EUROPEAN ORGANISATION
FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

METHODOLOGY REPORT FOR A

SAFETY TARGET ACHIEVEMENT ROADMAP (STAR)

Issued: 10th May 2007

REPORT DOCUMENTATION PAGE

Reference:	**Security Classification:** Unclassified
Originator: EEC - **RMS**	**Originator (Corporate Author) Name/Location:** EUROCONTROL Experimental Centre Centre de Bois des Bordes B.P.15 F - 91222 Brétigny-sur-Orge Cedex FRANCE Telephone: +33 (0)1 69 88 75 00
Sponsors: **Directorate of ATM Programmes - Safety Enhancement (DAP/SSH)** **EEC Mid-Term Validation (MTV)**	**Sponsor (Contract Authority) Name/Location:** EUROCONTROL Agency 96, Rue de la Fusée B-1130 Brussels Telephone: +32 2 729 90 11 WEB Site: www.eurocontrol.int

TITLE:

MAIN REPORT FOR THE 2005/2012 INTEGRATED RISK PICTURE FOR AIR TRAFFIC MANAGEMENT IN EUROPE

Prepared by	Date	Pages	Figures	Tables	Annexes	References
Graham VERNON (DNV) Eric Perrin (EEC)	10/05/07	xviii+19	8	1	0	1

EEC Contact	Project	Task No. Sponsor	Period
Eric Perrin (EEC)	IRP_STAR		April-Dec 2006

Distribution Statement:

(a) Controlled by: Head of SRT
(b) Special Limitations: None
(c) Copy to NTIS: ~~YES~~ / NO

Descriptors (keywords):

Integrated Risk Picture, STAR

Abstract:

The present report consists of an outline of the methodology of the STAR Tool that is attached to the IRP. The methodology has been applied to the IRP and some initial results are presented, but the main objective of the present report is to verify the methodology.

The methodology has been implemented in the form of an Excel tool (i.e. the STAR version of IRP), an early version of which is available for user testing together with this report. The Roadmap itself will be generated through an optimisation process making use of the STAR Tool.

Management Summary

In parallel with the future generation of Air Traffic Management (ATM) (SESAR, NextGen) and logical architecture development, a roadmap for achieving the safety improvements is required. It will show how and when the different pieces of the future system have to fall into place and highlights a safety-informed transition from now onwards till the end state (□2020), underscoring the expected safety benefits along the way. During 2004 and 2005, EUROCONTROL and the US FAA constructed an Integrated Risk Picture (IRP), showing the overall contribution of Air Traffic Management (ATM) to aviation accident risks, and highlighting possible interdependencies, so that the priorities for safety improvements can be identified in a systematic way. In 2006 and the first quarter of 2007, EUROCONTROL improved the IRP risk modelling in the areas of target level of safety apportionment, safety impacts of ATM changes, uncertainty modelling and by the construction of a Safety Target Achievement Roadmap (STAR).

Indeed, previous versions of the IRP predicted the current and future risk, but was not optimized to show the changes in risk between these points (*i.e.* ATM as it is now and the end state of future CONOPS implementation) or to explore alternative implementation strategies to minimize risks. The first version of the STAR Tool now developed fills this conceptual gap by allowing the user to examine the relative merits of different implementation strategies. STAR is a particular version of the IRP into a tool that can show how risks will be affected as Operational Improvements (ATM Changes) are implemented and traffic grows, and to help optimize the implementation strategy from the safety point of view. Some changes will be implemented throughout large areas (e.g. ECAC-wide) at once, but most changes are likely to be introduced at some trial locations and then gradually spread until they are used in the maximum practical fraction of cases. Consequently, based on the set of changes that are being developed to sustain air transport growth, the STAR gives the overall risk profile for the years between 2005 and the end state as a set of risk measures presented for each of the accident categories. It also provides an integrated risk measure that is simply the total number of accidents in the whole period 2005-end state.

To summarize, the purpose of the STAR Tool is to allow its users to compare the influence of possible ATM Changes over time with the Targets for Safety that are mandated. The Tool provides a framework in which candidate ATM Changes can be weighed against each other in the context of the Integrated Risk Picture. Therefore, the STAR Tool could form part of the methodology for the achievement of strategic safety targets, but only together with due consideration for external factors such as the practicability of the candidate ATM Changes (especially the implementation time-tables) and cost-benefit analysis.

The report presents an outline of the methodology of the STAR Tool, concentrating on inputs and outputs. The methodology has been applied to the IRP and some initial results are also presented. Then, the paper also presents the further development of the Tool.

Contents

1. INTRODUCTION

1.1 Background

During 2004 and 2005, EUROCONTROL constructed an Integrated Risk Picture (IRP), showing the overall contribution of Air Traffic Management (ATM) to aviation accident risks, and highlighting possible interdependencies, so that the priorities for safety improvements can be identified in a systematic way.

EUROCONTROL now wishes to improve the IRP risk modelling in the areas of target level of safety apportionment, safety impacts of ATM, and by the construction of a Safety Target Achievement Roadmap (the STAR). The present report addresses the STAR, which forms Work Package 3 in the project.

For clarity, the current baseline risk picture is termed “IRP 2005” below, and the future predictions that were based on it are termed “IRP 2005/2012”. The improved version developed in the current project is termed “IRP 2006”, and future predictions to be based on it are termed “IRP 2006/2020”.

IRP 2005/2012 predicts the current and future risk, but is not optimised to show the changes in risk between these points or to explore alternative implementation strategies to minimise risks. The STAR Tool developed fills this conceptual gap by allowing the user to examine the relative merits of different implementation strategies.

1.2 Objectives

The objective of this part of the project is to develop a particular version of the IRP into a tool that can show how risks will be affected as Operational Improvements (ATM Changes) are implemented and traffic grows, and to help optimise the implementation strategy from the safety point of view. That version of the IRP has now been developed and is called the STAR Tool throughout this document.

The present report consists of an outline of the methodology of the STAR Tool that is attached to the IRP. The methodology has been applied to the IRP and some initial results are presented, but the main objective of the present report is to verify the methodology.

The methodology has been implemented in the form of an Excel tool (i.e. the STAR version of IRP), an early version of which is available for user testing together with this report. The Roadmap itself will be generated through an optimisation process making use of the STAR Tool.

1.3 Report Structure

This report contains the following:

- A high-level description of the STAR Tool, concentrating on the inputs and outputs. (Section 2).

- A detailed description of the methodology of the STAR Tool (Section 3). This Section includes a description of how the present Tool can be manipulated to model different ATM Change implementation strategies as well as a walk-through of the process whereby new candidate ATM Changes might be included into the STAR Tool.

- Some notes on the further development of the Tool and on how the Tool might be transported to other versions of the IRP. (Section 4).

2. OVERVIEW OF THE STAR TOOL

The **inputs** of the STAR Tool are:

- A set of ATM Changes. "ATM Changes" are the representation within IRP of Operational Improvements that are being developed as projects within EUROCONTROL.

- The present version of the STAR Tool includes a set of ATM Changes that is drawn from a combination of Appendix I and Reference 1 and users of the STAR Tool are able to select from that pre-defined list. However, the intention is that users who are conversant with the operation of the IRP and expert in the effect of ATM Changes will be able to add new candidate ATM Changes together with their effects on the IRP.

- The implementation profile for each ATM Change. The implementation profile refers to the growth of usage of that ATM Change with time in the ECAC region. Some changes (e.g. RVSM) are implemented throughout ECAC at once, but most changes (e.g. TBS) are likely to be introduced at some trial locations and then gradually spread until they are used in the maximum practical fraction of cases. The relevant fraction (e.g. fraction of movements, fraction of conflicts etc) is defined as part of the definition of ATM Changes. The user might define a linear implementation profile between specified dates of introduction and completion, or might specify fractional implementation for each year between 2006 and 2020.

- The risk measure required from the calculation. The user is able to select a risk measure that is one of the outputs from IRP. It might be fatal accident frequency or frequency of ATM direct contribution to ICAO accident, for instance. The possibility of using risk measures other than frequencies (e.g. the proportional contribution of ATM systems to overall accident frequency) will be considered in future work. At present, the Tool provides risk measures in terms of frequency of accidents (fatal or ICAO-defined) as annual frequencies or as frequencies per flight. These measures can be either the overall rate or just the ATM direct contribution to that rate.

- All other parameters that form inputs to IRP (e.g. traffic growth rates, safety nets switched on or off, flight phases etc).

The **outputs** of the STAR Tool are:

- The overall risk profile for the years 2005 to 2020. The profile is the set of risk measures selected by the user, calculated for each year between 2005 and 2020 and presented for each of the accident categories.

- An integrated risk measure. This is simply the total number of fatal accidents in the whole period 2005-2020. No explicit discounting to give weight to early risk reductions is done, although this metric will nevertheless naturally give a greater weight to early improvements because early implementation will result in an improved for a greater number of years. User optimisation of the ATM Changes could be done on the basis of this figure.

- The contribution of each ATM Change. The measure used is the difference in the fatal accident frequency per flight in 2020 that that ATM Change makes when all the other ATM Changes are turned off.

Desirable outputs, not part of the STAR Tool at present but to be included where practical in future versions, are:

- Confidence ranges in each output. These are very important but first require the methodology that has been developed in IRP 2006 to be applied to the complete set of IRP results. The STAR Tool will provide for including confidence ranges once IRP is able to deliver these.

- Interactions between ATM Changes. The interactions between ATM Changes that are modelled in IRP should be made plain to the user in future work.

- Sensitivity to implementation timescale. The sensitivity of overall risks to the implementation profiles would allow automated optimisation. The possibility of calculating differential risks per unit change in timescale will be considered.

Constraints on the tool included:

- The tool development had to proceed in parallel with IRP development. Hence, the IRP version for tool development in this work package was fixed, with the intention of updating it near the end of the project. The version of the IRP selected for the STAR Tool was “IRP 2005/2012”. Changes to the existing parts of the IRP were minimised, so that they can be added to the independently developed version(s).

- The non-expert user of the STAR Tool should not need any knowledge of IRP. The tool is envisaged as a user interface for the existing IRP. All inputs and outputs should be handled through the tool, and IRP should operate invisibly within it. This requirement has been accounted for in the present version of the STAR Tool.

- Full traceability of the results should be maintained. An expert user should be able to set IRP to mimic the results of the STAR Tool for any year, in order to check and explain them.

3. METHODOLOGY OF THE STAR TOOL

3.1 Definition of ATM Changes

Operational improvements (OIs) are described in the ATM 2000+ Strategy, and are listed without explanation in the ConOps. In IRP 2005/2012, these were grouped into packages and called “ATM Changes”. These are the basic building blocks of the current study. Appendix I includes various changes that have occurred since IRP 2005/2012.

The STAR Tool requires clear definitions of the ATM Change implementation timescales. The ConOps shows the timescale of implementation of ATM Changes affecting the period after 2011. The roadmap covers the period 2005-2020, and therefore requires the timescales for ATM Changes throughout this period. Appendix I shows preliminary assumptions for selected ATM Changes.

The expert user of the STAR Tool may require information on how an ATM Change is represented in IRP. The necessary information is also documented in Appendix I, which collects assumptions previously mentioned at various points in the IRP Methodology Report. How this information is implemented in the IRP spreadsheet is also easily traced from the STAR Tool interface sheets.

The present version of the STAR Tool includes representations of all the ATM Changes documented in Appendix I of the present document. How the STAR Tool user can select whether these changes are made and over what timescales is described in Section **Error! Reference source not found.**.

How the advanced user could examine the effect of new ATM Changes (i.e. those that are not already included in Appendix I) is considered in Section **Error! Reference source not found.** by means of a walk-through by example of the process for including such new changes.

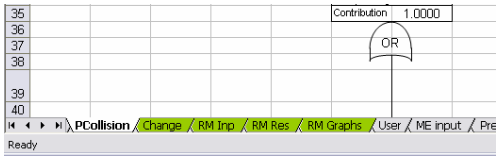
3.2 The STAR Tool: A View of the Structure in Excel

The STAR Tool is essentially a wrapper programme for the IRP that recalculates the IRP for successive scenarios corresponding to different years together with different input assumptions, governed by the user’s choice of anticipated ATM Changes and other inputs.

The STAR Tool consists of a copy of the 2005/2012 IRP spreadsheet together with the addition of some Visual Basic for Applications (VBA) code and four extra worksheets.

The VBA code is not displayed to the user (although easily viewable in the Visual Basic Editor). It should not be necessary for a user to view the code, but for someone familiar with VBA, it may enhance understanding of what the STAR Tool does. For the most part, however, the only interface required with the code part of the STAR Tool is a command button labelled “Run STAR Tool”.

The four extra sheets in the IRP spreadsheet are important for the user, however. They are made obvious with green worksheet tabs and they are labelled *RM Imp, RM Res, Change* and *RM Graphs.*



A description of each of those three new worksheets now follows.

RM Imp
This is the main input sheet. The user must select from the list of candidate ATM Changes which ones to select and what the implementation timescales for those changes is.

There is a copy of the "Run STAR Tool" button on this sheet that will run the roadmap and present the results in the two charts that are held on this sheet.

RM Res
This is where the results of the roadmap calculations are held, in numerical form. There is another copy of the command button on this sheet, but there is no specific user input required on this sheet.

There are up to eight groups of results recorded on this sheet
- Fatal Accidents per flight
- ICAO-defined accidents per flight
- Fatal Accidents per year
- ICAO-defined Accidents per year
- ATM direct contribution to fatal accidents per year
- ATM direct contribution to fatal accident per flight
- ATM direct contribution to ICAO accident per flight
- ATM direct contribution to ICAO accidents per year

The user would perhaps be interested in charting some more of the results stored on this sheet, other than those already displayed as examples on the RM Imp sheet.

Change.
This is the sheet on which the bulk of the STAR Tool – specific spreadsheet calculation takes place. The user inputs of RM Imp are processed here to provide year-on-year IRP inputs for the VBA code to insert into the "User" sheet of the main IRP model as appropriate.

RM Graphs.
This is merely a place holder for charts of the results on the sheet RM Res. There is one graph for each of the possible output metrics. The built-in charts include all the accident categories but it is suggested that the user may want to duplicate the chart and delete some of the series for clarity.

3.3 Selection of existing candidate ATM Changes the STAR Tool

The version of the IRP including the STAR Tool interface (called "IRP 2005 STAR Tool") requires manual inputs of the modelling assumptions to represent ATM Changes. The STAR Tool requires the user to select individual ATM Changes, without requiring knowledge of the modelling in IRP. Therefore a link is needed to automatically generate the modelling parameters from the user inputs of ATM Changes.

This link is now complete in IRP 2005 STAR Tool for the set of ATM Changes that have been identified hitherto. (For newly-considered ATM Changes, i.e. those that have not

already been included into Appendix I, please see Section **Error! Reference source not found.**.)

In particular, each ATM Change in the list of ATM Changes is associated in the STAR Tool with its consequences in terms of the changes to the IRP 2005/2012 modelling parameters. The user has the facility to select whether a particular ATM Change is implemented or not and what the timescale of that implementation is, by entering a start date and end date.

The IRP modelling parameters corresponding to each selected ATM Change are changed by the STAR Tool in a linear fashion from the start date to the end date. Table 1, below, shows a section of the input interface in the STAR Tool that allows the user to select whether a particular ATM Change is to be included in the calculated results of the STAR Tool and the implementation timescale, which is assumed to be linear.

A value of 1 should be used when the ATM Change is selected for consideration, and 0 when it is not. When the ATM Change is not selected, the Start- and End-year parameters are not used.

Table 1: User input for ATM Change selection and scheduling.

STEP 0.		User inputs		
ID	ATM CHANGE	Selected?	Start year	End year
01	Airspace simplification	1	2006	2012
02	Civil/military co-ordination	1	2005	2012
03	User-preferred trajectories	0	2005	2012
04	Airspace optimisation	1	2005	2012
05	ATC sector design optimisation	0	2005	2012
11,12,13	Strategic flow and capacity planning	1	2005	2012
211	Extended STCA	0	2005	2012
	… et cetera			

3.4 A walk-through of the process for including new proposed ATM Changes

This Section is intended for those users of the STAR Tool who wish to consider the effect of an ATM Change that is not included in the present proposed list of ATM Changes. This Section can be skipped entirely by those who are content with the pre-programmed list of candidate ATM Changes.

By extension, understanding the process for adding a new ATM Change will allow an experienced user of the STAR Tool to edit the effect of a presently-included ATM Change. In particular, those ATM Changes in the STAR Tool that are presently assessed as having no significant effect could be modified using the methods of this Section.

Identifying the IRP Input Parameters to be changed.

Experienced users of the IRP STAR Tool may want to examine the effect of proposed changes to the ATM system that are not yet shown in the list of ATM Changes. To do this, they must consider the way that that change may be implemented into the IRP.

This Section provides a walk-though of the general method, starting with a functional description of the ATM Change, comparing that description with a high-level diagram of the elements of the IRP itself, producing a standard-format description of the ATM Change in the

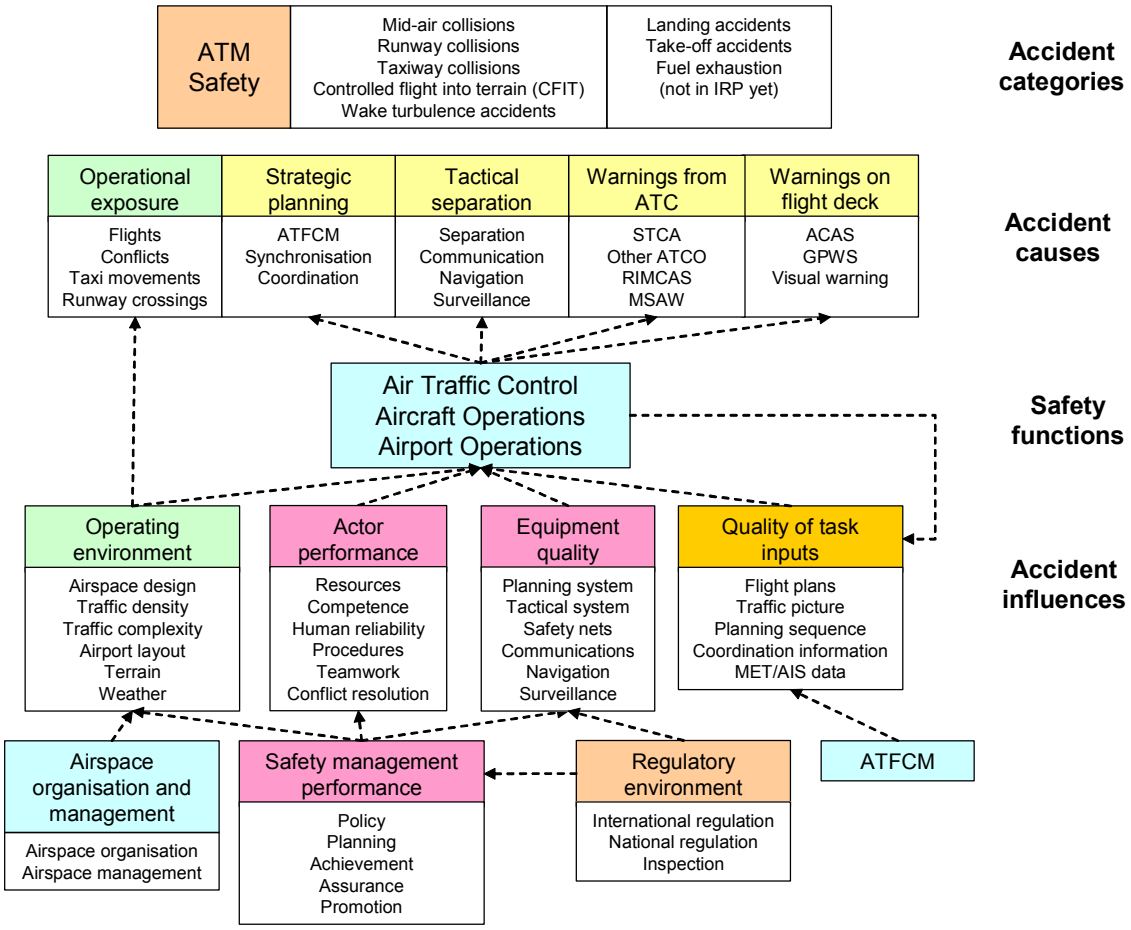
format of Appendix I, and concluding with a demonstration of how the new ATM Change can be programmed into the STAR Tool. This is not a fixed recipe for delivering STAR Tool representations of new ATM Changes since considerable case-by-case consideration is still required, but it will illustrate the general steps and concepts.

This walk-through illustration is for the ATM Change labelled in Appendix I as 231: Mode S. This ATM Change was assessed from first principles, resulting in the following table (an extract from Appendix I).

Change definition	**Mode S** Selective addressing to downlink aircraft parameters (DAP) via enhanced SSR radar.
Operational improvements included	Mode S enhanced surveillance, assumed to be used in all high traffic airspace by 2012, involving downlink of aircraft identification, state vectors and selected altitude. This will replace Mode A codes and provide automatic correlation with the aircraft flight plan. Mode S controller support tools will include display of vertical stack list, including same level alerts, and display of DAPs in a target window.
Sources of further information	www.eurocontrol.int/mode_s/
Benefit focus	Safety and capacity
Safety benefits	Reduced corruption (garbling) of surveillance picture, preventing errors due to target swapping and erroneous Mode A codes. Clearer presentation of traffic picture in stack and crossing departing aircraft, enhancing situation awareness and reducing misjudgements in control of stacks. Reduced VHF workload due to radar control of stacks (no need for communication to verify stack level vacated) and unique aircraft identification (no need to communicate Mode A code). Selected altitude information allowing earlier checks on level busts due to incorrect altitude setting. Improved accuracy of STCA and MSAW warning using state vectors.
Safety hazards	Extra surveillance information implies more opportunities for anomalies and misuse of data. Intent information may be misleading where aircraft fails to capture selected altitude. Loss of redundancy if FPS depends on aircraft identification from surveillance.

This sort of first-principle consideration of the ATM Change results in a more explicit description of the changes that may be expected as a result, but does not answer the question of how the ATM Change can be represented in the IRP. To do this, one must compare the effects described with the IRP itself to find correspondences. Figure 1, below, is an qualitative illustration of the structure of the IRP. This diagram is useful in identifying the areas of the IRP that may be affected by an ATM Change under consideration.

Figure 1: Qualitative Description of the IRP.



In the present case of the proposed mode S change, effects on the IRP might be anticipated in multiple sections as shown below, together with the phrases from the table above that might prompt the selection of the areas of the IRP shown below.

Actor Performance

Human Reliability (through decreased VHF workload, improved situational awareness, etc.)

Conflict resolution (use of state vectors and selected altitude)

Quality of Task Inputs

Traffic picture (clearer presentation, enhanced situational awareness, etc.)

Coordination information (use of state vectors and selected altitude)

Equipment Quality

Tactical System (more accurate STCA, use of state vectors and selected altitude)

Communication (decreased VHF workload)

Safety Nets (more accurate STCA)

This process has identified three functional areas of the IRP in which the ATM Change might be expected to have an effect. Those with detailed knowledge of the IRP can now identify those IRP input parameters which should be altered as a result of this ATM Change.

The task is now to match up the consequences of the ATM Change (above) with the IRP input parameters. Those parameters are grouped under the following headings.

Traffic Data

Switches

Flight Phases

Management Performance

Actor Performance

Equipment Performance

ATM Task Performance

System Coverage

Operating Environment

Airport Configuration

Sector Operations.

By comparing the two lists, the expert can now narrow down what headings might be relevant to the new ATM Change. In the present case of Mode S implementation, the following groupings appear to be of relevance.

Actor Performance (37 candidate inputs)

Equipment Performance (24 candidate inputs)

ATM Task Performance. (17 candidate inputs).

All the IRP inputs are grouped together on the worksheet “User”. Inspection of these 78 candidate inputs on that sheet reveals that many are irrelevant to this ATM Change, leaving just two:

Surveillance Performance Score

STCA warning failures.

To complete the assessment process for this ATM Change, the degree to which these two inputs might change must be estimated, resulting in the following completion of the Appendix I entry for this ATM Change. The explanation for this quantification can be found in the corresponding section of the main IRP methodology report, as it can for each ATM Change considered so far.

Representation in IRP	Improved surveillance picture quality.
Effect of full implementation	- ATC errors due to surveillance reduced by 30%, Max. Effect = 38%, resulting in Surveillance PS=78 for en-route and TMA. - STCA warning failures reduced by 20% (MB3.2), (Max. effect = 95%) achieved by setting STPS PS to 72. (IRP 2005 Methodology Report III.8.6)
Implementation profile	Linear between 2005 and 2012
Interaction with other changes	Enabled improvement in STCA included under Mode S.

Representing the time-dependent implementation of the new ATM Change in the IRP Roadmap tool.

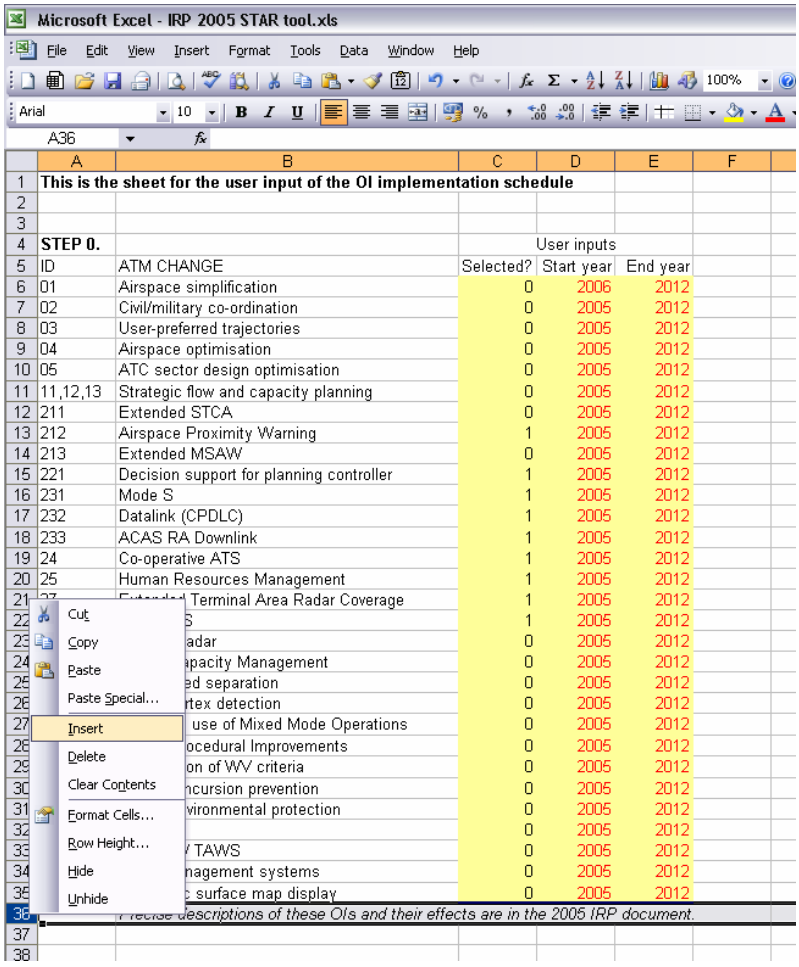
Once the effect of the ATM Change in terms of the IRP input parameters has been determined, new ATM Changes must be encoded into the STAR Tool. This Section describes the changes that must be made to the appropriate part of the STAR Tool. The demonstration proceeds for the same example as the walk-through example above, ATM Change 231. (This is for demonstration only – the original inclusion of this ATM Change is retained in the pre-existing list of ATM Changes.)

It must be noted that although the instructions that follow as are complete as possible, the advanced user must exercise caution at every stage that all new formulae inserted to correspond with newly inserted ATM Changes are correct. In particular, whether the formulae refer to the correct rows in the preceding "Steps". This cannot be guaranteed automatically because succeeding Steps may alter the number of new rows required, which means that there must necessarily be a mixture of absolute and relative row references. Therefore, the advanced user must monitor these issues most carefully.

Step 0.

Insert a new row into the ATM selection and implementation timescale section of the STAR Tool as shown in Figure 2. This Section is on the worksheet "RM Imp".

Figure 2: Inserting a row into user input section.



Type in the ATM Change ID and its name and the initial values for the Selected? and implementation timescale fields into the new empty row. This row will serve as the standard STAR Tool user interface and control for this new ATM Change.

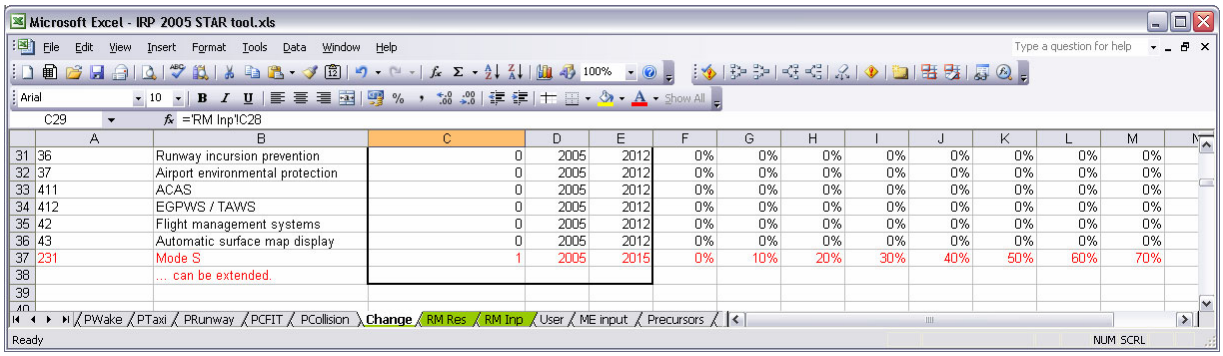
Step 1.

This step and all subsequent steps take place in the worksheet "Change".

This Step 1 simply allocates the implementation timescale for this ATM Change across the relevant years. In the "Step 1" section of the "Change" worksheet, insert a new row in the appropriate place and drag the formulae from the row above to fill the new empty row.

The completed part of the step 1 portion of the "Change" sheet is shown in Figure 3 (with the new row in red).

Figure 3: Completed new row in Step 1 section.



	A	B	C	D	E	F	G	H	I	J	K	L	M
31	36	Runway incursion prevention	0	2005	2012	0%	0%	0%	0%	0%	0%	0%	0%
32	37	Airport environmental protection	0	2005	2012	0%	0%	0%	0%	0%	0%	0%	0%
33	411	ACAS	0	2005	2012	0%	0%	0%	0%	0%	0%	0%	0%
34	412	EGPWS / TAWS	0	2005	2012	0%	0%	0%	0%	0%	0%	0%	0%
35	42	Flight management systems	0	2005	2012	0%	0%	0%	0%	0%	0%	0%	0%
36	43	Automatic surface map display	0	2005	2012	0%	0%	0%	0%	0%	0%	0%	0%
37	231	Mode S	1	2005	2015	0%	10%	20%	30%	40%	50%	60%	70%
38		... can be extended.											
39													

Note. If the user wishes to model the effect of a non-linear implementation time-table, then this Step 1 part of the Change sheet is where it can be done. Instead of using the standard formulae in this section, the user can overtype the formulae with hard-coded numbers representing the cumulative implementation of the ATM Change.

Step 2.

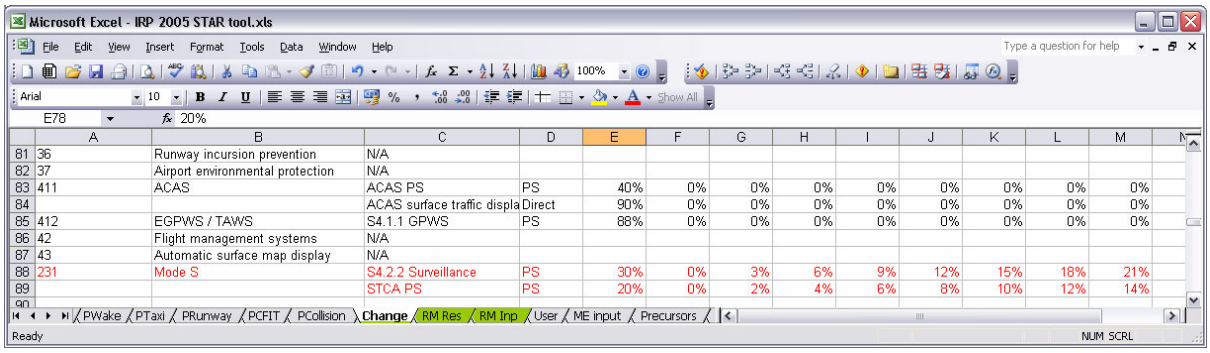
In the "Step 2" section (in the "Change" sheet, below part 1), insert new rows in the corresponding place. In the present example, the ATM Change affects two parameters, namely "S4.2.2 Surveillance" and "STCA PS", so two rows are used for this example. The cells must be populated as follows.

Columns A and B can be filled in by copying the cells down from above. Column C must be set to be the name of the affected parameter. In the present example, the ATM Change affects two parameters, namely "S4.2.2 Surveillance" and "STCA PS", so two rows are used for this. Column D must record whether the parameter to be changed is a performance score ("PS") or a directly-input parameter ("Direct"). Column E is the full-scale effect of the ATM Change on the parameter under consideration. In the present case, the number of ATC errors due to surveillance is reduced by 30% (see the Appendix I extract above) and STCA warning failures are similarly reduced by 20%.

Columns F to U can be copied from the (non-blank) rows above, although care must be taken that when the ATM Change being added affects more than one IRP parameter, the formulae point to the correct row in the "Step 1" section. Manual checking required of the absolute / relative references here.

Part of the completed Step 2 section is shown in Figure 4, with the two new rows shown in red. This step allocates the underlying parameter change across the years as appropriate.

Figure 4: Completed section of Step 2.



	A	B	C	D	E	F	G	H	I	J	K	L	M
81	36	Runway incursion prevention	N/A										
82	37	Airport environmental protection	N/A										
83	411	ACAS	ACAS PS	PS	40%	0%	0%	0%	0%	0%	0%	0%	0%
84			ACAS surface traffic displa	Direct	90%	0%	0%	0%	0%	0%	0%	0%	0%
85	412	EGPWS / TAWS	S4.1.1 GPWS	PS	88%	0%	0%	0%	0%	0%	0%	0%	0%
86	42	Flight management systems	N/A										
87	43	Automatic surface map display	N/A										
88	231	Mode S	S4.2.2 Surveillance	PS	30%	0%	3%	6%	9%	12%	15%	18%	21%
89			STCA PS	PS	20%	0%	2%	4%	6%	8%	10%	12%	14%

Step 3.

Insert the appropriate number of new rows into the “Step 3” section of the “Change” worksheet.

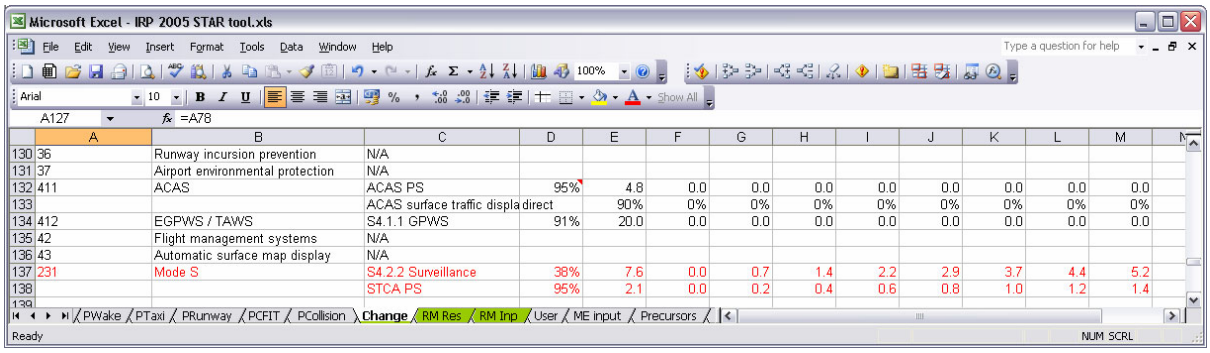
Columns A-C can be copied down from the rows above, although only one row is required in columns A and B, and (possibly) multiple rows in all subsequent columns. The contents of Column D depends on whether the parameter in question is a Performance Score (PS) or a direct parameter input.

If the parameter is a PS, column D must be filled in with the Maximum Effect of each input parameter. This data can be obtained from the IRP Methodology report (Reference 1). If it is a direct input, this fact should be recorded by putting the word “direct” in the appropriate row in column D.

The columns E to U can be filled in from the rows above, but the formulae must be copied from a row with similar “PS” or “Direct” designation. Again, it must be visually verified that the formulae refer to the appropriate Step 2 rows.

Part of the completed Step 3 section is shown in Figure 5, with the two new rows shown in red. This step either sets the performance scores for each of the assessment years (in the case of PS parameters) or just repeats the Step 2 allocation (in the case of direct parameters).

Figure 5: Completed section of Step 3.



	A	B	C	D	E	F	G	H	I	J	K	L	M
130	36	Runway incursion prevention	N/A										
131	37	Airport environmental protection	N/A										
132	411	ACAS	ACAS PS	95%	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
133			ACAS surface traffic displa	direct	90%	0%	0%	0%	0%	0%	0%	0%	0%
134	412	EGPWS / TAWS	S4.1.1 GPWS	91%	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
135	42	Flight management systems	N/A										
136	43	Automatic surface map display	N/A										
137	231	Mode S	S4.2.2 Surveillance	38%	7.6	0.0	0.7	1.4	2.2	2.9	3.7	4.4	5.2
138			STCA PS	95%	2.1	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4

Step 4.

Step 4 summarises the effect on all the affected input parameters by adding the effects for each affected input parameter across all ATM Changes. Thus, the possibility that more than one ATM Changes affects a particular input parameter is accounted for here.

To complete step 4, the advanced user must first inspect the list of affected parameters in column B.

If all the affected parameters of the new ATM Change are already in this list, then no extra rows are required here. It must be checked however that the formulae in the block of formulae refer to all the rows in the Step 3 section. It is also important to notice that the name of the parameter to be altered must be exactly the same as in Column C of the Step 3 part.

If the new ATM Change has introduced a new parameter into the list of affected parameters in Step 4, then that parameter must be added to the bottom of the list. In this case, the advanced user must also identify the corresponding cell on the “User” sheet. All the relevant cells are in column M of the User sheet.

For instance, the parameter STCA PS is stored in the user sheet in cell User!M116 and this information is recorded in column C of the Step 4 section by inserting a reference in the appropriate row in column C to cell User!M116. Of course, this cell just reports the present value of cell User!M116, but the visual basic code that runs the Roadmap follows this reference *in reverse* to set the value of cell User!M116 according to the values determined in Step 4.

Column D must contain the initial (that is 2005) value of the parameter. The remaining columns E-U can be copied from the rows above, although as usual, care must be taken to check that all the appropriate rows in Step 3 are referred to.

3.5 Interaction of ATM Changes

In IRP 2005/2012, the modelled effects of an ATM Change are assumed to be independent of the context in which it is made, with the exception of certain modelled interactions such as common causes, positive and negative interactions. In reality, the effects depend on the ATM situation at the time the change is made, and may vary subsequently as other ATM Changes are added. In principle, such changes could be modelled in IRP, but this would require judgements of the effects of each ATM Change in each combination. In practice the available ATM experts are not yet ready to make such fine distinctions in their quantitative judgements.

One of the requirements for the tool is that interactions between ATM Changes that are modelled in IRP should be made plain to the user. Before this can be done, it will be necessary to investigate selected interacting ATM Changes in detail.

At present, if an ATM Change is dependent on another, the correct scheduling of that ATM Change is a matter to be accounted for by the user. For the ATM Changes that are presently implemented in IRP 2005/2012 and the roadmap, there are no effects that exhibit this sort of interdependence.

Note that certain interactions between elements of the IRP are indeed modelled. These appear as common causes in the IRP documentation and they continue to operate while the STAR Tool is being used.

3.6 Running the STAR Tool

Once the user has selected the ATM Changes that are to be included in the STAR Tool calculation, and the timescales for their implementation, the STAR Tool operates according to these general steps to produce the risk metric outputs for each year from 2005 to 2020. This process is illustrated in a schematic way in Figure 6. In this Figure, the pale blue boxes are the stages of the process that are undertaken by the user of the STAR Tool, and the green ones are those performed by the STAR Tool or IRP software itself.

1. The tool generates a set of input cases for IRP for each year between 2005 and 2020 based on the implementation profiles. It then aggregates the effects of all the selected ATM Changes on the IRP modelling parameters for each year from 2005 to 2020 (Spreadsheet programming.)

The step above is incorporated as part of the normal IRP spreadsheet programming and proceeds automatically. There is a control button labelled "Run Roadmap" for the user to initiate the following steps.

2. The IRP modelling parameters for the currently selected year (starting from 2005 and as calculated in step 1) are inserted into the appropriate places in the IRP. The level of traffic for this year is also calculated and inserted at this stage.

3. The IRP is recalculated.

4. The results for the currently selected year are stored on the sheet "RM Res". What results are output depends on the selections made by the user on the "RM Imp" sheet.

5. The currently selected year is incremented by 1 and the tool resumes the process at step 2 until the year 2020.

6. This yields a complete set of results for 2005-2020. The STAR Tool produces graphs at this point depicting the progression of the selected risk metrics from 2005 to 2020 (Figure 7). The user can then optimise the selection and timing of ATM Changes and restart the process to assess the strategy for achieving safety targets..

Figure 6: Roadmap Modelling Approach

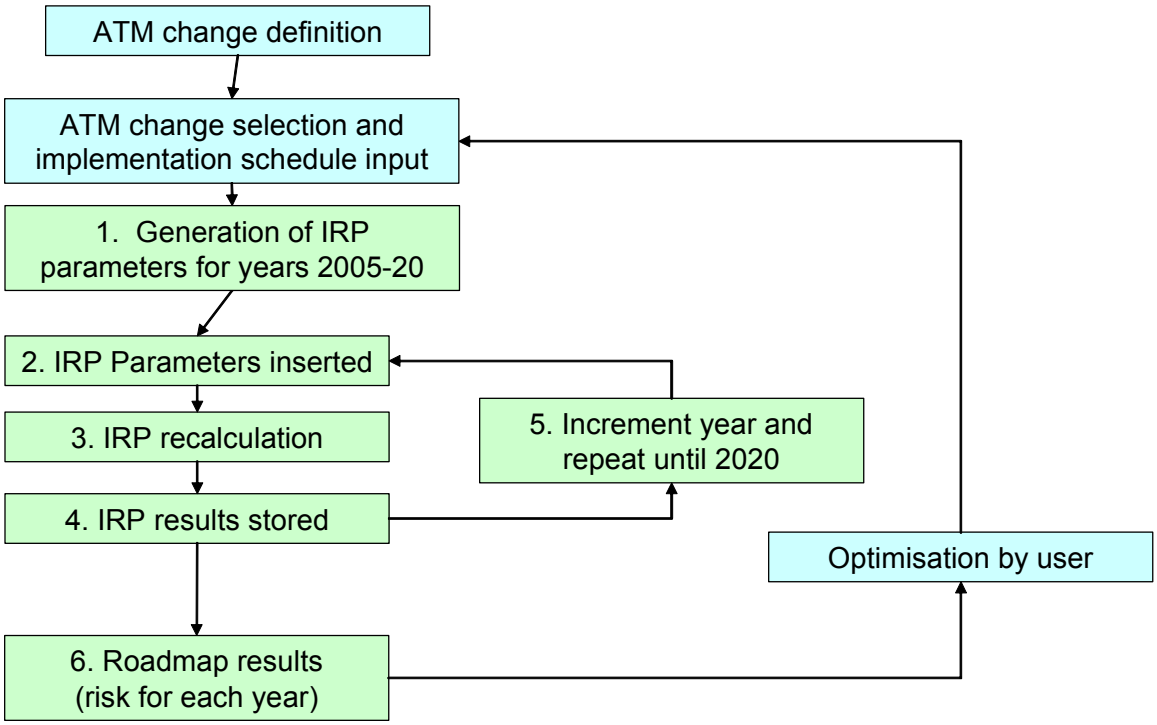
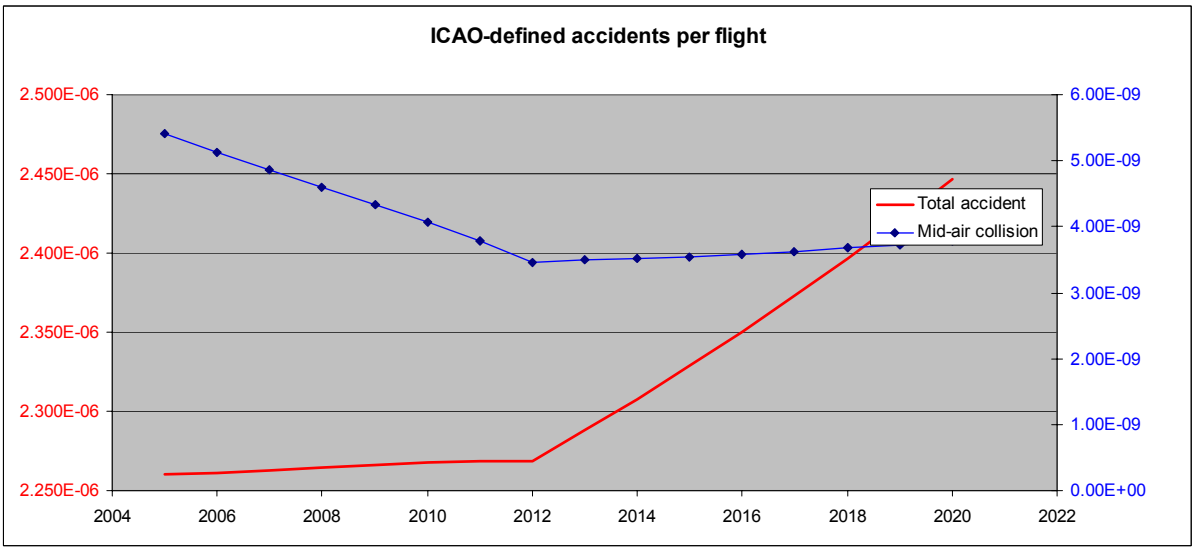


Figure 7, below, shows an example of the graphical output from the STAR Tool. It is an example in the sense that two particular outputs from the model have been selected, namely the total ICAO-defined accident frequency per flight (red line and red y-axis scale) and the component of that total accident frequency accounted for by mid-air collisions.

Figure 7: Example of the graphical output from the STAR Tool – illustration only



Demonstrating the effect of each ATM Change

The STAR Tool has an in-built facility for assessing the impact of each ATM Change in isolation. It does this by recording the results for the ATM contribution to the frequency of

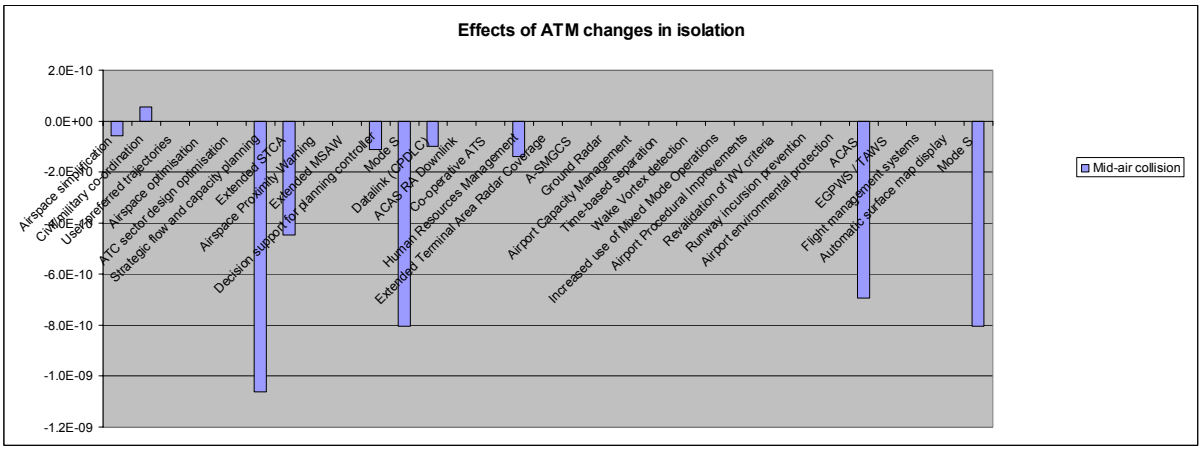
Fatal accidents with all the ATM Changes turned off and then recording the same results with the ATM Changes turned on one by one.

The inputs for this feature are a little different from the main STAR Tool in that the "Selected?" input is inoperative. However, all the other inputs, for the time-dependencies of the model and for whether safety nets are accounted for remain in operation.

This feature is run by pressing the button labelled "Assess effect of ATM Changes in isolation".

The results of the programme run are stored in the worksheet "RM Res", in a block starting at column Y. The results are shown in a graph on the "RM Graphs" worksheet (for all accident categories) and specifically for Mid-Air collisions in Figure 8, below.

Figure 8: The effects of the candidate ATM changes in isolation - illustration only.



3.7 Transport of the STAR Tool to Other IRP Versions

Care has been taken in the development of the STAR Tool to make the transport of the tool from IRP 2005/2012 to later versions of the IRP as easy as possible. This has been done by making the STAR Tool modular and limiting its interaction with the IRP to as few worksheets in the IRP as possible and by the use of named ranges in the IRP. Developers or users of a particular IRP version will be able to move cells in the IRP without necessitating re-programming of the STAR Tool code.

However, it is anticipated that the transport of the STAR Tool to other IRP versions will still require some careful intervention, especially if the modelling parameters of the subsequent IRP versions differ from those of IRP 2005/2012.

4. ACHIEVEMENT OF SAFETY TARGETS USING THE STAR TOOL

The purpose of the STAR Tool is to allow its users to compare the influence of possible ATM Changes over time with the Targets for Safety that are mandated. The Tool will not in itself suggest an optimum strategy for the achievement of safety targets, but rather provides a framework in which candidate ATM Changes can be weighed against each other in the context of the Integrated Risk Picture.

Therefore, the STAR Tool could form part of the methodology for the achievement of strategic safety targets, but only together with due consideration for external factors such as the practicability of the candidate ATM Changes (especially the implementation time-tables) and cost-benefit analysis.

5. REFERENCES

1. EUROCONTROL, “Methodology Report for the 2005/2012 Integrated Risk Picture for Air Traffic Management in Europe”.