



Australian Government
Australian Transport Safety Bureau

Hard landing involving an Airbus A330-323, 9M-MTA

Melbourne Airport, Victoria | 14 March 2015



Investigation

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Addendum

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Safety summary

What happened

On 14 March 2015 Malaysia Airlines Airbus A330, registered 9M-MTA, began its approach to Melbourne (Tullamarine) after a flight from Kuala Lumpur. In the final stages of the approach, at approximately 50 feet, the captain reported feeling the aircraft sink and manually increased the thrust to the engines in an attempt to slow the rate of descent. Despite this action, the aircraft experienced a hard landing of a magnitude requiring replacement of the aircraft's main landing gear. There were no reported injuries as a result of the occurrence.

What the ATSB found

The ATSB found that as a result of the pilot flying's control inputs after disengaging the autopilot (approximately 700 feet above the ground), the final approach had become unstable, descending below the desired vertical profile. The continuation of the approach and an inappropriate attempt to recover the situation led to a high rate of descent at touch down.

What has been done as a result

Soon after the event, the operator circulated a memorandum to their A330 flight crew highlighting the incident and advising of the relevant procedures intended to minimise the chances of a similar occurrence. The flight crew involved also undertook additional training and assessment before returning to flight duties.

Safety message

A stable approach significantly reduces the risk of a hard landing.

If an approach does become unstable, a rushed attempt to recover the approach may produce an undesirable aircraft response. There is also a risk of breaking down the shared understanding between the pilots, which in turn limits the opportunity of the other flight crew to detect or react to inappropriate actions.

When landing, pilots should maintain a safety philosophy of "if in doubt, go around".

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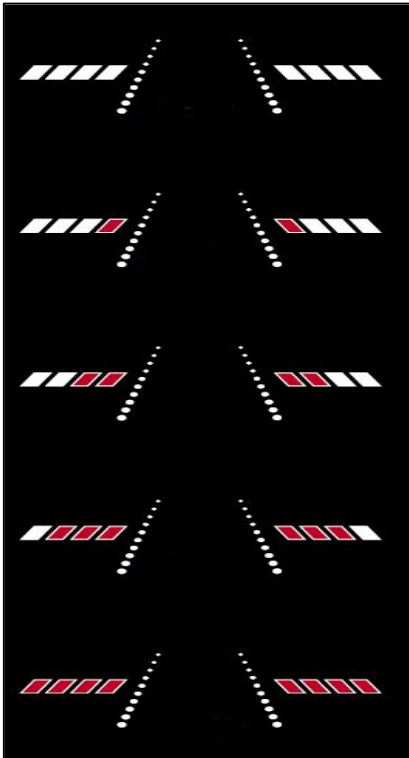
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The occurrence

On 14 March 2015, at about 0750 EST¹ an Airbus A330-343 (A330) aircraft registered 9M-MTA and operated by Malaysia Airlines Berhad, began its final approach to runway 34 at Melbourne Airport. The flight was a regular passenger service from Kuala Lumpur, Malaysia to Melbourne, Australia. Bureau of Meteorology weather data was consistent with the flight crew's reports of fine flying conditions. The flight crew consisted of a captain, who was the pilot flying (PF²) and a first officer, who was pilot monitoring (PM).

The approach to runway 34 at Melbourne airport was not equipped with an Instrument Landing System (ILS), so a non-precision approach was performed. Runway 34 had a precision approach path indicator (PAPI) system consisting of four lights that provided visual guidance for the pilots to determine if the aircraft was maintaining the correct glide path. Figure 1 shows what a crew flying using the PAPI system would expect to see depending on their relative height to the correct approach path. A crew maintaining the nominal 3° path should see two white lights and two red lights.

Figure 1: Precision approach path indicator (PAPI) system



Melbourne airport is equipped with a precision approach path indicator (PAPI) system. The system provides a method for pilots to maintain the 3° glide path by referencing the colour of the four lights. The crew of an aircraft on the 3° glide path would see two white lights and two red lights.

Source: Flight Safety Australia

Unstable approach developed

Flight data showed that the PF disengaged the autopilot at approximately 700 feet above ground level (AGL) and from that point until touchdown there was an increase in the frequency and magnitude of sidestick pitch control inputs by the PF (Figure 4).

In response to these inputs the aircraft's autothrottle system varied the engine thrust to maintain a target speed, as per system design, and the aircraft pitch angles fluctuated between approximately -0.5° nose down and +5.0° nose up. The net result of the varying thrust settings

¹ Eastern Summer Time was Coordinated Universal Time (UTC) + 11 Hours

² Pilot Flying (PF) and Pilot Monitoring (PM) are procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances; such as planning for descent, approach and landing. The PM carries out support duties and monitors the PF's actions and aircraft flight path.

and pitch angles was a fluctuating rate of descent between approximately 380 and 960 feet per minute.

Large sidestick inputs, specifically nose-down, also have the potential to inhibit the vertical speed reduction function, which is an automated function that provides some protection against touchdown at very high vertical speeds.

The Operator's Flight Crew Training manual included the following information about the disconnecting of the Autopilot:

AP Disconnect

During the final approach with the AP engaged, the aircraft will be stabilised. Therefore, when disconnecting the AP for a manual landing, the pilot should avoid the temptation to make large inputs on the sidestick.

The pilot should disconnect the autopilot early enough to resume manual control of the aircraft and to evaluate the drift before flare. During crosswind conditions, the pilot should avoid any tendency to drift downwind.

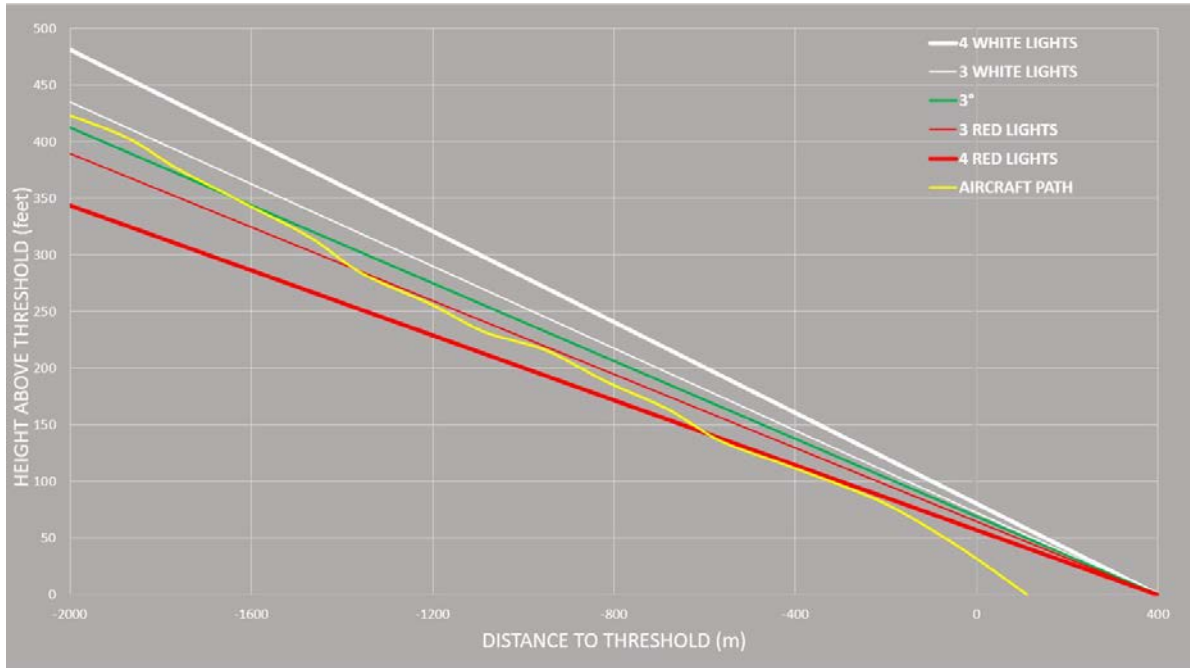
Some common errors include:

- *Descending below the final path, and/or*
- *reducing the drift too early.*

As the aircraft passed 300 feet above ground level (AGL) a rate of descent of 960 feet per minute was recorded. This neared the operator's maximum stabilised approach limit of 1000 feet per minute when below 500 feet AGL. As well as a high rate of descent, actual exceedances of the operator's stabilisation criteria included:

- large changes to pitch inputted by the pilot flying, including negative pitch values,
- fluctuations in the rate of descent over a large range that were abnormal for the phase of flight,
- incorrect glide path. From approximately 250 feet AGL, the aircraft was trending low and continuing below the glide path. At this point the pilots would have been able to observe 3 red lights and one white light on the PAPI. This trend was allowed to continue until the aircraft was well below the desired glide path to the extent that the PAPI would have indicated 4 red lights from approximately 125 feet AGL (Figure 2). From this point the PF made numerous pitch commands which were mostly nose down. These included a full range nose down deflection at 24 feet AGL.

Figure 2: Aircraft path relative to the PAPI indications the pilots would have observed during the approach



Source: ATSB

Figure 2 displays in green the ideal glide path during an approach and the PAPI thresholds in red (low) and white (high). The yellow is the actual path of the aircraft derived from the flight data. Just below 150 feet 4 red light would have been indicated to the crew.

Unstable approach was continued

The company procedures and manufacturer’s recommendations dictated that if an approach becomes unstable below 500 feet AGL, a go-around must be initiated by the pilot flying (PF) and/or the pilot monitoring (PM) must alert the PF of the unstable approach and encourage a go-around (Figure 3).

Included in the operator’s flight crew training manual and the manufacturer’s operating philosophy of the aircraft were a set of ‘golden rules’ to be followed by flight crew at all times whilst operating the aircraft. Rule number 4 was as follows:

If the aircraft does not follow the desired vertical or lateral flight path, or the selected targets, and if the flight crew does not have sufficient time to analyse and solve the situation, the flight crew must immediately take appropriate or required actions, as follows:

The PF should change the level of automation:


- From managed guidance to selected guidance, or
- From selected guidance to manual flying.

The PNF should perform the following actions in sequence:

- Communicate with the PF
- Challenge the actions of the PF, when necessary
- Take-over, when necessary.

During flight crew interviews there was no indication that the pilot not flying (PNF-now referred to as the PM) communicated with the PF about the unstable approach conditions, considered taking over from the PF, and/or encouraged the PF to conduct a go-around.

Figure 3: Extract from the operator’s Operations Manuals current at the time of the occurrence.

		Operations Manual – Part A
8.3.0.7.8	Stable approach criteria	
8.3.0.7.8.1	Stable approach exists when aircraft is configured for landing, on the normal approach path, with correct thrust, rate of descent and airspeed required under the prevailing conditions.	
8.3.0.7.8.2	It is mandatory to execute go-around and/or reject the landing at any time whenever the crew feels that the aircraft safety is jeopardised. The Company will not initiate disciplinary measures for a go-around executed under any unsafe or unstabilised approach.	
8.3.0.7.8.3	All flights must be stabilised by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC).	
8.3.0.7.8.4	Notwithstanding the meteorological conditions above, all Straight-in Approaches excluding Visual Circuits and Circling Approaches shall have Landing Gears and Landing Flaps configured by 1000 feet above airport elevation.	
8.3.0.7.8.5	<p>An approach is stabilised when all the following criteria are met (specific Fleet type OM Part B elements may apply):</p> <ol style="list-style-type: none"> a. The aircraft is on the correct flight path; b. Only small changes in heading/pitch are required to maintain the correct flight path; c. The aircraft speed is not more than Vref +20 knots indicated airspeed and not less than Vref; d. The aircraft is in the correct landing configuration; e. Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted; f. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the OM B (FCOM). g. All briefings and checklists have been conducted; h. Specific types of approaches are stabilised if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localiser; a Category II or Category III ILS approach must be flown within the expanded localiser band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and i. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilised approach require a special briefing. 	
8.3.0.7.8.6	An approach that becomes unstabilised below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.	
15 Jan 2015	Operating Procedures Issue 6 (Revision 0)	8.3-39

Source: Malaysian Airlines

Attempted recovery from unstable approach

At 60 feet AGL the captain moved the thrust levers forward momentarily into the TOGA (Take-off/Go Around) detent. The captain stated that this was done in response to a feeling that the aircraft was sinking below the path, and the intention was to reduce this sink by applying more thrust to the engines. The placement of the thrust lever into TOGA placed the aircraft automation into the go-around autopilot modes and changed the display on the primary flight display flight mode annunciator (FMA). The captain subsequently reduced the thrust levers.

The PM, on seeing the modes on the FMA change assumed that a go-around was being conducted and awaited further announcement from the captain. The PM reported noticing the thrust levers reducing and that the aircraft was not flaring and applied nose up input to the sidestick at the same time as the PF.

At the time of the occurrence there was no procedure on the A330 for the use of manual thrust for this purpose. Prior to 2009, a procedure existed in the Airbus A330 documentation that allowed a specific use of manual thrust in difficult environmental conditions. Airbus advised that after an analysis of in-service events the procedure was removed from all operational documents. A flight crew operations manual (FCOM) Bulletin was published at the time which explained the removal of the procedure

Manipulation of the thrust levers in this manner had the effect of:

- disengaging the autothrottle thereby inhibiting some of the available auto flight system protections including the target speed function (which automatically maintained the desired speed and adjusted for fluctuation in the wind), and the vertical speed reduction function
- causing a pitch up tendency – as underslung engines increase thrust, they typically apply an upward pitching moment to the aircraft. This usually requires a large nose down input by the pilot flying to prevent the aircraft from pitching up. At this stage in the approach applying large nose down inputs differed from the gradual nose up input normally required to complete the flare.
- breaking down of the shared mental model between the pilot flying and pilot monitoring in that the pilot monitoring believed the advancement of the thrust levers was the initiation of a go-around.

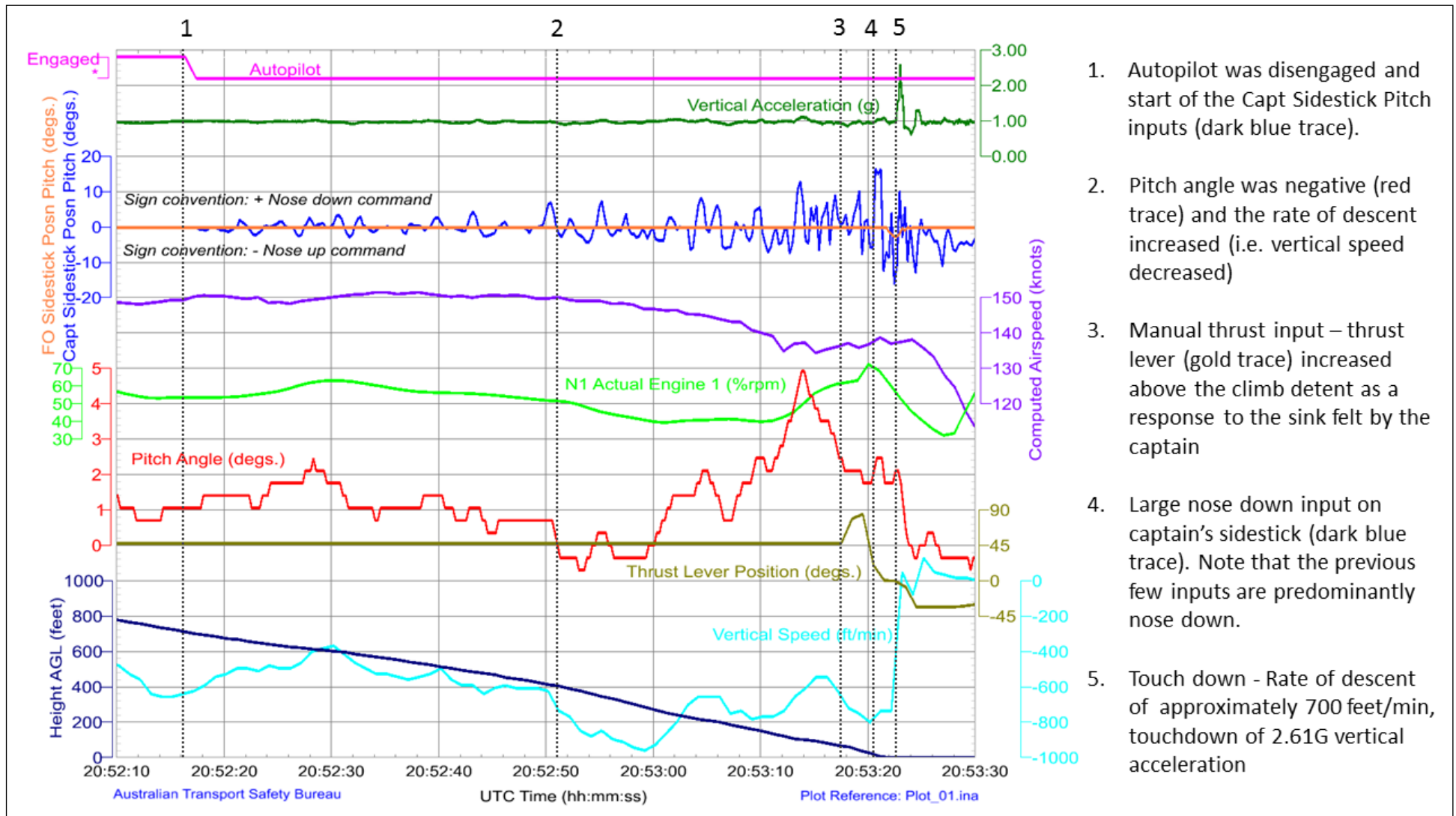
Shortly after this action, the aircraft touched down at a vertical speed of approximately 700 feet per minute and a vertical acceleration of 2.61 G was recorded. The aircraft also touched down at approximately 170m (560 feet) from the landing threshold, short of the normal touchdown zone of between 304m (1000 feet) and 609m (2000 feet).

The manufacturer of the aircraft produced a complete load analysis of the event based on recorded flight data provided by the operator. The conclusion of this analysis was that several components in the left and right gear had “exceeded their design load limits and may have been detrimentally overloaded”.

The manufacturer’s analysis assessed the affected components to be unserviceable and requiring replacement before the next flight. Several supplementary inspections were also required.

There were no injuries reported as a result of the hard landing.

Figure 4: Graphical representation of the flight data from the incident approach



1. Autopilot was disengaged and start of the Capt Sidestick Pitch inputs (dark blue trace).
2. Pitch angle was negative (red trace) and the rate of descent increased (i.e. vertical speed decreased)
3. Manual thrust input – thrust lever (gold trace) increased above the climb detent as a response to the sink felt by the captain
4. Large nose down input on captain’s sidestick (dark blue trace). Note that the previous few inputs are predominantly nose down.
5. Touch down - Rate of descent of approximately 700 feet/min, touchdown of 2.61G vertical acceleration

Safety analysis

A stable approach is a crucial element of final approach. Identifying an unstable approach and taking the appropriate corrective action is key to maintaining safety at touch down. This analysis examines the stability of the aircraft and the decision making in the final stages of the approach.

Stability of the final approach

Information published by the Flight Safety Foundation (*Flight Safety Digest, August 2004, Stabilized Approach and Flare Keys to Avoiding Hard Landings*) indicated that in 2004, hard landings were the highest number of recorded accidents in the preceding 10 years. The study found that a stable approach and flare were key to avoiding hard landings.

Analysis of the flight data relating to the stability of the final approach showed from 300 feet the approach was unstable due to large control inputs, erratic rates of descent and deviation below the glide path. Throughout the final approach, the PF's sidestick inputs determined the aircraft's vertical profile and, in the absence of any external factors, were therefore contributing to the unstable approach.

Monitoring and Communication

Researchers (Klein 1999, Kahneman, 2011) have stated that, in time-constrained environments, individuals can make decisions using intuitive reasoning where the steps are often unconscious and based on pattern recognition. For intuitive decision-making, an experienced individual will identify a problem situation as similar to a situation they have dealt with before and will extract a plan of action from memory. If time permits, they will confirm their expectations prior to initiating action. If time does not permit, actions will be initiated with uncertainty that may result in a poor decision.

In this investigation, the PM was late to recognise that the approach was unstable and as such did not encourage the PF to conduct a go-around, as per the operator's standard operating procedures.

During the last 50 feet of the approach (4 seconds before touch down) the PF inappropriately used the thrust levers in an attempt to arrest the high rate of descent. Despite the absence of the standard phraseology of 'go-around' by the PF, the PM mistook this advancement of the thrust levers as the initiation of a go-around. The PM, expecting that the PF had initiated a go-around and realising that the aircraft was still descending with a nose-down attitude, placed their hand on the sidestick and applied a nose up input. A dual input was therefore recorded as the aircraft touched down.

Probably due to time constraints, neither crew member communicated their intentions. Neither the initial thrust advancement nor the subsequent thrust reversal by the PF were communicated to the PM. As a result, the PM was unclear about the action taken by the PF.

Continuation of the approach

Large and erratic pitch inputs by the PF, as well as large fluctuations in the rate of descent and visual reference of the PAPI lights provided opportunities for the crew to recognise an unstable approach. Despite this, there was no evidence of actions or support language to suggest that the unstable approach was identified. The operator's procedures whereby an unstable approach should result in a go-around, were not followed.

The manual thrust technique used by the captain to arrest the sink and recover the approach was used on other aircraft types previously flown by the captain. There was no current approved procedure on the A330 for this technique. However, analysis of the flight data determined that this action alone did not contribute to or increase the severity of the hard landing.

The captain and first officer advised at interview that, in retrospect, they should have conducted a go-around in accordance with the operator's training procedures. The Flight Safety Foundation publication noted earlier indicated that runway contact from a late go-around is preferable to attempting to recover an unstable approach.

Elements of an unstable approach are not unusual during flight operations. However the actions taken by flight crew in response are key to maintaining flight safety. The training records of the crew were reviewed to establish the possibility that a training or performance issue led to the PF's actions. Apart from the PF's misunderstanding of the use of the thrust levers to reduce the rate of descent, there was no indication of a systemic issue with either crew member.

Findings

From the evidence available, the following findings are made about the hard landing involving an Airbus A330-343, registered 9M-MTA that occurred at Melbourne Airport, Victoria on 15 March 2015. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The final approach became unstable at around 300 feet above the ground due to the control inputs from the captain.
- Inadequate monitoring and communication by the crew led to a lack of recognition of the undesirable flight state and the continuation of an unstable approach.
- Continuation of the unstable approach led to a high rate of descent at touchdown and resulted in a hard landing in excess of the aircraft design loads and short of the normal touchdown area.

Other safety factors

- The captain used an unapproved manual thrust procedure in an attempt to recover the approach.

General details

Occurrence details

Date and time:	14 March 2015 – 0800 EST	
Occurrence category:	Accident	
Primary occurrence type:	Hard landing	
Location:	Melbourne Airport	
	Latitude: 37° 40.9825' S	Longitude: 144° 50.428' E

Aircraft details

Manufacturer and model:	Airbus A330-323	
Year of manufacture:	2011	
Registration:	9M-MTA	
Operator:	Malaysian Airlines Berhad	
Serial number:	MSN 1209	
Total Time In Service	18,527 hours	
Type of operation:	Regular Passenger Transport	
Injuries:	Crew – nil	Passengers – nil
Damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Flight recorder data.
- Airbus
- Malaysian Airlines Berhad Safety
- Flight Safety Foundation

References

Klein, G. (1999). *Sources of power: How people make decisions*. Cambridge, MA: MIT Press.

Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Straus and Giroux.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Civil Aviation Safety Authority (CASA), Malaysian Airlines Berhad, the Malaysian Ministry of Transport and Airbus.

Submissions were received from Airbus and CASA. The submission were reviewed and where considered appropriate, the text of the draft report will be amended accordingly.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

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Investigation

ATSB Transport Safety Report Aviation Occurrence Investigation

Hard landing involving an Airbus A330-323, 9M-MTA
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