USING AIRCRAFT AS SENSORS **TO MEASURE RUNWAY CONDITION**

Many hull loss accidents occur on runways where braking performance is degraded by runway surface contaminants. Airbus and its subsidiary NAVBLUE is helping to enhance real-time awareness of runway conditions, via aircraft data shared in real time to better understand, anticipate and mitigate runway conditions. **Daniel Percy, Logan Jones** and **Fabien Moll** describe this new development.

KEY POINTS

1. **Runway excursions are a top cause of accidents; 35% occur on contaminated runways.**
2. **The way braking action is identified today is primarily via pilot reports, but such assessments can be difficult to make.**
3. **In 2018, Airbus and NAVBLUE will commercialise a new service that will address the request from national safety bodies for a viable technology to collaboratively and objectively measure and disseminate runway braking action.**

Background

In the world of commercial jets, it is well known that Runway Excursions (RE) are one of the top three causes of accidents. Airbus's own accident statistics show that RE caused 35% of hull-losses and 14% of fatal accidents between 1997-2016 (Airbus, 2017). Given this status, Airbus and other manufacturers are investing in the development of technology to reduce RE accidents.

Product features such as Airbus's ROPS (Runway Overrun Prevention System) are already in service and providing real time, energy and landing performance monitoring information to flight crews. However, with IATA identifying in their 2016 Safety Report that 35% of RE accidents occur on 'POOR' or contaminated runways (IATA, 2017), a clear case can also be made for the need to improve pilot awareness of runway surface conditions. Indeed, national Safety bodies including the NTSB of the USA and the UK AAIB have identified the need to develop "an operationally feasible airplane-based braking ability/ runway surface condition measurement and communication system" (NTSB, 2007, p. 13).

Today's means of measuring runway surface conditions

Today, there are typically three methods available by which runway surface conditions are evaluated:

- runway contaminant type and depth observations
- ground surface friction measurements
- braking action reports from pilots.

Contaminant type and depth observations are, in general, conducted physically by airport personnel on the runway surface. The conditions are assessed through a combination of visual observations and spot-checks. However, it can be a difficult task to consolidate what may be differing conditions across the entire width and length of the runway into a succinct runway condition report. In addition, during active precipitation and/ or freezing/melting conditions, the validity of the information may become outdated soon after it is issued

Ground surface friction measurements provide a more qualitative approach to taking measurements along certain points on a runway. However, as noted by the NTSB, they are useful for identifying trends in runway surface condition but are not recommended for use in predicting aircraft stopping performance. This is due to the lack of correlation with aircraft braking performance, as well as variability in equipment design and calibration (NTSB, 2007).

While the airport operator is responsible for generating the Runway Condition Codes for a runway, pilots are responsible for providing accurate braking action reports. Indeed, providing braking action reports is a significant role that pilots play in preventing runway excursions for all airplanes. Braking action reports contain the pilot's assessment of the manner in which an aircraft responds to the application of wheel brakes. The terminology for these reports is defined within ICAO Doc 4444 PANS, as illustrated in Table 1 below.

Reports should be provided by pilots whenever requested by ATC, or if the pilot has assessed braking action is less than previously reported. ATC receives the pilot reports by voice, and will disseminate them to other pilots on approach. ATC will also disseminate the current runway condition code.

If runway surface conditions deteriorate enough that two consecutive reports of 'Poor' conditions are received, the airport has to re-assess the runway conditions. If 'Less Than Poor' braking action is reported, the runway will be closed to further operations until the airport operator can improve the runway's condition.

These reports thus play an important part in the cycle of runway surface condition assessment and reporting.

Difficulties involved in making braking action reports

Aeroplane deceleration results from several forces: aerodynamic drag forces, generated by the airframe and in particular the ground spoilers; reverse thrust, if available; and, wheel braking.

In general, a braking action report should characterise the availability (or lack thereof) of wheel braking. The difficulty for a pilot is in differentiating in real-time which portion of the total deceleration is coming from the wheel-brakes. This difficulty is compounded by the typical use of autobrakes on contaminated runways. As the autobrake commands an overall

Pilot report of runway braking action	Description	Runway Condition Code (RWYCC)
N/A		6
GOOD	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal	5
GOOD TO MEDIUM	Braking deceleration OR directional control is between good and medium	4
MEDIUM	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced	3
MEDIUM TO POOR	Braking deceleration OR directional control is between medium and poor	2
POOR	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced	1
LESS THAN POOR	Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain	0

Table 1: Runway Condition Codes (RWYCC) as per ICAO Doc 4444 PANS

airplane deceleration rate, the pilot is able to detect a lack of wheel-braking when the target deceleration is not achieved, however it is still difficult to differentiate how much each component is contributing to the deceleration.

Once the aircraft decelerates to lower speeds (generally below 60kt), pilots often use manual braking and at these speeds the aerodynamic drag and reverse thrust forces are negligible. It is often in this zone where pilots are able to more easily 'feel' the runway by using the brake pedals to understand the braking action.

Given these complexities, making an accurate report can be a difficult task for a pilot, and braking report quality can become subject to differences of subjectivity between different pilots. To resolve this and provide objective and consistent braking action reports, Airbus has developed technology that will use aircraft data recorded during the ground run to identify the available braking action.

Using the aircraft as a sensor to identify runway condition

Airbus has been developing a new technology to address the need identified by the NTSB and other national aviation safety bodies, for 'an operationally feasible airplane-based braking ability / runway surface condition measurement and communication system'.

The fundamental principle of the technology is, post landing, to use the data recorded by the aircraft during its deceleration roll to identify the braking action level. By using the aircraft performance model the technology can differentiate the part of deceleration coming from either aerodynamic, thrust reverse, or wheel-braking. Subsequently, by comparing the actual wheel braking performance to models of wheel-braking performance under different runway conditions, the algorithm can compare and determine the runway state that most closely resembles the experienced deceleration.

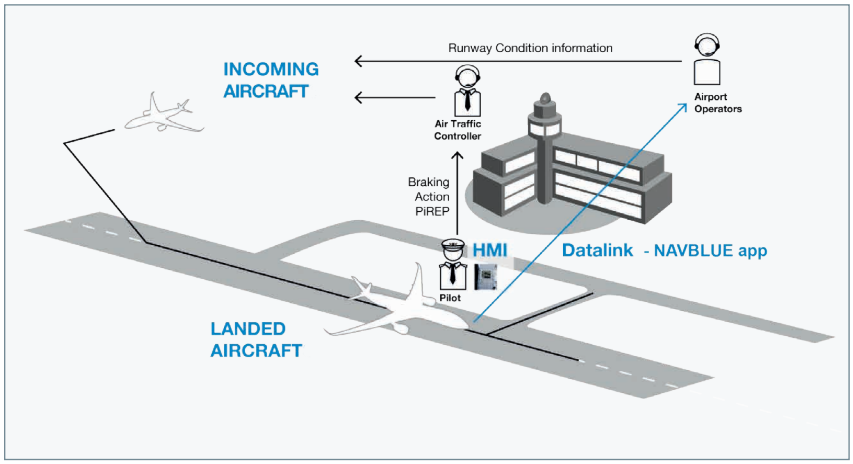

Figure 1: Principles of data connection providing runway condition reports to incoming aircraft from landed aircraft

As illustrated in Figure 1, after landing the information is simultaneously disseminated in two ways:

- The result is displayed to the pilot to assist him or her in making an objective report, to be provided to the ATC
- The result is sent by ACARS message to Airbus subsidiary NAVBLUE, which will collect and display the results on a web-service platform for use by ATC, airports, and airline operational centres

This technological approach is collaborative by nature. It resembles the various mobile traffic applications which share traffic data in real-time to allow drivers to see and avoid traffic jams. Indeed, the goal of this new Airbus-NAVBLUE technology is to provide a platform where airspace users are sharing reports in real-time to better understand how the runway condition is trending, and to allow the airport to anticipate and mitigate slippery conditions. The more aircraft that participate in the sharing, the better the real-time map of conditions becomes.

This technology has now been thoroughly tested via comparison with historical flight data, flight tests as with on board operational trials with participating airlines. Airbus and NAVBLUE have therefore launched the commercialisation of the function, details of which will be provided to the industry during 2018.

References

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