THE CONTINUING THREAT OF RUNWAY INCURSIONS

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While taxiing along the runway, the Pan American 747 was struck by a KLM 747 which was taking off on the same runway and had just begun to rotate. The fuselage of the KLM 747 skidded over the Pan American aircraft's aft fuselage destroying it and shearing off the empennage. The KLM aircraft continued in flight for a further 150 meters after the impact before striking the ground. Both aircraft caught fire and were destroyed.

Neither the KLM nor the Pan American crew saw the other aircraft until the last seconds before the impact. Visibility at the time of the accident was poor with fog patches and light rain. At the time of the accident the Pan American 747 had been cleared to back-track the active runway due to congestion on the taxiway. The 747 was still taxiing when the KLM aircraft began its take-off roll during the delivery of its ATC clearance. It had not been given permission to take-off. The report of the Subsecretaria de Aviacion Civil, Spain concluded that the *"fundamental cause of this accident was the fact that the KLM captain took off without clearance, did not obey the stand by for take-off from the tower, did not interrupt take-off when Pan Am reported that they were still on the runway and, in reply to the flight engineer's query as to whether the Pan American airplane had already left the runway replied emphatically in the affirmative"*. The KLM flight engineer had apparently heard the Pan American crew report that they were still on the runway.

The above report, taken from the Airclaims CASE Database, describes briefly what must be one of the saddest accidents in the history of aviation. Sad, for the obvious reason that all but 59 of the 644 passengers and crew on board the two airplanes were killed. Sad too because this accident was so unnecessary. This brief report with
its clear-cut conclusions hides the fact that there were many other factors involved. This accident has been dissected and analyzed many times (see, for example, "The Naked Pilot" by David Beaty) but there is still much that is not known. We may never fully understand what happened, but we cannot hide from the fact that a very experienced captain flying a fully serviceable aircraft commenced the take-off run whilst another aircraft was still on the runway.

If that sounds a bit like the definition of Controlled Flight Into Terrain (CFIT), perhaps we should ask whether there are other common features. Of course there are, and the saddest of all is that in spite of what we have learned, accidents like this continue to happen. Unless something is done to break the chain it can only be a matter of time before loss of life on a similar scale to Tenerife occurs again.

Here are a few more examples:

- **1982**

Aeroflot Tul 34 collided with a Let 410 during takeoff from Babusheri, Russia. The Let 410 was taxiing for take-off. Eleven passengers and crew were killed.

- **1983**

Iberia B727 collided with an Aviaco DC-9 on takeoff from Madrid, Spain. The B727 had been cleared to take off and at 120 kt saw lights on the runway ahead. The B727 took immediate avoiding action but without success. It is thought that the DC-9 accidentally strayed onto the active runway. Ninety-three passengers and crew from both aircraft were killed.

- **1983**

As a Trident entered the runway for take-off at Guilin, China, it was struck by a fighter which was apparently landing on the same runway. Eleven passengers were killed.

- **1984**

Aeroflot Tu 144 collided with vehicles on the runway after landing at Omsk, Russia. The Tower controller had fallen asleep and not told the Approach controller that the vehicles were on the runway. One hundred and seventy eight passengers, crew and ground personnel were killed.

- **1990**

Northwest B727 struck a Northwest DC-9 on takeoff from Wayne County, USA. The DC-9 was taxiing for take-off and accidentally entered the runway. Visibility at the time was 0.25 miles in snow with 8 octas cloud at 100 ft. Eight passengers and crew were killed.

- **1991**

USAir B737 landed on top of a Skywest Metro, which was awaiting take-off clearance at Los Angeles, USA. The controller, who was under considerable pressure due to other traffic, apparently cleared both aircraft. Thirty-four passengers and crew from the two aircraft were killed.

- **1996**

Beech 1900 collided with a King Air on the runway after landing at Quincy, USA. The Beech 1900 was landing on Runway 13 while the King Air was taking off on Runway 04. Quincy is an uncontrolled airport and the King Air pilot apparently failed to monitor the common frequency. All 14 passengers and crew on the two aircraft were killed.

- **2000**

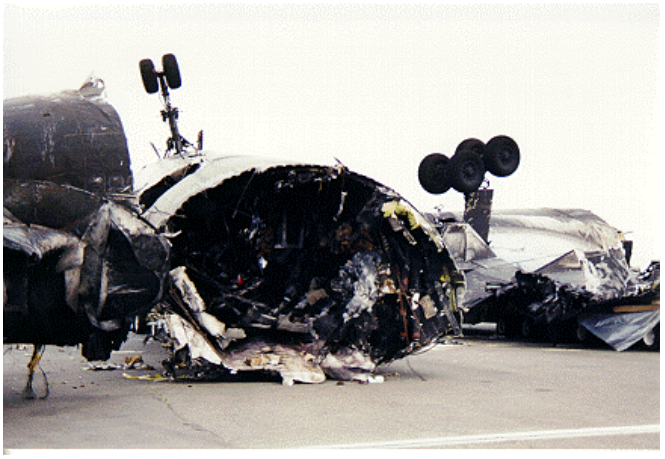
Air Liberté MD-83 struck a Streamline Shorts 330 on take off from Paris CDG, France. While taxiing for departure, the Shorts 330 apparently began to enter Runway 27 at a taxiway intersection about halfway down the runway. It was struck by the left wing of the MD-83 which was taking off. One pilot on the Shorts 330 was killed. A preliminary report has been published.

These are a few of the fatal ones that have hit the headlines. As usual, behind the relatively small number of actual accidents lies a huge crop of near misses. In order for an incident to be classified as a runway incursion, there must be a collision hazard or a loss of separation. If an aircraft intending to land is sent around within one mile of the landing threshold due to an aircraft, vehicle, or pedestrian incurring on the runway, that is a runway incursion. If the aircraft on finals was a mile or more from the landing-threshold, it is classified as a surface incident. If a departing aircraft has been cleared for take- off and is rolling down the runway when the take-off clearance is cancelled, that is a runway incursion. If the take-off roll has not commenced, it would be a surface incident. If there is no loss of separation, the key question to be answered is *"was there a collision hazard?"*. Well, there certainly was in the following example.

The pilot of a United Airlines jet bound for Washington, DC, with 133 people aboard averted disaster by swooping into the air over an Aeromexico plane that strayed into his takeoff path. "Our pilot did take evasive action," said United spokesperson, Matt Triaca, "It was a near-miss." The incident occurred at 10:35 p.m. after Aeromexico Flight 432, arriving from Baxio in central Mexico with 36 passengers and crew, landed on the southernmost runway at Los Angeles International Airport. An air traffic controller told the pilot to exit along a taxiway to the right and stop before the inboard runway. The controller repeated that instruction, but the Aeromexico pilot did not respond and proceeded to cross the inboard runway. Meanwhile, United Flight 204 had been given clearance to take off and was zooming west down the inboard runway. The United Airlines pilot managed to pull his plane up and over the Aeromexico jet. The Aeromexico jet's co-pilot told the control tower that he was preoccupied and thought he heard an instruction to cross the runway. "The United Airlines Boeing 757-200 missed the Aeromexico MD-80 by only a wing-length, or about 60 feet", said an unidentified official.

Runway incursion may not be the primary cause of an accident but it was certainly a major contributory factor in the following accident, which occurred at John Wayne Airport, USA in 1981.

Flight 336 took off from San Jose for a flight to John Wayne, CA. 48 Minutes later, the crew received a clearance for a visual approach to Runway 19R. While Flight 336 approached, the controller cleared Air California Flight 931 for a Runway 19R take-off. After recognizing the hazard, the controller ordered Flight 336 to abort the landing and go-around and Flight 931 to abort the take-off. Flight 931 rejected its take-off, but Flight 336 landed with the gear retracted. The B737 left the runway surface at 900ft past the threshold and skidded another 1,170 ft before coming to rest 115 ft to the right of the centerline. The NTSB determined that the probable cause of the accident was the captain's failure to immediately initiate a go- around when instructed to do so by the tower controller and his subsequent failure to correctly execute the specified go-around procedure which resulted in the retraction of the landing gear after the aircraft touched down on the runway.



In the USA, the problem is recognized as being so serious that it has been placed among the top six safety objectives being addressed by the US Safer Skies, Commercial Aviation Safety Team (CAST). As yet, the problem has not achieved the same notoriety in Europe, and does not feature on the agenda of the JAA Joint Safety Strategy Initiative (JSSI), although JSSI are keeping a close watch on the results of work done by CAST. However, history tells us that we should beware any temptation to be complacent: what is a problem in USA today has a nasty habit of becoming a European problem tomorrow, as the recent Air Liberté/Streamline accident at Paris/Charles de Gaulle Airport confirms. In the USA, a Runway Incursion Study is under way. The study gathers information from pilots involved in runway incursions in an effort to determine their cause. A group of regional aviation safety inspectors in each FAA region serve as a Flight Standards Incursion Team, responsible for interviewing individuals involved in runway incursions, writing a report on the event and sending the information to FAA headquarters. FAA encourage participation in the programme by offering certain assurances to airmen regarding enforcement action.

The FAA Runway Safety Program (RSP) is aggressively pursuing numerous means to prevent or mitigate runway incursion and other surface incidents. These solutions should greatly improve the current level of surface safety for pilots, airport operators, and controllers. Many runway incursion incidents take place at night or in poor visibility and technology can provide safety mechanisms enabling pilots to avoid making errors that they cannot see. Solutions are being developed which concentrate on improving surface surveillance and providing visual and aural warning of a potential incursion to controllers.

In Europe, technological solutions are also being developed. For example, National Aerospace Research Laboratory (NLR) of the Netherlands has designed a Runway Incursion Alert tool, (RIA), which provides an aid to the controllers in the control tower. RIA enables ground movement capacity to be optimized while maintaining safety. RIA can support the ground and tower controller in maintaining high safety and throughput for sustained periods, especially under low visibility conditions.

On RIA, information about moving vehicles is depicted graphically in real time on an airport map for advanced surveillance. To alert controllers, labels of conflicting moving vehicles are displayed in red. In addition, information about the conflicting objects is displayed in a pop-up window. Upon acknowledgement by the controller, the color of the label can be returned to its default setting, while the information in the pop-up window remains available to the controller.

A different approach is being pursued by Rockwell Collins Flight Dynamics. As an extension to their existing Head-up Guidance System (HGS) they are developing a Surface Guidance System (SGS) which will provide continued guidance from roll-out to the stand. The existing FMS database will be updated to contain additional accuracy and detail and Flight Dynamics are working with Jeppesen in this regard. Symbols on the HGS will help the pilot stay on the taxiway centerline, tell him how far he has to go to his next turn, which way to turn and what speed he should be aiming for. As he approaches a turn or hold he will be told whether his current deceleration profile is OK. Initially, taxi instructions will continue to be passed by radio.

Ultimately, transmission from ATC to the aircraft will be by data-link, although this will probably always be backed up by voice communication. When a holding point is reached, warning cones will appear across the screen and the target speed will change to zero. When clear, the warning cones will disappear and the message "Clear to Proceed" will appear on the screen. It may eventually be possible for the taxi route and instructions to be adjusted by the controller in real time according to the changing circumstances at the airport.

A further system enhancement (under development) will be provided by short-range infrared sensors which can detect an obstacle in the aircraft path. These sensors would not give sufficient warning for an aircraft to abort at take-off at speed, but they should prevent collision with, for example, an animal or pedestrian while taxiing at normal speed. Ultimately, data-linking from aircraft to aircraft and from aircraft to tower will be the best means for letting the pilot know that there is another aircraft that could be a potential threat to him.

Non-technological solutions address such areas as standardized cockpit procedures and reduction of vehicular traffic on runways as well as increasing awareness of all airport users.
In the USA, Runway Incursion Action Teams (RIAT) are an Air Traffic initiative that brings together groups of FAA and industry experts who meet at airports that are having a high number of runway incursions and surface incidents. These airports are identified by the number of runway incursions and surface incidents within the previous 12-month period. The RIAT conducts an on-site evaluation, and then the local FAA and airport team meets monthly until the incursions have been reduced enough for the airport to drop off the "Top 20" list.

Many airports have had special surface-control radar and light systems in place for years, and we have seen that further advances are on their way, but technology on its own cannot provide a complete answer. Current technology would not have been much help in preventing the 1996 Quincy accident, which took place on an uncontrolled airport and involved relatively unsophisticated aircraft. Moreover, over-reliance on technology to prevent an incident can lead to problems when the technology malfunctions or is lacking.

We must study the factors that give rise to runway incursions, ensure that operating procedures are in place to reduce the likelihood of incidents occurring, and ensure that all personnel - pilots, controllers, drivers, etc. - follow these procedures. We must look closely at the "near misses" too and see what caused them to happen. We must also look at the surface incidents - incidents that would have been runway incursions if loss of separation. or collision hazard had existed.

At their most basic, runway incursions happen because an aircraft is allowed to enter an area where it is not safe for it to be. Here are some reasons why this might happen :

- Pilot acts contrary to clearance.
- Pilot misunderstands ATC instructions.
- Pilot does not receive ATC instructions and assumes he is OK.
- ATC gives incorrect or unclear instructions.
- Pilot loses his way whilst taxiing and enters active runway by accident.
- Vehicle enters active runway without permission.

You will think of many more. In each case, standard operating procedures (SOPS) exist as a first line of defense to prevent an accident:

- Pilots must not proceed without clearance.
- Pilots must read back the clearance.
- ATC must challenge an incorrect read-back.
- Pilots must question a confusing clearance.
- Vehicles must not enter a runway without permission; and so on.

All that is obvious. So why do these accidents and incidents keep on happening? The answer in most cases is because of our old enemy, Human Factors. Human failure is the underlying cause of many, perhaps most runway incursion incidents. Looking back on Tenerife, there were many of these in play. Beaty (ibid.) lists fatigue, frustration, uncertainty, irritation, lack of familiarity with route flying, the desire not to lose face, inexperience and lack of assertiveness, together with language difficulties among the factors at play. There was also a suggestion, not mentioned by Beaty, that ATC might have been distracted by a football commentary playing in the control tower.

Here are some more incidents, mostly taken from the ERA Safety Information System but not necessarily involving ERA aircraft.

Weather conditions at Brussels: visibility 0.9 km, FG, cloud SCT/100ft, RVR 1500m. Landing aircraft callsign was xx74H. Taxiing aircraft callsign was xx49H. On changing frequency to tower and arriving at the holding point, the taxiing aircraft thought they had received line-up clearance and read back that clearance. In fact, the tower transmission was probably the landing clearance for xx74H. On seeing xx49H line up on the landing runway, Tower ordered xx74H to *"go-around"*. The reporter suspects that both aircraft read back the clearance together and so blocked the frequency.

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Having received instructions from Brussels ATC to hold and taxi behind an A321, the reporter (in an Saab 340) started to follow the A321, but had to brake to avoid collision with an MD80 which was following the A321. Ground was informed but was unable to get any response from the MD80 which continued to taxi to the holding point.

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At 100 ft above DH (Leeds/Bradford, UK, Runway 32) an aircraft crossed the holding point and infringed the active runway. A go-around was carried out and the aircraft was re-vectored to an ILS final.

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An Saab 340 captain believed he was cleared to line up on the runway at an intersection. He read back the clearance and it was not challenged. As he was lining up an MD80 was cleared to line up and take off from the threshold. The Saab 340 captain stopped his aircraft just short of the runway edge, asked the controller if he was clear to line up and explained his position. ATC again cleared the MD80 to takeoff. It did so.

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While taxiing for Basel (Switzerland), Runway 26, the pilot missed the turning. He stopped just past the intersection but before the runway holding-point. From this position it was not possible to reach the correct taxiway. The only possible course of action was to enter the runway and back-track a short distance in order to leave at another intersecting taxiway. The pilot thought mistakenly that ATC had cleared this. He taxied past the holding point, but as he was about to enter the runway he noticed traffic at the threshold beginning its take-off roll so he stopped, just short of the runway. The departing traffic passed clear but quite close. The pilot accepts responsibility for incident but points out that ATC procedure in force at this airport, leaving change to tower frequency until just before take-off, meant that he and departing traffic were on different frequencies and so each was unaware of what the other was doing.

The departure was delayed due to technical faults. A clearance was given for take-off on Geneva Runway 05 (23 was in use) in order to expedite the flight. During the take-off roll, at about 100 kt, an airport car entered the runway from the high-speed taxiway, saw the aircraft approaching, stopped and reversed off the runway. It appears that the Tower controller (who was under supervision) forgot to set the traffic-lights to red. There is no communication between Tower and vehicles on this airfield.

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During departure from Gate C22 at Paris Charles de Gaulle, a bus approached at high speed on the left side of the aircraft. It crossed the path of the aircraft, just in front of it, forcing the crew to stop.
After being cleared for take-off from Paris Charles de Gaulle, Runway 26L (OAT -10°C with ice patches) the crew noticed flashing lights entering at the far end of the runway. The aircraft had accelerated through 95 kt (V1 was 118 kt) and the captain elected to continue the take-off. A rejected take-off might have been more hazardous given the runway conditions.

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At Milan Malpensa (Italy) the aircraft was cleared to line up at an intersection. At the same time, another aircraft had been cleared to take off from the full length of the same runway. The crew reported the error to Tower who admitted their mistake and cancelled the line-up clearance.

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After leaving the runway at Stockholm Arlanda (Sweden), the aircraft was cleared "After Fokker 100 taxi to stand 29B". Conditions were dark, with snow, and braking action was poor-to-medium. The previous landing aircraft was taxiing South on Taxiway Z. The crew believed that this was the conflicting aircraft because no other traffic was in sight. Shortly before entering Taxiway Y, a Fokker 100 passed in front at high speed and with very little separation. The reporter commented that ATC instructions should be full and explicit in such weather conditions.

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While holding at an intersection, before entering the main apron at Milan Malpensa (Italy), the pilot noted a B747 taxiing out of the apron. It was approaching rapidly from right to left and apparently without enough wing clearance. The crew asked tower for instructions and while waiting for the B747 to stop taxiing, the crew elected to "power back" 20 meters to avoid a collision. After Ground Control orders the B747 stopped taxiing. At present, there is no Apron management at this airport and all operations are at pilot's discretion. The Airport Authority has been asked to take action to resolve this safety issue.

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After touchdown on a wet runway at Lyons (France), ATC asked the aircraft to expedite runway vacation. When a turn was commenced the aircraft began to slide, so the turn was aborted and the aircraft remained on the runway, just past the turn-off point. ATC were informed of the aircraft's position and they insisted that the aircraft should vacate immediately. They were told once more that the aircraft had passed the turn-off. When the aircraft turned to backtrack, a B727 was observed to have landed on the runway. It was in the final stages of roll-out.

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While taxiing for take-off Runway 25R, Brussels Ground Control cleared the aircraft to cross Runway 02/20. ATC then called "STOP" but the aircraft was already on the runway so the crew continued across and vacated. At the same time they saw an aircraft aborting take-off on Runway 20. Apparently it had been cleared for take-off on the Tower frequency.

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At Zurich (Switzerland), the aircraft was cleared for take-off, 30 seconds after departing traffic. At 90 kt during the take-off roll, the crew saw another aircraft approaching the runway intersection at speed. Take-off was abandoned and at the same time ATC called for abort. Apparently the taxiing aircraft had been given crossing clearance by the Ground frequency.

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Washington National Ground cleared the aircraft to cross Runway 15 on Taxiway J. At the same time another jet was cleared to cross the runway at K. While starting to cross the runway the crew noticed a company aircraft (a Dash 8), with its landing lights on, coming down Runway 15 on its take-off roll. The crew stopped the aircraft on the edge of the runway (the other crossing aircraft also stopped) and the Dash 8 aborted the take-off roll. Ground again confirmed that the flights were cleared to cross and the crew continued to Runway 19. No explanation was offered. The captain called Tower and they said that there was a miscommunication between Tower and Ground.

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After being cleared for an ILS on the right parallel runway at Newark, USA, Tower told the crew to side-step to the left parallel runway and cleared them to land. At 150 ft agl an ATR-42 crossed the left runway and simultaneously Tower ordered a go-around. The second approach was uneventful.

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After starting engines at Minneapolis, MN, the crew were given clearance to "taxi to Runway 22 via Echo... Runway 22 for a departure on 22 at C6". After holding for landing traffic on 30R, the aircraft departed from Runway 22, as cleared. After crossing Runway 3OL/1 2R during the take-off roll, the first-officer noticed a truck on the right side of the runway. The aircraft was at V1 and the crew felt it was safer to continue rather than abort. Take-off was continued with a slightly higher pitch up than normal, to avoid the truck. A follow-up revealed the runway had been closed (via ATIS) prior to the controller giving clearance for take-off. Tower was unaware of the error until the crew called (after take-off) to report the truck on the runway. The controllers responsible for the error were removed from active duty for one week and required to undergo recurrent training.

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The aircraft was at 500 ft on approach when the crew noticed another aircraft crossing the runway. This traffic did not stop short of the runway and as very slow in crossing. The crew executed a go around at 100 ft agl with the traffic still in the middle of the runway. The captain called Tower after landing and discovered that Tower thought the aircraft had gone-around because the preceding *landing* aircraft was slow to clear the runway. The captain was concerned that Tower had no knowledge of the crossing aircraft.

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A Dash8 was cleared to line up at Paris Charles de Gaulle, Block 11, Runway 09, with an Fokker 27 cleared to line up at Block 12. The F27 was then cleared take-off. The Dash 8 stopped short of the runway. This was a controller error.