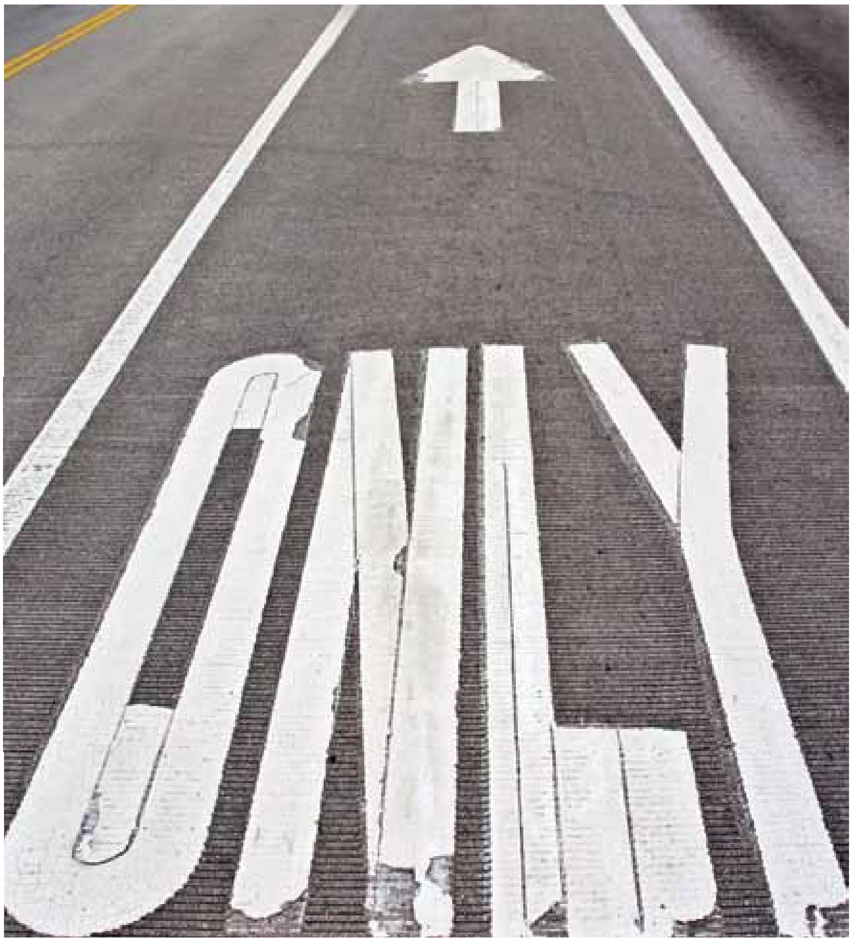
Understanding cockpit factors

By Captain Rob van Eekeren

Despite statistics, pilots tend to think that a runway excursion will never happen to them. In many cases, they are correct. However, some will face an uncontrollable aircraft leading to a runway excursion; a horrifying experience.

Research shows that many reasons and factors could lead to a runway excursion. Basically there are two scenarios: an aircraft can either overrun at the end or veer-off at the side of a runway. Overruns often occur after a high energy aborted take-off or landing. Although pilots are trained to abort a take-off before V1, take-off overruns do occur. After landing, pilots may find having reduced braking capability, resulting in less remaining landing distance than expected.



The industry wants high performance at reduced costs; current calculation technology is accurate but only as good as the quality of the input variables. This quality is lacking, thus leading to a false sense of safety. At the same time, efforts are being made towards optimisation of performance, environmental restrictions, payload, fuel, maintenance and operational factors. Without adequate margins to cover for real world system imperfections, safety would be directly negatively affected.

Performance input variables

Let's first focus on the quality of the parameters needed for runway landing distance and take off distance calculation. Runway length, slope, QNH, weight of the aircraft, fuel load and technical status are in general precise. Contrary to these though are; wind, the factual runway friction, and consequent braking efficiency, which are often unreliable. Wind varies stochastically, while runway friction measurements are not always related to the behaviour of the specific aircraft type. A couple of knots more headwind instead of a tailwind could make a difference of up to 5000kg in payload which could lead to an overweight aircraft for the actual conditions. Are such variations in input variables possible and

Captain Rob van Eekeren

flies the Airbus A330 with KLM Royal Dutch Airlines. He has been heavily involved in runway safety since 2001 and works with various organisations to enhance runway safety.

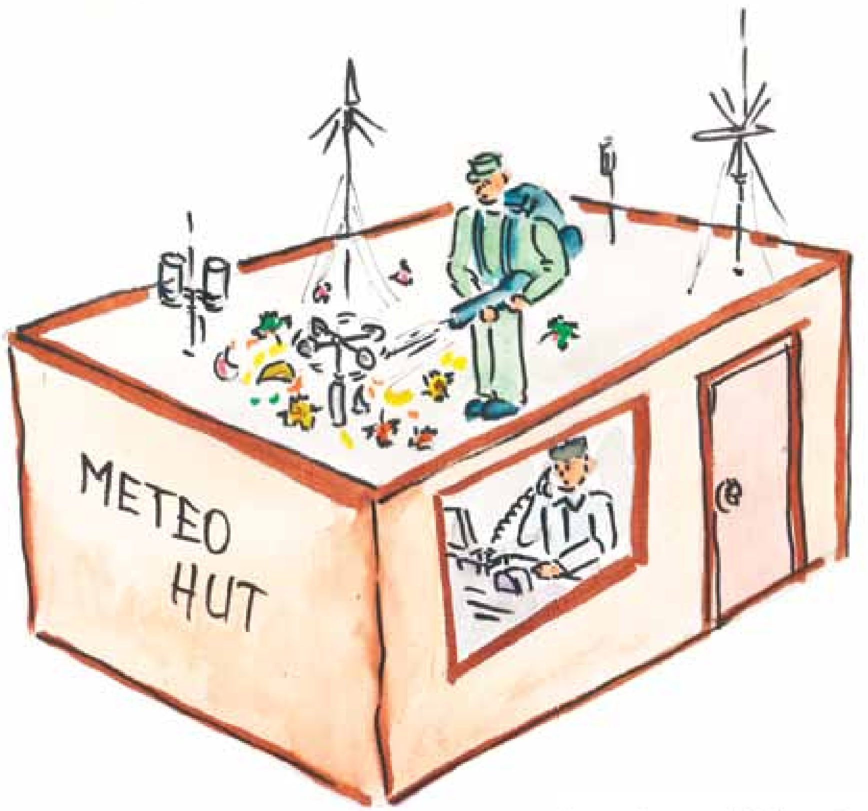
Runway excursions: cleared to land ... ready or not! (cont'd)

realistic? Yes. ICAO Annex 3 allows even for a wind margin of 60 degrees and 9 knots (reporting threshold gusts). The actual runway condition state poses an even greater threat with a possible fault margin of over 100%. Current runway contamination measurement methods give an output that is varied along a runway and not calibrated to relate to aircraft performance parameters often derived by aircraft computers which require and use inputs to the millimetre of accuracy. Due to the lack of correlation between the runway measurement output and the aircraft performance, computation pilots can face an unbalanced take-off without being aware of it. If then faced with an engine failure, an overrun would occur.

Why does this not occur frequently? Probably because the chance of an engine failure at the most critical moment (V1) is very low and landings on critical-length runways in critical conditions are rare. The industry therefore compensates the flaws in the system by luck, if not there, a runway excursion is unavoidable.

Rubber deposits

Another issue is rubber deposits on the runway. After landing, the main braking forces are reverse thrust and aerodynamic drag during the initial high speed portion (> 60 knots), and then the brakes are the main retarding force. When the runway is covered with rubber deposits and when the runway is moist or even wet, there would be virtually no friction left, resulting inevitably in a low speed overrun The same logic applies to contaminated or slippery runways. Rubber deposits are frequently found at the touchdown point, which could be the end of the (opposite) runway in use. That is precisely the low speed area after landing or an RTO and thus likely to result in a slow speed overrun.



My readings show strong wind gusts with rapid direction changes...

Rule makers will have to accept that adequate margins are essential to cover for imperfections of the theoretical system.

Reverse thrust

Another worrying development is the restrictions on the use of reverse thrust for environmental reasons. It does not only take away the most effective braking system during the initial part of the landing, but it also has a huge effect on the brake temperatures. Generally hot brakes do not have the same braking performance or could be the source of a wheel well fire. Performance calculations are not based on hot brakes. Hot brakes caused by a lack of reverse thrust will not only affect the current flight, but also the next flight since dense operations require a quick turnaround. Thus a take-off with possible hot brakes as a result of the previous landing is likely to occur. Hence why a high speed aborted take-off could very well result in an excursion.

Soft landing

Let's get back to the landing. A good landing will help a good run on the runway surface and thus prevent an excursion. However, long landings increase the chance of an overrun. Passengers like a soft landing, but this increases the chances of an incorrect flare followed by floating. But a too hard landing increases the risk of bouncing and structural failures. Although a firm and correct touchdown, especially in wet conditions, reduces the chance of a long landing, passenger comfort is in normal operations found to be very important. So, when pilots are in the normal habit of making soft landings, it is unlikely that these habits are changed under difficult or stressful circumstances like adverse weather.

A good landing is made possible by a good flare. A good flare is an art, especially in gusty conditions. This requires excellent and regular training or exposure. For pilots based in windy airports, the gust exposure can be up to 50%. But pilots flying occasionally into these airports could face their first windy, gusty landing for years. Autopilot limitations preclude autolands in these conditions. Moreover, the different manufacturers have produced aircraft with different flying and especially flaring characteristics. This, in combination with a lack of exposure and/or training could lead to phenomena known in the literature as, 'pilot induced oscillations', which result in a poor flare and an uncontrolled, hard or long landing.

Stable approach

A stable approach helps perform a good flare. Being at the correct airspeed on the correct glidepath at the extended centreline, with wings level in the correct angle of attack at the right moment describes the best essence of a stable approach. Since flight operations are in a dynamic environment, this ideal situation is virtually impossible to achieve. Thus certain variables have to be within certain limits. The aerodynamics of modern aircraft, being vectored with high or relatively high airspeed, pose a real threat to performing a stable approach. Runway change or late runway allocation can also lead to an unstable approach. Glide paths over 3 degrees (due to terrain or noise considerations) increase the risk of an unstable approach considerably. For example, the approach speed of a fully loaded Boeing 737-900 in gusty conditions on a 3 degrees glide path requires a vertical speed of 900 feet per minute. The Ground proximity Warning System gives an alarm with 1000fpm (the stable approach limit); there is little room for corrections. Even a small tail wind would make a stable approach impossible. Furthermore, each knot of tail wind represents one-knot square more energy to lose on the runway.

Wind and vortices

Another factor is a wind shift during the approach. Wind on the runway might indicate a head wind, whilst during the approach a gradual or sudden (shear) wind shift occurs from tail to head. For example, some airports are known to have a 20-30 knot tailwind in the approach, changing at the very last minute to a headwind during landing. This might be a positive slow shear, but it will make a stable approach extremely difficult to achieve. Preferential runway allocation systems are often based on strict ground wind limits, but vertical shears are rarely taken into account.

Finally, aircraft wake vortices could make a stable approach very difficult to achieve. Although ICAO has produced guidelines for spacing, these are not always sufficient for performing stable approaches. Approach speeds could differ up to 60 knots in modern aircraft. Trying to optimise runway occupancy, ATC often restricts aircraft not to fly at their ideal approach speed, but faster or slower (e.g. 160 knots until the Outer Marker, poses a real challenge for aircraft like the A330). These speeds increase the chance of an unstable approach, increase workload in the cockpit and thus will increase the chance of a runway excursion.

Conclusions and recommendations

Nowadays, computerised and design optimisation to the millimetre without adequate margins leaves no room for stochastic real world variations. When at an unfortunate moment an unexpected situation arises, the chance of a runway excursion is likely.

Pilots and air traffic controllers work together in the same aviation environment with the same goals: safe and efficient flights. So how can ATCOs and ANSPs help pilots to reduce the chance of a runway excursion?

First of all, air traffic controllers should understand precisely all elements of a stable approach. The design of good approach procedures will help pilots perform a stable approach. Good ATC guidance will help the execution of a stable approach.

Secondly, they should understand fully the importance of timely and factual information needed by aircrew for their performance calculations which is in the range of …?. The three / four-dimensional wind and runway friction characteristics are the "biggies" here. Controllers should also realise that runway optimisation, while good for throughput, might have a direct and adverse effect on flight safety.

Finally, rule makers will have to accept that adequate margins are essential to cover for imperfections of the theoretical system. Optimisation in figures after the comma, without these margins, might look good on paper, but disrespect the dynamic forces of nature and the human being.

Unless these three recommendations are respected, it is reasonable to conclude that runway excursion accidents will continue to disrupt airport operations and to cause casualties. We do not want that; it is therefore imperative that air traffic controllers and pilots work closely together to prevent runway excursions.