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NETWORK MANAGER - SISG SAFETY STUDY

"Runway Incursion Serious Incidents & Accidents - SAFMAP analysis of 2006 - 2016 data sample"

Edition Number : 1.0

Edition Validity Date : 02 APRIL 2017

Runway Incursion Serious Incidents & Accidents - SAFMAP analysis of 2006 - 2016 data sample

Executive summary

This document describes the process and the results of the analysis of a worldwide sample of runway incursion accidents & serious incidents that occurred in the period 2006 - 2016 and for which an investigation report has been published, in English, by the respective national air accident investigation body (AAIB). The analysis was carried out by means of the Safety Functions Maps (SAFMAP) barrier model.

The purpose of this report is to support the review of the European Action Plan for the Prevention of Runway Incursions (EAPPRI).

The analysis was performed using the approach applied by EUROCONTROL for the identification of the Network Manger Top 5 safety priorities and in a previous analysis of runway incursion incidents. The previous analysis used a sample of runway incursion incidents of severity category A and B that occurred in 2013, 2014 and 2015 and were reported to EUROCONTROL.

The analytical process for this and the previous study is based on plotting the incident information onto the SAFMAP barrier structure that provides defence against runway collision accidents. Additionally, some findings and conclusions of this and of the previous (based on European incidents only) safety studies are presented in parallel in Annex 2 to ease the comparison of similarities and key differences.

This incident analysis provides information about Safety-I (i.e. safety functions that failed) but also about Safety-II (i.e. safety functions that performed well). In particular, at barrier level, the resilience (Safety-II) is addressed by identifying the barrier that stopped the incident from propagating further, while Safety-I is addressed by analysing the previous barriers. With regard to Safety-I, the information regarding the barriers' components that failed is available in most cases. As regards Safety-II, incidents of lower severity level would need to be analysed in order to build a reliable picture of 'what worked well'.

The data sample included in this study includes 71 runway incursion events with different outcome ranging from a runway incursion with no immediate safety effect to an accident (runway collision).

Although the publication of accident and serious incident investigation reports in English is a widespread practice of the AAIBs, many reports are available only in the national language of the investigation body. Therefore, whilst the sample may not be fully representative of global runway incursion frequency rates, it is large and diverse enough to provide sufficient confidence that the findings are indicative of likely trends affecting global runway incursions and that the acquired knowledge for the possible causes/contributors to different scenarios provides a valuable insight into this key safety risk area.

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1. INTRODUCTION

1.1 Accident and incident sample

The study used a worldwide sample of runway incursion (RI) accidents & incidents that occurred in the period 2006 - 2016 and for which an investigation report has been published in English by the respective national accident investigation body (AAIB). The availability of publicly accessible full investigation reports allowed for an extended SAFMAP coding of the data sample as provided in Annex 1.

The analysed data sample includes 71 RI runway incursion events with different outcomes ranging from a runway incursion with no immediate safety effect to an accident (runway collision). The reasons for AAIBs to select an event for investigation, in general, are not provided in the investigation reports.

Although the publication of accident and serious incident investigation report in English is a widespread practice of the AAIBs, many reports are available only in the national language of the investigation body. Therefore, whilst the sample may not be fully representative of global runway incursion frequency rates, it is large and diverse enough to provide sufficient confidence that the findings are indicative of likely trends affecting global runway incursions and that the acquired knowledge for the possible causes/contributors to different scenarios provides a valuable insight into this key safety risk area.

1.2 Approach to the data analysis

The sample of 71 incidents was analysed using the same approach applied to the identification of Network Manager Top 5 safety priorities and to a previous analysis of reported RI incidents that occurred in Europe in the period 2013 – 2015. It is based on plotting the incident information on the Safety Functions Map (SAFMAP) barrier structure providing defence against runway collision accidents. The used model version is “Safety Functions Map Configuration Description Model” of 18 November 2016.

The SAFMAPs are barrier models based on a structured documentation of the available defences against particular unwanted accident outcomes. These barriers are either part of the ATM system (ground and/or airborne component) or can impact the safety performance of ATM and/or aircraft navigation. Each discrete barrier is considered as a safety function. The functions used are rather generic: for example the function “Pilot/driver detection that RWY protected area entry will be incorrect” does not specify the actual means to implement this function such as stop-bars, runway guard lights or runway entry lights.

SAFMAPs are hierarchical structures in which each higher level structure (function) can be decomposed into several lower level structures (sub-functions). The top levels are called basic safety functions. The basic safety functions for the prevention of runway collision are presented on Figure 1 overleaf.

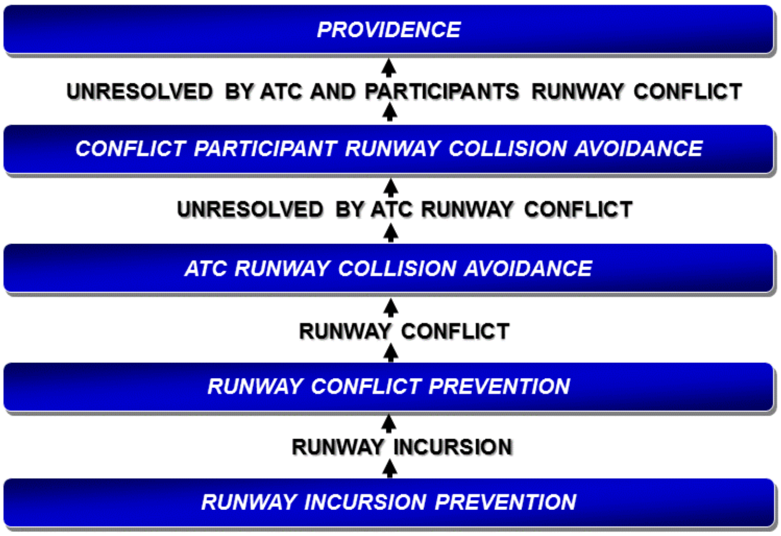

Figure 1: Basic barriers for runway collision prevention

In addition, some findings and conclusions of this and of the previous (based on European incidents only) safety studies are presented in parallel in Annex 2 to ease the comparison of similarities and key differences.

2. GENERAL ANALYSIS OF BARRIERS' PERFORMANCE

2.1 Overall performance of SAFMAP basic barriers

The information presented on Figure 2 below provides an indication of the barrier strength, i.e. the identified potential[1] of the basic barriers to stop an event developing into a more severe outcome and ultimately into a runway collision. An exception is the barrier 'Runway incursion prevention' - all the events included in the data sample and analysed with the help of the SAFMAP model have been considered serious incidents and investigated by the national AAIB, hence it is obvious that the 'Runway incursion prevention' barrier has failed in the vast majority of the analysed cases. Information about the Runway incursion prevention' barrier strength could be obtained by analysis of safety occurrences of lower severity, i.e. reported cases when this barrier 'worked well'.

In the analysed sample the 'Runway conflict prevention' barrier was tested 70 times and worked 16 times, i.e. its recorded efficiency is 23 %.

The 'ATC runway collision avoidance' barrier has been tested 54 times and worked 15 times, i.e. its recorded efficiency is 28 %.

The 'Conflict participant runway collision avoidance' barrier has been tested 39 times and worked 30 times, i.e. its recorded efficiency is considerably higher reaching 77 %.

In 6 out of 9 cases the conflict geometry (chance) helped avoid the collision and in 3 cases the ultimate outcome was runway collision. This means that the overall recorded efficiency of the runway conflict prevention and collision avoidance barriers is 87 %.

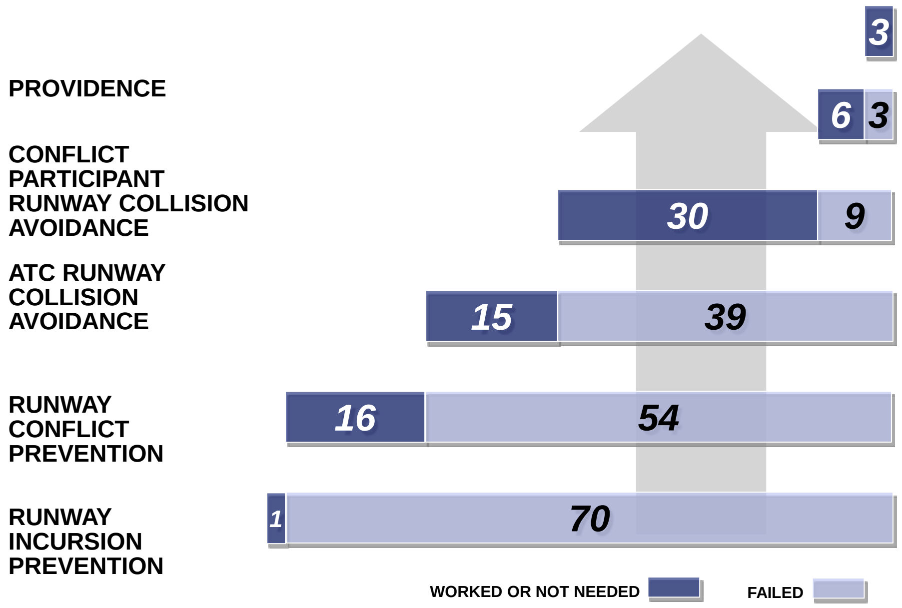

Figure 2: Basic barriers' performance

As shown in Annex 2, the derived values of barrier deficiency are consistent with the values derived by the analysis of the reported RI incident in Europe for the years 2013-2015. The absolute values of all barriers are lower (due to the higher severity of the events in the data sample), however the relative barrier efficiency follows the same pattern.

[1] According to the results of the analysis of the described RI accident and incident data sample

Figure 3 below provides further insight into the barriers' strength. It identifies the number of events stopped by a barrier in terms of absolute number (shown to the left of the barrier bars) and percentage (shown to the right of the barrier bars) of all accidents and incidents analysed.

Figure 3 also identifies the number of times the next barrier was not challenged despite the failure of the previous one. For example, in 5 out of 70 events (7%) there was no need for runway conflict prevention and in 6 out of 39 events (15%) there was no need for collision avoidance by the conflict participants. The former include events of unauthorised entry by a mobile onto an active runway without the presence of conflicting traffic at that moment on the runway. The latter include events of concurrent presence of 2 mobiles on an active runway (one of them taking off or landing) when there was no need for the pilot/driver to alter the mobile trajectory in order to avoid collision (e.g. presence of a mobile at the runway edge and the landing aircraft coming vacating before reaching its position).
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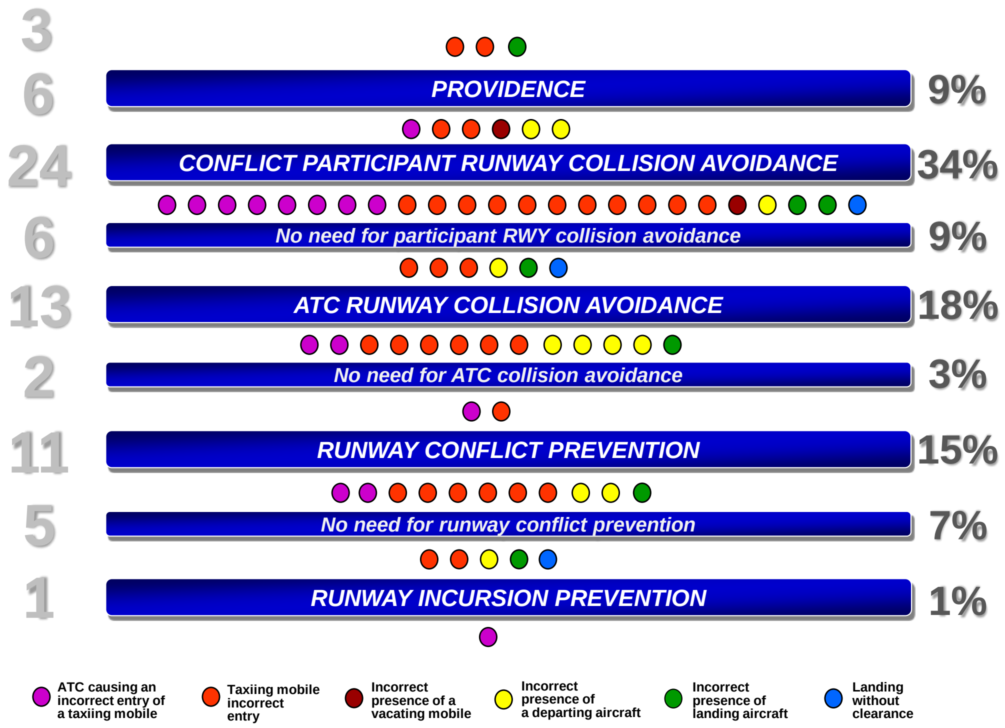

Figure 3: Number of events stopped by a barrier

Figure 4 overleaf illustrates the events that were stopped (to develop into a runway collision) by one of the ATC barriers, but where only providence was left as a further barrier had the ATC barrier that stopped them failed.

Figure 4: Events with only providence left as alternative barrier

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier with only providence left as alternative barrier.

2.2 Barrier resilience per initiator

The barriers' resilience per initiator is illustrated on Figure 5 below. The initiators are failures of one of the 6 sub-functions (sub-barriers) of the 'Runway Incursion Prevention' basic safety barrier:

- Prevention of ATC causing incorrect entry of a taxiing mobile into the RWY protected area.
- Prevention of taxiing mobile from incorrectly entering the RWY protected area
- Prevention of incorrect presence of a vacating mobile in the RWY protected area
- Prevention of incorrect presence of a departing aircraft in the RWY protected area
- Prevention of incorrect presence of landing aircraft
- Prevention of incorrect presence of people in the RWY protected area

Three groups of initiators dominate clearly in descending order:

- Incorrect runway entry by a taxiing mobile;
- Incorrect runway entry by a taxiing mobile caused by ATC;
- Incorrect presence of a departing aircraft in the RWY protected area.

In addition to the barrier resilience per initiator, Figure 5 illustrates the events that were stopped from developing into runway collision by one of the barriers, but where only providence was left as a further barrier had the barrier that stopped them failed. It is to be noted that such events have been caused by:

- incorrect runway entry by a taxiing mobile (4 events), and
- presence of departing aircraft on the runway protected area (3 events).

The 3 events with outcome runway collision are initiated by incorrect entry of a taxiing mobile onto the runway (2 events) and by incorrect presence of landing aircraft on the runway (1 event).

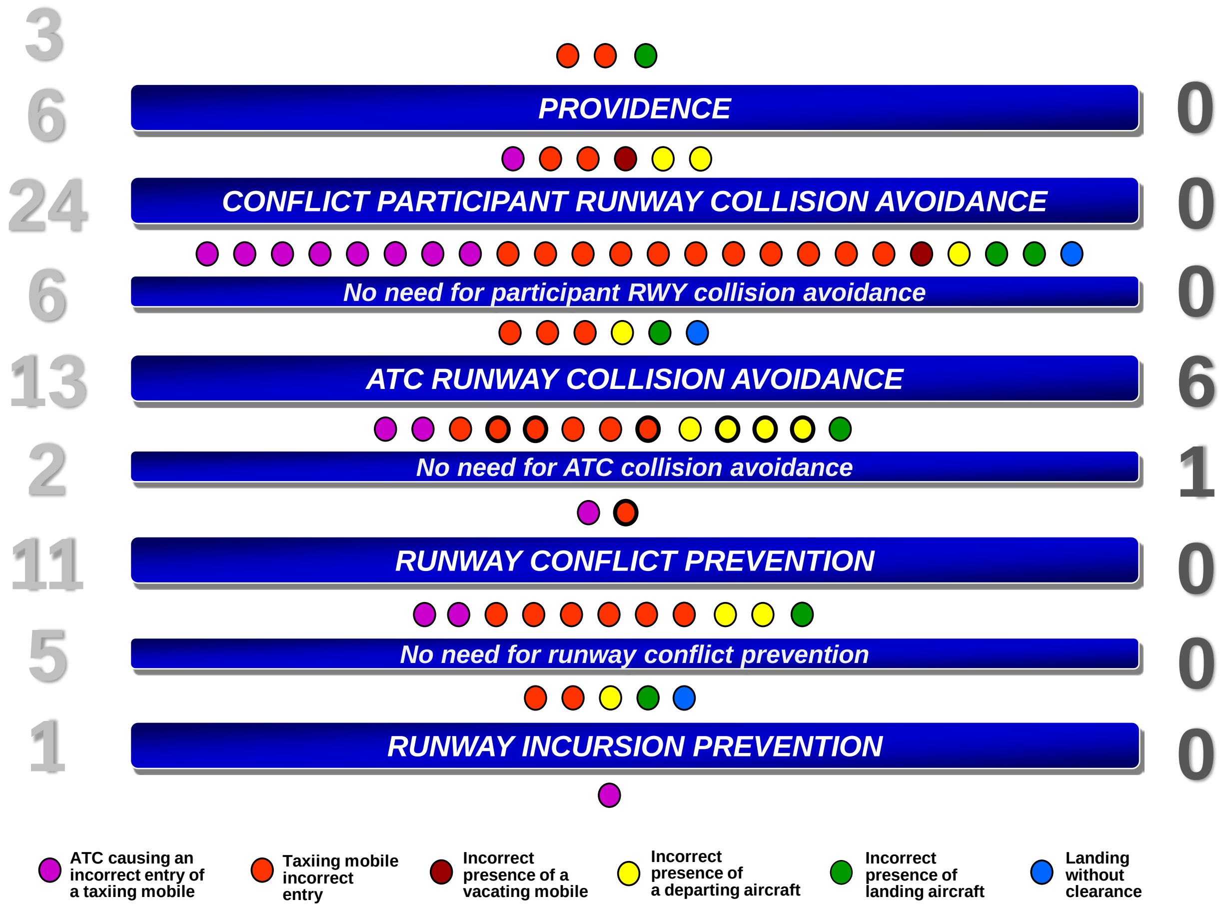

Figure 5: Barrier resilience per initiator

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier with only providence left as alternative barrier.

Figure 6 overleaf presents the share of the various initiators in the overall sample of events analysed. The incorrect entry of a taxiing mobile into the runway protected area is a clearly outstanding initiator (45 % of events analysed).

The share of other initiators is as follows:

- Incorrect entry of a taxiing mobile into the runway protected area caused by ATC (20%);
- Incorrect presence of a departing aircraft in the runway protected area (15%);
- Incorrect presence of a landing aircraft in the runway protected area (10%);
- Landing without clearance (3%);
- Incorrect presence of a departing aircraft in the runway protected area (2%).

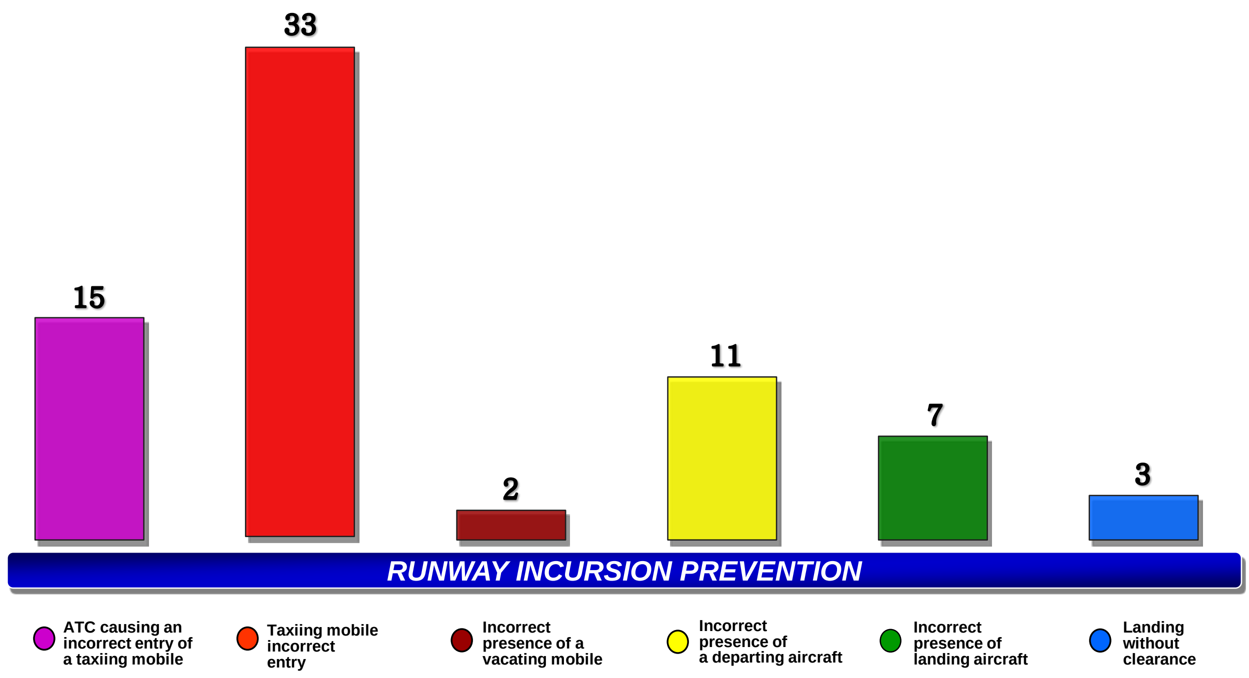

Figure 6: Event distribution per initiator

The comparison with the share of the various initiators in the analysed sample of RI events in Europe for the years 2013-2015 (see Annex 2) reveals that:

- the relative share of events caused by incorrect entry of a taxiing mobile into the runway protected area is consistent in both samples;
- the share of events caused by incorrect entry of a taxiing mobile into the runway protected area due to incorrect ATC instruction/clearance is significantly higher (20 % vs 8%);
- the share of events caused by incorrect presence of landing aircraft into the runway protected area is significantly lower (10 % vs 25%);
- the share of events caused by landing without clearance is considerably lower (3 % vs 11%).

3. ANALYSIS OF EVENTS WITH SPECIFIC CONTEXT

3.1 Sudden High Energy Runway Conflict

A Sudden High Energy Runway Conflict (SHERC) scenario typically involves a runway conflict in which, once initiated, the time available to ATC to prevent a collision is likely to be less than the time so needed.

Figure 7 below illustrates the barriers' efficiency in mitigating the risk of Sudden High Energy Runway Conflicts (SHERCs).

SHERC events account for 28 % of the analysed sample, which is significantly higher compared to the share of SHERC events (10%) in the analysed European RI data sample for the years 2013 – 2015. A possible explanation is that the current sample contains events with outcomes of higher severity.

The two main initiators of the SHERC events in the analysed sample are incorrect runway entry by a taxiing mobile and incorrect runway entry clearance issued by ATC. The most safety critical initiator appears to be the incorrect runway entry by a taxiing mobile as it initiated the 2 SHERC events, one of which was stopped by the 'providence' barrier and the other one resulted in a runway collision.

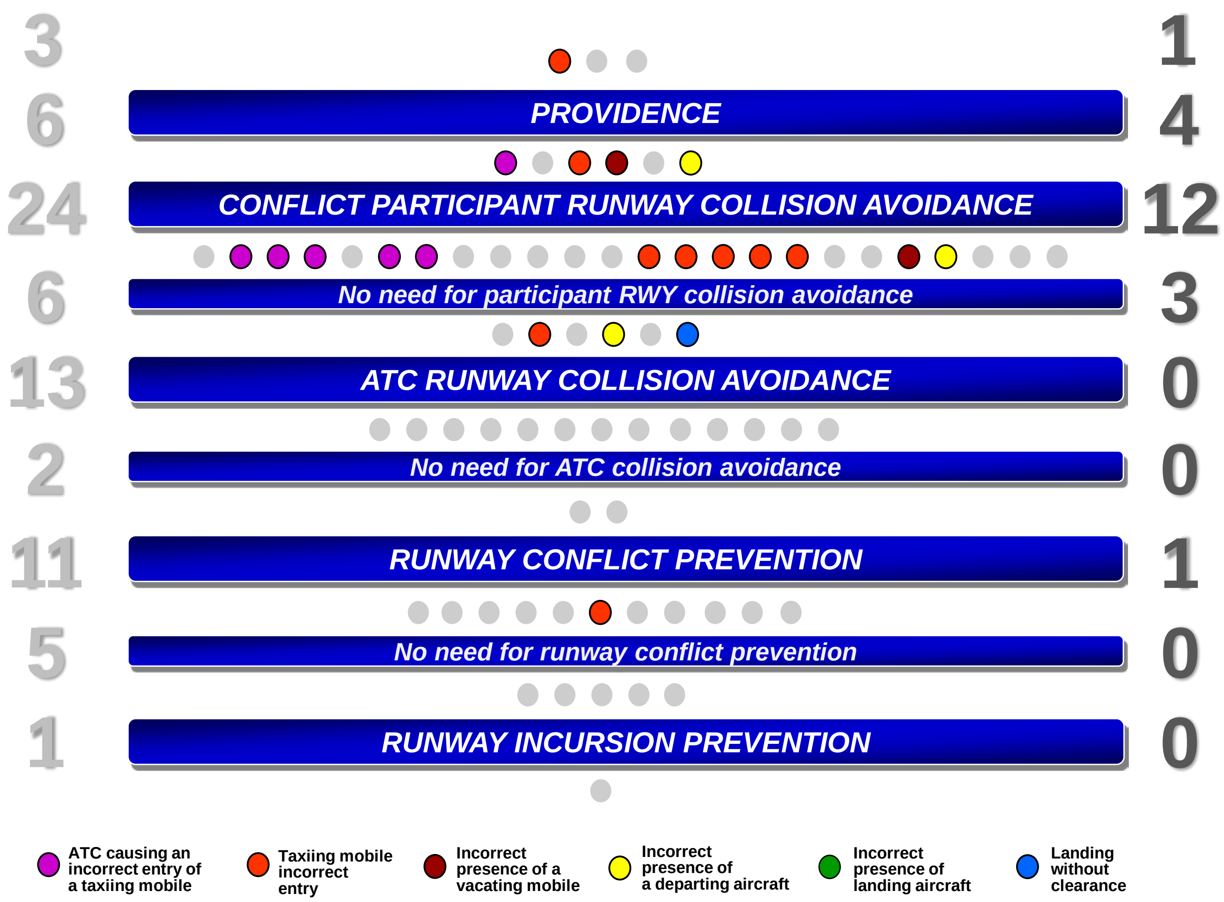

Figure 7: Sudden High Energy Runway Conflict events

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of SHERC events stopped by that barrier.

3.2 ATC not identifying occupied runway

The ATC (Tower controller) did not identify that the runway is occupied when issuing a runway use clearance in 28 events, i.e. in 39 % of the analysed events. As illustrated on Figure 8 all barriers contribute to preventing such events from developing into runway collision. However, the barrier efficiency is not particularly high – two of the events resulted in runway collision and in 3 cases "the providence saved the day".

The main scenarios of RI events associated with ATC not identifying that the runway is occupied are: incorrect runway use clearance issued by ATC and unauthorised entry of a taxiing mobile into the runway protected area which was not identified by the TWR controller. Causal and contributory factors for the issue of incorrect runway use clearance by ATC include controller error and distraction, failed coordination between GND and TWR controllers, runway configuration change, and position handover.

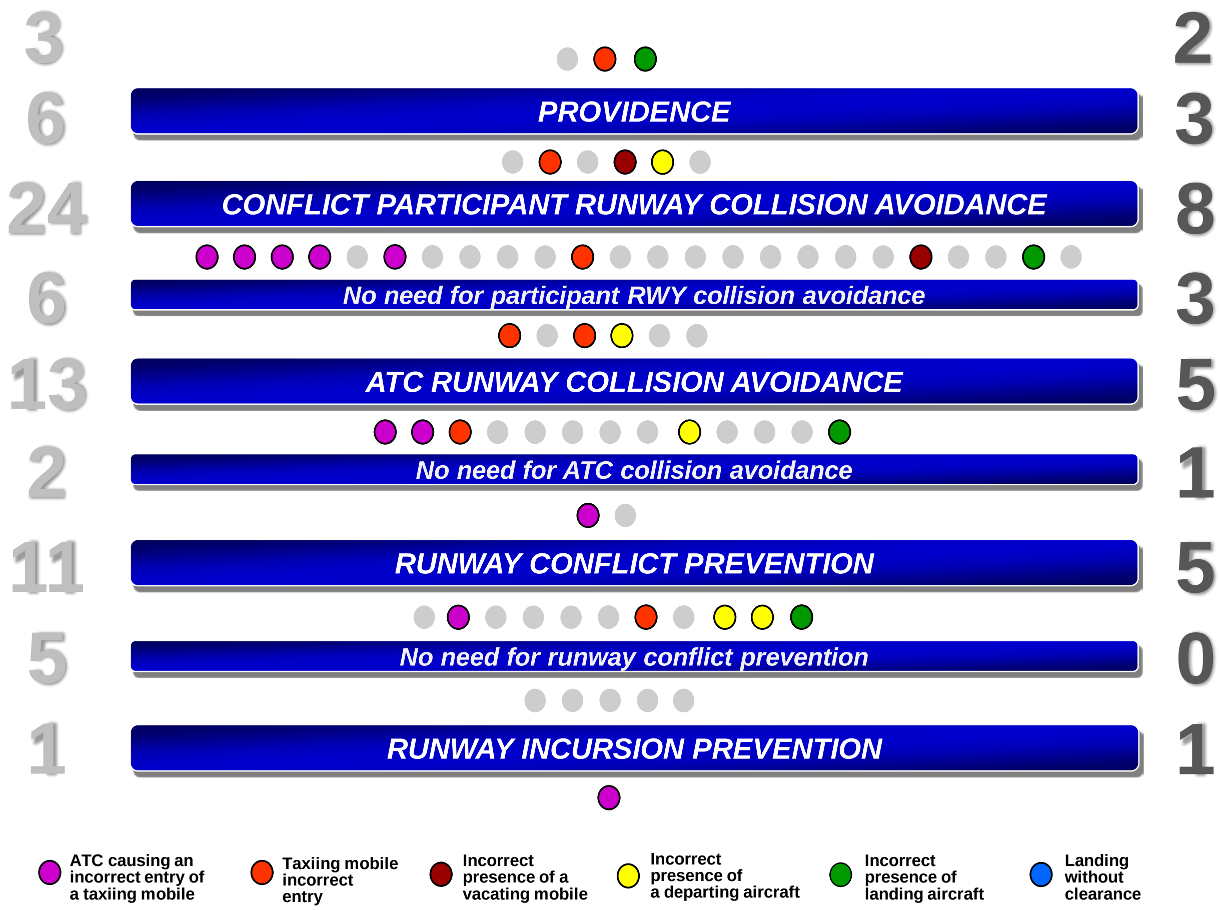

Figure 8: Events involving ATC not identifying occupied runway

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier in which the TWR controller did not identify that the runway was occupied (with or without proper authorisation) when issuing a runway use clearance.

3.3 Vehicles participating in the event

The runway incursion events involving the presence of vehicle(s) in the runway protected area represent 30 % of the analysed data sample. It is to be noted that the ATC conflict prevention and collision avoidance barriers are not particularly efficient at stopping these events – 66% of the events passed these basic barriers. This finding is consistent with the finding of the analysis of reported RI events in Europe for the years 2013-2015.

Figure 9 below illustrates that the safety effect of the events involving presence of vehicles on an active runway is of the highest severity – in 4 events the 'providence' prevented the runway collision and 3 events resulted in runway collision. (Note: The analysed sample includes 3 events with outcome runway collision.)

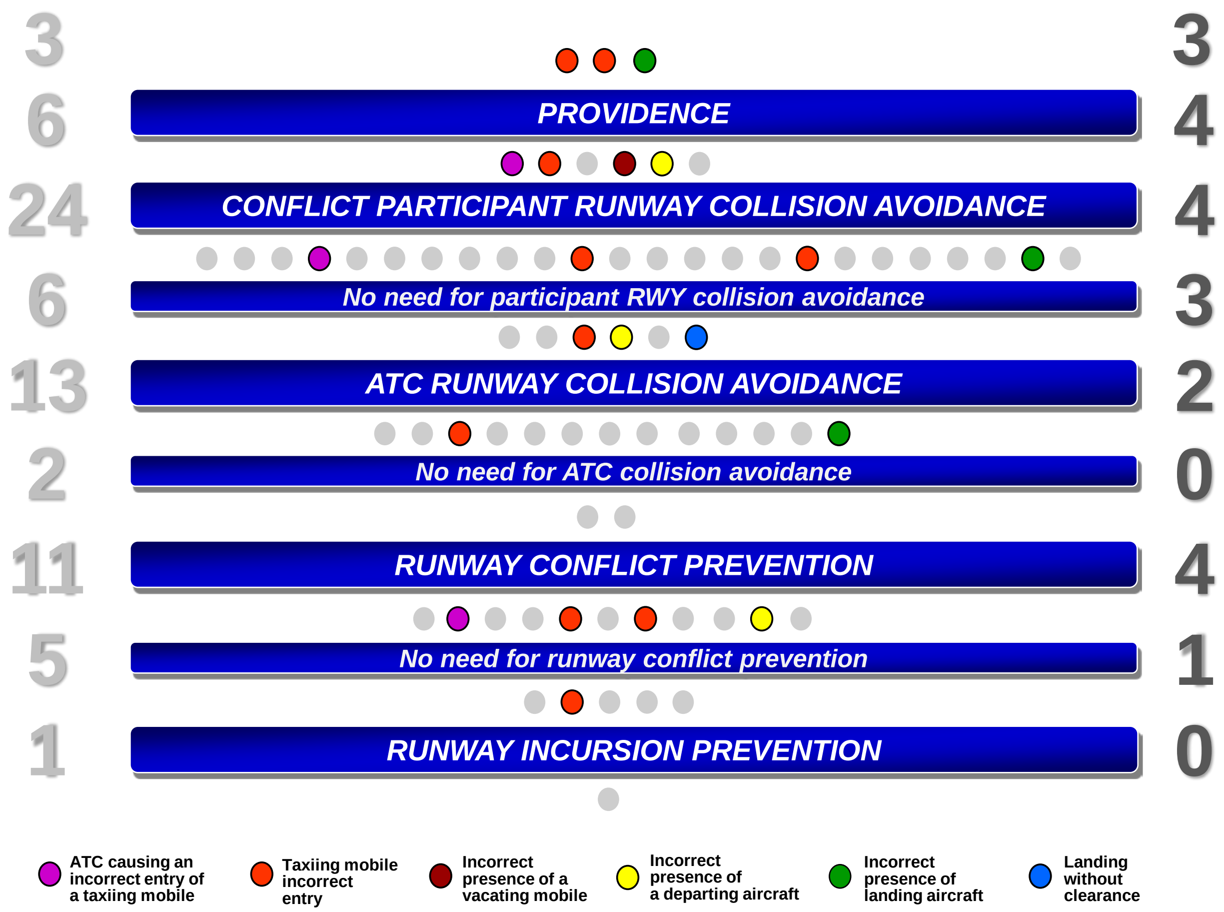

Figure 9: Runway incursion events involving vehicles

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events with vehicle participation stopped by that barrier.

3.4 Hand-over & take-over of ATC operational positions

In the analysed sample the TWR position hand-over and take-over (HOTO) contribution to the occurrence of the RI events is limited – HOTO is reported as a factor in 7% of the events (5 events only). As illustrated in Figure 10 below, the majority of those events were stopped by the conflict participant collision avoidance barrier. This differs from the analysed sample of reported events in Europe for the years 2013-2015 presented in parallel in Annex 2. In the latter sample the majority of events were stopped by ATC conflict prevention and collision avoidance barriers.

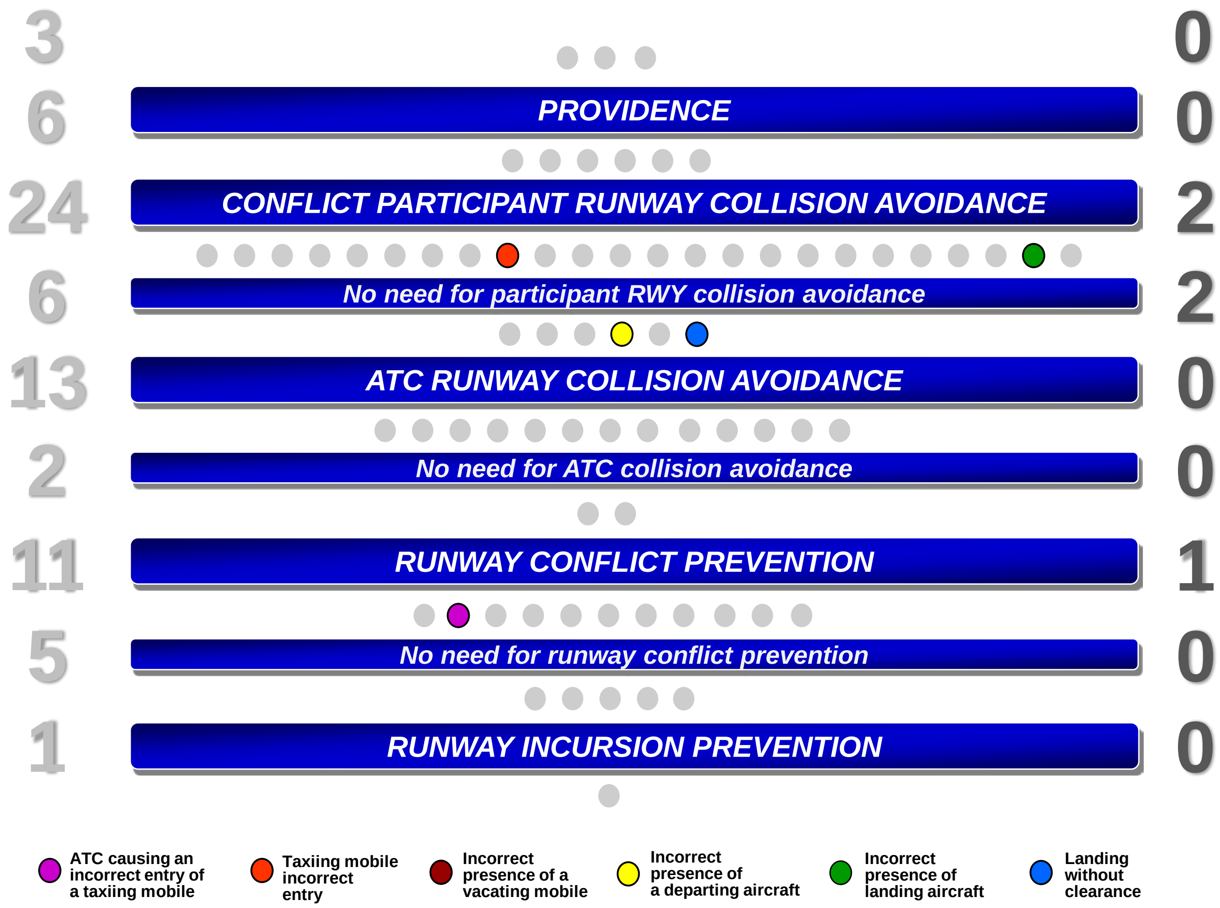

Figure 10: Events involving hand-over & take-over of operational positions

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier in which hand-over / take-over was reported as a factor.

3.5 Events during LVO

The share of safety events that occurred during low visibility operations (LVO) in the analysed sample is quite limited - five events or 7%. Two of the events are of low effect severity and two events are of the highest severity. The latter involve landing aircraft and vehicle on the runway.

The limited number of this type of event in the analysed sample does not allow drawing firm and well justified conclusions.

Figure 11: Events during low visibility operations

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events that occurred during LVO and were stopped by that barrier.

3.6 Events during night time

As illustrated in Figure 12 below the big majority of the events in the analysed sample occurred during daytime. The share of safety events that occurred during night time is 28%. However, the distribution is turned upside-down if the effect severity is considered. The share of events that occurred during night time and passed all barriers up to and including the 'Conflict participant runway collision avoidance' barrier is 66%. The majority of those (high severity) events involve incorrect runway entry by a taxiing mobile. The night time might have been a factor in the failed identification of this unauthorised entry.

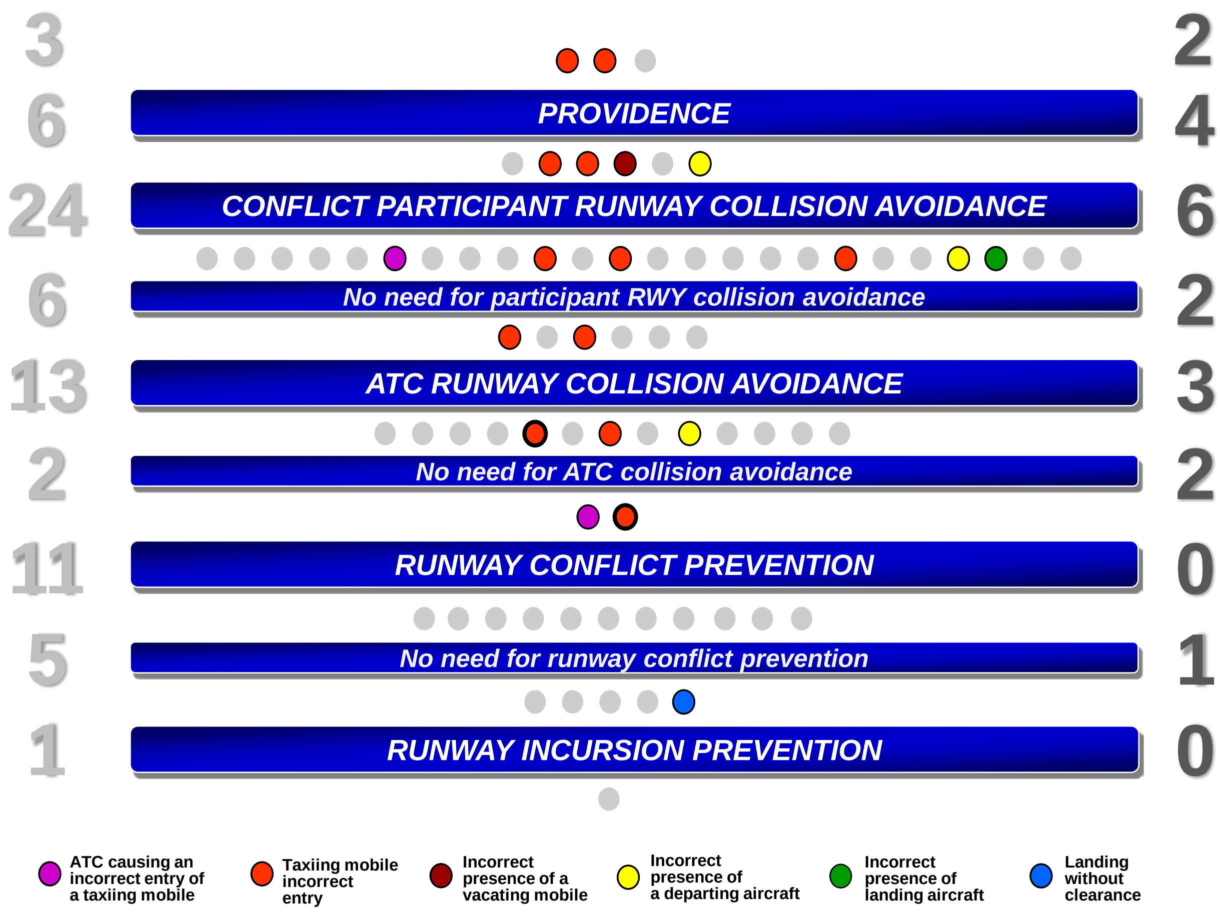

Figure 12: Events during night time

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events that occurred during night time and were stopped by that barrier.

3.7 Crossing lit stop bars

Figure 13 below shows the risk potential of the events involving crossing of lit red stop bar by the conflict participant in the analysed data sample. There are 7 events in total, i.e. around 10% of the overall data sample. This corroborates the conclusion of the SAFMAP analysis of the reported RI incidents in Europe for the years 2013 – 2015 (see Annex 2 for further details) that crossing lit red stop bar is a relatively rare event. It is to be noted that the severity of the safety effects in this sample is considerably higher compared to the severity of the safety effects of the events included in the above referred study. A possible explanation of this difference could be the fact that this sample includes events investigated by AAIBs, i.e. serious incidents.

The initiator of all but one event is the incorrect entry of a taxiing mobile into the runway protected area.

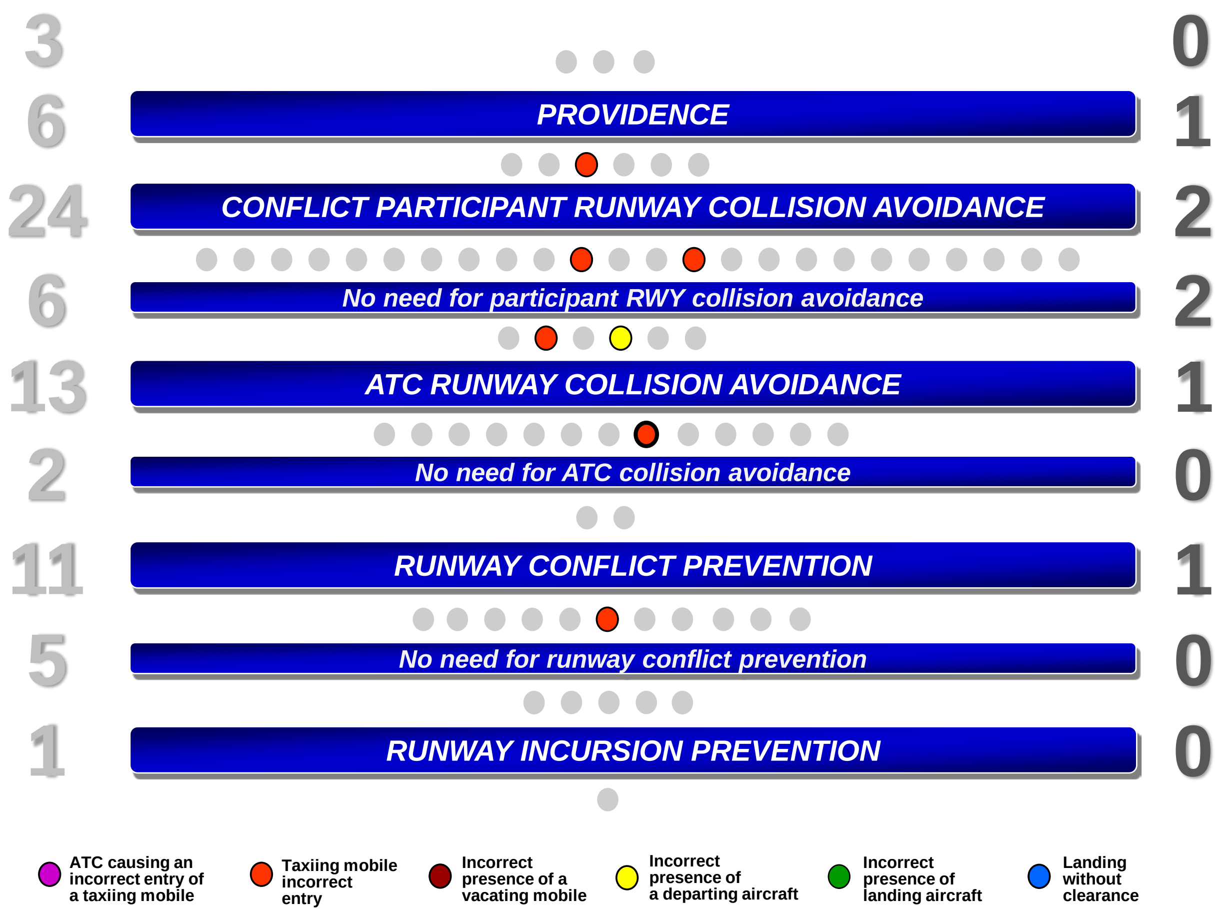

Figure 13: Events involving crossed red lit stop bars

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier in which a red lit stop bar was crossed by a mobile.

3.8 Risk mitigation potential of stop bars

In order to better assess the potential of the red stop bars as a RI prevention barrier, an additional analysis of the events involving incorrect presence of a taxiing mobile into the runway protected area was done. This analysis is based on the premise that if stop bars existed, the ATCO would have switched them on correctly and the pilot/driver would have stopped upon observing the red light. Figure 14 below identifies the RI events that could have been prevented and the barriers that actually stopped them in the analysed sample.

Out of the 33 events triggered by “Taxiing mobile incorrect entry”, there are 22 events where there is a reasonable expectation that stop bars could have prevented the incursion.

Out of the 15 events triggered by “ATC causing an incorrect entry of taxiing mobile”, there are 5 cases where there is a reasonable expectation that stop bars could have prevented the runway incursion.

The above means that more than half of the events (approx. 56%) could have been prevented had stop bars been in operation at the occurrence airports. Moreover, 12 events of higher severity and one of three runway collisions included in the sample could have been prevented. This finding is consistent with the finding of the SAFMAP analysis of the reported RI incidents in Europe for the years 2013 - 2015 regarding stop bars risk mitigation potential.

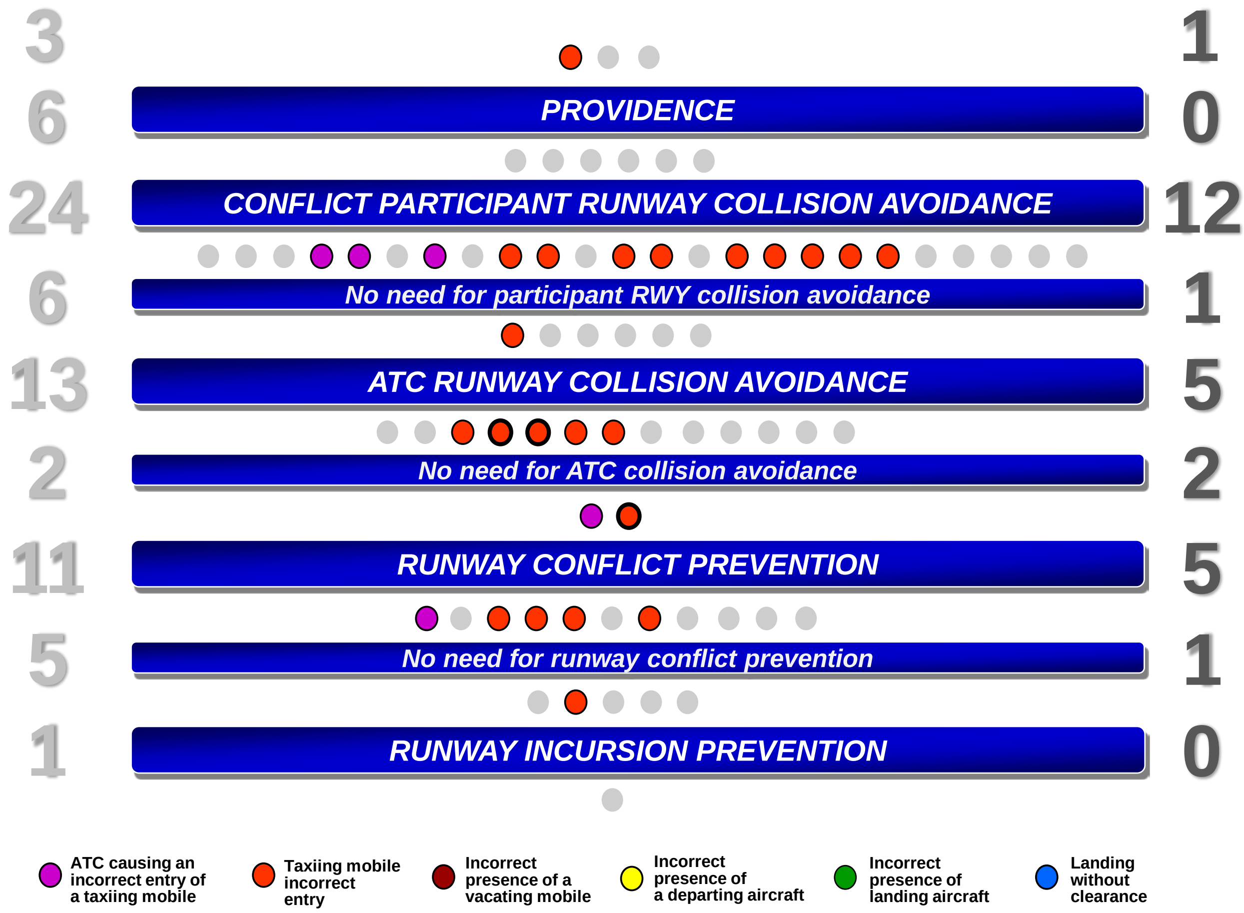

Figure 14: Events that could have been stopped by lit red stop bars

The number shown to the left of a barrier bar identifies the total number of events s stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events that could have been stopped had stop bars been in operation at the occurrence airports.

3.9 Use of conditional clearances

Although the share of events involving use of conditional clearance is quite low in the analysed data sample (5 events, i.e. 7%), the potential for a high severity outcome exists. As shown in Figure 15 below, more than half of the events were stopped by the conflict participant collision avoidance barrier.

In three of the events the initiator was the incorrect entry of a taxiing mobile into the runway protected area. It should be noted that the conditional clearance in this scenario is not necessarily the cause of the runway incursion.

In two events the incorrect entry into the runway protected area was triggered by air-ground communication issue.

The limited number of this type of event in the analysed sample does not allow to draw firm and well justified conclusions.

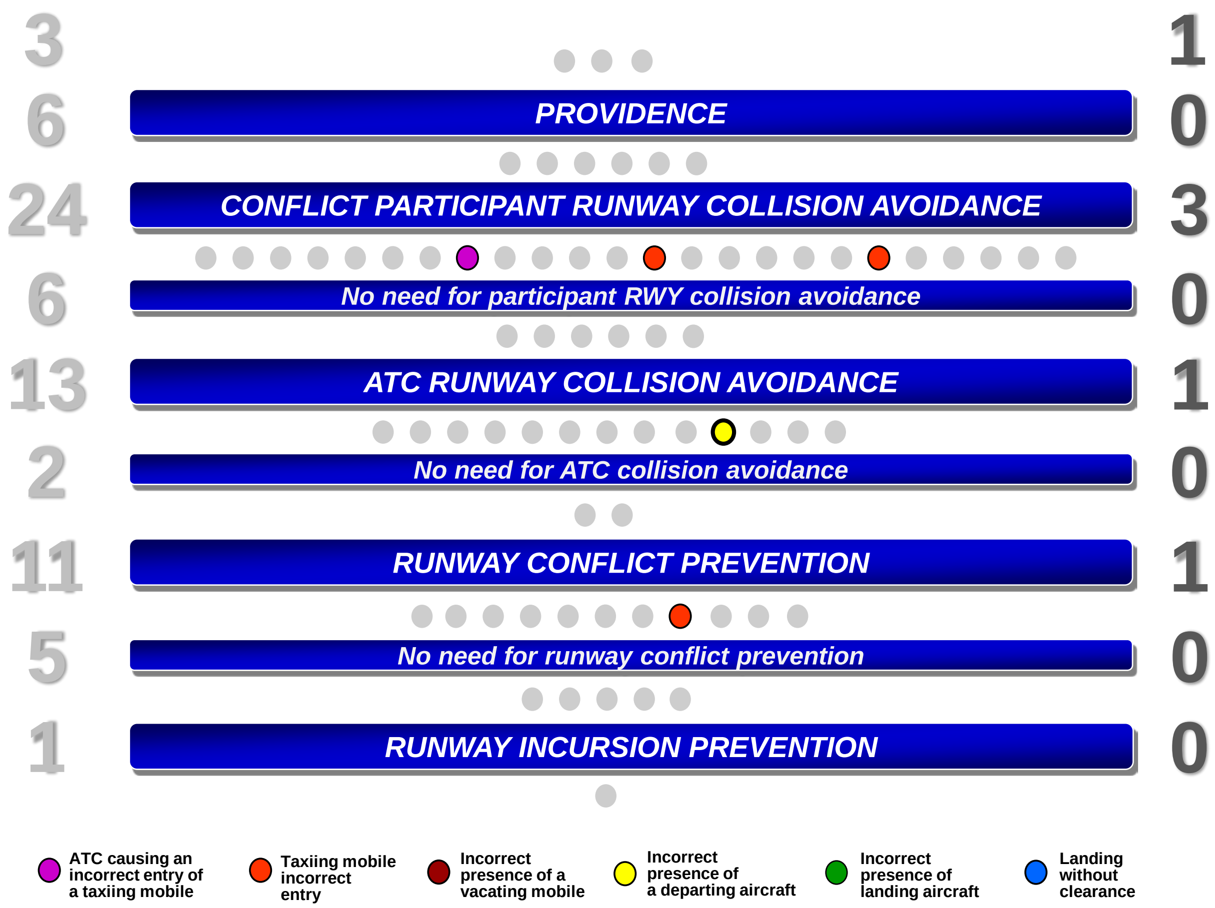

Figure 15: Events involving conditional clearances

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier in which the use of conditional clearance was a factor.

3.10 A-SMGCS issue

Figure 16 below identifies the events that occurred at airports with installed A-SMGCS that was not used to prevent or mitigate the safety effect of the reported and investigated event. The issues that prevented the effective use of the installed A-SMGCS vary and include inter alia: system not yet fully operational, incorrect tuning of the surveillance and/or the alerting functions and lack of, or inappropriate A-SMGCS use procedures.

It is to be noted that a considerable number of events of higher severity, including one runway collision, could have been prevented had the A-SMGCS been appropriately tuned and in operational use.

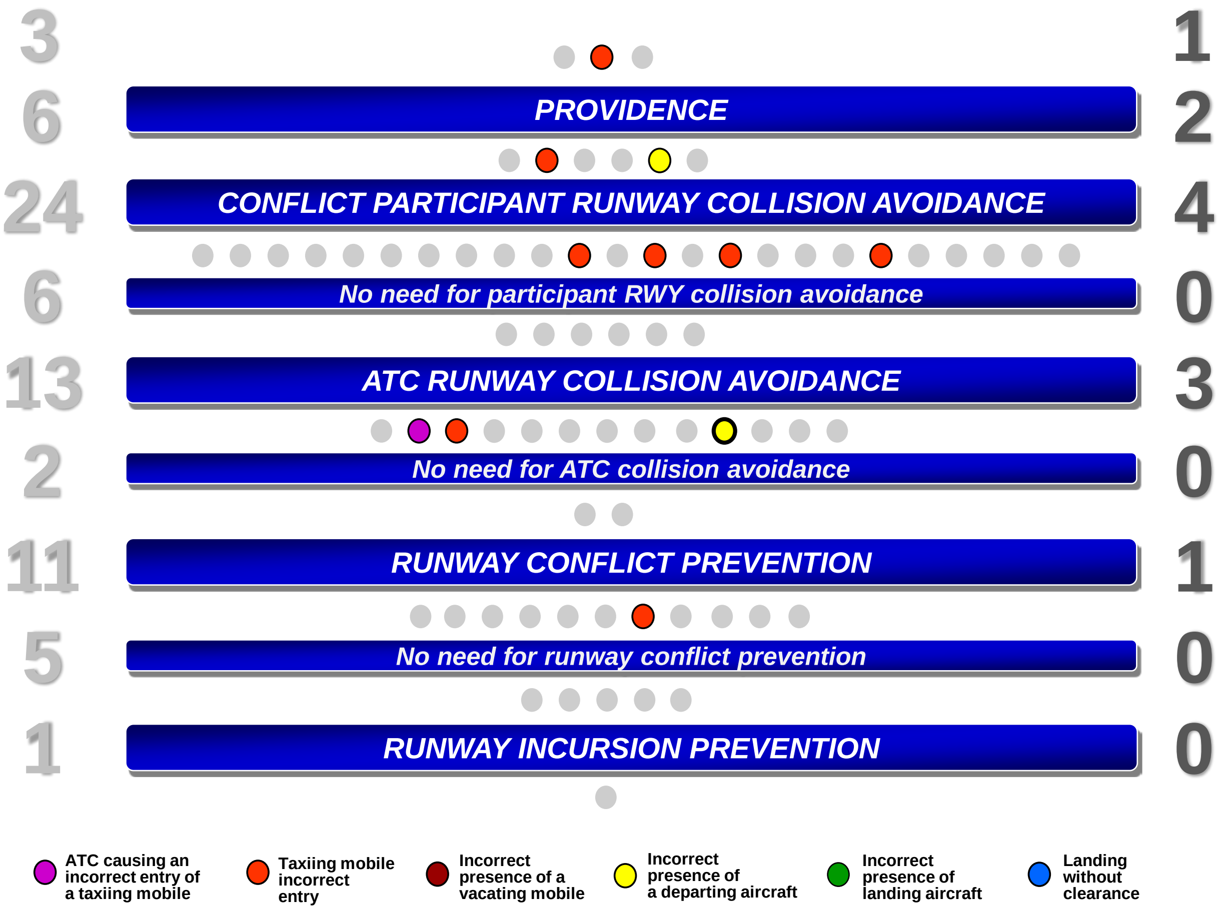

Figure 16: Events with ASMGCS issue

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier in which there was an issue with the use of the installed A-SMGCS.

3.11 Events during OJT

Figure 17 below identifies the events that occurred during OJT in the ATC tower. The sample includes 8 events that represent 11% of the total number of analysed events.

In the majority of the investigated events the ongoing OJT was identified as relevant to the occurrence. It is to be noted that half of the events are of higher severity, including one runway collision.

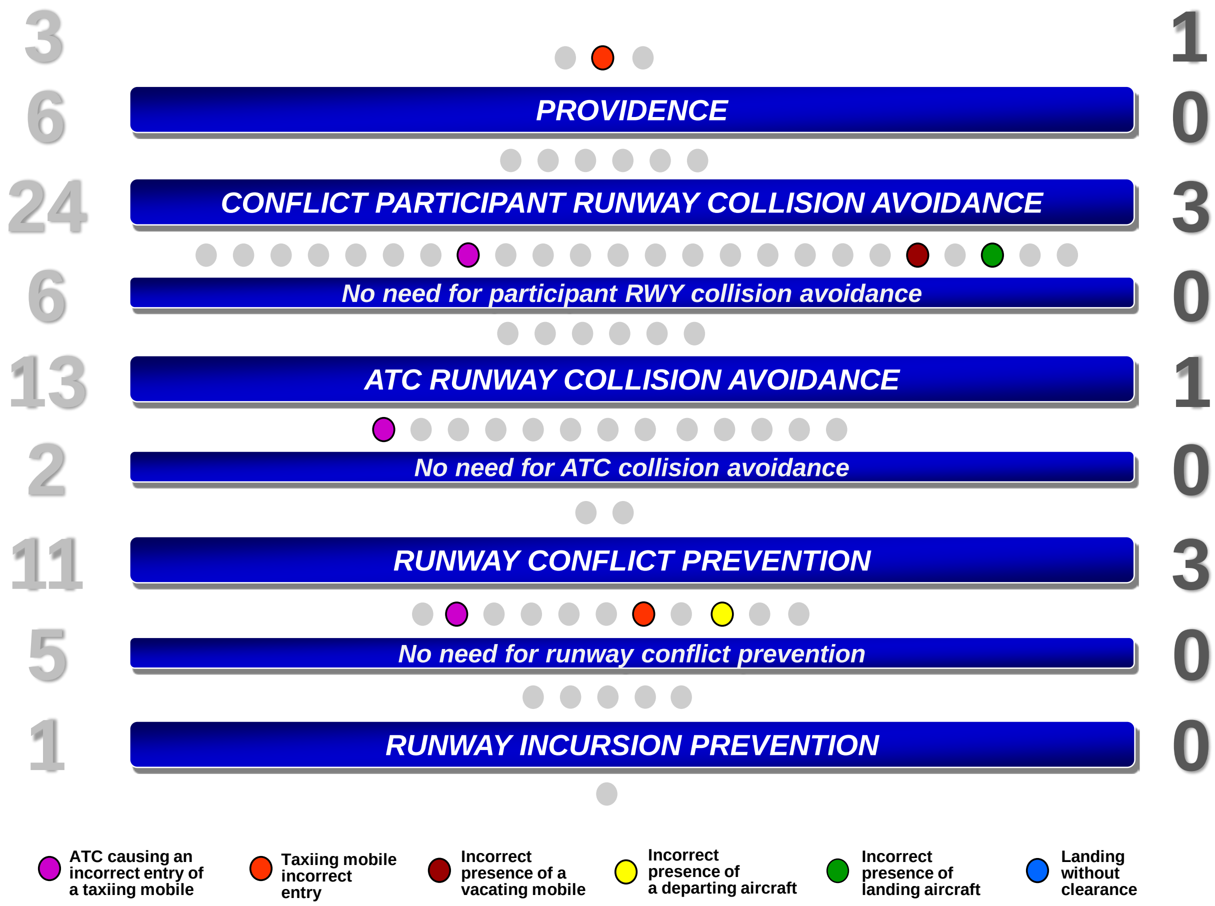

Figure 17: Events during OJT

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier which occurred during OJT in the ATC control tower.

3.12 Events related to runway configuration change

The events in which the runway configuration change was reported as a factor are illustrated in Figure 18 below. They represent nearly 10% of the total number of analysed events.

In all but one event the initiating factor is incorrect entry of a mobile into the runway protected area caused the ATC. It is to be noted that nearly half of the events are of higher severity, i.e. have been stopped by the 'Conflict participant collision avoidance barrier'.

The limited number of this type of event in the analysed sample does not allow drawing firm and well justified conclusions.

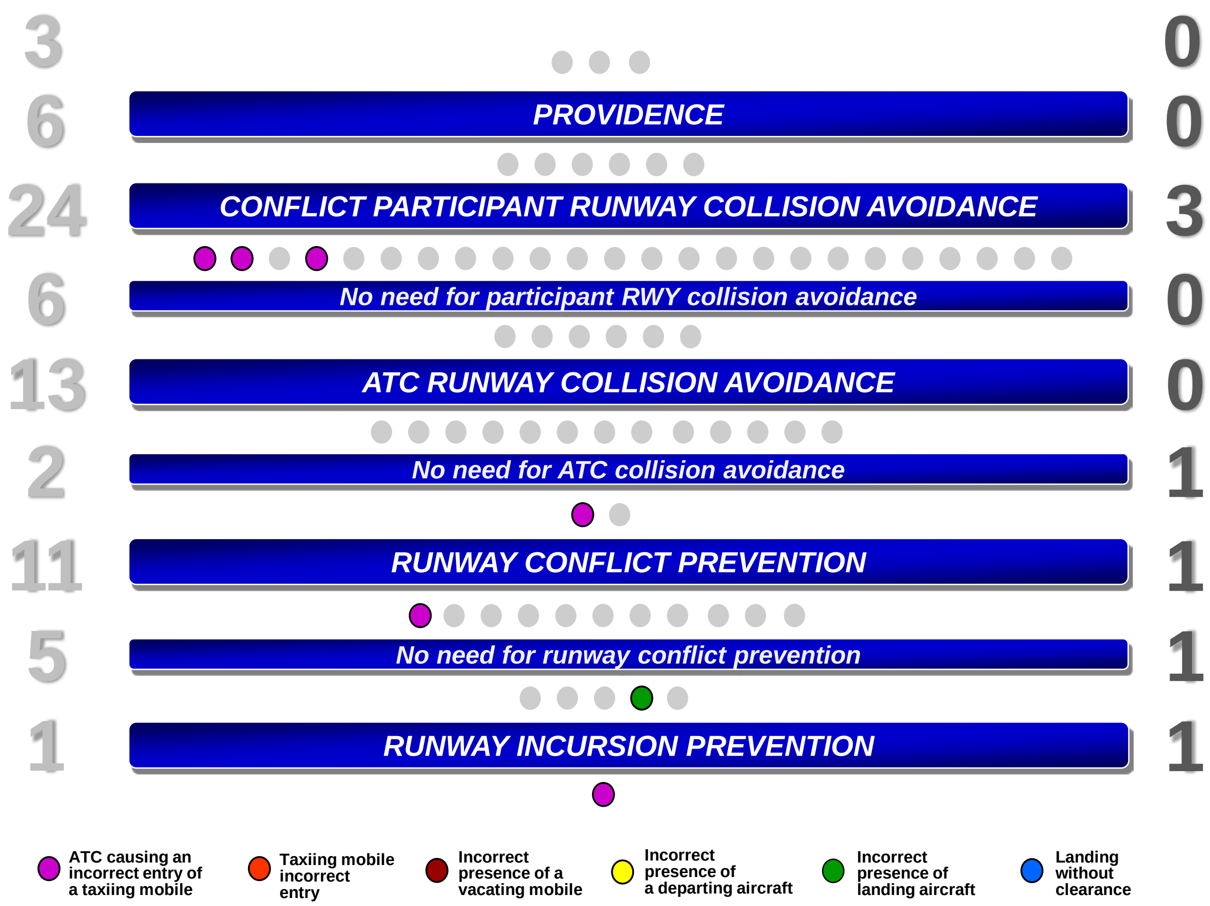

Figure 18: Events related to runway configuration change

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier in which the runway configuration change was reported as a factor.

3.13 Taxiing mobile incursion conflicts – other participants

Figure 19 below provides information about the other participant in a runway conflict caused by the incorrect presence of a taxing mobile in the runway protected area. This other participant is a landing or taking off aircraft with almost equal share - 19 events involving landing and 17 events involving taking off aircraft.

The conflicts with the participation of departing aircraft appear to be of higher severity – 2 events were stopped by the 'providence' and 2 resulted in runway collisions.

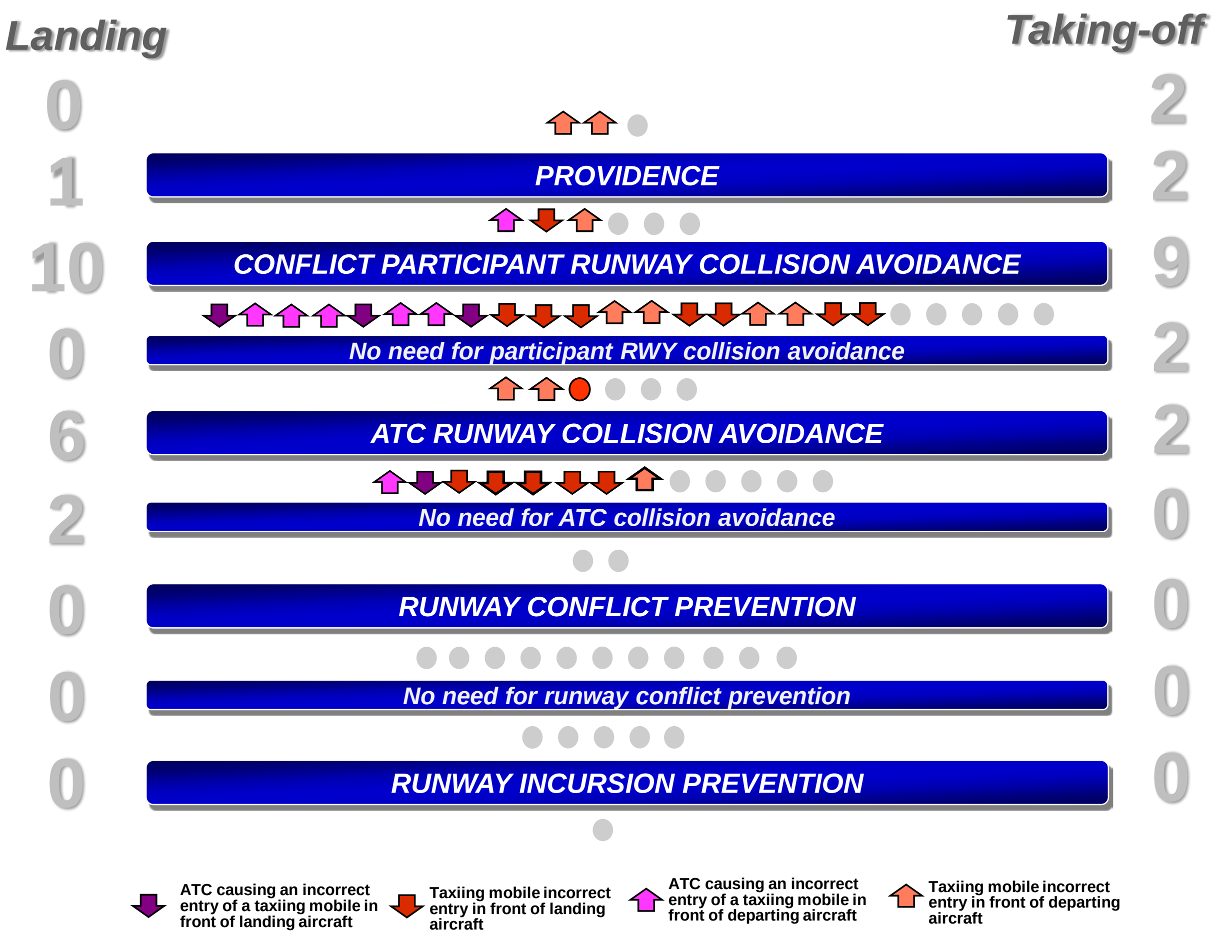

Figure 19: Runway conflict events involving taxiing mobile

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier in which the other participant was a landing aircraft. The number shown to the right of a barrier bar identifies the number of events stopped by that barrier in which the other participant was a taking off aircraft.

4. PERFORMANCE OF THE RUNWAY INCURSION PREVENTION BASIC BARRIER

4.1 Incorrect entry of taxiing mobile into the RWY protected area

The incorrect entry of a taxiing mobile into the RWY protected area is the strongest initiator in the analysed sample of RI events. It accounts for 45 % of the sample events. As illustrated in Figure 20 below the factors with the highest contribution to the incorrect runway entry are communication issues (misunderstanding), positional confusion and incorrect execution of ATC clearance (non-compliance).

The above finding is consistent with the related finding of the SAFMAP analysis of the reported RI incidents in Europe for the years 2013 – 2015.

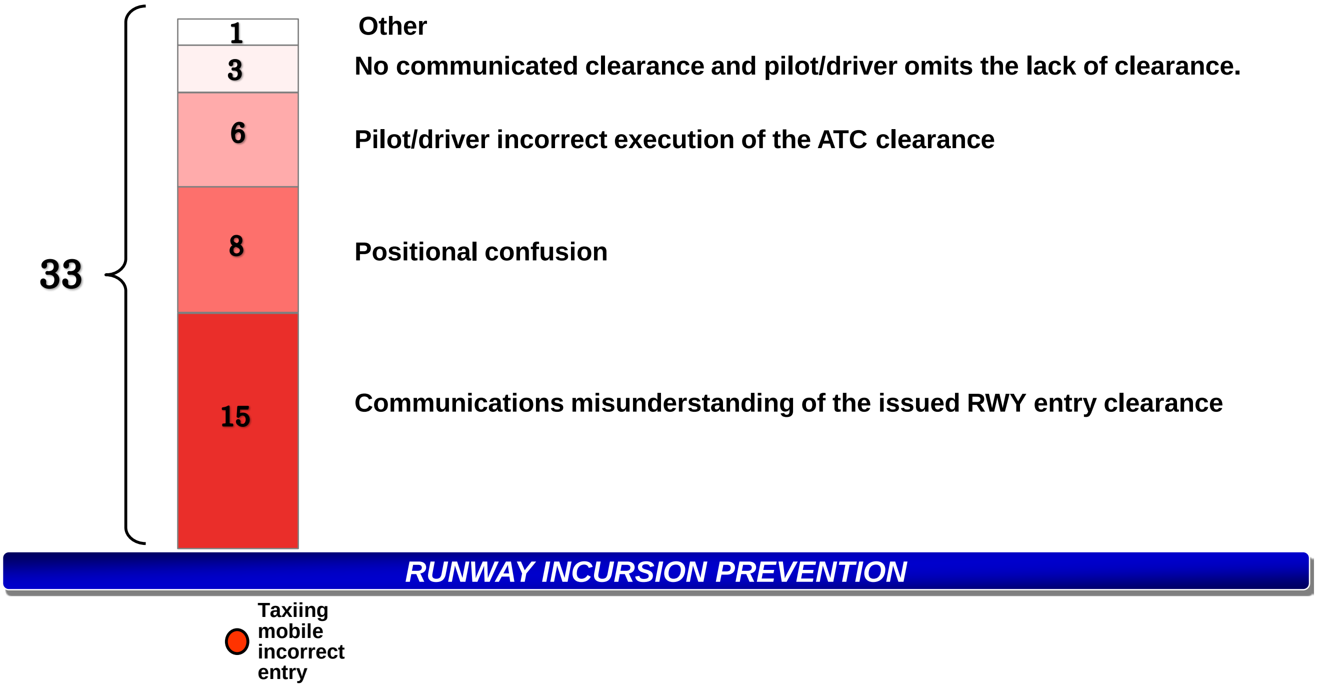

Figure 20:

Incorrect entry of a taxiing mobile into the RWY protected area – factors

More than the half of the events involving communication misunderstanding passed through the ATC barriers. As shown in Figure 21 below, nearly 55 % of these events were stopped by the conflict participant barrier and providence, and two events resulted in runway collision.

A particular causal factor could not be singled out as the main contributor to the high severity events in the analysed data sample.

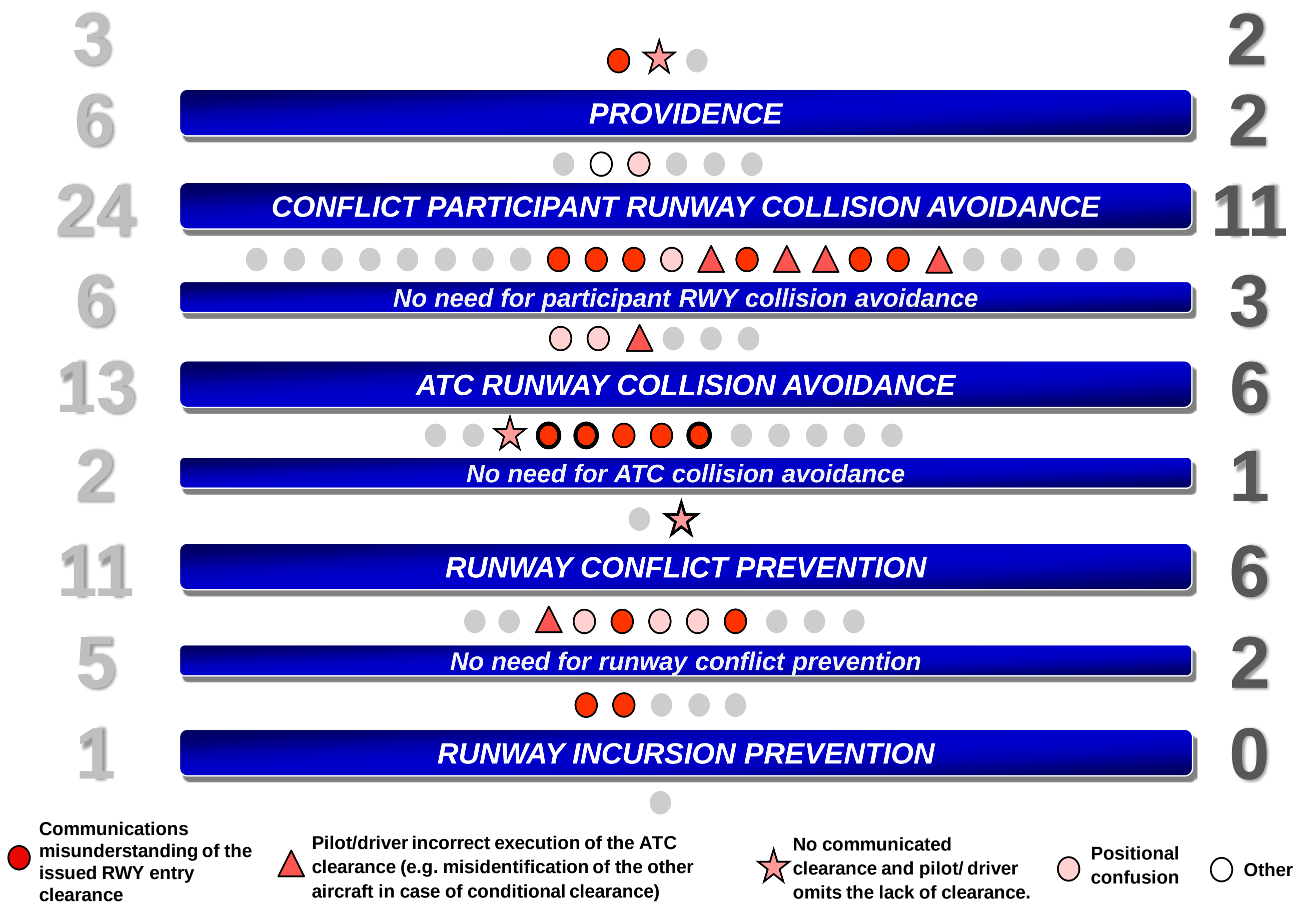

Figure 21:

Incorrect entry of a taxiing mobile into the RWY protected area – barrier resilience

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events initiated by an incorrect entry of a taxiing mobile into the runway protected area and stopped by that barrier.

4.2 ATC causing an incorrect entry of a taxiing mobile

Incorrect presence of a taxiing mobile in the runway protected area caused by ATC is the second important initiator of runway incursions in the analysed sample. The 15 events account for 20% of the analysed sample of reported events. This differs from the related finding of the SAFMAP analysis of the reported RI incidents in Europe for the years 2013 – 2015. In the latter study the incorrect presence of taxiing mobile in the runway protected area was identified as the fifth important initiator of runway incursions.

As shown in Figure 22 below, the two main causes of the 10 events when ATC caused incorrect entry of a taxiing mobile into the runway protected area are incorrect plan of work (5 events) and inadequate detection or interpretation of the potential runway conflict. This finding is fully in line with the related finding of the above referenced study of RI events in Europe.

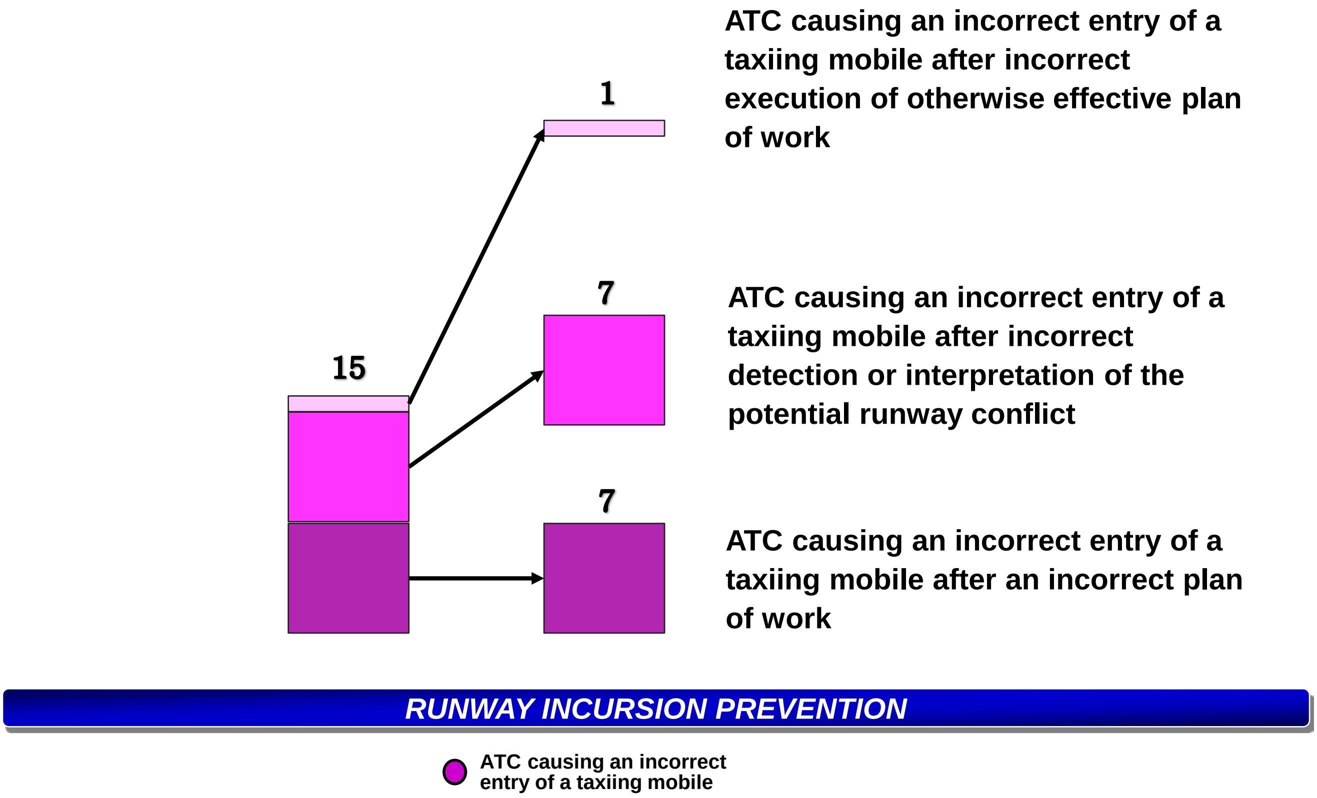

Figure 22:

ATC causing incorrect presence of a taxiing mobile – factors

The resilience of the basic safety barriers to the initiator “ATC causing an incorrect entry of a taxiing mobile” is shown on Figure 23 below.

The majority of this type of event are of high severity - half of the events were stopped by the ‘conflict participant collision avoidance barrier’ and one event did not turn into runway collision due to ’providence’. The two main causal factor discussed above appear to have equal contribution to the high severity events.

Figure 23:

ATC causing incorrect presence of a taxiing mobile – barrier resilience

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events initiated by incorrect presence of a taxiing mobile caused by ATC and stopped by that barrier.

4.3 Incorrect presence of a departing aircraft

Incorrect presence of departing aircraft in the runway protected area is the third important initiator of runway incursions in the analysed sample. The 11 events account for 15% of the analysed sample of reported events. This finding is consistent with the related finding of the SAFMAP analysis of the reported RI incidents in Europe for the years 2013 – 2015.

As illustrated by Figure 24 below, ATC is the main causal factor of this group of events. In 64% of the cases (11 events) involving incorrect presence of a departing aircraft ATC did not ensure that the runway is not going to be occupied during the take-off. Also, in one case ATC issued take-off clearance for a closed runway. This error could have been corrected by the use of standard R/T phraseology; use of single frequency to manage traffic on the manoeuvring area; optimal tuning of the function alerting of occupied runway; better use of surveillance and runway status information available in the TWR; and visual traffic monitoring.

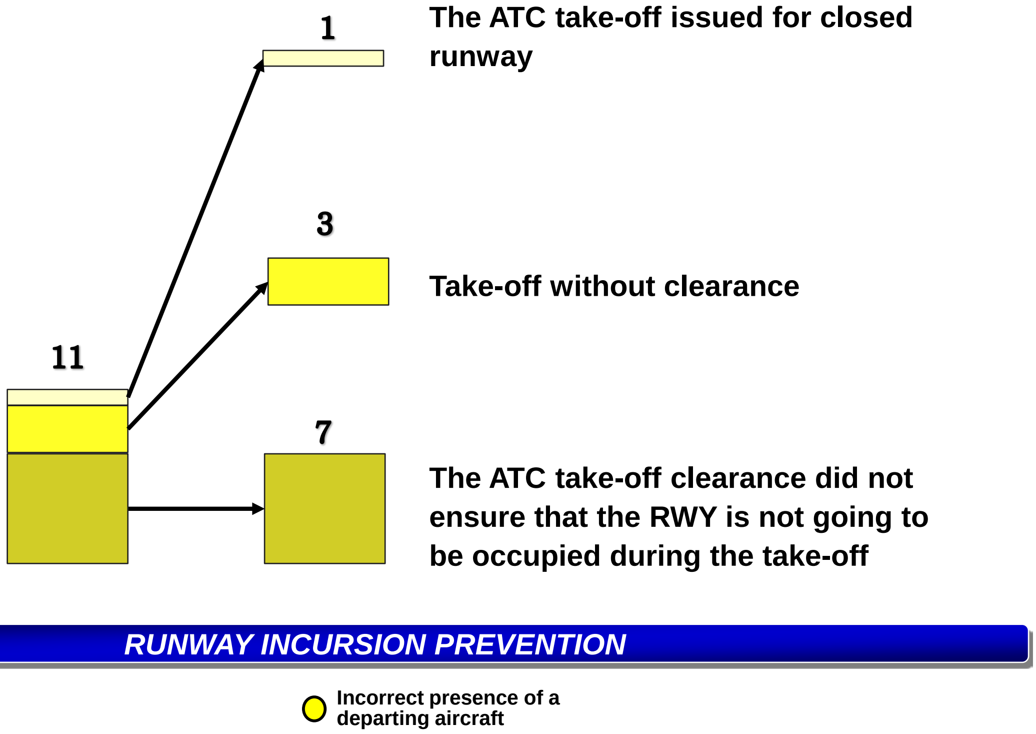

Figure 24: Incorrect presence of a departing aircraft – factors

The resilience of the basic safety barriers to the initiator “Incorrect presence of a departing aircraft” is shown on Figure 25.

Most of the events (73%) involving incorrect presence of departing aircraft required collision avoidance either by ATC or the conflict participant. In the 3 events of highest severity (in two cases ‘providence’ prevented a runway collision) the initiator was ATC who did not ensure that runway was clear during the take-off.

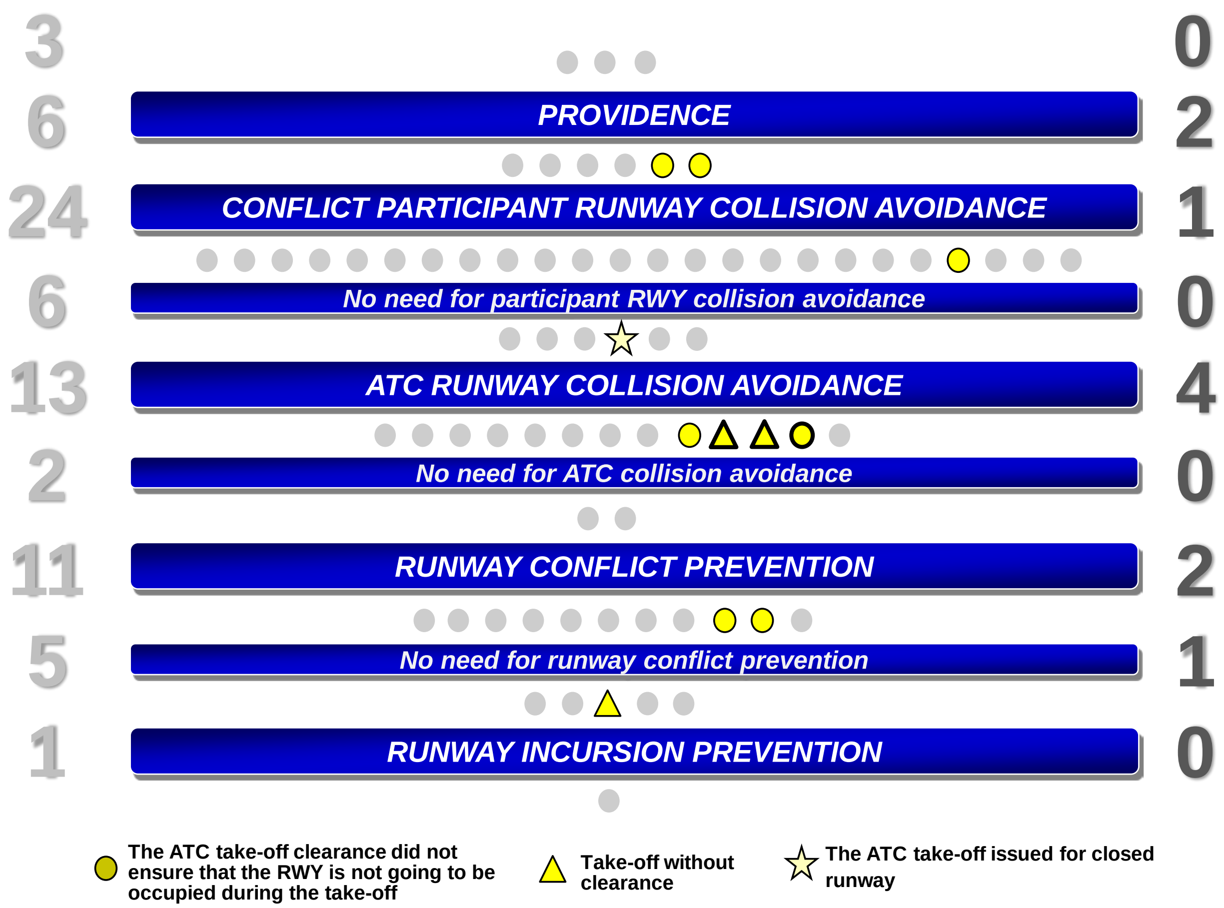

Figure 25: Incorrect presence of a departing aircraft – barrier resilience

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events initiated by incorrect presence of departing aircraft and stopped by that barrier.

4.4 Incorrect presence of landing aircraft

Incorrect presence of landing aircraft is the fourth important initiator of runway incursions in the analysed sample. The 7 events account for 10% of the analysed sample of reported events. This differs from the related finding of the SAFMAP analysis of the reported RI incidents in Europe for the years 2013 – 2015. In the latter study the incorrect presence of landing aircraft in the runway protected area was identified as the second important initiator of runway incursions.

As shown in Figure 26 below, the most important factor for the incorrect presence of landing aircraft is because ATC did not provide correct and timely landing clearance leading to the landing aircraft incorrectly passing beyond the specified spacing limits or entering the RWY protected area.

Note: The spacing limits are locally defined and may vary – for example 4NM, RWY threshold, distance from RWY threshold when the clearance to land is issued, etc.

The limited number of this type of event in the analysed sample does not allow carrying out a more in-depth analysis and draw firm and well justified conclusions.

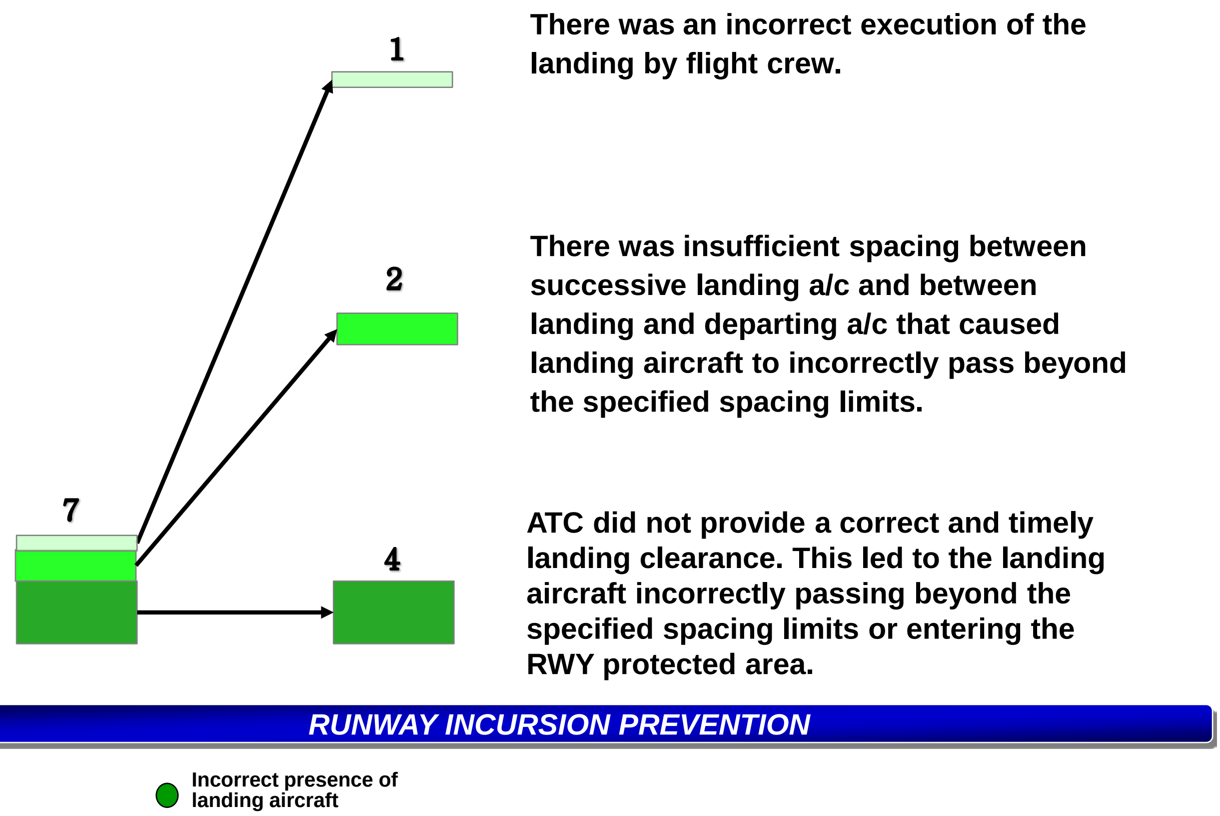

Figure 26: Incorrect presence of landing aircraft – factors

Landing without clearance can be regarded as a particular kind of incorrect presence of landing aircraft in the runway protected area. This type of events is separately illustrated in Figure 27 overleaf to provide additional insight.

The number of these events is very limited to allow for well-grounded conclusions. Notwithstanding, the comparison with the findings of the SAFMAP analysis of the reported RI incidents in Europe for the years 2013 – 2015 justifies the finding that runway confusion and loss of communication are major factors contributing to landing without clearance.

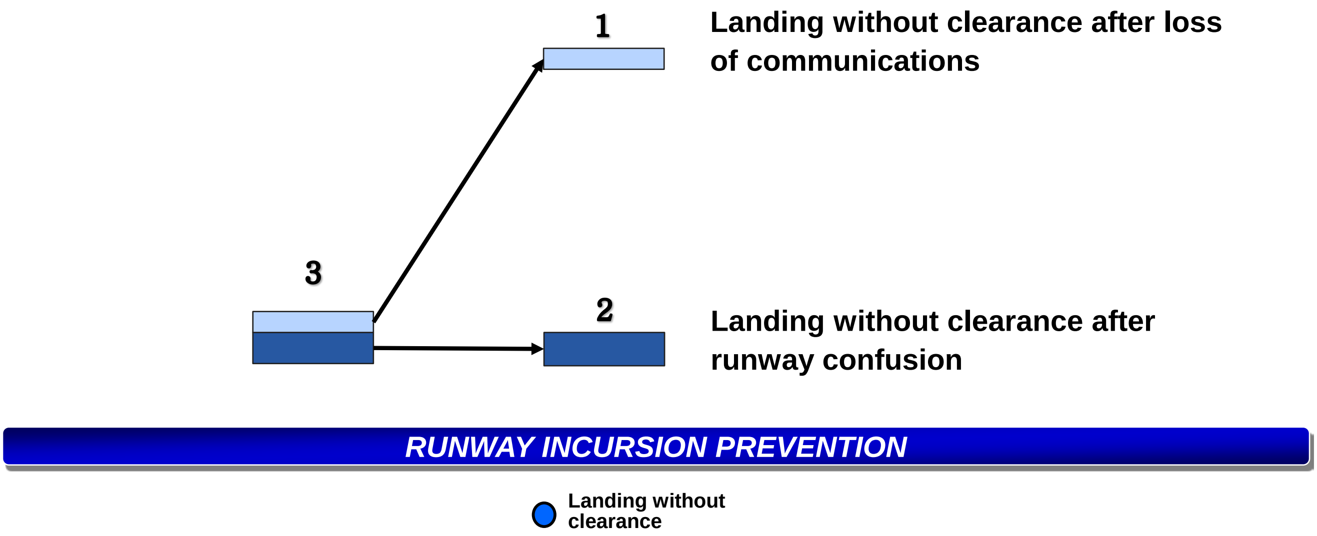

Figure 27 : Landing without clearance – factors

The resilience of the basic safety barriers to the initiators “Incorrect presence of landing aircraft” and “Landing without clearance” is illustrated by Figure 28 overleaf.

ATCOs not providing correct runway clearances and the insufficient spacing between successive landings and between landing and departing aircraft are the main causes of this type of event and have resulted in high severity outcomes, including one runway collision.

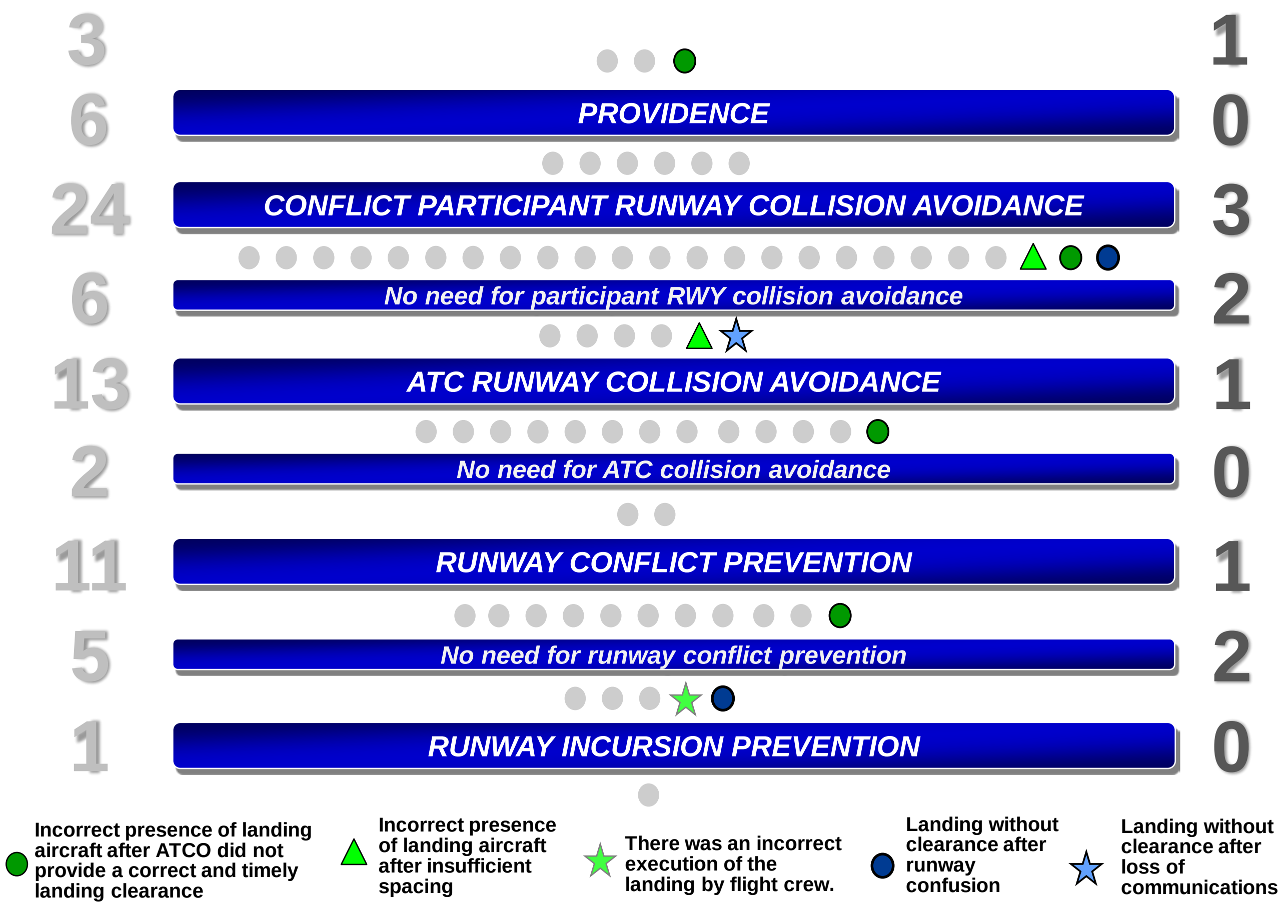

Figure 28:

Incorrect presence of landing aircraft (including landing without clearance) – barriers resilience

The number shown to the left of a barrier bar identifies the total number of events stopped by that barrier. The number shown to the right of a barrier bar identifies the number of events initiated by incorrect presence of landing aircraft and stopped by that barrier.

5. PERFORMANCE OF THE RUNWAY CONFLICT PREVENTION BASIC BARRIER

5.1 Runway incursions that turned into runway conflicts

The second basic safety barrier 'Runway Conflict Prevention' was challenged 70 times; it prevented the runway conflict in 16 of the analysed events (23 % efficiency) and failed 54 times (77% failure rate). As illustrated by Figure 29 below, in 37 events (53 %) when the barrier failed, the clearance for the intended RWY use had already been given prior to the incorrect entry into the RWY protected area and there was no opportunity for ATC to prevent the runway conflict.

ATCO conflict prevention barrier was challenged 23 times. When challenged (runway incursion leading to potential conflict), it worked five times and failed 18 times. In 12 out of these 18 cases when conflict prevention by the ATCO failed, the conflict participants also failed to identify and prevent the runway conflict.

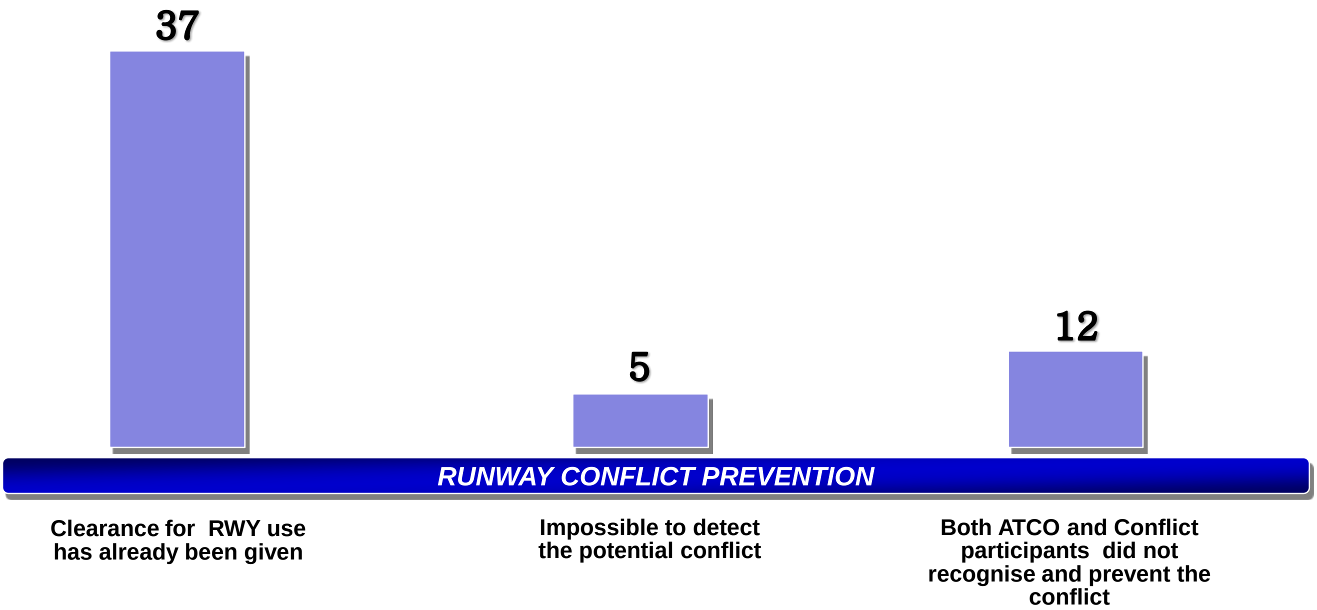

Figure 29: Runway incursions that turned into runway conflicts - causes

The relatively low performance of this barrier found by this study is consistent with the findings of the SAFMAP analysis of the reported RI incidents in Europe for the years 2013 – 2015.

5.2 Initiators of scenarios involving clearance for RWY use already given

The “zoom” into the 37 events that involved clearance for RWY use already given (to the other conflicting mobile) provided in Figure 30 shows that the distribution of the initiators in the overall sample of runway incursion events (illustrated by Figure 6, section 2.2) is very similar to the distribution of the initiators of the runway incursion events that occurred when runway use clearance was already issued to the other participating mobile.

This finding is consistent with the correlation established by the SAFMAP analysis of the reported RI incidents in Europe for the years 2013 – 2015.

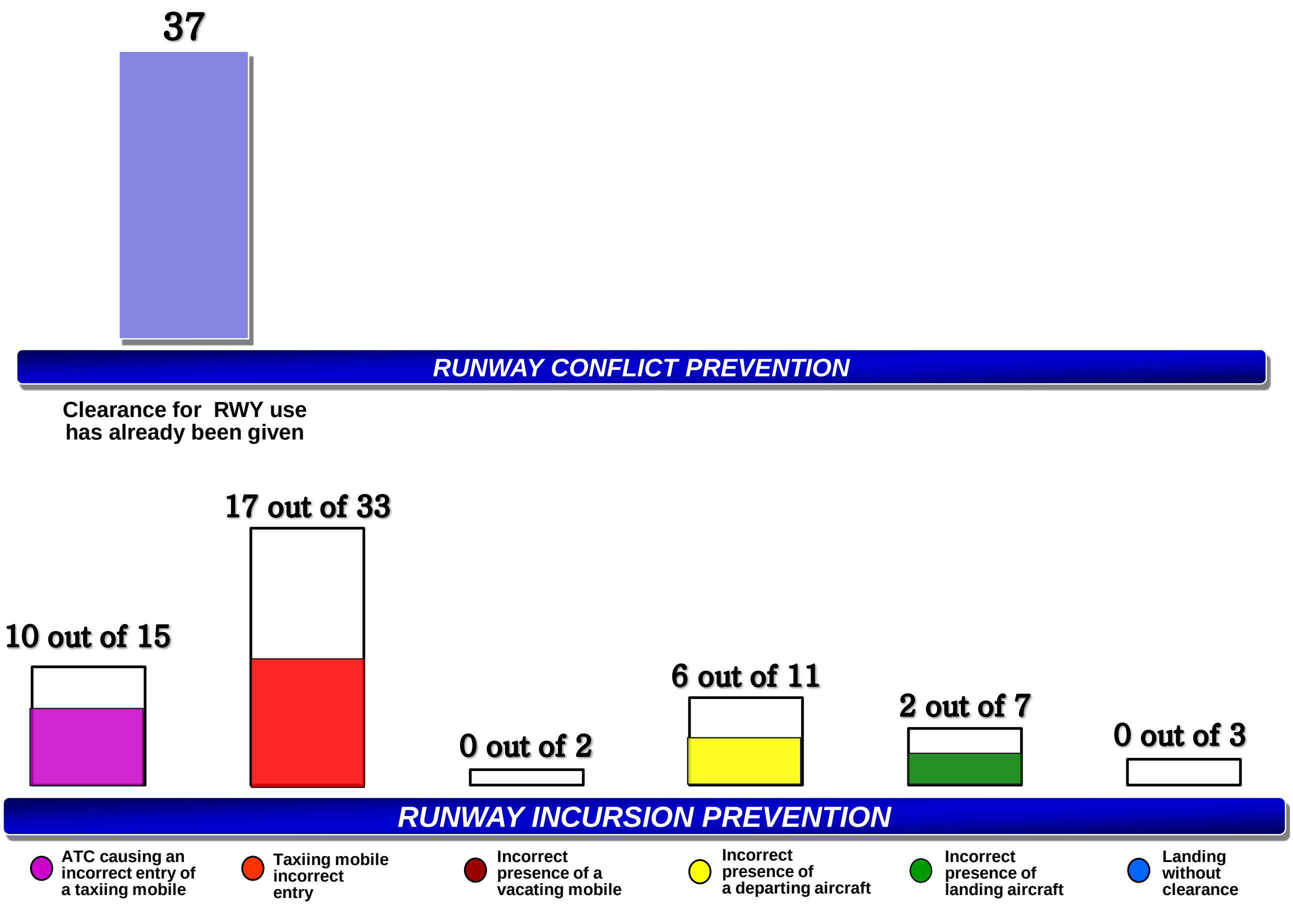

Figure 30:

Initiators of scenarios involving ‘clearance for RWY use already given’

5.3 Initiators of scenarios involving ATCO not recognising and preventing the conflict

ATCO conflict prevention barrier was challenged 23 times. When challenged (runway incursion leading to potential conflict), it worked 5 and failed 18 times.

As illustrated by Figure 31 below, the initiators and their relative share are very similar to the distribution in the scenarios when runway use clearance was already issued to another mobile.

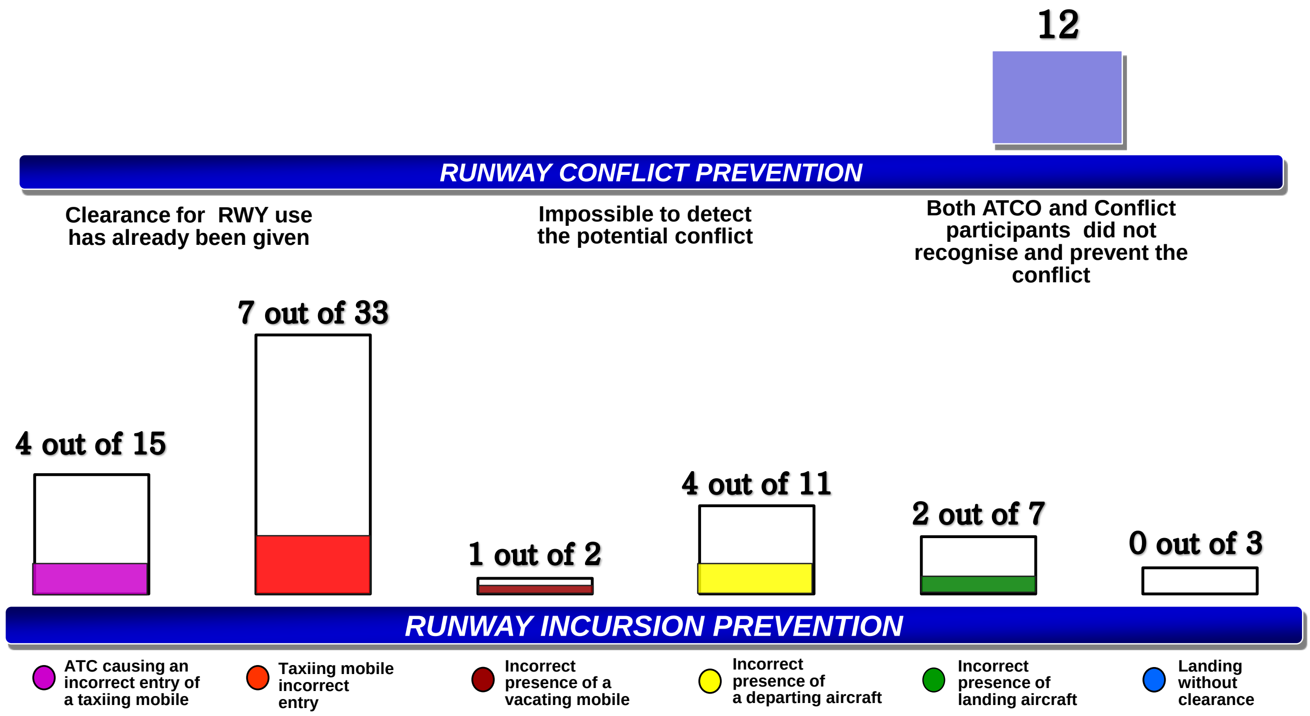

Figure 31:

Initiators of scenarios involving 'ATCO not recognising and preventing the conflict'

5.4 Initiators of scenarios when conflict detection was not possible

In the analysed data sample, the initiators of scenarios, when conflict detection was not possible, are incorrect entry onto the runway by a taxiing mobile and landing without clearance (see Figure 32 below).

The limited number of events (in the analysed data sample) when conflict detection was not possible does not fully support the conclusion that the above mentioned causal factors are representative for this scenario.

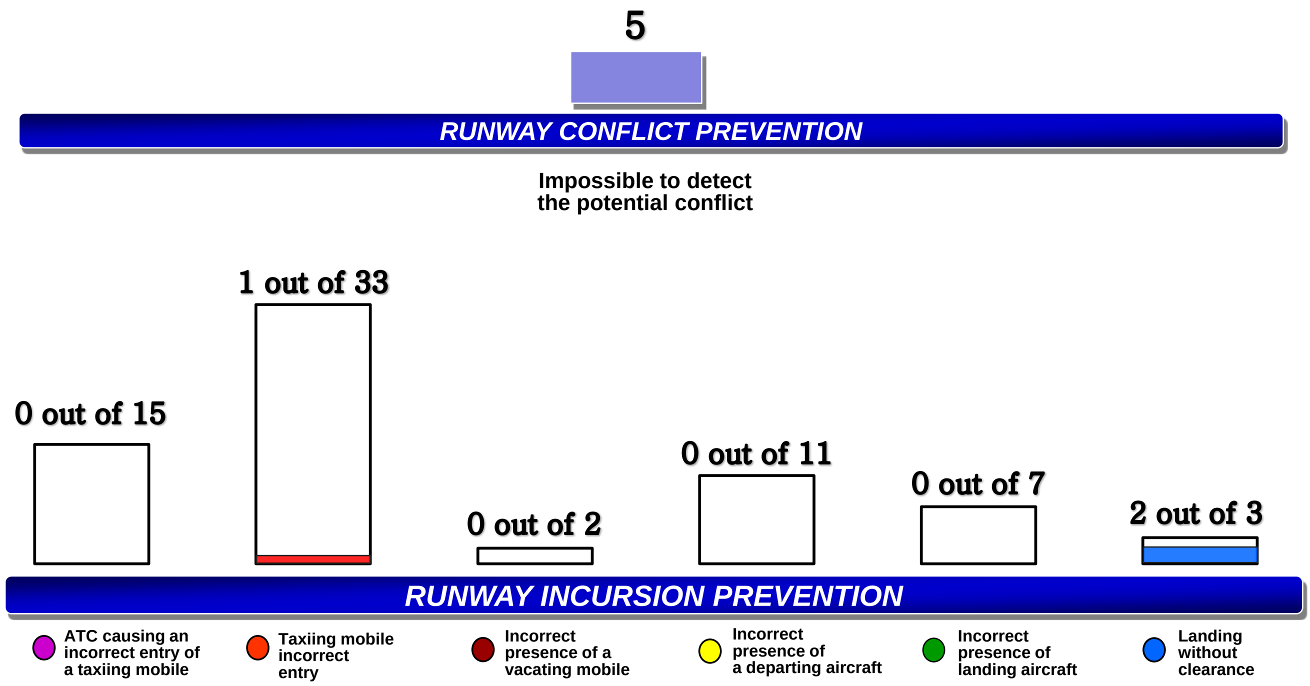

Figure 32:

Initiators of scenarios when conflict detection was not possible

6. PERFORMANCE OF THE ATC RUNWAY COLLISION AVOIDANCE BASIC BARRIER

6.1 Conflicts not resolved by ATC runway collision avoidance

As shown in section 2.1, the 'ATC runway collision avoidance' barrier has a rather low recorded efficiency of 28 %. It has been challenged 54 times and worked 15 times.

As illustrated by Figure 33 below, two main factors contributing to the barrier's failure stand out:

- ATCO did not detect or did not interpret correctly the runway conflict, and
- Insufficient time for ATCO reaction following conflict detection.

In order to improve the overall performance of this barrier, means and measures to improve timely conflict detection by ATCO (e.g. A-SMGCS) could be considered.

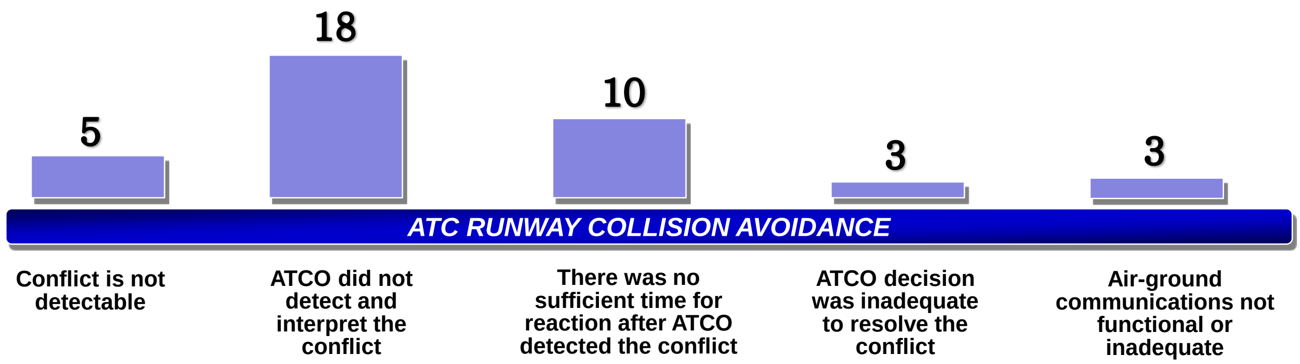

Figure 33:

Runway conflicts not resolved by ATC runway collision avoidance - causes

6.2 Scenarios of inadequate conflict detection and interpretation by ATCO

Figure 34 below provides an insight in the recorded causal factors for the inadequate conflict detection and interpretation by ATCO. Failure to detect the conflict is likely preceded by a failure to detect the potential conflict.

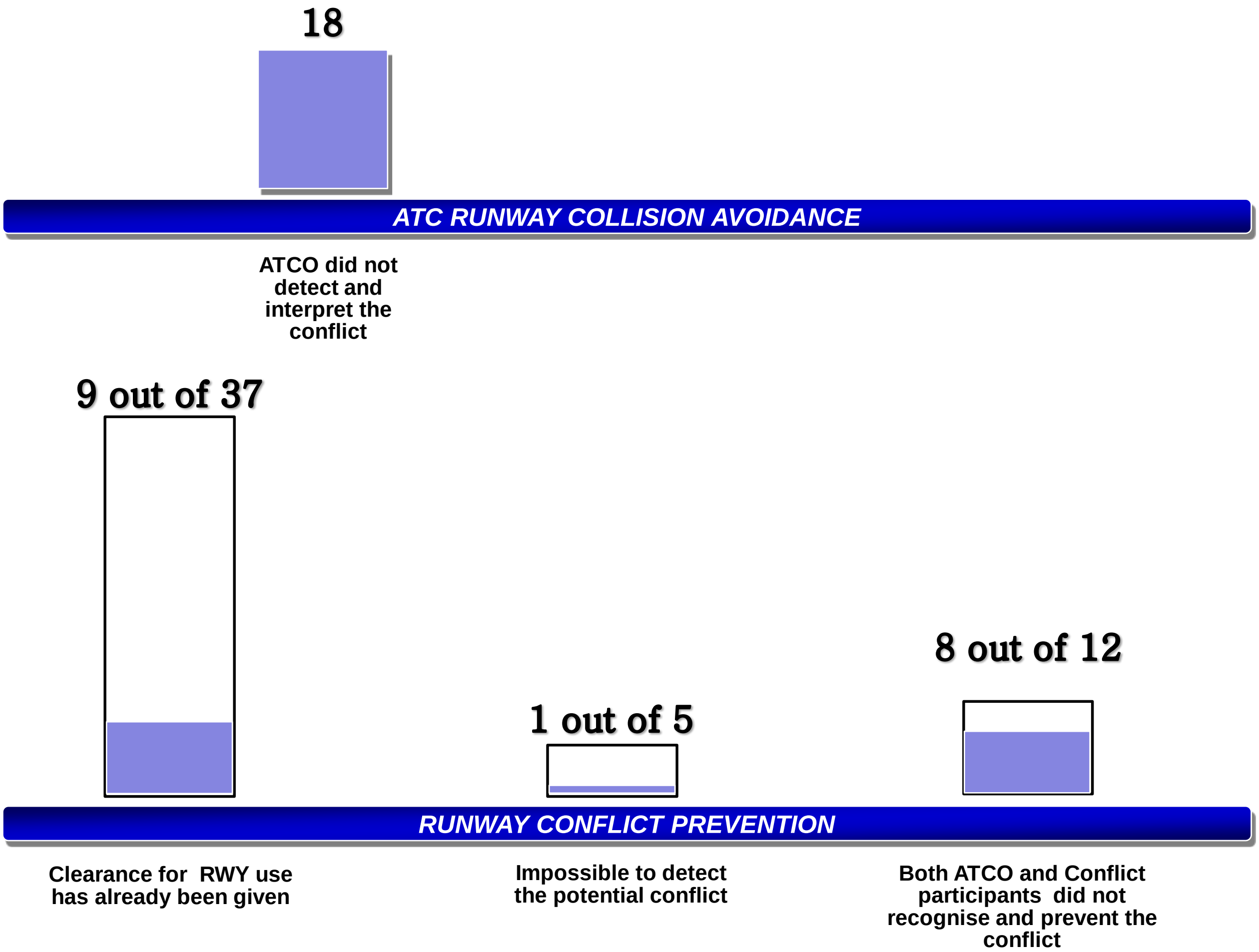

Figure 34:

Initiators of scenarios involving inadequate conflict detection and interpretation by ATCO