Runway incursions – clear and constant danger

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DOI: 10.13111/2066-8201.2014.6.3.7

Abstract: *Runway safety plays an important role in aviation industry. This paper deals with runway safety – runway incursion as a serious safety concern. Focusing attention on this issue is necessary due to many collisions with a significant loss of life and many aircraft damages. The first paragraph deals with general information about runway incursions with concentration on statistical overview of runway incidents. The second paragraph describes possible ways of mitigating processes that will lead to decreasing rate of incidents mainly at airports with confusing runway/taxiway orientation, such as Zurich Airport. It also emphasises importance of hot spots identification and subsequently their location at each airport. The last part of this paper deals with practical illustration of runway safety at mentioned Zurich Airport due to its confusing emplacement of runways and taxiways. Not less important are also positions of Action Plans and Action Teams at the point of solving problems related to runway incidents. Briefly, runway safety is an ongoing effort and we are committed to finding ways of making a safe system even safer. In addition to current runway safety initiatives, the following efforts will further the progress of increasing runway safety over the next several years.*

Key Words: *runway incursions, ATC clearance, vehicle deviation, pilot deviation, hot spots.*

1. INTRODUCTION

Runway safety is a vital component of the aviation safety as a whole – with the expected grows of air traffic sheer numbers of incidents are bound to rise, unless held in check by pragmatic, sensible solutions. It is indispensable that improvements come from attention to detail. Runway Incursions (RI) are dangerous for all flight operations. One RI happens every day at European airports. In this case, flight crew, ATC members and other personnel play a significant role in helping to reduce the human factor elements that contribute to an accident. Moreover, major progress has been made in the runway safety area. For instance, in 2012 we could see a significant reduction in runway-related accidents where decreasing rate was 21% when compared to 2011. Also, the global accident rate involving scheduled commercial operations decreased to 3.2 accidents per million departures. Despite the above mentioned facts, we still have to be careful and concentrate ourselves on the effort to keep as low as possible the numbers of incidents, because safety is a top priority.

2. RUNWAY INCURSIONS OVERVIEW

The risk of a runway incursion is still a serious problem. Fortunately, this problem has been exhaustively studied by dozens of experts and many mitigating processes have been applied. ICAO organisation defines runway incursion as *any unauthorised presence on runway,*

regardless of whether or not an aircraft, vehicle or pedestrian presents a potential conflict to an aircraft authorised to land, take-off, or taxi on a runway (ICAO Doc 444 – PANS-ATM). [1]. Typical scenarios of runway incursions are described below:

- *ATCO (AIR Traffic Control Officer)- related situation*

Low visibility procedures mainly due to fog, controller gives a clearance to an Aircraft without subsequently checking for a correct read-back from the flight crew who have misunderstood the instructions.

Without checking the location of the first aircraft, which has entered the active runway contrary to clearance and at an intermediate point, the controller clears a second aircraft for a full-length take-off.

- *Flight Crew-related situation*

An aircraft lands at an unfamiliar airport and the flight crew becomes disoriented when they exit the runaway. Then the situation leads to not being confident of their position and instead of taxing, they inadvertently enter an active runway.

- *Driver-related situation*

It is related to driver who enters and starts to operate at an airside without an escort, and after that it enters an active runway without first obtaining ATC clearance.

Many of mentioned situations happen due to related factors, such as weather, multiple simultaneous line-ups, simultaneous use of intersecting runways, and use of non-standard phraseology, concurrent use of more than one language for ATC communications or just distraction. All this is dangerous and it is necessary to communicate properly and then avoid the runway incidents. [2] [4].

We recognise 3 categories as can be seen below:

1.) *Vehicle/pedestrian deviation (V/PD)* – when a vehicle or person causes the incursion
2.) *Operational error (OE), Operational Incident (OI)* – a mistake caused by ATC or related incidents.
3.) *Pilot deviation (PD)* – when the pilot is at fault. Additional focus has been given to the General Aviation (GA) community, because the largest portion of runway incursions involves GA pilots, as it is shown in *Figure 1* below.

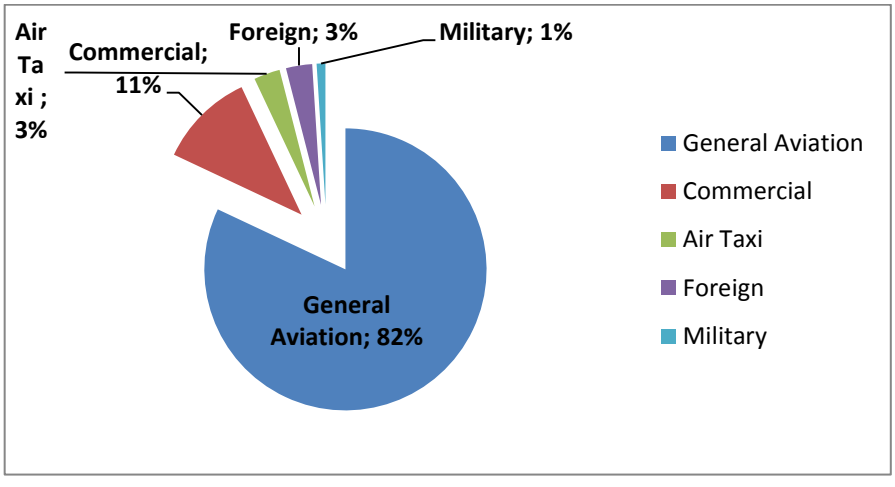

Figure 1 – Pilot deviation in different type of aviation industry [3]

Moreover, the FAA further categorises runway incursion events by severity is shown in *Figure 2* below.

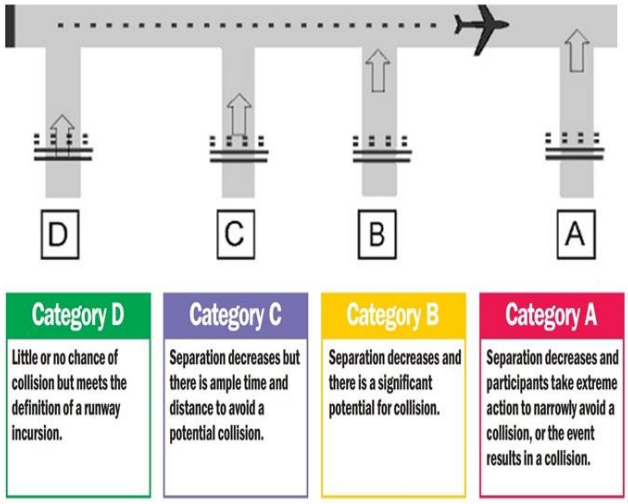

Figure 2 – Illustration of runway incursion severities [2]

As a matter of fact, runway-incursion occurrences happened most frequently in the following scenarios (*Figure 3*).

Scenarios	***Percentage***
Aircraft surface movement where TWY crosses a RWY	33%
Simultaneous take-off and landing operations on the same RWY	11%
Taking off or landing on the wrong parallel RWY or lining up for take-off on the wrong parallel RWY	13%
Take-off and landing occurring simultaneously on intersecting RWYs	13%

Figure 3 – Breakdown of frequent scenarios of RIs [1]

Further to this, according to FAA statistics we can see breakdown of total RIs in the following time periods, as can be seen in *Figure 4.*

Year	**OE/OI**	**PD**	**V/PD**	**Other**	**Total**
2014	204	588	188	8	**988**
2013	243	783	211	4	**1241**
2012	57	722	200	2	**1150**
2011	178	593	183	0	**954**
2010	156	629	181	0	**966**
2009	153	599	199	0	**951**

Figure 4 – Breakdown of frequent scenarios of RIs [compiled by author]

According to *Figure 4* above, we can see decreasing rate of runway incursion in 2014 compared to 2013. And the similar decreasing rate is notable in 2011 compared to 2012. We can say that all measures that were proposed by FAA lead to mitigation of runway incidents. On the other hand, we should focus on improvement of crew operations because the biggest percentage of incidents is caused by crew deviations, as can be seen in the next paragraph.

However, another analysis of data from 71 RIs occurrences (aircraft-aircraft) worldwide shows the following:

1.) 70% involved crew deviations from standard operating procedures

2.) 46% are related to failure caused by an ATC to provide separation

3.) 34% are related to darkness or twilight (in comparison with daylight conditions it is 2-times higher)

4.) 23% of occurrences were in visibility less than reported runway visual range of 1,200 ft. [2]

In brief, RIs are the consequence of multiple operational and/or environmental factors. One of the most serious contributing factors is the crew lack of situational awareness during airport surface operations, induced by weather considerations, by complex airport factors or by crew technique itself. ICAO identified 3 high-risk occurrence categories:

1.) Runway safety-related events (it consists of abnormal RWH contact, Bird Strikes, Collision with Obstacle…)

2.) Loss of control in-flight,

3.) Controlled flight into terrain.

A lot of serious incidents we could see in the past, such as:

1. April 2010 – Piper PA28 entered RWY25 at Taxiway F without clearance whilst a LET 410 was on rotation same RWY abeam Taxiway G.
2. January 2011 – ATC unable to raise approaching aircraft. DHC Dash 8 was lined up on RWY for take-off. Socata TBM700 passed over the top of the Dash 8 without clearance to land.
3. May 2011 – aircraft crossed active RWY in front of the departing aircraft. Departing aircraft aborted take-off at 120 knots to avoid collision.
4. August 2012 – Lufthansa A320 from Frankfurt to Prague had been cleared to land on RWY 24 and touched down on RWY 24 and vacate via Taxiway D (the TWY past the intersection with RWY 12) but turned onto RWY 12 instead. [1]

Partly conclusion

Many operational staff has experienced a runway incursion and has contributed to the future prevention of runway incursions through incident reports.

The result is that the majority of contributory and causal factors are concerned with communication breakdown, ground navigation errors due to inadequate or ambiguous signs and markings and relevant information needed in the cockpit. Besides, communication is again a priority for runway incursion prevention, with new emphasis on visibility and tracking of traffic.

3. MAJOR CAUSES RELATED TO RUNWAY INCIDENTS

To prevent many accidents and to continue with improved processes in aviation safety, we have to look not at the accidents themselves but at the myriad much smaller and less consequential precursor to those accidents. Certainly, one of the major causes is *FOD (Foreign Object Debris).* It is a term used for all of loose bits and pieces that can be found lying around any airport operating surface. Concorde case is a worldwide example. As we know, the most expensive parts to repair are engines and their operating blades with uncorrected damage may suffer a 1, 5% fuel efficiency loss, costing up to $108 per flight. All of this is correlated with engine damage, after that for example, tires can be needed to be replaced at the airport due to tears, punctures or gouges. On top of those active replacements, fully 4% of tires that seemed to be in otherwise good condition fail re-tread due to embedded FOD. For instance, Goodyear data suggest that the cost of embedded FOD come to $7,350 per aircraft per year for a typical wide body yet.

Bird strikes are innocuous. A large airport suffers one bird strike every 3 days. 92% of most strikes cause no damage, but the average cost still comes to $22.741 per strike. Another fact is that 41% of all bird strikes occur on the runway. Of these, up to 50% are caused by birds actually sitting on runway rather than simply flying past. Comparison of selected factors related to runway incidents are shown in *Figure 6.*

PREVENTION OF RUNWAY INCURSIONS

Constantly reducing the likelihood of airplanes colliding with obstructions on airport runways – whether they are other aircraft, vehicles, individuals, or wildlife – is the primary objective of the Runway Safety Group. In this case, we must focus our limited resources on the causal factors with the highest risk of contributing to the likelihood of significant safety events**.** Therefore the ways of reducing runways incursion risks are very important. *Figure 5* presents the possible ways to reduce RIs.

Figure 5 – Diagram of the ways of reducing the RWY incursion [compiled by author]

Moreover, *Hot spot* settlement plays an important role in aviation. It is a runway related problem area or intersection on an airport. Also, it is a complex or confusing taxiway/taxiway or taxiway/runway intersection. Incidents are related to many facts, such as, airport geometry, ground traffic flow, markings, or even human factors impact.

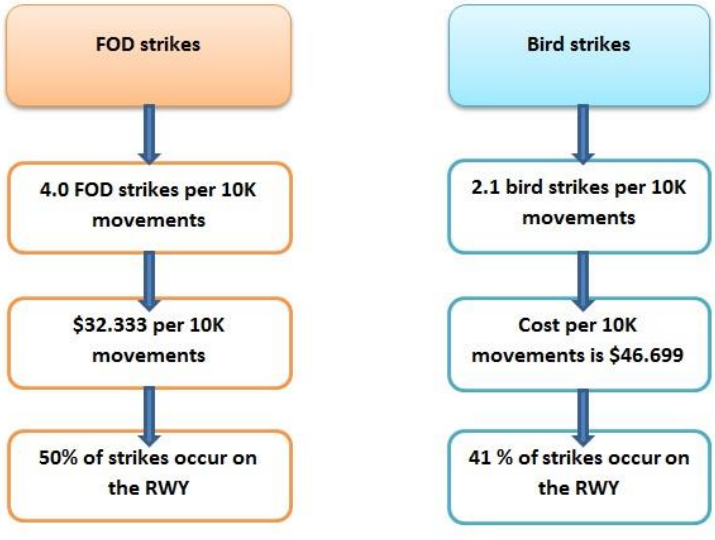

Figure 6 – Illustration of the data related to FOD strikes and Bird strikes [compiled by author]

A confusing condition may be compounded by a miscommunication between a controller and a pilot, and may cause an aircraft separation standard to be compromised.

The important fact is to improve *Taxiway Geometry,* for instance, *3-Node taxiway intersection, TWY/RWY interface, Entrance TWYs.*

Another thing is that by identifying *hot spots,* it is easier for airport users to plan the safest possible way of movement. They also call attention to potentially confusing airport areas so pilots can exercise extra care (*Figure 6*). [7]

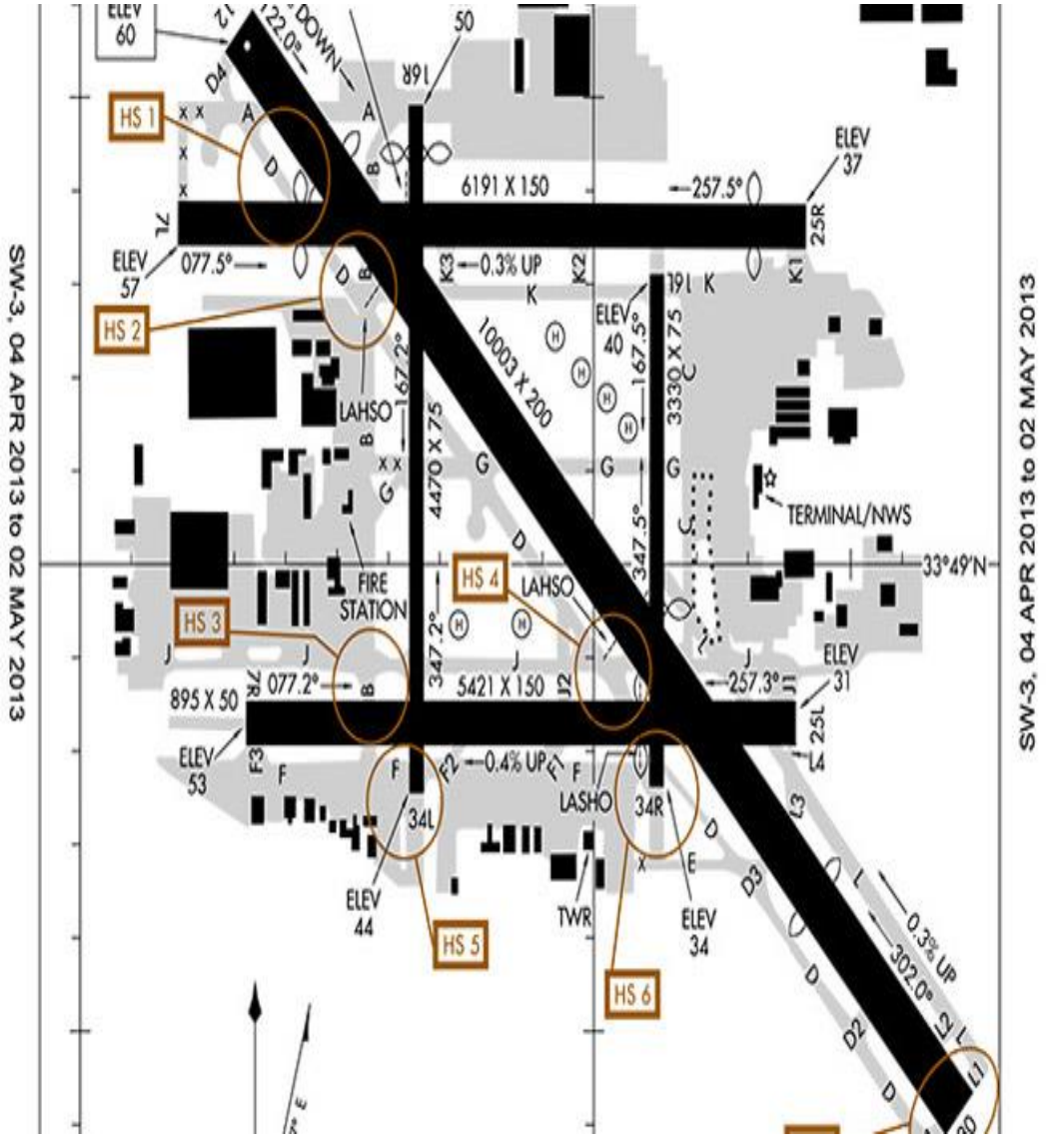

Figure 7 – Airport diagram of hot spots [7]

Planning of aircraft surface movements and cooperation with air traffic control, and another staff help to avoid of confusion by eliminating last-minute questions and building familiarity with known problems areas. Another important point of view is based on non-recommended types of TWYs that we should avoid to build, as can be seen in *Figure 8* below.

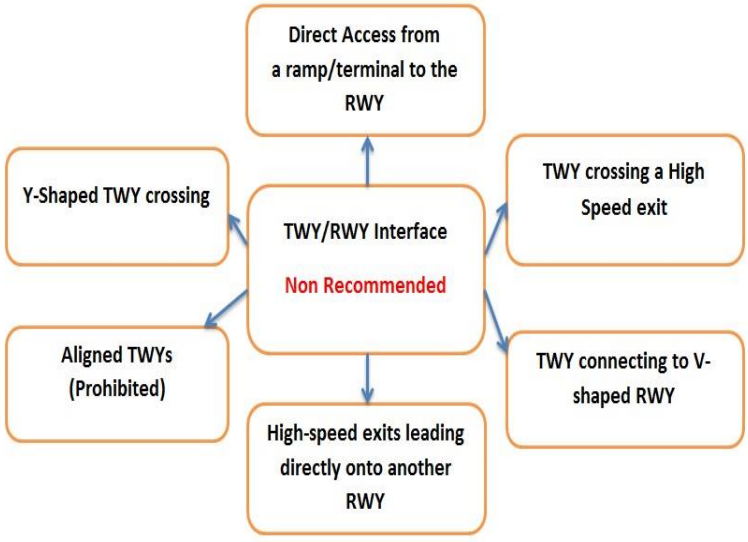

Figure 8 – Diagram of non-recommended types of taxiways [compiled by author]

Another thing, *Runway confusion* is a subset of runway incursions and often results in unintentionally taking off or landing on a taxiway or wrong runway. For instance, in August 2006, the flight crew of a commercial regional jet was cleared for take-off on RWY 22 but mistakenly lined up and departed on RWY 26, a much shorter runway. As a result, the aircraft crashed off the end of the runway. Runway confusion is a particular problem at aerodromes with parallel runway systems where it is relatively easy to mistake runways during the day or night. [7] [8]

Partial conclusion

Runway safety is a major concern for the aviation industry. The reduction in runway incursion incidents represents an opportunity to enhance the runway safety.

To move to the next level of safety, the safety metrics and analysis capabilities must continue to evolve and provide predictive indicators of potentially adverse situations, and it must continue to work aggressively to correct problems and mitigate risk.

Moreover, in high-reliability industries such as air transportation, safety risk and safety performance cannot be solely measured by the absence of fatalities or by traditional methods that rely on counting the numbers of observed precursor incidents.

4. ILLUSTRATION OF RUNWAY SAFETY AT SELECTED AIRPORT

Runway incursions are a danger to the safety of flight operations. There are numerous causes that lead to runway incursions and that's why many large airports with complex runway and taxiway systems lead to temporary disorientation. One of these kinds of airport is *Zurich Airport.* Runway 10/28 crosses runway 16/34. The location of runway 28 between the north and south aprons is also critical, as we can see *at Figure 9*. This layout means that taxiing aircraft often cross runways. The fact that apron control is divided into north and south sectors also means that frequency changes are common. Thus, anyone operating a vehicle at Zurich Airport must therefore always be on the alert.

Figure 9– Illustration of Zurich airport runways [6]

For instance, let's take look at an example of an accident that happened in 2002. Flight XY received the clearance to taxi from the "G-Stands" via taxiways E and A to the holding point RWY 28. On its way to RWY 28 the aircraft XY crossed RWY 28 on taxiway E without clearance and the crew realised this only once they were crossing the RWY. As one can expect the investigation revealed a chain of errors and several contributing factors. Nevertheless, at the crossing of taxiway E and RWY 28 a "RED STOP BAR" is installed and was activated. This should have been a last line of defence and considered by the crew of XY as a wall of concrete. [6] This position of runways and taxiways is critical, and that's why airport designs mitigation strategies, as can be seen in *Figure 10*. Another way of mitigating strategies is based on de-icing pad south of RWY 28 that leads to decreasing of crossing numbers by around 6000 (it is about 5%, *Figure 11*).

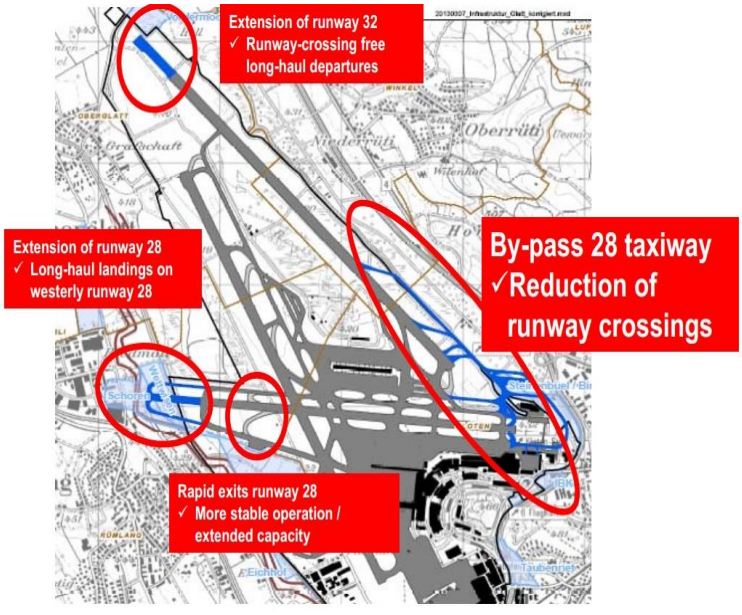

Figure 10 – RI's mitigating strategies for Zurich Airport

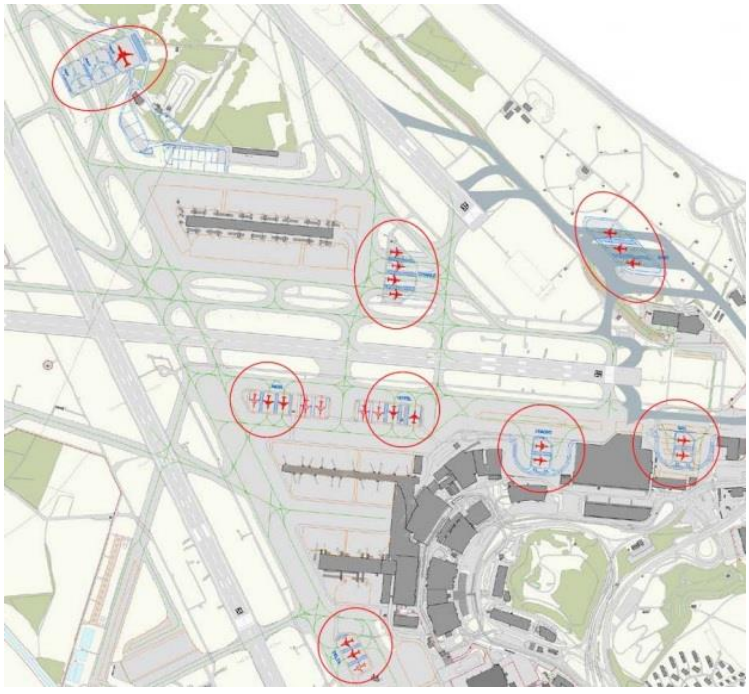

Figure 11 – Another way of RI's mitigating strategy for Zurich Airport

Local Runway Safety Team plays also an important role as it analyses occurrences, issues awareness campaigns and recommends best practices for safe runway operation at Zurich Airport. The team includes flight crew members, air traffic controllers and vehicle drivers. We are convinced that safe flight operations commence with a good flight preparation and finish only when the aircraft has turned its engines off at its final parking position.

A *Safety Alert for Operators* contains important safety information and may include recommended action. SAFO content is especially valuable to air carriers in meeting their statutory duty to provide service with the highest degree of safety in the public interest.

The *Runway Safety Challenge* is an innovative way of gathering information on the types of safety-related materials that pilots and vehicle drivers need the most. To participate, the users take an interactive electronic quiz and assessment of runway safety knowledge through the Runway Safety website.

Each question consists of an image and 4 possible answers. By tracking responses, the information helps the Runway Safety Group understand the gaps in runway safety knowledge for emphasis in future education and training initiatives. [9]

Partial conclusion

Since, the first release of the Action Plan, *Local Runway Safety Teams* has been established at hundreds of airports across Europe. EASA has embedded the plan's concept as an essential requirement to the EU (EASA Basic Regulation), a key element in helping to raise the safety of runway operations at European airports. No doubt, the runway incursion problem is difficult to solve. One of the important challenges is that pilots and drivers on a runway without a valid ATC clearance believe they have permission to be there. Communication is again a priority for runway incursion prevention, with new emphasis on visibility and tracking of traffic.

5. RESULTANT CONCLUSIONS

It is clear that aircraft and flight crews operate in complex airport environments every day. They fly in all types of adverse weather and often in limited visibility conditions. They complete the demanding tasks of safe landing and take-off over and over. We have to realize that all of these tasks demand vigilance and high situational awareness. It is really important, because the risk for runway incursions in aviation is constantly increasing, although many of the initiatives implemented are already providing a positive impact on runway safety.

Pro-active and preventive ATM Safety management is the key to safe air traffic in Europe. Thus, we have to focus on improving data gathering and the reporting mechanisms, increasing the knowledge and understanding of safety risks and on promoting best practice amongst European stakeholders. While 2010 was the safest year ever in the history of civil aviation, the consistent growth in air traffic over the coming decades means that we have to act now to develop and implement proven technological and operational solutions that will make sure we improve upon our remarkable safety record.

In August 2013, ICAO introduced the Matrix Management concept to the Air Navigation Bureau, involving a transition from the use of traditional, single-discipline teams to a more flexible multidisciplinary team approach to problem solving. This structure is conducive to providing the Organization greater agility in setting up projects that require resources from various sections or disciplines. The objective is for flight operations, aerodrome and ATM experts, for instance, to develop solutions together rather than separately in isolation of each other, which will benefit industry stakeholders, as well. It represents a cultural change in the delivery of implementation assistance that will require training as team members become accustomed to this new way of working. If the Runway Safety Programme is not implemented using a Matrix Management approach, or something similar involving multi-disciplinary collaboration between multiple internal and external entities, it won't be achieved as effectively and efficiency as it could be. [5]

Many of the initiatives implemented are already providing a positive impact on runway safety. This is an ongoing effort and we are committed to finding ways of making a safe system even safer. In addition to current runway safety initiatives, the following efforts will further the progress of increasing runway safety over the next several years.

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