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Safety Assessment of Airport Airside Capacity Enhancement (ACE)

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Abstract

This document presents a safety assessment of the Airside Capacity Enhancement (ACE) Project. All the ACE recommended practices have been analysed individually and collectively. Risk mitigation, based primarily on documentation from ICAO, the European Action Plan for the Prevention of Runway Incursions (EAPPRI) and the ACE project, has been identified with the aim of ensuring that airport risks do not increase.

Keywords

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Safety Assessment
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EXECUTIVE SUMMARY

Objectives and Method

This document presents the safety assessment for the Airside Capacity Enhancement (ACE) project. Safety assessments have been prepared in parallel for Runway Safety (RWY SAF) and Airport Collaborative Decision Making (A-CDM).

The objectives of the ACE safety assessment are:

1. To evaluate the safety impact of each individual Recommended Practice (RP) within the project;
2. To evaluate the collective safety impact of all the RPs within the project;
3. To identify any extra risk mitigations (if relevant) to ensure that the RPs will be tolerably safe.

The project RPs have been drawn from all the relevant ACE project documentation. To fulfil the objectives above, the following approach has been taken:

- Each RP has been analysed individually. After documenting whether an RP is compatible with ICAO requirements or recommendations it is then evaluated in terms of safety benefits and any potential concerns. Current risk mitigations associated with the RP have been identified. Risk impact has then been assessed using a model based on the bow-tie concept of hazard causes and consequences (widely used in recent EATM safety assessments).
- The collective impact of the ACE RPs has been evaluated by mapping the RPs onto relevant accident categories and considering the overall balance of potential positive and negative safety impacts.
- The modelling of the individual and collective impacts has enabled extra risk mitigations to be identified and recommendations to be made.

Conclusions and Recommendations

Based on this generic safety assessment the following conclusions have been drawn:

- There are no "show-stoppers"[1], i.e. for all the RPs where safety concerns have been identified practicable mitigations have been identified with the potential to reduce risk to a tolerable level.
- Mitigations, based primarily on documentation from ICAO, the European Action Plan for the Prevention of Runway Incursions (EAPPRI) and the ACE project, have been developed plus additional options for local consideration. There are some RPs, in the context of the accident category "Runway Collisions" (namely Conditional Clearances, Intersection Departures and Multiple Line-ups), which will require strong and effective packages of risk mitigation measures in order to ensure that safety is

[1] A "show stopper" is defined in this context as a safety concern or new hazard for which no practicable risk mitigation measure can be identified.

not negatively affected. These mitigations and effective safety monitoring following implementation must be given a high priority.

- In the other accident categories, the analysis has indicated that the ACE RPs will have either a neutral or even a slightly positive impact on safety with the identified mitigations in place. However, as noted in the EAPPRI all these ACE RPs need local safety assessments as local factors can have a critical effect on the safety implications of all these RPs.

Recommendations have been produced in this report covering primarily:

- Specific risk mitigations for each RP which are detailed in Appendix I and Section 4 of this report;
- The capacity measurement and modelling process used within ACE (Section 4.9); and
- Further work relating to more data analysis (Section 5.3).

CONTENTS

1 INTRODUCTION

1.1 Background

The EATM Airport Operations Programme (APR), maintained by the Airport Operations Domain, consists of the following four projects:

1. Runway Safety Project (RWY SAF)
2. Airside Capacity Enhancement (ACE)
3. Airports Collaborative Decision Making (A-CDM)
4. Advanced Surface Movement Guidance and Control System (A-SMGCS)

The A-SMGCS project has already been the subject of a Safety Case [**1**]. Safety assessments and Preliminary Safety Cases are now being conducted for the three other projects in parallel. This document presents the safety assessment for the ACE project.

1.2 Objectives of Safety Assessment

The objectives of the ACE safety assessment are:

1. To evaluate the safety impact of each individual Recommended Practice (RP) within the project;
2. To evaluate the collective safety impact of all the RPs within the project;
3. To identify any extra risk mitigations (if relevant) to ensure that the RPs will be tolerably safe individually and collectively.

1.3 Overview of Safety Assessment Approach

The project RPs have been drawn from all the relevant ACE project documentation. They are presented in full in Appendix I. To fulfil the objectives above, the following approach has been taken:

- Each RP has been analysed as shown in Figure 1.1. After documenting whether an RP is compatible with ICAO requirements or recommendations it is then evaluated in terms of safety benefits and any potential concerns. Current risk mitigations associated with the RP have been identified. Risk impact has then been assessed using a model based on the bow-tie concept of hazard causes and consequences (widely used in recent EATM safety assessments). This model has been used to structure the analysis of each RP (see Figure 1.2).

Figure 1.1 The Overall Safety Assessment Process

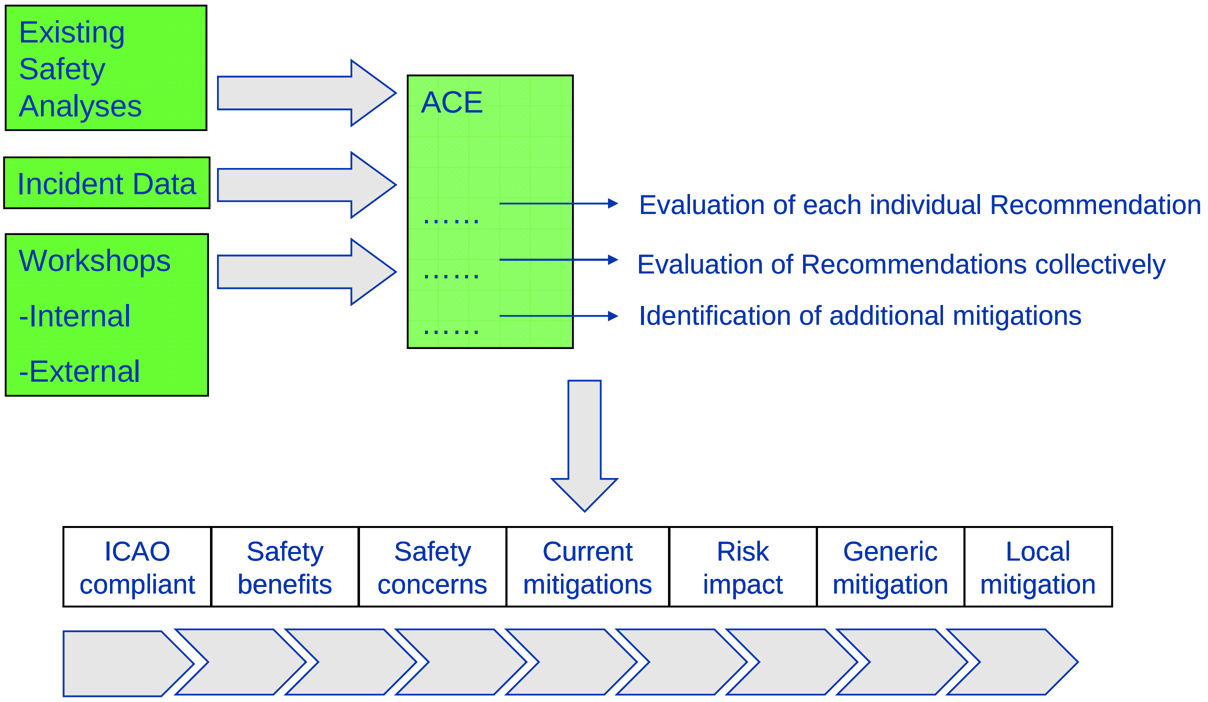
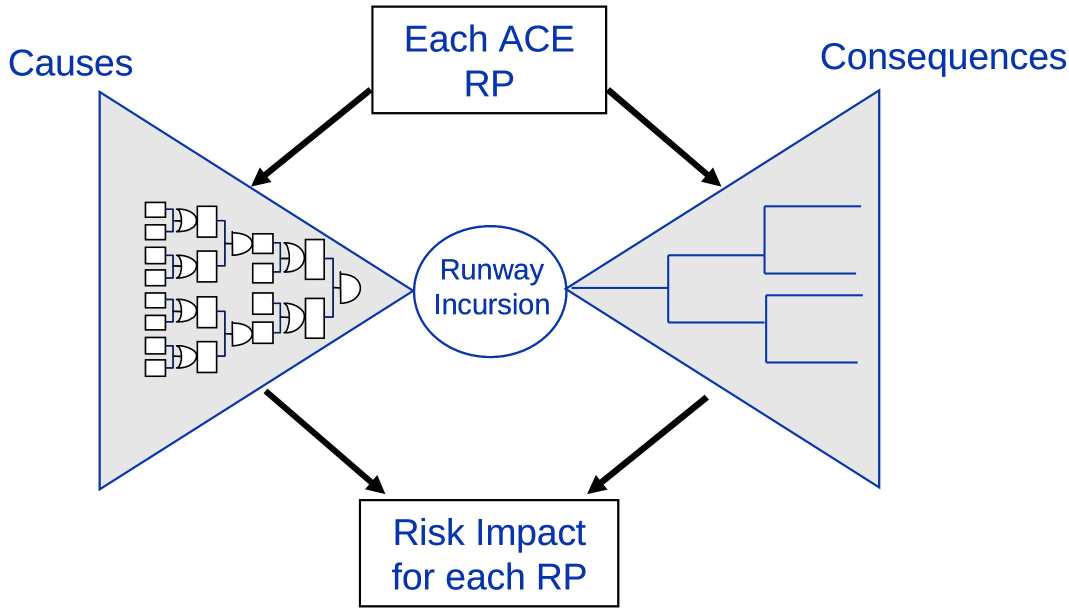


Figure 1.2 Use of Bow Tie Model



- The collective impact of the ACE RPs has been evaluated by mapping the RPs onto relevant accident categories and considering the overall balance of potential positive and negative safety impacts making use of existing safety studies [**2, 3, 4**] and expert judgement to support the analysis.
- The modelling of the individual and collective impacts has enabled extra risk mitigations to be identified and recommendations to be made.

Within the safety assessment the following safety criteria have been used (see Safety Plan [**5**]):

- Airport risks are not to be increased (consistent with ESARR4 and ATM 2000+); and
- Airport risks are to be further reduced As Far As Reasonably Practicable.

1.4 Document Structure

This safety assessment report is structured as follows:

- Section 2 provides a system description of the ACE project;
- Section 3 presents the risk models used to conduct the safety assessment;
- Section 4 covers the Functional Hazard Assessment and Preliminary System Safety Assessment, i.e. the analysis of the impact of ACE RPs on hazards, their consequences and their frequencies;
- Section 5 is an overall evaluation and discussion of the impact of ACE on airport safety;
- Section 6 summarises the validation and verification activities associated with this safety assessment; and
- Section 7 presents the main conclusions and recommendations.

Appendix I provides the full analysis of each of the ACE RPs. Appendix II provides additional bow tie models. Appendix III lists the relevant EAPPRI RPs which are referred to in the main report.

Safety assessment reports are being prepared for the RWY SAF and A-CDM projects in parallel with this document. Three safety case documents will also be prepared for RWY SAF, ACE and A-CDM. As noted above a safety case already exists for A-SMGCS.

1.5 Participants

EUROCONTROL's ACE Project has received considerable support from EUROCONTROL's DAP/SSH department and external stakeholders in the conduct of this safety assessment. Workshops, post-workshop analysis and reviews of documents have been supported by personnel with a mix of disciplines and expertise including pilots, flight safety engineers, ATCOs, airport specialists and safety assessment experts. This assistance is gratefully acknowledged. Further details of participants in the safety assessment are given in Appendix I.

1.6 Definitions

Mitigation	Steps taken to control or prevent a hazard [or concern] from causing harm and reduce risk to a tolerable or acceptable level (taken from ESARR4)
Generic Mitigation	A mitigation to be considered by EUROCONTROL, ICAO and other industry bodies (e.g. within future updates of ACE documents)
Local Mitigation	A mitigation to be considered by airport stakeholders at a local level
Recommendation	In the context of this ACE safety assessment, recommendations primarily cover mitigations to specific RPs and the capacity measurement and modelling process used by ACE

2 SYSTEM DESCRIPTION

2.1 Purpose of the ACE Project

Satisfying existing traffic demand already generates a challenge for Airport Stakeholders (i.e. airport operators, aircraft operators, ATC and ground handlers etc). Traffic forecasts estimate that this demand may double in the next 15 years.

Whilst it is recognised that in the long term new runways will be required to overcome capacity constraints, the ACE project focuses on Short and Medium Term Airside Capacity Assessment and Planning Processes to free up existing latent capacity.

The ACE project is aimed at providing airport operators with the tools to assess available capacity and identify the current and future constraints that are limiting the use of this capacity.

The ACE Manuals provide guidance on how to use these assessment tools and then how to put in place the systems, processes and procedures to utilise this capacity and raise awareness amongst all airport stakeholders about the importance of efficient airport operations.

2.2 Process of the ACE Project

EUROCONTROL has worked with the airport stakeholders to develop the ACE tools, methodology and guidance. As part of this work, there have been operational validations carried out of these at a number of airports including Prague and Lisbon. Implementation of ACE is a process facilitated by EUROCONTROL ACE experts with each participating airport and involves a number of steps. These commence with the identification of ACE changes (Recommended Practices) which will most benefit capacity and are agreed for implementation, through stakeholder liaison, implementation and finally review.

2.3 Description of RPs

In total 89 Recommended Practices (RPs), also referred to as "Best Practices", are listed in Appendix I. These have been drawn from the ACE documentation, principally:

- "Enhancing Airside Capacity – The Complete Guide".
- "Airside Capacity Enhancement Implementation Manual".
- ACE Project ATS Awareness CD.

For ease of reference these 89 RPs have been divided in Appendix I mainly by flight phase:

- Pushback (ACE 2.2) – including tactical pushback and remote hold;
- Taxi-ing (ACE 2.3) – including nomination of preferred Rapid Exit Taxiway (RET), use of published standard taxi-routes etc.;
- Taxiway infrastructure (ACE 2.4) – including provision of Alternate Parallel Taxi Lanes (APT);
- Holding and line-up (ACE 2.6) – including use of conditional clearances, multiple holding points, multiple line-ups and intersection departures;
- Take-off (ACE 2.7) – including target Flight Crew Reaction Time to Take-Off (FRTT);

- Departure (ACE 2.8) – including use of distance based separation using Tower radar information;
- Approach (ACE 2.9) – including new systems to reduce wake turbulence separation; and
- Landing (ACE 2.5) – including use of reduced spacing on the runway.

In addition to this division by flight phase other RPs under the following headings have been analysed:

- Airport Scheduling (ACE 2.1);
- ATC Roles and Responsibilities (ACE 2.10);
- Low Visibility Procedures (ACE 2.11);
- Airline Recommended Practices (ACE 2.13); and
- General and location specific RPs (ACE 2.12 and 2.14).

During the course of the safety assessment, 12 of these 89 RPs have been withdrawn; their descriptions have been left in Appendix I for completeness, but they are all labelled as “WITHDRAWN”. Of the remaining 77 RPs, only 2 have not been considered in this safety assessment. These are RP 2.6.9 which relates to increasing runway capacity through use of Time Based Separation (TBS) or a specific wake turbulence predictive tool and RP 2.9.1 which involves improving runway utilisation with a Converging Runway Display Aid. TBS is currently the subject of an ongoing stand-alone Safety Case by EUROCONTROL; similarly any wake turbulence predictive tool or Converging Runway Display Aid would also require a stand-alone Safety Case. Thus the generic ACE safety assessment has not covered these RPs.

In addition to analysing these RPs, the safety assessment has also considered potential safety impacts arising from the use of the capacity analysis tools, PIATA+ and CAMACA [**6, 7**] in Section 4.9 of this report.

3 RISK MODELS

3.1 Overview

A typical ATM safety assessment usually starts with identifying hazards of a new or changed system and then evaluating their risks. However, in order for the ACE safety assessment to be compatible with the RWY SAF assessment and allow impacts on safety to be combined, existing risk models have been used. This has also been done in the RWY SAF safety assessment and allows the impact of each Recommended Practice (RP) to be systematically analysed as well as combinations of RPs.

The risk models have been developed and used in the following way:

- All accident categories potentially affected by ACE RPs were identified. The accident categories used in this assessment are:
  - Runway Collisions;
  - Taxiway Collisions;
  - Mid-Air Collision;
  - Wake Turbulence (Vortex) Accident;
  - Controlled Flight Into Terrain (CFIT);
  - Loss of Control (LOC) on Landing or Take-Off; and
  - Jet Blast.

- Appropriate hazards (or “bow tie centres”, see below) were identified for each accident category defining the scope for the cause/ consequence analysis.

- Event trees were developed to assist the consequence analysis. The nodes of the event trees have been considered in assessing the impact of each RP on the hazard consequences (see Appendix I, column entitled “Impact of RP on Hazard Consequences”).

- The impacts of all RPs on the causes of hazards and their frequencies have been assessed and documented based on the subjective analysis of experts (see Appendix I for relevant expertise) plus input from incident and accident data ([**2**], [**3**] and [**4**]) where appropriate (see Appendix I, column entitled “Impact of RP on Hazard Frequency”).

3.2 Runway Collision Bow Tie Risk Model

A bow tie risk model consists of:

- Fault trees on the left hand side of the bow tie showing the factors that can cause a hazard;
- A defined hazard in the middle of the bow tie; and
- Event trees on the right hand side of the bow tie showing the possible consequences (also termed effects) of the hazard.

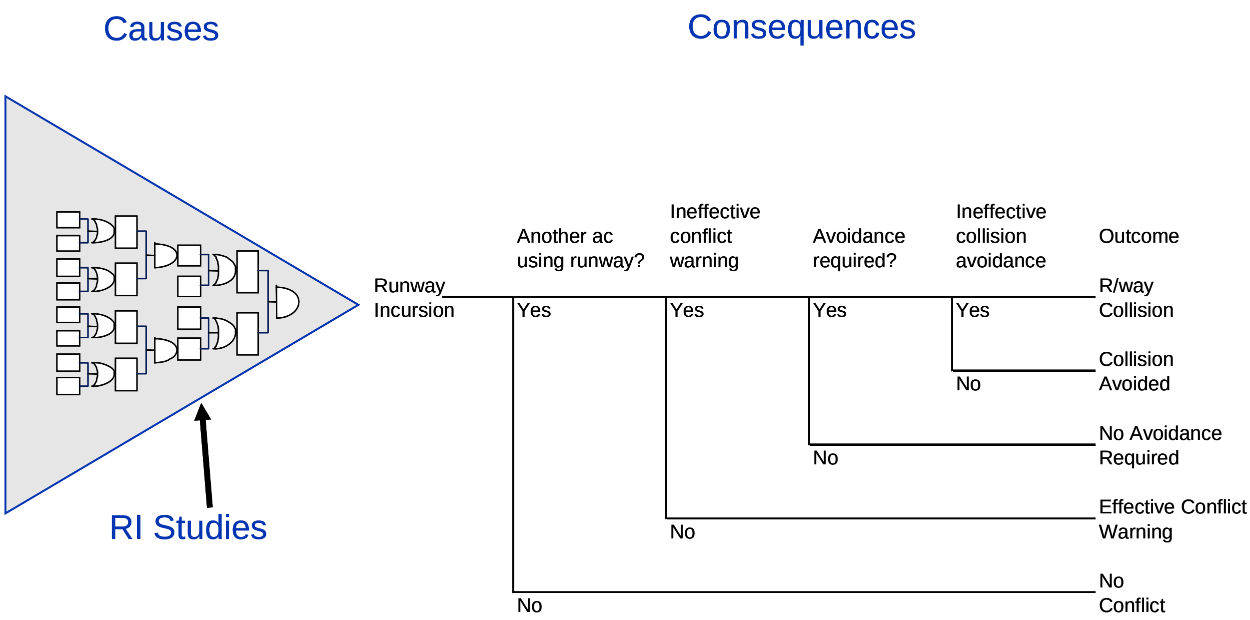
The centre of the bow-tie for this accident category has been chosen to be "Runway Incursion". The consequences of Runway Incursions are analysed by considering the nodes in the Event Tree below (Figure 3.1), i.e.

- Is there another aircraft (ac) using the runway?
- Is conflict warning (i.e. RIMCAS) effective?
- Is avoidance action required?
- Is collision avoidance (initiated by ATC or pilots) effective?

This structure has been adopted from the Integrated Risk Picture (IRP) study, recently published by the EEC [**4**].

The multiple causes of Runway Incursions are represented by the Fault Tree schematic below. In terms of assessing the ACE RPs relevant to runway collisions, existing safety studies on Runway Incursions ([**2**], [**3**]) provide direct indications of the impact of many of the RPs on Runway Incursion (RI) frequency.

Figure 3.1 Bow Tie Structure for Runway Collisions



3.3 Taxiway Collision Bow Tie

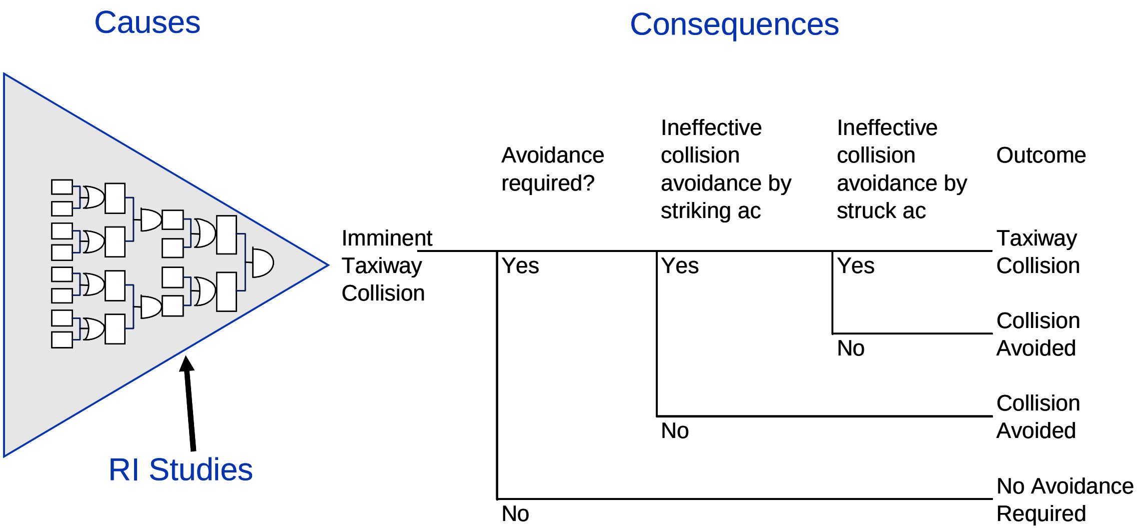
The centre of the bow-tie for taxiway collisions is "Imminent Taxiway Collision". The consequences are analysed by considering the nodes in the Event Tree below (Figure 3.2), i.e.

- Is avoidance action required?
- Is collision avoidance initiated by the pilots onboard both relevant aircraft effective?

This structure has also been adopted from the Integrated Risk Picture (IRP) study.

As above, existing safety studies and the expert judgement of the workshop personnel (Appendix I) have provided information about the causal factors of imminent taxiway collisions and their relative importance with respect to the RPs.

Figure 3.2 Bow Tie Structure for Taxiway Collisions



3.4 Other Bow Ties

The ACE RPs could potentially impact other accident categories. Bow tie models have also been developed for mid-air collision, wake turbulence encounter, Controlled Flight Into Terrain (CFIT) and Loss of Control on landing or take-off. These are shown in Appendix II.

An additional accident type that was identified in the ACE analysis was jet blast (affecting aircraft or people). Developing a Bow Tie model for this accident category was not found to help the analysis; rather the impact of an RP on the frequency of jet blast accidents was considered directly in the relevant column of the spreadsheet in Appendix I.

4 FHA/PSSA

4.1 Overview

The safety assessment has systematically examined the impact of the ACE RPs on the consequences of hazards (FHA) and their causes/ frequency (PSSA). This mirrors the process used in the RWY SAF safety assessment. For ease of reading, the FHA and PSSA stages have been brought together below for each accident category, and arranged from “left to right” in the bow tie model, i.e. considering first the frequency of the hazard and then its consequences.

The analysis below is based on a series of three workshops held between March and September 2006. Details of the workshop participants are given in Appendix I. Following the workshops minutes were distributed and commented on and post-workshop analysis conducted.

4.2 Runway Collisions

4.2.1 Frequency of Hazard (Runway Incursion)

Table 4.1 below lists the RPs in Appendix I which potentially have an impact on the ***frequency*** of Runway Incursions (RIs). A “+” indicates a positive impact on safety, i.e. reduction in RI frequency. A “-” indicates a negative impact on safety, i.e. increase in RI frequency. A “0” indicates risk neutral, i.e. no significant change in RI frequency. Where there is uncertainty a combination of these symbols has been used with associated explanatory text in the table. The last column in this table and subsequent tables includes comments and some of the relevant mitigations from Appendix I. For the full list of mitigations, three columns in Appendix I should be consulted, namely “Current/ Planned Mitigations”, “Extra Generic Mitigations” and “Extra Local Mitigations”.

Table 4.1 Impact of ACE RPs on RI Frequency

ACE ID[2]	RP Description	Impact on Frequency of RI	Frequency Mitigation/ Comment
2.3.2	Use of Published Standard Taxi-Routes	(+) Ref. [2] indicates significant benefit of this RP in reducing RI frequency	This is effectively the same RP as EAPPRI 4.5.9.
2.3.7	Progressive taxi instructions	(+) Ref. [2] indicates significant benefit of this RP in reducing RI frequency	This is effectively the same RP as EAPPRI 4.5.10.
2.4.7	Selectable green taxiway lights	(+) Ref. [2] indicates significant benefit of this RP in reducing RI frequency	
2.6.3	Conditional clearances	(+/-) Ref. [2] indicates that without risk mitigators the	High priority on implementing adequate risk mitigation package

[2] See Appendix I for more detail on each ACE RP.

ACE ID[2]	RP Description	Impact on Frequency of RI	Frequency Mitigation/ Comment
		introduction of conditional clearances could increase RI frequency. However, Ref. [2] also indicates that the introduction of a comprehensive risk reduction package based around ICAO, EAPPRI and ACE safety recommendations has the potential for reducing historical RI frequency	based around ICAO, EAPPRI and ACE documentation (see Appendix I) and subsequent safety monitoring.
2.6.5 and 2.6.10	Multiple line-ups and Intersection departures (grouped together in this summary)	(0/-) Ref. [2] and IRP indicate that increased use of intersection departures without adequate risk mitigation could have a significant impact on frequency of RIs	High priority on implementing adequate risk mitigation package based around ICAO, EAPPRI and ACE documentation (see Appendix I) and subsequent safety monitoring.
2.7.4	Target for Flight Crew Reaction to Take Off & any consequent pilot perception of ACE time pressure	(0) Potential for more errors leading to RIs and premature take-offs, however expected to be mitigated to be “risk neutral”	ACE and RWY SAF awareness campaigns to reinforce the “no rush” message.
2.7.5	Complete as many checks as possible before line-up	(+) Improved pilot vigilance reducing probability of RI	
2.7.6	Provide take-off clearance early	(+) Reduced chance of premature take-off	
2.11.1 & 2.11.2	Safeguarding when entering LVP conditions	(+) No free-range vehicle movements, therefore reduced RI frequency. Ref. [2] predicts significant risk reduction	

Table 4.1 presents a mixed set of impacts from ACE RPs, some with a likely positive impact on safety and some potentially negative. The main potential for negative safety impacts concern the use of conditional clearances, intersection departures and multiple line-ups.

All three RPs are ICAO compliant, however historic problems with these areas appear often to have been associated with failure to use correct procedures. A mitigation package based around ICAO, EAPPRI [**8**] and ACE documentation is presented in Appendix I. It is reproduced below in Table 4.2.

Table 4.2 Summary of Main Mitigations for Conditional Clearances, Intersection Departures and Multiple Line Ups

RP	Main Current Mitigations	Additional Potential Local Mitigations[3]
ACE 2.6.3: Conditional clearances	1. Use of standard ICAO phraseology including issuing the restriction and the identity of the restricting traffic before the clearance. 2. ICAO compliant readback shall be given and checked by controller. 3. Pilots shall have traffic in sight. ATS Awareness CD states that it is particularly important not to make runway entries from oblique angled entry points for conditional clearances. 4. ATS Awareness CD states that if subject of clearance is landing aircraft, then that aircraft must be first on approach. In case of multiple departures, subject must be immediately ahead in departure sequence. 5. EAPPRI section on communications (4.3.1 – 4.3.5) & some from section ANSP (4.5).[4] 6. Part of rating and unit endorsement training for controllers. 7. If pilots have doubts about clearance they must ask for clarification.	1. Methods for showing an occupied runway to counter forgetting that cond. clearance has been given. 2. Level 2 A-SMGCS. 3. Limitation on number of conditional clearances. 4. Visibility criteria (tower can see all aircraft). 5. Investigate combination of conditional clearances with intersection departures and/or multiple line ups as part of local safety assessment. 6. CBT on runway safety measures (widely used).
ACE 2.6.10: Intersection departures	1. ACE documentation refers to restriction on use of oblique angled taxiways in context of intersection departures. 2. ICAO phraseologies. 3. ICAO compliant marking, lighting and signs. 4. AIP & charts. 5. Awareness campaign/ leaflet.	1. Improvement of runway entry points to improve line of sight. 2. Local ATC procedures such as stating line-up point when issuing a line up instruction via an intermediate holding point to prevent mis-interpretation. 3. Training of ATCOs. 4. A-SMGCS Level 2.
ACE 2.6.5: Multiple line-ups	1. EAPPRI – restriction on use of oblique angled taxiways (4.5.15). 2. Compliance with ICAO published phraseology and other conditions (see DOC 7030, Part 3, Sec. 3.1 Conditions for application). 3. Flight progress strip management to show occupied runway and sequence (not universally used). 4. Pilots trained in relevant signage etc (EAPPRI 4.4.1).	1. A-SMGCS Level 2. 2. Restrictions during hours of darkness (UK and others). 3. Local safety assessment including looking at combination of conditional clearances and multiple LUs and setting visibility criteria. 4. Constraints on rolling take-offs.

[3] To be determined based on local analysis (requirement of ESARR4)

[4] See Appendix III for relevant EAPPRI recommended practices

4.2.2 Consequences of Hazard

Table 4.3 below lists RPs in Appendix I, which potentially have an impact on the ***consequences*** of Runway Incursions (RIs).

Table 4.3 Impact of ACE RPs on RI Consequences

ACE ID	RP Description	Impact on Consequences of RI	Consequence Mitigation/ Comment
2.3.1	Nomination of preferred Rapid Exit Taxiways	(+) Reduced Runway Occupancy Time (ROT), less prob. of collision	
2.3.4	Pilots should always vacate the runway expeditiously with safety paramount	(+) Reduced ROT, less prob. of collision	
2.3.9	Procedures that abandon the use of 90-degree exits to reduce the actual runway occupancy time.	(+) Reduced ROT, less prob. of collision	
2.6.5	Multiple line-ups	(0/-) Increased chance of another aircraft being on runway	EAPPRI 4.5.15 on non-use of oblique angled access: reduces RI frequency but can also help collision avoidance
2.6.10	Intersection departures	(0/-) Aircraft at more vulnerable part of runway, increased chance of avoidance being required Positive impact (on mixed mode runway operation) of the increased distance between departing traffic and the subsequent arrival when using this RP	Non-use of oblique angled access
2.7.4, 2.13..1	Target for FRTT and ACE awareness campaigns could lead to pilot perception of ACE time pressure	(0) Decreased pilot vigilance for collision avoidance but should be adequately mitigated.	ACE and RWY SAF awareness campaigns to reinforce the “no rush” message.
2.7.5	Complete as many checks as possible before line-up	(+) Improved pilot vigilance for collision avoidance	

ACE ID	RP Description	Impact on Consequences of RI	Consequence Mitigation/ Comment
2.7.6	Provide take-off clearance early	(+) Reduced ROT, less prob. of collision	
2.10.1	Dedicated tower co-ordinator role in ATC	(+) Improved ATC vigilance for collision avoidance	

Table 4.3 shows that the ACE RPs have mixed impacts also on the consequences of RIs. The potential negative impacts result from intersection departures and multiple line ups. However, it appears more effective to mitigate their contribution to RI occurrence frequency rather than specific mitigation of their impact on consequences.

4.2.3 Overall Evaluation of ACE on Runway Collision Risk

The ACE RPs potentially have a mixed effect on both the frequency and consequences of RIs. To offset any potential negative effects from conditional clearances, intersection departures and multiple line-ups a long list of mitigations based primarily around ICAO, EAPPRI and ACE documentation has been developed. It is, however, very important to emphasise the importance of local safety assessments and safety monitoring in connection with the implementation of these RPs in order to ensure their safety.

4.3 Taxiway Collisions

4.3.1 Frequency of Hazard (Imminent Taxiway Collision)

Table 4.4 below lists the RPs in Appendix I which potentially have an impact on the ***frequency*** of imminent taxiway collisions.

Table 4.4 Impact of ACE RPs on Imminent Taxiway Collision Frequency

ACE ID	RP Description	Impact on Frequency of RI	Frequency Mitigation/ Comment
2.3.2	Use of Published Standard Taxi-Routes	(+) Ref. [2] indicates significant benefit in reducing RI frequency and this is also expected to have similar benefits for reducing imminent taxiway collisions	This is effectively the same RP as EAPPRI 4.5.9.
2.3.7	Progressive taxi instructions	(+) Ref. [2] indicates significant benefit in reducing RI frequency and this is also expected to have similar benefits for reducing imminent taxiway collisions	This is effectively the same RP as EAPPRI 4.5.10.

ACE ID	RP Description	Impact on Frequency of RI	Frequency Mitigation/ Comment
2.4.5	Alternate Parallel Taxi (APT) lanes and simultaneous push back	(0) No increase in taxiway imminent collisions providing mitigation package adopted	See Appendix I for key ACE and EAPPRI mitigations. EAPPRI 4.4.1 (pilot training on aerodrome signage, markings etc) and 4.4.5 (promote best practices while taxi-ing) are particularly important.
2.4.7	Selectable green taxiway lights	(+) Ref. [2] indicates significant benefit in reducing RI frequency and this is also expected to have similar benefits for reducing imminent taxiway collisions	
2.6.4	Multiple hold points (including for intersection departures)	(0) More potential close encounters. However, with correct taxiway design and sound ATCO and pilot technique the frequency of imminent taxiway collisions is expected to be kept constant	EAPPRI 4.4.1 (pilot training on aerodrome signage, markings etc) and 4.4.5 (promote best practices while taxi-ing) are again particularly important.

The ACE RPs are assessed as having a positive or at least neutral effect with respect to imminent taxiway collision frequency. The introduction of APTs with non ICAO compliant lighting and marking is associated with a significant number of mitigators (see Appendix I) and is expected at this generic level to be risk neutral.

4.3.2 Consequences of Hazard

Table 4.5 below lists the RPs in Appendix I which potentially have an impact on the ***consequences*** of imminent taxiway collisions.

Table 4.5 Impact of ACE RPs on Imminent Taxiway Collision Consequences

ACE ID	RP Description	Impact on Consequences	Consequence Mitigation/ Comment
2.3.1 and 2.3.9	Nomination of preferred Rapid Exit Taxiways and Abandoning use of 90 degree exits	(0) Increased speed into taxiway system – potentially reduced avoidance time but should be adequately mitigated.	Mitigated by RET design and consideration of taxi traffic flows.
2.13.1	Produce Company guidance to raise ACE awareness and reduce ROT	(0) If pilot perception is to rush, could result in decreased pilot vigilance for collision	ACE and RWY SAF awareness campaigns to reinforce the “no rush” message.

ACE ID	RP Description	Impact on Consequences	Consequence Mitigation/ Comment
		avoidance. However is expected to be adequately mitigated.	

With the identified mitigations the ACE RPs are assessed as having a neutral effect with respect to imminent taxiway collision consequences.

4.3.3 Overall Evaluation of ACE on Taxiway Collision Risk

Taking account of both the effect of ACE RPs on hazard frequency and consequences, it appears from this generic analysis that ACE will have a neutral - positive effect on taxiway safety with the identified mitigations in place.

4.4 Mid-Air Collision

This and the subsequent accident categories are less impacted by ACE and are therefore summarised below in a simpler way without splitting the frequency and consequence analysis.

Table 4.6 below lists the RPs in Appendix I which potentially have an impact on the mid-air collision ***risk.***

Table 4.6 Impact of ACE RPs on Mid Air Collision Risk

ACE ID	RP Description	Impact on Mid Air Collision Safety	Key Mitigations/ Comments
2.5.6	The use of reduced spacing on the runway (PANS-ATM Doc 4444 Nov 2005 amendment, para. 7.10)	(0) Expect to be risk neutral with the relevant mitigations within PANS-ATM Doc 4444	
2.6.9	The runway capacity could be increased by reducing the wake turbulence separation minima for given strong wind conditions or with the help of specific wake turbulence predictive tool.	Not known	Requires specific safety assessments/ cases for Time Based Separation or specific wake turbulence predictive tools. Ex-scope from this safety assessment.
2.8.1, 2.8.2 & 2.8.3	Early turn departure procedures, more diverging SIDS, high performance SIDs	(0) Generic mitigations available in ACE documentation expected to ensure RPs are risk neutral	Local safety assessment should include the impact of the proposed new procedures on aspects such as controller workload, sector co-ordination and abnormal procedures

ACE ID	RP Description	Impact on Mid Air Collision Safety	Key Mitigations/ Comments
			(e.g. comms failure procedure).
2.8.6	Visual separation immediately after departure by ATCO and pilot	(0) Adequately mitigated by current visual separation procedures	
2.8.7, 2.8.10 & 2.8.11	Use of distance based departure separation using Tower radar information, Implementing departure separation restrictions based on Distance in Trail & Mixed time and distance-based separation procedure to optimise the Minimum Departure Interval (MDI).	(0) Generic mitigations available in ACE documentation expected to ensure RPs are risk neutral	Real-time simulations of change on controller workload. Comprehensive local safety assessment. Publication of ATC procedures including what to do if radar surveillance is not available. Need certified radar system and controller to implement these.
2.9.3	Use minimum radar separation and consistent speed control	(0) Consistent speed control expected to offset increased probability of loss of separation arising from using MRS more often.	

With all impacts being neutral this generic analysis indicates that ACE will have a neutral effect on mid-air collision risk with the identified mitigations in place (see Appendix I for more detail).

4.5 Wake Turbulence (Vortex) Accident

Table 4.7 below lists all the RPs in Appendix I which potentially have an impact on the wake turbulence/ vortex ***risk***.

Table 4.7 Impact of ACE RPs on Wake Vortex Risk

ACE ID	RP Description	Impact on Wake Vortex Safety	Key Mitigations/ Comments
2.6.9	The runway capacity could be increased by reducing the wake turbulence separation minima for given strong wind conditions or with the help of specific wake turbulence predictive tool.	Not known	Requires specific safety assessments/ cases for Time Based Separation or specific wake turbulence predictive tools.
2.8.6	Visual separation immediately after departure by ATCO and pilot	(0) Adequately mitigated by current	

ACE ID	RP Description	Impact on Wake Vortex Safety	Key Mitigations/ Comments
		visual separation procedures	
2.8.7, 2.8.10 & 2.8.11	Use of distance based departure separation using Tower radar information, Implementing departure separation restrictions based on Distance in Trail & Mixed time and distance-based separation procedure to optimise the Minimum Departure Interval (MDI).	(0) Wake Vortex separation rules take priority	
2.9.3	Use minimum radar separation and consistent speed control	(0) Consistent speed control expected to offset increased probability of loss of separation arising from using MRS more often	

This generic analysis indicates that ACE will have a neutral effect on Wake Vortex risk with the identified mitigations in place (see Appendix I for more detail).

4.6 Controlled Flight Into Terrain (CFIT)

Table 4.8 below lists the limited number of RPs in Appendix I which potentially have an impact on CFIT ***risk.***

Table 4.8 Impact of ACE RPs on CFIT Risk

ACE ID	RP Description	Impact on CFIT Safety	Key Mitigations/ Comments
2.8.1	Early turn departure procedures. Removal of slower, NPR exempt aircraft from SID.	(0) Generic mitigations available in ACE documentation expected to ensure RP is risk neutral	No aircraft should be instructed to commence a turn below a height of 500 feet. The actual turning point will be determined locally, as part of a comprehensive safety assessment, and will depend on such things as terrain and noise sensitive areas.

ACE ID	RP Description	Impact on CFIT Safety	Key Mitigations/ Comments
2.8.2	Early split as soon as possible after departure (including introduction of more diverging SIDs). Not specifically aimed at turbo-props.	(0) Generic mitigations available in ACE documentation expected to ensure RP is risk neutral	As above

As can be seen from table 4.8 ACE is predicted to be risk neutral with respect to CFIT with the mitigations in place.

4.7 Loss of Control on Landing or Take-Off

Table 4.9 below lists the RPs in Appendix I which potentially have an impact on Loss of Control ***risk.*** Runway overrun is included under Loss of Control.

Table 4.9 Impact of ACE RPs on Loss of Control Risk

ACE ID	RP Description	Impact on Loss of Control Safety	Key Mitigations/ Comments
2.3.1	Nomination of preferred Rapid Exit Taxiways	(0) No negative effect with mitigations	Pilot assessment of safe speed. ICAO compliant RET design and RETILs. Provision of information on ATIS concerning runway/ taxiway conditions.
2.3.4	Pilots should always vacate the runway expeditiously with safety paramount	(0) No negative effect	
2.3.9	Procedures that abandon the use of 90-degree exits to reduce the actual runway occupancy time.	(0) No negative effect with mitigations	As for 2.3.1 above.
2.4.8	Distance to go information should be provided to the pilot by: - RETILS for night & low vis - Equivalent markings for day / good vis	(+) Reduced chance of turning off at too high a speed	
2.4.9	With the exception of the final stop	(+) Limit of 3 RETs	

ACE ID	RP Description	Impact on Loss of Control Safety	Key Mitigations/ Comments
	exit, all runway exits should (where possible) be RETs. The number should normally be limited to 3 RETs plus a standard exit at the rwy end. Perpendicular exits may be retained for crossing traffic.	reduces potential for pilot confusion	
2.6.10	Intersection departures	(0) Neutral with mitigations (see App I)	Pilot ensures that reduced declared distance conforms to aircraft certified performance. Publication of declared distances for intersection departure. Signage with RWY distances available and pilot training in signage (EAPPRI 4.4.1). Airline procedure to have alternative take-off performance (see ACE 2.13.4 below).
2.10.5	ATC should delegate the management of surface clearing operations to a specific coordinator.	(+) Surface contamination could affect frequency of loss of control. Hence RP should be beneficial in clarifying responsibilities	
2.10.6	ATC should delegate the management of de-icing operations (de-icing assistance requirement, ground taxiing to de-icing operation location, etc) to a specific supervisor of de-icing operations	(+) Aircraft icing could affect frequency of loss of control. Hence RP should be beneficial in clarifying responsibilities	
2.13.4	Airlines to introduce a procedure for preparing alternative take off performance prior to taxi - for airports where late changes are likely.	(+) Safeguard for 2.6.10.	

This generic analysis indicates that ACE will have a positive effect on LOC risk with the identified mitigations in place (see Appendix I for more detail).

4.8 Jet Blast

For a limited number of the ACE RPs, a potential impact on jet blast risk was identified in Appendix I. This accident category is less amenable to a bow tie modelling approach. Thus, to establish some indication of baseline current jet blast risks an extensive data search was made of historic incidents. Airclaims Worldwide Aviation Accident Summary (CAA CAP479) was reviewed. Between 1990-2005 there are over 7000 accidents described in this source. In only 1 event was jet blast a contributory factor. In this event in 2003 in the US, a Cessna passed behind a Canadair CRJ which was conducting a ground engine run. The jet blast blew the Cessna over onto its left wing. This event is not considered relevant to any of the ACE measures.

Other data sources have also been reviewed and no events involving aircraft damage from jet blast have been found. Thus current risks to aircraft from jet blast appear to be adequately controlled by current practices and procedures.

As noted in EAPPRI 4.5.13 it is important that ACE measures receive an adequate local safety assessment. An example of this is a local assessment of jet blast risk by Prague Airport due to simultaneous push-backs (ACE 2.4.5). Such assessments are expected to maintain the current low levels of jet blast risk.

4.9 Data Collection and Capacity Analysis Tools

As well as the 89 RPs the ACE project also involves processes and tools to analyse and predict capacity and to recommend effective capacity enhancement measures. These processes have been considered at a high level from a safety perspective and the outputs summarised in Table 4.10. The details of the PIATA and CAMACA [**6, 7**] tools have not been analysed, rather the process steps have been considered at a generic level. The outputs in Table 4.10 are based on outputs from the safety workshops and a review conducted with one of the ACE capacity tool analysts.

Table 4.10 Safety Issues Associated with Capacity Measurement and Modelling

Process Stage	Potential Safety Issues	Current Mitigations	Safety Recommendation
Data collection	Data collectors block view of ATCOs or cause distraction in control room	Data collectors, trained by EUROCONTROL, are aware of this issue	Provide guidance for data collectors from other stakeholders to mitigate this hazard.
	Measurement of pilot performance may create pressures for unsafe acts	Awareness campaigns Low ROTs are not recorded as these may reflect undesirable methods of operation and hence reduce safety margins.	-

Process Stage	Potential Safety Issues	Current Mitigations	Safety Recommendation
	Inaccuracies in data collection, e.g. due to non-standardised manual methods	Automated tools such as EUROCONTROL's PROMET Training and independent checking	-
Input data into tools	Checking validity of input data. In particular are changes in airport configuration and other characteristics always passed onto updated runs of the models?	-	Ensure there is a change management procedure associated with the input data to the tools.
Run tools	Robustness of tools	Verification and certain degree of validation of tools has been carried out and documented	Prepare complete verification and validation documents for all tools used including where possible cross checks between PIATA and CAMACA.
Analyse results, generate capacity enhancement recommendations	Too high a capacity declared Inappropriate (unsafe) capacity enhancement recommendations generated	Experts analyse results and produce recommendations. Steering group reviews outputs Requirement in EAPPRI for local safety assessment of ACE measures.	Establish guidelines for experience/ training of experts who turn tool results into recommendations as these tools are rolled out to more stakeholders.
Steering group reviews results and recommendations	None. This stage is an important safeguard on preceding stages.	-	-
Review by tool analysts of feedback following implementation of capacity enhancement recommendations	None. Again this stage is an important safeguard on preceding stages.	-	-

5 OVERALL EVALUATION

5.1 Discussion of Results

In section 4 of this document the ACE RPs have been systematically analysed with respect to relevant accident categories to determine overall impacts on safety. Based on this generic analysis the following has been found:

- There are no "show-stoppers"[5], i.e. for all the RPs where safety concerns have been identified practicable mitigations have been identified with the potential to reduce risk to a tolerable level.

- Mitigations based primarily around documentation from ICAO (Doc. 4444, Annexes 11 and 14), EAPPRI and ACE (see section 2.3) have been developed plus additional options for local consideration. There are some RPs, in the context of the accident category "Runway Collisions" (namely Conditional Clearances, Intersection Departures and Multiple Line-ups), which will require strong and effective packages of risk mitigation measures in order to ensure that safety is not negatively affected. These mitigations and effective safety monitoring following implementation must be given a high priority.

- In the other accident categories, the analysis has indicated that the ACE RPs will have either a neutral or even a slightly positive impact on safety with the identified mitigations in place. However, as noted in the EAPPRI all these ACE RPs need local safety assessments as local factors can have a critical effect on the safety implications of all these RPs.

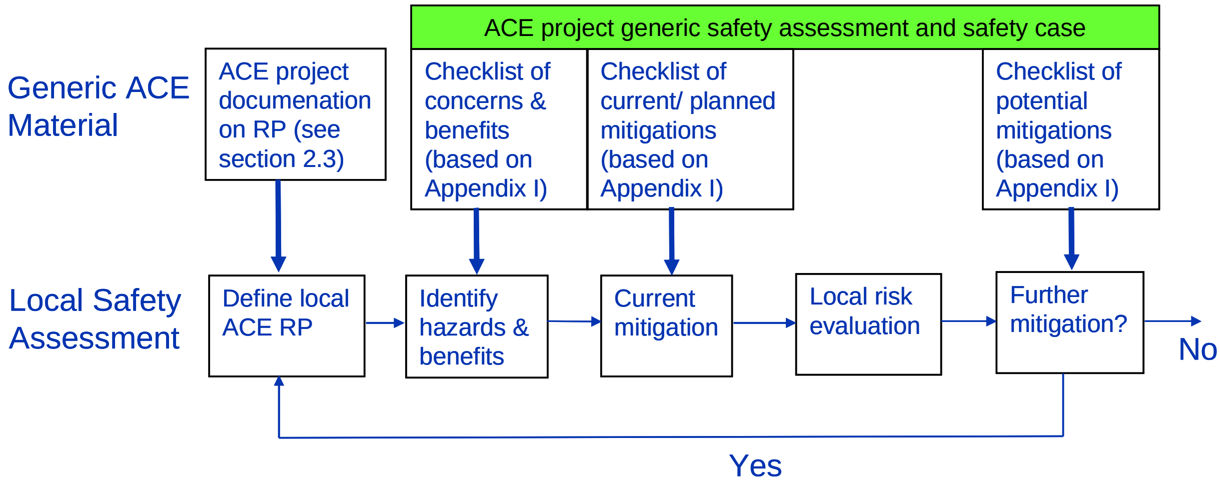
5.2 Link between EUROCONTROL Safety Assessment and Local Safety Assessments

Although the safety assessment documented in this report has been comprehensive in terms of covering all relevant RPs in the ACE documentation, it cannot take account of local factors and specific airport features. Thus local safety assessments will also be required before local implementation of the RPs. Such local safety assessments are a requirement under ESARR4 whenever ATM system changes are to be made.

Guidance material to assist stakeholders in conducting safety assessments is provided in EUROCONTROL's Safety Assessment Methodology, SAM V2 (see www.eurocontrol.int/safety/public/site_preferences/display_library_list SAM Electronic V2). In addition to this generic guidance, local safety assessments can also make specific use of ACE project material and this EUROCONTROL ACE safety assessment as shown in Figure 5.1 below.

[5] A "show stopper" is defined in this context as a safety concern or new hazard for which no practicable risk mitigation measure can be identified.

Figure 5.1 How Generic Safety Assessment Can Feed Local Safety Assessment



The ACE manuals and guidance documents can help define “the system”, i.e. the proposed ACE related change. This is the first stage in any safety assessment. The material in this document, particularly the detailed analysis in Appendix I, can then be used to prepare checklists for use in hazard identification and safety workshops, which are usually key inputs for a safety assessment. This process was followed with the participants listed in Section 1.5 in a safety workshop in September 2006. Four RPs were considered in detail with respect to Prague and Lisbon airport. The generic material from this document was found useful in facilitating the workshop and generating practicable risk mitigation.

5.3 Further Work

A number of safety data analyses have been carried out recently which are relevant to airport safety. In particular, the recent EUROCONTROL publication “Safety Analysis of Runway Incursions in Europe” [**3**] and “Development of an aerodrome runway incursion assessment model” [**2**] contain processed results based on extensive data analysis. Within these sources there are indications of significant numbers of events which are potentially related to ACE RPs such as conditional clearances and intersection departures. It would be very useful if further analysis were to be carried out of these datasets to validate that no important safety issues or key mitigation measures have been left out in this generic safety assessment.

Once such analysis has been conducted it would be possible to carry out awareness campaigns focused on these measures to help mitigate risk further.

In addition during the current updating of the ACE documentation it should be ensured that the content and tone of the documentation is consistent with EUROCONTROL’s safety documentation.

6 VALIDATION AND VERIFICATION

The following verification activities have been conducted during this safety assessment:

- Review of Safety Plan describing safety assessment activities to be carried out by EUROCONTROL's APR stakeholders and DAP/SSH (2 review cycles)
- Internal APR Progress meetings at which updates to the method were discussed and agreed with EUROCONTROL's APR stakeholders and DAP/SSH (28th February, 22nd June and 10th August 2006)
- External stakeholder meetings at which the method was presented and feedback received (3rd May and 6th September 2006)
- Review of safety assessment document structure and of the draft safety assessment report by EUROCONTROL's APR stakeholders and DAP/SSH.

The following validation has also been carried out:

- Review of safety assessment outputs by internal and external stakeholders at 3 safety workshops, 16th March (internal), 3rd May and 6th September 2006 (external and internal stakeholders).
- Review by APR stakeholders of the outputs in Appendix I of this report (3 review cycles)
- Review of outputs by DAP/SSH at these workshops and through review of the draft safety assessment.

7 CONCLUSIONS AND RECOMMENDATIONS

The three objectives set out in Section 1.2 have been met, namely:

1. The safety impact of each individual Recommended Practice (RP) within the project has been evaluated (in Appendix I and summarised in section 4);
2. The collective safety impact of all the RPs within the project has been evaluated with respect to common accident categories in Tables 4.1 to 4.9;
3. Extra risk mitigations (if relevant) to ensure that the RPs will be tolerably safe have been identified (in Appendix I and summarised in section 4).

Based on this generic safety assessment the following conclusions have been drawn:

- There are no "show-stoppers"[6], i.e. for all the RPs where safety concerns have been identified practicable mitigations have been identified with the potential to reduce risk to a tolerable level.

- Mitigations based primarily around ICAO, EAPPRI and ACE documentation have been developed plus additional options for local consideration. There are some RPs, in the context of the accident category "Runway Collisions" (namely Conditional Clearances, Intersection Departures and Multiple Line-ups), which will require strong and effective packages of risk mitigation measures in order to ensure that safety is

[6] A "show stopper" is defined in this context as a safety concern or new hazard for which no practicable risk mitigation measure can be identified.

not negatively affected. These mitigations and effective safety monitoring following implementation must be given a high priority.

- In the other accident categories, the analysis has indicated that the ACE RPs will have either a neutral or even a slightly positive impact on safety with the identified mitigations in place. However, as noted in the EAPPRI all these ACE RPs need local safety assessments as local factors can have a critical effect on the safety implications of all these RPs.

Recommendations have been produced in this report covering primarily:

- Specific risk mitigations for each RP which are detailed in Appendix I and Section 4 of this report;
- The capacity measurement and modelling process used within ACE (Section 4.9); and
- Further work relating to more data analysis (Section 5.3).

8 ABBREVIATIONS AND ACRONYMS

Abbreviation	Description
ac	Aircraft
A-CDM	Airport Collaborative Decision Making
ACE	(Airport) Airside Capacity Enhancement
AIM	Aeronautical Information Management
AIP	Aeronautical Information Publication
ANS CR	Air Navigation Service of the Czech Republic
ANSP	Air Navigation Service Provider
AO	Aircraft Operator
APR	Airport Operations Programme
APT	Alternate Parallel Taxi Lanes
A-SMGCS	Advanced Surface Movement Guidance and Control Systems
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATIS	Automatic Terminal Information Service
ATS	Air Traffic Service
CBT	Computer Based Training
CFIT	Controlled Flight Into Terrain
CSA	Czech Airlines
DAP/SSH	Directorate ATM Programmes/ Safety, Security, Human Factors
EAPPRI	European Action Plan for the Prevention of Runway Incursions
EATM	European Air Traffic Management
EATMP	European Air Traffic Management Programme
ECAC	European Civil Aviation Conference
EEC	EUROCONTROL Experimental Centre
ESARR	EUROCONTROL Safety Regulatory Requirement
FHA	Functional Hazard Assessment
FTA	Fault Tree Analysis
GA	General Aviation
ICAO	International Civil Aviation Organization
IRP	Integrated Risk Picture
LRST	Local Runway Safety Team
LU	Line Up
LVP	Low Visibility Procedure
MDI	Minimum Departure Interval
PSSA	Preliminary System Safety Assessment
RETIL	Rapid Exit Taxiway (Indicator Lights)
RI	Runway Incursion

Abbreviation	Description
RIMCAS	Runway Incursion Monitoring and Collision Avoidance System
RP	Recommended Practice
RT	Radio Telephony
RTS	Real Time Simulations
RWY SAF	Runway Safety Project
ROT	Runway Occupancy Time
SID	Standard Instrument Departure
SMGCS	Surface Movement Guidance and Control Systems
SMS	Safety Management System
TO	Take Off
WV(E)	Wake Vortex (Encounter)

9 REFERENCES

1. EUROCONTROL (2006): “A-SMGCS Levels 1 and 2 Preliminary Safety Case”, Edition 1.4, October 2006

2. EUROCONTROL (2006): “Development of an aerodrome runway incursion assessment model”, 10 August 2006, Rev 4c

3. EUROCONTROL (2005): “Safety Analysis of Runway Incursions in Europe”, Edition 1.0, August 2005

4. EUROCONTROL (2006): “Main Report For The 2005/2012 Integrated Risk Picture For Air Traffic Management In Europe”, EEC, March 2006

5. EUROCONTROL (2006): “Safety Plan for 3 Airports Projects (ACE, A-CDM and RWY SAF)”, Edition 1.0, May 2006

6. EUROCONTROL (2005): “PIATA Plus User Guide”, TRS 143/03, June 2005

7. EUROCONTROL (2002): “Commonly Agreed Methodology for Airport Airside Capacity Assessment (CAMACA), User Manual Document”, September 2002

8. “European Action Plan for the Prevention of Runway Incursions”, Release 1.2

Appendix I – Spreadsheet of RPs

The analysis presented in this appendix is based on a series of safety workshops and post-workshop analysis. The participants in this process are detailed in the Table below together with the organisation they were representing. Three workshops were held (one internal and two with external stakeholders, see details in Section 6) and the participation in each is indicated below.

Name	Role/ Organisation	Internal	External 1	External 2
Eric Miart	APR Programme Manager, EUROCONTROL	✓	✓	
Yvonne Page	RWY SAF Project Manager, EUROCONTROL	✓	✓	✓
Gregory de Clercq**	ACE Project Manager, EUROCONTROL	✓	✓	✓
Andrew Taylor**	ACE Project, EUROCONTROL	✓	✓	✓
Palle Larsen**	ACE Project, EUROCONTROL			✓
David Booth	CDM Project/ EUROCONTROL	✓	✓	
Ton van der Veldt	IATA		✓	
Manuel Araujo	Nav Portugal		✓	✓
Vladimir Bohac	ANS CR, ATCO		✓	✓
Jiri Mosnicka	CSA, Technical Pilot		✓	✓
Denisa Kontarova	CSA, Flight Safety Deputy Director			✓
Marc Matthys	Belgocontrol, Capacity and Punctuality		✓	
Luigi Locoge	Belgocontrol, ATCO		✓	
Christopher Machin	DAP/SSH, EUROCONTROL	✓	✓	✓
Edward Smith*	DNV, Facilitator	✓	✓	✓
Heather Selwyn*	DNV, Recorder	✓		
Roger Lee*	DNV, Recorder		✓	

*** Main post-workshop analysis**
**** Main reviewers**

As noted in Section 2.3 of the main report, 12 of the original 89 RPs were withdrawn during the course of the analysis. Their descriptions have been left in the spreadsheet for completeness but they are labelled as "WITHDRAWN" and coloured red.

For RPs 2.3.1, 2.4.5, 2.6.3, 2.6.5 and 2.6.10, the long lists of Current Mitigations and Extra Mitigations are linked to the safety concerns through numbering.

ID	Re-commended Practice	ICAO Compliant?	Safety Benefits?	Safety Concerns?	Grouping, Potential Conflicts	Current/ Planned Mitigations	Mapping to Risk Model (Accident Categories)	Impact of RP on Hazard Frequency	Impact of RP on Hazard Consequence	Generic Mitigation	Potential Local Mitigations
ACE 1	**CAPACITY & PERFORMANCE MEASURING - safety assessed in main report section 4.9**										
ACE 2	**BEST PRACTICES**										
ACE 2.1	**AIRPORT SCHEDULING**										
ACE 2.1.1	Rolling 60-minute airport slot scheduling	N/A	Potentially can reduce bunching that can be experienced with fixed hour scheduling	No	-	Aircraft separations still apply determining maximum capacity Shorter term maximums can be applied in addition (e.g. over 15 minute periods)	No significant impact on risk - not modelled	N/R	N/R	No	-
ACE 2.1.3	Set up slot monitoring and slot abuse committees and ensure that these adopt CDM	N/A	No	No	-	-	No significant impact on risk - not modelled	N/R	N/R	No	-
ACE 2.2	**PUSH-BACK & START-UP PROCEDURES**										
ACE 2.2.2	Tactical push-back & remote hold prior to start up. Hot Hold After Start-up.	N/A	Smoother flow of traffic - potential for reduced controller workload	Jet Blast & Engine Ingestion risks require adequate separation and communication regarding use of hard-stand areas for start-up. This procedure may not be applicable to all airfield layouts since it requires sufficient space to safely hold aircraft prior to departure without encroaching on runways, taxiways, etc.	Hold points need to be checked if Alternate Parallel Taxi Lanes (APTs) are used - ACE 2.4.5	It requires sufficient space to safely hold aircraft prior to departure without encroaching on runways, taxiways, etc. Minimum safe separation distances must be maintained at all times. Adequate separation must also be maintained to ensure that ground crew and other airfield users do not suffer from jet blast and engine ingestion at any time during the tactical pushback. (ATS Awareness CD, Stand Utilisation)	Taxiway Collision Jet Blast	RP will lead potentially to more aircraft "obstacles" holding, but mitigations are expected to ensure that collision freq. and jet blast damage freq. does not increase.	No effect on avoidance actions.	No	A satisfactory local risk assessment must be carried out prior to adoption/publication of this procedure. Ground crew must be fully trained to ensure that the new procedure is correctly implemented and adhered to. (ATS Awareness CD, Stand Utilisation)

ID	Re-commended Practice	ICAO Compliant?	Safety Benefits?	Safety Concerns?	Grouping, Potential Conflicts	Current/ Planned Mitigations	Mapping to Risk Model (Accident Categories)	Impact of RP on Hazard Frequency	Impact of RP on Hazard Consequence	Generic Mitigation	Potential Local Mitigations
ACE 2.2.3	Don't Issue Start-up clearance until you are sure that the a/c can make their CTOT	N/A	Reduces subsequent need for extra comms and workload	No	-	N/R	N/R	N/R	N/R	N/R	N/R
ACE 2.3	**TAXIING PROCEDURES**										
ACE 2.3.1	**Preferred Exit Taxiways** - Airports should recommend preferred RETs by aircraft type and promulgate through AIP. Controllers should agree with airlines the most advantageous Rapid Exit Taxiway (RET) under normal operating conditions for a given type of aircraft.	N/A	Pilots awareness raised by information in AIP about airport RETs Identification of RET improves predictability for ATCOs and planning for pilots Reduced likelihood of hard braking for inappropriate exits. Reduced ROT	• Vacating via nominated RET at high speed in bad weather (S1, S2, S3, S4, S5, S6, ES1). • Exiting a/c at higher speed potentially conflicts with a/c on other taxiways. (S1, S2, S6). • Possible degraded braking action on taxiway compared to runway (S3, ES1).	-	1. Pilot assessment of safe exit to use given speed, runway conditions etc (see ACE "The Guide", pages 3.2 to 3.3). 2. ICAO compliant RET design (see EAPPRI 4.2.1). 3. Provision of information on ATIS concerning taxiway conditions. 4. RETILs (ICAO recommendation). 5. Awareness campaign/ leaflet. 6. EAPPRI RPs on communications (4.3) to improve situational awareness, best practices while taxi-ing (4.4.5) and pilots trained in relevant signage markings, lighting etc (4.4.1)	Runway Collision Landing Accidents Taxiway Collision	No effect on freq. of RI With mitigations no effect With mitigations no effect	Reduced ROT reduces probability of another ac on runway No effect on conseqs. Increased speed into taxiway system – potentially reduced avoidance time but expected to be mitigated by RET design and consideration of taxi traffic flows	Standardisation in AIP of nominated RWY exits and other HIRO techniques.	1. Extra guidance about when HIRO should be terminated (e.g. runway/ taxiway contamination) 2. Local safety assessment taking account of use of preferred RETs on likely flows of taxiing traffic 3. Measurements of braking action in a range of runway conditions

ID	Re-commended Practice	ICAO Compliant?	Safety Benefits?	Safety Concerns?	Grouping, Potential Conflicts	Current/ Planned Mitigations	Mapping to Risk Model (Accident Categories)	Impact of RP on Hazard Frequency	Impact of RP on Hazard Consequence	Generic Mitigation	Potential Local Mitigations
ACE 2.3.2	**Published Standard Taxi-Routes -** Use of standard taxi routes (including circular one-way systems).	YES - ICAO Doc 4444 para 7.5.3.1.1.3	Reduces Controller Workload. Reduced radio transmission due to simpler message. Reduced pilot workload due to increased familiarity with taxi routes - reduced confusion. Better traffic flow = increased safety.	Potential for reduced ATCO monitoring of aircraft movements - less likely to observe incorrect movement / potential conflicts.	Same as RWY SAF 4.5.9. When crossing of active runways required - explicit clearance still required. This needs to be clear to all partners. See RWY 4.5.3. and 4.4.7.	If it is necessary to cross a runway during taxi then the standard route should only be as far as the point at which aircraft must hold short of this runway. An individual crossing clearance should then be issued by the controller and read back by the crew (see European Action Plan for the Prevention of Runway Incursions). (ATS Awareness CD, Taxiway congestion)	Runway Collision & Taxiway Collision	Ref. [2] - significant potential for reduction in overall incursion frequency dependent on airport type	No effect on consequences	NO	During implementation, check controller monitoring of aircraft taxiing. Signage, markings and airfield lighting systems need to support the rerouting of aircraft (even if not done very often, it may still be necessary to reroute, for example when taxiways are closed). A satisfactory risk assessment must be carried out for each option prior to selection and adoption/ publication.
ACE 2.3.3	Taxiing out on one engine	N/A	No	No	-	N/R	N/R	N/R	N/R	N/R	N/R
ACE 2.3.4	Pilots should always vacate the runway expeditiously with safety paramount	N/A	Reduced ROT and potential for collision	Potential for extra pressure on pilots to manoeuvre at high speed		Pilot assessment of safe exit to use given speed, runway conditions etc (see ACE "The Guide", pages 3.2 to 3.3). ICAO PANS ATM 12.3.4.20 "Runway Vacation and Comms After Landing"	Runway Collision Landing Accidents Taxiway Collision	No effect on freq. of RI With safeguard no effect With safeguard no effect	Reduced ROT reduces probability of another ac on runway No effect on conseqs. No effect on conseqs.	Investigation of HIRO with wet/ flooded runways and taxiways	Airline and ANSP SMS should be safety monitoring pilot performance in exiting runways and taxi-ing

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ACE 2.3.5	Company (Airline) procedures should be reviewed to eliminate the requirement for checklists to be completed whilst on the runway. In the event that crew is waiting for the download of performance data this should be accomplished off the runway.	N/A	Reduced ROT and potential for collision. Improved safety through earlier completion of critical tasks.	No	N/R	N/R	Conservatively no benefit explicitly modelled.	N/R	N/R	N/R	N/R
ACE 2.3.6	Minimum safe separation distances must be maintained at all times.	Yes	Caution should help control ground collision risk	No	N/R	N/R	Runway Collision Taxiway Collision	No benefit explicitly modelled as assumed that minimum separations are already being complied with	No benefit explicitly modelled as assumed that minimum separations are already being complied with	N/R	N/R

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ACE 2.3.7	Provide pilot with progressive taxi instructions when the complete taxi route is not yet known (or is unusually complicated) or pilot is unfamiliar with airport.	ATS OPS Manual (training) Radiotéléphonie manual (Doc9432)	Reduce pilot confusion leading to error. Reduced controller workload in having to repeat instructions.	Local factors such as taxiway configuration and traffic densities could affect safety of progressive taxi instructions.	In alignment with RWY 4.5.10.	Local safety assessment (EAPPRI 4.5.13)	Runway Collision & Taxiway Collision	Ref. [2] - potential for reduction in overall incursion frequency: In significant fraction of RIs causal factor was crew not familiar with the airport.	No effect on consequences	NO	Progressive instructions to be risk assessed for specific operating environment to check risks associated with congestion due to progressive taxi instructions. Risk analysis should take account of taxiway configurations, traffic densities, controller workloads, airport visibility and tool availability (e.g. surface guidance).

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ACE 2.3.9	Procedures that abandon the use of 90-degree exits to reduce the actual runway occupancy time.	ICAO Compliant signage for closed exits will be applicable	Reduced ROT and thereby reduced potential for collision	Aircraft may stop adjacent to a closed exit if they are unfamiliar with recent closure - increased ROT. Exiting a/c at higher speed potentially conflict with a/c on other taxiways. RET design should consider required deceleration & traffic flow should also be considered.	N/R	Pilot assessment of safe exit to use given speed, runway conditions etc (see ACE "The Guide", pages 3.2 to 3.3). ICAO PANS ATM 12.3.4.20 "Runway Vacation and Comms After Landing"	Runway Collision Landing Accidents Taxiway Collision	No effect on freq. of RI With safeguard no effect With safeguard no effect	Reduced ROT providing ac do not stop at closed exit No effect on conseqs. Increased speed into taxiway system – potentially reduced avoidance time but expected to be mitigated by RET design and consideration of taxi traffic flows	NO	Publication and controller advice of exit status. ANSP SMS to monitor exit closure effects. + see ACE 2.3.1
ACE 2.3.10	WITHDRAWN Procedures to enable ATC to request pilots to continue taxi after vacating a runway even if they have not received a taxi clearance yet may lead to improvements in runway capacity.	NO - ICAO Doc 4444 Chpt 7.5 states that clearance to taxi should be given to an aircraft whilst still on the runway.		However, the possible safety implication, particularly during low visibility conditions, need to be fully considered prior to implementation. The need to cross active runways and use of taxiways other than RET's need to be considered.							

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ACE 2.3.11	Taxi distance and time should not be considered (by the pilot) when selecting the RET to be used.	N/A	No	No	N/R	N/R	N/R	N/R	N/R	N/R	N/R
ACE 2.3.12	Use of airport surveillance systems (A-SMGCS).	YES	Improved identification of aircraft, reduced radio transmission, Level 2 gives incursion warnings - reduced runway incursions.	No	Implications covered in A-SMGCS Safety Case.	Implications covered in A-SMGCS Safety Case.	Implications covered in A-SMGCS Safety Case.	N/R	N/R	N/R	N/R
ACE 2.4	**INFRASTRUCTURE (e.g. TAXIWAY DESIGN, MARKINGS, SIGNAGE ETC)**										
ACE 2.4.1	Pilots need to be informed of non-standard RETs.	All RET's should be designed in accordance with ICAO Annex 14 provisions. ICAO Annex 14 and ICAO Aerodrome Design Manual (Doc9157), Part 2.	Improved pilot awareness of potential hazard	Lack of standardised RET design could increase complexity for new pilots who are unfamiliar with the location specific design. Informing pilots is ok as a short-term measure, but not ideal solution.	-	This RP is a safeguard against non-standard RET provision	Runway Collision (if RET is too shallow and ac slow to clear runway width) Landing Accidents (if RET too sharp) Taxiway Collision (if speed exiting RET is too high)	Providing this information should have some benefit. However, no benefit modelled explicitly. A more effective measure would be to provide ICAO compliant RETs.	No effects on consequences	No	Local Risk Assessment of deviation from ICAO RET design.

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ACE 2.4.2	Addition of 'fillets' to improve access to taxiways.	YES - ICAO Annex 14 Chpt 3. para 3.9.6	Can improve pilot visibility	No	N/R	N/R	N/R	N/R	N/R	N/R	N/R
ACE 2.4.3	Multiple access taxiways (see ACE 2.6.10) and/or runway holding bays (see ACE 2.6.4)	-	-	-	-	-	-	-	-	-	-
ACE 2.4.4	Improved Taxiway Friction	YES	Improved braking - reduced collision and landing accident risk.	No	-	-	No benefit modelled explicitly	N/R	N/R	N/R	N/R
ACE 2.4.5	Alternate Parallel Taxi Lanes (APTs) allowing simultaneous pushback and taxi-ing.	YES if a system such as London Stanted is used. However, subject to local safety assessment, a harmonised colour coded version could be used by stakeholders	Max span markings on APTs Reduced workload for Ground Movement Controller due to smoother traffic flow.	Apron collision due to wingspan exceeding spacing. (S1, S2, S6) Pilot or driver confusion due to increased number of markings. (S1, S5, S7-9) Confusion might increase in LVP and winter conditions.(S7-9) Proximity of APTs to manoeuvring area. (S3) Temporary works might affect clarity	Potential conflict with additional hold points - ACE 2.2.2	1. Use of simultaneous push-backs and APTs require additional training with handling agents and risk assessment (ACE - ATS Awareness CD). Where aircraft are parked close together, there has to be a joint training exercise with relevant handling agents to ensure all staff are aware of the appropriate procedures (ACE - Keep Them Moving CD). 2. "Max Span" markings on APT centrelines. 3. Generic ICAO documentation on taxiway design etc. 4. To reduce the risk of incursions onto a main taxiway system, a taxi-holding position marking should be displayed on the taxi-lanes prior to the junction of the APTs and the main taxiway.	Taxiway Collision	Potential increase in apron imminent collision freq. expected to be controlled by mitigations to ensure no net change	No effect on avoidance actions.	APT Design Guidance supported by ICAO ASMGCS Level 1	1. Training for drivers 2. Ensuring consistency of maps and charts 3. Publication of Hotspot maps 4. Adherence to taxiway speed guidance 5. Guidelines in power-back procedures 6. Local safety assessment and implementation will need to ensure that APT markings are clear and visible in all conditions (including temporary works),

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				of APT markings. (ES6) No consistency in APT markings. (S1-S9) Variation in adaptation of ICAO wing span analysis. (S3) Lack of guidance during power-back phase of flight (ES5)		5. Procedures are fully documented in the relevant AIP and the ground markings are clear and unambiguous 6. Pilots training (EAPPRI 4.4.1 and 4.4.5) - are responsible for obtaining clearances and should not accept a clearance which is unsuitable for their aircraft type. 7. The lighting system should provide an adequate guidance on APTs, curves and intersections in accordance with ICAO recommendations. 8. Taxi and pushback instructions shall include the name, colour (where appropriate) and direction of the relevant APT. 9. Phraseology used should be clear and unambiguous (EAPPRI section on comms, 4.3).					not inducing confusion. 7. Local assessment needed to check safety for ground staff (e.g. Prague Airport safety assessment) 8. File a local difference in national AIP
ACE 2.4.6	ICAO compliant Taxiway centreline lighting (providing routing guidance) should be provided for all RETs	YES	Reduced likelihood of confusion for pilots.	No	-	-	Risk benefit modelled in RWY SAF 4.2.1 concerning Annex 14 compliance	See RWY SAF 4.2.1	See RWY SAF 4.2.1	N/R	N/R

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ACE 2.4.7	Visual Improvement of taxiway routes by use of green selectable centreline lighting and/ or painting of large expanses of concrete (with green "grass" areas) so that pilots can more easily identify the taxiway itself	YES with additional features	Reduced likelihood of confusion for pilots.	These painted fields might be difficult to see at night under artificial light or when apron is wet due to the reflections from the lighting. Use of green selectable taxiway lighting can lead to red stop bar lighting going off and misleading following aircraft.	-	This RP is a safeguard against taxi-ing risks	Runway Collision & Taxiway Collision	Ref. [2] - significant potential for green taxiway CL lights to reduce RI risk	No effect on consequences	No	Local monitoring of any problems with painted fields at night under artificial light or when apron is wet due to the reflections from the lighting. Safety assessment of lighting design and in particular interactions with stop bar lighting.
ACE 2.4.8	Distance to go information should be provided to the pilot by: - RETILS for night & low vis - Equivalent markings for day / good vis	YES	Pilot better able to judge deceleration to chosen RET - Hard braking less likely. Increased pilot situational awareness.	No	-	-	Landing accidents	Reduced likelihood of loss of control	No effect on consequences	No	No

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ACE 2.4.9	With the exception of the final stop exit, all runway exits should (where possible) be RET's. The number should normally be limited to 3 RETs plus a standard exit at the rwy end. Perpendicular exits may be retained for crossing traffic.	This RP clarifies the ICAO (Doc 9157, Part 2) recommendation that "Sufficient entrance and exit taxiways for a runway should be provided to expedite the movement of aeroplanes to and from the runway and provision of rapid exit taxiways considered when traffic volumes are high".	Limit of 3 RETs reduces potential for pilot confusion	Use of RETs as oblique entry points (made clear in ACE CD that this is not allowed). Needs to be made clear that RETs are not to be used as crossing points or for access (made clear in ACE CD that this is not allowed). If perpendicular crossing points are retained, it needs to be clear that they are not used for exiting the rwy. Specific number of RETs might not be appropriate for all eventualities (covered by use of word "normally")	-	Extra words in RP introduced to address concerns EAPPRI 4.5.15 for not using oblique entry points.	Landing Accidents (if provision of RETs not appropriate)	No change in accident freq.	No effect on consequences	-	-
ACE 2.4.10	RETs should be positioned according to the design mix of traffic. Assessment of fleet performance should be based on actual operator data.	YES	-	No	N/R	N/R	N/R	N/R	N/R	N/R	N/R

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ACE 2.5	**LANDING PROCEDURES**										
ACE 2.5.1	**Conditional Clearances - Generic addressed under ACE 2.6.3**										
ACE 2.5.2	WITHDRAWN 'Land after the departing A/C' procedures.	NO	Pilots are explicitly aware of traffic ahead.	Confusion over the transfer of responsibility for separation - i.e. is responsibility officially transferred to the pilot? Possible conflict in case of go around where procedures do not assure separation from departing traffic - reduced separation scenario which requires the controller to manage in this case.							
ACE 2.5.3	WITHDRAWN 'Land after the landing A/C' procedure.	NO	Pilots are explicitly aware of traffic ahead.	Confusion over the transfer of responsibility for separation - i.e. is responsibility officially transferred to the pilot?							

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ACE 2.5.4	Issue a landing clearance as early as practicable. This could be done by use of anticipated clearances (where these are permitted - discussion with regulators may be required).	YES	An early clearance allows the pilot better planning and focusing on landing checks due to certainty of landing clearance.	In a critical situation (e.g. where runway suddenly becomes unavailable), this could potentially increase the workload for a controller in cancelling these clearances	-	ICAO PANS Doc 4444 chapter7.9.2 allows only one aircraft to be given an anticipated landing clearance hence, if runway became unavailable, only 1 go-around would be required. Controller workload should therefore, not be impacted greatly.	No safety benefit explicitly modelled and concern can be mitigated by local safeguard	N/R	N/R	N/R	Prior to the introduction of such procedures, a local risk assessment must be carried out. The procedure should cover what to do in contingencies such as sudden runway closure. Controllers must be trained in the use of the procedure and made fully aware of any limitations.
ACE 2.5.5	On arrival, early planning by pilot of which RET will be used, and an alternate exit in case this is passed. As always, situational awareness and common sense plays its part. There is no need to vacate the runway in 30s if there is no-one directly behind or waiting to take-off.	N/A	Increased planning reduces pilot workload at critical point (during landing). Leaves extra capacity to cope with other tasks that may occur.	No	-	N/R	N/R	N/R	N/R	N/R	See ACE 2.3.4 for monitoring

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ACE 2.5.6	The use of reduced spacing on the runway can provide operational flexibility, although the safety implications of such a procedure must be fully considered.	PANS-ATM Doc 4444 Nov 2005 amendment, para. 7.10	Defined minimum separations with associated mitigations	No, assuming ICAO minimum separations are safe	-	PANS-ATM Doc 4444 Nov 2005 amendment, para. 7.10.6, i.e.: a) wake turbulence minima shall be applied, b) visibility shall be at least 5 km and ceiling shall not be lower than 300m, c) tail wind component shall not exceed 5kt, d) there shall be available means, such as suitable landmarks to assist the controller in assessing the distances between aircraft (a surface surveillance system may be used if a safety assessment has been conducted), e) min sep continues to exist between 2 departing aircraft immediately after take-off of the second aircraft, f) traffic information shall be provided to the flight crew of the succeeding aircraft concerned, and g) the braking action shall not be adversely affected by runway contaminants	Mid-air Collision Runway Collision	No increase in risk with ICAO mitigations	No increase in risk with ICAO mitigations	-	PANS-ATM Doc 4444 Nov 2005 amendment, para. 7.10.7.1, i.e. Consideration should be given to increased separation between high performance single-engine aircraft and preceding Category 1 or 2 aircraft

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ACE 2.6	**HOLDING & LINE-UP PROCEDURES**										
ACE 2.6.1	Hold allocation management technique in ATC. The line-up sequence should depend on consideration of wake vortex categories, aircraft speed and SID's.	N/A	No	Nothing specific to this RP. Any resulting safety implications covered by RPs 2.6.4 and 2.6.10	Related to ACE 2.6.4 and 2.6.10	N/R	N/R	N/R	N/R	N/R	N/R
ACE 2.6.2	Complete as many take off checks as possible before entering the runway.	N/A	Reduced ROT and potential for collision. Improved safety through earlier completion of critical tasks	No	Group with ACE 2.3.5	N/R	Conservatively no benefit explicitly modelled.	N/R	N/R	N/R	N/R

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ACE 2.6.3	A. Use of conditional ATC clearances. Conditional Clearances for line up after departure and landing (mixed mode) and conditional crossing clearance. – B. “This means that pilots may proceed past the holding point, even though the preceding aircraft may not have started its take-off roll.”	YES. Doc 4444 chapter 12.2.4 covers phraseology and visual ID of subject aircraft or vehicle. Doc 9432 chapter 4.5.7 on correct ID of landing aircraft. Annex 11 para 3.7.3 general requirement for readback of clearance to enter runway.	1. Possible reduction of controller workload. Improved pilot situational awareness Less rushed operations for pilots and controllers due to better planning ATCO can choose best moment to issue clearance, thereby optimising RT use. Allows extra thinking time for controller	A. • Mis-identification of subject of condition by pilot receiving clearance (more likely in hours of darkness) (S1, S2, S3, S4). • Controller does not state condition before the clearance - pilot acts on clearance only (S1). • During a chain (or a single use of) of conditional clearances circumstances change and controller fails to detect/ has less possibility to intervene (S4, ES3). • Potential for extra risk if combined with intersection deps or multiple line-ups? (ES5). • Controller forgets issuing conditional clearance (ES1). • If conditional clearances are issued in an environment where aviation English and local language are used together, pilot situational	Potential conflict between ACE ATS CD which implies that vehicle drivers can receive conditional clearances and EAPPRI pg B.3 last para. Note 2 which says they are not covered by this procedure. The vehicle driver reference will be removed from the ACE ATS Awareness package.	1. Use of standard ICAO phraseology including issuing the restriction and the identity of the restricting traffic before the clearance. 2. ICAO compliant readback shall be given and checked by controller. 3. Pilots shall have traffic in sight. ATS Awareness CD states that it is particularly important not to make runway entries from oblique angled entry points for conditional clearances. 4. ATS Awareness CD states that if subject of clearance is landing aircraft, then that aircraft must be first on approach. In case of multiple departures, subject must be immediately ahead in departure sequence. 5. EAPPRI section on communications (4.3.1 – 4.3.5) & some from section ANSP (4.5). 6. Part of rating and unit endorsement training for controllers. 7. If pilots have doubts about clearance they must ask for clarification.	Runway Collision Jet Blast Events	Ref. [2] indicates that without risk mitigators the introduction of conditional clearances could increase RI frequency. However, the introduction of a comprehensive risk reduction package based around ICAO, EAPPRI and ACE recommendations has the potential for reducing historical RI frequency. Accidents/ incidents due to jet blast currently form a negligible proportion of events (see AIRCLAIMS WAAS).	No effect on consequences	Harmonisation of ATC techniques for application of conditional clearances based around ICAO, EAPPRI and ACE documentation.	1. Methods for showing an occupied runway to counter forgetting that cond. clearance has been given. 2. Level 2 A-SMGCS. 3. Limitation on number of conditional clearances. 4. Visibility criteria (tower can see all aircraft). 5. Perform a local Safety Assessment in accordance with EAPPRI 4.5.13 and ESARR4. This should include looking at combination of conditional clearances with intersection departures and/or multiple line ups. 6. CBT on runway safety measures (widely used).

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				awareness will be lowered – has also more general implications beyond conditional clearances but during conditional clearances situational awareness is especially important (S5). • Use of oblique angled taxiways where visibility is restricted in combination with conditional clearances (S3, S4). • Mis-timed conditional clearance could be mis-interpreted (S6). B. Jet blast considerations.				With current industry mitigations and suitable local risk assessment this is not predicted to change.			

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ACE 2.6.4	Provision of **multiple holding points at a single rwy entry point.** This allows the departure sequence to take into account aircraft performances by allowing aircraft to overtake others already at a hold point.	YES including taxi way design to prevent a/c collisions. Annex 14, para. 3.12	Enables smoother more efficient ordering of aircraft and improves the ability to present aircraft in the hold in the best order for departure, so reducing pressure on pilots due to extended delays.	Wing tip collisions if spacing is tight.	Group with ACE 2.4.3	The suitability of available holding points should be assessed in line with guidelines published in EUROCONTROL's European Action Plan for the Prevention of Runway Incursions (ATS Awareness CD, Departure Sequence). EAPPRI 4.4.1 (pilot training on aerodrome signage etc) and 4.4.5 (promote best practices while taxi-ing) particularly important. Wing tip clearance between taxiway centre lines should be in accordance with ICAO guidelines. Airport design to take account of distance between intersection holding point and centreline of taxiway to rear. Leads to limitations on size of holding aircraft and requires adherence by pilots to holding procedures/ techniques. ATS guidance and training to maintain clearance	Taxiway collisions	More potential close encounters. However, with correct taxiway design and sound ATCO and pilot technique the frequency of imminent taxiway collisions is expected to be kept constant	No effect on avoidance actions in ETA	-	Airline and ANSP SMS should be safety monitoring hazardous taxi-ing events

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ACE 2.6.5	**Multiple line-ups (incl single entry point or multiple entry points).** Aircraft are in a position to depart as soon as take-off clearance is given. Enables smoother more efficient ordering of aircraft and improves the ability to present aircraft in the hold in the best order for departure.	DOC7030 Part 3, Section 3.0:MULTIPLE LINE-UPS ON THE SAME RUNWAY, standard phraseology in PANS-ATM (Doc. 4444) Chapter 12, + Page F.2 of the EAPPRI	Reduced controller workload due to optimising departure sequence	• Potential confusion for pilot (e.g. anticipating they are next) or controller or driver. (S1, S2). • Controller forgets the second aircraft that has been lined up (S4). • Out of sequence t/o. (S4). • Jet blast – no guidelines available. (S5 & ES3). • Used with conditional clearances multiple line ups could be a concern? (ES4) • Taxiway collision at hold point - see ACE 2.6.4 (S3).	Used with conditional clearances (ACE 2.6.3) this could be an additional hazard? See RWY 4.5.14 >90s occupancy conflicts with this where more than 2 a/c lined up.	1. EAPPRI – restriction on use of oblique angled taxiways (4.5.15) 2. Compliance with ICAO published phraseology and other conditions (visibility, local considerations, use of same radio frequency, provision of essential traffic information, pilot readback requirements see DOC 7030, Part 3, Sec. 3.1 Conditions for application). 3. ICAO compliant design to take account of clearance between taxiway centre-lines and between holding points and centreline of adjacent taxiway. 4. Flight progress strip management to show occupied runway and sequence (not universally used). 5. In each aircraft manual there is safe jet blast distance (take-off power). 6. Pilots trained in relevant signage etc (EAPPRI 4.4.1)	Runway Collision Jet Blast Events	For effect on freq of Runway Incursions, group with intersection/ intermediate departures - see ACE 2.6.10 Accidents/ incidents due to jet blast currently form a negligible proportion of events (see AIRCLAIMS WAAS). With current industry mitigations and local risk assessment this is not predicted to change.	Increased probability of another aircraft being on runway	-	1. A-SMGCS Level 2. 2. Restrictions during hours of darkness (UK and others). 3. Local safety assessment taking account of safe jet blast distances published in aircraft manuals. 4. Local safety assessment looking at combination of ccs and multiple LUs and setting visibility criteria. 5. Constraints on rolling take-offs.

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ACE 2.6.6	**WITHDRAWN Use of Visual holding points** replaces CAT I/II and III hold points with points as close as 75m to the runway centreline.	NO - ICAO Annex 14 Chpt 3, Table 3-2. a/c should not be held closer to a runway than designated hold points. Minimum distance for Precision approach CAT I or above is 90m.		Operating an instrument rwy as if a visual rwy in terms of hold points. Potential for infringement of ILS protection zone if/when a/c on instrument approach.	-	-	-	-	-	-	-
ACE 2.6.7	Holding and bypass bays - evaluated under 2.6.4	YES	Same as 2.6.4 and 2.4.3	Same as 2.6.4 and 2.4.3	Same as 2.6.4 and 2.4.3	-	-	-	-	-	-

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ACE 2.6.8	WITHDRAWN Use of automated coordination between stop bars and clearance on electronic flight strips may help avoid delays. However, caution must of course be used to protect against runway incursions.		No	Runway Incursions.	-	-	-	-	-	-	-
ACE 2.6.9	The runway capacity could be increased by reducing the wake turbulence separation minima for given strong wind conditions or with the help of specific wake turbulence predictive tool.	NO	No	Reduced separation - being addressed in separate TBS Safety Case + Safety Cases looking at specific WT predictive tools.	N/R	N/R	Wake Vortex Encounter (WVE) Mid-air collision (MAC)	To be studied in TBS Safety Case	No effect on consequences (to be checked in TBS Safety Case)	Safety Cases needed for TBS + specific WV predictive tool	To be derived in generic TBS Safety Case
ACE 2.6.10	Intersection Departures can be used to reduce taxi time or take an aircraft out of normal queues to improve departure sequence.	DOC7030, Part 3 Section 2.0: Intersection Take-Off & Annex 14 para. 5.4.3.5 - TORA signage, chapter 5	Can reduce crossing active runway (e.g. Lisbon). Reducing pressure on controllers – more time to	Late ATC instruction of intersection departure affects pilot calcs or preparation (e.g. wrong flap setting) (S9, S11) Performance data	Can be linked with multiple line-ups (ACE 2.6.5).	Runway Collision mitigations 1. ACE documentation refers to restriction on use of oblique angled taxiways in context of intersection departures. 2. ICAO phraseologies. 3. ICAO compliant marking, lighting and signs. 4. AIP & charts. 5. Awareness campaign/ leaflet.	Runway Collision	Ref. [2] and IRP indicate that increased use of intersection departures could have a significant impact on	Could increase the need for avoidance as incursing aircraft sometimes placed in more vulnerable position with	A-SMGCS 2	Improvement of runway entry points to improve line of sight Local ATC procedures such as stating line-up point when issuing a line up

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		markings and lighting	fit a departure between 2 arrivals. Increase distance between departure and arrival. Description of HIRO in AIP improves predictability for controllers and pilots thereby reducing workload for both.	for full length runway used (S6) Line ups in front of departing/ landing ac (especially if poor line of sight) (S1, S2, S3, S4) Pilots turn wrong way and line up on opposite runway (S4, S5) Pilot needs full length and backtracks unexpectedly (S4, S5) Extra "heads down" time for pilots in preparing for intersection TO (S9, S11) Potential for Work in progress (WIP) to further reduce runway length (S12) Puts ac in potentially more vulnerable position on runway - if at start of runway then landing ac may fly over it Taxiway collision at hold point (see ACE 2.6.4)		Runway Overrun mitigations 6. Pilot ensures that reduced declared distance conforms to aircraft certified performance. 7. Publication of declared distances for intersection departure. 8. Signage with RWY distances available (ICAO Annex 14, paragraph 5.4.3.5.) and pilot training in signage (EAPPRI 4.4.1). 9. Airline procedure to have alternative TO performance (see ACE 2.13.4). 10. AIP & charts. 11. Awareness campaign/ leaflet. 12. Current WIP mitigations, e.g. NOTAMs, signage etc.	Runway Overrun Taxiway Collision	frequency of critical RIs. High priority on implementing adequate risk mitigation package and subsequent monitoring. With mitigations aim to keep freq. of overrun constant With mitigations aim to keep freq. of taxiway collision constant	respect to landing aircraft. No effect on consequences No effect on consequences		instruction via an intermediate holding point to prevent mis-interpretation Constraints on use of conditional clearances when combined with use of line up via intermediate hold points/ intersections Training of ATCOs A-SMGCS Level 2 Airline procedures covering going through TO checklist again in event of last minute intersection departure

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ACE 2.7	**TAKE-OFF PROCEDURES**										
ACE 2.7.1	WITHDRAWN Rolling take offs - When cleared to line-up, pilots should anticipate being able to roll straight into the take off. Avoid a complete stop.	-	No	Controller confusion that moving a/c has had t/o clearance. Pilots anticipating TO clearance and taking off without clearance	-	-	-	-	-	-	-
ACE 2.7.2	**Conditional Line-up Clearances** - enables Flight Crews to move to the next stage of the airside process immediately upon their own observation that a restriction has disappeared.	YES	See 2.6.3	See 2.6.3	Already covered in 2.6.3	-	Already covered in 2.6.3	-	-	-	-

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ACE 2.7.4	Target Flight Crew Reaction Time to Take-off (FRTT) should be +/- 7 sec	N/A	No	Pressure on pilots leading to them anticipating clearances	-	Caution in ACE "The Guide" not to rush. "The period between line-up/ take-off clearance and starting the take-off roll is not a time to be rushing. The priority for pilots is to ensure that the aircraft is correctly configured, that ATC clearances are understood and complied with, and that the position and activity of other aircraft are known."	Runway Collision	Adequate mitigations are expected to be in place to ensure that the freq. of premature take-offs does not increase due to this RP.	No effect on consequences	EUROCONTROL to review ACE documentation to ensure that potential mixed messages are identified and harmonised (e.g. "Every second counts" v EAPPRI RPs)	Reinforcement of "No Rush" message in ACE guide from airlines and ANSPs. Monitoring to check safety impact.
ACE 2.7.5	Review procedures for carrying out checks prior to take-off. Complete as many checks as possible before line-up, line-up early and safely, anticipating take-off clearance and reacting promptly to it.	N/A	Better prepared - higher probability of a complete & accurate check. Also allowing better heads-up monitoring by the pilots.	No	In compliance with RWY 4.4.6.	N/R	Runway Collision	Ref. [2] - indicates that excessive workload has been a contributor in a number of RIs - this RP should help smooth workload.	Better vigilance, higher probability of avoidance.	Change text to "line-up promptly" instead of "early"	-

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ACE 2.7.6	Provide take-off clearance early	ICAO Doc 4444 Chpt 7 states "In the interest of expediting traffic, a clearance for immediate take-off may be issued to an aircraft before it enters the runway. On acceptance of such clearance, the aircraft shall taxi out to the runway and take-off in one continuous movement."	Less likelihood of t/o without clearance. Lower ROT and probability of collision.	No	-	N/R	Runway Collision	Reduction in premature take-off.	Lower ROT	No	Pilots would need warning that this type of immediate take-off clearance was being used so that they can anticipate and commence spool-up prior to receiving clearance for take-off.
ACE 2.8	**DEPARTURE PROCEDURES**										

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ACE 2.8.1	Early turn departure procedures. Removal of slower, NPR exempt aircraft from SID.	YES	Reduced controller workload associated with separating aircraft on same dep routes	Potential CFIT/MAC risk if turn done at wrong point	-	In principle, the procedure requires that the turn of the deviating aircraft is visually confirmed, which limits its application to good visibility conditions. If an Aerodrome Traffic Monitor (ATM) display supports the Tower Controller in her/his work, the use of this procedure may be extended into poorer visibility conditions by confirmation of the turn on the ATM radar. No aircraft should be instructed to commence a turn below a height of 500 feet. The actual turning point will be determined locally, as part of a comprehensive safety assessment, and will depend on such things as terrain and noise sensitive areas. (ATS Awareness CD, Departure Rate) If modified SID is used, then clearly design of SID procedure is a key safeguard.	Mid-air collision (MAC) CFIT	Concerns expected to be adequately mitigated by mitigations.	No effect on consequences No effect on consequences	No	Introduction of this change requires a satisfactory local Safety Assessment and Environmental Impact Assessment of the proposed new operational concept together with approval by the National Aviation Regulator. Safety assessment should include the impact of the proposed new procedure on aspects such as controller workload, sector co-ordination and abnormal procedures (e.g. comms failure procedure). (ATS Awareness CD, Departure Rate)
ACE 2.8.2	Early split as soon as possible after departure (including introduction of more diverging SIDs). Not specifically aimed at turbo-props.	YES	Reduced controller workload associated with separating aircraft on same dep routes	Potential CFIT/MAC risk if turn/ split done at wrong point	-	As for ACE 2.8.1	Mid-air collision (MAC) CFIT	As for ACE 2.8.1	As for ACE 2.8.1	No	As for ACE 2.8.1

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ACE 2.8.3	High performance SIDs (including grouping SID traffic by speed).	N/A	More reliable speed control and simplified sequencing and therefore reduced controller workload	Wrong SID chosen	-	ATC planning and pilot flight planning	Mid-air collision	Concerns expected to be adequately mitigated by mitigations.	No effect on consequences	-	-
ACE 2.8.4	Grouping SID traffic by speed (same as ACE 2.8.3 - therefore not analysed further)	-	-	-	-	-	-	-	-	-	-
ACE 2.8.5	Separation of the aircraft for each SID by making use of more than one hold (queue) at different holding points. (same as ACE 2.6.4 - therefore not analysed further)	-	-	-	-	-	-	-	-	-	-

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ACE 2.8.6	**Visual separation immediately after departure by ATCO and pilot.** Where possible use visual departure separation. The use of visual departure separation as compared to time or radar separation expedites traffic and assists in maintaining a high capacity departure rate.	Yes - Doc 4444 Chapter 6 Section 6.1	Potential for improved situational awareness with respect to other traffic.	Potential for reduced separation and more WV encounters. However, this is controlled by normal pilot monitoring and is ICAO compliant.	-	Current visual separation procedures	Wake Vortex Encounter (WVE) Mid-air collision (MAC)	Could be more close encounters. However, overall risk should be controlled by current visual separation procedures.	Higher probability of avoidance of WVE and losses of separation in visual conditions, better situational awareness with respect to loss of control	ECAC monitoring	Local monitoring

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ACE 2.8.7	Use of distance based departure separation using Tower radar information	NO - as it is the Aerodrome Controller that is determining the departure interval required to ensure minimum radar separations rather than the Approach Radar Controller/ Departure Radar Controller.	No	Concerns if aerodrome ATC inadequately equipped, trained etc (see mitigations)	-	Requires approval from local regulator, local risk assessment, controller training, tower based surveillance facilities etc. WV sep rules take priority. (ATS Awareness CD)	Wake Vortex Encounter (WVE) Mid-air collision (MAC)	No effect on frequencies with mitigations	No effect on consequences with mitigations	No	Real-time simulations of change on controller workload. Comprehensive local risk assessment. Publication of ATC procedures including what to do if radar surveillance is not available. Need certified radar system and controller to implement this. (ATS Awareness CD)
ACE 2.8.8	Priority for arrivals or departures applied depending on the demand.	N/A	Reduced need for holding traffic in air - no safety benefit assumed.	No	-	N/R	N/R	N/R	N/R	N/R	N/R

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ACE 2.8.9	WITHDRAWN In dual/multiple runway operations, consider inserting additional departures on the arrival runway when there is a lull in arrivals.	-	-	Extra Controller Workload	-	-	-	-	-	-	-
ACE 2.8.10	Implement departure separation restrictions based on **Distance in Trail**	NO - see ACE 2.8.7	Area Control Sectors have benefit of more structured flow of traffic that is already separated and speed controlled. Reduction of workload in adjacent sectors.	See ACE 2.8.7	Similar issues to ACE 2.8.7	Departures speed controlled with relevant spacing provided (ATS Awareness CD). Plus See ACE 2.8.7	See ACE 2.8.7	See ACE 2.8.7	See ACE 2.8.7	-	See ACE 2.8.7

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ACE 2.8.11	Mixed time and distance-based separation procedure to optimise the Minimum Departure Interval (MDI).	NO	Reduced Controller workload - no longer required to request a radar release for each departure.	See ACE 2.8.7	Similar issues to ACE 2.8.7	See ACE 2.8.7	See ACE 2.8.7	See ACE 2.8.7	See ACE 2.8.7	-	See ACE 2.8.7
ACE 2.8.12	Group aircraft departures by wake category (very similar to ACE 2.6.1, 2.6.4 and 2.8.5 and not analysed further)	-	-	-	-	-	-	-	-	-	-
ACE 2.8.13	WITHDRAWN. Issue departure clearance as soon as possible (i.e. before start-up and taxi) within local constraints especially if there is no GMP controller.	-	-	-	-	-	-	-	-	-	-

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ACE 2.9	**APPROACH PROCEDURES**										
ACE 2.9.1	Converging instrument approaches utilising a Converging Runway Display Aid (CRDA) should enable increased runway utilisation, especially under IMC.	NO. It is assumed that a new system such as this will require its own System Safety Case and hence is not analysed further.	-	-	-	-	-	-	-	-	-
ACE 2.9.2	WITHDRAWN as an explicit RP. Recommendation to accept a certain % of go arounds to achieve maximum capacity	N/A	-	-	-	-	-	-	-	-	-
ACE 2.9.3	Use minimum radar separation and consistent speed control	YES	Consistent speed control can reduce probability of loss of separation	Reduced average aircraft separation, but within MRS given by ICAO.	-	Speed control	Wake Vortex Encounter (WVE) Mid-air collision (MAC)	Consistent speed control expected to offset increased probability of loss of separation arising from using MRS more often. How these factors balance will depend on local	No effect on consequences of loss of separation	ECAC monitoring	Local monitoring

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								situation. Aim should be to ensure that frequency of loss of separation on approach does not increase.			
ACE 2.9.4	The runway capacity could be increased by reducing the wake turbulence separation minima for given strong wind conditions or with the help of specific wake turbulence predictive tool covered under ACE 2.6.9 - not analysed further)	-	-	-	-	-	-	-	-	-	-
ACE 2.9.5	Group Aircraft by wake category (covered under ACE 2.8.12 - not analysed further)	-	-	-	-	-	-	-	-	-	-

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ACE 2.10	**ATC ROLES & RESPONSIBILITIES**										
ACE 2.10.1	Dedicated tower co-ordinator role in ATC Focusing on 'the bigger picture', the Co-ordinator can take an active role in the planning process; strategic and tactical decision-making or simply assisting individual controllers overcome traffic problems.	N/A	This role aims to facilitate co-ordination between individual controllers and to improve overall Situational Awareness and planning within the tower. Improves Tower dynamics through consideration of task division, controller workload and breakout roles as the tasks expand or traffic increases.	Potential for confused Roles & Responsibilities. Controllers have to work in different modes depending on whether Coordinator role is active or not. Could cause omission of a controller's task due to assumption that co-ordinator is taking that role.	Group with ACE 2.14.4	ACE documentation states that clear roles should be defined as part of this best practice implementation.	All accident categories above where ATC can have a contributory cause - focus on Runway Collisions for this analysis as highest risk category	Ref. [2] identifies Tower staffing problems as linked to certain percentage of Runway Incursions. This RP will have benefit.	Could help avoidance of collisions following incursions due to better vigilance/ teamwork.	No	Clear definition of Roles & Responsibilities. Training for this new role and interface positions.
ACE 2.10.2	WITHDRAWN General familiarisation of the ATCO with the airport is vital	-	-	-	-	-	-	-	-	-	-
ACE 2.10.3	Merged with 2.10.1	-	-	-	-	-	-	-	-	-	-

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ACE 2.10.4	WITHDRAWN In case of a single frequency for ground operations (ATS, winter operators, aircrew, etc.), R/T training and qualification of the winter operators are required and should be enforced	N/A	-	-	-	-	-	-	-	-	-
ACE 2.10.5	ATC should delegate the management of surface clearing operations to a specific coordinator. This coordinator will be responsible for assessing the surfaces contamination level and launching the clearing operations	N/A	Clearly defined responsibilities for surface contamination control - helps manage risk of loss of control due to poor friction.	Inadequate delegation	-	Overall responsibility defined at high level in RP	Landing/ Take Off Loss of Control	Surface contamination could affect frequency of loss of control. Hence RP should be beneficial in clarifying responsibilities.	Surface contamination could affect potential for pilot to regain control. Hence RP should be beneficial in clarifying responsibilities.	-	Local control measures on delegation and clear definitions of Roles and Responsibilities

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ACE 2.10.6	ATC should delegate the management of de-icing operations (de-icing assistance requirement, ground taxiing to de-icing operation location, etc) to a specific supervisor of de-icing operations	N/A	Clearly defined responsibilities for aircraft de-icing	Inadequate delegation	-	Overall responsibility defined at high level in RP	Take Off Loss of Control	Aircraft icing could affect frequency of loss of control. Hence RP should be beneficial in clarifying responsibilities.	Aircraft icing could affect potential for pilot to regain control. Hence RP should be beneficial in clarifying responsibilities.	-	Local control measures on delegation and clear definitions of Roles and Responsibilities
ACE 2.10.7	Use of a separate Clearance Delivery Controller & Radio Frequency as appropriate.	YES	Reduces the workload for the GMC and probability of RT blockage at busy airports	No	-	-	-	-	-	N/R	N/R
ACE 2.10.8	Enable the Clearance Delivery Controller to give planning support to the GMC	N/A	Making GMC workload more manageable - helping to smooth workload peaks caused by stand availability problems for example.	Possibility of role and responsibility confusion if Clearance Delivery controller takes on some GMC tasks.	-	-	Overall should be beneficial with correct control of Roles and Responsibilities.	-	-	No	Clear definition of roles and responsibilities for Clearance delivery Controller and GMC. Procedures and training to back this up.

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ACE 2.10.9	Measure the effectiveness of practices designed to match capacity to demand (job splitting/ combining) to help decide the optimum staffing levels and roster patterns.	N/A	Should help detect if personnel are becoming overloaded	Inappropriate combining of ATC positions if measurement of effectiveness is flawed	-	-	Provided measurement of effectiveness is sound, this should be risk beneficial. No explicit credit taken in overall assessment.	-	-		Local safety assessment of reductions in staffing, new combining of positions.
ACE 2.11	**LOW VIS PROCEDURES**										

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ACE 2.11.1	**All Weather Safeguarding** - All aspects related to safeguarding when entering LVP conditions - e.g. ensures critical areas (e.g. ILS, taxiways) are ready for CAT II/III conditions prior to reaching the minima	YES	Smooth transition to LVP - reduced aircraft delays, minimising aircraft in holding stack or needing to divert. No free-range vehicle movements, therefore reduced rwy incursion risk. Reduced probability of an a/c suffering an ILS deflection during transition from CAT I to CAT II/III conditions.	No	Group with ACE 2.11.2	N/R	Runway Collision CFIT	Ref. [2] estimates that restrictions on vehicles on manoeuvring area achieves significant reduction in RI frequency. ILS deflections by other aircraft has caused near misses on final approach but never an actual CFIT (see GBAS CAT I Safety Case). Therefore this benefit is likely to have only a small effect on CFIT risk – conservatively assume negligible in overall evaluation.	No effect on consequences	No	A satisfactory risk assessment must be carried out prior to adoption/publication of All Weather safeguarding procedures. Once developed it is important to ensure that all those involved receive adequate training to ensure implementation is efficient and does not introduce further risk. (ATS Awareness CD, Transition to low visibility)

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ACE 2.11.2	When low visibility affects or is likely to affect operations, use a **phased approach** to the transition to and from Low Visibility Procedures.	YES	As above - ACE 2.11.1	No	Group with ACE 2.11.1	N/R	As above - ACE 2.11.1	As above - ACE 2.11.1	As above - ACE 2.11.1	As above - ACE 2.11.1	As above - ACE 2.11.1
ACE 2.11.3	Determination of the capacity level to be used in LVC should be part of the task of a dedicated working group in charge of the LVP.	N/A	Realistic workloads for all parties.	No	N/R	N/R	Risk benefits not explicitly modelled	-	-	-	-
ACE 2.11.4	WITHDRAWN Whenever possible use digital ATIS (D-ATIS) to transmit RVR for the runway in use	-	-	-	-	-	-	-	-	-	-
ACE 2.12	**LOCATION SPECIFIC RECOMMENDATIONS**										
ACE 2.12.1	Production of awareness leaflet as part of ACE exercise	N/A	Effective form of communication about ACE related changes	No	N/R	N/R	Risk benefits not explicitly modelled - part of SMS improvements in RWY SAF 4.1.1	-	-	-	-

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ACE 2.13	**AIRLINE RECOMMENDED PRACTICES**										
ACE 2.13.1	Produce Company guidance to raise awareness and reduce ROT. Include suggested techniques or company policy such as autobrake settings, exit speed guidance, preferred RETs (by type) at each destination and include in company pages in charts and manuals.	Note ICAO Annex 14 ATT A-16. 14.3 states that a roll-out speed of 60 knots until the first RETIL is seen as optimum.	Standardisation of proven good practices. Reduces probability of hard braking.	Increased pressure on pilot during critical phases of flight (i.e. take-offs and landings) to reduce ROT. Pilots may feel obliged to take a particular RET (beyond other considerations) if it is in the company procedures.	Linked to ACE 2.13.5 regarding companies nominating preferred and back-up exits for each aircraft type, and ACE 2.3.1 where airports recommend preferred RETs.	See ACE 2.3.1 and ACE 2.3.4	See ACE 2.3.1	See ACE 2.3.1	See ACE 2.3.1	See ACE 2.3.1 & 2.3.4	See ACE 2.3.1 + Airline SMS - procedures, training and monitoring.

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ACE 2.13.2	Emphasis during normal training that the operating pilot should be aware of and take active consideration of the proposed runway exit, during the initial phase of landing, even though they may hand over control during the rollout.	N/A	More likely to make desired RET and reduce ROT - reduced collision risk.	No	-	N/R	Risk benefits not explicitly modelled	-	-	-	-
ACE 2.13.3	Make ATC aware if a long spool-up time (e.g. 10 - 30s) is require prior to taxiing. With advanced notice, the controller may provide more effective sequencing, without the aircraft being penalised in terms of take-off time.	N/A	Potentially less controller workload	No	Consistent with RWY SAF 4.4.4/ 4.5.14		Risk benefits not explicitly modelled	-	-	-	-

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ACE 2.13.4	Introduce a procedure for preparing alternative take off performance prior to taxi - for airports where late changes are likely.	N/A	If an intermediate rwy entry is offered and new rotate speeds are calculated under pressure, whilst taxiing, they may be more prone to error. Therefore pre-planned alternative take off data is likely to be more reliable.	No	Linked to ACE 2.6.10 - this is a safeguard for Intersection Departures and other intermediate TO points	N/R	Runway Overrun	This is one of the mitigations designed to ensure that frequency of runway overruns does not increase with ACE 2.6.10	No effect on consequences	See ACE 2.6.10	See ACE 2.6.10
ACE 2.13.5	Airlines should nominate, for each relevant airport, a preferred and back-up exit for each aircraft type - and pilots should be made aware of these. This should be done with reference to airports own preferred RETs (ACE 2.3.1) if possible.	Note - ICAO Annex 14 ATT A-16. 14.3 states that a roll-out speed of 60 knots until the first RETIL is seen as optimum.	More likely to make desired RET and reduce ROT - reduced collision risk. Better advanced planning allowing more time for other critical or unexpected tasks.	No	ACE 2.3.1 and 2.13.1	See ACE 2.3.1	See ACE 2.3.1	See ACE 2.3.1	See ACE 2.3.1	See ACE 2.3.1	See ACE 2.3.1 + Airline SMS - procedures, training and monitoring.

ID	Re-commended Practice	ICAO Compliant?	Safety Benefits?	Safety Concerns?	Grouping, Potential Conflicts	Current/ Planned Mitigations	Mapping to Risk Model (Accident Categories)	Impact of RP on Hazard Frequency	Impact of RP on Hazard Consequence	Generic Mitigation	Potential Local Mitigations
ACE 2.14	**GENERAL**										
ACE 2.14.1	Set up an airport steering group and capacity enhancement team comprising airport stakeholders. Convene pilot and controller working groups to discuss and promote airside capacity enhancement and to develop and action plan.	N/A	Collaboration- improved shared awareness	Action plan items could potentially conflict with safety initiatives.	-	N/R	Risk benefits not explicitly modelled - part of SMS improvements in RWY SAF 4.1.1	-	-	-	Liaison between capacity enhancement team and runway safety team. Local risk assessment of action plan items.

ID	Re-commended Practice	ICAO Compliant?	Safety Benefits?	Safety Concerns?	Grouping, Potential Conflicts	Current/ Planned Mitigations	Mapping to Risk Model (Accident Categories)	Impact of RP on Hazard Frequency	Impact of RP on Hazard Consequence	Generic Mitigation	Potential Local Mitigations
ACE 2.14.2	Collaborative Forums - Pilot, Airport Operator & Controller Forums	N/A	Studies have shown that in many cases pilots and air traffic controllers are unaware of the reasons for some of each other's operating practices. Shared and increased awareness on both sides has been shown to reduce confusion and potential impact on these issues.	No	-	N/R	Risk benefits not explicitly modelled - part of SMS improvements in RWY SAF 4.1.1	-	-	-	-

ID	Re-commended Practice	ICAO Compliant?	Safety Benefits?	Safety Concerns?	Grouping, Potential Conflicts	Current/ Planned Mitigations	Mapping to Risk Model (Accident Categories)	Impact of RP on Hazard Frequency	Impact of RP on Hazard Consequence	Generic Mitigation	Potential Local Mitigations
ACE 2.14.3	Tower Resource Management & Communication - Implementation of Teamwork forums, Tower Coordinator role and VCR for data sharing	N/A	Tower Coordinator Role + use of shared VCR has been shown to improve communication and simplify co-ordination between the various roles and simplify data transfer.	The Tower Resource Management practices identified above represent a significant departure from traditional ways of working at ATC towers.... It was noted that the Tower Resource Management methods do not necessarily lend themselves to every tower or airport.	See ACE 2.10.1	-	Considered as included either under ACE 2.10.1 or SMS improvements under RWY SAF	-	-	-	Local risk assessment of organisational changes
ACE 2.14.4	Implementation of Tower Coordinator Role during peak traffic periods (covered under ACE 2.10.1 - not analysed further)	N/A	-	-	-	-	-	-	-	-	-

ID	Re-commended Practice	ICAO Compliant?	Safety Benefits?	Safety Concerns?	Grouping, Potential Conflicts	Current/ Planned Mitigations	Mapping to Risk Model (Accident Categories)	Impact of RP on Hazard Frequency	Impact of RP on Hazard Consequence	Generic Mitigation	Potential Local Mitigations
ACE 2.14.5	**Paint the Picture** ATCOs should aim to keep pilots informed of the traffic situation. E.g. expected departure time, number ahead in the departure queue, arrival order, departure ahead when on final approach (meaning to expect a late landing clearance).	N/A	Improved Pilot Situational Awareness - better anticipation, less need to rush	Increased information leads potentially to radio congestion, extra potential for miscommunication or blocked communication	-	EAPPRI RPs to prevent miscommunication	Conservatively judged that beneficial impact on risk will be small. Risk benefits not explicitly modelled in overall evaluation.	-	-	-	Local monitoring of RT loading
ACE 2.14.6	Brief controllers fully on the methods, procedures and problems of high intensity runway operations. Ensure that they are fully understood and accepted.	N/A	Increased awareness of safety issues associated with HIRO	No	-	N/R	Risk benefits not explicitly modelled - part of SMS improvements in RWY SAF	-	-	-	-

Appendix II – Other Bow Tie Models

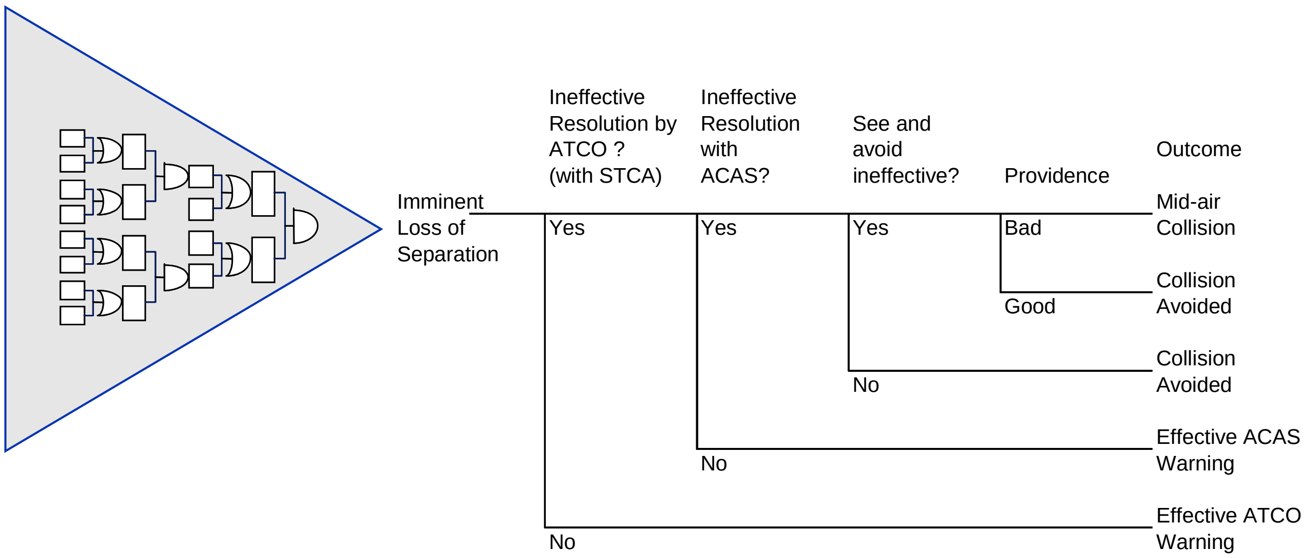
Mid-air Collision

The centre of the bow-tie for this accident category is “Imminent Loss of Separation”. The consequences are analysed by considering the nodes in the Event Tree below, i.e.

- Is the ATCO effective in initiating resolution of the imminent loss of separation (with the assistance of STCA if available)?
- Is ACAS effective in initiating avoidance actions?
- Is pilot “See and avoid” effective?
- Is the collision avoided through providence (“luck”)?

This structure and the ones below (except Landing and Take Off Loss of Control) have also been based on the Integrated Risk Picture (IRP) study.

Bow Tie Structure for Mid-air Collision

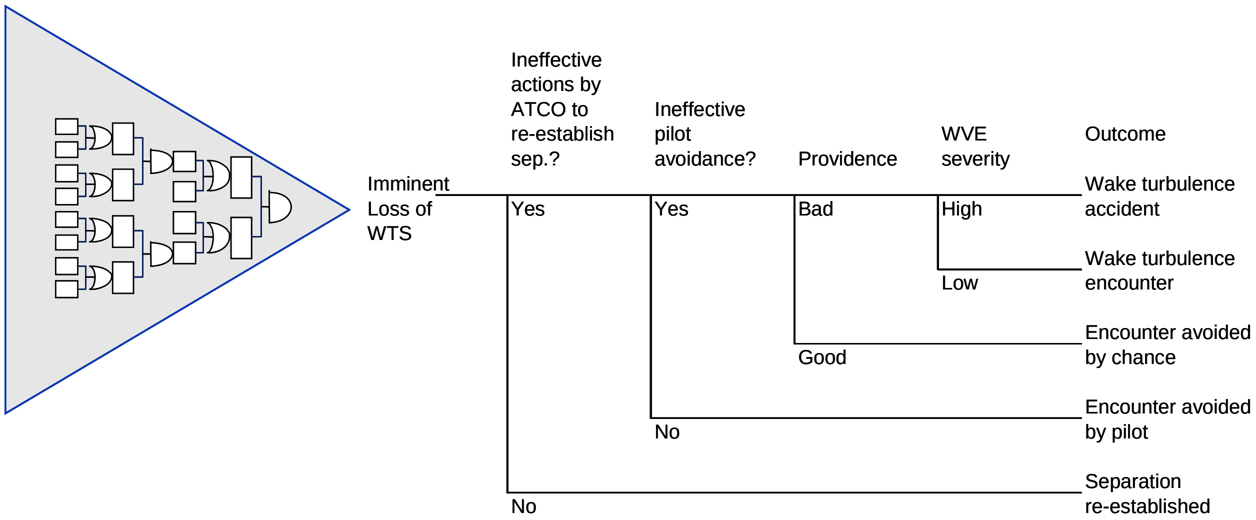


Wake Turbulence (Vortex) Accident

The centre of the bow-tie for this accident category is “Imminent Loss of Wake Turbulence Separation (WTS)”. The consequences are analysed by considering the nodes in the Event Tree below, i.e.

- Is the ATCO effective in re-establishing loss of WTS?
- Is pilot avoidance effective?
- Is the wake vortex encounter avoided through providence (“luck”)?
- Is the wake vortex encounter severe enough to cause an accident or not?

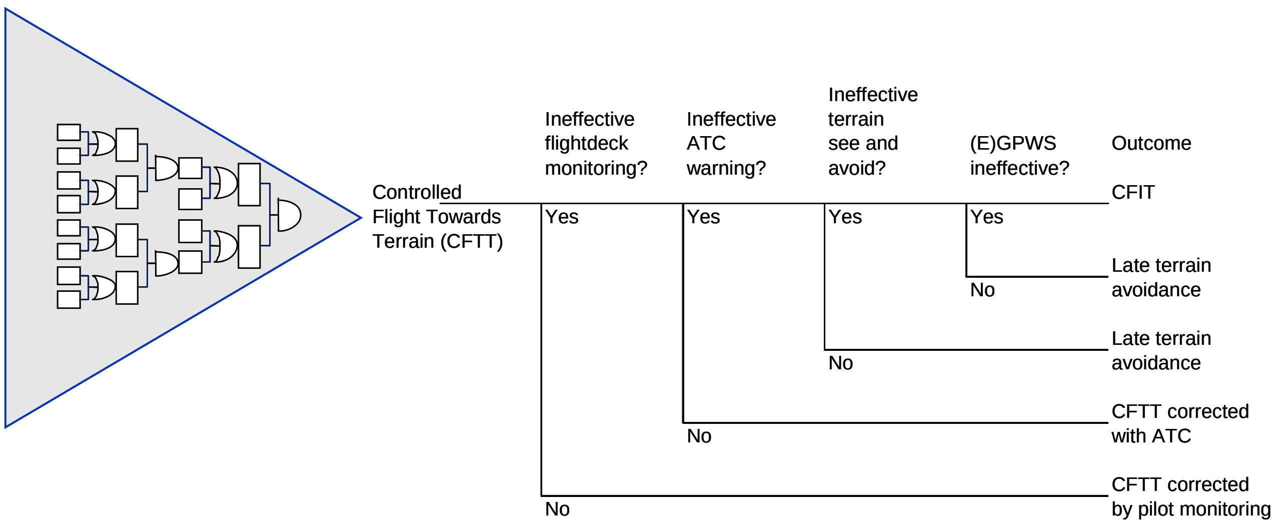
Bow Tie Structure for Wake Turbulence Accident



CFIT
The centre of the bow-tie for this accident category is "Controlled Flight Towards Terrain (CFTT)". The consequences are analysed by considering the nodes in the Event Tree below, i.e.

- Is monitoring of flightdeck instruments by the pilot effective in detecting and curtailing CFTT?
- Is the ATCO effective in detecting and curtailing CFTT?
- Does the pilot detect and avoid a CFIT through visual acquisition of terrain?
- Is (E)GPWS effective in alerting the pilot and enabling a CFIT to be prevented?

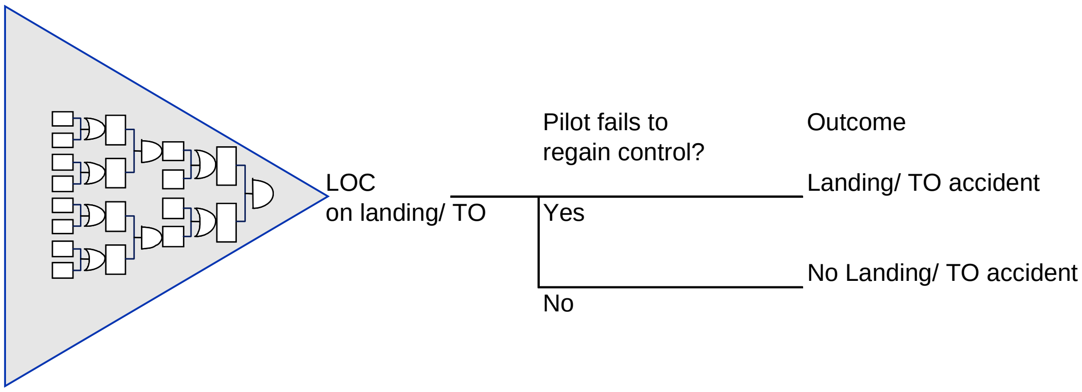
Bow Tie Structure for CFIT



Loss of Control on Landing or Take-Off

The spreadsheet analysis of consequences and causal initiating factors for this accident category is based on the simple structure below. The scope of this accident category includes (amongst other events) runway overrun and leaving the paved area while using RETs.

Bow Tie Structure for Loss Of Control on Landing or Take-Off



Appendix III – Relevant EAPPRI RPs

ID	Recommended Practice
4.3 Communications	
4.3.1	To avoid the possibility of call sign confusion, use full aircraft or vehicle call signs for all communications associated with runway operations.
4.3.2	Verify the use of standard ICAO RT phraseologies.
4.3.3	Use the ICAO read-back procedure (including Drivers and other personnel who operate on the manoeuvring area).
4.3.4	Improve situational awareness, when practicable, by conducting all communications associated with runway operations using aviation English.
4.3.5	Improve situational awareness, when practicable, by conducting all communications associated with runway operations on a common frequency. (note - aerodromes with multiple runways may use a different frequency for each runway.)
4.4 Aircraft Operators	
4.4.1	Provide training and assessment for Pilots regarding Aerodrome signage, markings and lighting.
4.4.5	Promote best practices on flight deck procedures while taxiing - to include the “Sterile flight deck” concept.
4.5 ANSP	
4.5.5	Aircraft shall not be instructed to cross illuminated red stop bars when entering or crossing a runway unless contingency measures are in force, e.g. to cover cases where the stop bars or controls are unserviceable. Stop bars that protect the runway must be controllable by the runway controller.
4.5.6	Ensure that ATC communication messages are not over long or complex.
4.5.7	Ensure that ATC procedures contain a requirement for explicit clearances to cross any runway. Includes non-active runways.
4.5.9	Use standard taxi routes when practical to minimise the potential for pilot confusion, on or near the runway.
4.5.10	Where applicable use progressive taxi instructions.
4.5.11	Avoid infringing sight lines from the tower and assess any existing visibility restrictions from the tower, which have a potential impact on the ability to see the runway, and disseminate this information as appropriate. Recommend improvement when possible and develop appropriate procedures.
4.5.13	Identify any potential hazards of runway capacity enhancing procedures when used individually or in combination and if necessary develop appropriate mitigation strategies. (Intersection departures, multiple line up, conditional clearances etc.)
4.5.15	When using multiple line-ups, do not use oblique or angled taxiways that limit the ability of the Flight crew to see the runway threshold or the final approach area.