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Australian Transport Safety Bureau

Landing gear retraction overspeed involving Saab 340B, VH-ZRJ

Sydney Airport, New South Wales | 4 December 2014



Investigation

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Addendum

Page	Change	Date

Safety summary

What happened

On the evening of 4 December 2014, a Saab Aircraft Co. 340B aircraft, registered VH-ZRJ and operated by Regional Express, was on a scheduled passenger service from Sydney to Narrandera, New South Wales. After take-off from runway 34 Left the crew inadvertently did not retract the landing gear. The crew later identified this and instinctively retracted the gear whilst the aircraft was above the maximum landing gear retraction speed.

What the ATSB found

The ATSB found that at the time of the occurrence the first officer (FO) was experiencing a level of fatigue that affected performance. However, the FO's ability to self-assess their level of fatigue was impeded by a lack of training and objective tools to determine their suitability to operate.

The ATSB also found that the FO did not recall hearing the captain's 'gear up' call, which meant that the gear was inadvertently not retracted. The factors that influenced this omission and its non-detection included both crew focusing on departure procedures and the local weather, and the crew likely expecting that the landing gear was retracted as normal.

The crew detected the error when conducting the climb checklist. As this checklist was designed to confirm the configuration of the aircraft, the time that it was conducted coincided with a time when the aircraft's speed was above the maximum gear retraction speed. Therefore, there was an increased risk that crew would react to the unexpected gear position before slowing the aircraft.

What's been done as a result

In March 2013, the Civil Aviation Safety Authority released new rules on fatigue management for flight crew. At the time of the occurrence, air operators that already held, or had applied for an air operator's certificate after April 2013, had until April 2016 to transition to the new fatigue management rules. Consistent with this timeline, Regional Express was planning for their transition to meet those requirements at the time of the occurrence. In November 2015, this deadline was extended to May 2017.

Safety message

This occurrence demonstrates some of the factors that increase the risk of making and not detecting errors of omission, particularly actions prompted by verbal cues. The use of a checklist helps identify errors, but they are most effective in this regard, if they are timed to be conducted before approaching aircraft limits.

Further, while this occurrence highlights the difficulties associated with assessing fatigue, operators and crew share responsibility for managing the risk of fatigue. Operators can reduce fatigue risk by providing crew with adequate rest opportunity, comprehensive training in fatigue management, and tools designed to support objective self-assessment of their alertness. Crew can then use the knowledge and tools to help identify when fatigue is present and may affect safety.

Contents

The occurrence	1
Context	4
Personnel information	4
Aircraft information	4
Meteorological information	6
Recorded data	7
Take-off and climb procedures	7
Operator fatigue management processes and practices	8
Fatigue training	9
Related occurrences	9
Safety analysis	12
Introduction	12
Crew fatigue	12
Omission of gear selection during the take-off sequence	12
Crew expectancy of the position of the landing gear during the climb	13
Instinctive retraction of the landing gear	14
Operator fatigue management	14
Timing of the climb checklist	15
Findings	16
Contributing factors	16
Other factors that increase risk	16
General details	17
Occurrence details	17
Aircraft details	17
Sources and submissions	18
Sources of information	18
References	18
Submissions	19
Australian Transport Safety Bureau	20
Purpose of safety investigations	20
Developing safety action	20

The occurrence

On the evening of 4 December 2014, a Saab Aircraft Co. 340B aircraft, registered VH-ZRJ (ZRJ) and operated by Regional Express as 'Rex 473', was on a scheduled passenger service from Sydney to Narrandera, New South Wales. The captain was designated as the pilot flying.¹

At about 1712 Eastern Daylight-saving Time,² the crew received a clearance from the Sydney Tower controller to take off from runway 34 Left (34L)³ on the SYDNEY SIX (RADAR) standard instrument departure. This departure required a turn at 600 ft onto the published heading of 230° and a subsequent climb to 3,000 ft above mean sea level (AMSL). Whilst taxiing, the crew discussed the significant weather observed in the region and the possible effect it may have on their route.

At about 1715, the aircraft departed from runway 34L (Figure 1). The captain reported that, after becoming airborne they⁴ called 'positive rate, gear up'. The captain expected that on this command the first officer (FO) would retract the landing gear, and so looked out to the left of the aircraft to observe the thunderstorms to the west and north of the airport. The FO did not recall hearing the captain's call and the landing gear was not retracted, nor was the subsequent standard call 'selected' made by the FO. The FO reported also focusing on the weather in the area and, due to the FO's relative unfamiliarity with Sydney departures, on the requirement to turn at 600 ft. The FO selected the yaw damper⁵ ON and recorded data indicated that the flaps were selected to zero and the flight director engaged.

Shortly after, the aircraft reached an initial climb speed of 146 kt indicated airspeed. When climbing through about 600 ft, the crew initiated a left turn onto heading 230°. The tower controller then instructed the crew to contact the departures controller. Soon after, the FO engaged the autopilot.

At about 1716, the crew commenced the 'climb scan-action flow', which included setting climb power. The aircraft's airspeed increased to 182 kt and soon after, the FO established contact with the departures controller.

Throughout the climb, the crew continued to focus on the weather to the west. They also recognised that the aircraft's climb performance was slightly less than normal, but did not establish the reason for this. Neither recalled noticing anything else unusual.

Climbing through 3,800 ft, the captain called for the climb checklist and the FO read the first item, 'gear'. At that time, the crew identified that the gear was still down. The captain started to respond by saying 'up', but immediately revised their words to 'not up'. At the same time, the FO instinctively selected the gear up and then realised that the aircraft's airspeed was above the maximum landing gear retraction speed of 150 kt. The crew reported that the gear retracted normally.

Information from the flight data recorder showed that the landing gear retracted and locked into position about 5 minutes after take-off while climbing through 4,000 ft. The airspeed at that time was 182 kt, 32 kt above the maximum landing gear retraction speed.

¹ Pilot Flying and Pilot Monitoring 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.

² Eastern Daylight-saving Time was Coordinated Universal Time (UTC) + 11 hours.

³ Runways are named by a number representing the magnetic heading of the runway.

⁴ Gender-free plural pronouns such as they, them and their may be used throughout the report to refer to an individual.

⁵ 'Yaw' is the term used to describe the motion of an aircraft about its vertical or normal axis. The yaw damper is a sub-system of the aircraft's automatic flight system that senses the onset of yaw and immediately applies corrective rudder to eliminate it.

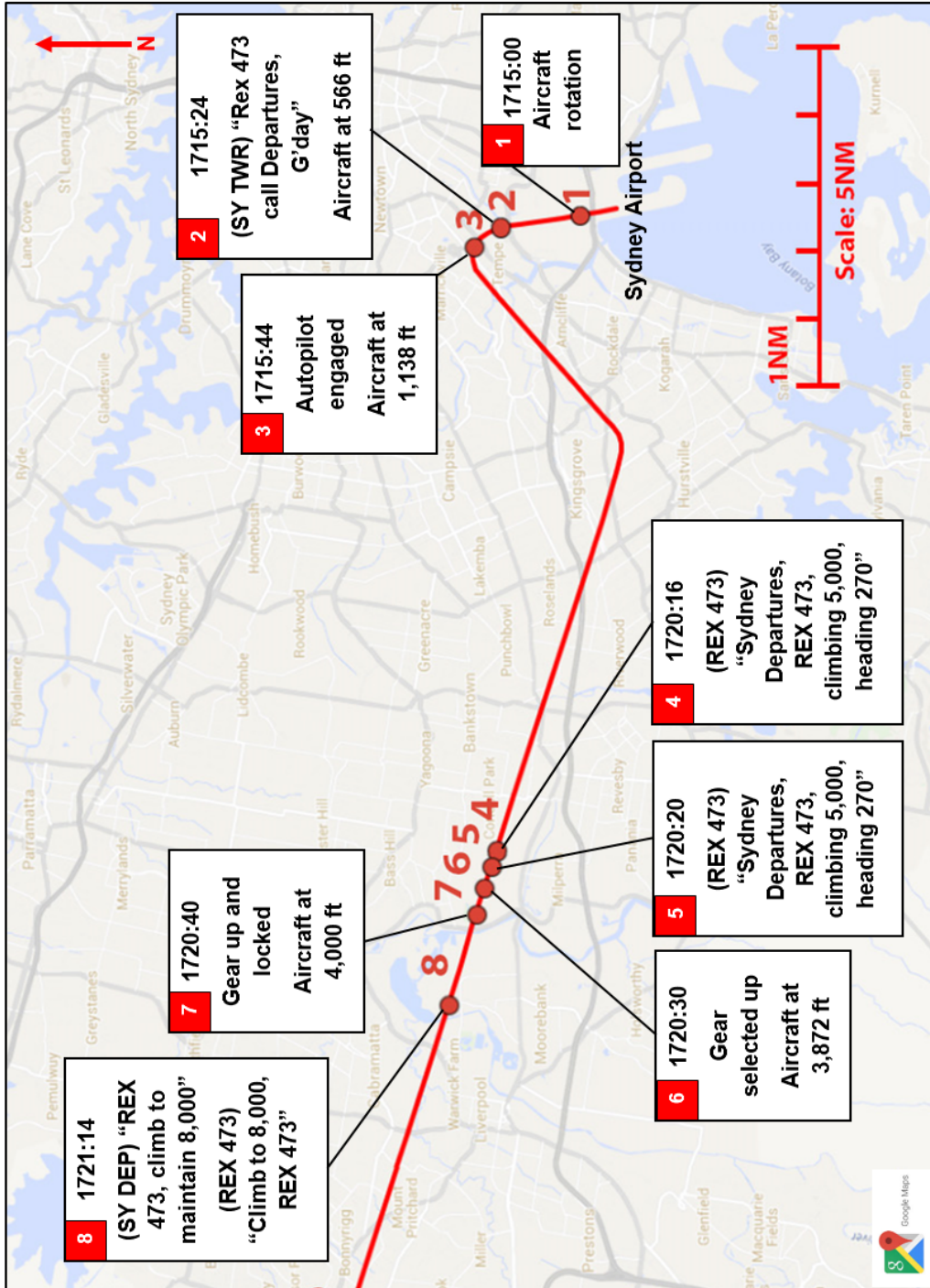
The departures controller then cleared the aircraft to climb to 8,000 ft and track to Katoomba. The remainder of the climb was uneventful.

The crew discussed the implications of retracting the landing gear above the maximum landing gear retraction speed and they elected to continue the flight based on the following considerations:

- the gear had retracted normally
- the aircraft's airspeed was below the maximum landing gear extension speed of 200 kt at the time
- maintenance facilities were available at Wagga Wagga, about 100 km east-south-east of Narrandera
- the adverse weather conditions in the vicinity of Sydney
- minimising the potential for passenger disruption.

On arrival at Narrandera, the landing gear extended as normal and the landing was uneventful. Engineers conducted a visual inspection of the landing gear as per maintenance requirements, with no damage identified. The aircraft was subsequently ferried with the landing gear extended to Wagga Wagga, where a more detailed inspection was performed and no defects were found.

Figure 1: ZRJ (REX473) departure track (in red) from Sydney towards Narrandera, with the key actions annotated



Source: Google Maps, modified by the ATSB

Context

Personnel information

Qualifications and experience

Captain

The captain held an Air Transport Pilot (Aeroplane) Licence and had a total flying experience of 12,810 hours, of which about 4,900 were on the Saab 340 aircraft. The captain commenced flying with Regional Express (Rex) on 19 August 2013 and was based in Sydney. Prior to this time, the captain was operating in Europe. The captain held a valid Class 1 Aviation Medical Certificate.

The captain completed a Sydney Airport route qualification check on 10 February 2014 and conducted human factors revalidation training on 26 November 2014.

First officer

The first officer (FO) held an Air Transport Pilot (Aeroplane) Licence and had a total flying experience of about 8,300 hours, of which about 4,800 were on the Saab 340 aircraft. The FO had been a training captain since August 2012 and was based in Melbourne, Victoria. The FO held a valid Class 1 Aviation Medical Certificate.

The FO obtained a right seat endorsement on 30 March 2012 and completed a Sydney Airport qualification check on 16 November 2011. The FO had operated from Sydney as pilot in command on eight occasions since June 2014. The FO indicated a relative level of unfamiliarity with operating to/from Sydney as compared to operations to/from Melbourne, and that they not done so 'that often'.

The FO underwent human factors revalidation training on 17 September 2014.

Crew duty

Captain

On the day of the occurrence, the captain woke at about 0800 and commenced duty in Sydney at 1558. The captain reported feeling well rested. In the 2 days prior, the captain completed a line check, which included an overnight stop. The captain indicated having adequate sleep that night.

First officer

The FO reported usually obtaining about 8 hours of sleep a night between 2200 and 0600. The following outlines the FO's sleep and work schedule leading up to and including the day of the occurrence:

- **2 December.** The FO had a rostered day off and obtained between 2 and 4 hours sleep that night. The FO indicated that this was due to a line check that was scheduled for the next day, and that they tended to sleep poorly in the days leading up to a check.
- **3 December.** The FO commenced duty for the line check at 1525. Landing back into Melbourne was delayed until 2013 due to in-flight weather diversions and the FO was recorded as signing off at 2058. After completing the line-check paperwork and an extended transit to the car park, the FO recalled leaving the airport at about 2200 on a 1-hour commute home.
- **4 December.** After returning home from the previous nights' flight, the FO went to bed between 0100 and 0200 and obtained a reported 2 hours of interrupted sleep (due to storms in the area) before waking at about 0600. The FO reported feeling tired after waking and, although initially considering calling in sick or fatigued, the FO instead decided that they were not fatigued and elected to remain on reserve duty. The FO reflected that it was difficult to self-assess fatigue given its 'insidious' nature. The FO's reserve duty commenced at 0700. Network Operations contacted the FO at about 1015 and asked the FO to operate an overnight flight from Sydney–

Narrandera–Griffith. The FO accepted this requirement, travelled to the airport and signed on at 1330, before positioning on a commercial flight from Melbourne to Sydney that departed at 1400. The FO reported feeling:

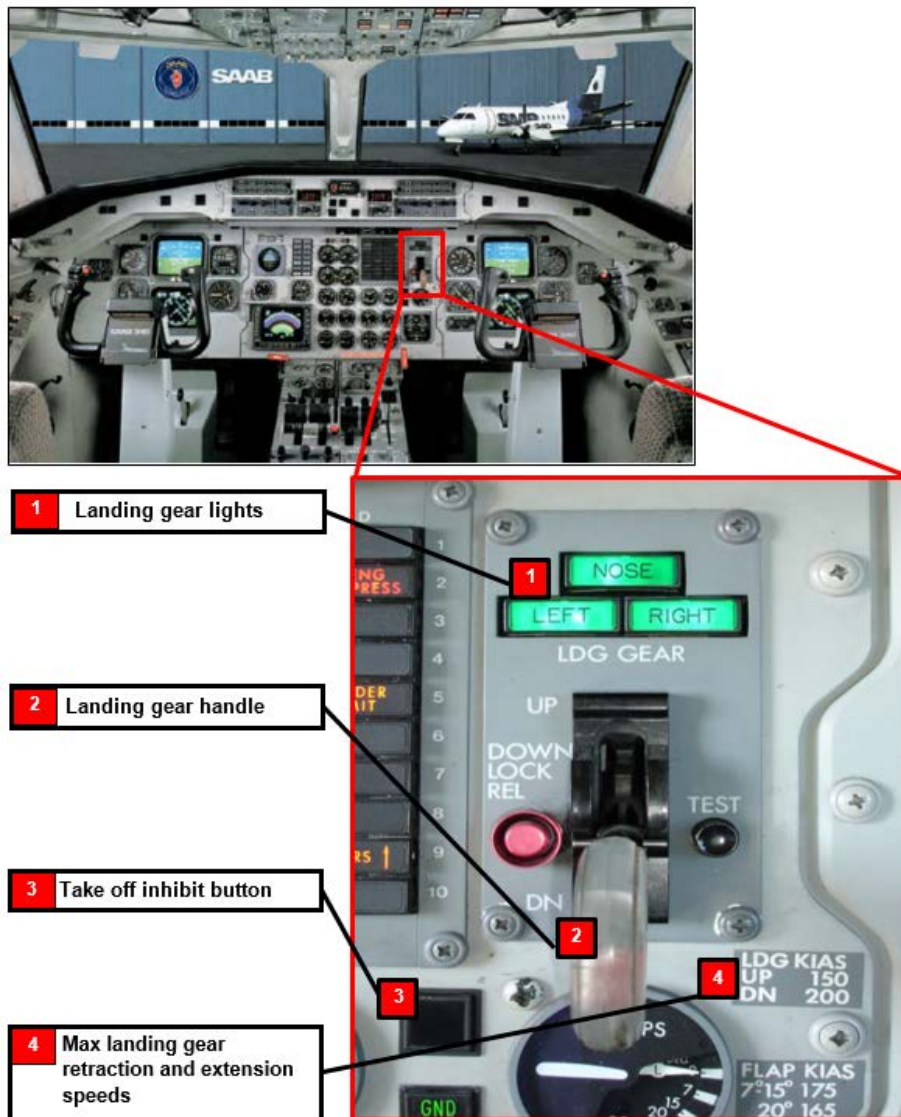
- drowsy and dozing off during that flight
- 'pretty tired' prior to signing on for the occurrence flight at 1558.

Aircraft information

Landing gear system

The aircraft is equipped with a retractable landing gear with the main and nose wheel gears retracting forward. The landing gear control panel is to the left of the FO (Figure 2). The panel incorporates three green indicator lights and the landing gear handle. When the landing gear is in the 'down' (DN) position, all three green down lock lights illuminate. The panel also displays the maximum landing gear retraction and extension speeds.

Figure 2: Photograph of the Saab 340 flight deck (with the landing gear panel emphasised) showing the gear indicator lights and handle, and position of the take-off inhibit button. Note that the placard to the right of the handle annotates the maximum landing gear retraction speed is 150 kt and the maximum landing gear extension speed of 200 kt



Source: www.aerospacetechnology.com and Rex, modified by the ATSB

Take-off inhibit mode

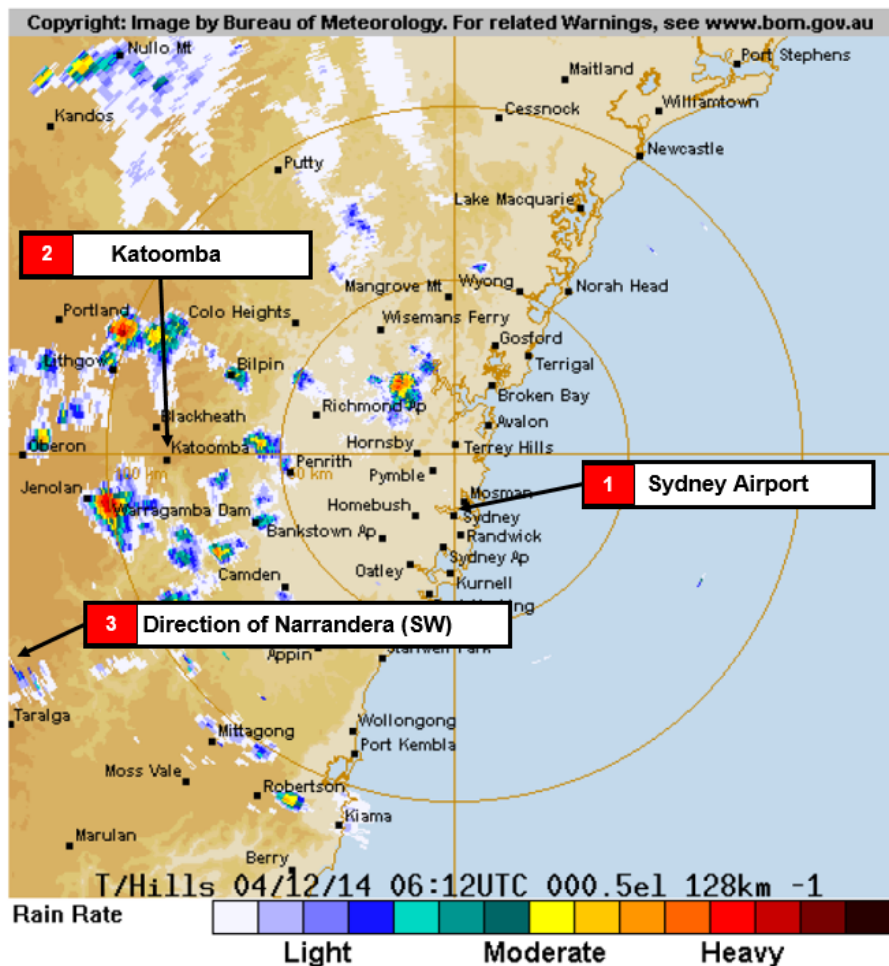
Prior to departure, the take-off inhibit button, which is located on the centre instrument panel is selected and illuminates blue to indicate its selection (Figure 2). This mode inhibits non-essential warnings and cautions during take-off. It also inhibits some lights, including illumination of the bleed valve push-button on the overhead panel.

Amongst other methods, the take-off inhibit mode is reset automatically when the landing gear is retracted. The crew then confirm that the take-off inhibit light is extinguished as part of the climb checklist. As the landing gear remained extended after take-off on the occurrence flight, the take-off inhibit mode also remained active and the associated blue light illuminated.

Meteorological information

Sydney automatic terminal information service (ATIS)⁶ ‘Alpha’, issued at 1634, indicated that thunderstorms with rain showers were present to the west and north-west of the airport. This was consistent with the Bureau of Meteorology radar image at 1712, which showed areas of light to heavy rain in the same area (Figure 3).

Figure 3: Bureau of Meteorology radar image at 1712 showing rain to the west and north-west of Sydney Airport



Source: Bureau of Meteorology, modified by the ATSB

⁶ An automated pre-recorded transmission indicating the prevailing weather conditions at the aerodrome and other relevant operational information for arriving and departing aircraft.

Recorded data

A copy of the recorded flight data for the occurrence flight and six previous sectors (flown by other crew) was downloaded for subsequent examination. A review of the previous sectors, two of which included a departure from Sydney, showed that the crews generally retracted the landing gear about 7–8 seconds after becoming airborne, at airspeeds between 128–140 kt.

Take-off and climb procedures

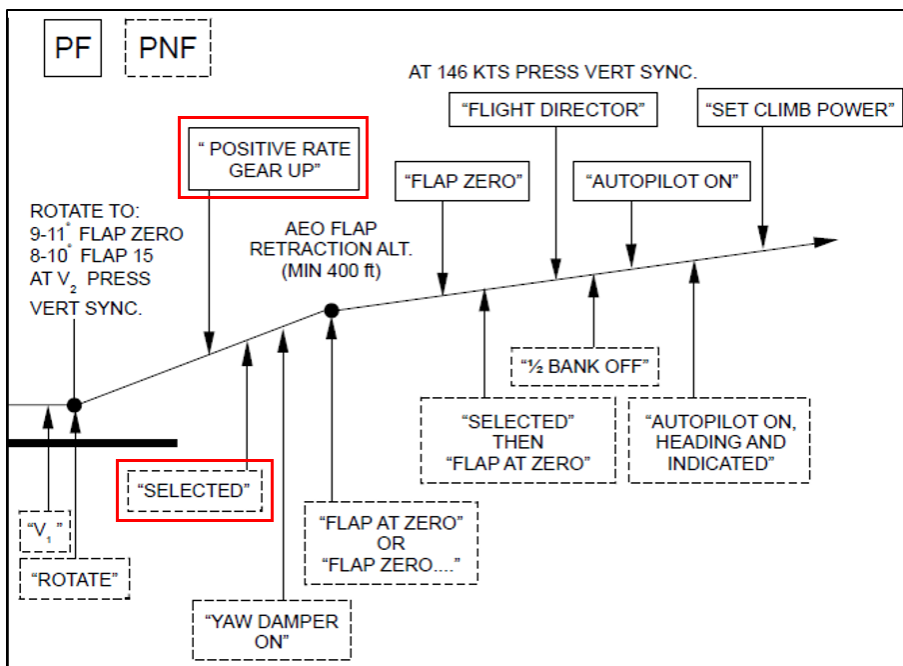
Take-off sequence

The Rex Flight Crew Operations Manual detailed the actions to be completed by the crew for a normal take-off sequence and climb (Figure 4). These actions included:

- after rotation, when a positive rate of climb has been established, the pilot flying (PF) calls 'positive rate, gear up'
- the pilot not flying (PNF) confirms that the aircraft has a positive rate of climb and then selects the landing gear up and calls 'selected'
- when the landing gear transit light has extinguished, the PNF turns the yaw damper on and calls 'yaw damper on', before adjusting the heading bug if required
- the crew complete a number of actions relating to the wing flaps, the flight director and autopilot.

On the occurrence flight, the captain reportedly made the call 'positive rate, gear up', but the FO reported not hearing it or recall calling 'selected'. Through flight data and crew recollections, it appeared that all other calls and actions associated with the take-off sequence were completed. This included the retraction of the flaps, engaging the flight director and autopilot and setting climb power. The ATSB could not determine whether the call 'yaw damper on' was made or whether the heading bug was adjusted.

Figure 4: The Rex normal take-off profile showing the actions to be taken by the PF (shown in a solid-lined box) and the PNF (shown in a dash-lined box) The PF calls 'positive rate, gear up', followed by the PNF calling 'selected' once the gear is up (both calls outlined in red)



Source: Rex, modified by the ATSB

Climb scan-action flow

Not below 1,000 ft above ground level and the best gradient of climb speed outside icing conditions the PF calls 'set climb power'. The PNF then commences the climb scan-action flow, which includes selecting the bleed valves to AUTO. However, as the take-off inhibit mode was still active, the bleed valve light would not have been illuminated at that time. The FO reported not noticing the absence of the bleed valve light.

Climb checklist

After completing the climb scan-action flow and a number of other criteria have been satisfied, the PF calls for the climb checklist. The first item on the checklist was to confirm that the landing gear was up and locked. The PF calls 'gear' and the PNF checks that the three green down lock lights have extinguished and responds with the call 'up'. The climb checklist was the first time after the retraction of the landing gear where the crew confirmed its position. By this time, the aircraft's airspeed is generally above the maximum landing gear retraction speed.

Referring to the aircraft's airspeed prior to landing gear selection

Although the Rex Policies and Procedures Manual required crew to monitor the aircraft's flight instruments in a positive manner, there was no documented requirement for the crew to reference, then call out, airspeed prior to retracting the landing gear. The FO reported that it was common, and usually their practice, for crew to place their hand on the gear lever, check the airspeed and then select the gear up. However, checking that there was a positive rate of climb took priority, especially as the aircraft's airspeed was unlikely to be above 150 kt seconds after take-off.

Operator fatigue management processes and practices

Fatigue Management System

Rex had implemented fatigue management policies and procedures aligned with Civil Aviation Orders (CAO) Part 48 *Flight Time Limitations*. Under CAO 48.1 Instrument 2013, all Air Operator Certificate holders must implement a fatigue risk management system (FRMS) by May 2017.

Civil Aviation Advisory Publication 48-1(1) *Fatigue management for flight crew* on an operator's responsibilities to manage fatigue, in accordance with FRMS implementation. This includes that:

- operators should be mindful of the requirement for crew to have prior sleep opportunity before undertaking a period of duty or standby
- off-duty periods should include defined blocks of time where crew are not contacted
- management should encourage crew to complete and submit fatigue occurrence forms after fatigue has or could impact on performance
- staff in managerial and non-operational roles should be educated and aware of their contributions to fatigue management in operations
- operators need to conduct initial and recurrent training and assessment in the nature of fatigue and sleep and fatigue countermeasures.

Individual assessment of fatigue

The Rex fatigue management policy stated that 'a pilot will not carry out a rostered duty if the pilot is suffering from fatigue or illness which may affect judgement or performance to the extent that safety may be impaired.' It was up to the individual crew to make this assessment prior to or during a duty period. At the time of the occurrence, Rex did not have specific tools or guidelines that might be expected to provide for a level of objectivity in crew assessments of their fatigue prior to a duty.

The FO recalled feeling 'tired' when commencing the reserve period on the morning of the occurrence, but did not think of it as being 'fatigued'. The FO explained that it was difficult to self-assess fatigue and that it was too 'insidious' to detect.

Crew declaring fatigued prior to or during a duty

The Rex Policies and Procedures Manual documented pilots' responsibilities to 'immediately report to Network Operations, prior to or during a duty period if they know or suspect they are suffering from fatigue'. If a crew member declared they were fatigued prior to sign on, at sign on or prior to completing the first sector, 'Network Operations will allocate this as Sick Leave (SL).' If a pilot declared they were fatigued after completing at least one sector, then Fatigue Leave was allocated (which did not affect leave accruals). If identified later that the pilot's fatigue was due to 'personal circumstances' then the leave would be re-classified as sick leave.

The FO reported to have considered declaring fatigued to Network Operations, first on the evening of 3 December and then on the morning of 4 December. However, the FO concluded that their fatigue level was insufficient to trigger the declaration.

Crew rostering practices: rostered time off between duties

Rex managed its crew flight and duty times in accordance with section one of CAO 48 titled *Flight Time Limitations – Pilots*. These requirements stated that:

- ...a tour of duty or period of reserve time at home shall be preceded by a rest period on the ground of at least (a) 9 consecutive hours embracing the hours between 10pm and 6 am local time or (b) 10 consecutive hours.

The FO's sign off time of 2058 on 3 December resulted in Network Operations delaying the commencement of the FO's reserve duty the following day by 1 hour to 0700. The FO's rest period between their duty on 3 December and the commencement of the reserve duty on 4 December complied with the existing CAO 48.1 requirements.

Fatigue training

Industry approach to fatigue management training

Over the past decade, the requirement for operators to implement systems to manage fatigue (now referred to as fatigue risk management systems) gained momentum and the guidance material for designing, implementing and assessing this training became readily available. This included a focus on fatigue training for crew.

International Civil Aviation Organization (ICAO) Annex 6 to the Chicago Convention *Operation of Aircraft* advocated that operators implement '[fatigue] training programs to ensure competency commensurate with the roles and responsibilities of management, flight and cabin crew under the planned FRMS'. In addition, ICAO produced guidance material including the *Fatigue Risk Management Systems: Implementation Guide for Operators* (2011) that outlined suggested training content.

Locally, CASA also produced guidance material for the Australian aviation industry, including the release/publishing of:

- In 2011, CAAP SMS-3(1) *Non-Technical Skills Training and Assessment for Regular Public Transport Operations*. This CAAP recommended specific non-technical skills (NTS) training topics including fatigue management and methods to develop fatigue awareness, knowledge and skills for pilots.
- In 2012, a suite of guidance material on fatigue management was released, including the *Fatigue Management for the Australian Aviation Industry: A Training and Development Workbook*. This workbook stated that 'an important part of any system consists of training all employees about the safety hazards of fatigue and how effectively to manage them...beyond simply raising awareness.'

- In 2013, CAAP 48-1(0) *Fatigue Management for Flight Crew Members*. This CAAP provided guidance for operators transitioning to the new fatigue rules. The CAAP included that, as part of crew fatigue training, flight crew should be made aware of the operator's fatigue procedures, limits and all shared responsibilities. The CAAP outlined specific subject areas that should be part of a typical fatigue training program, including the consequences of fatigue on safety, fatigue in accidents and high-risk situations and a range of fatigue countermeasures.

Operator fatigue management training

At the time of the occurrence, Rex was required to comply with CAO Part 48 Section 48.1 *Flight Time Limitations – Pilots*. Under CAO 82.5, they were also required to implement and maintain a safety management system, and specifically a human factors/non technical skills (HF/NTS) training and assessment program.

Rex conducted compulsory initial and revalidation NTS courses for their flight crew. The initial course, 'Introduction to Human Factors' was of 2 days duration. The Regional Express HF/NTS Program Manual documented the program syllabus, which was based on 12 HF/NTS elements that determined training content. One of these elements was fatigue.

The initial course included 'sleep and fatigue' as one of the topics, which was delivered over a 45-minute period. The syllabus included the following topics:

- requirements for effective sleep
- the effects of fatigue on performance
- identifying the signs of fatigue and how to counter its effects.

Flight crew completed a 1-day HF/NTS revalidation course every 12 months, with the course content designed to cycle through the 12 elements over a 3-year period. The 2013 and 2015 NTS courses included fatigue. The revalidation course syllabus (including the course held in 2013) included:

- the definition of fatigue
- an introduction to fatigue management
- examination of the legislative changes relating to fatigue management
- examination of the fatigue precursors
- examination of circadian rhythms.

The FO conducted a revalidation course on 4 October 2013, and recalled that fatigue was discussed during the day and that the facilitator showed participants an individual fatigue assessment tool used by another operator, although it was not utilised by Rex. The FO completed their initial NTS course in 2007, although it is not certain whether that initial training included an examination of fatigue and its effects.

Related occurrences

Landing gear retraction occurrences

A review of the ATSB occurrence database identified two other occurrences in the previous 5 years where the landing gear was not retracted as part of the aircraft's published take-off sequence. These were:

- During the take-off run and initial climb, the crew of the de-Havilland Canada Dash 8 were distracted and the gear-up call was missed. The landing gear was not retracted until after the transition altitude.⁷
- During the take-off, the crew of the de-Havilland Canada Dash 8 were distracted by an auxiliary power unit warning and forgot to retract the landing gear, resulting in a landing gear overspeed.

Fatigue-related occurrences

In addition, a number of recent ATSB investigations have included an analysis of crew fatigue. Two are summarised below and available at www.atsb.gov.au.

ATSB investigation AO-2013-010

The crew of an Embraer Regional Jet 170 were conducting a scheduled passenger service from Darwin to McArthur River Mine, Northern Territory. Shortly after passing navigational waypoint SNOOD, the aircraft's flight path started diverging from the planned track. The problem was identified by air traffic control and the crew were advised. The ATSB found that, due to restricted sleep in the previous 24 hours, the crew were probably experiencing a level of fatigue known to have a demonstrated effect on performance. Although the operator's rostering practices were consistent with the existing regulatory requirements, it had limited processes in place to ensure that fatigue risk due to restricted sleep was minimised.

ATSB investigation AO-2013-130

The crew of a Boeing 777 aircraft were conducting an approach into Melbourne Airport. After passing waypoint SHEED, the aircraft descended below the approach path to about 500 ft above ground level. The crew recognised the error and re-intercepted the profile and continued the approach to land. The ATSB found that, due to extended wakefulness, the crew were probably experiencing fatigue at a level that has been demonstrated to affect performance, although fatigue could not be confirmed as contributing to the error in developing the approach profile.

⁷ The altitude at or below which the vertical position of an aircraft is controlled by reference to altitudes.

Safety analysis

Introduction

During take-off, the crew unintentionally left the landing gear extended until this was identified in the climb checklist. The first officer (FO) reacted instinctively to retract the gear.

The following analysis examines the various human performance factors that influenced the crew's actions and ability to detect and react to the landing gear inadvertently being left extended while above the maximum retraction speed.

Crew fatigue

The International Civil Aviation Organization (ICAO 2011) defined fatigue as:

A physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety related duties.

Fatigue can have a range of adverse influences on human performance. These include:

- slowed reaction time
- decreased work efficiency
- increased variability in work performance
- lapses or errors of omission (Battelle Memorial Institute 1998).

Sleep is vital for recovery from fatigue, with both the quantity and quality of sleep being important. It is generally agreed that most people need at least 7 to 8 hours of sleep each day to achieve maximum levels of alertness and performance. A review of relevant research (Dawson and McCulloch 2005) concluded:

...we can make broad assumptions from existing literature that obtaining less than 5 h [hours] sleep in the prior 24 h, and 12 h sleep in the prior 48 h would be inconsistent with a safe system of work.

Acute sleep disruptions are reductions in the quality or quantity of sleep that have occurred within the previous 3 days (Transportation Safety Board of Canada 2014). Losing as little as 2 hours of sleep will result in acute sleep loss, which will induce fatigue and degrade subsequent performance and alertness (Dinges and others 1996).

Other research has indicated that less than 6 hours sleep in the previous 24 hours can increase risk. Thomas and Ferguson (2010) examined the effects of different amounts of sleep on the performance of Australian airline flight crews. Crew error rates was higher during flights when the crew included a captain with less than 6 hours sleep or an FO with less than 5 hours sleep in the previous 24 hours.

The FO reported obtaining a total of between 4 and 6 hours sleep in the 48 hours prior to the occurrence. Accordingly, it is reasonable to conclude that the FO was experiencing a level of acute fatigue known to have at least a moderate effect on performance.

The types of errors made by the crew, including an error of omission that was not detected, are consistent with the effects of fatigue. However, as discussed in the following sections, there were other factors that could lead to the development and non-detection of such errors. While it is difficult to conclude that fatigue alone led to the FO's errors on this occasion, it was considered contributory to the occurrence.

Omission of gear selection during the take-off sequence

During the take-off sequence, the FO unintentionally missed the step of selecting the landing gear up, and also missed making the subsequent associated call 'selected'. The actions included in the

take-off sequence immediately following this were completed. When considering how the call 'positive rate, gear up' was not perceived, or how the action was not otherwise recalled, the following are relevant:

- Skill-based errors can occur when a pilot is undertaking highly-learned, well-developed behaviours that are essentially sub-conscious (Harris 2011). Retracting the landing gear was a frequent action for crew and therefore conducted automatically, with little conscious oversight.
- Omitting a step in a task is one of the most common types of human error. A step is more likely to be omitted if the instructions are given verbally (Reason 2007). Raising the gear was triggered by a standard verbal cue (that is, 'positive rate, gear up'), and not retracting it could be considered an error of omission. The risk of making errors of omission can increase when experiencing fatigue.
- Reliance on predictable cues may make items more vulnerable to being forgotten when the cues are not available, or not perceived (Nowinski et al 2003). The verbal cue to raise the gear was not heard by the FO.

Additionally, given the FO was based in Melbourne, their familiarity with Sydney Airport operations had reduced due to the low frequency of rostered flights departing Sydney since June 2014. This required the FO to apply a high level of attention to the departure procedures for runway 34 Left.

Crew expectancy of the position of the landing gear during the climb

During the climb, the crew did not detect that the landing gear was still down. There were indicators that the gear remained extended, including:

- the absence of the call 'gear, selected'
- the illumination of the green landing gear lights
- the absence of the light on the bleed valve push-button (due to the take-off inhibit mode still being active)
- the partially-degraded climb performance.

The crew likely expected that the landing gear was retracted, reducing the chance that they would detect that it remained extended. This is due to human attention being *guided* by two factors: expectancy (an individual will look where they expect to find information) and relevance (an individual will look to information relevant to their important tasks and goals). At the same time, an individual's attention is *attracted* by the salient events in their environment. The key factor is expectancy. It is well-demonstrated that people are more likely to detect targets when they are expected and less likely to detect targets when they are not expected (Wickens and McCarley, 2008). This lack of detection occurs even when targets are salient, important and in an area to which a person is looking (known as inattention blindness) (Chabris and Simon 2010).

A range of conditions influenced the crew not detecting that the landing gear remained extended:

- Errors of omission are often difficult to detect by the people who make them (Sarter and Alexander 2000).
- The absence of something is more difficult to detect than the presence of something (Thomas and Wickens 2006), depending on its salience. In this case, the absence of certain illuminations as a result of the take-off inhibit mode being active were not likely to be identified.
- Both crew had a lot of experience on the aircraft without making this error before, and probably had a high degree of expectancy that the gear was actually retracted.
- The crew's focus of attention during the climb was predominantly on the weather conditions in the region and other operational tasks.
- The crew detected a degraded climb performance. However, its relevance was not recognised as there were other valid explanations.

- The green landing gear ‘down’ lights were within the crew’s line of sight. It was likely the lights were not detected due to inattentive blindness arising from an assumption that the gear was up.

Instinctive retraction of the landing gear

The crew realised the landing gear remained extended when they conducted the climb checklist. The FO recalled instinctively reaching out to select the gear up. The FO usually referenced the aircraft’s airspeed before any configuration changes, but in this case, the FO’s action was in response to the surprise of discovering that the gear was still extended.

Surprise is a cognitive-emotional response to something unexpected. It results from a mismatch between one’s mental expectations and what actually happens around them. Experiencing surprise is a combination of physiological, cognitive and behavioural responses (Rivera and others 2014). If a pilot is not expecting things to go wrong, then the level of surprise can result in taking no action, or the wrong action (Martin 2012).

Operator fatigue management

Individual assessment of fatigue

Caldwell (2003) notes the difficulty with individuals knowing ‘...when the amount of fatigue has crossed the line from being simply an unpleasant feeling to being a hazard to safe flight...’.

It has been well demonstrated that ‘fatigued people are not very good judges of their own fatigue level or their ability to perform well’. They tend to overestimate their abilities, particularly if the fatigue levels experienced are anything other than approaching sleep at the time (Transportation Safety Board of Canada, 2014). Flin and others (2008) add that ‘subjective methods [such as] scales give a numerical measure of sleepiness...[although] people are not necessarily good at judging their levels of fatigue, and so subjective measures may underestimate levels of sleepiness.’

It is for this reason that Civil Aviation Advisory Publication 48-1(1) *Fatigue Management for Flight Crew Members* advocates the use of individual fatigue assessment tools that take into account sleep history, behavioural indicators and nature of sleep to avoid crew relying only on their subjective assessment of how fatigued they feel. It encourages crew to ‘consider what factors are associated with the tasks allocated to them prior to presenting as fit for duty.’ The Regional Express (Rex) Policies and Procedures Manual outlined their approach to managing fatigue at the time. However, there were no specific guidance or tools to better facilitate crew recognising their own fatigue.

In this case, the FO relied upon their understanding of fatigue to determine whether they were fit for duty. This understanding did not take into account the inadequate amount of sleep they had obtained in the past 48 hours and their own feeling of being tired.

Fatigue training

The FO felt that being tired was not a sign of fatigue, nor recognise that obtaining between 4 and 8 hours of sleep over the previous two nights was an indication of a significantly increased risk of experiencing fatigue that would likely impair performance.

When comparing the operator's syllabus and available training material to the recommended industry approach, it was identified that the initial human factors/non-technical training course included a discussion of factors that contribute to fatigue and some of the consequences. One topic in the syllabus was 'identifying the signs of fatigue and how to counter its effects', but this did not appear to be included in the training material for the course.

Overall, at the time of the occurrence the content of the provided fatigue training was limited to a general awareness of fatigue, sleep and fatigue countermeasures which may not provide crew with an adequate opportunity to develop the skills or utilise tools that could best help them identify signs of fatigue in themselves or others. Noting that Rex was not required to comply with the new fatigue rules on training at the time of the occurrence, it could be expected that, as they work towards implementing those requirements by May 2017, the training content will be revised to align with a fatigue risk management system approach.

Crew rostering practices

It is widely acknowledged that minimising fatigue is a responsibility for both flight crew and operators, and that crew should ensure they use the rest periods provided to obtain adequate sleep where possible. Under a fatigue risk management system, there is a greater requirement for the operator to tailor their rostering practices to manage fatigue risk with the nuances of their operational demands. In doing so, the operator should provide adequate time for crew to get the required sleep opportunity (8 hours), sufficient time for bodily functioning (eating, hygiene, and so on), and time to travel to and from the suitable sleeping accommodation (CAAP 48-1(1)). This advisory publication also recommends that operators take into account the impact on fatigue levels of training and checking requirements when designing and setting limits.

On 3 December, the FO signed off duty at 2058 then reportedly was only able to leave the airport at about 2200. To allow a flight crew to commute to and from an airport, deal with a range of personal requirements, and allow for an adequate sleep opportunity is very difficult with only 9 hours time off duty. Additionally, the time between the commencement of the FO's standby duty at 0700 and sign on at 1330 was also not likely a plausible opportunity to gain restorative sleep.

Rex managed its flight crews' flight and duty times to comply with CAO 48.1. Although compliant with those requirements, Rex's rostering processes did not wholly account for the:

- potential for the conduct of the flight check to have impacted on the FO's sleep preceding the check
- unforeseen extension of the FO's previous duty period and the associated time between sign off and being able to leave the airport.

Both of these factors influenced the adequacy of the FO's sleep opportunity in the period before the occurrence.

Timing of the climb checklist

Checklists help crew detect the omission of an action (Nowinski and others 2003). In this case, the use of the climb checklist detected the unintended gear position. As the climb checklist is designed to confirm the configuration of the aircraft, there is the potential for its conduct at a time when the aircraft's speed is above the maximum gear retraction speed. As in this case, this increases the risk of crew reacting to an unexpected gear position by retracting the landing gear before slowing the aircraft.

Findings

From the evidence available, the following findings are made with respect to the landing gear retraction overspeed involving Saab Aircraft Co. 340B, registered VH-ZRJ, which occurred near Sydney Airport, New South Wales on 4 December 2014. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- During the take-off sequence both crew were focused on the departure procedures and local weather that, combined with the effects of fatigue on the first officer, likely led to the landing gear not being retracted.
- The first officer's ability to assess their own level of fatigue was impeded by a lack of training and objective tools to do so, resulting in a decision to operate the flight instead of calling in fatigued.
- During the climb, the crew likely expected that the landing gear was retracted, reducing the likelihood that they would detect the indicators that it was still extended.
- When the crew identified that the landing gear was still extended, the first officer instinctively retracted the gear before identifying that the aircraft was above the maximum landing gear retraction speed.

Other factors that increase risk

- Although compliant with regulations at the time, the Rex rostering processes did not wholly account for the unforeseen extension of the first officer's previous duty period or the effects on performance of conducting a check flight, both of which impacted the adequacy of the first officer's sleep opportunity on the evening before the occurrence.
- The only checklist item to confirm that the gear was up was carried out when the aircraft's airspeed was above the maximum landing gear retraction speed, increasing the risk that crew would retract the landing gear before slowing the aircraft.

General details

Occurrence details

Date and time:	4 December 2014 – 1720 EDT	
Occurrence category:	Incident	
Primary occurrence type:	Landing gear retraction overspeed	
Location:	Sydney Airport, New South Wales	
	Latitude: 33° 54.57' S	Longitude: 150° 58.90' E

Aircraft details

Manufacturer and model:	Saab Aircraft Co. 340B
Year of manufacture:	1996
Registration:	VH-ZRJ
Operator:	Regional Express
Serial number:	340B-396
Type of operation:	Air transport – low capacity

Sources and submissions

Sources of information

The sources of information during the investigation included:

- Regional Express
- the crew of VH-ZRJ
- the Bureau of Meteorology
- the Civil Aviation Safety Authority
- Airservices Australia.

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Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the 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 crew of VH-ZRJ, Regional Express, the manufacturer and the Civil Aviation Safety Authority.

Submissions were received from the Civil Aviation Safety Authority and Regional Express. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The 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 fare-paying passenger operations.

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

Landing gear retraction overspeed involving Saab 340B, VH-ZRJ
Sydney Airport, New South Wales, 4 December 2014

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