Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A03O0273

RUNWAY EXCURSION

PARTNER JET INC.
GULFSTREAM AEROSPACE LP ASTRA SPX C-GSSS
TORONTO/LESTER B. PEARSON INTERNATIONAL AIRPORT
TORONTO, ONTARIO
26 SEPTEMBER 2003

Canada

Aviation Investigation Report

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Summary

The Israel Aircraft Industries Astra SPX aircraft (registration C–GSSS, serial number 80), with two crew and four passengers on board, was landed on Runway 05 at Toronto Pearson International Airport at 1826 eastern daylight time. As the nosewheel touched down, a severe nosewheel shimmy developed, and the flight crew had difficulty controlling the aircraft. As the flight crew attempted to steer the aircraft, an uncommanded full-left steering input was experienced, and the aircraft began to veer to the left. The first officer attempted to turn the steering control to the right, but was unable to move the control. The flight crew attempted to correct for the full-left input using differential braking and reverse thrust, but were unable to keep the aircraft on the runway. The aircraft skidded off the north side of the runway and came to rest in the infield between Runway 05 and taxiway Juliet, just before the intersection at Runway 15R.

The captain contacted the tower and requested emergency services. Meanwhile, the first officer exited the aircraft to check for damage and to ensure there was no further danger to crew or passengers. Assessing the situation to be safe, the first officer re-entered the aircraft, and the flight crew and passengers waited for emergency services to arrive. There was minor damage to the aircraft.

Ce rapport est également disponible en français.

Other Factual Information

The captain occupied the right seat, held a valid airline transport pilot licence, and had recently completed a pilot proficiency check on type. He had accumulated a total flying time of approximately 17 500 hours, with 500 hours on type. The first officer held a valid airline transport pilot licence and had recently completed the Astra/G100 pilot recurrent course. He had accumulated a total flying time of approximately 8300 hours, with 775 hours on type. At the time of the occurrence, the first officer was the pilot flying, occupying the left seat. This allowed the first officer to cover all aspects of his flight leg, including taxiing, since the Astra SPX is equipped with only one steering tiller located on the left side of the cockpit. The first officer was qualified to occupy this seat.

The 1800 eastern daylight time[1] weather report for Toronto Pearson International Airport was as follows: wind 100 degrees True at 8 knots, gusting to 15 knots; scattered clouds at 1500 feet above sea level (asl); broken cloud at 2800 feet asl; visibility greater than 15 miles; temperature 17°C; dew point 10°C. The runway was bare and dry. Magnetic variation at Toronto is 10° west.

Examination of the aircraft revealed that the nose landing gear steering assembly upper and lower attachment brackets had failed near the attachment to the aircraft bulkhead. The left steering actuator was found fully extended and the right steering actuator was found fully retracted; this corresponds to a full-left steering input. The entire steering assembly was rotated and jammed against the right side of the nose landing gear bay, beyond the normal steering range for the nose landing gear.

The steering assembly (see Photo 1) comprises an upper and lower attachment bracket, a left and right steering actuator, and a shaft with a universal joint to mate to the nose landing gear. The brackets are bolted together at four points using nuts and bolts with a spacer to maintain separation. The entire steering assembly is then bolted to the aircraft at the nose landing gear bay aft bulkhead.

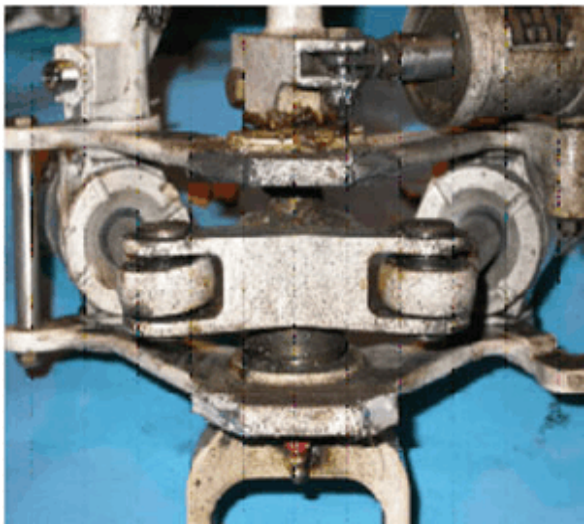

Photo 1. Rear view of steering assembly removed from the aircraft

[1] All times are eastern daylight time (Coordinated Universal Time minus four hours).

There was fretting[2] found on the mating surfaces of the upper and lower brackets at the attachment to the aircraft bulkhead (see Photo 2). The upper bracket fracture surfaces were heavily contaminated with blackened Skydrol hydraulic fluid, and had a polished appearance. As well, the paint around the fracture surfaces was softened and blistered in much the same manner as a painted surface with paint stripper applied. By comparison, the lower bracket fracture surfaces were clean and dull in appearance, and the paint showed no signs of softening or blistering. Both the upper and lower bracket fracture surfaces had smearing damage from the fracture surfaces impacting each other. The entire steering assembly was forwarded to the Transportation Safety Board (TSB) Engineering Branch Laboratory for further examination.

Photo 2. Upper and lower attachments on aft bulkhead

Laboratory examination showed there was no indication of fatigue cracking on any of the fractured surfaces and all of the fracture surfaces were representative of overstress failures. A test was conducted to see how long it would take for the paint to start blistering if contaminated with Skydrol hydraulic fluid. This consisted of scratching through the paint to the metal on a cleaned portion of the attachment bracket. This would be representative of a typical crack in the paint at a fracture site. The area was then contaminated with Skydrol hydraulic fluid; it took approximately three weeks for the test area to show any signs of paint blistering.

The aircraft was maintained on an approved phase inspection program, with inspection packages due every 62.5 flight hours. The steering actuator assembly, including attachments, is inspected every 250 hours or every fourth phase. The last time the steering assembly was inspected was during the Phase 5 inspection, 171 hours prior to the occurrence on 25 April 2003. The inspection revealed no discrepancies.

An examination of the aircraft logbooks showed several instances of nosewheel shimmy dating back to 23 March 2002. Most of these were directly attributed to a loose B nut fitting on the steering selector valve. When steering is not being actuated, hydraulic fluid flows through restrictors in the steering control valve, dampening nosewheel shimmy. The loose B nut allowed hydraulic fluid to leak excessively and hinder the dampening characteristics of the steering selector valve. Tightening of the B nut eliminated the problem in all but one case, which was attributed to a loose nosewheel torsion shaft. There is no means of ensuring the safety of the B nut to prevent it from loosening.

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[2] *Fretting* is a condition of surface erosion caused by slight movement between two parts that are fastened together with considerable pressure.

Worldwide, there have been six other occurrences of nosewheel steering assembly bracket failures on this type of aircraft. This is the first failure on a Canadian-registered aircraft and the first TSB investigation into this type of failure. In most cases, a nosewheel shimmy was experienced by the flight crew prior to the failure being discovered. An examination of these failures indicated they were the result of exceeding the steering limits with the steering links (scissors) connected.

The aircraft manual stipulates the maximum steering range for the nose landing gear is 58° either side of centre. It also cautions that, "The nose landing gear can be damaged if turn limits are exceeded with scissors connected or due to low strut." The maximum steering angle with the scissors disconnected is 90° either side of centre. There are no visual indicators of the maximum steering ranges. The operator has indicated that they try to ensure the aircraft is towed with the scissors disconnected at all times. However, this is not always possible. The aircraft is often parked away from home base, at a fixed base operator, and, due to operational requirements, the aircraft may be moved to an alternate parking position without the flight crew's knowledge.

There have been several service bulletins (SBs) issued that relate directly to the nose gear steering system on Astra SPX. On 25 June 1998, the manufacturer issued SB 1125–11–181, which added the warning placard "DISCONNECT SCISSORS BEFORE TOWING" to the landing gear doors. The warning placard serves as a visual reminder for ground-handling personnel to disconnect the scissors prior to towing, to prevent damage to the nose landing gear steering brackets. This SB was further emphasized on 25 June 1999, through service information letter No. 1125–09–096, recommending a review of the towing procedures in the Astra maintenance manual, Chapter 9–00–00 (page 1) and Chapter 9–10–00 (pages 1 through 6), and the incorporation of SB 1125–11–181.

On 26 February 2001, the manufacturer issued SB 1125–32–225, which provided instructions to modify the nosewheel steering angle limitation system, in order to reduce the maximum steering angle by up to 2°. This would eliminate hydraulic hammer[3] at the end of the steering stroke while using extreme steering angles during taxiing. In addition, on 20 April 2001, the manufacturer issued SB 1125–32–187, which called for the replacement of the bell crank connecting shaft on the steering assembly. This replacement was intended to prevent over tightening of the bell crank connecting nut, which could cause stiff nosewheel steering and might affect the centring of the nose gear.

None of the SBs noted above were complied with prior to the occurrence, nor was compliance required by regulation. Transport Canada issued Airworthiness Notice (AN) B055 Edition 1, 4 July 2000, titled "Service Bulletin Compliance," clarifying the need to comply with service bulletins. Section 2 of the AN deals with publications that recommend the incorporation of modifications, the performance of inspections, or times between overhaul. This section states, in part, the following:

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[3] *Hydraulic hammer* is a condition caused by the sudden stoppage of moving liquid. The hydraulic surge created by this condition increases with the speed at which the liquid is moving. A pressure surge may go as high as four times the normal working pressure. This can cause severe physical damage to fluid conductors and other components in a system.

> Except where otherwise specified in Std 625, Appendix C, compliance with publications dealing with these topics is optional. However, aircraft owners have a duty to be aware of the contents of these publications, and to evaluate the need for compliance in light of their own circumstances. Commercial operators should have a formalized process for conducting this evaluation, as part of the evaluation program required by CAR[4] 706.

As such, the SBs were reviewed by the person responsible for maintenance at the time they were issued, and a decision was made not to implement them.

Analysis

The aircraft and flight crew were properly certified for the flight, and documentation indicated that the aircraft was maintained to current standards and regulations. It was determined that the weather was not a factor in this occurrence.

It was concluded that the top attachment bracket was overstressed and failed at sometime prior to the occurrence. It was not possible to determine when the top attachment bracket failed; however, the combination of the polished fracture surfaces, the blackened Skydrol contamination on these surfaces, and the softened paint around the fractures are indicative of an old failure that had been working or rubbing together for sometime. Additionally, the fretting found on the mating surfaces of the upper and lower attachment brackets supports this analysis. The fretting indicates that the attachments to the aircraft were moving due to the transfer of steering loads to the lower brackets. The clean, dull fracture surfaces of the lower bracket were overload failures at the time of the occurrence.

Failures of the attachment brackets on other aircraft have shown that towing the aircraft with the scissors connected can damage the brackets if steering limits are exceeded. The manuals and SBs support this conclusion; however, there are no visual indicators of the steering limits on the aircraft for reference by ground personnel. As well, it is conceivable that the steering brackets could also be damaged while towing the aircraft with scissors connected, without exceeding the steering limits of the aircraft. The shimmy dampening characteristics of the steering system dampen or restrict movement of the nose gear system; a sharp turn while towing with scissors connected, or turning the aircraft while towing the aircraft on an uneven surface, could transfer damaging forces to the brackets. The manuals also caution that sharp turns and abrupt stops could damage the aircraft during ground handling.

It is most likely that the occurrence aircraft was towed beyond the steering limits with the scissors connected at some time prior to the occurrence. This resulted in the fracture of the upper bracket but did not immediately affect the handling characteristics of the aircraft. The nosewheel shimmy on landing in Toronto stressed the lower attachment to the point that it failed in overload. With the steering assembly free to move, inputs to the steering tiller would be ineffective in maintaining directional control of the aircraft.

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[4] CAR – Canadian Aviation Regulation

The operator did not implement the SBs, but this did not affect the serviceability of the aircraft. Notwithstanding, had the placard called for in SB 1125–11–181 been attached to the landing gear doors, the initial failure might have been avoided.

Findings as to Causes and Contributing Factors

1. It is most likely that the occurrence aircraft was towed beyond the steering limits with the scissors connected, resulting in the fracture of the upper bracket.

2. A nosewheel shimmy on landing stressed the remaining lower attachment bracket to overload and failure, which allowed the steering assembly and nose gear to rotate uncontrollably.

3. The aircraft became uncontrollable and exited the runway after the steering assembly failed.

Finding as to Risk

1. Although the aircraft manuals caution against exceeding steering limitations with the scissors connected, there are no external markings which identify the steering limitations of the aircraft nose gear.

Other Finding

1. Although SBs were issued that might have prevented the initial failure, there was no regulatory requirement to comply with them.

Safety Action Taken

On 21 October 2003, the State of Israel, Ministry of Transportation, Civil Aviation Administration, issued Airworthiness Directive (AD) 32–03–10–05, effective 28 October 2003, requiring a one-time inspection of the upper and lower steering assembly brackets within 50 flight hours or 25 landings, whichever comes first. This AD was endorsed by Transport Canada on 17 November 2003.

On 24 October 2003, Gulfstream Aerospace LP issued Alert Mandatory SB 100–32A–275, titled "Nosewheel Steering – Inspection of Upper and Lower Steering Assembly Brackets," which called for a one-time inspection of the brackets and an inspection of the nose-centring spring. This was further revised to Revision Number 1 on 24 December 2003. The visual inspection changed to eddy current and the non-destructive-testing (NDT) inspection became part of the periodical inspection of Aircraft Maintenance Manual (AMM) CH–5 every 250 hours. (Refer to 5–24–01, Rev–9, dated 30 December 2003). Also, it should be noted that SB 1125–11–181 (mentioned above) was published as Revision Number 1 on 24 December 2003 and changed from Recommended to Mandatory.

On 3 October 2003, Partner Jet issued Operational Memo 02–25, reminding pilots that the steering scissors are to be disconnected after flight to ensure that the aircraft is not towed with the scissors connected. Pilots are also advised they may have to remind ground handlers that the aircraft is not to be towed with the scissors connected. In addition, the company complied with the previous SBs mentioned in this report.

Partner Jet filed Service Difficulty Report (SDR) 20030929004, regarding the nosewheel steering failure and subsequent aircraft departure from the runway. Transport Canada has published SDR Advisory AV 2004–06 to disseminate this safety information to the aviation community. This advisory was produced to remind aviation personnel to follow proper towing procedures and respect nosewheel-turning limits.

On 30 June 2004, Gulfstream Aerospace LP issued a revision to AMM CH 09–00–00, "Towing and Taxiing – System Description," and to AMM CH–09–10–00, "Towing Maintenance Practices." The revision changed the wording of AMM CH–09–00–00, general section, to indicate that the aircraft can be towed or pushed back with scissors disconnected and removed the steering limitation with scissors disconnected. The AMM CH–09–10–00, Section C, second caution, was changed to indicate that the scissors must be disconnected prior to towing and that failure to do so could result in damage to the steering system support brackets.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 11 August 2004.