ROPS - AN ACTIVE SAFETY NET FOR RUNWAY OVERRUNS

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by Logan Jones

Among incident and accident statistics, runway overruns continue to stand out. And now with the advances made on Airline Safety Management Systems reporting, we are able to track the number of events which did not result in an incident or accident but which showed minimal safety margins that could have ended much worse. How can we better understand what leads to these events and how to prevent them? When the aircraft is dispatched, a first calculation is made to ensure that the destination airport and preferred runway are indeed long enough for the conditions expected at landing. This is called the Required Landing Distance check or Dispatch check.

As the dispatch calculation is based on a set of regulatory assumptions, authorities around the world (and aircraft manufacturers) have started to recommend that the flight crew calculate an In-Flight Landing Distance during the descent preparation. This In-Flight Landing Distance check uses more operational assumptions of the aircraft performance and the most current conditions expected at landing (runway state, temperature, wind conditions etc…). The recommended safety factor to be added to the In-Flight Landing distance is 15%[1].

Why is that not always enough to prevent a runway overrun? From an aircraft performance point of view, small changes can have a surprisingly large impact on the landing distance. We have to remember that a 60 ton aircraft travelling at a typical approach speed of 135 knots (250km/hr) represents a lot of energy that needs to be dissipated.

To give you some examples (based on an A320 aircraft):

Whilst in the air:

- If the tail-wind increases by 5kt, aircraft speed over the ground will increase which can add 5% to the landing distance;
- Crossing the threshold at 60ft instead of 50ft can add 6% to the landing distance;
- A nominal touchdown from threshold is calculated as 7 seconds. Each additional second over 7 seconds can add 7% to the landing distance.

Once on the ground:

- Every one second of delay on applying pedal braking will add 7% to the landing distance;
- A delay of three seconds in selecting maximum reverse on a wet runway can add 4% to the landing distance;
- If the runway friction is 10% worse than predicted the landing distance will be 5% longer;
- Note: a failure of the spoilers to deploy can increase the landing distance by over 25%.

The end result is that, whereas during approach preparation the runway seemed sufficiently long, just a couple of small deviations can quickly put the flight crew into a situation where they are right on the edge of the capability of the aircraft to stop in the available runway length.

This is at the heart of why Airbus developed the Runway Overrun Prevention System (ROPS). ROPS is a safety net designed to continuously calculate whether the aircraft can safely stop in the runway length remaining ahead of the aircraft. If at any point the system detects there is a risk of a runway overrun, flight deck alerts are generated to help the crew in their decision making.

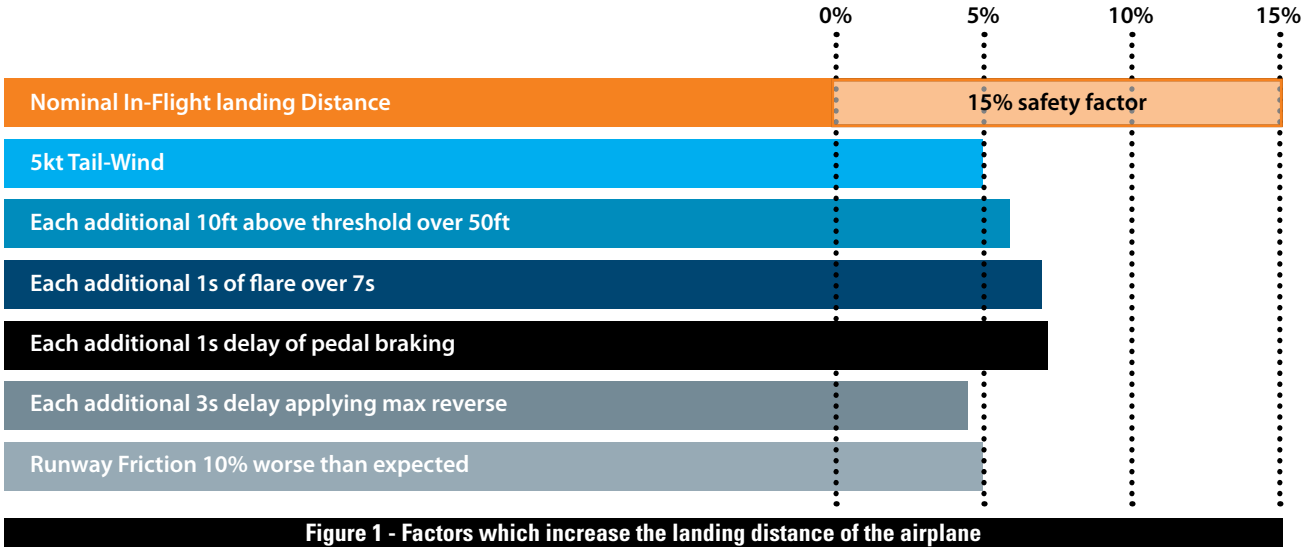

Figure 1 - Factors which increase the landing distance of the airplane

1- FAA AC No: 91-79A – Mitigating the Risks of a Runway Overrun Upon Landing

Research into ROPS began in 1998. In 2006, the system was officially launched and was certified for the first time on the A380 in 2009. Since then Airbus has achieved certification on the A320 family in 2013, the A350 in 2014 and lastly the A330 in 2015.

So how does ROPS work?

ROPS is embedded in the aircraft avionics and has access to all of the parameters that may affect the landing distance of the aircraft such as: aircraft weight, slat/flap configuration, ground speed, wind velocity, outside air temperature and the aircraft current vertical and horizontal position. ROPS also has access to a runway database on-board the aircraft which contains the runway characteristics. With the runway database, ROPS will auto-detect which runway the aircraft is approaching. In fact, all the information that ROPS uses is contained on-board the aircraft; no additional information is received from the ground (ILS, weather etc…). The current version of ROPS is certified for Dry and Wet runways only. However Airbus has already begun work on extending the system to cover contaminated runways based on the flight crews input of the reported runway state.

With the available onboard information, ROPS can instantly calculate (8 times per second) the amount of runway the aircraft needs to stop and compare this to how much runway remains ahead of the aircraft. The system begins active monitoring during final approach at 500ft above ground and continues throughout the flare, touchdown and roll-out.

The visual and audio alerts that the system generates change between the in-air phase and the on-ground phase. In-Air, the system will generate an alert "RUNWAY TOO SHORT". The procedure associated with this alert is to perform a Go-Around. Once on the ground, with the spoilers selected and the Go-Around no longer a safe option, ROPS will generate alerts which incite the crew to use all available deceleration means. These alerts may be "BRAKE, MAX BRAKING" and/or "SET MAX REVERSE" depending on the pilot actions. An additional functionality provided on Airbus A380 and A350 is that, when in autobrake mode, ROPS will also automatically activate maximum braking. Even after an alert is generated, the system continues to calculate the aircraft deceleration capability and if the aircraft is no longer at risk, the alerts are cancelled.

The design goals of ROPS were two-fold:

- ensure that the system alerted the pilot in a timely manner if there was an overrun risk
- ensure the system did not unnecessarily increase the number of go-arounds

The nature of the achieved design ensures both. The system is based on the actual capability of the aircraft to stop so that if the system triggers an alert, it is directly related to an imminent runway overrun risk.

Thus far the system has fully met its design goals. In years of in-service experience, Airbus has not been advised of any unjustified in-air alerts. In addition, ROPS has already shown its worth on several

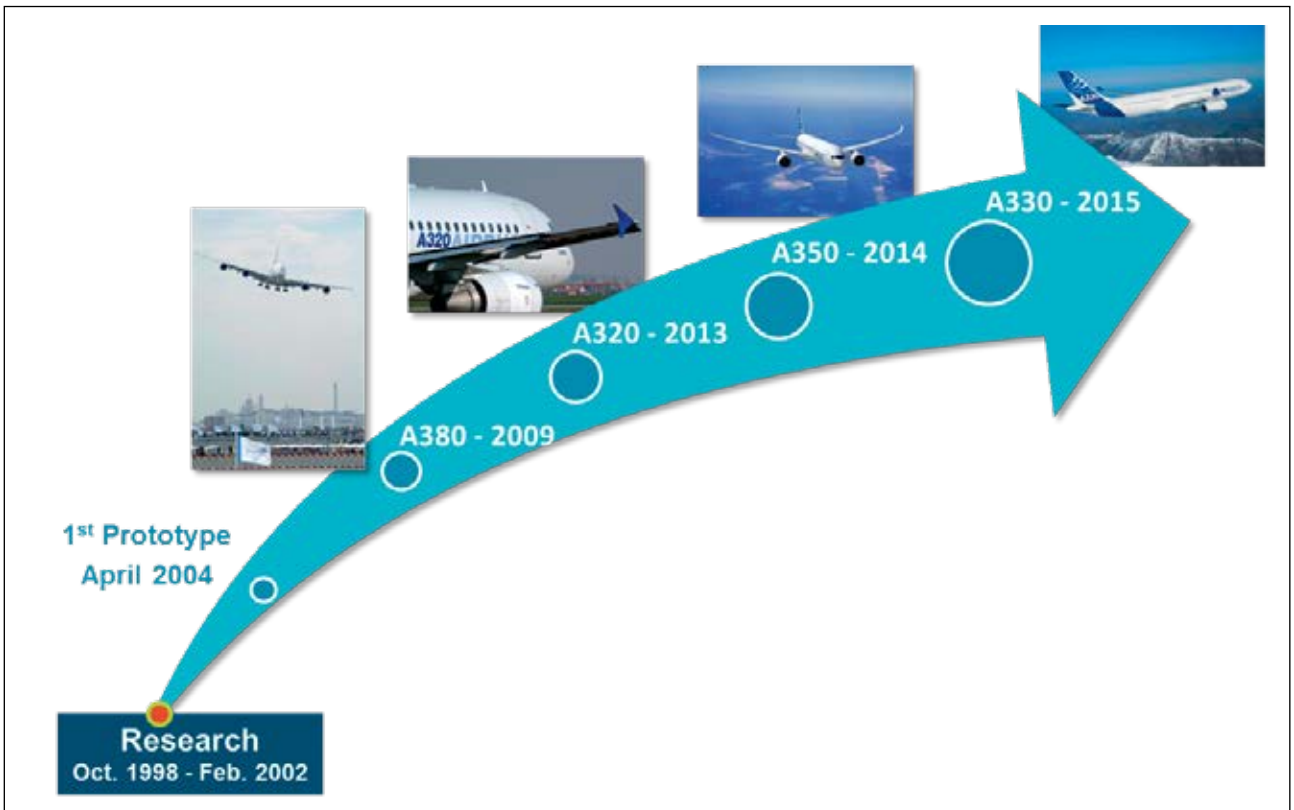

Figure 2 - Timeline of ROPS implementation in Airbus aircraft

Figure 3 - ROPS In-Air alerts for runway overrun risk

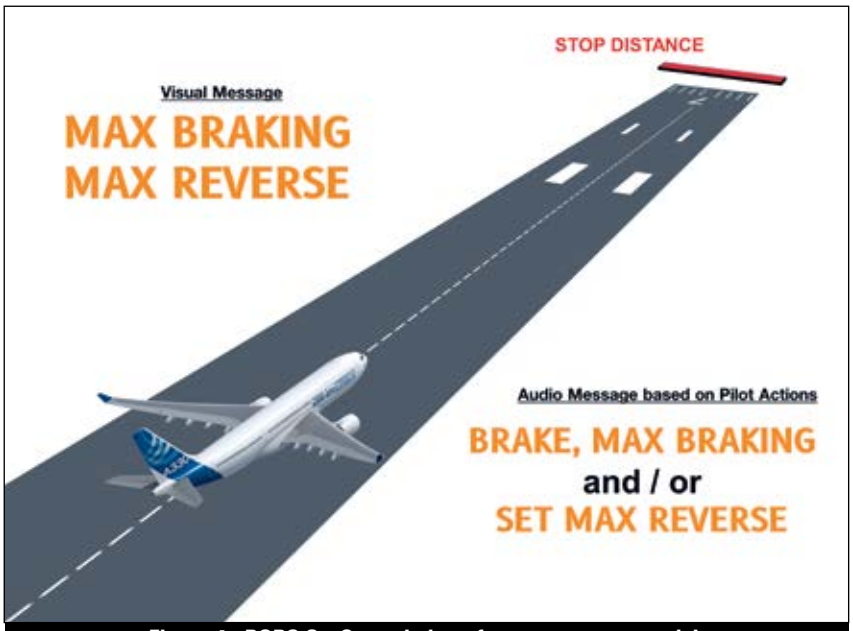

Figure 4 - ROPS On-Ground alerts for runway overrun risk

occasions, correctly alerting the flight crew that, due to rapidly changing conditions, the aircraft was now at a risk of a runway overrun. In all of these cases, the flight crews promptly followed procedures: one of these cases involved a low altitude Go-Around after the tail-wind increased by 10kt during short final, another case prompted the crew to Set Max Reverse on a slippery runway (even though ROPS is only currently certified on dry and wet runways) and another case prompted the crew to override 'Autobrake Low' and apply max manual braking.

The market response to ROPS so far has been remarkable. Nearly every A380 operator has selected ROPS, the system is standard equipment on every A350, ROPS has recently been certified for the A330 and is now entering into service and 150 Airbus A320 family in-service aircraft are already equipped.1 in 4 Airbus aircraft being delivered now have ROPS installed. Development has started on A350 to extend ROPS to contaminated runways.

Nevertheless, it is important to remember that ROPS is only one link in the global runway safety chain. As described in the European Action Plan for the Prevention of Runway Excursions (EAPPRE), each entity has a part to play in reducing runway excursions.

For aircraft operators, training and procedures remain fundamental to mitigate the risk of runway overruns. Whether an aircraft is equipped with ROPS or not, strict adherence to airline standard operating procedures (SOPs) and maintaining a stabilised approach are key components for a safe landing. Reviews of past overruns show that many runway excursions occurred despite aircraft meeting the stabilised approach criteria at the specified (e.g.1000ft/500ft) gates. For this reason, it is important to continuously monitor aircraft parameters and the aircraft's current position throughout the final approach, flare, touchdown and rollout. Once on the ground, timely application of deceleration devices will ensure the aircraft can stop in the planned and expected distance. ROPS, even if important, is only a last safety net before a major overrun risk.

For the civil aviation authorities, up-to-date information in the Aeronautical Information Publications (AIPs) is a key component to runway safety. ROPS uses an onboard runway database whose original source of information is the AIPs. Thus if ROPS is expected to correctly issues alerts to the flight crew, then the integrity of the runway database is essential.

For aerodromes, properly maintained runways play a key-role in ensuring that the aircraft can indeed achieve the stopping distance predicted. During contaminated runway conditions, it is essential to monitor changing conditions, report significant changes and clean the runway when necessary. A safe landing distance calculation is dependent on the flight crew knowing the actual runway state they will be landing on.

Together we can reverse the trend of runway overruns and improve safety during landing.

EDITOR'S NOTE:

More on the European Action Plan for the Prevention of Runway Excursions (EAPPRE) referred to above can be found at:

http://www.skybrary.aero/index.php/European_Action_Plan_for_the_Prevention_of_Runway_Excursions_(EAPPRE)