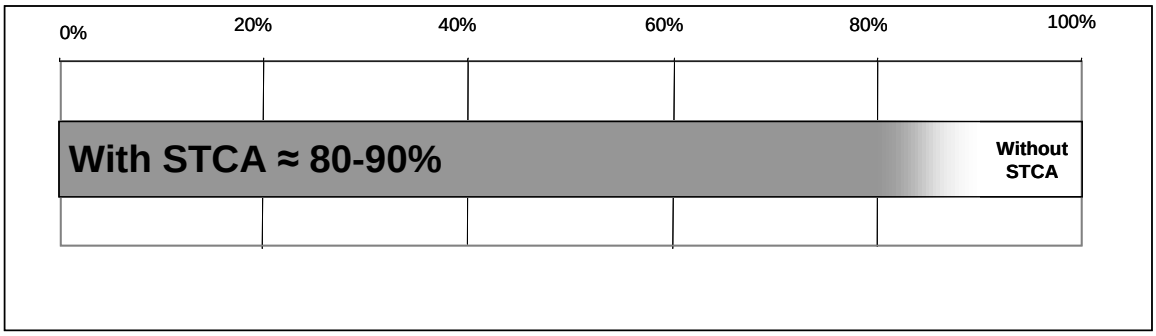

Figure 5-1 Flight hours controlled supported by STCA

5.2.2 There are several reasons why a system such as Level 2 STCA should be implemented:

1) It is a European requirement. Implementing Level 2 STCA is now an agreed pan-European ECIP objective (See Ref: 9).

2) It offers safety benefits. Having an operational and effective Level 2 STCA, ie a system that meets the European required performance objectives, means that controllers gain from having a high probability of getting alerts about potential mid-air collisions, without also getting too many false alarms. This enhances safety, and thus helps to bring the ANSP concerned up to European 'best practice'.

3) Organisations will be exposed to increased business risk without it. Not having a Level 2 STCA means that there are risks in the unimproved ATC system that could have been reduced, or eliminated, by reasonably practicable means. The key point is that the improvement costs would be insignificant compared with the total costs of RDP and FDP systems. In the event of a mid-air collision, an ANSP that had made the decision not to have STCA, or had neglected to consider such an option, would probably be considered to have a degree of culpability, and would be legally 'at fault'.

5.2.3 The increase in safety is mentioned in this report as a qualitative benefit.

6 Data analysis

6.1 Introduction

6.1.1 We have used a number of data sources to produce the economic assessment. These include:

- Performance Review Commission ACE 2003 Benchmarking Study (Ref: 11). This provides data for EUROCONTROL States regarding the number of ATCOs in operations, the number of sectors per unit and the number of flight hours controlled per unit.
- Various data sources to assess whether each individual unit has implemented STCA and the implementation Case (A, B, C or D) they fit into. Data sources include:
  - Local Convergence and Implementation Plans (LCIPs).
  - Literature searches. Both book and web based.
  - Incident reports.
  - ATM industry manufacturers.

6.1.2 Expert judgement, followed by validation with ANSPs and industry, has been used to estimate the different costs of implementing STCA for each of the deployment cases and scenarios for an illustrative unit.

6.1.3 This illustrative unit manages approximately 20 sectors with a mix of enroute airspace and TMA, with approximately 420 ATCOs.

6.2 Data limitations

6.2.1 The validation work has been crucial to ensure that ANSPs are represented correctly in this economic assessment.

6.2.2 It has been possible to identify whether a unit has STCA. However, it has not been possible to assess whether the STCA complies with EUROCONTROL specifications (Case D) or not (Case C). Therefore, in Section 7 we analyse the sensitivity of the results to the distribution of STCA systems between Cases C and D.

6.3 Summary of effort and costs

6.3.1 This section provides a summary of the estimated effort and costs for each unit to implement STCA for each of the deployment cases. These estimates are based on an illustrative ANSP, as described in paragraph 6.1.3.

6.3.2 Table 6-1 shows the effort and cost summary for a unit implementing Level 1 STCA (**Baseline Scenario**), with the unit achieving objective ATC02.1. The assumptions and calculations for this scenario are shown in Table 8-1.

	Baseline scenario			
	A	**B**	**C**	**D**
Project administration	162	173	126	0
Research and development	130	175	175	0
Procurement	719	719	497	0
Implementation	524	584	584	0
Ongoing maintenance	250	250	0	0
Total Effort (man days)	1785	1901	1382	0
Cost per man day (k)	€0.5	€0.5	€0.5	€0.5
Effort Cost (k)	€893	€951	€691	€0
Other costs				
System hardware (k)	€150	€150	€150	€0
Maintenance (over 10 years) (k)	€400	€400	€400	€0
Total Costs (k)	€1,443	€1,501	€1,241	€0

Table 6-1 Effort and cost summary for the Baseline Scenario

6.3.3 Table 6-2 shows the effort and cost summary for a unit implementing Level 2 STCA (**Level 2 Scenario**), with the unit achieving objective ATC02.2. The assumptions and calculations for this scenario are shown in Table 8-2.

	Level 2 Scenario			
	A	**B**	**C**	**D**
Project administration	158	165	99	5
Research and development	93	110	110	0
Procurement	719	719	313	0
Implementation	519	567	567	50
Ongoing maintenance	250	250	0	0
Total Effort (man days)	1739	1811	1089	55
Cost per man day	€0.5	€0.5	€0.5	€0.5
Effort Cost (k)	€870	€906	€544	€28
Other costs				
System hardware (k)	€150	€150	€150	€0
Maintenance (over 10 years) (k)	€400	€400	€400	€0
Total Costs (k)	€1,420	€1,456	€1,094	€28

Table 6-2 Effort and cost summary for the Level 2 Scenario

6.3.4 Table 6-3 shows the effort and cost summary for a unit implementing Level 2 STCA, through collaboration with other ANSPs (**Collaboration Scenario**), with the unit achieving objective ATC02.2. The assumptions and calculations for this scenario are shown in Table 8-3.

	Collaboration Scenario			
	A	**B**	**C**	**D**
Project administration	151	157	86	5
Research and development	73	90	90	0
Procurement	719	719	208	0
Implementation	517	565	560	50
Ongoing maintenance	200	200	0	0
Total Effort (man days)	1660	1731	944	55
Cost per man day (k)	€0.5	€0.5	€0.5	€0.5
Effort Cost (k)	€830	€866	€472	€28
Other costs				
System hardware (k)	€150	€150	€150	€0
Maintenance (over 10 years) (k)	€400	€400	€400	€0
Total Costs (k)	€1,380	€1,416	€1,022	€28

Table 6-3 Effort and cost summary for the Collaboration Scenario

6.4 Summary of implementation cases

6.4.1 The estimation of the effort and cost for a unit implementing STCA in the various scenarios focused on an illustrative unit, as defined in paragraph 6.1.2. This analysis has shown the items of cost a unit can expect to incur. However, despite some similarities in scale between ANSPs, they vary in size in terms of geographical area covered, number of flight hours controlled and number of ATCOs in operation.

6.4.2 Table 6-4 summarises the results for the units in this assessment. The data collected includes the number of ATCOs in operations, the number of flight hours controlled by each unit as well as the status of STCA implementation in that unit (Case A, B, C or D). We collected this information from a number of sources, as described in paragraph 6.1.1.

6.4.3 The data from units has been sorted into six groups according to the number of ATCOs in operations:

- over 300;
- 250 to 300;
- 200 to 249;
- 150 to 199;
- 80 to 149;
- under 80.

6.4.4 The data has then been split depending on the individual deployment cases within each group.

ATCOs in operations	Case	Sum of ATCOs in OPS	Thousands of flight hours controlled	Thousands of Flight hours not covered by STCA	Cost (€k)		
					Baseline Scenario	Level 2 Scenario	Collaboration Scenario
Under 80	A	286	183	183	7457	7196	6956
	B	125	117	117	5184	4908	4748
	C/D	589	670	0	0	63	63
80 to 149	A	578	478	478	6384	6167	5966
	B	305	375	129	3993	3787	3667
	C/D	1826	2101	0	0	132	132
150 to 199	A	0	0	0	0	0	0
	B	355	617	177	2738	2600	2520
	C/D	730	1033	0	0	47	47
200 to 249	A	0	0	0	0	0	0
	B	0	0	0	0	0	0
	C/D	653	809	0	0	41	41
250 to 299	A	0	0	0	0	0	0
	B	0	0	0	0	0	0
	C/D	1361	1294	0	0	81	81
Over 299	A	0	0	0	0	0	0
	B	0	0	0	0	0	0
	C/D	1708	2016	0	0	98	98
Totals		8516	9693	1084	25757	25119	24318

Table 6-4 Summary of results

6.4.5 The breakdown of the units per deployment case is shown in Figure 6-1.

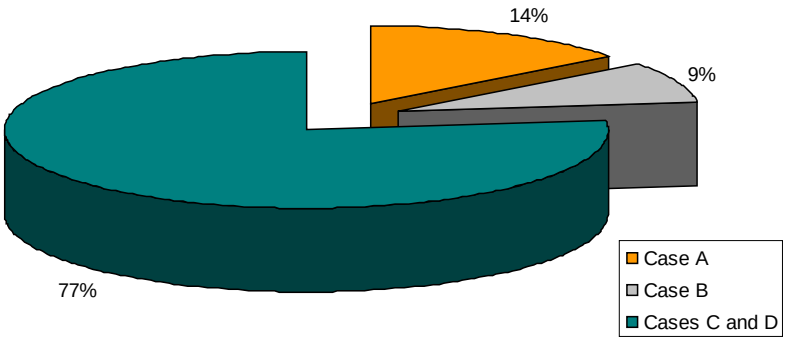

Figure 6-1 Number of units per deployment case

6.4.6 The majority of units (77%) fit into Cases C and D. This means that they have STCA implemented.

6.4.7 The study has not obtained enough information to distinguish between:

- units that have STCA and use it operationally and comply with EUROCONTROL standards (Case D), and
- units that have STCA but do not use it, or the STCA does not meet EUROCONTROL standards (Case C).

6.4.8 There is anecdotal evidence of STCA being 'switched off' in TMA environments. However, the STCA has remained in operational use in the corresponding enroute airspace.

6.4.9 The costs of implementing Level 2 STCA (Scenarios 2 and 3) are shown in Figure 6-2, relative to the Baseline Scenario.

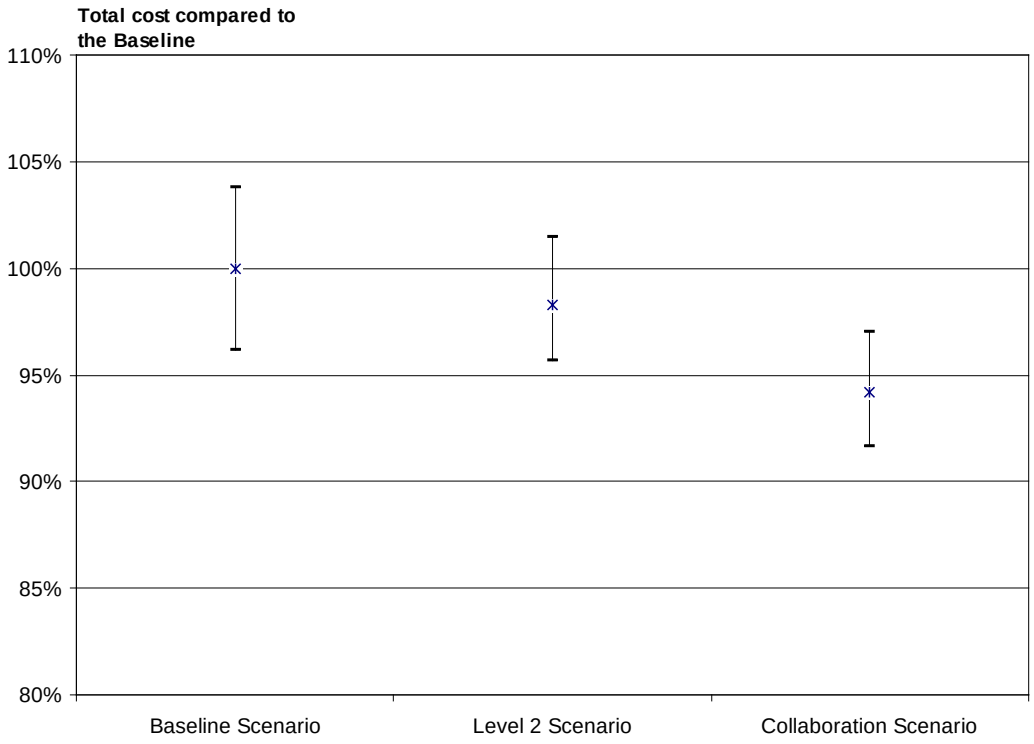

Figure 6-2 Overall cost summary per scenario

6.4.10 The results presented in Figure 6-2 show that the costs of implementing STCA in Europe in a standardised way (Level 2 Scenario) are nearly equal to the costs without standardisation. The potential financial benefits of standardisation are small, however the overall effectiveness of the STCA will increase significantly and project risks are also reduced.

6.4.11 Our estimates show that there is potentially a 6% saving from ANSPs achieving Level 2 STCA in collaboration with other ANSPs. This saving through collaboration has the potential to be greater, especially considering the recent news of the COOPANS agreement between Thales and ANSPs for collaborative upgrades for ATM systems.

6.4.12 Figure 6-3 below breaks down the costs according to the number of ATCOs in operations at the units.

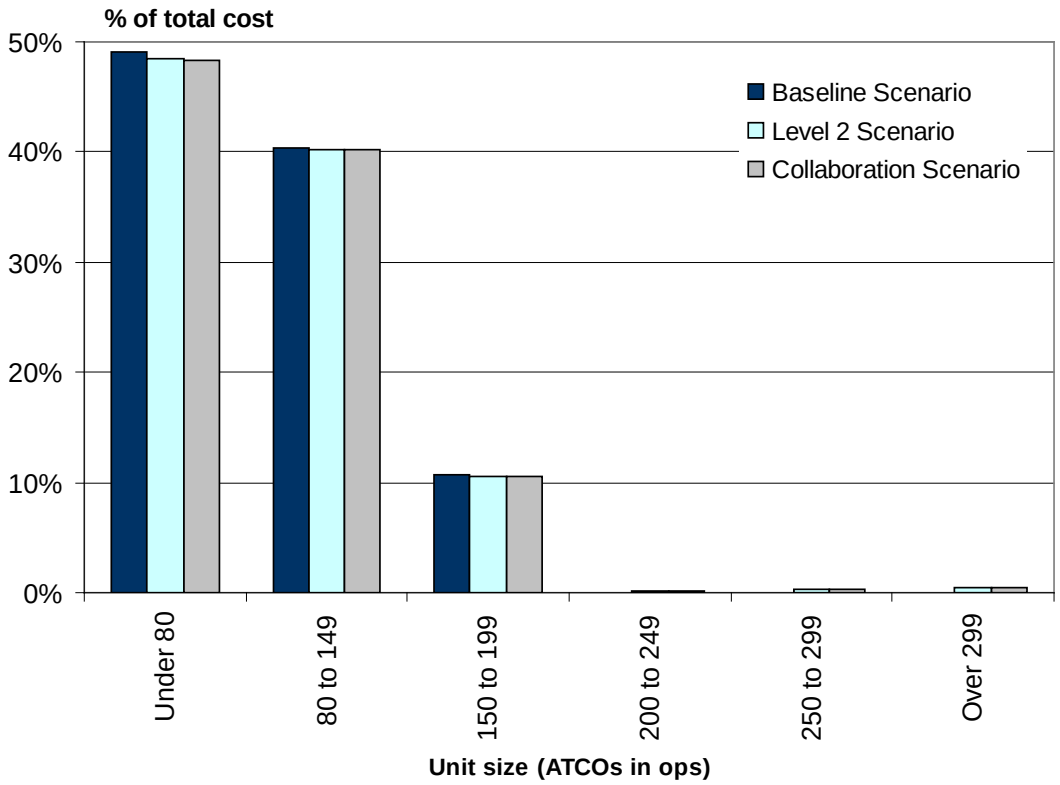

Figure 6-3 Overall cost summary per number of ATCOs in operations

6.4.13 Figure 6-3 shows that the majority of the costs of implementing STCA impact on smaller units (less than 150 ATCOs). These units have not yet implemented STCA.

6.4.14 The results also show that if the Baseline Scenario were adopted, all of the cost would be borne by smaller units.

7 Sensitivity analysis

7.1 Introduction

7.1.1 In this section, we analyse the sensitivity of the results presented.

7.1.2 In Section 6, we estimated that 77% of units have STCA included in the ATM system. However, it was not possible to split this figure between the two cases. In this section we present how the results of the economic assessment depend on the distribution of Case C and Case D.

7.1.3 We also present the uncertainties in costs of implementing STCA.

7.2 Impact of distribution between Cases C and D

7.2.1 We ran several simulations, each giving a result depending on the distribution of units that are in Cases C and D. The results in Section 6.4 show the outcome when 100% of the units in Case C and D are treated as Case D. This is a conservative assumption and provides the minimum benefit.

7.2.2 This analysis assesses the impact of different distributions between the two cases.

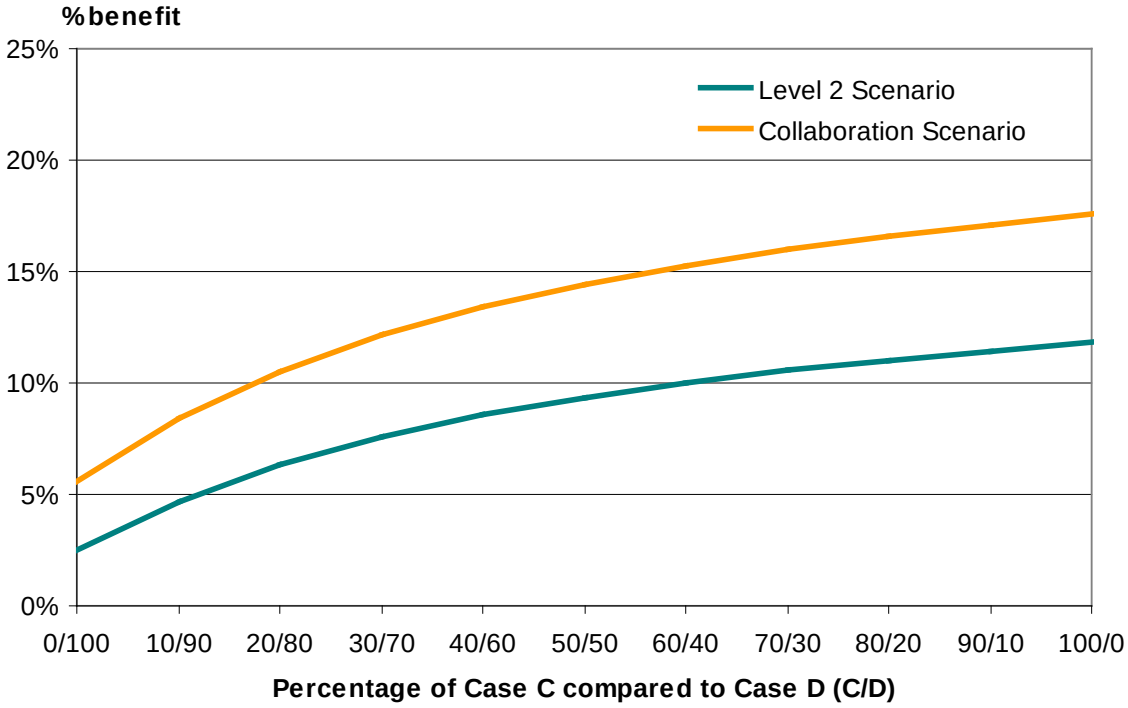

Figure 7-1 Impact of Case C/D distribution on the benefits

7.2.3 Figure 7-1 shows that as the percentage of units in Case C increases, so do the benefit of standardising STCA compared to the Baseline Scenario. If all STCA implementations are already compliant with Level 1 (and therefore technically compliant with Level 2 STCA) then the benefit is between 2.5% and 5.6% for standardisation, depending on the amount of collaboration.

7.2.4 This benefit increases to between 6.3% and 10.5% if 20% of units are in Case C and increases further to between 9.3% and 14.4% if half of the units are in Case C.

7.2.5 In summary, the results show that if a large percentage of current STCA systems already comply with the EUROCONTROL specification then the financial benefits of standardising STCA are potentially small. However, as the percentage of systems that do not comply increases so do the financial benefits. This is because the units that do comply incur a small cost to ensure that they comply fully with the specifications, whereas those that do not comply derive a reduction in costs.

7.2.6 The consequence is that these units incur no cost in the Baseline Scenario, but incur a cost for the Level 2 Scenario. Hence, when the number of these Case D units is reduced the benefits of the Level 2 Scenario increase.

7.3 Impact of project uncertainty

7.3.1 In this section we analyse the sensitivity of the ECAC-wide cost of implementing standardised (Level 2) STCA to the individual costs groups.

Baseline Scenario

7.3.2 Figure 7-2 shows the sensitivity of the overall cost of achieving harmonised STCA throughout ECAC to the individual cost groups for the Baseline Scenario.

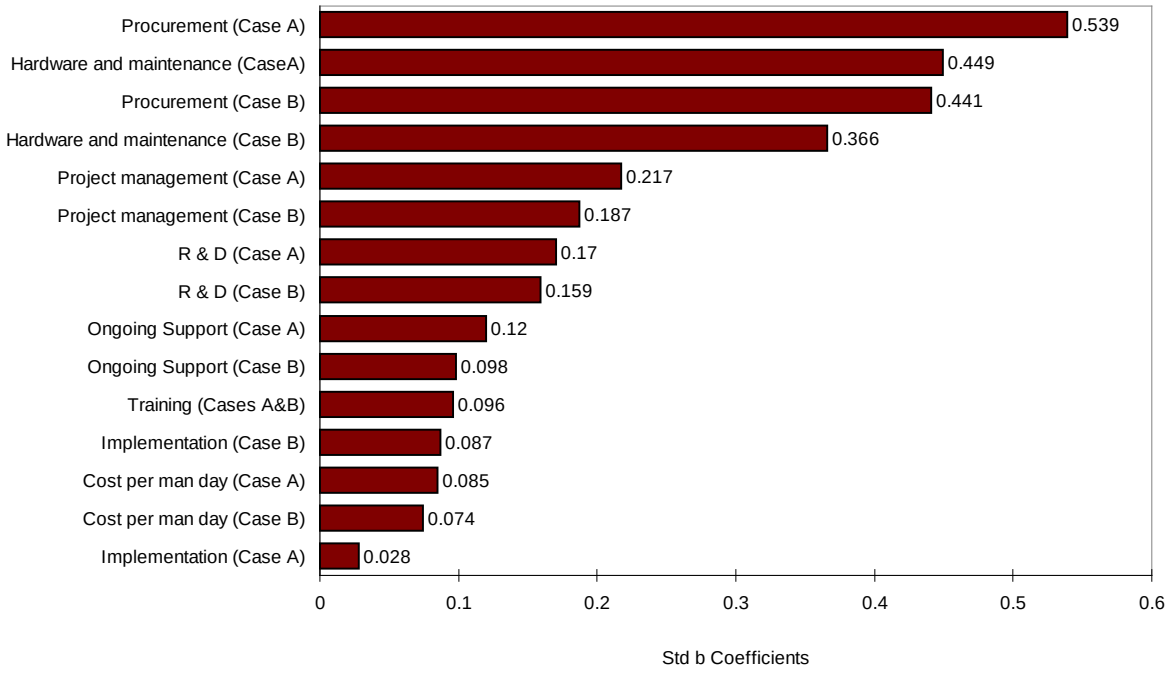

Figure 7-2 Sensitivity analysis – Baseline Scenario

7.3.3 For the Baseline Scenario it shows that the overall costs are most sensitive to the procurement costs and the hardware and maintenance costs for Cases A and B. For example, a one standard deviation increase in the procurement costs for units in Case A increases the total cost for the Baseline Scenario by 0.539 standard deviations.

Level 2 Scenario

7.3.4 Figure 7-3 shows the sensitivity of the overall cost of achieving harmonised STCA throughout ECAC to the individual cost groups for the Level 2 Scenario.

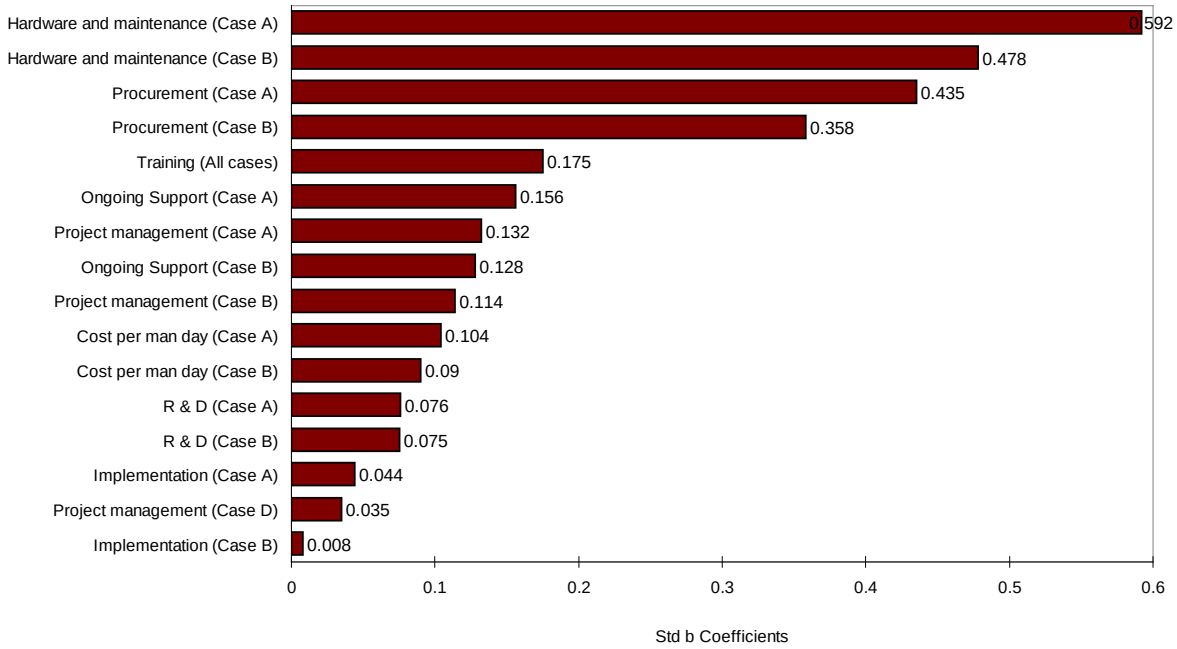

Figure 7-3 Sensitivity analysis – Level 2 Scenario

7.3.5 It shows that for the Level 2 Scenario the overall costs remain most sensitive to the procurement costs and the hardware and maintenance costs for those units who will implement a new STCA (Cases A and B). It also shows a slight reduction in the sensitivity of the costs to the cost of procurement for Cases A and B compared to the Baseline. This is due to a reduction in the uncertainty in effort of adapting the STCA to the local site and testing the STCA.

Collaboration Scenario

7.3.6 Figure 7-4 shows the sensitivity of the overall cost of achieving harmonised STCA throughout ECAC to the individual cost groups for the Collaboration Scenario.

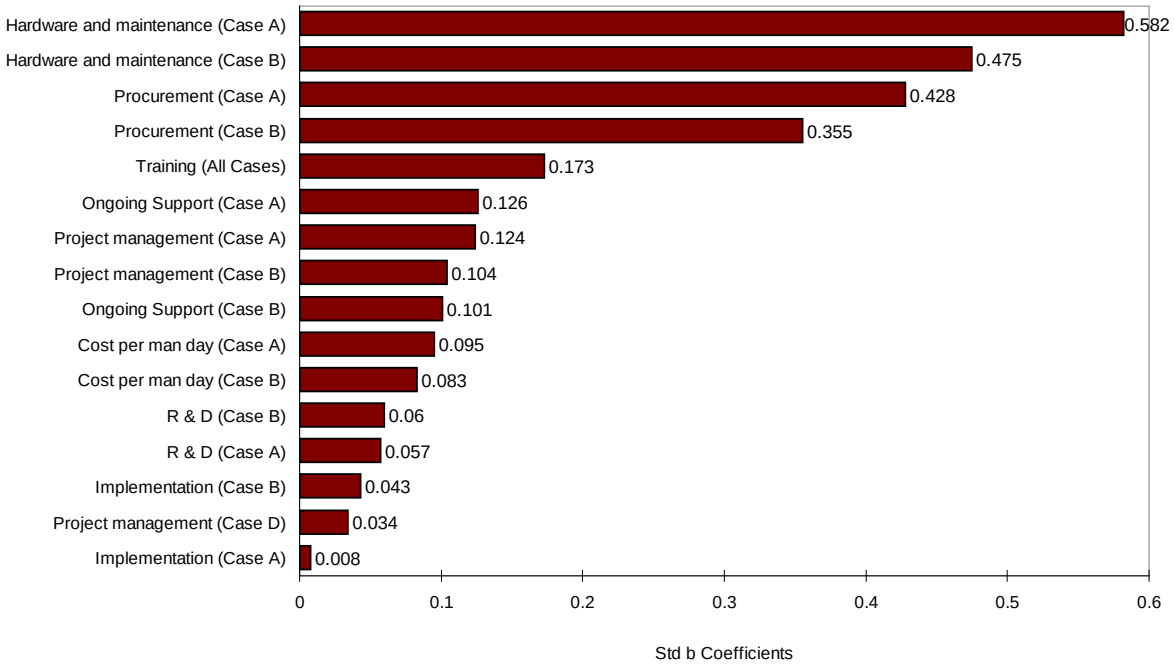

Figure 7-4 Sensitivity analysis – Collaboration Scenario

7.3.7 The results are similar to the Level 2 Scenario, with the main difference being due to a reduction in effort for research and development activities. However, the sensitivity of this to the overall costs is small and so the impact is negligible.

8 Conclusions

8.1 Basis for conclusion

8.1.1 The results of this study are based on the expert judgement of the project team and EUROCONTROL and have been reviewed and validated by ANSPs and industry.

8.2 Drivers for standardisation

8.2.1 The over-riding driver for standardising STCA is to increase the level of safety in European airspace. We have not attempted to 'put a price on safety', but have provided evidence that there are economic benefits from adopting a standardisation approach. The benefit comes from reducing the effort and risk of implementation and is due to the provision of EUROCONTROL standards and guidance material.

8.2.2 This economic assessment has identified the reduction in effort required for the research and development phase of STCA implementation as a major driver for standardisation for ANSPs. The research and development phase of STCA implementation is a key to its success. Time lost at this stage of STCA implementation can have major implications for the overall outcome of the project, both in terms of quality of the project and overall cost of the project. The EUROCONTROL guidelines provide support and help to reduce project risks and effort required during this phase.

8.2.3 Based on the current level of documentation for a Level 2 STCA this could be in the order of a 50% saving in the concept development work. However, validation activities would still be required to fine-tune the concept to the local environment.

8.2.4 There is also an associated reduction in the effort required for project management. This is due to the overall reduction in effort required to carry out the implementation, and hence a reduced requirement for project management.

8.2.5 The procurement aspect of STCA implementation has proved to be a difficult area to assess. This study has not indicated any benefit in the cost of procuring Level 2 STCA, other than to reduce the uncertainty of adapting the system to local conditions. There are other potential benefits, however these have been difficult to assess due to the sensitivity of commercial data.

8.2.6 There may also be potential for greater savings through collaboration and joint procurement. The recent COOPANS agreement between ANSPs and Thales is thought to have resulted in cost reduction through collaboration with other ANSPs for upgrading ATM systems. Although not a major driver, the possibility of an ANSP collaborating with other ANSPs is worth considering when procuring STCA.

8.3 Cost reductions

8.3.1 The analysis has shown that, despite conservative assumptions, there is a modest financial benefit from implementing STCA Level 2 compared to implementing Level 1 STCA. The Level 2 Scenario provides a 2% cost reduction over the Baseline Scenario and the Collaboration Scenario provides a 6% cost reduction over the Baseline Scenario. As stated above, the cost reduction from inter-ANSP collaboration may be greater but is not investigated further at this stage.

8.4 Sensitivities

8.4.1 This study was unable to identify the units in which STCA was included in the ATM system but was not compliant with EUROCONTROL specifications. Therefore, we presented a sensitivity analysis to assess how this might affect the benefits of implementing Level 2 STCA.

8.4.2 The analysis showed that as the number of units that do not comply with EUROCONTROL specifications increase, so does the benefit. For the Level 2 Scenario the benefits rise from 2% to 6% if one-fifth of STCA systems within ECAC do not comply with the EUROCONTROL standards. This rises to 9% if half of STCA systems do not comply.

8.4.3 The analysis also showed that the total costs for STCA are most sensitive to the cost of procurement, hardware and maintenance; independent of scenario.

Annex A**References**

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Annex B **Scenario assumption summaries**

B.1 Cost breakdown summaries

B.1.1 Baseline Scenario

B.1.1.1 All assumptions have been validated by ANSPs and industry (where appropriate).

Effort Summary

Project administration

Project management:

10% of overall effort.

Research and Development

Requirements analysis:

Based on expert judgement, from knowledge of amount of requirement development needed. Identical for each case.

Design Safety Case:

Based on expert judgement, from knowledge of typical safety case. Case A lower because STCA safety case occurs in parallel to other ATC safety case designs.

Procedure Development:

Based on expert judgement, from knowledge of amount of procedure development needed. Identical for each case.

Procurement

Code:

Based on expert judgement, from knowledge of amount of code needed. Code expected to be implemented at 15 lines per day. Case C lower because existing code is modified.

Estimated code per ATC component:

- STCA – 5 000 lines
- ADAPT – 100 lines
- HMI – 1 000 lines
- FDP – 100 lines
- RECAP – 500 lines

Site adaptation:

Based on expert judgement, from knowledge of nature of local modifications. Similar for all cases.

Testing:

Based on expert judgement, from knowledge of amount of testing required. Identical for each case.

Implementation STCA Tuning: Based on expert judgement with the major driver being the complexity of airspace. Identical for each case. Implementation Safety Case: Based on expert judgement, from knowledge of typical safety case. Case A lower because STCA safety case occurs in parallel to other ATC safety case designs. Operational Validation: Based on expert judgement, from knowledge of typical validation work. Case A lower because STCA operational validation occurs in parallel to ATC system validation. Training: Based on expert judgement, from knowledge of ATM training. Identical for each case.
Ongoing Support and Maintenance Same for Cases A and B. Based on one man supporting the ongoing support and maintenance of the STCA, including analysis of the performance to optimise the STCA and to identify any shortcomings at an early stage. There is no cost associated with this for Case C and D as unit is deemed to be carrying out this support already.
Cost Summary
Hardware System Hardware: EUROCONTROL figures, estimated at €150 000, for all cases. Maintenance: EATCHIP figures, estimated at €400 000 over ten years, for all cases.
Effort Man Days Effort: Estimated to be highest for Case B. Man Days Cost: Estimated at €500 per man day.

Table 8-1 Summary of the Baseline Scenario cost analysis

B.1.2 Level 2 Scenario

B.1.2.1 All assumptions have been validated by ANSPs and industry (where appropriate).

Effort Summary

Project administration

Project management:

10% of overall effort.

Research and Development

Requirements analysis:

Based on expert judgement, from knowledge of amount of requirement development needed. Cases A, B and C are identical because level of analysis is the same for unused and new systems. No effort is required for Case D because the existing STCA will comply with the Level 2 technical specifications.

Design Safety Case:

Based on expert judgement, from knowledge of typical safety case. Case A has a low figure because STCA safety case occurs in parallel to other ATC safety case designs. No effort is required for Case D.

Procedure Development:

Based on expert judgement, from knowledge of amount of procedure development needed. Cases A, B and C are identical because development required is the same for unused and new systems. No effort is required for Case D because the existing STCA will comply with the Level 2 technical specifications.

Procurement

Code:

Based on expert judgement, from knowledge of amount of code needed. Code expected to be implemented at 15 lines per day. Case C is lower because existing code is modified.

Estimated code per ATC component:

- STCA – 5 000 lines
- ADAPT – 100 lines
- HMI – 1 000 lines
- FDP – 100 lines
- RECAP – 500 lines

No effort is required for Case D.

Site adaptation:

Based on expert judgement, from knowledge of nature of local modifications. Case C is lower because an existing STCA system is upgraded. No effort is required for Case D.

Testing:

Based on expert judgement, from knowledge of amount of testing required. Similar for Cases A, B and C. No effort is required for Case D.

Implementation

STCA Tuning:

Based on expert judgement, with an estimated reduction of 50% of the effort which is required in the Baseline Scenario due to the provision of a standard safety case provided by EUROCONTROL. No effort is required for Case D.

Implementation Safety Case:

Based on expert judgement, from knowledge of typical safety case. Case A lower because STCA safety case occurs in parallel to other ATC safety case designs. No effort is required for Case D because existing STCA safety cases are technically Level 2 compliant.

Operational Validation:

Based on expert judgement, from knowledge of typical validation work. Cases B and C are identical because a newly-activated system requires same level of validation regardless whether new or not. Case A is much lower because operational validation occurs in parallel to ATC system validation. No effort is required for Case D.

Training:

Based on expert judgement, from knowledge of ATM training. Identical for Cases A, B and C, lower for Case D as ATCOs will already have operational experience.

Ongoing Support and Maintenance

Same for Cases A, B and C. Based on one man supporting the ongoing support and maintenance of the STCA, including analysis of the performance to optimise the STCA and to identify any shortcomings at an early stage.

There is no cost associated with this for Case D as unit is technically compliant and is deemed to be carrying out this support already.

Cost Summary

Hardware

System Hardware: EUROCONTROL figures, estimated at €150 000, for all cases.

Maintenance: EATCHIP figures, estimated at €400 000 over ten years, for all cases.

Effort

Man Days Effort: Estimated to be highest for Case B and much lower for Case D.

Man Days Cost: Estimated at €500 per man day.

Table 8-2 Summary of the Level 2 Scenario cost analysis

B.1.3 Collaboration Scenario

B.1.3.1 All assumptions have been validated by ANSPs and industry (where appropriate).

Effort Summary

Project administration

Project management:

10% of overall effort.

Research and Development

Requirements analysis:

Based on expert judgement, from knowledge of amount of requirement development needed. Cases A, B and C are identical because level of analysis will be the same for unused and new systems. Case D is lower because this is an STCA upgrade.

Design Safety Case:

Based on expert judgement, from knowledge of typical safety case. Case A has a low figure because STCA safety case occurs in parallel to other ATC safety case designs. No effort is required for Case D.

Procedure Development:

Based on expert judgement, from knowledge of amount of procedure development needed. Cases A, B and C are identical because development required is the same for new and unused systems. No effort is required for Case D because the existing STCA will comply with the Level 2 technical specifications.

Procurement

Code:

Based on expert judgement, from knowledge of amount of code needed. Code expected to be implemented at 15 lines per day. Case C is lower because existing code is modified.

Estimated code per ATC component:

- STCA – 5 000 lines
- ADAPT – 100 lines
- HMI – 1 000 lines
- FDP – 100 lines
- RECAP – 500 lines

No effort is required for Case D.

Site adaptation:

Based on expert judgement, from knowledge of nature of local modifications. Case C is lower because an existing STCA system is upgraded. No effort is required for Case D.

Testing:

Based on expert judgement, from knowledge of amount of testing required. Identical for each case. No effort is required for Case D.

Implementation

STCA Tuning:

Based on expert judgement, with an estimated reduction of 50% of the effort which is required in the Baseline Scenario due to the provision of a standard safety case provided by EUROCONTROL. No effort is required for Case D.

Implementation Safety Case:

Based on expert judgement, from knowledge of typical safety case. Case A lower because STCA safety case occurs in parallel to other ATC safety case designs. No effort is required for Case D.

Operational Validation:

Based on expert judgement, from knowledge of typical validation work. Case A is much lower because operational validation occurs in parallel to ATC system validation. No effort is required for Case D.

Training:

Based on expert judgement, from knowledge of the amount of training required. Identical for each case. Lower for Case D as ATCOs will already have operational experience.

Ongoing Support and Maintenance

Same for Cases A, B and C. Based on one man supporting the ongoing support and maintenance of the STCA, including analysis of the performance to optimise the STCA and to identify any shortcomings at an early stage.

There is no cost associated with this for Case D as unit is technically compliant and is deemed to be carrying out this support already.

Cost Summary

Hardware

System Hardware:

EUROCONTROL figures, estimated at €150 000, for all cases.

Maintenance:

EATCHIP figures, estimated at €400 000 over ten years, for all cases.

Effort

Man Days Effort: Estimated to be highest for Case B and much lower for Case D.

Man Days Cost: Estimated at €500 per man day.

Table 8-3 Summary of the Collaboration Scenario cost analysis

Annex C**Cost tables**

C.1 Case A - This represents those ANSPs that have not implemented an STCA but will include it as part of a new ATC system design from the beginning

	Baseline Scenario			**Level 2 Scenario**			**Collaboration scenario**		
	Min	Base	High	Min	Base	High	Min	Base	High
Project Management	146	162	211	142	158	174	136	151	166
Project administration Subtotal	146	162	211	142	158	174	136	151	166
Operational Concept + Reqs	45	50	65	14	15	17	9	10	11
Validation (e.g. FTS)	23	25	33	23	25	28	23	25	28
Design Safety Case	5	5	7	3	3	3	3	3	3
Procedure Development	45	50	65	45	50	55	32	35	39
R&D Subtotal	118	130	170	85	93	103	67	73	81
STCA	314	330	347	314	330	347	314	330	347
HMI	62	65	68	62	65	68	62	65	68
ADAPT	7	7	7	7	7	7	7	7	7
FDP	7	7	28	7	7	28	7	7	28
RECAP	33	35	37	33	35	37	33	35	37
Site adaptation	209	220	286	209	220	242	209	220	242
Testing	52	55	72	52	55	58	52	55	58
Procurement Subtotal	684	719	845	684	719	787	684	719	787
STCA Tuning	9	10	13	7	8	9	5	6	7
Implementation Safety Case	5	5	7	3	3	3	3	3	3
Operational Validation	5	5	7	4	4	4	4	4	4
Training	454	504	554	454	504	554	454	504	554
Implementation Subtotal	473	524	581	468	519	570	466	517	568
System hardware	135	150	165	135	150	165	135	150	165
Maintenance (over 10 years)	380	400	420	380	400	420	380	400	420
Hardware and maintenance Subtotal	515	550	585	515	550	585	515	550	585
Ongoing Support Subtotal	238	250	275	238	250	275	190	200	220
Cost per man day	495	500	505	495	500	505	495	500	505
Number of Man Days	1659	1785	2082	1617	1739	1909	1543	1660	1822
Effort Cost Subtotal	821	893	1051	800	870	964	764	830	920
Total Cost	1336	1443	1636	1315	1420	1549	1279	1380	1505

C.2 Case B – This represents those ANSPs that have not implemented an STCA yet and will implement one as part of an existing ATC system.

	Baseline Scenario			Level 2 Scenario			Collaboration scenario		
	Min	Base	High	Min	Base	High	Min	Base	High
Project Management	156	173	225	148	165	181	142	157	173
Project administration Subtotal	156	173	225	148	165	181	142	157	173
Operational Concept + Reqs	45	50	65	14	15	17	9	10	11
Validation (e.g. FTS)	23	25	33	23	25	28	23	25	28
Design Safety Case	45	50	65	18	20	22	18	20	22
Procedure Development	45	50	65	45	50	55	32	35	39
R&D Subtotal	158	175	228	100	110	122	82	90	100
STCA	314	330	347	314	330	347	314	330	347
HMI	62	65	68	62	65	68	62	65	68
ADAPT	7	7	7	7	7	7	7	7	7
FDP	7	7	28	7	7	28	7	7	28
RECAP	33	35	37	33	35	37	33	35	37
Site adaptation	209	220	286	209	220	242	209	220	242
Testing	52	55	72	52	55	58	52	55	58
Procurement Subtotal	684	719	845	684	719	787	684	719	787
STCA Tuning	9	10	13	7	8	9	5	6	7
Implementation Safety Case	18	20	26	9	10	11	9	10	11
Operational Validation	45	50	65	41	45	50	41	45	50
Training	454	504	554	454	504	554	454	504	554
Implementation Subtotal	526	584	658	511	567	624	509	565	622
System hardware	135	150	165	135	150	165	135	150	165
Maintenance (over 10 years)	380	400	420	380	400	420	380	400	420
Hardware and maintenance Subtotal	515	550	585	515	550	585	515	550	585
Ongoing Support Subtotal	238	250	275	238	250	275	190	200	220
Cost per man day	495	500	505	495	500	505	495	500	505
Number of Man Days	1762	1901	2231	1681	1811	1989	1607	1731	1902
Effort Cost Subtotal	872	951	1127	832	906	1004	795	866	961
Total Cost	1387	1501	1712	1347	1456	1589	1310	1416	1546

C.3 Case C - This represents those ANSPs that have deployed an STCA which, however, is not in full operational use throughout all their ATC sectors (including Enroute airspace and TMA) and/or does not comply with Level 2 specifications.

	Baseline Scenario			**Level 2 Scenario**			**Collaboration scenario**		
	Min	Base	High	Min	Base	High	Min	Base	High
Project Management	113	126	163	89	99	109	77	86	94
Project administration Subtotal	113	126	163	89	99	109	77	86	94
Operational Concept + Reqs	45	50	65	14	15	17	9	10	11
Validation (e.g. FTS)	23	25	33	23	25	28	23	25	28
Design Safety Case	45	50	65	18	20	22	18	20	22
Procedure Development	45	50	65	45	50	55	32	35	39
R&D Subtotal	158	175	228	100	110	122	82	90	100
STCA	157	165	173	78	83	87	39	41	43
HMI	31	33	34	15	16	17	8	8	9
ADAPT	3	4	4	2	2	2	1	1	1
FDP	3	4	14	2	2	8	1	1	4
RECAP	17	18	18	8	9	9	4	4	5
Site adaptation	209	220	286	139	147	161	93	98	108
Testing	52	55	72	52	55	58	52	55	58
Procurement Subtotal	472	497	601	296	313	342	198	208	228
STCA Tuning	9	10	13	7	8	9	5	6	7
Implementation Safety Case	18	20	26	9	10	11	9	10	11
Operational Validation	45	50	65	41	45	50	36	40	44
Training	454	504	554	454	504	554	454	504	554
Implementation Subtotal	526	584	658	511	567	624	504	560	616
System hardware	135	150	165	135	150	165	135	150	165
Maintenance (over 10 years)	380	400	420	380	400	420	380	400	420
Hardware and maintenance Subtotal	515	550	585	515	550	585	515	550	585
Ongoing Support Subtotal	0	0	0	0	0	0	0	0	0
Cost per man day	495	500	505	495	500	505	495	500	505
Number of Man Days	1269	1382	1650	996	1089	1197	861	944	1038
Effort Cost Subtotal	628	691	833	493	544	604	426	472	524
Total Cost	1143	1096	1418	1008	1094	1189	941	1022	1109

C.4 Case D – This represents those ANSPs that have deployed an STCA which is in operational use through all their sectors (including Enroute airspace and TMA) and complies with STCA Level 1 specifications.

	Baseline Scenario			Level 2 Scenario			Collaboration scenario		
	Min	Base	High	Min	Base	High	Min	Base	High
Project Management	0	0	0	4	5	6	4	5	6
Project administration Subtotal	0	0	0	4	5	6	4	5	6
Operational Concept + Reqs	0	0	0	0	0	0	0	0	0
Validation (e.g. FTS)	0	0	0	0	0	0	0	0	0
Design Safety Case	0	0	0	0	0	0	0	0	0
Procedure Development	0	0	0	0	0	0	0	0	0
R&D Subtotal	0	0	0	0	0	0	0	0	0
STCA	0	0	0	0	0	0	0	0	0
HMI	0	0	0	0	0	0	0	0	0
ADAPT	0	0	0	0	0	0	0	0	0
FDP	0	0	0	0	0	0	0	0	0
RECAP	0	0	0	0	0	0	0	0	0
Site adaptation	0	0	0	0	0	0	0	0	0
Testing	0	0	0	0	0	0	0	0	0
Procurement Subtotal	0	0	0	0	0	0	0	0	0
STCA Tuning	0	0	0	0	0	0	0	0	0
Implementation Safety Case	0	0	0	0	0	0	0	0	0
Operational Validation	0	0	0	0	0	0	0	0	0
Training	0	0	0	45	50	55	45	50	55
Implementation Subtotal	0	0	0	45	50	55	45	50	55
System hardware	0	0	0	0	0	0	0	0	0
Maintenance (over 10 years)	0	0	0	0	0	0	0	0	0
Hardware and maintenance Subtotal	0	0	0	0	0	0	0	0	0
Ongoing Support Subtotal	0	0	0	0	0	0	0	0	0
Cost per man day	495	500	505	495	500	505	495	500	505
Number of Man Days	0	0	0	49	55	61	49	55	61
Effort Cost Subtotal	0	0	0	24	28	31	24	28	31
Total Cost	0	0	0	24	28	31	24	28	31