Introduction

In this article, Airbus would like to take you through a case study and use it to learn some lessons and share our safety first culture.

The article is split into three distinct parts:

- The first will describe the event
- The second, targeted at flight crews, will discuss and develop the stabilization criteria and present a prevention strategy against unstable approaches. It will also insist on the need to use the appropriate level of automation at all times.
- The third part, targeted at maintenance personnel, will illustrate the need to always use the Aircraft Maintenance Manual (AMM) as the source document for maintenance operations.

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Hard Landing, a Case Study for Crews and Maintenance Personnel

Description of the Events

Approach and Landing

An A330 is on an ILS in rain. The Captain is PF, with AP1, both FDs and A/THR engaged. At 6 NM from touchdown the aircraft is in flap configuration 3, on glide slope and localizer at Vapp. ATC provided the flight crew with latest weather information: 10 kt tailwind with windshear reported on final.

Passing 1,500 ft, AP and A/THR are disconnected and the approach is continued manually. An initial LOC deviation of ¼ of a dot is corrected by PF. Passing 1,000 ft, the crew report runway in sight. Passing 500 ft, several flight parameters (localizer, glide slope, vertical speed, pitch, bank...) briefly exceed the published "approach stabilization criteria" but each is corrected by PF.

However, by 150 ft radio altitude, the aircraft is above the glide by more than one dot and two nose-down inputs are applied. The rate of descent increases to -1,100 ft/min and the EGPWS alert "SINK RATE" sounds twice, the second time below 50 ft. Despite a nose up input during the flare the aircraft impacts the ground at -1,260 ft/min with a vertical acceleration of 2.74 g.

After Landing

The flight crew reported the hard landing in the tech logbook and passed the information to the station's maintenance.

The technician applied customized technical notes that specified that in the absence of load report 15 - generated by the Aircraft Condition Monitoring System (ACMS) in case of hard landing - and if the Data Management Unit (DMU) is functioning properly, no aircraft inspection was required and the DAR disc was to be replaced and kept in the aircraft for further analysis at the home base.

On that particular case the DMU was considered to be functioning because messages had been received by the home base during the flight. Load report 15, however, was not transmitted via ACARS until the following day, due to an internal failure known as a DMU lock up (REF A).
The aircraft was cleared to be dispatched for the return flight.

After take-off, due to the damage sustained during the hard landing, the landing gear failed to retract and the flight crew elected to perform an In Flight Turn Back after enough fuel was burnt to land below MLW. The aircraft landed safely.

Operational Recommendations

Stabilization criteria

The Flight Crew Training Manual (FCTM) and Flight Crew Operating Manual (FCOM) both state that deviation from the normal stabilization criteria should trigger a call-out from Pilot Monitoring. These calls should in turn trigger, at the very least, an acknowledgment from PF, and, where necessary, corrective action. The criteria vary from type to type but typically a call should be triggered if:

- The speed goes lower than the speed target by 5 kt, or greater than the speed target by 10 kt.
- The pitch attitude goes below 0°, or above 10°.
- The bank angle exceeds 7°.
- The descent rate becomes greater than 1,000 feet/min.
- Excessive LOC or GLIDE deviation occurs: ¼ dot LOC; 1 dot G/S.

There are generally considered to be three essential parameters needed for a safe, stabilized approach:

- Aircraft track
- Flight Path Angle
- Airspeed

What could the crew have done to prevent this event?

Preventing unstable approaches

The prevention strategy against unstable approaches may be summarized by the following key words:

- **Train**
- **Anticipate**
- **Detect**
- **Correct**
- **Decide**

Train

Prevention can be emphasized through dedicated training for:

- Stabilized approaches
- Pilot Monitoring
- Difficult and unexpected reasons to initiate a go-around as part of recurrent training – not just go-around from minima, "nothing seen!" Try introducing a sudden, late wind shift…

Anticipate

First, define and brief a common plan for the approach including energy management and the use of automation.

Then, identify and discuss factors such as non-standard altitude or speed restrictions, approach hazards, system malfunctions.

Finally, brief several scenarios in readiness for anticipated ATC requests or other needs to change your initial plan: What if?

Detect

Make time available and reduce workload by avoiding all unnecessary / non pertinent actions, monitor flight path for early detection of deviations and provide timely and precise deviation call-outs. Be alert and adapt to changing weather conditions, approach hazards or system malfunctions.

Correct

It is very important to correct as early as possible any deviation throughout the approach. To do that, various strategies can be used such as using speed brake to correct excessive altitude (not recommended in final approach), early extension of landing gear to correct excessive airspeed or extending the outbound or downwind leg will provide more distance for approach stabilization.

Acknowledge all PM call-outs for proper crew coordination and take immediate corrective action before deviations develop into a challenging or a hazardous situation.

Decide

Assess whether stabilized conditions will be recovered early enough prior to landing, otherwise initiate a go-around.

Be go-around-prepared:
Discuss the go-around maneuver during descent preparation and approach briefing. Keep it in mind while monitoring the descent, task sharing... Be ready to challenge and change plans as necessary.

Be go-around-minded:
"Let's be prepared for a go-around and we will land only if the approach remains stabilized, and we have adequate visual references to make a safe landing"

In this regard the flight crew need to:

- Maintain stable approach criteria throughout the approach and into the landing flare.
- Ensure that the necessary ATC clearances have been received in a timely way.
- Ensure that the visual references below DH or MDA are maintained.
- Ensure that the runway is clear.
- Be open and ready for a go-around until the thrust reversers have been selected.

Remember - a go-around is always possible until the reversers have been selected. Up to that point, it is never too late to go around.

Appropriate Use of Automation

Before and during that approach there were plenty of clues that should have warned the crew of the high probability of a challenging approach. Indeed, the crew subsequently reported that they had to, "fight to maintain the airplane on track".

Passing 1,500 ft, PF disconnected AP and A/THR, thereby depriving himself of additional help that automation offers. Keeping A/THR engaged longer would have reduced the workload of the flight crew in the management and control of the airspeed.

During the very last part of the approach, the tailwind may have been seen as a threat as regards idle thrust values and slow spool up times in the event of a go-around. The use of A/THR in this situation might have stabilized the thrust more quickly than a pilot could using manual thrust, especially with such high workload. This would have resulted in a higher thrust setting, above idle and enabled a more rapid thrust response in the event of a go-around.

The issue here is that the workload required to maintain stability became excessive at a very late stage, when the crew experienced the rapidly changing winds on short final, making the last part of the approach rather difficult to handle in terms of trajectory and speed. But there were clues that the workload was building throughout, long before it became critical. In other words, the workload had become so great that the crew had lost their capacity to fly the aircraft at the required level of precision!

Stability is therefore not just a matter of numbers (speed, pitch etc) but also the effort PF is applying to maintain stability. If that effort equals or exceeds his ability, a go-around must be immediately performed. On this approach, an appropriate use of automation might have allowed the flight crew to better gauge the need to go around, thereby avoiding the hard landing.

This is lesson one, in fact, the appropriate use of automation is one of our Golden Rules (fig. 1), presented in issue 15 of this magazine in January 2013.

Figure 1
Airbus Golden Rule for Pilots #2 states
"Use appropriate level of automation at all times"

Lesson number two can be considered as follows.
Perhaps we would now summarize the criteria for a stabilized approach in a slightly different way. We can now take the three essential quantitative parameters needed for a safe, stabilized approach plus one additional qualitative consideration:

- Aircraft track
- Flight Path Angle
- Airspeed
- Workload Capacity

Note: The first three are "classical' measures of achieved performance. The last is a judgment of how hard the PF is working to control the aircraft. Achieving all the numbers is only fine if the crew are still capable of dealing with something else unexpected. Capacity will be reduced in cases of high manual workload. Therefore, using the right level of automation helps.

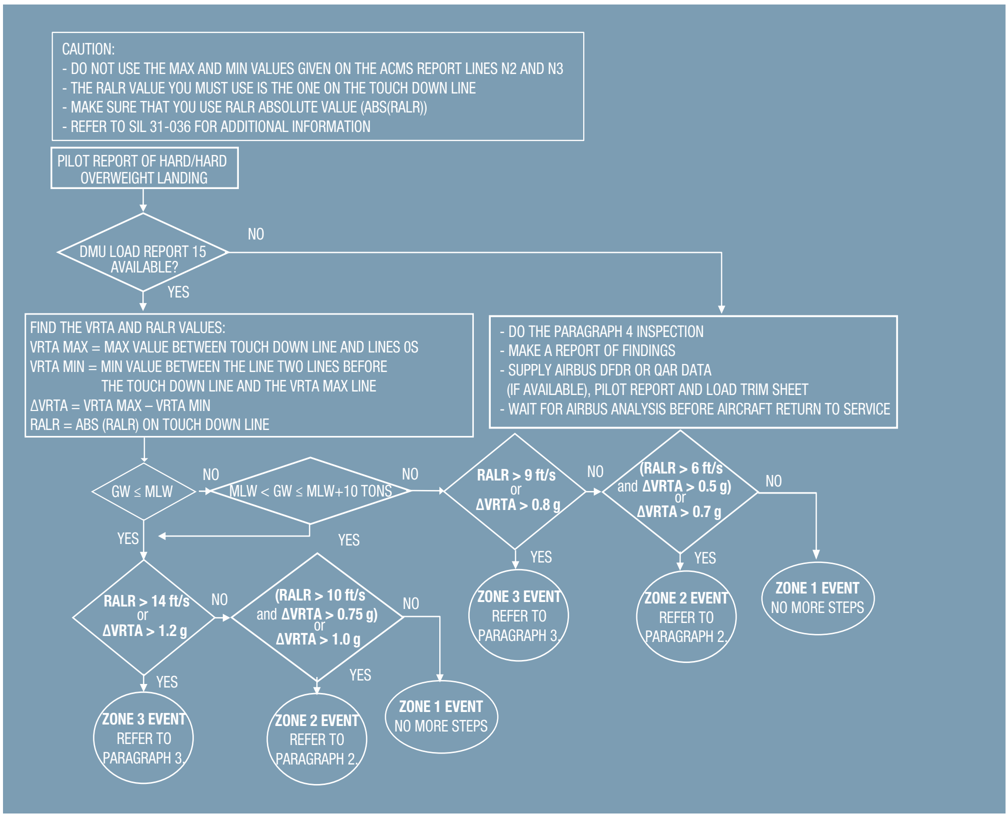

Figure 2
Hard landing flowchart to be added to the A330/A340 AMM in April 2014

Maintenance Recommendations

In this event, customized technical notes were used by the operator, instead of the Airbus originated AMM and as a result the aircraft was cleared to be dispatched for the return flight.

The AMM states that the primary source for a suspected hard landing is the flight crew. From this point on, a hard landing situation has to be fully considered until damage is assessed and it is clearly proven that there are no "downstream effects".

This will trigger some aircraft inspections defined in AMM 05.51.11 that could be alleviated by using load report 15 or DFDRS (DFDR, QAR, DAR…). The load report 15 should not to be used to confirm a hard landing but used in a way to determine easily the level of inspection that may be needed.

At the time of this event, AMM 05.51.11 B(2)(b) "Procedure to Confirm a Suspected Hard/Hard Overweight Landing", stated:

"If you do not (or if you cannot) read the landing impact parameters from the load report 15, or the DFDRS, do these steps before the subsequent flight:

- Supply DFDR or QAR data (if available) to Airbus with the pilot report and the load trim sheet.
- Do the inspection in paragraph 4 and make a report of damage or what you find.
- Airbus will do an analysis of the incident to find if the aircraft can return to service. (The aircraft cannot return to service without Airbus decision)."

To avoid any possible confusion, A330/A340 AMM 05.51.11 will be amended in April 2014 to include:

- A modified wording of the first phrase of the above procedure, which now reads: "If load report 15 or the DFDRS data are not available or you cannot read them…"
- A flowchart to guarantee the same level of readability as on the A320 Family AMM (fig 2).

Figure 3
Damage on the aircraft following the hard landing: aircraft's Landing Gear

Figure 4
Damage on the aircraft following the hard landing: ripples on the fuselage

The load report 15 is generated automatically by the ACMS memory right upon landing and should be available via the MCDU / ACMS MENU / STORED REPORTS.

DMU reports can be obtained by 4 non-exclusive manners:

- Manual print out by crew
- Automatic print out (depending of equipment via MCDU (AMM task 31-36-00) or ACMS (ground programming vendor tool)
- ACARS transmission
- ACARS request (depending on A/C configuration)

Operators are encouraged to review their policy to optimize the access to the load report 15, by being made aware of the four alternative ways that the DMU report can be accessed.

Note: The DMU is not a No Go item. An aircraft can be dispatched with none operative and the repair interval is fixed at 120 calendar days in the MMEL.

Conclusion

This in-service case study allowed to illustrate three messages that ought to be highlighted:

- Use the appropriate level of automation at all times
- There are four essential parameters needed for a safe, stabilized approach:
  - Aircraft track
  - Flight Path Angle
  - Airspeed
  - Workload capacity, which may be reduced in case of high workload
- Always use the Airbus AMM as the base documentation for maintenance operations.

Reference:

A: Technical Follow-Up (TFU) ref 31.36.00.070 LR Honeywell DMU Lock-up issue