Australian Government
Australian Transport Safety Bureau

A340 Tailstrike Melbourne Airport

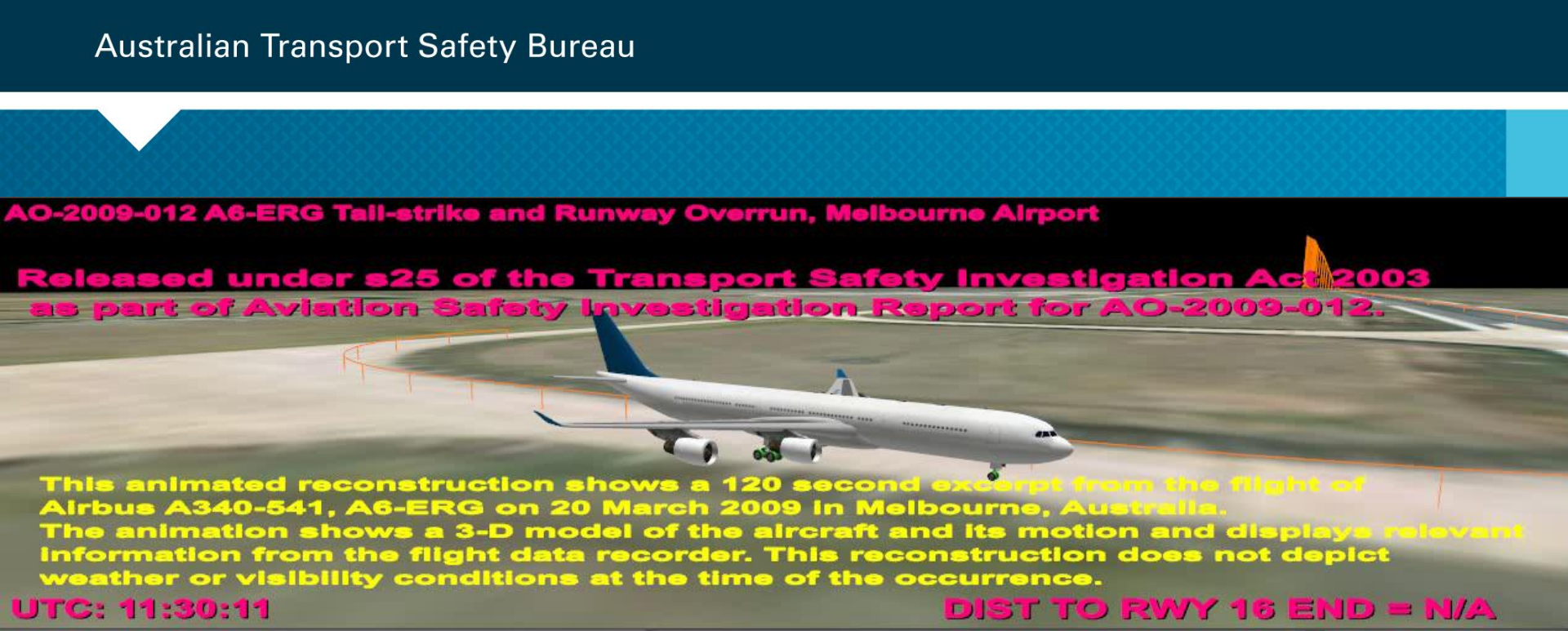
Is good airmanship enough for gross error detection?

Presented by
Paul Ballard
Senior Transport Safety Investigator

The accident:

- ATSB Investigation: AO-2009-012
- Melbourne Airport
- Friday 20 March 2009 22:30
- It is 3 hours since the sun set and there is no moon
- Airbus A340-542 operating as Emirates flight EK407 to Dubai, UAE, is taxied onto Runway 16 at Melbourne Airport
  - 275 passengers
  - 18 crew (4 flight crew and 14 cabin crew)

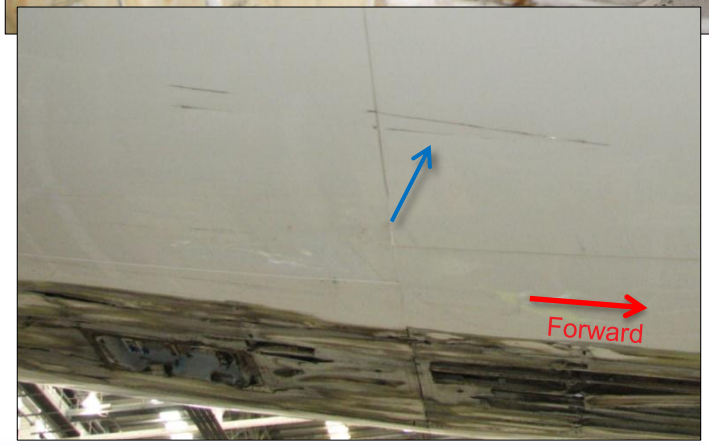
AO-2009-012 A6-ERG Tail-strike and Runway Overrun, Melbourne Airport

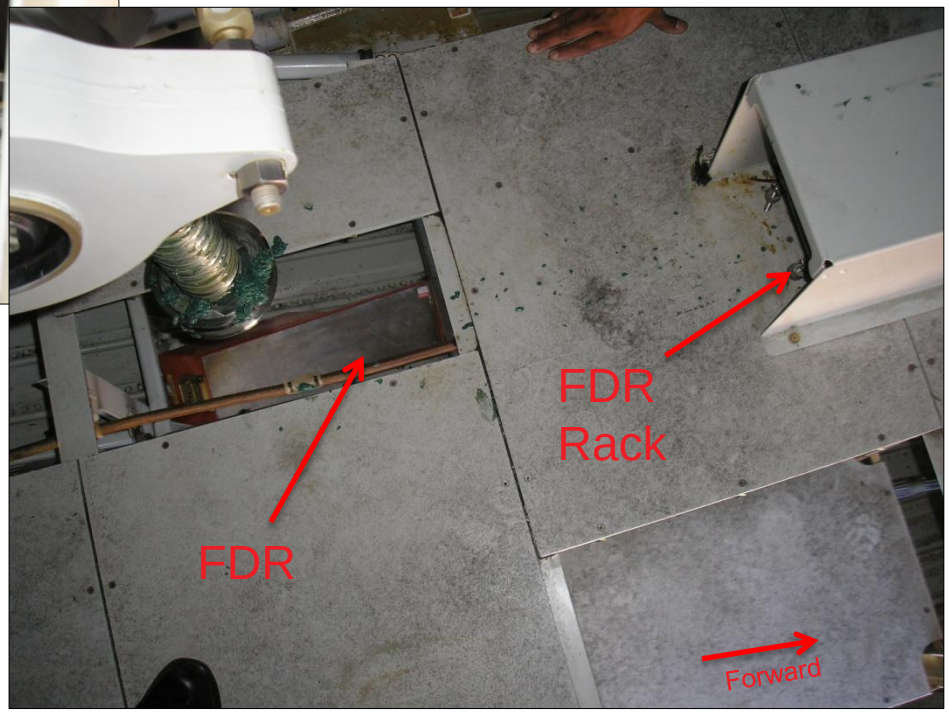


- Crew notified of tailstrike from ECAM message and call from ATC
- Crew decided to return to Melbourne and climbed aircraft to 7,000 ft
- ATC provided radar vectors over Port Phillip Bay while crew jettisoned fuel
- While the crew prepared for landing they noticed that the weight used to perform the take-off performance calculations was 262.9 tonnes instead of the planned 362.9 tonnes
- PAN declared

- Report from engineers via ATC for crew to expect ‘significant damage to the tail’
- Weight reduced to 280 tonnes for landing (above MLW)
- During approach to Runway 34, report of smoke in rear cabin
- Safe approach and landing made
- Inspected by ARFF on runway and cleared to return to terminal

Damage to aircraft


Forward


FDR
Rack
FDR
Forward

Other damage

Weight error formation

- Pre-flight, approximately 20 minutes before pushback
- First officer inadvertently entered a TOW of 262.9 tonnes into the EFB when performing the take-off performance calculation. [Intended TOW was 362.9 tonnes]
- The resulting performance figures, including the erroneous take-off weight transcribed onto Flight Plan
- Captain and FO discussed peculiarity of the SID
- EFB passed to Captain to check the performance figures (done silently)
- Captain enters performance figures into the FMGS

- At the same time the FO confirmed the departure clearance with ATC
- Captain crosschecked the data entered into the FMGS with the First Officer – TOW not part of this check
- Captain read aloud the green dot speed as 225 knots (FO responded ‘checked’)
- EFB handed back to FO and loadsheet confirmation procedure carried out
  - FO read TOW from FMGS as 361.9 tonnes
  - FO read 326.9 tonnes from flight plan, then immediately corrected it to 362.9 tonnes, TOW on flight plan changed
- FO read aloud green dot speed from FMGS as 265 knots (Captain paused then responded with ‘yes’)

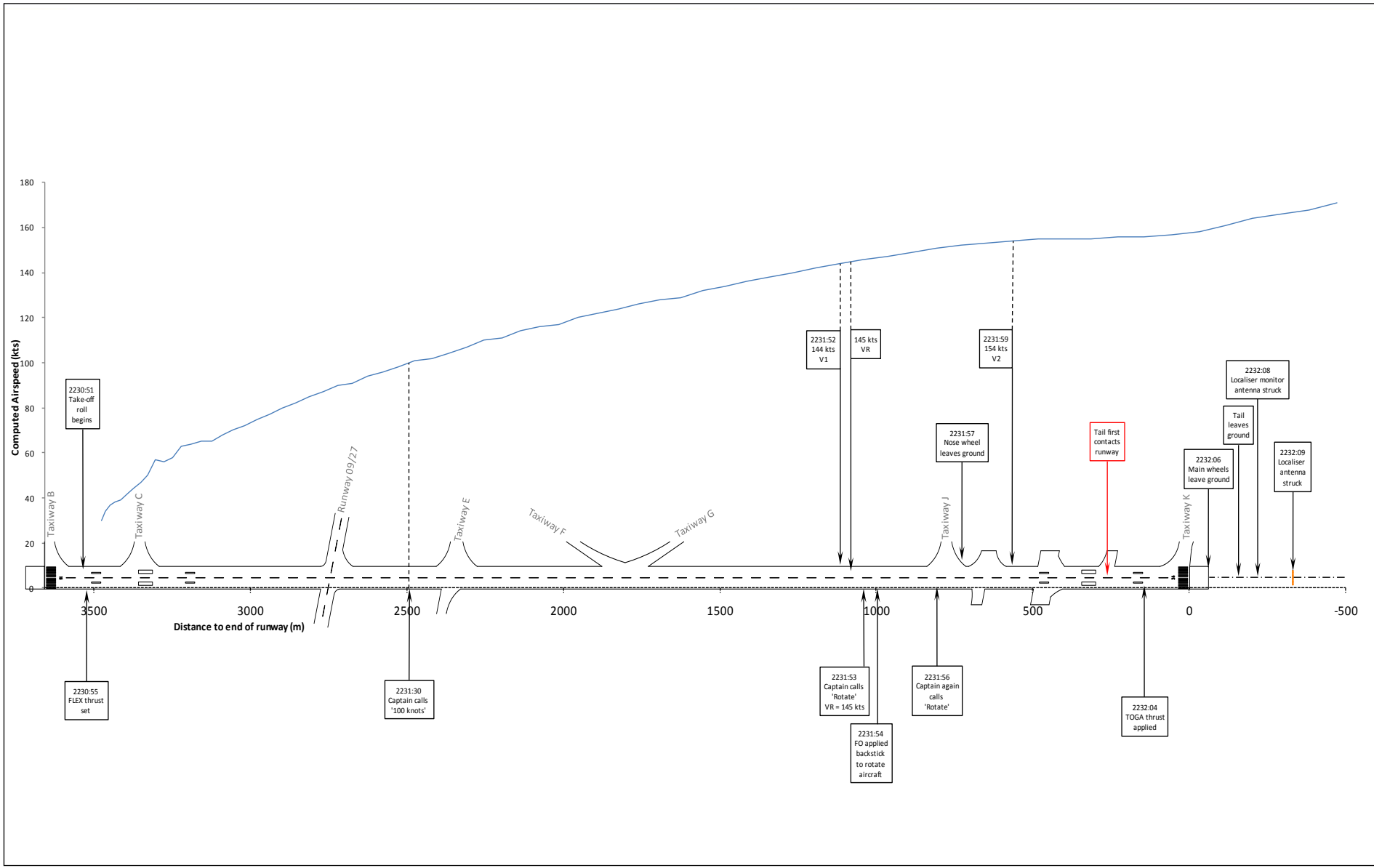
Take-off performance

- Planned as a reduced thrust takeoff
- Termed ‘FLEX’ takeoff on Airbus aircraft
- Flight crew monitor and react to take-off reference speeds (V_1, V_R, V_2)
- Performance calculations determine take-off reference speeds, flap configuration and an ‘assumed’ temperature
- Assumed (FLEX) temperature used to reduce thrust produced by engines
- Acceleration not directly monitored!

- Comparison of performance figures

Take-off Weight (tonnes)	Take-off reference speeds (kts)			Flex Temperature (°C)	Configuration of high lift devices	Green Dot Speed (kts)
	V_1	V_R	V_2			
262.9	143	145	154	74	1+F	225
362.9	149	161	173	43	3	265

	V_1		V_R		V_{LOF}		V_2	
	Speed	Dist	Speed	Dist	Speed	Dist	Speed	Dist
Expected	149	1,710	161	2,065	174	2,540	173	2,470
Actual	144	2,418	145	2,496	161	3,652	154	2,973


Computed Airspeed (kts)
180
160
140
120
100
80
60
40
20
0
Taxiway B
Taxiway C
Runway 09/27
Taxiway E
Taxiway F
Taxiway G
Taxiway J
Taxiway K
2230:51
Take-off roll begins
2231:52
144 kts
V1
145 kts
VR
2231:59
154 kts
V2
2231:57
Nose wheel leaves ground
Tail first contacts runway
2232:06
Main wheels leave ground
Tail leaves ground
2232:08
Localiser monitor antenna struck
2232:09
Localiser antenna struck
3500
3000
2500
2000
1500
1000
500
0
-500
Distance to end of runway (m)
2230:55
FLEX thrust set
2231:30
Captain calls '100 knots'
2231:53
Captain calls 'Rotate'
VR = 145 kts
2231:54
FO applied backstick to rotate aircraft
2231:56
Captain again calls 'Rotate'
2232:04
TOGA thrust applied

What went wrong?

- Erroneous performance figures resulted in:
  - Over-rotation and tailstrike (low V_R and flap setting)
  - Long take-off roll and runway overrun (low thrust setting)
- Erroneous TOW entry likely due to ‘finger trouble’
- Erroneous take-off weight in performance calculations not detected (opportunities missed)
  - Non-adherence to standard operating procedures
  - Captain’s check of EFB (task interruption)
  - FO read correct weight during loadsheet check
  - FO changed flight plan without investigation
  - Green dot speed check (2 occasions)

- Degraded take-off performance not detected
  - Acceleration not monitored
    - reference (minimum required) acceleration not provided
    - actual acceleration not presented to flight crew
  - Crew experienced a wide range of performance figures (MFF)
  - Darkness reduced visual cues

How did this happen?

- Poor airmanship?
  - qualified and experience crew
  - other aspects of preparation and flight carried out professionally
- Interruption and distraction
  - number of distractors present during critical tasks
  - management and training
- SOP design and usability
  - potential for perceived doubling up of checks
  - linear procedure/non-linear information flow
  - work-around to prevent doubling up (last minute changes)
- ‘Reasonableness’ check

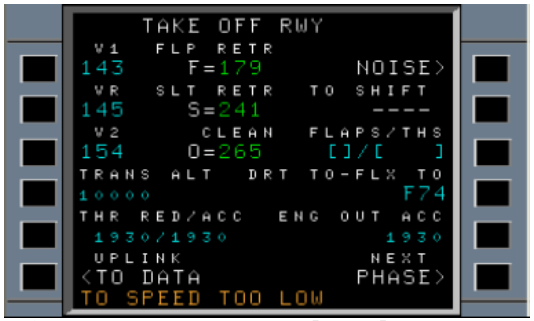
Is that it?

- Is this a problem for this operator only?
  - Mar 1991 United States DC-8
  - Aug 1999 Denmark Boeing 767
  - Jun 2002 Germany Airbus A330
  - Mar 2003 South Africa Boeing 747
  - Mar 2003 New Zealand Boeing 747
  - Oct 2003 Japan Boeing 747
  - Jul 2004 France Airbus A340
  - Oct 2004 Canada Boeing 747 (7 fatalities)
  - Aug 2005 China Airbus A340
  - Dec 2006 France Boeing 747
  - Oct 2008 Jamaica Airbus A330
  - Dec 2008 United Kingdom Boeing 767

- ...and that is only a portion of the reported occurrences between 1989 and 2009 that shared multiple similarities with this accident! [ATSB research report AR-2009-052, *Take-off performance parameter errors: A global perspective*]
- And they continue to occur!
- So, is reliance on good airmanship enough for detection of gross errors in take-off performance?
- Is enough being done about this?
  - At least 9 previous investigations with recommendations regarding monitoring of take-off performance
  - Numerous research projects and patents since 1950s
  - No commercial system currently available that can detect degraded take-off performance
  - No design standards or requirements by any NAA

So what is being done?

- The operator has improved its procedures and training to strengthen their defences.
- Airbus producing a system that will automatically check the reasonableness of the performance data entered into the FMGS



- Safety Advisory Notices to Flight Safety Foundation and International Air Transport Association to encourage development of guidance for flight crew on formation of appropriate mental models for weight and associated performance.

- The operator working with avionics manufacturer to develop a take-off performance monitoring system
- European Aviation Safety Agency (EASA) working with EUROCAE to develop a design standard for take-off performance monitoring systems and rulemaking to require such systems
- Recommendation to Federal Aviation Administration
- Airbus conducting feasibility study for potential future take-off performance monitoring system

The investigation - lessons

- Value of crew listening to CVR
  - Identification of crew activities from sounds
  - Improved recollection of events
  - Unexpected additional information
  - Assisted crew in recovery from event
- Set environment for CVR
  - Cockpit mock-up
  - Timing for crew
- Data mining
  - Previous events (research project)
  - Historical data for flight crew (identified large variations in figures)

Australian Government
Australian Transport Safety Bureau

Thank you

Australia's national transport safety investigator

AVIATION | MARINE | RAIL

www.atsb.gov.au