Network Manager
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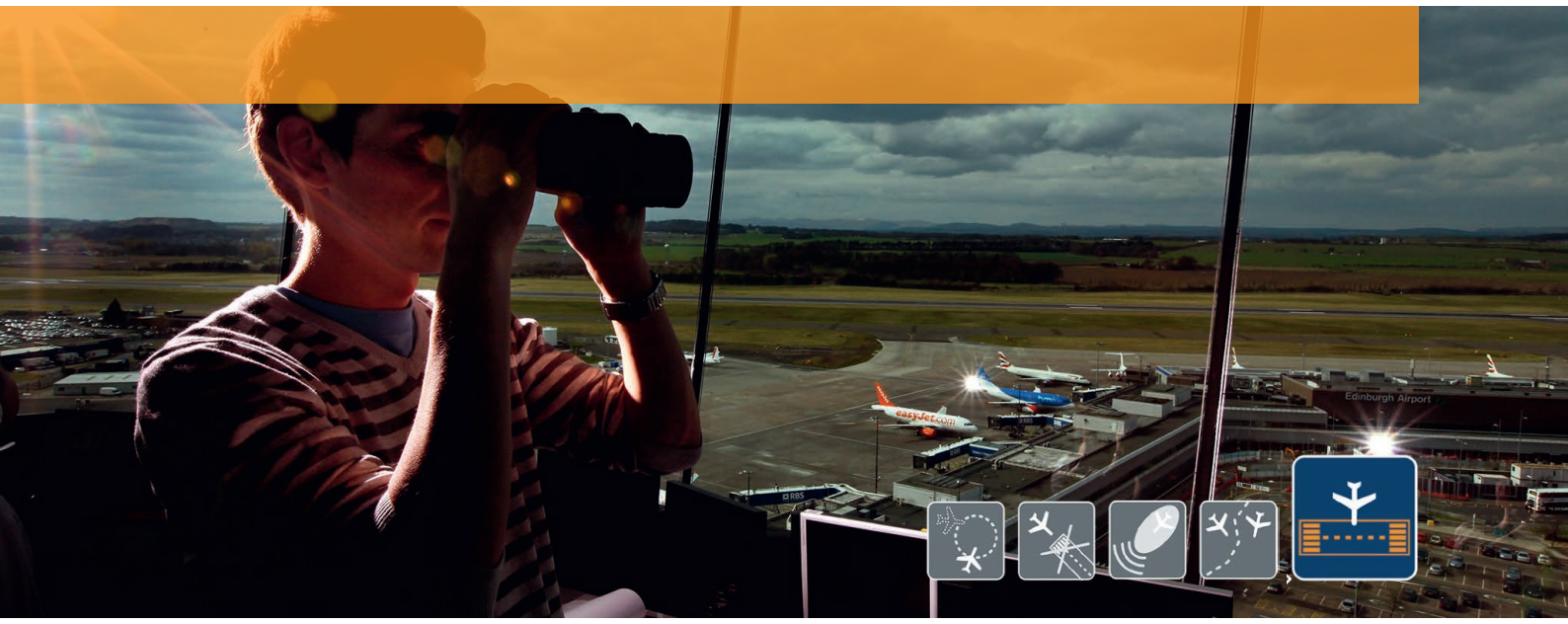
EUROCONTROL

Operational Safety Study: Controller Detection of Potential Runway and Manoeuvring Area Conflicts



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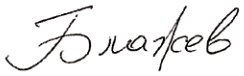
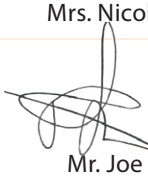
DOCUMENT APPROVAL

The following table identifies all management authorities who have successively approved the present issue of this documents.

Authority	Name and signature	Date
Operational Safety Coordinator, DNM/NOM/SAF	 Mr. Tzetomir Blajev	01/12/2015
Head of Safety Unit, DNM, NOM	 Mr. Antonio Licu	02/12/2015
Head of Network Operations Management Division	 Mrs. Nicola Cooper	02/12/2015
Director NM	 Mr. Joe Sultana	07/12/2015

DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

Edition Number	Edition Date	Reason for change	Pages affected
0.1	29/09/2013	Creation of the Working Draft	All
1.0	20/01/2014	First draft version	All
2.0	29/08/2014	Second draft version	All
3.0	08/10/2015	Third draft version	All
4.0	30/11/2015	Proposed Issue	All
1.0	01/12/2015	Released Issue	All

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The EUROCONTROL Safety Improvement Sub-Group (SISG), reporting to the EUROCONTROL Safety Team, was tasked to identify the Top 5 ATM Operational Safety Priorities.

SISG performed a review during summer 2012 and involved a series of dedicated workshops with 6 ANSPs, representing a large part of European air traffic. Comprehensive barrier models – Safety Functions Maps (SAFMAPs) - were developed and populated with representative data from the participating ANSPs. The incident data is for high severity (classified as 'A' and 'B') events, which are on one side thoroughly investigated and on the other side – highly informative because the incident scenarios 'test' the majority of the available safety barriers.

As a result of the SAFMAP analysis the Top 5 priority areas were suggested, agreed by SISG and endorsed by the Safety Team:

- Risk of operation without transponder or with a dysfunctional one
- Landing without ATC clearance
- Detection of occupied runway
- "Blind spot" – inefficient conflict detection with the closest aircraft
- Conflict detection with adjacent sectors

The purpose of this report is twofold:

- To document the operational safety study on the third of the Top 5 Network Manager operational safety priorities for 2014/15 – "Detection of occupied runway."
- To serve as a reference for the Network actors in case they undertake operational safety analysis and improvement activities regarding the risk related to un-detection of the occupied RWY.

Note: *It was decided that to extend the original requirement to consider the barriers available to ATC to prevent or mitigate other potential conflicts on the Manoeuvring Area. This includes landing or departing on a taxiway and ground collisions. Consequently the title was changed to "Controller Detection of Potential Runway and Manoeuvring Area Conflicts."*

The priorities were reviewed by SISG with SAFMAP analysis of the data for year 2013 and re-confirmed as Top 5 priorities for 2014.

The methodology employed was as follows:

- Generate a set of generic scenarios from possible scenario sources, mechanisms and outcomes.
- Consider what barriers exist that if implemented and deployed correctly could prevent a runway incursion as result of un-detection of the runway occupation.
- Consider what barriers exist that if implemented and deployed correctly could mitigate the impact of a runway incursion as result of un-detection of the runway occupation.
- Analysis of each generic scenario against the potential barriers to establish which of these barriers could be most effective over the whole range of scenarios.
- Review a set of actual events to confirm that the barriers suggested by the generic analysis validate that the same barriers should be the most effective in the live environment.
- Consider current industry best practice and known future developments.
- Draw conclusions from the study and make recommendations to stakeholders.

This study has identified eight basic operational scenario outcomes involving controller detection of potential runway and manoeuvring area conflicts. Ten barriers were identified as being available to ATC to prevent or mitigate the impact of such events.

The single most efficient barrier is the input and display of ATC clearances and surveillance data to jointly detect non-conformance to clearance and the potential impact of incorrect clearances. This functionality is not yet widely available; however, this study lends strong support to its development and deployment.

This study also found that ATC resolution following an alert from a pilot or driver was the common and effective barrier employed in the mitigation of runway and manoeuvring area conflicts. This validates the importance of cross-industry training in safety awareness.

This study identified that the most frequent ATC contributing factors present in the sequence of actions leading to runway and manoeuvring areas safety occurrences are:

- Memory – most commonly a failure to check/monitor i.e. not following normal practice.
- Perception – most commonly a failure to see something.
- Operational environment – commonly distractions, visual impairments and noise.
- Communication errors – incomplete, incorrect or ambiguous RTF.

The study also noted a significant number of individual factors that were within the remit of Airport Authorities. Recommendations are made that:

- European ANSPs and Airport Authorities review the identified preventive barriers and contributory factors in case they undertake operational safety analysis and improvement activities for Controller Detection of Potential Runway and Manoeuvring Area Conflicts
- European ANSPs and the EUROCONTROL Safety Improvement Sub-Group (SISG) monitor occurrences involving Controller Detection of Potential Runway and Manoeuvring Area Conflicts to determine changes in frequency and severity.
- All European industry stakeholders monitor and support the development of tools and functionality that include the input and display of ATC clearances and surveillance data to jointly detect non-conformance to clearance and the potential impact of incorrect clearances.
- European ANSPs and the EUROCONTROL Safety Improvement Sub-Group (SISG) undertake an operational safety study on the subject of sudden high energy runway conflicts.

CHAPTER 1 - INTRODUCTION

1.1 What is the purpose of this document?

Documenting and communicating

The purpose of this report is twofold:

- To document the operational safety study on one of the Top 5 Network Manager operational safety priorities for 2014 – "Controller Detection of occupied RWY".
- To serve as a reference for the Network actors in case they undertake operational safety analysis and improvement activities for controller detection of occupied RWY.

Note: *It was decided to extend the original requirement to consider the barriers available to ATC to prevent or mitigate other potential conflicts on the Manoeuvring Area. This includes landing or departing on a taxiway and ground collisions. Consequently the title was changed to "Controller Detection of Potential Runway and Manoeuvring Area Conflicts."*

1.2 What are the Network Manager Top 5 ATM Operational Safety Priorities for 2014/2015?

1. ***Risk of operation without transponder or with a dysfunctional one***

   Operations without transponder or with a dysfunctional one constitute a single threat with a potential of "passing" through all the existing safety barriers up to "see and avoid".

2. ***Landing without ATC clearance***

   For various reasons, aircraft sometimes land without ATC clearance resulting in Runway Incursions that are often only resolved by 'providence'.

3. ***Detection of occupied runway***

   Some Runway Incursion incidents could have been prevented if controllers had had better means to detect that the runway was occupied at the time of issuing clearance to the next aircraft to use the runway.

4. ***"Blind spot" – inefficient conflict detection with the closest aircraft***

   Loss of separation "Blind Spot" events are typically characterised by the controller not detecting a conflict with the closest aircraft. They usually occur after a descent clearance and in the context of a rapidly developing situation – often when the conflicting aircraft are 1000ft and 15 nm apart.

5. ***Conflict detection with adjacent sectors***

   Losses of Separation in the En-Route environment sometimes involve "inadequate coordination" of clearance with an adjacent sector. These typically involve either an early (premature) transfer of control to or from the neighbouring sector.

1.3 How was the 'Top 5' identified?

The Network Manager identifies Network safety issues to enable aviation stakeholders to identify existing hazards and anticipate new operational risks

Our ultimate goal is to keep the Network safe and able to increase its capacity and efficiency.

The EUROCONTROL Safety Improvement Sub-Group (SISG), reporting to the EUROCONTROL Safety Team, was tasked to identify the Top 5 ATM Operational Safety Priorities. The SISG followed a structured two-step process of operational safety prioritisation. Firstly SISG identified a list of priority areas.

The first step was to define broad priority areas for further prioritisation.

The agreed list contains work priority areas addressing operational threats, safety precursors or undesired safety outcomes. The list includes:

- Airspace Infringement
- Runway Incursion
- Loss of Separation
- ATC sector overloads
- Level Bust
- Severe Weather Risk
- Air Ground communications
- Runway Excursion

The list of agreed priority areas contains issues that are too broad to be a part of a focussed work program. There was a need to get more "granularity" and select some of the areas for a detailed review. Based on the availability of reliable safety information, two of the risk areas were selected for detailed review:

- "Runway Incursion" and
- "Loss of Separation En-Route".

The review was performed during summer 2012 and involved a series of dedicated workshops with 6 ANSPs, representing a large part of European air traffic.

The second step was a detailed review with SAFMAPS.

Comprehensive barrier models – Safety Functions Maps (SAFMAPs) - were developed and populated with representative data from the participating ANSPs. The incident data is for high severity (classified as 'A' and 'B') events, which are on one side thoroughly investigated and on the other side – highly informative because the incident scenarios 'test' the majority of the available safety barriers.

As a result of the SAFMAP analysis the Top 5 priority areas were suggested, agreed by SISG and endorsed by the Safety Team:

- Risk of operation without transponder or with a dysfunctional one
- Landing without ATC clearance
- Detection of occupied runway
- "Blind spot" – inefficient conflict detection with the closest aircraft
- Conflict detection with adjacent sectors

The priorities were re-confirmed for 2014

The priorities were reviewed by SISG using the same approach of analysing the high severity incident with SAFMAPs. As a result SISG re-confirmed the Top 5 priorities for 2014.

CHAPTER 2 - STUDY SCOPE AND PRE-SET ASSUMPTIONS

2.1 Scope

- Runway Incursion conflicts that could have been prevented if controllers had had better means to detect that the runway was occupied at the time of issuing clearance to the next aircraft to use the runway.
- This study extends the original requirement to consider the barriers available to ATC to prevent or mitigate other potential conflicts on the Manoeuvring Area. This includes landing or departing on a taxiway and ground collisions.
- This study is exclusively aimed at tools and methodology available to ATC. It excludes airport barriers that are primarily to provide barriers to pilots and drivers e.g. stop bars, runway guard lights and signage.

2.2 Pre-Set Assumptions

- All barriers are deemed to be operationally available and operated correctly.
- It is assumed that controllers will react correctly to all aural and visual safety nets
- All barriers are limited by the responsiveness of the players to the signals.
- Deliberate non-conformance is excluded from the analysis.

2.3 Definition of Barriers for the purposes of this study

2.3.1. Preventative Barriers

In the case of runway operations, preventative barriers are to prevent a runway incursion.

In the case of Manoeuvring Area operations it is normally only after an action has commenced that ATC can react. Prevention is ATC action that maintains standard safety requirements

EUROCONTROL RAT (Risk assessment Tool) documentation gives the following guidance on standard safety requirements:

a) Events on the Manoeuvring Area (excluding active runways) only compromise standard safety requirements if one party has to take immediate action to stop or vacate the area in order to avoid the possibility of a collision.
b) Events on the Apron and all events involving push backs only compromise standard safety requirements if sudden abrupt braking is required to avoid a potential collision.

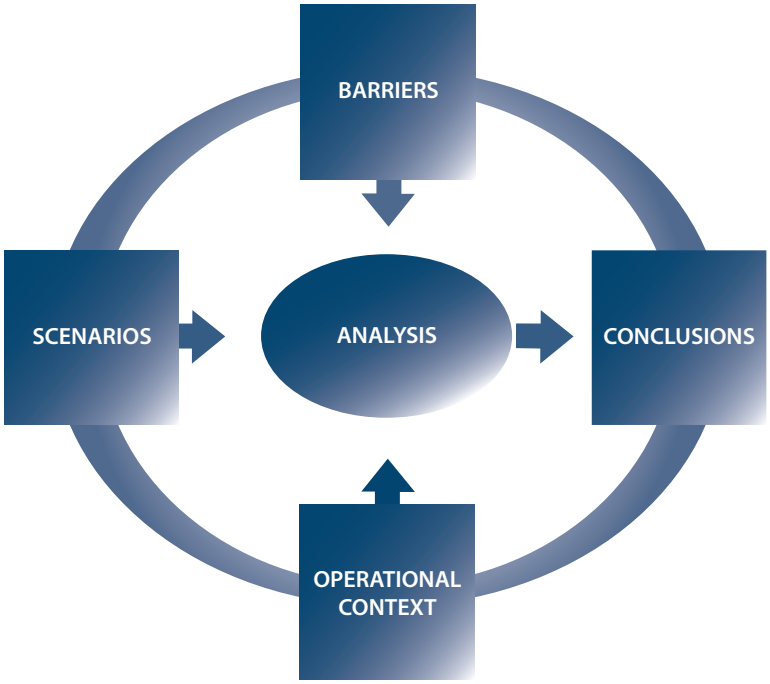
2.3.2. Mitigating Barriers

In the case of runway operations, mitigating barriers do not prevent the incursion but mitigate its impact to prevent a collision.

In the case of Manoeuvring Area operations standard safety requirements have been compromised and the mitigating barrier is available to prevent a ground collision.

CHAPTER 3 - THE GENERIC PROCESS

The figure below provides an overview of the generic steps in the Operational Safety Study

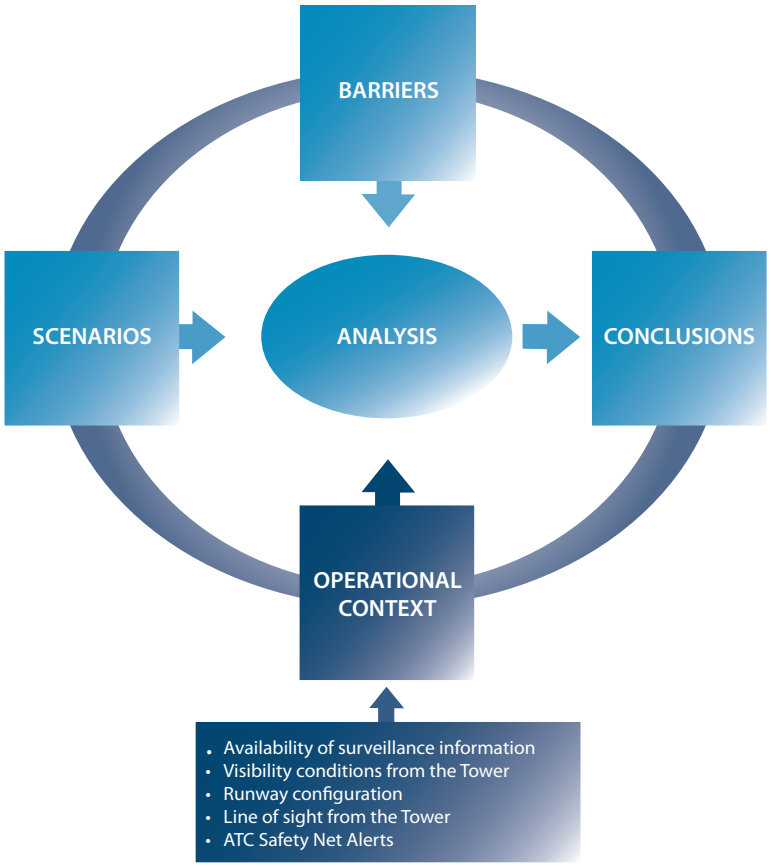


A generic process was designed to analyse ATM Operational Safety Priorities (the Top 5) in order to provide a common methodology for assessment and evaluation. The process starts with three preparatory steps:

- Identification of the operational context pertaining to the operational area considered.
- Definition of the operational scenarios.
- Identification of safety barriers (both preventing and mitigating the effect of the event).

Once all those data are collated an analysis of effectiveness of barriers against the identified operational scenarios is performed and correlated with analysis of real life occurrences. Once the analysis is complete the study provides the conclusions.

CHAPTER 4 - OPERATIONAL CONTEXT



4.1 Operational contexts

The operational context that may affect the efficiency of barriers

The local operational context with relevance for the present study are identified as follows:

- Availability of surveillance information
- Visibility conditions from the Tower
- Runway configuration
- Line of sight from the Tower
- ATC Safety Net Alerts

4.2 Surveillance information

The level of ATC service and may differ depending on equipage

The availability of surveillance data affects the likelihood of detection of RWY incursions and incorrect movement on the Manoeuvring Area.

- Basic Surface Movement Radar (SMR)
- Advanced Surface Movement & Guidance Control System (A_SMGCS) Level 1
- Advanced Surface Movement & Guidance Control System (A_SMGCS) Level 2
- Integrated Tower Working Position (ITWP) using input and display of the ATC clearances in addition to surveillance to enable the use of early warnings to highlight any non-conformance to clearance.

4.3 Visibility conditions from the Tower

The possibility of recognising potential threats in good time may differ depending upon visual impairment

The visibility from Visual Control Room (VCR) and subsequence ability to recognise potential conflicts can be limited by:

- Day/Night
- Fog/Mist
- Low Cloud affecting high control towers
- Sunlight and glare during day
- Precipitation on windows
- Airport floodlighting during night, especially temporary work in progress

4.4 Runway configuration

Runway configuration could impact upon complexity and performance

The runway configuration can influence how the operations on each runway can be affected by the operations on the adjacent ones and therefore how the specific barriers can be applied:

- Multiple Parallel/Intersecting runways, Mixed mode/Single mode operations

4.5 Line of sight

Geometrical visibility could impact on ATC service

The line of sight from the ATC Tower can differ based on:

- The position, height, design, equipment and distance of the tower can restrict the direct view of the relevant part of the runways and Manoeuvring Area.

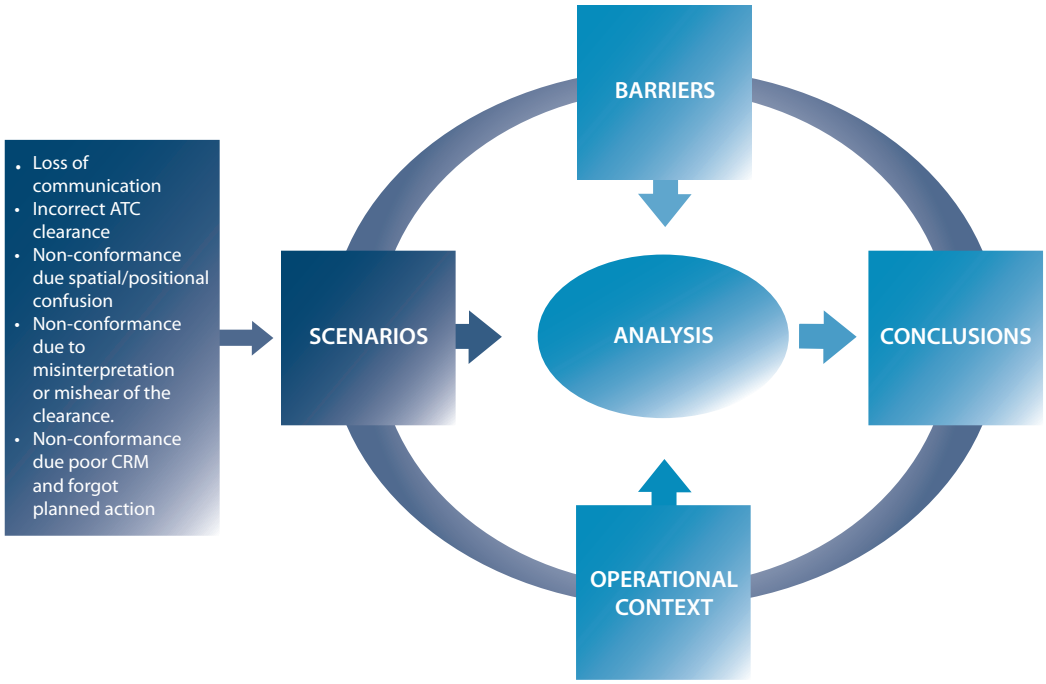
4.6 ATC Safety Net Alerts

Availability of ATC Safety Nets could impact upon the timeliness of conflict resolution

The availability and functionality of Safety Net Alerts:

- A-SMGCS Level 2
- Conflicting ATC Clearances (CATC)
- Conformance Monitoring for Controllers (CMAC)
- Airport Ground Systems e.g. Runway Guard Lasers and Loops

CHAPTER 5 - GENERIC SCENARIOS



5.1 How should generic operational scenarios be defined?

Combination of top-down and bottom-up approaches

Generic operational scenarios are needed to deconstruct the complexity of analysis. Scenario definition is specific to help decide the efficiency of the safety barriers whilst generic enough to keep their number relatively small. The definition of generic operational scenarios takes the form of a synthesis of two sources of information:

- A systematic analytical break-down of the operational scenario into sub-scenarios. This is based on all theoretically possible combinations of the scenario (1) sources, (2) mechanisms and (3) outcomes.
- A review of the publicly available information from investigation reports of accidents and serious incidents investigated following the provisions of ICAO Annex 13 and confidentially provided data in respect of less significant incidents.

5.2 Analytical deconstruction of operational scenarios

Scenario Sources

The following could lead to a potential Runway Incursion pertaining to the generic detection of occupied RWY scenario:

A. Loss of communication
B. Incorrect ATC clearance
C. Non-Conformance with ATC clearance due spatial/positional confusion
D. Non-Conformance with ATC clearance due to misinterpretation or mishear of the clearance
E. Non-Conformance with ATC clearance due poor CRM and forgot planned action

Scenario Mechanisms

The mechanisms as a scenario element describe the flight after the scenario sources occurred. In this case the actors may be in one of the following situations:

- During Take-off
- During Landing
- During Surface Movement

The scenario sources are not necessarily applicable to all scenario mechanisms and the various valid combinations will be reflected by the generic operational scenarios.

Scenario Outcomes

The traffic situation related to the occupied runway detection can be described by one of the options:

1. **Landing on runway already occupied**
   - **a.** Aircraft/Vehicle already on runway
   - **b.** Aeroplane/vehicle with clearance to enter runway
2. **Take-off on runway already occupied**
   - **a.** Aircraft/Vehicle already on runway
   - **b.** Aeroplane/vehicle with clearance to enter runway
3. **Entry of runway by aircraft taxying for departure or by vehicle**
   - **a.** Landing or Departing aeroplane
4. **Runway crossing of runway by aircraft/vehicle**
   - **a.** Landing or Departing aircraft
5. **Surface Movement conflict on runway by two or more**
   - **a.** Aircraft/Vehicles entering/crossing runway at reciprocal points
6. **Departing/Landing on intersecting runways**
   - **a.** Departing/Departing on intersecting runways
   - **b.** Departing/Landing on intersecting runways
   - **c.** Landing/Landing on intersecting runways
   - **d.** Departing or Landing against surface movement on intersecting runways
7. **Departing/Landing on a taxiway not the active runway**
   - **a.** Departing or Landing on a taxiway occupied by aircraft/vehicle
8. **Incorrect aircraft movement on Manoeuvring Area**
   - **a.** Aircraft takes incorrect taxy route
   - **b.** Aircraft incorrectly pushes back/enters on to Manoeuvring Area

5.3 The resulting list of generic operational scenarios for analysis

1. Landing on runway already occupied

A1a Landing after loss of communication on runway already authorised occupied

A1b Landing after loss of communication on runway together with aircraft/vehicle with clearance to enter runway

B1a Landing after receiving incorrect ATC clearance on runway already authorised occupied

B1b Landing after receiving incorrect ATC clearance on runway together with aircraft/vehicle with clearance to enter runway

C1a Landing after non-conformance with ATC clearance due spatial/positional confusion on runway already occupied

C1b Landing after non-conformance with ATC clearance due spatial/positional confusion, together with aircraft/vehicle with clearance to enter runway

D1a Landing after non-conformance with ATC clearance due misinterpretation or mishear of the clearance, on runway already occupied

D1b Landing after non-conformance with ATC clearance due to misinterpretation or mishear of the clearance, together with aircraft/vehicle with clearance to enter runway

E1a Landing without ATC clearance due poor CRM and forgot planned action on runway already occupied

E1b Landing without ATC clearance due poor CRM and forgot planned action, together with aircraft/vehicle with clearance to enter runway

2. Take-off on runway already occupied	**B2a**	Departing after receiving incorrect ATC clearance on runway already authorised occupied
	B2b	Departing after receiving incorrect ATC clearance on runway, together with aircraft/vehicle with clearance to enter runway
	C2a	Departing after non-conformance with ATC clearance due spatial/positional confusion on runway already occupied
	C2b	Departing after non-conformance with ATC clearance due spatial/positional confusion, together with aircraft/vehicle with clearance to enter runway
	D2a	Departing after non-conformance with ATC clearance due misinterpretation or mishear of the clearance, on runway already occupied
	D2b	Departing after non-conformance with ATC clearance due to misinterpretation or mishear of the clearance, together with aircraft/vehicle with clearance to enter runway
	E2a	Departing without ATC clearance due poor CRM and forgot planned action on runway already occupied
	E2b	Departing without ATC clearance due poor RM and forgot planned action, together with aircraft/vehicle with clearance to enter runway
3. Entry onto runway by aircraft taxying for departure or by vehicle	**B3a**	Entry of runway by aircraft taxying for departure or by vehicle due incorrect ATC clearance, together with a landing or departing aircraft.
	C3a	Entry of runway by aircraft taxying for departure or by vehicle after non-conformance with ATC clearance due to spatial/positional confusion, together with a landing or departing aircraft
	D3a	Entry on runway by aircraft taxying for departure or by vehicle after non-conformance with ATC clearance due to misinterpretation or mishear of clearance, together with a landing or departing aircraft
	E3a	Entry on runway by aircraft taxying for departure or by vehicle without ATC clearance due poor CRM and forgot planned action on runway already occupied, together with a landing or departing aircraft
4. Runway crossing	**B4a**	Aircraft/Vehicle crossing runway occupied by landing or departing aircraft due incorrect ATC clearance
	C4a	Unauthorised Aircraft/Vehicle crossing runway occupied by landing or departing aircraft after non-conformance with ATC clearance due to spatial/positional confusion
	D4a	Unauthorised Aircraft/Vehicle crossing runway occupied by landing or departing aircraft after non-conformance with ATC clearance due to misinterpretation or mishear of clearance
	E4a	Unauthorised Aircraft/Vehicle crossing runway occupied by landing or departing aircraft without ATC clearance due to poor CRM or forgot planned action

5. Surface Movement Conflict on runway

B5a Surface movement on runway by two or more mobiles entering/crossing runway at reciprocal entry points due to an incorrect ATC clearance

C5a Surface movement on runway by two or more mobiles entering/crossing runway at reciprocal entry points after non-conformance with ATC clearance due to spatial/positional confusion

D5a Surface movement on runway by two or more mobiles entering/crossing runway at reciprocal entry points after non-conformance with ATC clearance due to misinterpretation or mishear of clearance

E5a Surface movement by Aircraft/Vehicle entering runway on reciprocal entry point to other mobile, without ATC clearance due to poor CRM or forgot planned action

6. Departing or Landing on intersecting runways

A6c Landing/Landing on intersecting runways after a loss of communication

A6d Landing against surface movement mobile on intersecting runways after a loss of communication

B6a Departing/Departing on intersecting runways after an incorrect ATC clearance

B6b Departing/Landing on intersecting runways after an incorrect ATC clearance

B6c Landing/Landing on intersecting runways after an incorrect ATC clearance

B6d Departing/Landing against surface movement mobile on intersecting runways after an incorrect ATC clearance

C6a Departing/Departing on intersecting runways after a non-conformance with ATC clearance due to spatial/positional confusion

C6b Departing/Landing on intersecting runways after a non-conformance with ATC clearance due to spatial/positional confusion

C6c Landing/Landing on intersecting runways after a non-conformance with ATC clearance due to spatial/positional confusion

C6d Departing/Landing against surface movement mobile on intersecting runways after a non-conformance with ATC clearance due to spatial/positional confusion

D6a Departing/Departing on intersecting runways after non-conformance with ATC clearance due to a misinterpretation or mishear of clearance

D6b Departing/Landing on intersecting runways after non-conformance with ATC clearance due to a misinterpretation or mishear of clearance

D6c Landing/Landing on intersecting runways after non-conformance with ATC clearance due to a misinterpretation or mishear of clearance

D6d Departing/Landing against surface movement mobile on intersecting runways after non-conformance with ATC clearance due to a misinterpretation or mishear of clearance

E6a Departing/Departing on intersecting runways without ATC clearance due to poor CRM or forgot planned action

E6b Departing/Landing on intersecting runways without ATC clearance due to poor CRM or forgot planned action

E6c Landing/Landing on intersecting runways without ATC clearance due to poor CRM or forgot planned action

E6d Departing/Landing against surface movement mobile on intersecting runways without ATC clearance due to poor CRM or forgot planned action

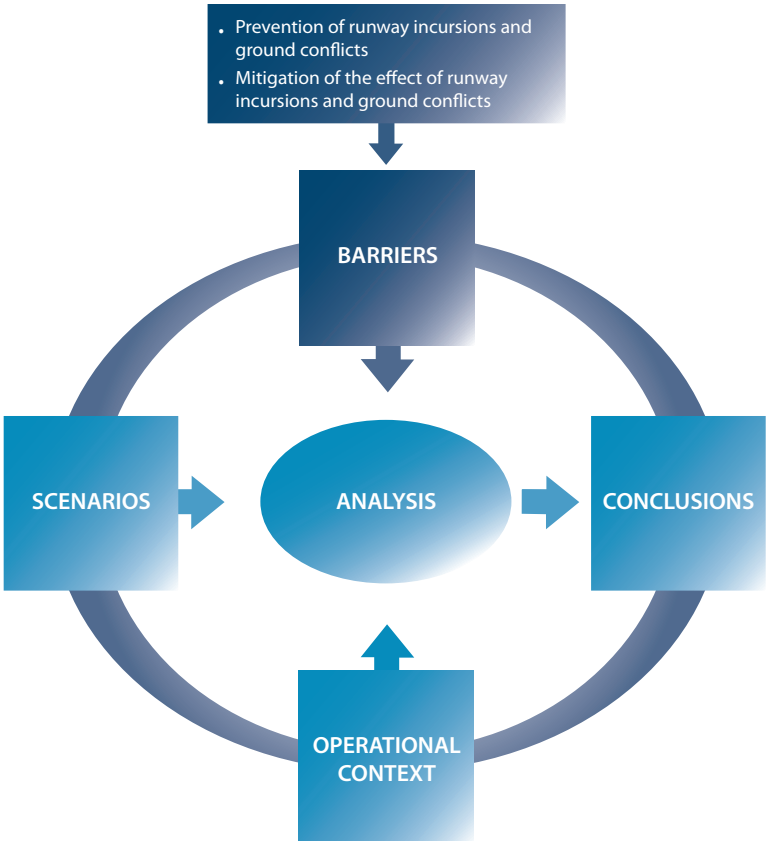
7. Departing/Landing on a taxiway not a runway

C7a	Landing/Departing on a taxiway after a non-conformance with ATC clearance due to spatial/positional confusion
D7a	Landing/Departing on a taxiway after non-conformance with ATC clearance due to a misinterpretation or mishear of clearance

8. Incorrect aircraft movement on Manoeuvring Area

B8a	Aircraft takes taxy route with potential conflict after an incorrect ATC clearance
B8b	Aircraft pushes back/enters on to Manoeuvring Area with potential conflict after an incorrect ATC clearance
C8a	Aircraft takes incorrect taxy route after a non-conformance with ATC clearance due to spatial/positional confusion
C8b	Aircraft incorrectly pushes back/enters on to Manoeuvring Area after a non-conformance with ATC clearance due to spatial/positional confusion
D8a	Aircraft takes incorrect taxy route after non-conformance with ATC clearance due to a misinterpretation or mishear of clearance
D8b	Aircraft incorrectly pushes back/enters on to Manoeuvring Area after non-conformance with ATC clearance due to a misinterpretation or mishear of clearance
E8a	Aircraft takes incorrect taxy route due to poor CRM or forgot planned action
E8b	Aircraft incorrectly pushes back/enters on to Manoeuvring Area runways without ATC clearance due to poor CRM or forgot planned action

CHAPTER 6 - BARRIERS



6.1 Barriers as an opportunity in some situations

The Barriers included in this risk review have been identified as possible ways that detection of an occupied RWY could be employed and or the consequences mitigated.

The barriers are not recommendations

Their inclusion does not imply that they are relevant to all situations and neither does it imply that promotion of their adoption by airport operators or ANSPs would necessarily be appropriate. It may be possible to identify more potentially useful barriers than are included here.

In order to define the barrier there is a need first to define the generic barrier groups for reducing the risk of detection of occupied RWY events. The figure below represents a generalised SAFMAP for Detection of occupied RWY.

A barrier model

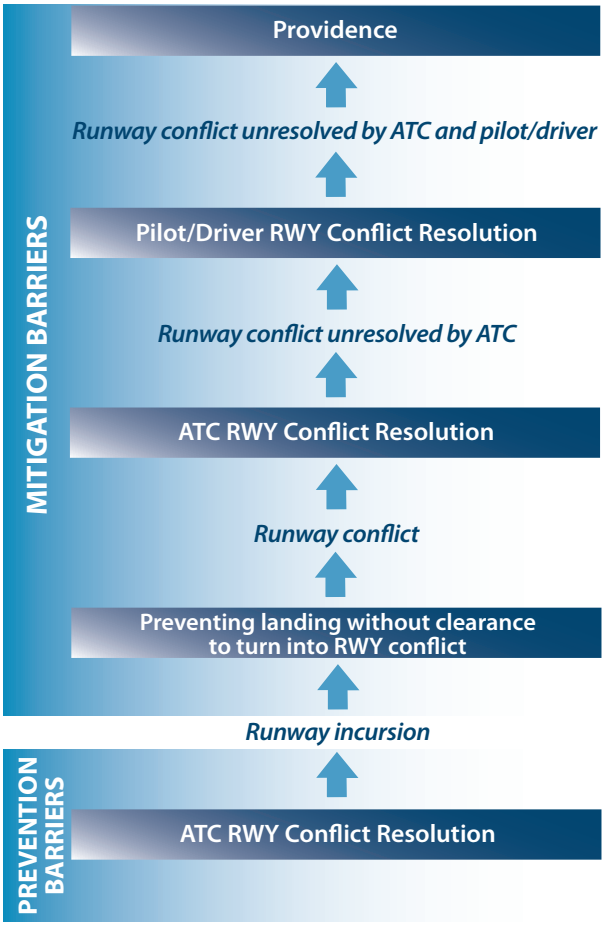
This generalised SAFMAP is derived from the Level 0 Runway Collision SAFMAP Version 0.8 and is the most generic barrier model for preventing runway collision because of situations of detection of occupied RWY.

6.2 Two types of barriers

There are two major sets of barriers which can reduce the risk associated with runway incursions events. These barriers are restricted to just one segment of Air Traffic Control and are identified based on a wide literature search and consultation, and are:

Balancing preventing and mitigating the risk associated with runway incursions

- **Prevention of runway incursions and ground conflicts.** These barriers, when deployed and employed correctly, are capable of alerting ATC in time to prevent runway incursions and ground conflicts. With regard to events on the Manoeuvring Area, these barriers are capable of alerting ATC before standard levels of safety are compromised.
- **Mitigation of the effect of runway incursions and ground conflicts.** These barriers, when deployed and employed correctly, are capable of alerting ATC to a runway incursion or a ground safety event in sufficient time for ATC to act in order to prevent a ground collision.


MITIGATION BARRIERS
Providence
Runway conflict unresolved by ATC and pilot/driver
Pilot/Driver RWY Conflict Resolution
Runway conflict unresolved by ATC
ATC RWY Conflict Resolution
Runway conflict
Preventing landing without clearance to turn into RWY conflict
Runway incursion
PREVENTION BARRIERS
ATC RWY Conflict Resolution

6.3 Barriers preventing runway incursion and ground safety events involving inadequate detection by controllers (PB)

Barriers to prevent runway incursions and manoeuvring area events

PB1 ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc

PB2 ATCO direct visual detection

PB3 ATCO visual detection using remote camera displays

PB4 ATCO resolution following pilot/driver report

PB5 ATCO detection of occupied runway by use of basic Surface Movement Radar

PB6 A-SMGCS level 1 surveillance with vehicles, in addition to aircraft, equipped with transponders in order to enhance surveillance

PB7 A-SMGCS level 2 conflict alerts

PB8a Use of input and display of the ATC clearances that enable the use of "early warning" surveillance and data (Integrated Tower Working Position (ITWP)to highlight any non-conformance to clearance

PB8b Use of input and display of the ATC clearances that enable the use of "early warning" surveillance and data (ITWP) to highlight the potential consequences of any incorrect clearance

PB9 Use of discrete names for holding positions and pilot reports e.g. reporting point BARKA instead of W2

PB10 All vehicles entering on a runway should display high visibility flashing/strobing lights on in all visibility conditions

6.4 Barriers mitigating runway incursion and ground safety events involving detection by controllers (MB)

Barriers mitigating the effects of inadequate detection of runway incursions and manoeuvring area events

MB1 ATCO direct visual detection

MB2 ATCO visual detection using remote camera displays

MB3 ATCO detection following pilot/driver report

MB4 ATCO detection using basic SMR

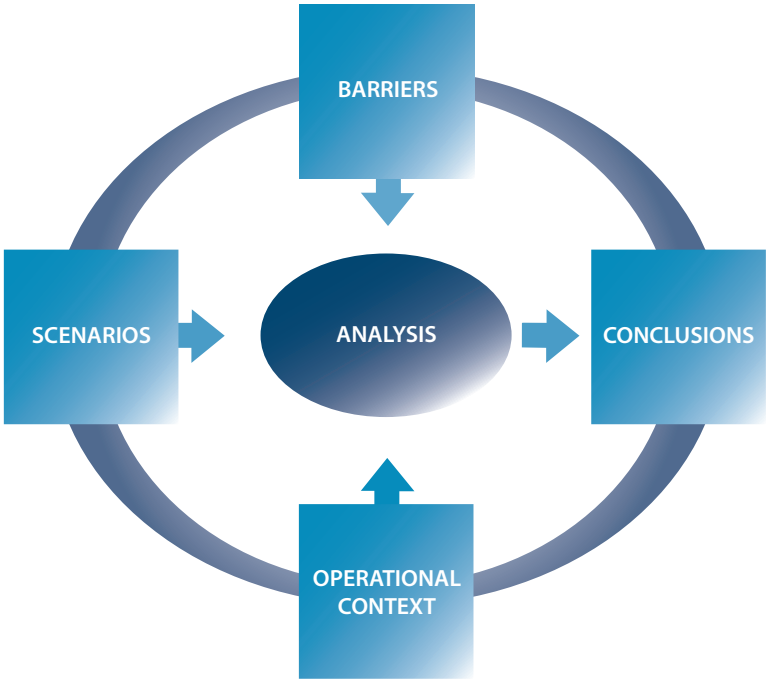
MB5 ATCO detection it using A-SMGCS level 1

MB6 ATCO detection it after alert from A-SMGCS level 2

MB7 ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).

MB8 ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

CHAPTER 7 - ANALYSIS OF BARRIERS IN GENERIC SCENARIOS



7.1 Prevention Barrier Assessment

The first step of the analysis consists of assessing the potential effectiveness of the prevention barriers in the defined operational scenarios. The high level assessment considers the various operational scenarios and is based on expert judgement. The barriers are assessed individually, the analysis does not consider the interactions or the results of more than one barrier acting in combination.

7.1.1 Dependencies

- All barriers are deemed to be operationally available and operated correctly.
- It is assumed that controllers will react correctly to all aural and visual safety nets.
- All barriers are limited by the responsiveness of the players to the signals.
- Deliberate non-conformance is excluded from the analysis.

7.1.2 Colour code used in the Barrier Analysis tables

Red	Barrier that is either inefficient or is not intended for the operational scenario
Yellow	Barrier that is partially effective or partially efficient for the operational scenario or efficient under certain conditions
Green	Barrier that is effective and efficient for the operational scenario

7.1.3 Key to Yellow constraints:

1. Prevention possible subject to time and opportunity to act.
2. Prevention possible subject to controller focus of attention on information that shows discrepancy.
3. Prevention possible subject to daytime/visibility/line of sight.
4. Prevention possible subject to controller noting anomaly, challenge mind-set and act.

7.1.4 Prevention Barrier Analysis Tables

Table 1: Analysis of Prevention Barrier Efficiency on Scenarios Set 1: Landing with runway already occupied

	A1a	A1b	B1a	B1b	C1a	C1b	D1a	D1b	E1a	E1b
PB1 - ATC memory aids										
PB2 - ATC direct visual detection	1,3	1,3	3,4	1,2,3,4	3	3	3	3	3	3
PB3 – ATC detection using remote camera displays										
PB4 - ATC resolution following pilot/driver report	2,3	2,3	2,3	2.3	2,3	2,3	2,3	2,3	2,3	2,3
PB5 – ATC detection with basic SMR			2,4	2,4						
PB6 – A-SMGCS level 1 with vehicles, in addition to aircraft, equipped with transponders			2,4	2,4					2	2
PB7 – A-SMGCS level 2 conflict alerts	1	1								1,2
PB8a – Input and display of ATC clearances and surveillance data (ITWP) to detect non-conformance to clearance	1	1	8b in use	8b in use						
PB8b – Input and display of ATC clearances and surveillance data (ITWP) to detect impact of incorrect ATC clearance					8a in use	8a in use	8a in use	8a in use	8a in use	8a in use
PB9 - Use of discrete names for holding positions and pilot reports e.g. point BARKA instead of W2										
PB10 - Vehicle have high vis flashing or strobe lighting	3		3			3			3	

Table 2: Analysis of Prevention Barrier Efficiency on Scenarios Set 2: Departing with runway already occupied

	B2a	B2b	C2a	C2b	D2a	D2b	E2a	E2b
PB1 - ATC memory aids								
PB2 - ATC display visual detection			1,3	1,3,	1,3,	1,3,	1,3,	1,3,
PB3 – ATC detection using remote camera displays			2,4	2,4	2,4	2,4	2,4	2,4
PB4 - ATC resolution following pilot/driver report		2,3		2.3		2,3		2,3
PB5 – ATC detection with basic SMR	1,2,4	1,2,4	1,2,4	1,2,4				
PB6 – A-SMGCS level 1 with vehicles, in addition to aircraft, equipped with transponders	1,2,4	1,2.4	1,2,4	1,2,4				1,2
PB7 – A-SMGCS level 2 conflict alerts	1,2,4	1,2,4	1,2,4	1,2,4				1,2
PB8a – Input and display of ATC clearances and surveillance data (ITWP) to detect non-conformance to clearance	8a in use	8a in use				1		1,2
PB8b – Input and display of ATC clearances and surveillance data (ITWP) to detect impact of incorrect ATC clearance			8a in use	8a in use		8a in use		8a in use
PB9 - Use of discrete names for holding positions and pilot reports e.g. point BARKA instead of W2								
PB10 - Vehicle have high vis flashing or strobe lighting	3		3		3	3,4	3	

Table 3: Analysis of Prevention Barrier Efficiency on Scenarios Set 3: Entry of runway by aircraft taxying for departure or by a vehicle

	B3a	C3a	D3a	E3a
PB1 - ATC memory aids	1,2,3,4			
PB2 - ATC display visual detection	1,2,3,4	3	3	
PB3 – ATC detection using remote camera displays		1,2	1, 2	1, 2
PB4 - ATC resolution following pilot/driver report	2,3	2,3	2,3	2.3
PB5 – ATC detection with basic SMR		2	2	
PB6 – A-SMGCS level 1 with vehicles, in addition to aircraft, equipped with transponders		2	2	
PB7 – A-SMGCS level 2 conflict alerts		2		
PB8a – Input and display of ATC clearances and surveillance data (ITWP) to detect non-conformance to clearance	8b in use	2		
PB8b – Input and display of ATC clearances and surveillance data (ITWP) to detect impact of incorrect ATC clearance		8a in use	8a in use	
PB9 - Use of discrete names for holding positions and pilot reports e.g. point BARKA instead of W2		1,2,4	1,2,4	
PB10 - Vehicle have high vis flashing or strobe lighting		3	3	3

Table 4: Analysis of Prevention Barrier Efficiency on Scenarios Set 4: Runway crossing

	B4a	C4a	D4a	E4a
PB1 - ATC memory aids				
PB2 - ATC display visual detection		2,3		
PB3 – ATC detection using remote camera displays				
PB4 - ATC resolution following pilot/driver report	1,3	1,3	1,3	
PB5 – ATC detection with basic SMR				
PB6 – A-SMGCS level 1 with vehicles, in addition to aircraft, equipped with transponders				
PB7 – A-SMGCS level 2 conflict alerts				
PB8a – Input and display of ATC clearances and surveillance data (ITWP) to detect non-conformance to clearance	7b in use	2	2	2
PB8b – Input and display of ATC clearances and surveillance data (ITWP) to detect impact of incorrect ATC clearance	2	7a in use	7a in use	7a in use
PB9 - Use of discrete names for holding positions and pilot reports e.g. point BARKA instead of W2				
PB10 - Vehicle have high vis flashing or strobe lighting				

Table 5: Analysis of Prevention Barrier Efficiency on Scenarios Set 5: Surface Movement conflict on runway

	B4a	C4a	D4a	E4a
PB1 - ATC memory aids				
PB2 - ATC display visual detection		2,3		
PB3 – ATC detection using remote camera displays				
PB4 - ATC resolution following pilot/driver report	1,3	1,3	1,3	
PB5 – ATC detection with basic SMR				
PB6 – A-SMGCS level 1 with vehicles, in addition to aircraft, equipped with transponders				
PB7 – A-SMGCS level 2 conflict alerts				
PB8a – Input and display of ATC clearances and surveillance data (ITWP) to detect non-conformance to clearance	7b in use	2	2	2
PB8b – Input and display of ATC clearances and surveillance data (ITWP) to detect impact of incorrect ATC clearance	2	7a in use	7a in use	7a in use
PB9 - Use of discrete names for holding positions and pilot reports e.g. point BARKA instead of W2				
PB10 - Vehicle have high vis flashing or strobe lighting				

Table 6: Analysis of Prevention Barrier Efficiency on Scenarios Set 6: Departing/Landing on intersecting runways

	A6c	A6d	B6a	B6b	B6c	B6d
PB1 - ATC memory aids						
PB2 - ATC display visual detection	3	3				
PB3 – ATC detection using remote camera displays						
PB4 - ATC resolution following pilot/driver report						
PB5 – ATC detection with basic SMR						
PB6 – A-SMGCS level 1 with vehicles, in addition to aircraft, equipped with transponders						
PB7 – A-SMGCS level 2 conflict alerts					1,2	1,2
PB8a – Input and display of ATC clearances and surveillance data (ITWP) to detect non-conformance to clearance			8b in use	8b in use	8b in use	8b in use
PB8b – Input and display of ATC clearances and surveillance data (ITWP) to detect impact of incorrect ATC clearance	8a in use	8a in use	1	1		
PB9 - Use of discrete names for holding positions and pilot reports e.g. point BARKA instead of W2						
PB10 - Vehicle have high vis flashing or strobe lighting						

Table 6: Analysis of Prevention Barrier Efficiency on Scenarios Set 6: Departing/Landing on intersecting runways

	C6a	C6b	C6c	C6d	D6a	D6b	D6c	D6d	E6a	E6 b	E6c	E6d
PB1 - ATC memory aids												
PB2 - ATC direct visual detection	1,3	1,3	1,3	1,3	3	3	3	3				
PB3 – ATC detection using remote camera displays	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2				
PB4 - ATC resolution following pilot/driver report												
PB5 – ATC detection with basic SMR												
PB6 – A-SMGCS level 1 with vehicles, in addition to aircraft, equipped with transponders	1,2	1,2	1,2	1,2				2				
PB7 – A-SMGCS level 2 conflict alerts	1,2	1,2	1,2	1,2		2		2		1,2	1,2	1,2
PB8a – Input and display of ATC clearances and surveillance data (ITWP) to detect non-conformance to clearance	1,2	1,2		2		2		2		1,2		
PB8b – Input and display of ATC clearances and surveillance data (ITWP) to detect impact of incorrect ATC clearance	8a in use	8a in use	8a in use	8a in use		8a in use	8a in use	8a in use		8a in use	8a in use	8a in use
PB9 - Use of discrete names for holding positions and pilot reports e.g. point BARKA instead of W2												
PB10 - Vehicle have high vis flashing or strobe lighting												

Table 7: Analysis of Prevention Barriers for Departing on a taxiway not a runway

	C7a	D7a
PB1 - ATC memory aids		
PB2 - ATC display visual detection	1,2,3	1,2,3
PB3 – ATC detection using remote camera displays		
PB4 - ATC resolution following pilot/driver report		
PB5 – ATC detection with basic SMR		
PB6 – A-SMGCS level 1 with vehicles, in addition to aircraft, equipped with transponders		
PB7 – A-SMGCS level 2 conflict alerts		
PB8a – Input and display of ATC clearances and surveillance data (ITWP) to detect non-conformance to clearance	1,2	1,2
PB8b – Input and display of ATC clearances and surveillance data (ITWP) to detect impact of incorrect ATC clearance	8a in use	8a in use
PB9 - Use of discrete names for holding positions and pilot reports e.g. point BARKA instead of W2	1,2	1,2
PB10 - Vehicle have high vis flashing or strobe lighting		

Table 8: Analysis of Prevention Barriers for Incorrect aircraft movement on Manoeuvring Area

	B8a	B8b	C8a	C8b	D8a	D8b	E8a	E8b
PB1 - ATC memory aids								
PB2 - ATC display visual detection	3,4	3,4	3,4	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4
PB3 – ATC detection using remote camera displays								
PB4 - ATC resolution following pilot/driver report	3,4	3,4	3,4	1,3,4	1,3,4	1,3,4	1,3,4	1,3,4
PB5 – ATC detection with basic SMR								
PB6 – A-SMGCS level 1 with vehicles, in addition to aircraft, equipped with transponders								
PB7 – A-SMGCS level 2 conflict alerts								
PB8a – Input and display of ATC clearances and surveillance data (ITWP) to detect non-conformance to clearance	8a in use	8a in use	1	1	1	1	1	1
PB8b – Input and display of ATC clearances and surveillance data (ITWP) to detect impact of incorrect ATC clearance			8a in use	8a in use	8a in use	8a in use	8a in use	8a in use
PB9 - Use of discrete names for holding positions and pilot reports e.g. point BARKA instead of W2			2		2		2	
PB10 - Vehicle have high vis flashing or strobe lighting								

In order to organise the results, a scoring system was considered. The main purpose is to give a comparison scale and an indication on how effective a barrier can be over all the considered scenarios and not to provide an absolute ranking (the higher the score doesn't necessarily equate to a more effective barrier). Also, it should be borne in mind that in this specific case the barriers are used for the detection of occupied runway meaning that the premises for a potential runway incursion are already in place (which may make a difference when considering the same barrier for the runway incursion itself).

The scoring system utilised to rank the applications is as follows: zero points for an ineffective barrier (red), one point for a partially effective barrier (yellow) and three points for and effective barrier.

Table 9: The ranking for the Preventing Barriers; this ranking indicates which are the barriers that are more effective in most operational scenarios.

Barrier	Barrier Description	Score
PB8	Input and display of ATC clearances and surveillance data (ITWP) to jointly detect non-conformance to clearance and the potential impact of incorrect clearances	100 *
PB7	A-SMGCS level 2	45
PB2	ATC visual detection including video and remote camera displays	42
PB4	ATC resolution following pilot/driver alert	34
PB1	ATC memory aids	31
PB3	ATC detection using remote camera displays	20
PB6	A-SMGCS level 1	16
PB10	Vehicle have high vis flashing or strobe lighting	12
PB9	Use of named HPs e.g. BARKA	11
PB5	Basic SMR	8

* Non-compliance element 67 & controller monitoring 33

7.2 Mitigation Barrier Assessment

Table 10: Analysis of Mitigation Barrier for Scenarios Set 1: Incorrect Landing with runway already occupied

	A1a	A1b	B1a	B1b	C1a	C1b	D1a	D1b	E1a	E1b
MB1 - ATCO direct visual detection										
MB2 - ATCO visual detection using remote camera displays										
MB3 - ATCO detection following pilot/driver report										
MB4 - ATCO detection using basic SMR										
MB5 - ATCO detection using A-SMGCS level 1										
MB6 - ATCO detection after alert from A-SMGCS level 2										
MB7 - ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).										
MB8 - ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)										

Table 11: Analysis of Mitigation Barrier for Scenarios Set 2: Departing with runway already occupied

	B2a	B2b	C2a	C2b	D2a	D2b	E2a	E2b
MB1 - ATCO direct visual detection								
MB2 - ATCO visual detection using remote camera displays								
MB3 - ATCO detection following pilot/driver report								
MB4 - ATCO detection using basic SMR								
MB5 - ATCO detection using A-SMGCS level 1								
MB6 - ATCO detection after alert from A-SMGCS level 2								
MB7 - ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).								
MB8 - ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)								

Table 12: Analysis of Mitigation Barrier for Scenarios Set 3: Entry of runway by aircraft taxying for departure or by vehicle

	B3a	C3a	D3a	E3a
MB1 - ATCO direct visual detection				
MB2 - ATCO visual detection using remote camera displays				
MB3 - ATCO detection following pilot/driver report				
MB4 - ATCO detection using basic SMR				
MB5 - ATCO detection using A-SMGCS level 1				
MB6 - ATCO detection after alert from A-SMGCS level 2				
MB7 - ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).				
MB8 - ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)				

Table 13: Analysis of Mitigation Barrier for Scenarios Set 4: Runway crossing by aircraft/vehicle

	C4a	D4a	E4a
MB1 - ATCO direct visual detection			
MB2 - ATCO visual detection using remote camera displays			
MB3 - ATCO detection following pilot/driver report			
MB4 - ATCO detection using basic SMR			
MB5 - ATCO detection using A-SMGCS level 1			
MB6 - ATCO detection after alert from A-SMGCS level 2			
MB7 - ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).			
MB8 - ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)			

Table 14: Analysis of Mitigation Barrier for Scenarios Set 5: Surface Movement conflict on runway

	B5a	C5a	D5a	E5a
MB1 - ATCO direct visual detection				
MB2 - ATCO visual detection using remote camera displays				
MB3 - ATCO detection following pilot/driver report				
MB4 - ATCO detection using basic SMR				
MB5 - ATCO detection using A-SMGCS level 1				
MB6 - ATCO detection after alert from A-SMGCS level 2				
MB7 - ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).				
MB8 - ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)				

Table 15: Analysis of Mitigation Barrier for Scenarios Set 6: Departing or Landing on intersecting runways

	A6c	A6d	B6a	B6b	B6c	B6d	C6a	C6b	C6c	C6d
MB1 - ATCO direct visual detection										
MB2 - ATCO visual detection using remote camera displays										
MB3 - ATCO detection following pilot/driver report										
MB4 - ATCO detection using basic SMR										
MB5 - ATCO detection using A-SMGCS level 1										
MB6 - ATCO detection after alert from A-SMGCS level 2										
MB7 - ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).										
MB8 - ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)										

Table 15: Analysis of Mitigation Barrier for Scenarios Set 6: Departing or Landing on intersecting runways

	D6a	D6b	D6c	D6d	E6a	E6b	E6c	E6d
MB1 - ATCO direct visual detection								
MB2 - ATCO visual detection using remote camera displays								
MB3 - ATCO detection following pilot/driver report								
MB4 - ATCO detection using basic SMR								
MB5 - ATCO detection using A-SMGCS level 1								
MB6 - ATCO detection after alert from A-SMGCS level 2								
MB7 - ATCO detection after alert from air-port ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).								
MB8 - ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)								

Table 16: Analysis of Mitigation Barrier for Scenarios Set 7: Departing on a taxiway, not a runway

	C7a	D7a
MB1 - ATCO direct visual detection		
MB2 - ATCO visual detection using remote camera displays		
MB3 - ATCO detection following pilot/driver report		
MB4 - ATCO detection using basic SMR		
MB5 - ATCO detection using A-SMGCS level 1		
MB6 - ATCO detection after alert from A-SMGCS level 2		
MB7 - ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).		
MB8 - ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)		

Table 17: Analysis of Mitigation Barrier for Scenarios Set 8: Incorrect aircraft movement on the Manoeuvring Area

	B8a	B8b	C8a	C8b	D8a	D8b	E8a	E8b
MB1 - ATCO direct visual detection								
MB2 - ATCO visual detection using remote camera displays								
MB3 - ATCO detection following pilot/driver report								
MB4 - ATCO detection using basic SMR								
MB5 - ATCO detection using A-SMGCS level 1								
MB6 - ATCO detection after alert from A-SMGCS level 2								
MB7 - ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).								
MB8 - ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)								

Table 18: The ranking for the Preventing Barriers; this ranking indicates which are the barriers that are more effective in most operational scenarios.

Barrier	Barrier Description	Score
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)	115
MB3	ATCO detection following pilot/driver report	107
MB2	ATCO detection using remote camera displays	60
MB1	ATCO direct visual detection	57
MB6	ATCO detection after alert from A-SMGCS level 2	56
MB5	ATCO detection using A-SMGCS level 1	32
MB7	ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).	27
MB4	ATCO detection using basic SMR	22

7.3 Combined Barrier Assessment

Tables 9 and 18 show the functionality supporting the Barriers PB8 and MB8

ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP) is likely to be the most effective ATC tool in the prevention and mitigation of runway incursions and ground safety events. This functionality is not yet widely available; however, this study does lend strong support.

The study suggests that proactive alerts from pilots and drivers that lead to ATC detection and resolution (PB4 and MB3) are likely to be very important barriers, especially in reducing the risk of collision in runway incursions.

ATC direct visual detection (PB2 and MB1) and the use of A-SMGCS level 2 (PB7 and MB6) are both strong barriers in the prevention and mitigation of runway events.

ATC detection of incorrect runway presence, using remote camera displays (MB2) is a strong mitigation barrier as it does not necessarily depend on good visibility and line of sight.

ATC memory aids (PB1) are likely to be strong barriers that aid ATC perception and memory. It is these areas of ATC action however that fail most often in actual events (see chapters 8 and 9).

CHAPTER 8 - ACTUAL RUNWAY INCURSION AND GROUND SAFETY EVENTS

The actual safety events described and analysed below are either in the public domain or have been supplied with the permission of the relevant authorities.

In order to dis-identify all stakeholders whilst maintaining the safety lessons, the following editorial actions have been taken.

- No airport, aircraft operator or ANSP is specified.
- The aircraft involved in each event are denoted solely by the aircraft type.
- Controller working positions have been generalised to two terms; TWR meaning the controller in control of the runway, and GMC meaning the controller in charge of the manoeuvring area excluding the active runway.
- Unless necessary to describe the event, no runway designation is mentioned. In cases where it is necessary to consider interacting runways, the runway designators have been changed whilst maintaining a general relationship.
- Unless necessary to describe the event, no taxiway designation is mentioned. In cases where it is necessary to consider interacting taxiways, the designators have been changed.

A Barrier model is used to show the following in each event:

Actual Recovery Barrier

ATC Barriers Breached

Remaining Barriers available that could have reduced risk of collision

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision

Where "x" is shown, it denotes an available barrier that is not in the ambit of ATC

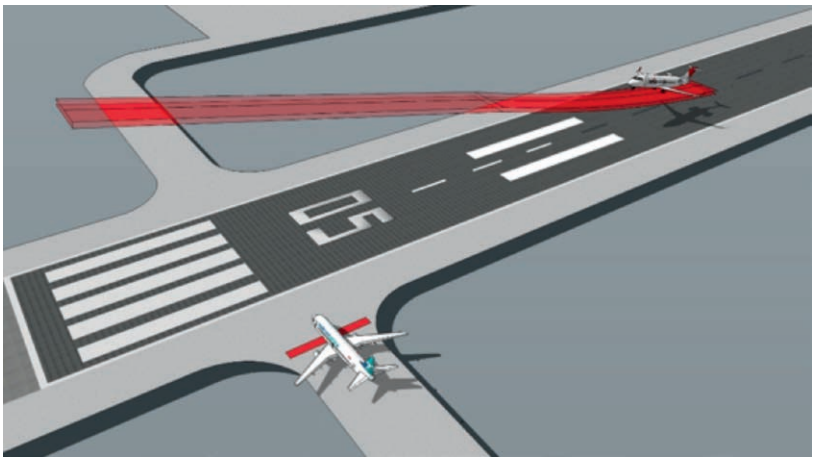
8.1 Event 1. Cleared to cross runway with aircraft departing

Generic Scenario:		
Runway crossing	B4a	Aircraft/Vehicle crossing runway occupied by landing or departing aircraft due incorrect ATC clearance.

A B737 is at a holding point ready to cross the active runway (stop bars on). The controller has already cleared an E135 for take-off, during this time the aircraft becomes obscured by a support beam for the glazing in the tower. The controller then clears the B737 to cross the active runway and deselects the stop bars.

The B737 pilot advises tower that there is a departing aircraft on the runway. The controller acknowledges the transmission and instructs the B737 to hold position and reselects the stop bars, the B737 did not move from the holding point and therefore did not enter the protected area. In mitigation the controller recovery actions were correct. Prior to this event he had to contend with an emergency on the opposite parallel runway...all of this happening on one frequency due to sickness.

There is basic SMR but no A-SMGCS.



Contributing Factors:
Memory - Controller forgot previous action – take-off clearance
Action – Task priority – Clearance given before moving strip
Operation Environment – Visual Impairment
Operation Environment – Distraction from previous emergency
Team Factors – Temporary Staffing constraints

Actual Recovery Barrier:	
B4a	ATCO resolution following pilot/driver report

ATC Barriers Breached:	
PB1	ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc.
PB2	ATCO direct visual detection

Remaining Barriers available that could have reduced risk of collision:	
MB1	ATCO direct visual detection
X	Pilot visual detection (departing aircraft)
X	Providence

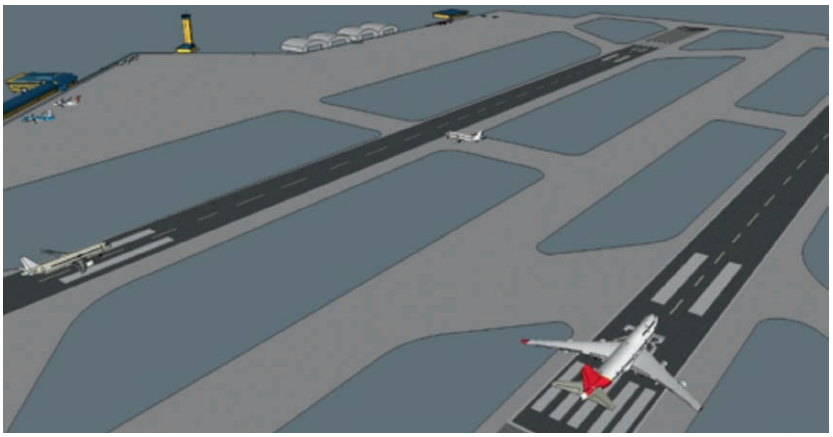
ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
PB8b	Use of input and display of the ATC clearances that enable the use of "early warning" surveillance and data (ITWP) to highlight the potential consequences of any incorrect clearance
MB6	ATCO detection it after alert from A-SMGCS level 2
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.2 Event 2. Cleared for take-off with aircraft crossing runway

Generic Scenario:		
Runway crossing	B4a	Aircraft/Vehicle crossing runway occupied by landing or departing aircraft due incorrect ATC clearance.

An E190 lands 28R and taxies towards 28L for crossing of the departure runway. On the apron side of the departure runway three aircraft are holding on the taxiway due to an aircraft that has pushed back ahead of them. The GMC controller asked the TWR controller to delay crossing the E190.

The A320 is cleared to line up from 28L and then the E190 is cleared to cross 28L after a long wait. The controller is checking the clock to confirm correct wake turbulence separation between the A320 and a previous departed Heavy, which gives him a gap in the departure sequence.



The controller is also increasingly monitoring on a tight landing or go-around situation on 28R. When the second aircraft lands, the previous lander is just clear of the runway and being asked to expedite clear.

The A320 is cleared take-off while E190 begins to cross 28L. The controller has forgotten that he has cleared the E190 to cross. The pilot of the A320 saw the E190 and announced immediately to the controller that he does not roll.

The controller does not detect errors in the strip bay. He believes that he was too busy looking out the window at the landing situation on 28L to look at his display. He was also aware that the E190 had been waiting a long time to cross and he was anxious to get him to the Apron.

Contributing Factors:
Memory - Controller forgot previous action – runway crossing clearance
Memory – Forgot to check/monitor runway
Operation Environment – Distraction from checking timed separation
Operation Environment – Distraction from checking situation on other runway
Organisation Factors – Balance of safety/service delivery

Actual Recovery Barrier:	
MB3	ATCO detection following pilot/driver report

ATC Barriers Breached:	
PB1	ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc.
PB2	ATCO direct visual detection

Remaining Barriers available that could have reduced risk of collision:	
MB1	ATCO direct visual detection
X	Pilot visual detection (both aircraft)
MB6	ATCO detection it after alert from A-SMGCS level 2
X	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

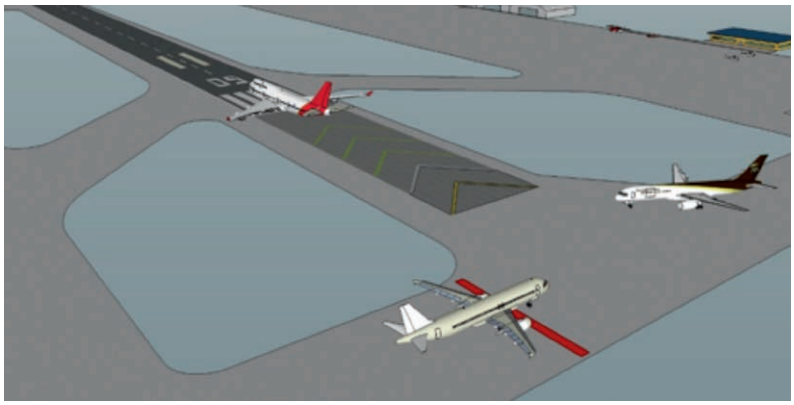
8.3 Event 3. Lining up without clearance

Generic Scenario:		
Surface Movement Conflict on Runway	D5a	Surface movement on runway by two or more mobiles entering/crossing runway at reciprocal entry points after non-conformance with ATC clearance due to misinterpretation or mishear of clearance.

Runway 05 was in use for departure. It was daylight and the runway holding point was visible from the VCR.

The following RTF exchange took place:
- ATC to A320: «after (company) 747 on your left hand side, left turn hold Bravo One.»
- A320: «After 747, line up and wait runway 05»
- ATC: «Negative sir, give way to the 747, then hold at Bravo One»
- A320: «Give way to the 747, Bravo»

A B757 holding on the opposite side of the runway was issued with a conditional clearance.
«After the (*company*) 747 departs, line up 08». The readback was correct and then the B747 is cleared for take-off.



The A320 begins to enter the runway, as does the B757 in accordance with his clearance. The B757 questioned the situation with the controller: "(B757 call sign), is there a misunderstanding here? We were cleared to line up behind the (*company*), right?» At this time the A320 was seen to be holding position over the CAT I holding point.

ATC confirm the runway entry clearance and instruct the A320 to hold position, which he confirms. ATC check that the B757 pilot is happy with the wing clearance from the A320 and it is subsequently given take-off clearance.

The pilot report from the A320 stated: We were at the holding point RWY05 by B1, the F/O confirmed me that he got acknowledgement from the TWR confirming that we were cleared to enter in the RWY05 behind the preceding traffic. I was speaking to the passengers at the time, as soon as that traffic starts his take-off run, we started to lining up in the RWY05, an aircraft in front of us, holding short at on the other side, turned on his landing lights at that moment so I stopped the plane to request confirmation, we had run 5 meters or so over. TWR said that the correct sequence was to enter in the RWY behind the B757.

The controller stated that, in hindsight, the second read back was not as definitive as he would have liked. He reported that he believed that after correcting the first incorrect read back using the word 'negative' the A320 had understood that his first read back had been incorrect.

He stated that he could have solved the issue by using a second conditional clearance and instructed the A320 to line up after the B757 to enhance situational awareness and ensure the A320 did not misinterpret his clearance.

Contributing Factors:
Action (Pilot) – Convey incomplete information
Perception – Misperceive auditory information
Pilot Actions – CRM issues

Actual Recovery Barrier:	
MB3	ATCO detection following pilot/driver report

ATC Barriers Breached:
Nil

Remaining Barriers available that could have reduced risk of collision:	
x	Pilot visual detection (both aircraft)
MB6	ATCO detection after alert from A-SMGCS level 2
x	Providence

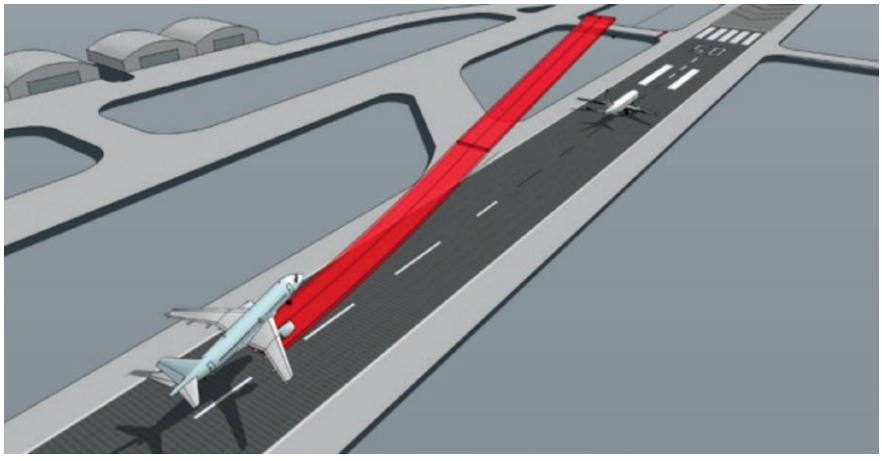
ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB7	ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers)
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.4 Event 4. Cleared for take-off with runway still occupied by previous aircraft

Generic Scenario:		
Take-off on runway already occupied	B2a	Departing after receiving incorrect ATC clearance on runway already authorised occupied

It is night and the runway lights and aircraft lights are difficult to establish from the TWR by a large amount of temporary lights for works on the taxiways close to the runway. Rapid Exit Taxiways Charlie and Bravo are closed for the work. Landing aircraft must either vacate earlier at Delta or continue to vacate at Alpha, the far end of the runway.

There is a 5 mile gap in the landing sequence and it is intended to depart one aircraft in between the landing aircraft. An A319 is instructed to line-up and wait after the landing B737. The B737 lands and is told to vacate at Delta and is seen to slow approaching Delta. ATC instruct the B737 to contact Ground Control (GMC). However the B737 misses Delta and begins to taxi slowly ahead on the runway.



The trainee TWR controller, mindful of the next aircraft on the approach at 2 miles, clears the A319 for take-off having assumed that the B737 was vacating as instructed. The TWR controller does not visually confirm the position of the B737 in the glare of the many temporary lights and neither the controller nor the trainee see the clear indication on the SMR that the B737 is still on the runway.

GMC is unaware of any problem and simply instructs the B737 to take the appropriate taxiway towards its stand. It is only as the A319 accelerates down the runway that an alert from A-SMGCS is triggered. The controller momentarily considers telling the A319 to stop but concludes that it is close to rotation speed and safer to allow the take-off. Meanwhile, GMC realises the situation and instructs the B737 to expedite clear of the runway.

The pilot report from the A319 shows that he was unaware of the B737 still being on the runway. He said that he "saw some unusual lights but there were so many close to the runway".

Contributing Factors:
Perception – Mis-see aircraft not vacating rwy
Perception – Not see aircraft symbol on SMR
Decision – Incorrect plan, transferring control of B737 to GMC whilst still on rwy
Training and Experience – Controller training in progress
Interaction with Environment – Airport – Work in Progress
Interaction with Environment – Airport – Airport Ground Lighting
Action (Pilot) – Convey no information (missed exit)

Actual Recovery Barrier:	
MB6	ATCO detection it after alert from A-SMGCS level 2

ATC Barriers Breached:	
PB1	ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc.
PB2	ATCO direct visual detection
MB1	ATC direct visual detection after take-off clearance

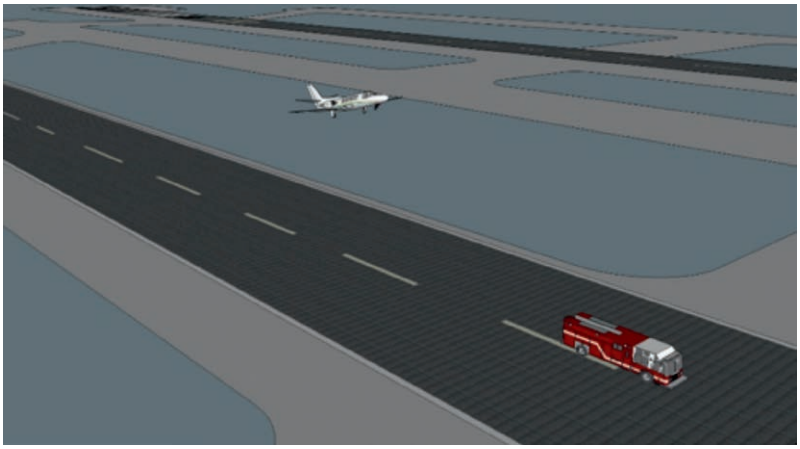
Remaining Barriers available that could have reduced risk of collision:	
X	Pilot visual detection (departing aircraft)
X	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.5 Event 5. Cleared for take-off on closed and obstructed runway

Generic Scenario:		
Take-off on runway already occupied	**B2a**	Departing after receiving incorrect ATC clearance on runway already authorised occupied

This event occurred at night. The southern end of the runway 17R/35L was under construction. Available runways are 35L only (reduced TORA) and 17L/35R. No departures 17R (towards the work).



Runway 17L is the notified duty runway in use.

The aircraft involved in this incident is a C510, a MEDEVAC flight. The C510 requests taxi and is cleared to taxi and cross runway 17R for runway 17L departure. There is an airport vehicle on runway 17R just south of the runway crossing point leading to runway 17L.

An illuminated white cross lies on the threshold of runway 17R to show it is closed. In order to avoid aircraft lining up runway 17R from the crossing point the procedure specified red lighting to be installed across the runway. However, to facilitate a quicker change of runway between 17 and 35 the red lighting had been replaced by "a mini cross" attached to a vehicle. The controller involved in the incident knew the existence of this vehicle.

ATC wanted to help the MEDEVAC flight by optimizing its departure route. The controller offers the C510 a runway 35L departure, giving the shortest taxi and direct flight routing. ATC gave the surface wind and the distances available. The C510 responded that the distance was sufficient. ATC cleared the C510 for take-off runway 35L.

The C510 takes off and then informs TWR that he just avoided collision with a truck on the runway. ATC then remembers it had not been removed. Because all controllers "know" the temporary procedure, there was no specific strip used for showing the vehicle blocking 17R/35L.

Another factor is that many spurious contacts exist on the ground radar display, especially with construction work, so vehicles have to be equipped with a specific beacon to allow ATC to confirm real contacts. The truck carrying the cross was not however equipped with this specific beacon.

Contributing Factors:
Organizational – balance of service/safety (desire to help CAT A)
Memory – no recall from working memory (vehicle on rwy)
Memory – no recall from long term memory (ATC procedure)
Perception – Not see
Procedures – Aerodrome (not following agreed procedure)
Procedures – Aerodrome (allowing vehicle without necessary equipment)
Procedures – ATC (display of long term rwy closure)

Actual Recovery Barrier:	
X	Providence and possible last minute visual detection by pilot

ATC Barriers Breached:	
PB1	ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc.
PB2	ATCO direct visual detection
PB5	ATC detection with basic SMR
PB10	All vehicles display high intensity flashing or strobe lighting
x	ATC Procedures for control and display of closed runways
MB1	Belated ATC visual detection
MB4	Belated ATC detection with SMR

Remaining Barriers available that could have reduced risk of collision:
Nil

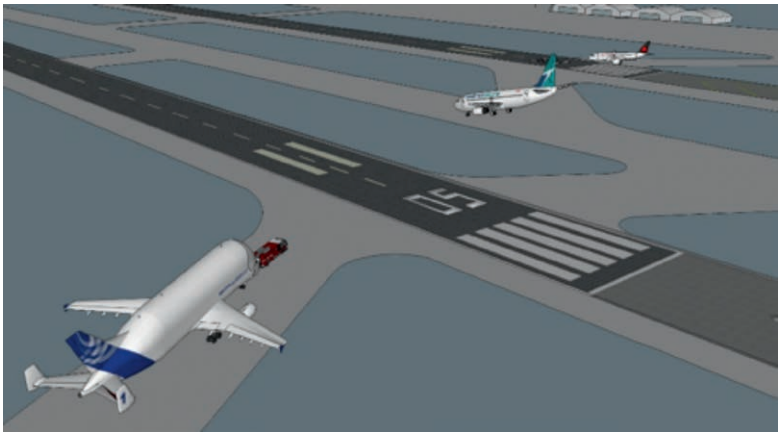
ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
PB3	ATC detection using remote camera displays
MB6	ATC detection after A-SMGCS alert
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.6 Event 6. Aircraft under tow crossing runway with misunderstood conditional clearance

Generic Scenario:		
Runway crossing	D4a	Unauthorised Aircraft/Vehicle crossing runway occupied by landing or departing aircraft after non-conformance with ATC clearance due to misinterpretation or mishear of clearance

Runway 05L is used for landing and runway 05R for take-off. A towed Beluga contacts TWR on holding point short of 05L for crossing of both runways for the main. ATC asks him to report in sight of the "aircraft on final". An A319 is taxying for departure rwy 05R. He is cleared to line up and take-off 05R.

ATC ask the Beluga tug driver if he is in sight of the traffic on final, the driver answers he is seeing an aircraft about to land. ATC clears the Beluga tug to "cross runway 05L behind the traffic on final and then maintain holding point Lima (between 05L and 05R). The tug driver replies "Roger for crossing rwy 05L and maintaining holding point 05R"



The departing A319, on hearing this conversation asks for confirmation of its line-up and take-off clearance and to check the runway of the landing aircraft.

The aircraft on final rwy 05L is cleared to land. Some 20 seconds later, ATC instruct the Beluga tug to hold position and then asks him if he is on the runway, to which the tug driver replies that he is. ATC cancel the A319 take-off clearance and instruct the aircraft on short final for 05L to go-around.

The driver did not understand the situation and made his own interpretation of the clearance he was given, which was that the landing aircraft some 4nm out was landing on 05R not 05L.

ATC did however detected the conflict and properly recovered the incident giving the right orders to both aircrafts and the towed Beluga.

Contributing Factors:
Action – Convey incomplete information
Comms – Non-standard phraseology
Comms – Complexity of ATC transmission
Comms – Conditional Clearance
Comms – Tug driver comms experience
Comms – Language. Comms to driver in native language, comms to aircraft in English – reduced situational awareness
Perception (Driver) – Misperceive auditory information
Action (Driver) – Convey incorrect information
Decision – Incorrect plan – Not challenge inaccurate readback

Actual Recovery Barrier:	
MB1	Belated ATC visual detection

ATC Barriers Breached:	
X	Correct use of ATC phraseology and read back requirements

Remaining Barriers available that could have reduced risk of collision:	
MB3	ATC resolution following pilot/driver report
X	Pilot visual resolution

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB2	ATC detection using remote camera displays
MB6	ATC detection after A-SMGCS alert
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.7 Event 7. Cleared for take-off on obstructed runway

Generic Scenario:		
Departing on occupied runway	**B2a**	Departing after receiving incorrect ATC clearance on runway already authorised occupied

During this incident, there has been three controllers succeeding on the TWR position (ATC1, ATC2 and ATC3). A check of the side lights of the runway is to be carried out by a maintenance team escorted by an airport Ops vehicle.

ATC1 clears the airport Ops vehicle and the maintenance vehicle to enter the runway. Six minutes later ATC2 (TWR Supervisor) relieves ATC1.

10 minutes after that ATC3 relieves ATC2. ATC2 informs ATC3 that a PC12 is about to taxy for departure but does not include the runway works in the handover. ATC3 tells the PC12 to taxi for the holding point of the runway and 5 minutes later ATC3 clears the PC12 to line up and take-off.

The Airport Ops vehicle driver hears the increase of the engines and calls back ATC to signal his presence on the runway. ATC3 immediately stops the take-off of the PC12. The aircraft is already moving but stops quickly. The pilot of the PC12 did not see vehicles.

The driver of the airport Ops vehicle did not immediately react to the take-off clearance given on the frequency. It was given in English so there is a possibility that the driver of the airport Ops vehicle, a native speaker, did not understand it. He heard the increase engine noise.

Contributing Factors:
Memory (ATC2) – Inaccurate recall from working memory
Action (ATC2) – Convey incorrect information
Operational Environment – Distraction from job-related issues (ATC2 Supervisory role)
Team Factors – Handover Issues
Operational Environment – Visual Impairment (lie of sight from TWR)
Procedures – Airport. Lack of standard method for display of occupied runway
Comms – Language. AGA to vehicle in native language. AGA to aircraft in English

Actual Recovery Barrier:	
MB3	ATC resolution after alert from pilot/driver

ATC Barriers Breached:	
X	ATC strip display procedures
X	ATC handover procedures

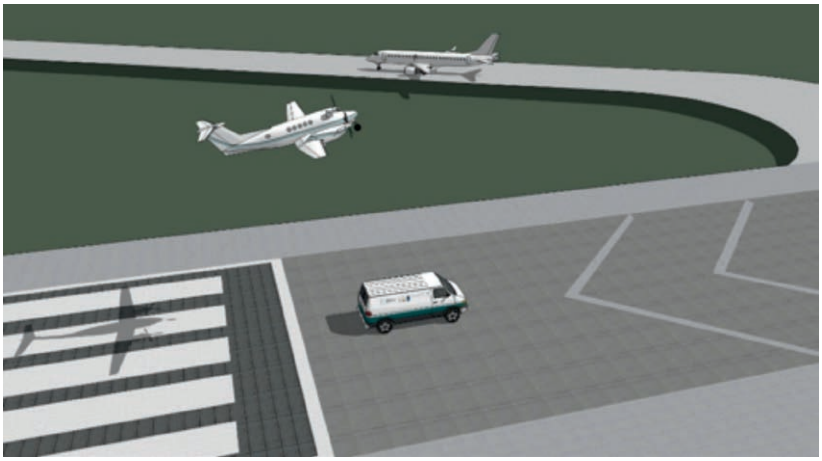
Remaining Barriers available that could have reduced risk of collision:	
X	Driver resolution
X	Pilot visual resolution

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
PB3	ATC detection using remote camera displays
MB4	ATC detection with basic SMR
MB5	ATC detection with Stage 1 A-SMGCS
MB6	ATC detection after A-SMGCS alert
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.8 Event 8. Vehicle entered runway without clearance

Generic Scenario:		
Entry onto runway by aircraft taxying for departure or by vehicle	**D3a**	Entry on runway by aircraft taxying for departure or by vehicle after non-conformance with ATC clearance due to misinterpretation or mishear of clearance, together with a landing or departing aircraft

A bird scaring vehicle operated by the airport had been cleared to holding point Alpha just south of the runway threshold by GMC and instructed to contact TWR for permission to enter the runway. A carrier wave was heard on the TWR frequency, which is likely to have come from the vehicle. ATC instruct an ERJ190 which had just landed to "Report Vacated". This is immediately followed by a further carrier wave with an unclear word or two.



The bird scaring vehicle then entered the runway and had begun to drive along it, stopping for a time where the driver had observed some birds. The birds dispersed and the vehicle continued along the runway. A handover of the TWR controller position took place and included the information that the bird scaring vehicle was holding at Alpha but had not yet checked in on the TWR frequency. The oncoming controller attempted to call the vehicle to confirm his position but when there was no reply, he asked GMC to attempt contact who, after receiving a reply, reminded the driver that he needed to contact TWR before entering the runway. The response was "hesitant" which led the GMC controller to ask for confirmation that the vehicle was still at Alpha. The driver replied "Negative, I'm leaving the runway at Bravo" which is at the far end of the runway. It became apparent that the vehicle had entered and driven the full length of the runway without permission.

TWR, aware of this exchange, was about to instruct an E121 aircraft on short final to go-around but the aircraft declared a go around due to lack of visual reference. The RVR being around 550 metres at the time.

The driver reported that he understood that it was necessary to monitor both frequencies, he had tuned the vehicle radio to GMC and the portable radio to TWR. He stated that he had established contact with GMC and been cleared to proceed to Holding Point Alpha and to contact Tower. Upon arrival there, he reported having contacted TWR using the portable radio and received a clearance to enter the runway and to report vacated.

The vehicle involved was fitted with a radio and the driver also carried a separate portable radio. The portable radio was intended to be used as a back -up in the event of radio failure or if the driver needs to temporarily leave the vehicle. However, it became apparent that some drivers habitually used the portable radios for normal communications and that a significant number of personnel did not properly understand the correct radio communication procedures.

Contributing Factors:
Pilot/Driver Action – Readback by wrong aircraft/vehicle
AGA – RTF Design. Suitability for portable radios, signal strength.
External – Airport Authority Airside Ops and Standards
Weather – Low Vis Procedures

Actual Recovery Barrier:	
X	Providence

ATC Barriers Breached:	
PB2	ATC direct visual detection

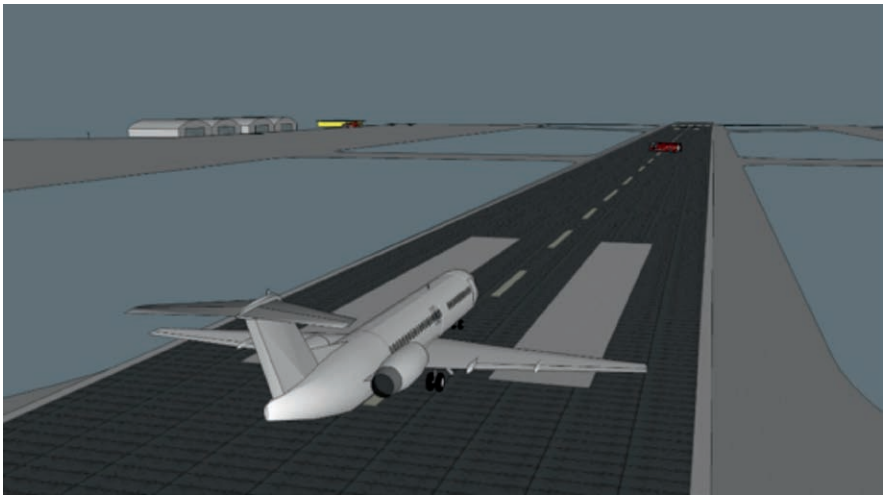
Remaining barriers available that could have reduced risk of collision:
Nil

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB2	ATC detection using remote camera displays
MB6	ATC detection with basic SMR
MB8	ATC detection with Stage 1 A-SMGCS
MB2	ATC detection after A-SMGCS alert
MB6	ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.9 Event 9. Cleared for take-off on obstructed runway

Generic Scenario:		
Departing on occupied runway	B2a	Departing after receiving incorrect ATC clearance on runway already authorised occupied

During this incident, the traffic is light so TWR and APP position are grouped with only one controller dealing both frequencies. Work is in progress in the building of the Tower with the presence of firemen testing the fire alarm which adds a lot of noise around the controller. Moreover, a military exercise is planned during the day and ATC is busy searching for information.



Start-up is approved for an E145. An Airport Ops vehicle is sent to the runway for inspection before the departure of the E145. The E145 is cleared to taxi to the runway holding point. ATC gives an initial clearance for departure to E145 and tells him to report ready for departure at the holding point.

A couple of other aircraft call for start or taxi. ATC starts coordination by telephone with a military ATC unit concerning an aircraft in transit and also the departure of the E145. During the telephone conversation, the E145 calls ATC ready for departure at the holding point. ATC does not respond. At the end of the telephone conversation, The E145 calls ATC a second time to repeat he is ready for departure. ATC is still busy with coordination and mechanically responds to the pilot. ATC gives the surface wind and clears the E145 to line up and for take-off. The vehicle driver immediately calls to confirm his presence on the runway. ATC cancels the take-off clearance given to the E145.

ATC did not look outside and did not look at his strips while giving the take-off clearance.

Contributing Factors:
Memory – Forgot previous action (clearance for vehicle)
Memory – Forgot to monitor/check (strips)
Memory – Forgot to monitor/check (runway)
Perception – Did not see (vehicle)
Operational Environment – Noise from equipment
Distraction – Job related (coordination)

Actual Recovery Barrier:	
MB3	ATC resolution following driver report

ATC Barriers Breached:	
PB1	ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc
PB2	ATC direct visual detection
PB10	All vehicles entering on a runway should display high visibility flashing/strobing lights on in all visibility conditions

Remaining Barriers available that could have reduced risk of collision:	
X	Vehicle driver resolution
X	Pilot visual detection
X	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB6	ATC detection after A-SMGCS alert
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

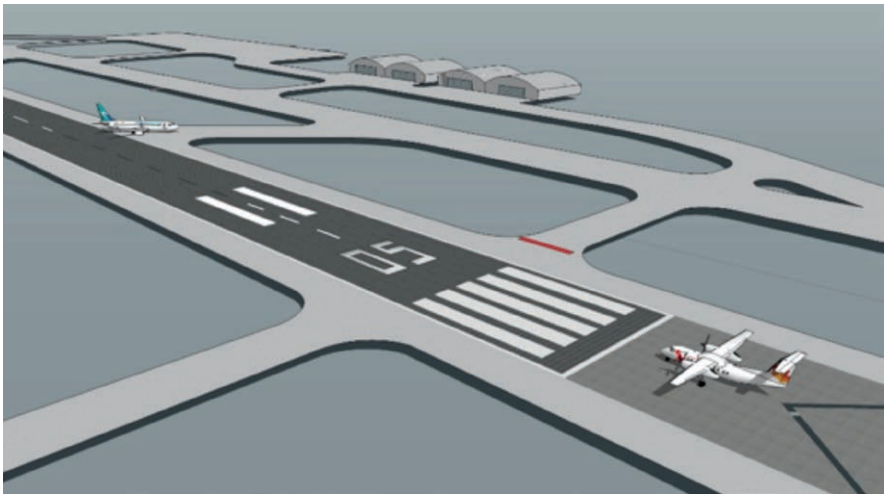
8.10 Event 10. Lined up without clearance

Generic Scenario:		
Entry on rwy by aircraft taxying for departure	E3a	Entry on runway by aircraft taxying for departure or by vehicle without ATC clearance due poor CRM and forgot planned action on runway already occupied, together with a landing or departing aircraft.

A DH8D failed to follow its correctly acknowledged ATC taxi clearance to the runway holding point for 05 and entered and lined up on the active runway at night in normal visibility at the same time as a B737 was landing on the opposite (23) direction of the same runway. The landing B737 was able to slow and vacate the runway before reaching the other aircraft.

The B737 was cleared to land on 23 at 8nm final whilst DHC8 was pushing back. ATCO attention was focused on the B737 landing and did not observe the runway incursion

The DH8D Captain requested taxi checks from the FO. Last item "clearances" was responded to as "to come". FO was predominately "heads in". The Captain then instructed FO to carry out Line Up checks. The Captain commented about a previous departure where they were held on the runway for a long time after line up before a take-off clearance was given. The Captain believes he reverted this scenario.



As the DH8D began to enter the runway, the FO commented on some moving lights on the rwy. The Captain believed it to be a vehicle. FO said it looked like an aircraft. At that point the Captain realized that no runway entry clearance had been given.

ATCO monitored B737 landing roll and only then saw the lights of DHC8 on the runway. The B737 only saw DHC8 as approaching taxi speed shortly before vacating the runway about 400m ahead.

It was concluded that the co-pilot was not adequately monitoring the commander and that a concurrent discussion between the pilots about an earlier departure that day from the same airport was likely to have conditioned the crew to expect the same clearance from ATC on this sector. The aircraft commander had asked for the 'Line Up' Check List despite the Taxi checklist not having been completed. All of these factors led the crew to become distracted enough to exceed their taxi clearance limit.

The Airport does not have red stop bars and that Licensing requirements only specify their provision at Holding Positions intended for use in RVR conditions less than 800 m, which did not apply. There are flashing wig wags at holding point B2, which are crossed before reaching the CAT1/visual holding point B1.

Contributing Factors:
Memory(pilot) – Forgot planned action (to stop at holding point)
Pilot Actions – CRM issues
Memory ATC – Forgot to monitor/check (runway)
Perception ATC – Did not see aircraft on rwy
Action – Incomplete information (checklists)
Distraction (pilot) – Job related

Actual Recovery Barrier:	
X	Belated pilot detection

ATC Barriers Breached:	
MB1	ATC direct visual detection

Remaining Barriers available that could have reduced risk of collision:	
X	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB4	ATCO detection using basic SMR
MB5	ATCO detection it using A-SMGCS level 1
MB6	ATC detection after A-SMGCS alert
MB7	ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers). ATCO detection after alert from airport ground systems that detect entry onto the runway (e.g. magnetic loops or lasers).
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.11 Event 11. Lined up without clearance

Generic Scenario:		
Entry on rwy by aircraft taxying for departure	B3a	Entry of runway by aircraft taxying for departure or by vehicle due incorrect ATC clearance, together with a landing or departing aircraft

During the hours of darkness an ATR42 was given a conditional line up clearance for Runway 07 but, contrary to this clearance, then taxied onto that runway as a B737 was landing on it. The landing aircraft missed the right wingtip of the ATR42 by "a few metres" at high speed.

A conditional clearance is given to the ATR42 "Behind next landing short final, line up 07 behind" The readback is correct. No reference, however, to the fact that an A321 will take-off before the next landing.

The A321 takes off. B737 is given clearance to land and ATR42 begins to move onto rwy. When the B737 landed, the ATR42 is 40m from rwy c/l. The B737 crew saw the ATR42 and deviated to right as soon as possible.

ATC did not see the ATR42 until the pass was taking place. ATR42 crew said they saw the A321 pass them and assumed that was the landing aircraft in the conditional clearance. The holding point for 07 that the ATR42 was using was a RET for rwy 25 and therefore the view from the flight deck of the ATR42 towards the 07 approach was restricted.

Contributing Factors:
Action – Convey incomplete information (conditional clearance)
Decision – Incorrect Plan (to give conditional clearance not relating to next rwy movement)
Perception ATC – Did not see aircraft lining up
Perception (Pilot) – Did not see landing acft
Perception (pilot) – Misinterpreted visual information (aircraft taking off)
Airport – Line of sight from RET
Procedures Airport – Use of RET for departures in mixed mode
Airport Systems – A-SMGCS failure

Actual Recovery Barrier:	
X	Pilot visual detection

ATC Barriers Breached:	
MB1	ATC direct visual detection
MB5	ATCO detection it using A-SMGCS level 1

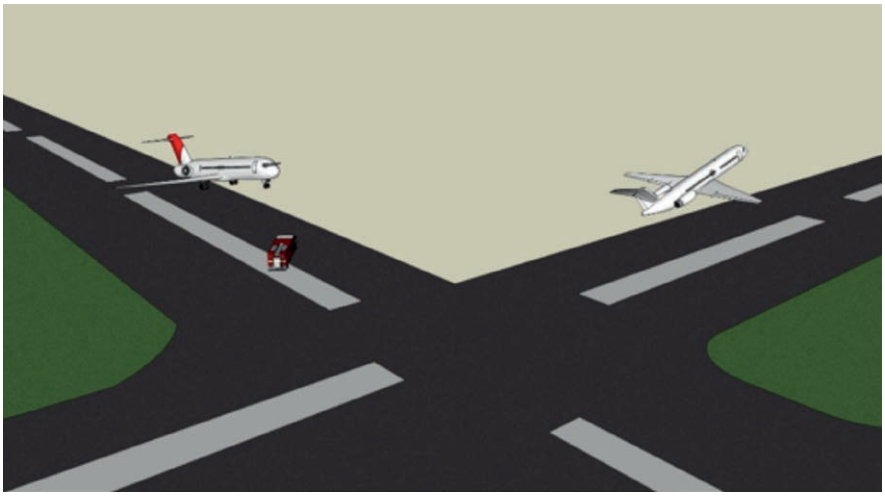
Remaining barriers available that could have reduced risk of collision:	
X	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:
Nil

8.12 Event 12. Cleared for take-off on obstructed runway

Generic Scenario:		
Landing on runway already occupied	B1a	Landing after receiving incorrect ATC clearance on runway already authorised occupied

Intersecting runways 05 and 14 were in use. A B717 was on an ILS approach to runway 14. A handover of the TWR position took place and soon afterwards, the B717 checked in on TWR frequency. The new controller then cleared an A330 to land on runway 05. At about the same time, an airport vehicle called in position at the holding point for runway 14 near the landing threshold awaiting entry to carry out a routine runway inspection. The TWR controller cleared the vehicle to enter runway 14 but hold short of runway 05 and wrote the callsign of the vehicle on the runway strip to indicate that the runway was occupied. At that time, the B717 had 7nm to run for runway 14; neither of its pilots recalled hearing the vehicle clearance.



The vehicle began to proceed along runway 14 in the direction of use, eventually arriving at the holding point prior to the intersection with runway 05. The A330 landed on runway 05 and, once it had vacated, the TWR controller cleared a FK100 to take off on runway 05. Whilst simultaneously observing the FK100 get airborne, the TWR controller then scanned runway 14 without seeing the vehicle on it, picked up the strip for the B717 and put it in the runway bay without noticing the vehicle strip also there. With the B717 now at a range of about 1.5nm (although still in cloud at that time), he gave it a landing clearance. The Vehicle Driver subsequently advised that they had heard this clearance but not the assigned runway and had assumed the aircraft would land on runway 05.

As the B717 touched down on runway 14 approximately 370 metres from the threshold, the FO saw the flashing lights of a vehicle ahead on the runway and immediately called «go round, car on the runway» and the Captain commenced a go-around. The aircraft became airborne again after a ground roll of about 370 metres. At this time, the vehicle was stopped on the centreline of runway 23 and 440 meters ahead. The vehicle driver did not see the aircraft until it had passed about 150 feet over his vehicle and promptly queried what had happened.

Until two months earlier, runway inspections such as the one being carried out were always conducted by a vehicle driving along any active runway in the opposite direction to that in use. However, following a request at that time from the ANSP, inspections had been conducted in the direction of active runway use. Consequently, the vehicle driver could not see the landing aircraft behind.

The B717 Captain commented that had they selected reverse thrust, which is usually done as soon as the aircraft has touched down, they would have been committed to completing a landing.

Contributing Factors:
Memory – Forgot previous action (clearing vehicle onto rwy)
Perception – Did not see rwy blocked indicator on display
Perception – Did not see vehicle on rwy
Perception (driver) – Did not see approaching aircraft
Perception (driver) – Misheard the rwy element of landing clearance
Procedures Airport – runway inspection procedure

Actual Recovery Barrier:	
X	Pilot visual detection

ATC Barriers Breached:	
PB1	ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc.
PB2	ATC direct visual detection
MB1	ATC direct visual detection

Remaining barriers available that could have reduced risk of collision:
Nil

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
PB8b	Use of input and display of the ATC clearances that enable the use of "early warning" surveillance and data (ITWP) to highlight the potential consequences of any incorrect clearance
MB4	ATCO detection using basic SMR
MB5	ATCO detection it using A-SMGCS level 1
MB6	ATCO detection it after alert from A-SMGCS level 2
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

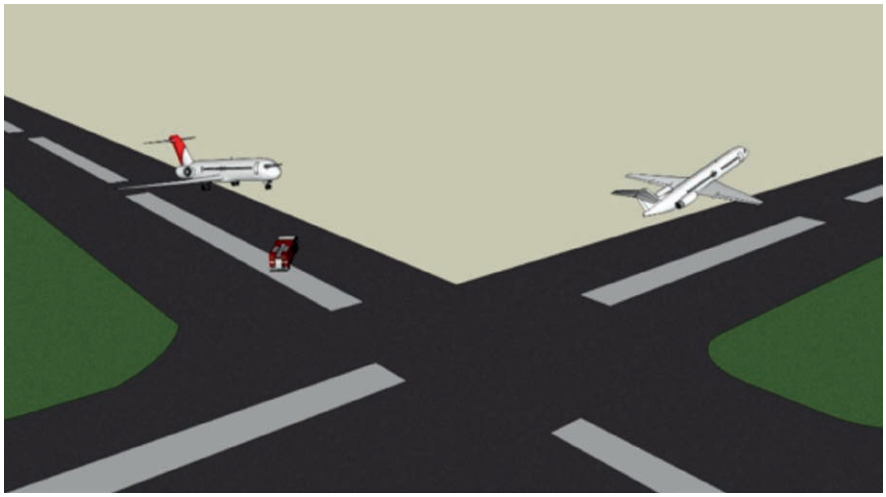
8.13 Event 13. Simultaneous take-off on intersecting runways after mishear of ATC clearance

Generic Scenario:		
Departing or Landing on intersecting runways	**D6a**	Departing/Departing on intersecting runways after non-conformance with ATC clearance due to a misinterpretation or mishear of clearance

An ATR42 began take off in good daylight visibility on runway 27 without ATC clearance, at the same time as an A340 began take off from intersecting runway 33 in accordance with its ATC clearance. ATC were unaware of this until alerted to the situation by the crew of another aircraft (C) which was waiting to take off from runway 27, after which the ATR 42 was immediately instructed to stop. It did this in time to clear the runway before the intersection with runway 33 whilst the A340 continued its departure on runway 33.

The ATR 42 had been previously advised that take off clearance should not be anticipated for a further 7 minutes after the line-up and wait instruction. Aircraft C was stationary at the runway 27 holding of the threshold at this time. One minute after the ATR 42 had received line up clearance, the A340 on runway 33 had been given take off clearance as follows:

ATC: (company) 971 wind 280/07 kts runway 33 cleared for take-off". This was correctly read back.



Unknown to ATC, the ATR 42 flight crew transmitted "we're cleared take-off (company) 937. This almost simultaneous transmission was not received by ATC. The ATR42 begun to roll on runway 27.

The crew of aircraft C had heard the A340 readback but had also heard the words "cleared for take-off" from a distinctively different voice and when the ATR 42 began take off, had called TWR "you may have two aircraft taking off at the moment". The reaction of the (TWR) controller to this report was immediate and resolved the situation.

The ATR 42 had reached a speed of 74 knots before beginning to decelerate. It had been able to clear the runway at a point approximately 750 metres prior to the intersection of runway 27 with runway 33.

It was concluded that the situational awareness of the ATR42 crew was inadequate. The take-off clearance from ATC to the A340 correctly included both the radio call sign and named runway 33. Given this and that they had previously been informed that could expect a take-off clearance in 7 minutes; had they been monitoring other transmissions on the TWR frequency, they would have recognised that another aircraft had received a conditional clearance to taxi onto runway 33 and was also awaiting a take-off clearance.

Callsign similarity may have been a factor. Although the company radio call signs of the two operators were completely different, two or the three digits in the flight number were the same.

The conflict situation was mitigated by the crew of Aircraft C who showed a very good overview of the situation and an active engagement with the perceived potential conflict.

The automatic selection of ground receiver location for the feed of each aircraft transmission to TWR had significantly favoured the relatively stronger signal from the A340 over the simultaneous one from the ATR 42; thus ATC could not hear the ATR42 transmission.

A Stage 2 RIMCAS Alert activated only after ATR 42 had already started to reject their take off and was moving at 61 knots and the A340 was accelerating through 71 knots. This was because this activation required that both aircraft must be, on the basis of the calculated projection, in the «critical circle».

At the time of the incident, a building programme was under way in and around the TWR VCR which caused an obstruction to the view towards the threshold of runway 27 and caused abnormal changes in the background noise level.

Contributing Factors:
Perception(pilot) – Mis hear auditory information
Pilot Actions – Readback by incorrect aircraft
AGA Comms – Call Swamping
Operational Environment – Visual Impairment
Operational Environment – Noise
Pilot Comms – Similar Call signs

Actual Recovery Barrier:	
MB3	ATC resolution following pilot report

ATC Barriers Breached:	
PB2	ATCO direct visual detection

Remaining Barriers available that could have reduced risk of collision:	
MB1	ATC direct visual detection
MB6	ATCO detection it after alert from A-SMGCS level 2
x	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB2	ATC detection using remote camera displays
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.14 Event 14. Cleared for take-off on obstructed runway

Generic Scenario:		
Departing on occupied runway	B2a	Departing after receiving incorrect ATC clearance on runway already authorised occupied

A B727 began take-off in normal night visibility until two snow clearing vehicles were observed on the runway ahead at which point a high speed rejected take off was accomplished with the aircraft coming to a stop clear of the position of the vehicles.

The TWR/GMC Controller, working alone whilst the other controller on duty was taking a break with all transmissions on GMC and TWR frequencies audible on both frequencies had, despite the indications on his strip display that the runway was occupied, issued a take-off clearance to the B727 whilst it was backtracking the runway. However, immediately after doing so, he had realized his error and **without releasing his PTT switch**, after a short pause added "*actually standby*».

The B727 First Officer acting as PM had begun to acknowledge the clearance as soon as the controller had finished giving it and as a result, only the very end of the readback - the aircraft callsign - was heard by the controller who assumed that the intended «cancellation» of the take of clearance had been understood.

He issued an instruction for the snow clearance vehicles to clear the runway and then looked away from it whilst giving taxi instructions to another departing aircraft still on the apron and, by the time he returned his attention to the runway, was surprised to see the B727 on the take-off roll. The take-off roll had gone unnoticed by the controller for more than 20 seconds».

Upon seeing the aircraft approximately 350 metres down the runway and accelerating, he instructed the B727 to "abort take off». There was no response or acknowledgement from the crew. The aircraft was just passing 80 kts and the required SOP check was being called and acknowledged. The first third of the runway has an incline from the threshold before flattening out. At that time of the instruction to abort the take-off, the crew were unable to see any obstruction ahead due to still being on the upslope. Shortly afterwards, as the aircraft approached the mid-section of the runway at 122 Kts, they saw the lights of the snow clearance vehicles ahead and immediately initiated a rejected take off. The B727 was brought to a stop approximately 365m from the snow sweepers. The vehicles had moved to the side of the runway in case the aircraft was unable to stop in time.

In respect of the overlooked 'Blocked Runway' indication on the controllers display, a review of 4 hours of recording around the time of the occurrence showed that aircraft had departed on runways that had a 'blocked runway' depiction at least three other times, although in all three cases, the runway was not in fact physically occupied».

The controller was his on first scheduled day off but he had been called 6 hours before commencement and offered the shift as overtime. He had initially declined. A second phone call informed him that no one else had volunteered. He felt he had to accept. The controller reported feeling fatigued at the time of the occurrence.

Contributing Factors:
Perception – Not see runway blocked indicator
Action – Convey unclear information (use of two instructions without release of PTT)
Actions – Convey incorrect information (non-standard phraseology)
Non-Conformance – Did not confirm partial readback
Non-Conformance – Routine giving clearance with runway blocked indication
Airport – Airfield Layout (upslope on rwy reducing time to visually detect conflict)
Organisational Factors – Adequacy of management support (Pressure to work on rostered day off)
Personal Factors – Fatigue

Actual Recovery Barrier:	
MB3	Pilot visual detection

ATC Barriers Breached:	
PB1	ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc.
PB2	ATCO direct visual detection
MB1	Belated ATC visual detection (did work but not correctly employed)

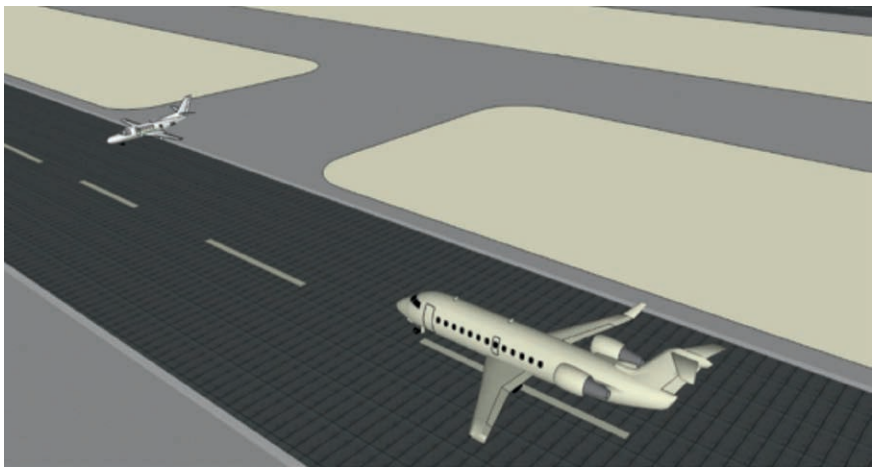
Remaining Barriers available that could have reduced risk of collision:	
X	Vehicle driver detection
X	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
PB8b	Use of input and display of the ATC clearances that enable the use of "early warning" surveillance and data (ITWP) to highlight the potential consequences of any incorrect clearance
MB2	ATCO detection using remote camera displays
MB4	ATCO detection using basic SMR
MB5	ATCO detection it using A-SMGCS level 1
MB6	ATCO detection it after alert from A-SMGCS level 2
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.15 Event 15. Entered runway without clearance after taxy navigation error

Generic Scenario:		
Entry onto runway be aircraft taxying for departure	**C3a**	Entry of runway by aircraft taxying for departure or by vehicle after non-conformance with ATC clearance due to spatial/positional confusion, together with a landing or departing aircraft

A Raytheon 390 Premier did not taxi for a night departure in good visibility in accordance with its clearance. It entered the departure runway 03 ahead of a Bombardier CRJ200 which had just begun its take- off roll. The CRJ200 crew saw the other aircraft and rejected their take off from a low speed, coming to a stop before reaching it.



The Raytheon crew had correctly read back their taxi clearance to the holding point for a full length departure. They had then become confused at the point where the taxiway centreline on taxiway B indicates two right turn options close together, first onto taxiway J, which was not in use and then further on, taxiway K (as cleared and with the centreline lit). The centreline lighting leading ahead onto taxiway 'B3' and the intermediate holding point for the runway was also lit and the aircraft followed that line instead of the right turn onto 'K'. The aircraft continued past the co-located flashing Runway Guard Lights, marked runway entry Cat 1 holding point and its four embedded and flashing lights and the painted words 'Runway Ahead' and onto the runway where they turned right.

The crew reported that they had briefed taxiway K was the second turn and thus followed the second lit turn. They did not realise that they had passed the holding point 'B3' and only became aware that they were on the runway when they saw the white edge lighting.

At the time of the incident, both the AIP taxi chart and the proprietary charts did not correctly depict the detail of the movement area layout at the junction of taxiways. This, and the use of lit taxiway centrelines on all taxiways available for use if so cleared were probable factors. Crew expectation and vigilance also led to the incursion.

The airport was not equipped with any SMR or system for detecting potential runway occupancy conflicts.

Contributing Factors:
Perception (pilot)– Misinterpreted visual information
Perception (pilot) – Not see runway guard lighting
Perception (pilot) – Not see Runway Ahead signage
Perception – Not see aircraft taking incorrect route
Documentation – Airport Charts
Airport – Airfield Lighting procedures

Actual Recovery Barrier:	
X	Pilot visual detection

ATC Barriers Breached:	
MB1	Belated ATC visual detection

Remaining barriers available that could have reduced risk of collision:
Nil

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB4	ATCO detection using basic SMR
MB5	ATCO detection it using A-SMGCS level 1
MB6	ATCO detection it after alert from A-SMGCS level 2
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.16 Event 16. Crossed active runway after incorrect clearance

Generic Scenario:		
Runway Crossing	B4a	Aircraft/Vehicle crossing runway occupied by landing or departing aircraft due incorrect ATC clearance

Runway 06 was in use for arrivals and departures, and Runway 13 was being used for departures of aircraft leaving the de-icing pad. As a consequence, the GMC and TWR controllers frequently exchanged responsibility for the control of Runway 13. Under these circumstances, best practices for issuing taxi instructions to any aircraft taxiing to Runway 06 would include a restriction to hold short of Runway 13. Nonetheless, the ground controller issued a Piaggio P180 a taxi clearance to cross runway 13 without restriction for departure on Runway 06.

The GMC controller issued instructions to a DH8C to taxi from the de icing pad to Runway 13. It was instructed to contact TWR once holding short of Runway 13. Coordination between the GMC and TWR was completed for the exchange of responsibility for Runway 13 to allow its use by the DHC8, at which point the airport controller took over responsibility for Runway 13.

The TWR controller completed a scan of the airport Manoeuvring Area and the Electronic Flight Display System. The TWR controller saw an aircraft (the P180) on the taxiway; however, as there was no indication on the airport controller's display screen that the aircraft was taxiing for a runway, it was assumed that the aircraft would turn right towards the de-icing pad.

The DHC8 was cleared for takeoff on Runway 13. Some 30 seconds later the P180 entered Runway 13. When the P180 was in the middle of Runway 13, the horizontal distance between the two aircraft was approximately 1000m. The GMC controller noticed the runway incursion and estimated that P180 would be clear of the runway by the time DHC8 reached the same point, if not airborne. Thus, no call was made for DHC8 to abort the takeoff. Neither P180 nor DHC8 was aware of the runway incursion.

The electronic data display system provides red runway obstruction headers that are used when a runway is unavailable for takeoff and landing and is under the jurisdiction of the GMC controller. Since the runway obstruction markers represent exchange of responsibility for the runway, when the airport and ground positions are not combined, only the AIR controller can insert the runway obstruction markers and only the GMC controller can remove them. Immediately before the event the GMC controller acknowledged a runway vacation call from a snow removal vehicle, and then removed the runway obstruction marker to transfer responsibility for Runway 13 to the AIR controller, temporarily forgetting the runway crossing clearance given to the P180.

When the ground controller transfers the Flight data entry (FDE) for a departing aircraft to the Taxied panel, it will appear on the TWR controller's display in the Departures panel for the intended departure runway. The ANSP manual requires that the GMC controller forward the FDE of an aircraft taxiing for departure to the Taxied panel so that an FDE will be generated in the applicable Departure panel of the AIR controller's display screen. However, it do not indicate when to initiate this

transfer, leaving the decision to the discretion of individual controllers. Following the issuance of taxi instructions to P180, the GMC controller did not initially forward the FDE from the Cleared panel to the Taxied panel, and therefore the AIR controller's display did not indicate that P180 was taxiing for Runway 06.

Contributing Factors:
Decision – Incorrect Plan – GMC rwy crossing clearance
Memory – Forgot previous action – GMC transfer rwy after crossing given
Action – Convey no information – GMC did not forward FDE
Memory – Forgot to check on position of P180 before transfer of rwy
Perception – Neither ATC saw P180 enter rwy in time to stop DH8 takeoff
Personal Factors – High workload on GMC.

Actual Recovery Barrier:	
MB1	Belated ATC visual detection

ATC Barriers Breached:	
PB1	ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc.
PB2	ATCO display visual detection

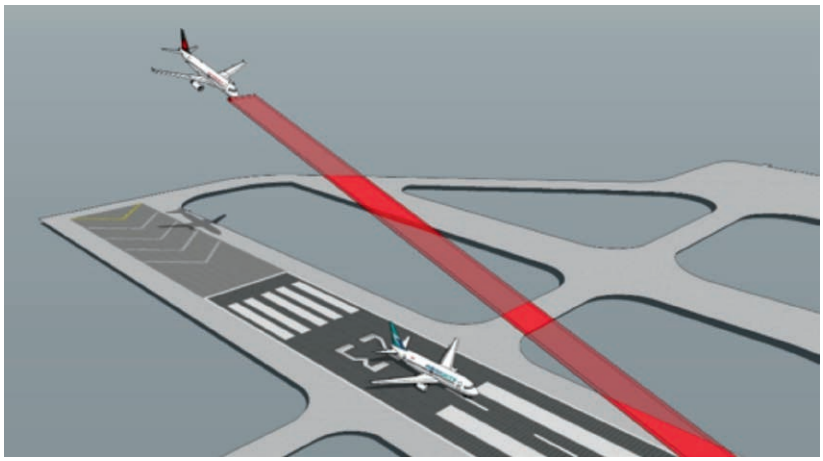
Remaining barriers available that could have reduced risk of collision:	
X	Pilot visual detection
X	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
MB6	ATCO detection it after alert from A-SMGCS level 2
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.17 Event 17. Cleared to land on obstructed runway

Generic Scenario:		
Landing on occupied runway	B1a	Landing after receiving incorrect ATC clearance on runway already authorised occupied

A B737 was lined up for departure when ATC were heard to issue a landing clearance for the same runway to an A320, which was still IMC on final approach. After two unsuccessful attempts to inform ATC of the error, the commander of the 737 instructed the A320 to go around. This was acknowledged and actioned from approximately 1nm and 400 feet by the A320 crew.



The TWR controller's plan was to depart 3 aircraft before the arrival of the A320. The first, an A319 had taken-off and the subject B737 was instructed to line up after the next departing A320 (B), which was subsequently also cleared for take-off. At this point the inbound A320 (A) checked in on frequency and would not have heard the line clearance already issued to the B737. As A320 (B) became airborne, the previously departed A319 requested a turn for weather avoidance. A turn and altitude restriction was coordinated with radar and relayed to the A319. By this time the inbound A320 (A) was 2.5nm from touchdown with the B737 still lined up on the runway. The electronic flight strip for the B737 was still in the runway bay but the ATCO concluded that he must have forgotten to move it, and cleared A320 (A) to land. The read back was blocked by a call from the 737 First Officer to the effect that they were still on the runway. The landing clearance was then re-iterated by ATC and read back. A second attempt by the 737 First Officer to advise ATC of their position was again blocked and a few seconds later, the 737 commander transmitted to the A320 "go around I say again go around." The controller stated that he had then heard the A320 crew read back the instruction to go-around. Having become aware that the 737 was still on the runway, he then gave go around instructions to the A320.

B734 pilot subsequent reported seeing the inbound A320 at 4.5nm on TCAS as they lined up and were constantly aware of it.

The controller error was attributed to the incorrect use of flight progress strips by the controller involved and his failure to make either a visual or Aerodrome Traffic Monitor check of the runway before issuing the A320 with a landing clearance. The controller's plan was inadequate in that it required everything to happen at optimum speed. The controller became distracted from the plan.

Contributing Factors:
Decision – Misjudgment
Distraction Job-related – dealing with weather avoidance co-ordination
Memory – Incorrect recall from memory – aircraft lined up
Memory – Forgot to check runway scan before landing clearance
Memory – Forgot to check situation display monitor
Decision – Incorrect decision – removed strip from rwy bay
AGA Comms – Call swamping – transmissions blocked

Actual Recovery Barrier:	
X	Pilot action

ATC Barriers Breached:	
PB1	ATCO memory aids for issued (not issued) clearances by standardised flight data displays including dedicated runway bays, blocking strips etc.
PB2	ATCO direct visual detection
PB6	A-SMGCS level 1 Surveillance with vehicles, in addition to aircraft, equipped with transponders in order to enhance surveillance information
MB1	ATCO direct visual detection
MB3	ATCO detection following pilot/driver report
MB5	ATCO detection it using A-SMGCS level 1

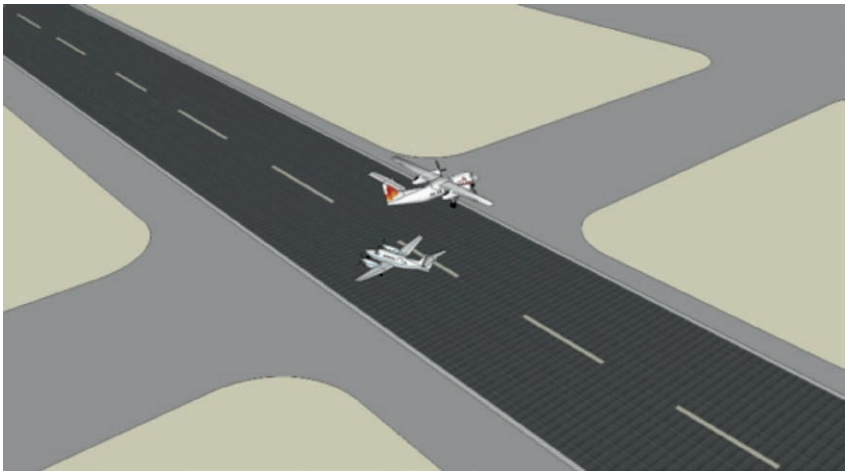
Remaining barriers available that could have reduced risk of collision:	
x	Pilot visual detection
MB6	ATCO detection it after alert from A-SMGCS level 2
x	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
PB3	ATCO detection using remote camera displays
MB2	Belated ATCO detection using remote camera displays
PB8b	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP) after incorrect clearance
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.18 Event 18. Crossed runway without clearance with aircraft taking-off

Generic Scenario:		
Runway Crossing	E4a	Unauthorised Aircraft/Vehicle crossing runway occupied by landing or departing aircraft without ATC clearance due to poor CRM or forgot planned action

A Bombardier DHC-8 landed on Runway 23. The GMC controller instructed the DHC8 to taxi on Taxiway E and hold short of Runway 27, which needed to be crossed to get to the gate. The hold short instruction was correctly read back. The TWR controller cleared a Beech A100 King Air to take off from Runway 27. Approximately 2 minutes later, the DHC8 entered Runway 27 without stopping. The BE100, which was approaching rotation speed, aborted take-off as soon as it saw the DHC8 on the runway. The BE100 veered to the right of the runway centreline and passed about 10m behind the DHC8.



On receipt of take-off clearance, the King Air crew switched on the landing lights, and without coming to a standstill, the aircraft continued its momentum to begin take-off. At this time, the flight crew of the DHC8, which was some 200m from the hold line of Runway 27, visually scanned the runway. The first officer indicated that the runway was clear to the right of the aircraft, and the captain did the same for the part of the runway to the left.

The GMC and TWR controllers simultaneously observed that the DHC8 was about to cross the runway. The GMC controller ordered the crew to stop, while the TWR controller only transmitted the DHC8 call sign. At about the same time, the DHC8 contacted the apron management service and continued travelling straight ahead, crossing the runway. The BE100 aborted its take-off at 102 knots and braked heavily. The decelerating King Air veered to the right of the runway centreline and passed at 37 knots, about 10m behind the DHC8. A few seconds later, the DHC-8 contacted ground control after being requested to do so by Apron Control.

The DHC8 pilots did not confirm between themselves the ground controller's instruction to hold short of Runway 27 notwithstanding the first officer's accurate readback of the instruction. The visual scan conducted by the DHC8 captain was ineffective and did not identify that the BE100 was on Runway 27. During the action of runway crossing, the captain of the DHC8 was talking to Apron Control, contrary to the operator's SOPs.

Contributing Factors:
Pilot Actions – CRM issues
Perception (pilot) – Did not see acft departing
Non-Conformance – Isolated Team non-conformance – deliberate departure from operator SOPs

Actual Recovery Barrier:	
X	Pilot action

ATC Barriers Breached:
Nil

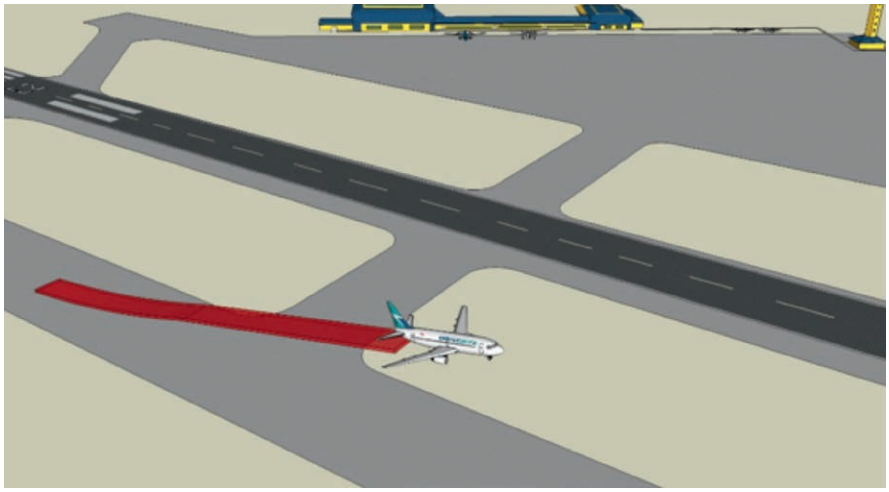
Remaining barriers available that could have reduced risk of collision:
Nil

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:
Nil

8.19 Event 19. Take-off on taxiway

Generic Scenario:		
Departing/Landing on taxiway	C7a	Landing/Departing on a taxiway after a non-conformance with ATC clearance due to spatial/positional confusion

A B737 took off in normal night visibility from a taxiway parallel to the runway for which take off clearance had been given. Because of the available distance and the absence of obstructions, the take-off was completed uneventfully.



ATC had given an instruction to taxi to the departure runway via taxiway 'A'. There were two parallel taxiways adjacent to the runway, 'A' and 'B'. Taxiway B is notified as anti-clockwise and generally used for departure traffic. Taxiway A is notified as clockwise and is normally used for landed traffic and towing traffic towards the gate. However the de-icing area was in use, which meant that some de-iced aircraft were using taxiway A initially against the flow of normal traffic. The crew expected a switch onto Taxiway B. Instead ATC kept the B737 on A and offered the B737 a departure from C3, which was accepted. This entailed a 90 degree right across taxiway B and onto C3 which was primarily a RET for landing aircraft using the reciprocal end of the runway. Soon afterwards and whilst between taxiway 'A' and taxiway 'B' received 'line up and wait' and then take off clearances in quick succession. It turned right again onto taxiway 'B' and after a short pause began a standing start take off.

At first, the TWR controller did not realize what had happened but, on becoming aware, decided not to order the aircraft to stop the take-off because it had already gained too much speed and there was no risk of collision ahead of it. Once the aircraft was safely airborne and in the climb, ATC advised the crew of the taxiway take-off, who were unaware of this. Subsequently, it was found that another aircraft had been taxiing on Taxiway 'B' in the normal had been approaching the left turn onto the section which the B737 was using for take-off to taxi along it in the opposite direction. As the B737 aircraft passed at a high ground speed in front of the other taxiing aircraft, the latter aircraft had been 280 metres away from the intersection.

There is no green centreline lights for entry to the runway from C3 (it primarily being a RET for the other end). A thin layer of snow impeded crew awareness of their position. The runway lights were inconspicuous at the location where the error occurred but the taxiway lights were clearly visible. The green taxiway centreline lights are all illuminated at all times the lighting system is in use rather than selected to correspond to a cleared taxiway route as applies at some other airports with complex taxiway networks.

The taxiway routing used by ATC was permissible, however if ATC had complied with the normal routing via taxiway B the crew error could not have occurred.

The flight deck crew's workload had increased after they had accepted the shorter route. As a result the crew had to enter changes in the flight management computer and had less time to visually check the aircraft's position at the airport from

the cockpit. The crew was not using a ground movement chart as they felt they were sufficiently familiar with their home base. The pilot in command was distracted by communications between the air traffic controller and a Boeing 747 taxiing in front of the aircraft that had taken a wrong route.

Contributing Factors:
Pilot Actions – Rushed Taxi
Perception (pilot)– Misinterpreted visual information – airport lighting
Weather – Snow
Airport – Ground lighting procedure of general illumination
Decision (pilot) – Insufficient Plan – Complacency, not using aerodrome chart
Distraction(pilot) – Ops related
Perception (ATC) – Did not see acft take incorrect route or commence take-off.

Actual Recovery Barrier:	
MB1	Belated ATC visual detection

ATC Barriers Breached:	
PB2	ATCO direct visual detection

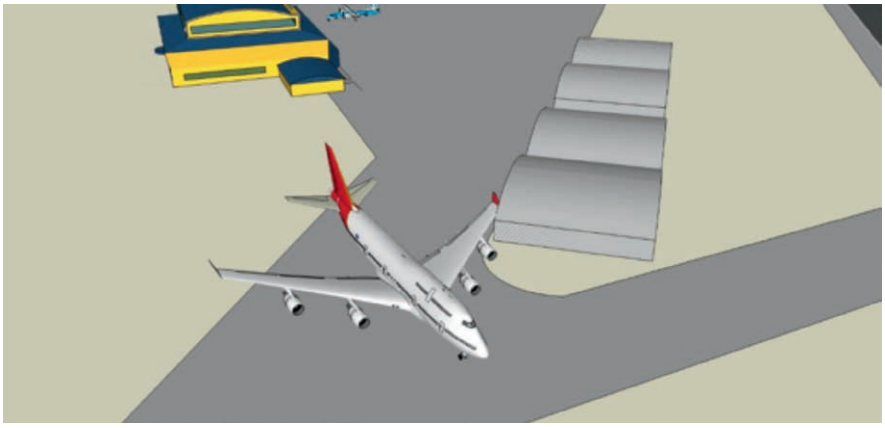
Remaining barriers available that could have reduced risk of collision:	
X	Pilot visual detection
X	Providence

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
PB8a	Use of input and display of the ATC clearances that enable the use of "early warning" surveillance and data (ITWP) to highlight any non-conformance to clearance
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

8.20 Event 20. Incorrect taxy route resulting ground collision

Generic Scenario:		
Incorrect aircraft movement on Manoeuvring Area	C8a	Aircraft takes incorrect taxy route after a non-conformance with ATC clearance due to spatial/ positional confusion

A B747 was taxiing for departure at night in normal ground visibility when the aircraft was involved in a collision with a building adjacent to the taxiway. A failure to re-brief for an unexpected taxi routing and a loss of situational awareness caused the crew to taxi onto a narrow taxiway unsuitable for B747s. ATC were unaware of the deviation in routing until after the collision.



All flight crew members were familiar with the airport through multiple previous visits and all had significant experience on the B747. A preflight brief was conducted prior to push back which included the expectation that the taxi routing they would get for departure runway would be via taxiway 'B'.

When the clearance came it was not the one briefed but the alternative of proceeding via taxiway 'A'. No revision to the earlier crew brief took place. Initially, the clearance as correctly read back was followed but, when taxiway 'A' turned to the left as it approached the runway Cat 2 holding point which was the clearance limit, the aircraft wrongly continued straight ahead on a narrower taxiway 'L' which unlike 'A' had no centreline lighting, just blue edge lights.. As soon as the aircraft entered 'L', the FO, who was PF, expressed his doubts about the apparent narrowness of the taxiway but there was no response from either of his colleagues and he continued ahead.

A further remark by the FO when the aircraft was about 10 metres from the building to the right of the taxiway that the wing was not very far from the building, was followed almost immediately by impact of the right wing with the building. Just prior to the collision, when he was unable to see the aircraft on taxiway 'A' the TWR controller checked the A-SMGCS display and discovered that the aircraft was on 'L'. He immediately transmitted to the aircraft to hold position but by this time, the collision had already occurred.

The Captain reported that as the junction between the 'A' and 'L' taxiways approached, the crew has just completed the "before take-off checks" so that his mind was focused on the objective of getting to the runway. He did not react adequately to concerns raised by the FO before the ground collision.

The pre-flight briefing had used only the aerodrome overview chart and not the text page which contained information which included a caution note specifically on the potential for confusion at the junction of taxiways 'A' and 'L'.

Some of the centreline lights on A were unserviceable. It was also noted that over a distance of approximately 300 metres up to the holding point, no centreline lights were installed. The direction information sign on the left side of taxiway 'A' ahead of the intersection of 'A' and 'L' which consisted of a black inscription on a yellow background was not lit.

Contributing Factors:
Decision (pilot) – Insufficient plan – no use of taxi charts
Decision (pilot) – Incorrect plan – no change of plan when cleared route was not as briefed
Perception (pilot)– Misinterpreted visual information – airport lighting
Decision(pilot) – No plan – no response by Capt. to concerns raised
Airport – Ground lighting
Airport – Signage
Perception (ATC) did not see aircraft take incorrect route

Actual Recovery Barrier:
Nil

ATC Barriers Breached:	
MB1	ATCO direct visual detection
MB4	ATC detected from A-SMGCS data

Remaining barriers available that could have reduced risk of collision:
Nil

ATC Barriers that, if deployed, could have prevented the runway incursion and/or reduced risk of collision:	
PB8a	Use of input and display of the ATC clearances that enable the use of "early warning" surveillance and data (ITWP) to highlight any non-conformance to clearance
PB9	Use of discrete names for holding positions and pilot reports e.g. reporting point BARKA instead of W2
MB8	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)

CHAPTER 9 - ANALYSIS OF ACTUAL SAFETY EVENTS

This analysis aligns with the Safety Function Map (SAFMAP) methodology in considering the levels of barriers in any safety event chain.

1. **What available ATC barriers were breached in the event?**
2. **What barrier stopped the event?**
3. **What available barriers remained untested?**
4. **What barriers may have reduced the risk of collision had they been deployed?**
5. **What are the most common contributing factors?**

9.1 What available ATC barriers were breached in the event?

Table 19: The 4 most common breached ATC barriers

PB2	ATCO Direct Visual Detection	**12**
PB1	ATC Memory Aids	**9**
MB1	Belated ATCO Direct Visual Detection	**7**
MB5	ATCO detection with A-SMGCS level 1	**3**

This shows that ATCO perception of visual information and lapses in memory are the most common failure modes.

9.2 What barrier stopped the event?

Table 20: The barrier that effectively stopped the event

MB3	ATCO resolution after pilot/driver alert	**7**
MB1	Belated ATCO Visual Detection	**4**
X	Belated pilot detection	**4**
X	Providence	**2**
MB6	ATCO detection after A-SMGCS alert	**1**
X	Proactive pilot action	**1**
	Nil – Collision	**1**

This table shows the importance of the "one team" awareness ethos involving ATC, pilots and drivers in stopping conflicts becoming collisions. It provides empirical evidence of the effectiveness of cross-industry safety awareness training. In 3 of

the 20 events all applied barriers failed, two were saved by providence but one event ended in a ground collision between an aircraft and a structure.

9.3 What available barriers remained untested?

Table 21: The 4 most common barriers that remained in place and untested when the event was stopped.

X	Pilot/driver visual detection	13
X	Providence	12
MB6	ATCO detection after A-SMGCS alert	5
MB1	Belated ATCO Visual Detection	3

This shows that the pilot resolution domain was still available in most circumstances as was Providence. However, as far as ATC barriers are concerned, in only 5/20 events did ATC have any remaining barrier available. MB6 x2, MB1+MB6 x 2 and MB1 x 1.

9.4 What barriers may have reduced the risk of collision had they been deployed?

Table 22: The 6 most common barriers that may have reduced the risk of collision if deployed.

MB7	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)	18
MB5	ATCO detection after A-SMGCS alert	11
MB3	ATCO detection with basic SMR	6
MB4	ATCO detection with A-SMGCS level 1	6
PB7	ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP)	6
MB2	ATCO detection using remote camera displays	5

This shows that functionality using the input and display of ATC clearances and surveillance could have reduced the risk of collision in all but two high-energy event, including the ground collision.

This also shows that any level of Surface Movement Radar would decrease risk, effectiveness increasing in line with increased functionality.

The study of actual events validates the analysis of generic barriers.

9.5 What are the most common contributing factors?

9.5.1 ATC

This study principally concerns ATC barriers. The first table shows the ATC contributing factors across the 20 events.

Table 23: ATC contributing factors

Memory	Forgot to check/monitor	7	**16**
	Forgot previous action	5	
	Recall from working memory	3	
	Recall from long-term memory	1	
Perception	Not see	12	**16**
	Misinterpret visual info.	2	
	Misinterpret audio info.	1	
	Mis-see	1	
Operational Environment	Distraction	6	**11**
	Visual Impairment from VCR	3	
	Noise in VCR	2	
Action	Convey incomplete information	2	**7**
	Convey incorrect information	2	
	Convey unclear information	1	
	Convey no information	1	
	Task priorities	1	
Decision	Incorrect Plan	4	**5**
	Misjudgement	1	
Organisational Factors	Desire to provide service over-riding safety	2	**3**
	Managerial pressure on staff rostered day-off	1	
Non-Conformance	Routine individual non-conformance		**2**
	Isolated individual non-conformance		
Team Factors	Temporary staffing constraints		**2**
	Handover issues		
Training	Controller training in progress		**1**
Personal Factors	Fatigue		**1**

This data is aligned with the barriers seen to be breached in the events. ATC contributing factors are mainly Memory or Perception; principally forgetting about something or not seeing something.

Various tools and standard operating procedures are available to aid ATC identification of potential conflicts and they work very well, in general. This study shows however that there are still safety gains to be achieved by developing new tools and in maintaining a vigorous training and day to day competency.

It is of interest that the third highest common arena of contributing factors is that of the ATC Operational Environment. Approximately half of these issues are organisational; visual impairments and noise in the VCR. The other half concerns job-related distractions. This is chiefly about using the available attention effectively. Tasks not involving the subject aircraft are prevalent e.g. checking a situation on another runway, concentrating on correct departure wake separation or co-ordinations.

9.5.2 Pilot/Driver

Pilot/Driver contributing factors are principally those of Perception, followed by poor Communication techniques, as shown in the table below:

Table 24: Pilot/Driver contributing factors

Perception	9
Action (Comms)	5
Decisions	4
CRM Issues	3

9.5.3 Airport Procedures and Equipment

The study of 20 events found 12 examples of Airport procedures or airport equipment being contributing factors, these were:

- Runway Inspection procedure
- Use of Rapid Exit Taxiways (RET) for departures during mixed mode operations.
- Routine incorrect use of portable radios carried by airside drivers in addition to the main radio
- Routine inappropriate use of company radio frequency whilst airside
- Use of native language to communicate with airside drivers and English for pilots
- Airports Ops department not following agreed procedure
- Permitting vehicles on airside without required lighting or radio
- Taxiway centrelines being permanently lit
- Work in Progress (WIP) agreements with ATC that severely restrict operational options, especially at night
- Excessive lighting around WIP severely restricting the ability of ATC to interpret visual information at night.
- Inadequate directional signage and signage lighting at night.
- Airfield lighting unserviceability

9.5.4 Combined contributing factors from all players

Table 25: Main areas of contributing factors from all players

Perception	25
Memory	17
Operational Environment	14
Action/Communication	12
Airport Procedures	12

The above table shows that the Human Performance areas of Perception, Memory and Communication actions are, as expected, prominent in runway incursion and ground safety events. Perhaps less anticipated are the contributions from the Operational Environment and from Airport Procedures.

CHAPTER 10 - CURRENT STUDIES AND FUTURE DEVELOPMENTS

10.1 EUROCONTROL – Air Traffic Control Situational Awareness Occupied Runways (2008)

This document identifies some of the operational tools widely used to provide a memory aid to air traffic controllers that a runway is already occupied.

The report focussed on the following areas:

- Air Traffic Control work station;
- *Methods to show an occupied runway;*
- Reinforcement of air traffic control awareness;
- Dedicated tools.

The report provided possible or potential methods to show an occupied runway.

10.1.1 Methods to show an occupied runway

10.1.1.1 RUNWAY OCCUPIED strip

This may be placed in a dedicated Strip holder of a different colour, usually red, to make it more noticeable.

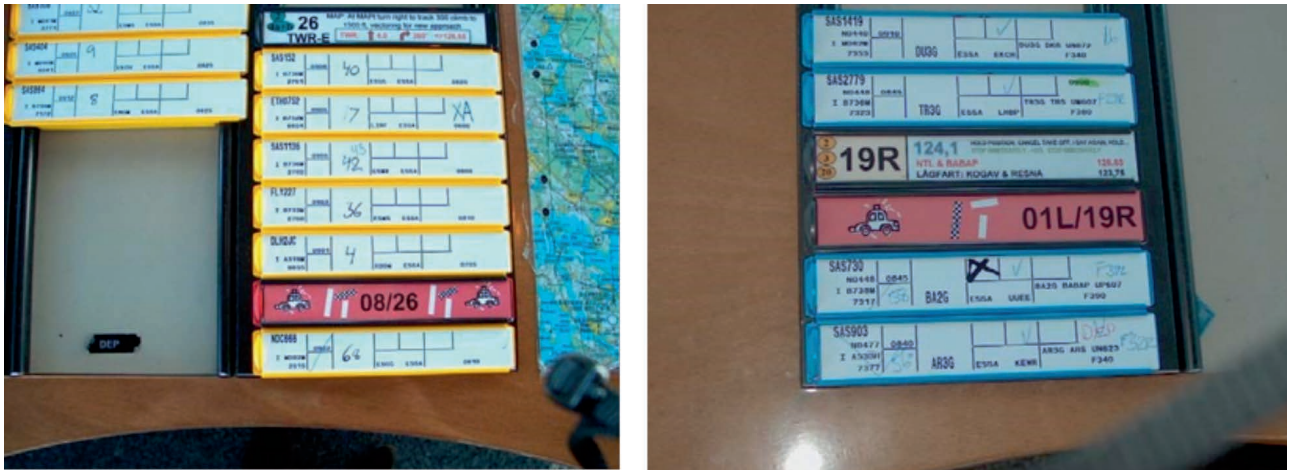


Fig 1 Dedicated flight strip for runway inspection (one per runway)

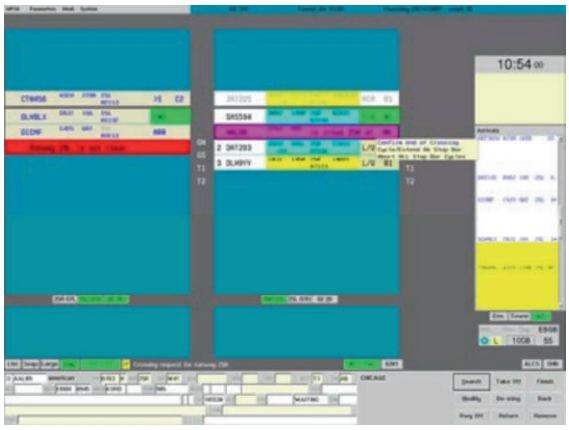


Fig 2 Electronic Flight Strip display with a clear indication in the left bay that a runway is occupied

10.1.1.2 Runway Occupied Boxes

Runway occupied boxes are a tool to remind a controller that the runway is occupied by a vehicle. It requires manual input by the controller. The controller places the box on the flight strip board during occasions when a vehicle is authorised to enter the runway. These types of devices normally have a flashing red light to remind the controller that the runway is occupied.

Figure 3. Runway occupancy indicator

Figure 4. «A runway occupied box» display panel - Flashing red light

10.1.1.3 Runway Occupancy Plate

The Runway Occupancy Plate (ROP) is manually activated and de-activated by the controller and provides a reminder for the controller that a runway is obstructed or closed. The runway occupancy plate is built to physically represent the runway configuration. When the controller switches on the ROP, in addition to a flashing red light, which acts as a memory aid that the runway is obstructed, the wind information is suppressed from the meteorological displays.

It is a requirement when giving a take-off or landing clearance to transmit the actual surface wind. If the wind information is not available this will act as a further reminder that the runway is occupied. The wind information remains unavailable until the runway occupancy plate is switched off by the controller.

The occupied runway is indicated by a red light on the runway occupancy plate that blinks until a new input is made by the Air Traffic Controller after the driver reports "runway vacated". When a request is made for one hour or more, the status of the runway will be "CLOSED" and represented by a steady red light displayed on the runway occupancy plate. The ROP is operational at Paris, Charles de Gaulle.

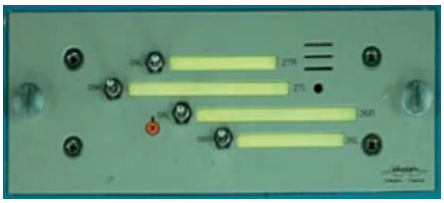


Figure 5. Runway open and free (all ROP lights are green)

Figure 6. Picture to the left (above) depicts the Runway closed and to the right the associated ATC MET Report Display is depicted with wind information suppressed. NOTE, when the runway is occupied the light is blinking red.

10.1.2 Dedicated Tools

10.1.2.1 Advanced Surface Movement Guidance and Control Systems (A-SMGCS)

A-SMGCS covers applications and systems for the air traffic controller, vehicle drivers and the aircraft pilots. Operationally available systems offer:

- Controller surveillance display,
- Runway incursion alerts for the controller,
- Selective switching of taxiway lights, stop and hold bars and
- Routing guidance functions,
- Runway protected areas penetration alerts and runway occupied alerts for the vehicle driver.

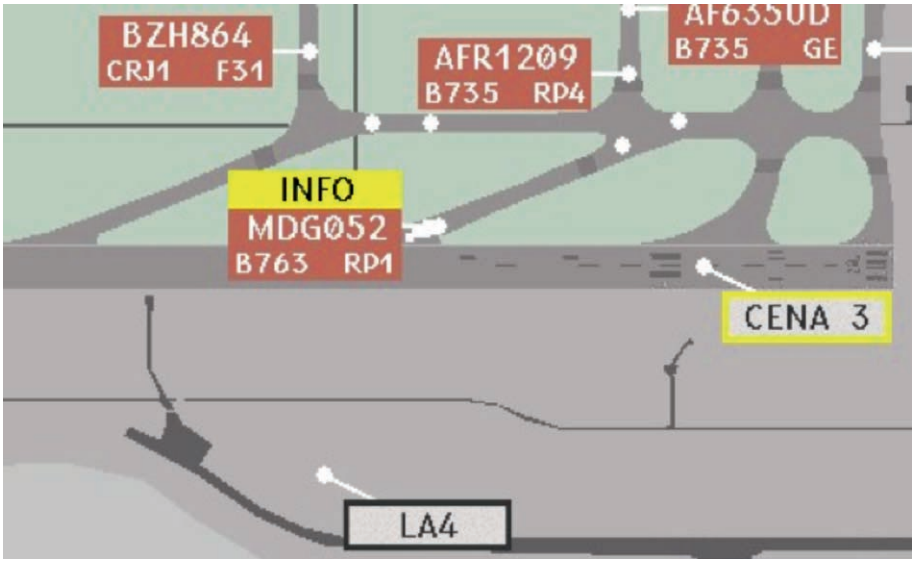


Figure 7. A-SMGCS display when an aircrafts in the runway strip and a car is on the runway

The most common level of implementation of A-SMGCS across Europe is a Surface Movement Radar together with a Mode S multi-lateration system and a runway incursion alerting system in the air traffic control tower. A-SMGCS technologies can help to prevent runway incursions and conflicts between aircraft and vehicles on the manoeuvring area.

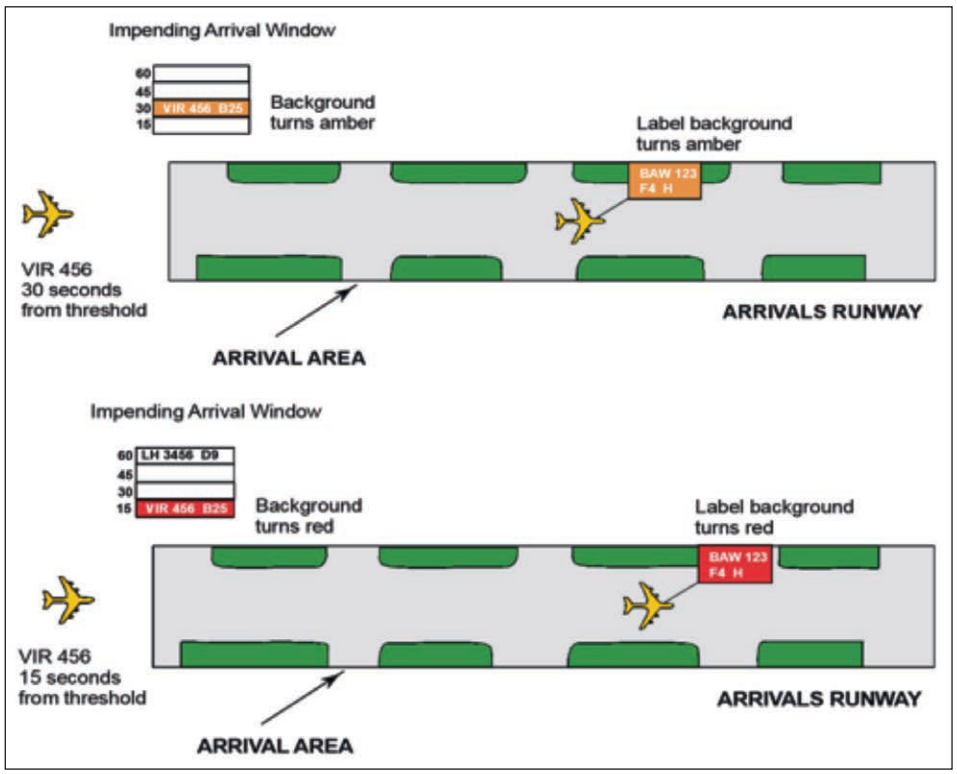


Figure 8. Example of A-SMGCS level II warning and alert in an approach scenario

10.2 SESAR - Airport Safety Nets P06.07.01

SESAR1 has studied and validated new Airport Safety Nets which are now including as one of the concepts that is part of the PCP (Pilot Common Project) 716/2014. The new Safety Nets build on the A-SMGCS Surveillance and Runway Incursion Monitoring System already in use at many European Airports today and have been categorised as follows. The concepts have been evolved as part of the development of the Integrated Tower Working Position (ITWP) at the EUROCONTROL Experimental Centre (EEC), Bretigny.

10.2.1 WA3 - Conflicting ATC Clearances (CATC)

This concept compares the clearances input by the Tower Runway Controller and provides an early prediction of situations that if not corrected would end up in hazardous situations that would be detected in turn by the RIMS if in operation. The detection of CATC is performed by the ATC system and the HMI can show the ATCO which clearance would be unsafe to give and in the case that a wrong clearance is made in error the ATCO will receive a CATC alert.

Several validations have been performed using industry prototypes and the concept should be able to be implemented relatively quickly if EFS and A-SMGCS Surveillance are already available.

10.2.2 WA4 - Conformance Monitoring Alerts for Controllers (CMAC)

The introduction of Electronic Flight Strips (EFS) at many airports means that the instructions given by the ATCO are now available electronically and can be integrated with other data such as flight plan, surveillance, routing, published rules and procedures. The integration of this data allows the system to monitor the information and when inconsistencies are detected, the ATCO can be alerted via the HMI or audibly. The main benefit of this is the early detection of flight crew / vehicle driver errors that, if not detected and resolved, might result in a hazardous situation. The current A-SMGCS RIMS will still exist as the last minute warning system based on the position of the mobiles. The V3 phase of validations will be completed by 2016 (many industry partners are developing CMAC and CATC prototypes) and already the concept is well defined (some of the alerts have already been implemented at airports in Europe). Like CATC, the CMAC alerts are included in PCP implementation plan.

10.2.3 Categories of Alerts

10.2.3.1 A-SMGCS Level 2 RIMS Stage 1

Triggers:

Non-LVP: INFORMATION around T1 = 30″ LVP: INFORMATION around T1 = 45″

CONFLICT	A-SMGCS Level 2 Surveillance Information Alert

10.2.3.1 A-SMGCS Level 2 RIMS Stage 1

ROUTE DEV	An aircraft deviates from cleared route on a taxiway
RWY/TWY TYPE	For a flight, when a selected runway is inappropriate / unsuitable w.r.t the aircraft type, i.e. runway is too short. (A380 a/c to take – off RWY26, negative)
STATIONARY	Aircraft has received a clearance and fails to move within a defined period
RWY CLOSED	For a flight, when a selected runway is closed. (e.g. 19L CLOSED) (RED Alarm if Aircraft given LUP/TOF)
TWY CLOSED	The taxi route is planned to go through a closed taxiway (RED Alarm if Aircraft enters closed area)
NO PUSH/TAXI CLR	Aircraft Pushes back or taxi without clearance from ATC
NO CONTACT /NO TRANSFER	Aircraft has reached a defined point without being assumed/transferred by the ATCO
HIGH SPEED	Aircraft taxies with speed exceeding x knots

10.2.3.3 A-SMGCS Level 2 RIMS

Triggers:

Non-LVP: ALARM around T2 = 15 seconds LVP: ALARM around T2 = 30 seconds

CONFLICT	A-SMGCS Level 2 (Surveillance Alarm)

10.2.3.4 CMAC Alarms (Stage 2)

RWY INCURSION	Mobile in runway protection area
ROUTE DEV	An aircraft deviates from cleared route on a taxiway near an active RPA
NO TOF CLR	Aircraft cleared to line-up and it takes-off without TOF clearance
NO LND CLR	Aircraft close to runway without a Landing Clearance
STATIONARY IN RPA	Aircraft that has landed and is within RPA for 30seconds, or lined up for more than 200secs or more without moving
RED STOP BAR CROSSED	Mobile Crosses a RED Stop bar

10.2.4 Safety Support Tools for Controllers

The system detects when 2 clearances are considered as not safe or not allowed.
Any combination of:

- Landing clearance
- Take-Off clearance
- RWY Crossing clearance
- RWY Enter clearance

Considered as not safe or not allowed will trigger a Conflicting ATC Clearance alert.
There follows some examples of the information and alert messages generated in the ITWP concept.
The list is illustrative and not exhaustive.

10.2.4.1 Incorrect ATC Clearance

In this example the ATCO has input cleared to land on LGL8011 and a pop up window appears asking the ATCO if they really want to accept the condition.

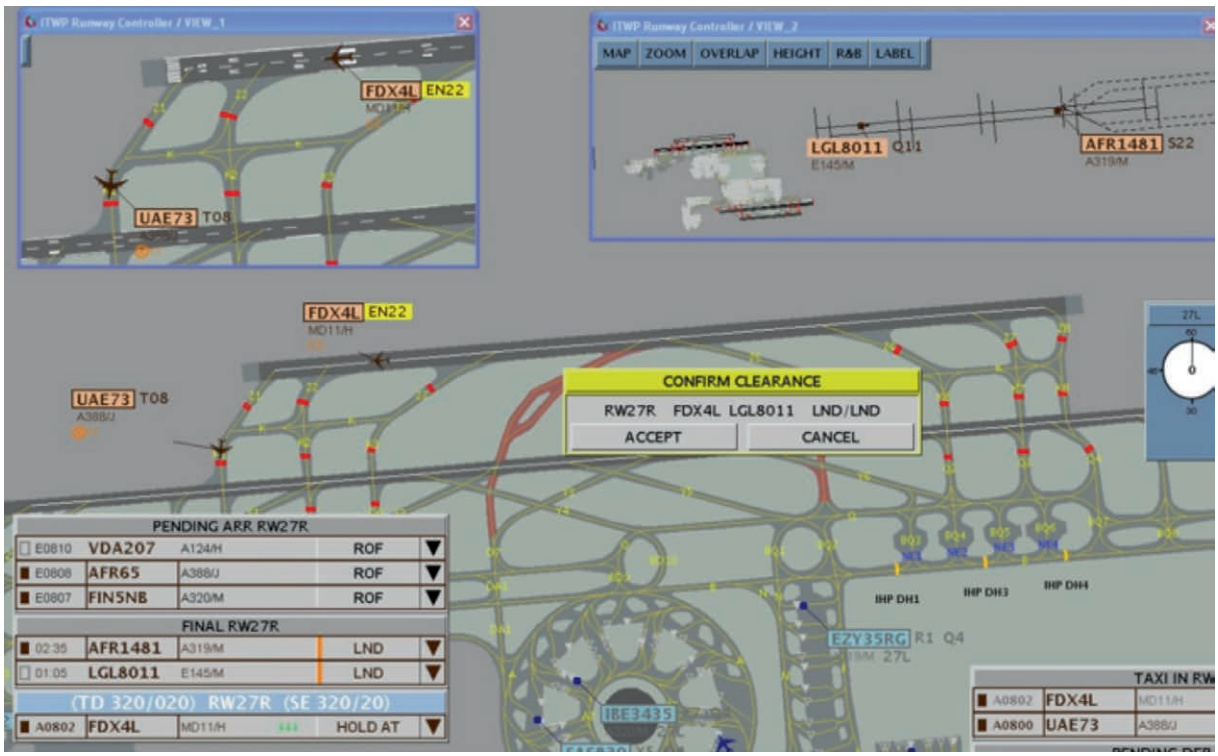


Figure 9. Pop up window in centre asks for confirmation of apparent conflicting clearances

10.2.4.2 NO CONTACT

This alert is generated for an aircraft on short final (less than 4NM) that is not on the RWY frequency.

Figure 10. Yellow Highlight appears in Alert Window at top of display and yellow highlight on ATM element for no TWR frequency contact with an aircraft within 4 miles.

10.2.4.3 NO LND CLR

This alert is generated for an aircraft on short final (less than 30 sec from threshold) that has not received a landing clearance

Figure 11. Red highlight appears in Alert Window at top of display and red highlight on ATM element and Arrivals elements for aircraft with no landing clearance within 1 mile.

10.2.4.4 NO LUP CLR

This alert is generated when an aircraft is lining up the runway without a runway entry clearance.

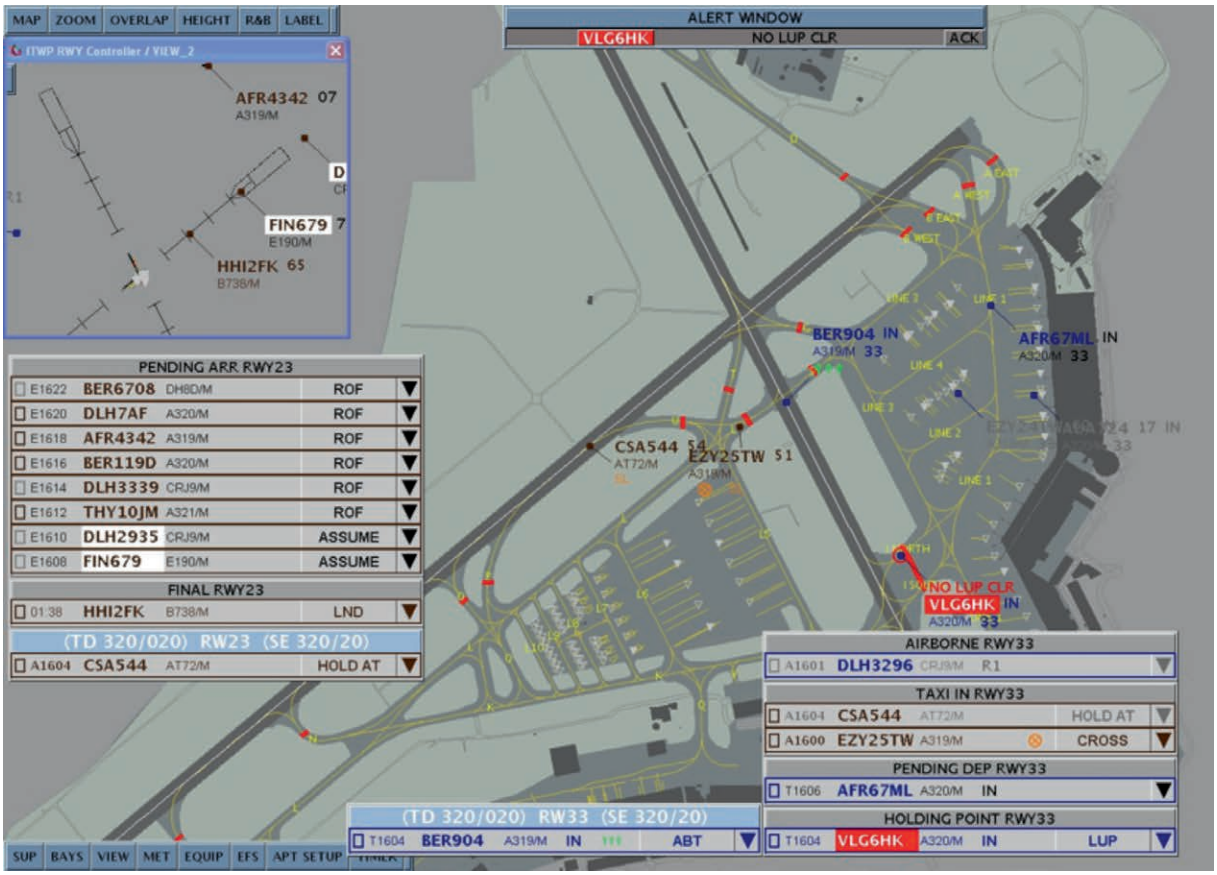


Figure 12. Red Highlight appears in Alert window at top of display and red highlight in Holding point bay and runway entry point for an aircraft that is entering the runway without a clearance.

10.2.4.5 Route Generation

- Automatically generated for every aircraft movement
- Takes into account default routes and taxiway usage rules
- Display of Route information triggered by placing the mouse cursor over the callsign (in EFS or in Radar Label)
- Routes can only be modified by controller who has ASSUMED the aircraft
- Route information is pre-requisite for Conformance Monitoring Route Deviation Detection and DTAXI (uplink of Routes to the cockpit)

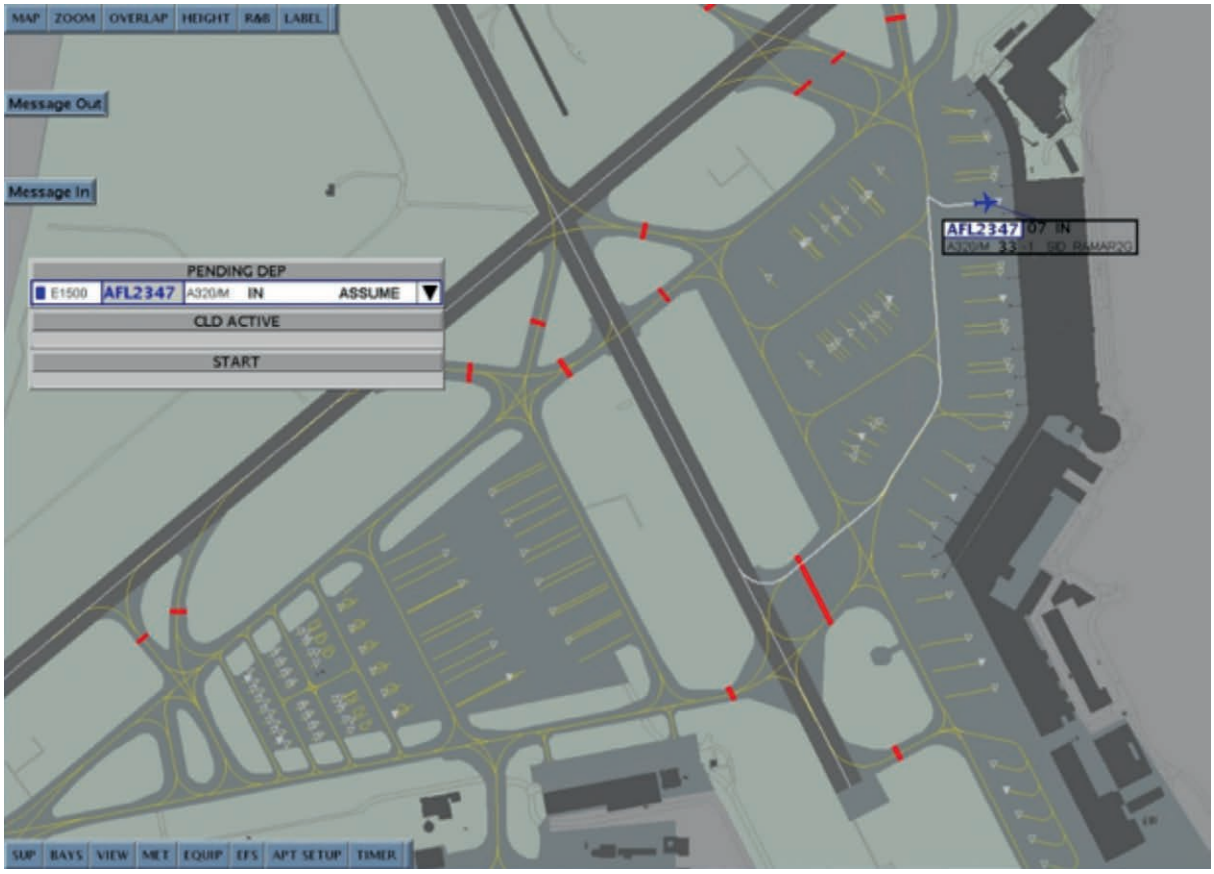


Figure 13. White line shows the default route from stand to holding point

10.2.4.6 ROUTE DEV

This alert is generated when an aircraft that is not taxiing in accordance with the clearance.
Cleared Trajectory is be displayed once the deviation is detected.

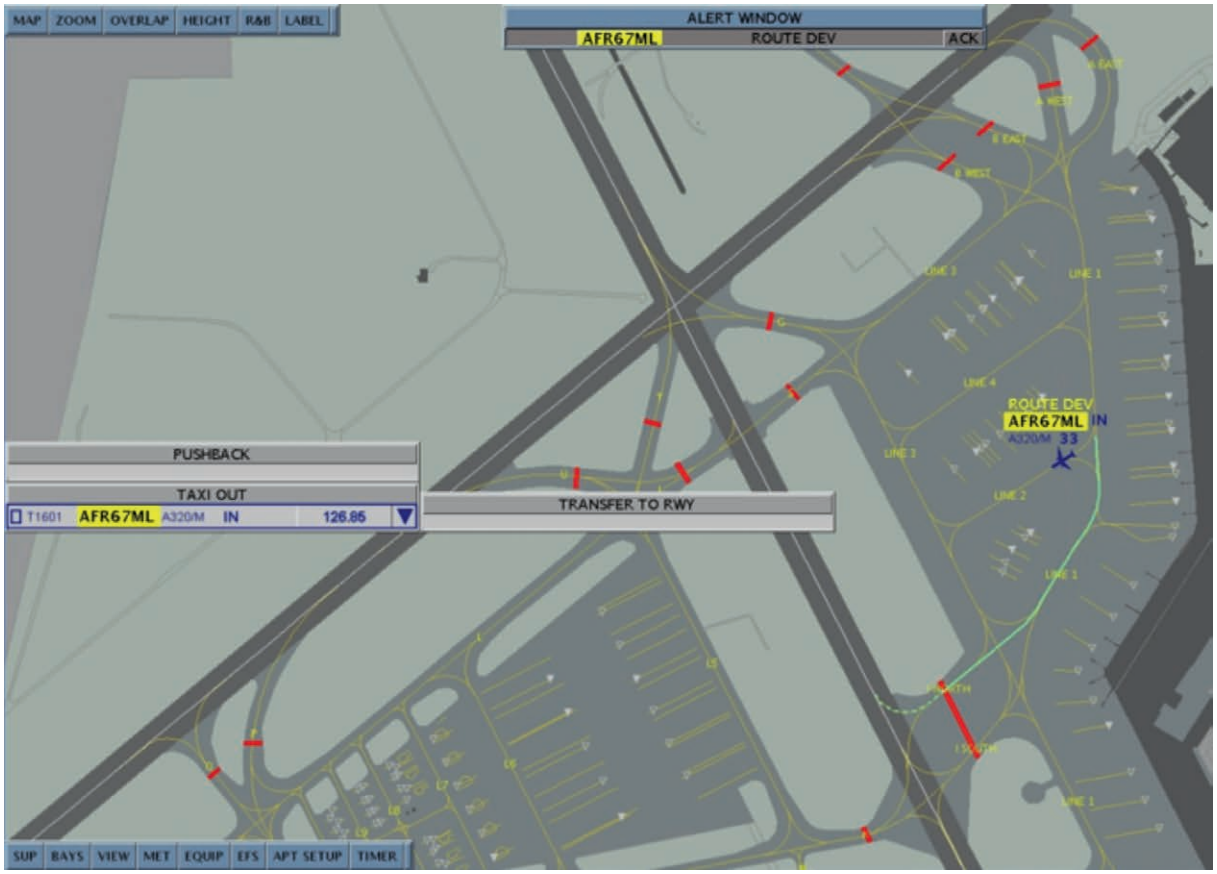
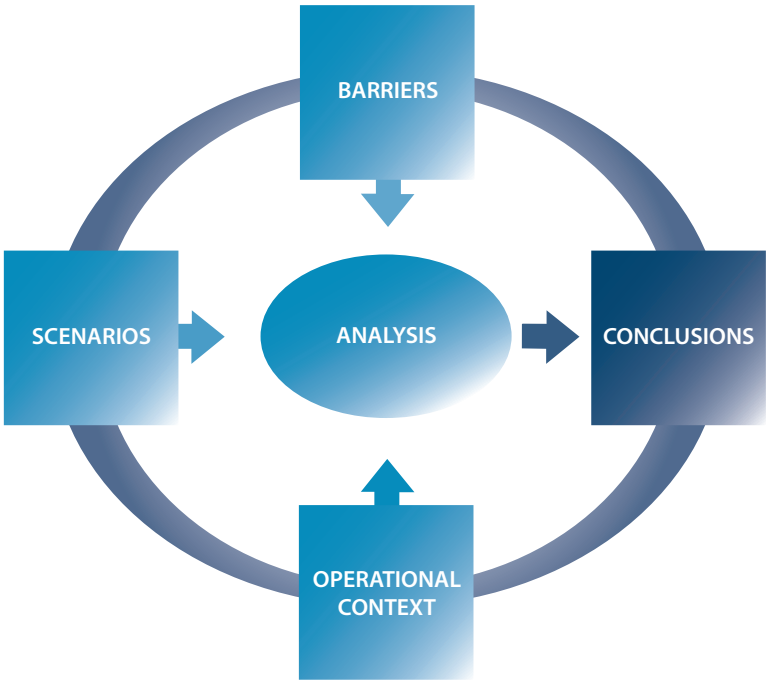


Figure 14. Yellow Highlight appears in Alert Window at top of display and yellow highlight on aircraft symbol and in Taxi bay for an aircraft that has deviated from the cleared routing.

CHAPTER 11 - CONCLUSIONS AND RECOMMENDATIONS



Conclusion 1

It was concluded during the scoping of the study that best value would be obtained by extending the original requirement, which was to consider the detection of occupied runways by controllers before they give the next instruction, to include the barriers available to ATC to prevent or mitigate potential conflicts on the Manoeuvring Area. This includes landing or departing on a taxiway and ground collisions.

Conclusion 2

This study identified ten barriers available to ATC that could potentially **prevent** runway incursions and ground safety events.

The single most efficient barrier is the Input and display of ATC clearances and surveillance data to jointly detect non-conformance to clearance and the potential impact of incorrect clearances. This functionality is not yet widely available; however, this study strongly supports its development and deployment.

Conclusion 3

This study identified eight barriers available to ATC that could potentially **mitigate** the impact of runway incursions and ground safety events.

The input and display of ATC clearances and surveillance data (ITWP) and ATC resolution following an alert from pilot or driver were equally the two most effective barriers.

Conclusion 4

Analysis of actual safety events showed that ATCO perception of visual information and lapses in memory are the most common failure modes.

The barrier that halted actual safety events most often was acting upon alerts received from pilots and drivers. This study therefore supports initiatives such as Local Runway Safety Teams in promoting the "one-team ethos".

ATCO detection after alert from the use of input and display of the ATC clearances and surveillance data (ITWP) would have resolved conflicts in almost all situations had such equipment been available. Any form of surface movement radar would reduce risk, rising with increased functionality.

Conclusion 5

This study identified the four most frequent ATC contributing factor areas that are present in the sequence of events leading to runway incursions.

- **Memory** - most commonly a failure to check/monitor i.e. not following normal practice
- **Perception** - most commonly a failure to see something
- **Operational environment** - commonly distractions, visual impairments and noise.
- **Communication errors** - incomplete, incorrect or ambiguous RTF.

The study also noted a significant number of individual factors that were within the remit of Airport Authorities.

Conclusion 6	Two of the actual events involved circumstances of high energy runway conflicts with available time for reaction less than the required time for the controller to detect the conflict, interpret it correctly, decide on a conflict resolution, communicate it to flight crew or vehicle driver, vehicle driver or flight crew action and aircraft or vehicle successful manoeuvre. There were no remaining barriers available and there were no existing barriers that if deployed could have prevented the runway incursion or reduce the risk. Both events were resolved by providence.
Recommendation 1	**It is recommended that ANSPs review the identified preventive barriers and contributory factors in case they undertake operational safety analysis and improvement activities for Controller Detection of Potential Runway and Manoeuvring Area Conflicts.**
Recommendation 2	**It is recommended that European ANSPs and the EUROCONTROL Safety Improvement Sub-Group (SISG) monitor occurrences involving Controller Detection of Potential Runway and Manoeuvring Area Conflicts to determine changes in frequency and severity.**
Recommendation 3	**It is recommended that all European stakeholders monitor and support the development of tools and functionality that include the input and display of ATC clearances and surveillance data to jointly detect non-conformance to clearance and the potential impact of incorrect clearances.**
Recommendation 4	**It is recommended that European ANSPs and the EUROCONTROL Safety Improvement Sub-Group (SISG) undertake an operational safety study on the subject of sudden high energy runway conflicts.**

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