DETECTION OF POTENTIAL RUNWAY AND MANOEUVRING AREA CONFLICTS OR "HOW DO YOU KNOW WHO'S ON YOUR RUNWAY?"

by Richard "Sid" Lawrence

Let us look closer at the importance of maintaining our situational awareness in the aerodrome environment. Specifically, let us see how some runway incursion and manoeuvring area conflicts could have been prevented if the controllers had had better means to detect that the runway (or another part of the manoeuvring area) was already authorised occupied at the time of issuing clearance to the next aircraft to use it.

A EUROCONTROL Operational Safety Study (OSS) had a closer look at this phenomenon with the aim to provide clues why these types of events occur, what protective barriers are already in place and what we can do further to reduce the chances of them happening in the future.

Common Scenarios

We identified a number of common scenarios that are the origins of this type of event:

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

In the real-life examples of some of the scenarios that follow, we'll see how the situational awareness of the controller/pilot/driver is affected and how easy it is to slip to the very edge of the runway safety margins.

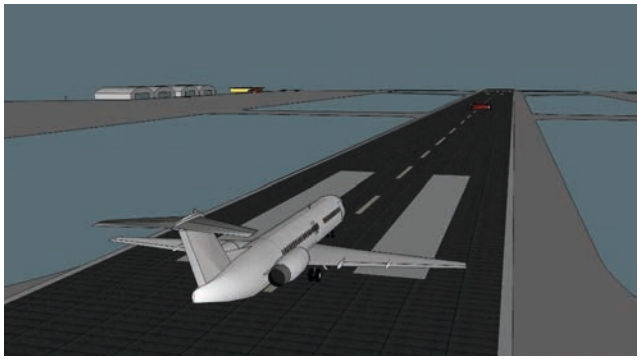
REAL-LIFE CASE STUDIES

CASE 1: 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 with 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

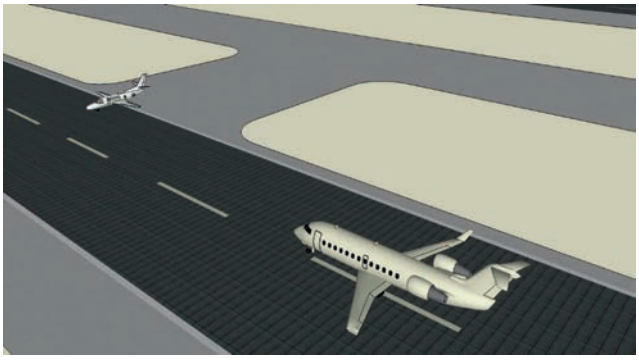


second time to repeat he is ready for departure. ATC is still busy with coordination and mechanically responds to the pilot. ATC gives the surface wind and clears the E145 to line up and take-off. The vehicle driver immediately calls to confirm his presence on the runway. ATC cancels the take-off clearance given to the E145.

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

CASE 2: 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.

CASE 3: 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 apron. ATC asks him to report in sight of the "aircraft on final".
An A319 is taxying for departure runway 05R; it 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, detect the conflict and properly recovered the incident giving the right orders to both aircraft and the towed Beluga.

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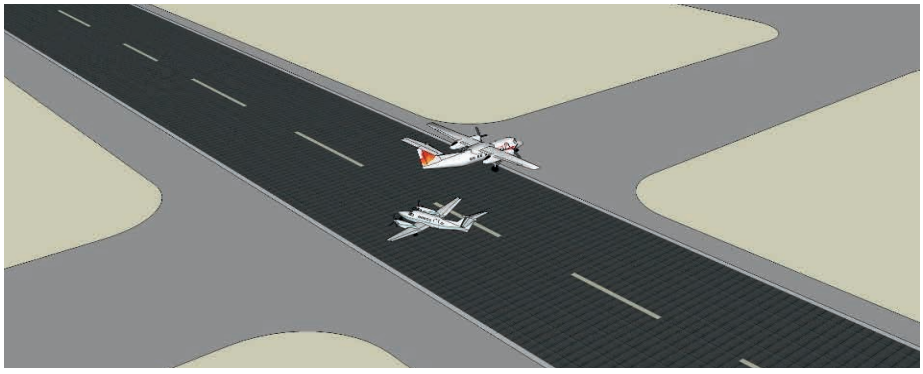
CASE 4: Unauthorised Aircraft/ Vehicle crossing runway occupied by landing or departing aircraft without ATC clearance due to poor CRM or forgot planned action

A Bombardier DHC-8 landed on Runway 23. The GMC controller instructed a 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 left 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 left 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.

Contributory Factors

These 4 events only provide a snap shot of some of the most common contributory factors. The OSS has more detailed analysis and lists, inter alia, the following common **ATC** contributory factors:

- Memory – most commonly a failure to check/monitor or forgetting something.
- Perception – most commonly a failure to see something.
- Operational environment – commonly distractions, visual impairments and noise.
- Communication errors – incomplete, incorrect or ambiguous RTF.

The OSS also lists the following most common **pilot/driver** contributory factors.

- Perception
- Action (communications)
- Decisions
- CRM issues

Importantly, the OSS also found many examples where **airport procedures and equipment** contributed to incidents including, inter alia:

- Routine inappropriate use of company radio frequency whilst airside
- Use of native language to communicate with airside drivers and English for pilots
- Permitting vehicles on airside without required lighting or radio
- Taxiway centrelines being permanently lit
- Excessive lighting around WIP severely restricting the ability of ATC to interpret visual information at night.
- Inadequate directional signage and signage lighting at night.

In the next section we'll take a look at how the ATC contributory factors link to situational awareness and see how they manifested themselves in the selected cases.

Memory

In Case 1, the ongoing work in progress disturbed the controller's situational awareness and he/she momentarily forgot about the vehicle he/she had previously cleared onto the runway. The ATCO also forgot to check his/her strips and to physically check that the runway was clear before he/she 'mechanically' gave take-off clearance to a waiting aircraft. Memory lapses were an ATC contributory factor in three quarters of the actual events studied.

Perception

In Case 2, the pilot of the taxying aircraft misinterpreted visual information and did not see runway guard lights and RUNWAY AHEAD signs; this breakdown in situational awareness was compounded because

the controller did not see the aircraft take an incorrect route. Although, like 'Memory', 'Perception' was a contributory factor in 16 out of the 20 actual events studied, in Case 2 systemic issues were also key contributing factors.

ATC Operational Environment

In the sample of 20 incidents, the third highest common area of contributing factors is ATC Operational Environment. Approximately half of these issues are organisational, e.g. visual impairments and noise in the VCR as in Case 1 when the controller's concentration is disturbed by the testing of fire alarms. The other half concerns job-related distractions. What this shows us is that we need to use the available 'attention' more effectively. Tasks not involving the subject aircraft are prevalent e.g. checking a situation on another runway, concentrating on correct departure wake separation or other co-ordinations.

Communications

In Case 3, the imprecise conditional ATC clearance meant the Beluga tow driver made his own interpretation of the clearance which led to a false perception of reality and he started to cross the runway instead of waiting for the landing aircraft to pass and then cross behind it. The situational awareness of the controller and the Beluga tow driver in this case was clearly different. Communication issues were, unsurprisingly, a contributing factor in just over a third of the real-life incidents analysed in the OSS.

So, what are the best ways to prevent these events happening and mitigate them when they do?

The analysis in the OSS clearly shows that some runway incursions could have been prevented if the controllers had had better means to **detect** that the runway was (authorised) occupied at the time of issuing clearance to the next aircraft to use it.

Prevention Barriers
The table below provides a theoretical ranking (highest at the top, lowest at the bottom) for 10 identified **prevention** barriers.

Barrier	Barrier Description
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
PB7	A-SMGCS level 2
PB2	ATC visual detection including video and remote camera displays
PB4	ATC resolution following pilot/driver alert
PB1	ATC memory aids
PB3	ATC detection using remote camera displays
PB6	A-SMGCS level 1
PB10	Vehicle have high vis flashing or strobe lighting
PB9	Use of named HPs e.g. BARKA
PB5	Basic SMR

PB8 is the single most efficient barrier. Unfortunately this functionality is not yet widely available; however, it is due to be rolled out in at least 19 large European aerodromes and the OSS strongly supports its development and deployment.

Mitigation Barriers
The table below (again in ranking order) indicates which mitigation barriers are theoretically likely to be more effective in most operational scenarios.

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

Combined Prevention and Mitigation Barriers
In addition to PB8/MB8, the OSS assessment of the theoretical effectiveness of combined barriers 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. The actions of the driver in Case 1 are a good example and also demonstrate the value of vehicles on the runway being on the Tower frequency as a good means to improve drivers' situational awareness.

Moreover, 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 – in Case 4, however, the unavailability of any runway safety nets meant that by the time the controllers had seen the aircraft crossing the runway it was already too late for them to take effective action. 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 also potentially strong barriers that aid ATC perception and memory; however, it is these areas of ATC action that fail most often in the 20 real-life events analysed in the OSS, providing an indication of the need for more technological solutions to overcome these known human frailties and help improve controllers' situational awareness.

Finally, the OSS highlights the importance of the **"one team" awareness ethos involving ATC, pilots and drivers in stopping conflicts becoming collisions** and provides empirical evidence of the effectiveness of cross-industry safety awareness training.