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Australian Transport Safety Bureau

Operational event involving an Airbus A320, VH-VNQ

Hobart Airport, Tasmania, 15 February 2014

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Addendum

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Operational event involving an Airbus A320, VH-VNQ

What happened

During the evening on 15 February 2014, the crew of a Tiger Airways A320 aircraft, registered VH-VNQ, was preparing for a flight from Hobart, Tasmania to Melbourne, Victoria. The crew had earlier completed flights from Melbourne to Sydney, New South Wales, and return, and from Melbourne to Hobart. The return flight from Hobart to Melbourne was the crew's final flight for the day. The first officer (FO) was the pilot flying for the return flight to Melbourne.

The flight was operating as a training flight for the FO who had recently joined the operator and was undergoing line training. The FO had completed a number of flights with a safety pilot present as part of the operator's normal line training program. The flight from Melbourne to Hobart was the FO's first flight without a safety pilot present. That flight was uneventful, although the crew encountered some weather on arrival in the Hobart area, requiring minor track diversions.

During the turn-around at Hobart, the FO entered relevant data into the flight management guidance system (FMGS)¹ in preparation for the return sector to Melbourne. This data entry included the runway in use (runway 12), the planned departure procedure, which at that stage was the Launceston Alpha 3 Standard Instrument Departure (SID), and relevant take-off data. Take-off data entered by the crew included take-off reference speeds (commonly referred to as V speeds)² and a flexible (flex) temperature.³ The captain checked the FMGS entries and the crew briefed the information in accordance with the operator's procedures prior to engine start. The crew started engines at about 2020 Eastern Daylight-saving Time and commenced taxi for runway 12 soon after. During the taxi, the crew completed the applicable parts of the operator's before take-off checklist,⁴ which included a check to confirm that runway 12 was set in the FMGS as the departure runway (Figure 1).

With thunderstorms in the area, the captain elected to delay departure and wait at holding pilot Charlie for the weather to clear (Figure 2). The weather proved more persistent than anticipated, resulting in a delay of about 75 minutes, while the crew continued to wait at the holding point.

¹ The FMGS performs a range of functions including lateral and vertical navigation, flight plan management and aircraft performance prediction and optimisation. The system includes two Flight Management Guidance Computers (FMGCs), two (typically) Multipurpose Control and Display Units (MCDUs), a Flight Control Unit (FCU) and two Flight Augmentation Computers (FACs). The MCDUs (one available to each pilot on the centre pedestal) allow the flight crew to enter and display a wide range of navigation and performance data, and provide a flight crew interface to the FMGCs for flight path and speed management. The FCU (located on the glare-shield) provides another interface to the FMGCs, typically used for short term profile and speed management, and to allow flight crew to switch between managed and selected auto-flight modes.

² Take-off reference speeds (V speeds) are:

- V_1 – decision speed (with respect to continuation of the take-off following an engine failure).
- V_R – speed at which the pilot initiates rotation of the aircraft to the take-off pitch attitude.
- V_2 – take-off safety speed (minimum speed that needs to be maintained up to the acceleration altitude, in the event of an engine failure after V_1).

³ Flex temperature (higher than the actual ambient temperature) is entered by the crew to allow for a reduced thrust (flex temperature) take-off.

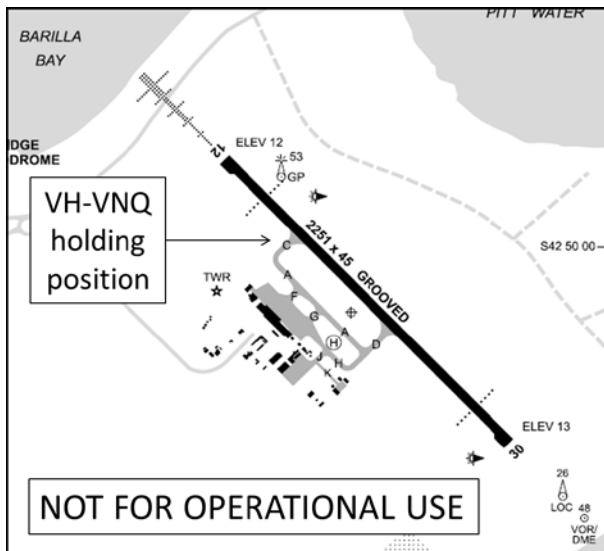
⁴ The before take-off checklist is broken into two parts – the first part, referred to as 'down to the line', is normally completed during taxi, before the aircraft enters the runway. The second part, referred to as 'below the line', is not completed until the crew is cleared to enter the runway by Air Traffic Control.

Figure 1: Operator's before take-off checklist (down to the line)

BEFORE TAKEOFF	
FLT CONTROLS.....	CHECKED (B)
INSTRUMENTS.....	CHECKED (B)
FLAPS.....	CONFIG XX (B)
FMGC.....	SET RWY XX
CABIN.....	SECURE (PM)
ECAM MEMO.....	T/OFF NO BLUE
	<ul style="list-style-type: none"> • SIGNS ON • SPOILERS ARMED • AUTOBRAKE MAX • FLAPS TO • TO CONFIG NORM
----- CLEARED FOR LINEUP/TAKEOFF-----	

Source: Operator – layout modified by the ATSB

Figure 2: Hobart airfield diagram illustrating VH-VNQ's holding position (holding point Charlie)



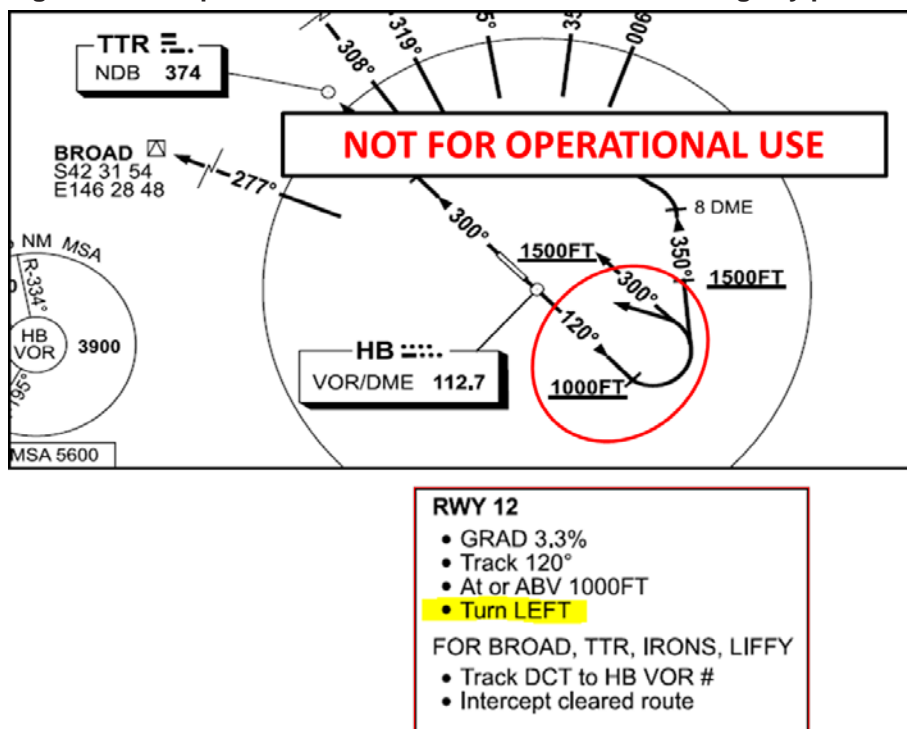
Source: Airservices Australia – modified by the ATSB

At about 2140, satisfied that the weather had cleared sufficiently to facilitate a safe departure, the crew entered the runway and back-tracked toward the threshold of runway 12. As they back-tracked on the runway, the crew were able to build a better appreciation of the weather to the north of the airport and along the intended departure route. The captain discussed the weather and departure options with Air Traffic Control (ATC), and the crew were subsequently re-cleared to conduct the Tea Tree (TTR) One SID (Figure 3).

The initial part of the TTR One SID required that the aircraft climb straight ahead after take-off, before making a left turn at or above 1,000 ft. Upon loading the TTR One SID into the FMGS however, the crew noticed that the navigation display⁵ indicated a right turn during the departure, contrary to the left turn required by the published procedure. The captain was aware that all Hobart runway 12 SIDs required a left turn after take-off to avoid high terrain to the west, and that the indicated right turn was clearly incorrect.

⁵ Each pilot has a navigation display that presents a range of information including the FMGS-programmed lateral track.

Figure 3: Excerpt from the Hobart SID North chart showing key points of the TTR One SID



Source: Airservices Australia – modified by the ATSB

In an attempt to clear the anomaly, the captain selected the reciprocal runway (runway 30) in the FMGS as the departure runway, before re-selecting runway 12. This was unsuccessful, and the navigation display continued to indicate that a right turn was required during the departure.

The crew were concerned at this point that the apparent break in the weather may be relatively brief and were mindful that another aircraft was also waiting for an opportunity to depart. In view of the circumstances, rather than persist with further attempts to clear the anomaly, the crew elected to continue with the departure, planning to use heading (HDG) mode to command a left turn in accordance with the published procedure, rather than allowing the auto-flight system to command a right turn in navigation (NAV) mode.⁶ The crew planned to climb straight ahead to an appropriate altitude before pulling the heading/track selector knob on the FCU to engage HDG mode, and then command a left turn using the heading selector knob to continue the departure.

The crew were unaware at the time, but by momentarily changing the runway in an attempt to clear the apparent departure anomaly, take-off reference speeds and the flex temperature previously entered into the FMGS (on the PERF TAKE OFF page of the MCDU) had been removed. The FMGS stores the previously entered data and displays it on the PERF TAKE OFF page in a reduced font size adjacent to the position in which the active data is normally displayed. Under these conditions, the take-off reference speeds are removed from each pilot's primary flight display airspeed indicator and an amber message 'CHECK TAKE OFF DATA' appears in the scratchpad of the MCDU.⁷ A 'CONFIRM TO DATA' prompt also appears on the PERF TAKE OFF page to allow the crew to revert to the previously entered take-off data by pushing a single line select key (adjacent to the 'CONFIRM TO DATA' prompt).

⁶ NAV is a managed mode. In NAV mode, the auto-flight system follows the FMGS-programmed lateral path. HDG is a selected mode. When HDG is selected by the crew, the FMGS steers the aircraft according to the heading selected by the crew on the FCU.

⁷ The MCDU scratchpad refers to the bottom line of the MCDU display window, used among other things to facilitate MCDU data entry, and to display FMGS messages.

As the crew positioned the aircraft at the threshold of runway 12, they were heavily occupied with weather assessment (including use of the aircraft weather radar) and communication with ATC, reviewing departure requirements and managing normal checklist procedures. The crew had completed the remainder of the before take-off checklist (below the line) after entering the runway in accordance with the operator's procedures, but nothing in that checklist required the crew to conduct another review of the FMGS take-off data, and nothing drew their attention to the 'CHECK TAKE OFF DATA' message in the MCDU scratchpad.

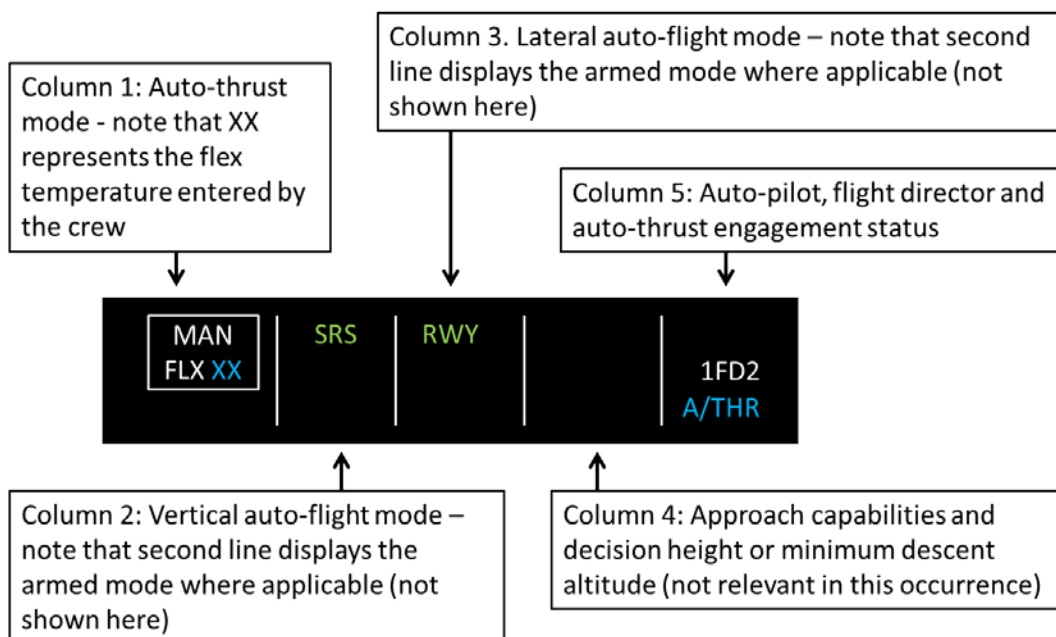
The take-off was commenced at about 2142, with the FO advancing the thrust levers to the flex temperature take-off thrust/maximum continuous thrust (FLX/MCT) detent – the setting used during a flex temperature (reduced thrust) take-off. As the take-off was commenced however, a number of things happened at about the same time:

- The crew noticed that flight mode annunciator (FMA)⁸ indications were not as they would normally appear during a flex temperature take-off when the thrust levers are set to the FLX/MCT detent (Figure 4):
 - Auto-thrust mode (column 1) normally displays MAN FLEX XX (where XX represents the flex temperature entered by the crew). In this case, available data indicates that no auto-thrust mode information initially appeared on the FMA.
 - Vertical auto-flight mode (column 2) normally displays SRS (speed reference system), which provides guidance to maintain speed within defined parameters after take-off. In this case, available data indicates that no vertical auto-flight mode information initially appeared on the FMA.
 - Lateral auto-flight mode (column 3) normally displays RWY (runway) which provides guidance with respect to the runway centre-line during take-off.⁹ In this case, available data indicates that no lateral auto-flight mode appeared on the FMA until the thrust levers were further advanced as the take-off continued (see following account).
 - Column 5 normally indicates that both flight directors are engaged (1FD2) and that the auto-thrust system is armed (A/THR appears in blue). In this case, available data indicates that both flight directors were engaged as normal (although the flight director bars do not appear on the primary flight displays until the corresponding vertical or lateral mode is active), but the auto-thrust system status annunciation initially remained blank (the auto-thrust system did not arm as it normally would when the thrust levers were advanced).
- The crew received an electronic centralised aircraft monitoring (ECAM) system caution (ENG THR LEVERS NOT SET) alerting them that the thrust levers were not set in accordance with the Full Authority Digital Engine Control system thrust mode.
- The crew noticed that the take-off reference speeds were not displayed on the primary flight display airspeed indicators as expected.

⁸ The FMA is positioned at the top of each pilot's primary flight display. It provides a range of information, including the auto-thrust system mode of operation, active and armed vertical and lateral auto-flight (auto-pilot/flight director) modes, and the engagement status of the auto-pilot, flight directors and auto-thrust system.

⁹ RWY is only displayed if the runway in use is equipped with a localiser (a ground installation normally associated with an instrument landing system that can be used to provide lateral guidance with respect to the runway centre-line). If the runway is not equipped with a localiser, RWY TRK (runway track) is normally displayed. Runway 12 at Hobart is equipped with a localiser.

Figure 4: Representation of typical FMA indications during a flex temperature take-off when the thrust levers are set to the FLX/MCT detent



Source: ATSB

In response to the ECAM caution message, the captain advanced the thrust levers to the take-off/go-around (TOGA) setting.¹⁰ This action took place as the aircraft was accelerating through about 60 kt. RWY appeared as the lateral auto-flight mode as the thrust levers were advanced to the TOGA setting, but the vertical auto-flight mode annunciation remained blank, and the auto-thrust system did not arm.

The captain noticed the 'CHECK TAKE OFF DATA' message on the MCDU scratchpad and immediately selected the MCDU line select key corresponding to 'CONFIRM TO DATA' on the MCDU PERF TAKE OFF page. This action restored the previously entered take-off data and enabled display of the take-off reference speeds on the airspeed indicators, but the FMA vertical auto-flight mode still remained blank.

The crew continued the take-off and, in the absence of vertical auto-flight mode SRS guidance, the FO set the pitch attitude to about 15° nose up after lift-off (consistent with the manufacturer's guidance with respect to a typical take-off pitch attitude after lift-off, with both engines operating). Soon after the aircraft lifted off, the lateral auto-flight mode sequenced to runway track (RWY TRK) mode (consistent with normal system behaviour), essentially guiding the aircraft straight ahead, on the track that existed at the time of mode engagement.

Soon after RWY TRK mode engaged, the vertical auto-flight climb (CLB) mode engaged. In CLB mode, flight guidance is determined by the vertical path defined in the FMGS. The crew engaged the auto-pilot soon after the aircraft climbed through about 1,000 ft, and at about the same time, RWY TRK was replaced by navigation (NAV) as the lateral auto-flight mode. In NAV mode flight guidance is determined by the lateral path defined in the FMGS.

¹⁰ The captain took control of the thrust levers after the FO had set them to the FLX/MCT detent, in accordance with the operator's procedures. The captain commented that the ECAM message 'ENG THR LEVERS NOT SET' sometimes appears because the thrust levers have not been positioned accurately in the FLX/MCT detent. The captain's response was to advance the thrust levers to TOGA based upon experience with similar training scenarios. By advancing the thrust levers to the TOGA setting, maximum available engine thrust was commanded.

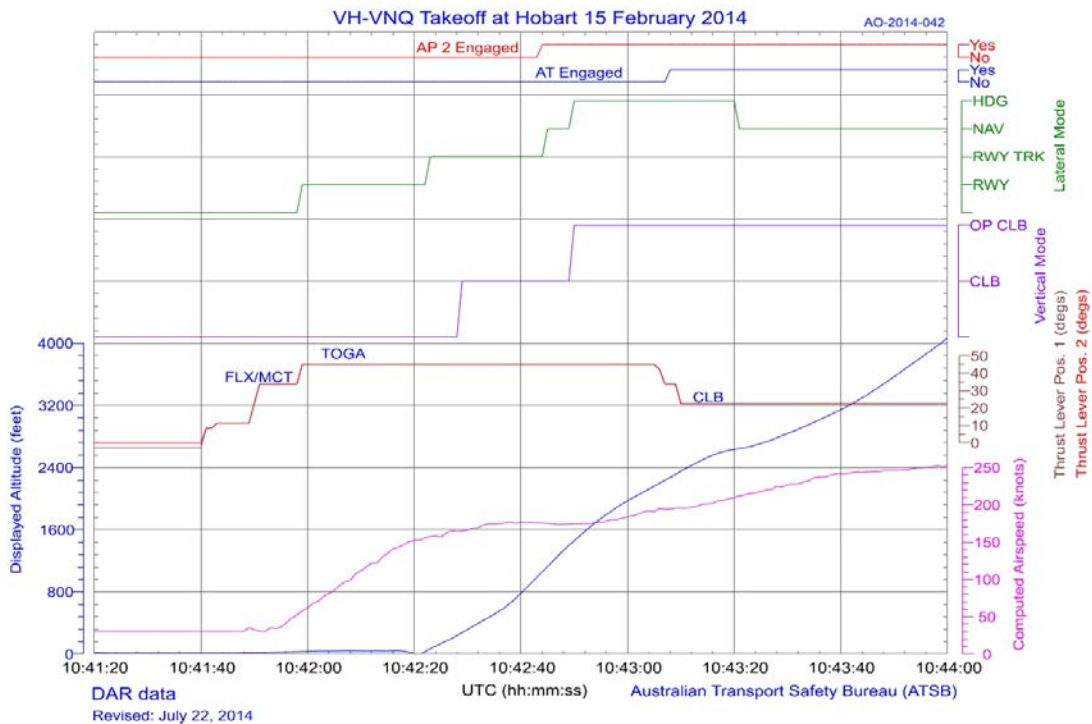
Moments after NAV mode engaged, the crew pulled the heading/track selector knob on the FCU to engage HDG mode as planned. When HDG mode was selected, the vertical auto-flight mode sequenced to open climb (OP CLB), consistent with normal system behaviour. In OP CLB mode, the aircraft climbs to the altitude selected by the crew on the FCU, disregarding any intervening altitude constraints. In HDG mode, the crew steered the aircraft into a left turn using the heading selector on the FCU to comply with the documented departure procedure.

During the initial part of the climb, the aircraft continued to accelerate, before the speed stabilised at about 175 kt. While the initial climb speed of the aircraft was higher than the speed that would have been commanded by SRS guidance had that mode been active, the initial climb angle still substantially exceeded the minimum climb performance requirements. The crew allowed the aircraft to accelerate further passing about 2,000 ft, following which the thrust levers were retarded to the climb (CLB) detent. The auto-thrust system was armed by the crew as the thrust levers were retarded, and sequenced to active when the thrust levers reached the CLB detent.¹¹ The crew re-engaged NAV mode as the aircraft climbed through about 2,700 ft and the flight to Melbourne continued uneventfully. A graphical representation of some relevant flight parameters, thrust lever position and auto-flight system modes is included below (Figure 5).

Crew comments

Leading up to the time the crew entered the runway for departure, they were mindful of the aircraft fuel state, given the amount of fuel consumed while they waited at the holding point and some concern about weather variations and the associated holding fuel requirements at the destination (Melbourne). At the same time, the crew were constantly assessing the weather situation surrounding Hobart, and departure options.

Figure 5: Flight data illustrating selected parameters and auto-flight guidance modes



Source: ATSB

¹¹ The thrust levers are normally set to the FLX/MCT detent or TOGA position for take-off, then retarded to the CLB detent as the aircraft passes the thrust reduction altitude or otherwise as required by the crew. When both engines are operative and the thrust levers are retarded to the CLB detent, the auto-thrust system sequences from armed to active.

The crew commented that they were busy following runway entry, reviewing the planned departure procedure, addressing the departure anomaly, reviewing weather in the direction of departure (including use of the aircraft weather radar) and completing checklist requirements. Additionally, the crew were concerned that the window of opportunity for departure may be limited given the unpredictable nature of the surrounding weather.

Although both pilots were compliant with the operator's duty and rest requirements, they were both feeling the effects of a relatively long day, and were nearing the end of a demanding series of duty days. The FO had been under training during the days leading up to the incident, imposing a greater cognitive workload on both the FO and the captain than might normally be the case.

The captain did not consider that the FMGS and FMA anomalies (that only became apparent after the take-off had been commenced) were sufficiently serious to reject the take-off. The captain commented that the decision to continue the take-off was based on an immediate assessment that the aircraft was able to be safely flown under the circumstances, and that a rejected take-off may be difficult given the combined effects of a relatively heavy aircraft and a wet and relatively short runway.

Had the captain been unable to quickly restore the take-off reference speeds, the crew could have referenced the take-off and landing data (TOLD) card for take-off reference speed information. Take-off reference speeds are written on the TOLD card during departure preparation, and the card is visible to both pilots during take-off and departure.

Operator's investigation

The operator made several comments and observations regarding the incident, some of which are broadly summarised as follows:

- There had been no previous reports indicating a database discrepancy with respect to the direction of turn during the TTR One SID at Hobart, and attempts to replicate the discrepancy in a simulator using the same database were unsuccessful.
- The operator's before take-off checklist requires that the crew confirm that the correct runway is set in the FMGS, before entering the runway. The checklist does not require the crew to review take-off reference speeds or the flex temperature as part of that check. In contrast, the corresponding check in the manufacturer's A320 Quick Reference Handbook (QRH) used by the operator requires that the crew check take-off reference speeds and the flex temperature.¹²
- The crew conducted the before take-off procedures out of sequence, in that the checklist was not completed again after the FMGS was reprogrammed (runway was re-set).¹³
- The operator identified that the flight simulator used for flight crew cyclic training had a previous version of the FMGS software installed, leading to differences in MCDU presentation and crew responses. With a different software version, the operator was unable to recreate the scenario in entirety, and was therefore unable to fully evaluate the response of the FMGS (and auto-flight system) under the conditions relevant to this incident.
- The captain's decision to respond to the 'CHECK TAKE OFF DATA' message on the MCDU scratchpad and select 'CONFIRM TO DATA' during the take-off, had the potential to introduce other problems as the take-off continued.

¹² Although consistency of the operator's checklist with that issued by the aircraft manufacturer is a significant point, it probably had little bearing on this incident. Had the operator's checklist replicated the manufacturer's A320 QRH, the take-off data would have been checked during conduct of the before take-off checklist, but it would still have been inadvertently removed when the captain subsequently and momentarily changed the departure runway.

¹³ While this observation appears valid, it should be noted that nothing in the operator's procedures alerted the crew to any requirement to repeat the before take-off checklist following modification of data entered into the FMGS. The manufacturer's Flight Crew Operations Manual requires re-insertion of take-off reference speeds and the flex temperature following a runway change, but that requirement appears in the 'above the line' before take-off checklist, completed before the aircraft enters the runway.

ATSB comment

Although it was not an issue during this incident, flight crew are reminded that the use of a selected lateral mode such as HDG, means that the aircraft auto-flight system will not be tracking a defined lateral path. Under these circumstances, the auto-flight system reverts to a selected vertical auto-flight mode, which in this case was OP CLB. As such, procedural altitude constraints are not recognised by the auto-flight system. The manufacturer’s Flight Crew Training Manual states that:

The crew should keep in mind that the use of HDG mode ... will revert CLB to OP CLB and any altitude constraints in the MCDU F-PLN page¹⁴ will not be observed unless they are selected on the FCU.

Having elected to continue the take-off, the crew focussed their attention foremost on manually flying a safe vertical and lateral flight path, and managing the aircraft configuration. As such, the actions of the crew were consistent with Airbus ‘Golden Rules for Pilots’ (Figure 6), particularly the first ‘golden rule’. Airbus ‘Golden Rules for Pilots’ are operational guidelines, introduced to help address the causes of many accidents and incidents, and assist with flight efficiency. The ‘Golden Rules for Pilots’ take into account the principles of flight crew interaction with automated systems, and the principles of crew resource management.

Figure 6: Airbus ‘Golden Rules for Pilots’



Source: Airbus

¹⁴ The MCDU F-PLN (flight plan) page is the page where flight plan lateral waypoints are displayed in sequence, along with any applicable speed and/or altitude constraints.

Safety action

The ATSB has been advised by Tiger Airways that, since this occurrence, the following safety actions have been implemented or are being considered by the operator:

- The operator has introduced a phased approach to align its procedures with those of the manufacturer. This transition includes:
 - Alignment of the before take-off checklist with the manufacturer's Flight Crew Operations Manual (FCOM).
 - Implementation of a revised crew briefing format (based upon risk assessment) that will provide additional threat and error management guidance to crews.
- The FCOM runway change procedure has been highlighted in educational material provided to flight crew (associated with update of the operator's procedures).
- The flight simulators used by the operator have been updated to accurately reflect the Flight Management Guidance Computer software status of operational fleet aircraft.
- The operator's training department is considering including the behaviour of the FMGS during this event in future pilot training scenarios.

Safety message

For operators, this incident highlights a number of important safety messages, including:

- The need for robust checklists and checklist management procedures that effectively cater for a wide range of operational scenarios, particularly with regard to safety-critical checklist items such as many of those that form part of before take-off procedures.
- The importance of ensuring that the performance of training equipment accurately reflects the performance of operational equipment. Any variance can undermine training effectiveness, and even lead to negative training.
- Although the operator could not replicate the FMGS database error (incorrect direction of turn) on this occasion, the incident nonetheless highlights the fundamental importance of consistently accurate FMGS aeronautical data.

While database anomalies are uncommon, flight crew should remain vigilant with respect to the possibility of a discrepancy between published data and the associated FMGS data. In this incident, the crew noted the apparent data anomaly and implemented a plan that ensured compliance with the published procedure. In another event involving a database error, an Airbus A320 on approach to Melbourne, Victoria, descended beneath its cleared altitude. A copy of the ATSB report dealing with that occurrence can be found at www.atsb.gov.au/publications/investigation_reports/2011/aair/ao-2011-070.aspx.

For flight crew, the incident also highlights the need for extra caution following an interruption to the normal sequence of events during preparation for departure. In an event with some similarities, an Airbus A380 departed Los Angeles International Airport without take-off reference speeds displayed. The associated ATSB investigation found that:

The runway change procedure was not entered in the aircraft's flight management guidance system in accordance with the operator's standard operating procedures, which resulted in the take-off speeds not being displayed during the take-off roll.

A copy of the ATSB report dealing with that occurrence can be found at www.atsb.gov.au/publications/investigation_reports/2011/aair/ao-2011-151.aspx.

General details

Occurrence details

Date and time:	15 February 2014 – 2142 EST	
Occurrence category:	Incident	
Primary occurrence type:	Flight preparation	
Location:	Hobart Airport, Tasmania	
	Latitude: 42° 50.17' S	Longitude: 147° 30.62' E

Aircraft details

Manufacturer and model:	Airbus A320-232	
Registration:	VH-VNQ	
Operator:	Tiger Airways Australia	
Serial number:	5218	
Type of operation:	Air Transport High Capacity	
Persons on board:	Crew – Unknown	Passengers – Unknown
Injuries:	Crew – Nil	Passengers – Nil
Damage:	None	

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

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.