Podcast 48, Windshear

Hello everyone, and welcome to another episode of the 737 Talk, where we try to help with aircraft & procedural technical refreshers, discussing together incidents involving the 737, from which we can all learn. We thought this time we'd have a brief discussion about windshear, it's detection, warnings and Boeing's recommended actions in the event of an encounter. Here, Ian and I will take a look at the technical and practical side of the topic to increase our knowledge and awareness

Windshear is a change of windspeed and or direction over a short distance along the flightpath. As a crew we must search for any clues indicating it's presence. So, what are some the ways we can do this? Visible weather, such as Thunderstorms and Virga, which is rain that evaporates before it hits the ground are a good sign, as well as potential at weather fronts and of course mountain waves and jet streams at higher levels. Also, the presence of other aircraft which we can glean pilot reports from is a useful resource.

There are certain airports where shear is more prevalent than others, due to their geographical location and associated orographic effects. Tenerife South in our neck of the woods is a good example.

Another system helping us identify the threat is the Low-Level Windshear alerting system, or LLWAS. This is a ground-based system which consists of anemometers strategically placed around, and within an aerodrome which predominantly measure horizontal shear. ATC will then relay alerts to pilots until they are placed on the ATIS and the pilot has acknowledged receipt of the appropriate code. This is still mainly a US based system.

We need to have an understanding of the Windshear Caution and Warning actions and what particular warnings the aircraft will provide. However, we also need to be aware that an aircraft can be in windshear without any of the relevant warnings annunciating.

The following is extracted from the QRH indicating that an aircraft may be in a Windshear without any warnings annunciating.

In general, unacceptable flight path deviations are recognised as uncontrolled changes from normal steady state flight conditions below 1000 feet AGL, in excess of any of the following (defined in the 737 QRH):

- 15 knots indicated airspeed
- 500 fpm vertical speed
- 5° pitch attitude
- 1 dot displacement from the glideslope
- unusual thrust lever position for a significant period of time.

These are the parameters we should be on the look out for in areas of known shear which if encountered should also lead to the Windshear escape Manoeuvre being flown. Remember there doesn't have to be the aural warning in order to perform the escape manoeuvre.

If the presence of wind shear is confirmed, we should delay take off or discontinue an approach.

We'll discuss a few of the mitigation strategies we can employ to avoid, trap or mitigate this threat, when it comes to TEM briefing a potential Windshear event.

Remember if any indications of sheer are around the departure area and you decide the risk is such that a take-off will be commenced, don't be rushed into accepting the take-off clearance. Use that weather radar once lined up for one final check as to whether you wish to depart or delay for more suitable conditions.

It is suggested to use the minimum flaps configuration compatible with take-off requirements to maximise climb gradient capability. You also have the increased Vr method which gives you increased stall margin and meets performance requirements. Practically you would set V speeds for actual gross weight but rotate at the higher agreed Vr. However, if you encounter shear when above Gross weight Vr you would not attempt to accelerate to the higher speed but rotate without hesitation.

When you know your all engine initial climb pitch attitude you can rotate to this at the normal rate for all non-engine failure take offs. Minimise reductions from this attitude until terrain and obstacle clearance is assured, unless of course stick shaker is activated.
CRM here is vital and as PF can be using full capacity to hold the aircraft possibly at intermittent stick shaker PM's role in calling deviations becomes critical.

The QRH also refers to a 'most suitable runway' as a way of further mitigation. By 'most suitable runway' they mean preferably one that avoids the shear area completely but is of course compatible with our cross and tailwind limitations.

The need to avoid large thrust changes in response to sudden airspeed increases is due to the fact that in wind shear a sudden airspeed decrease may follow and with engine spool up time you may put yourself in an unfavourable low speed recovery situation.

What about the thrust Setting on take-off During Potential Windshear:

If you were aware of a potential windshear on your take-off you would of course be looking at a full power take-off in any case unless perhaps a derate is required to meet dispatch performance.

Let's just remind ourselves though of some considerations should we have chosen a derate, ATM or both.

- When using de-rated take-off thrust, the take-off thrust setting is considered a take-off operating limit since minimum control speeds (VMCG and VMCA) and stabilizer trim setting are based on the de-rated take-off thrust.
- Thrust levers should not be advanced unless conditions are encountered during the take-off where additional thrust is needed on both engines, such as a windshear condition.

- When conducting a reduced thrust (ATM) take off, if more thrust is needed (up to full rated thrust) when thrust is in THR HLD mode, thrust levers must be advanced manually.
- If conditions are encountered during the take-off where additional thrust is needed, such as a windshear condition, the crew should not hesitate to manually advance thrust levers to full rated thrust.
- When conducting a de-rated thrust (fixed de-rate) take off or a take off with a combination ATM and fixed de-rate, take off speeds consider VMCG and VMCA only at the fixed de-rate level of thrust.
- The required levels of power/thrust required to escape a Windshear event may be beyond what the average pilot might consider necessary but, in fact are required by the situation.

It is important to note that if more thrust is needed (up to full rated thrust) when THR HLD mode is displayed, the thrust levers must be manually advanced. When the airplane is below 800 feet RA, full GA N1 can be determined by pushing a TO/GA switch a second time. This will set the reference N1 bugs for full GA thrust.
When the airplane is above 800 feet RA, pushing a TO/GA switch advances the thrust levers to full GA thrust.

The PWS uses Wx radar to scan for shear ahead of the aircraft. It can give us aural and visual cautions and warnings. In the take off phase we can receive the caution “MONITOR RADAR DISPLAY” or the warning “WINDSHEAR AHEAD, WINDSHEAR AHEAD”. In the approach phase we may also receive “MONITOR RADAR DISPLAY” and the warning “GO-AROUND, WINDSHEAR AHEAD”. As this system uses the weather radar it is monitoring moisture so will unlikely occur on a clear day where shear may still of course exist.

The MONITOR RADAR DISPLAY caution gives us the amber WINDSHEAR word on the ND as well as the black and red symbol showing the location and approximate geometric size of the shear. The parameters here are that the shear is within 3 miles and ahead of the aircraft. It is enabled during take off and approach below 1,200ft RA.

The WINDSHEAR AHEAD warning gives a RED WINDSHEAR word on both PFD’s as well as a red wind shear symbol and Red WINDSHEAR message on the ND’s. The parameters here are that Windshear is close to and directly ahead of the airplane. It is enabled during takeoff, below 1,200ft RA.

The “GO-AROUND, WINDSHEAR AHEAD” warning gives red WINDSHEAR of both PFD’s as well as a red wind shear symbol and red wind shear message on the ND’s. The parameters are that windshear is within 1.5NM and directly ahead. It is enabled during approach below 1,200ft RA

-The GPWS system does not provide windshear Caution, only Windshear warnings as this is when the aircraft is actually IN a windshear encounter.
-The weather radar provides the Windshear caution as a function of the PWS and are accompanied by the voice aural alert.

Note a Windshear warning indicates that :
The airplane is either in :-
- Energy Loss- Decreasing airspeed and increasing descent rate, or
- Energy Gain – Increasing airspeed and increasing climb rate.
This will be accompanied by two tone alert and aural “WINDSHEAR WINDSHEAR”
This warns us of excessive windshear at the current aircraft position and requires the Windshear Escape Manoeuvre to be flown.

Windshear alerts are only available during Take Off, Approach and landing. It is the GPWS that provides the warning if the airplane is actually in Windshear through a comparison between inertial and aerodynamic data.

If Windshear is encountered during FD takeoff or go-around the FD command bars provide commands to maintain the target speed until vertical speed decreases to approximately +600fpm.
At this point the FD commands a 15° nose up pitch attitude. If VS continues to decrease the F/D continues to command 15° pitch until a speed where approximately stick shaker is reached.

It will then command pitch attitudes that result in intermittent stick shaker. As you come out of shear the FD programming reverses, and as climb rate increases above +600fpm, the FD pitch command results in acceleration back to target speed. Just make sure that target speed is what you want it to be at that point.

If we’re operating in an environment conducive to windshear, we need to look at ways we can reduce the risks we’re exposed to.

You can also of course get windshear above the inhibit threshold on the take-off that can only be identified through the Airspeed indicator stalling or fluctuating significantly up or down. Here is where you get a bit of extra guidance in the Manoeuvres section.

If wind shear is encountered before V1, there may not be sufficient runway available to stop if an RTO is initiated at V1. At Vr, rotate at a normal rate toward a 15° pitch attitude. Once airborne, perform the Windshear escape manoeuvre.

If wind shear is encountered near the normal rotation speed and airspeed suddenly decreases, there may not be sufficient runway left to accelerate back to normal takeoff speed. If there is insufficient runway left to stop, initiate a normal rotation at least 2,000ft before the end of the runway, even if airspeed is low. Higher than normal attitudes may be needed to lift off the remaining runway. Ensure maximum thrust is set. To ensure this, as you will be in Thrust hold, you will need to manually advance the levers.

There’s no guidance here about identifying the last 2,000ft but we all know that our last 900m are split into 600m of red and white centre line lights followed by 300m of reds. So approximately halfway into the red and whites will leave you with that required 2,000ft. If

you don't have centre line lighting then the last 600m, approx 2,000ft are identified by yellow runway edge lights.

Let's have a think about windshear on Approach and Landing. Some mitigating techniques we could use include the use of Flap 30, establishing an early stabilised approach, again using the most suitable runway if possible, the addition of speed to Vref up to Vref +15 if the autothrottle is to be disengaged, good CRM with clear communication over deviations and to remind yourself to be wary of large thrust lever changes in response to airspeed fluctuations due to reversals and spool up times.

If wind shear is encountered during an ILS approach, both the F/D and A/P attempt to hold the aircraft on altitude or on glide slope (after G/S capture), this is done without any regard to the angle of attack required to do this. This may mean the aircraft is taken to stick shaker limits. The airspeed could carry on decreasing below stick shaker operation and eventually stall if the pilot does not take intervening actions by disconnecting the A/P and pressing the TOGA button to start that escape manoeuvre!

We will have been taught that if we suspect that we have entered a windshear encounter then we should not delay in executing the Windshear escape manoeuvre, even if the GPWS/PWS has not announced a windshear event.

We have two options when you here the PWS 'GO-AROUND WINDSHEAR AHEAD'. You can either perform the escape manoeuvre or a normal go around. This is because it's from that predictive system, so you are not currently in the wind shear but are likely to be shortly. One advantage to performing the normal go around to begin with is you have the chance to get the gear up before entering shear. The risk hear of course is that you may enter shear as you select the gear up and then you momentarily increase aircraft drag due to the gear doors. Something to think about that is left to pilot discretion, but proximity to terrain should also be taken into account and of course company procedures.

It's important to note that once clear of the shear there is the additional threat of recovering back to a desired state.

Always come back to what you know and consider the standard Go-Around procedure as a good place to go. Here it doesn't matter if you've already raised the gear prior to the encounter as it will just put you back in a place of relative comfort and you can continue through the procedure until the aircraft is clean and you are then ready to make your plan going forward. Be aware of that speed window. If it is open then make sure to select your desired speed.

Reporting the event to ATC is very important to give situational awareness to those operating nearby.

After all that we'll now look at our memory items for Windshear. As memory items, these are worth committing to long term muscle memory, so definitely worth thinking about regularly.

There are specific actions for both PF and PM:

For manual flight as PF we are to:

Disengage the A/P
Push either TOGA switch
AGGRESSIVELY apply maximum thrust
Disconnect autothrottle
Simultaneously roll wings level and rotate initially toward 15 degrees.
Retract speedbrakes, and
Follow the FD TOGA guidance

A few points of note here:
Maximum thrust can be obtained by advancing the thrust levers full forward if the EEC's are in the normal mode. If terrain contact is imminent, advance thrust levers full forward.

We must also not not exceed the PLI's when following the FD guidance.

As PM, we verify that:
-Maximum thrust has been applied and
-all PF's actions just discussed have been completed and to call out any omissions.

Remember as PM your role in assisting PF is vital. Let him/her know any trends of speed or altitude and V/S, and when you believe sheer is no longer a factor be sure to state it for their agreement. Something that includes the fact that speed and altitude trends are positive, and the visual and aural alerts are gone. You can then start that recovery from the recovery perhaps using that GA flaps 15 call.

There are a few differences should we decide to leave the A/P in. In this case, by definition we do not disconnect the AP and A/THR but press the TOGA switch and verify TO/GA mode annunciation and GA thrust is set. If TO/GA is not available, disengage AP and AT and fly manually. PM must monitor GA thrust is set and call any omissions as well as those helpful monitoring calls we just mentioned.

If we elect to leave the automatics in, we must be aware that severe wind shear can exceed the performance of the AFDS. So again, we must be prepared to disengage the AP and AT and fly manually. This is an important note as we may also find the automatics disconnect and hand the aircraft back to you in a difficult state to control. Something to think about when deciding how you will the escape Manoeuvre.

Just a common error to mention here, we must remember not to change configuration until wind shear is no longer a factor. We have often seen crews during training and assessments forgetting this and raising the gear and/or flap at inappropriate times. Remember the statement here "until windshear is no longer a factor". A quick agreement between you that you are through the shear should help with getting the procedures in the right order.

Another important note under these memory items in the Manoeuvres section of the QRH is:
Aft control column forces increase as the airspeed decreases, aircraft stall defences as we've

mentioned previously. In all cases, the pitch attitude that results in intermittent stick shaker or initial buffet is the upper pitch attitude limit. Flight at intermittent stick shaker may be needed to obtain a positive terrain separation. Use smooth, steady controls to avoid a pitch attitude overshoot and stall. We are flying the aircraft at its performance limit here so as you would expect being smooth with the controls is vital.

So that's about it. We hope this talk has been a good refresher for you and given you the tools necessary to cope with such an event yourself. Also remember from a checking point of view that this manoeuvre is an assessable item on so an examiner may well pick it to check competencies, primarily FPM and APK.

To get you thinking like your TRE he or she will be looking at things such as your planning and briefing around the event, your SA - did you anticipate the threats, were your communications accurate, clear and concise. Did you recognise high Workload and prioritise effectively? and a big one here, were deviations identified and corrected under flight path management.

In the briefing room Knowledge will be checked and in the sim application of that knowledge will be assessed. As a crew, Teamwork and other non-technical skills during wind shear is vital, so this manoeuvre is also an interesting one for your examiner to take a look at.

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