Do runway excursion accidents necessarily have precursors in lesser events?

By Captain Ed Pooley

It is generally considered that one of the ways to reduce the prospect of a serious incident or an accident is to ensure that careful attention is paid to all the lesser events[1]...

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The contributory factors which are identified in these lesser events usually involve potential precursors[2] of similar events, including accidents. It is also sometimes claimed 'in reverse' that accident investigations will invariably find that significant elements of the cause of an accident had visible and direct precursors in events with less serious outcomes. This model gives a heavy weight to the identification of precursors in lesser events as a means to accident prevention.

But is this always true? I am now going to take a look at one serious runway excursion that happened a couple of years ago in Denver, USA. Based on what the NTSB investigation[3] found had occurred and what was considered to have led to it, could this fortunately non-fatal, but nevertheless major, runway excursion have been foreseen on the basis of past experience of lesser events at either the airline or the airport concerned?

Photograph taken from the official accident report

The accident occurred when the pilot handling the initially uneventful night take off of a Continental Airlines Boeing 737-500 (the Captain) lost control near to rotation speed on a take off on gusty crosswinds. The aircraft left the runway and careered over 700 metres across mainly flat ground before coming to a stop. Fortunately, all the occupants escaped before a fuel fed fire turned the aircraft into a convincing hull loss. The result is shown in the photograph taken from the official accident report.

1- I define a 'lesser event' as one which excludes a 'Serious Incident' which ICAO define as one where an accident nearly occurred and prescribe an independent investigation under the same Annex 13 procedures as apply to the investigation of actual accidents.
2- A Precursor is "a thing that comes before another of the same kind" (OED)
3- http://www.skybrary.aero/index.php/B735,_Denver_USA,_2008_(WX_HF_RE_FIRE)

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There are a couple of interesting things about Denver (apart from the unusual design of the main terminal building) that some readers may be aware of. The first is that it is situated at an abnormally high altitude for a major commercial airport of over 5000 ft amsl and the second is that it is well known to be subject to mountain wave conditions as a result of its proximity to the Rocky Mountains. Although the first has a significant effect on aircraft take off and landing performance, it had no relevance to the accident we are looking at – the aircraft was about to get airborne about half way down the runway. The second, however, is the cause of 'interesting' wind velocity variations at Denver and has led to the setting up of one of the most comprehensive integrated systems for the tactical measurement of low level wind velocity in the world. ATC see summaries of this and other information as well as hear any pilot reports and are then faced with the decision of how best to give pilots useful information when they are about to make a take off or landing.

Let's look briefly at the matter of maintaining directional control of an aircraft in strong and variable crosswinds.

Although not all aircraft manufacturers stipulate a maximum crosswind component permitted during a take off or a landing in a particular type (Boeing did not do so for any of their aircraft types at the time of this accident), such limits are likely to be included under 'Limitations' in the applicable Operations` Manual current at the time and the figures for take off and landing may be slightly different. The question of whether it is probable that any take off or landing can be made without exceeding those limits is not a matter of measurement. The precise wind velocity to which an aircraft was actually exposed can only be discovered by referring to the aircraft flight data recorder after a flight. There is no readout of it on the flight deck. So what the pilot normally expects is to receive from ATC, by ATIS or directly, the available and relevant information about the actual wind velocity which has been recorded in the general vicinity of the runway concerned in the past few minutes. They will be aware that in gusty conditions, a change in the 'spot' wind speed can be expected to be associated with a simultaneous change in the exact wind direction (and that in the northern hemisphere, the instantaneous wind direction can be expected to back if the speed increases and veer if the speed decreases). Most pilots will be aware that there are formalised requirements to declare the range of wind directions and wind speeds either side of the mean, once either exceeds an officially specified threshold of variation. They will be grateful for ATC services which pre-empt their questions about wind velocity variation, but ready to ask for what has not been offered already and, in the context of what they know, is needed to complete the picture.

What about ATC and the information they pass on about the wind? It will not be the wind velocity where the aircraft actually is or is soon going to be. Instead, it will be a modest selection of the most useful data which will inform the decision of whether the imminent landing or take off should be executed. Most ATC TWR Units are good at ensuring that the pilot has the best available information. Some tend to respond to requests from the pilot but many do not wait to be asked but proactively offer what they have and keep it updated until the actual take off or landing is in progress. ▸

Do runway excursion accidents necessarily have precursors in less serious events (cont'd)

The investigation into the Denver accident found that the probable cause of the accident was:

"The Captain's cessation of right rudder input, which was needed to maintain directional control of the airplane, about 4 seconds before the excursion, when the airplane encountered a strong and gusty crosswind that exceeded the Captain's training and experience."

It also established that:

"Performance calculations indicated that the airplane's rudder was capable of producing enough aerodynamic force to offset the weathervaning tendency created by the winds the airplane encountered during the accident takeoff roll".

In other words, the (unanticipated) wind velocity conditions encountered exceeded the ability of the pilot involved on the day but not the capabilities of the aircraft. Despite the fact that the actual (momentary) crosswind component at the point where control was lost was estimated to have been at least 10 knots greater than the applicable Operations Manual limitation. It was observed in the probable cause statement that the specific training and experience of the pilot had not exposed him to a comparable challenge in the past and that, by implication, this had increased the likelihood of the handling error which directly led to the accident.

The investigation concluded that the main way forward regarding flight crew skills was to use a higher fidelity training simulator , so that pilots could be exposed during training to the full range of anomalous surface wind velocity conditions which they may possibly experience, even if only very rarely. With regard to the performance of the flight crew, no precursor from a lesser events was found for this accident, only that it had occurred in the context of insufficient training for circumstances which, in detail, were always going to be rare.

The investigation also noted that:

(1) "Mountain wave conditions were present at the time of the accident and resulted in strong westerly winds and very localized, intermittent wind gusts as high as 45 knots that crossed the airplane's path during the takeoff ground roll".

(2) The TWR ATCO "did not….provide information about the most adverse crosswind conditions that were displayed on his ribbon display terminal; therefore, the pilots were not aware of the high winds that they would encounter during the takeoff roll."

(3) "Other airplanes departed on runways 34L and 34R before the accident pilots' departure; the pilots of those departing airplanes did not report any crosswind-related issues or difficulties"

(4) "Currently, the Denver International Airport air traffic control tower runway selection policy does not clearly account for crosswind components when selecting a runway configuration".

Although there was no general evidence of especially challenging crosswind conditions at the time, ATC did not pass the accident aircraft all the potentially useful information on wind velocity which they had access to. Of course if there are procedures to guide the designation if active runways, then they must take proper account of likely crosswind components. Those at Denver did not. Furthermore, if there are procedures to guide the selection and transmission of observed wind velocities to aircraft about to land or take off, then these must guide controllers on the optimum selection of wind velocity data to be given to a pilot. Those at Denver did not. The recommendations provided procedural fixes to both issues but again no specific precursors were identified in any previous lesser events.

The (unanticipated) wind velocity conditions encountered exceeded the ability of the pilot involved on the day but not the capabilities of the aircraft.

The simple fact is that a take off successfully accomplished in challenging crosswind conditions leaves no trace. In such an accident, there were never going to be any Aircraft Operator or ATC precursors in lesser events and so in this example at least, the case is made. I would suggest that it invites a deeper review of how we can enhance accident prevention without relying so heavily on the database of lesser events to inform risk assessment. But that's for another time…and it is not in any way a general argument for not seeking to collect data on lesser events, for which there are many other sound justifications.