



Aviation Investigation Final Report

Location:	Newburgh, New York	Incident Number:	ERA111A316
Date & Time:	May 27, 2011, 09:28 Local	Registration:	N749QS
Aircraft:	ISRAEL AIRCRAFT INDUSTRIES GULFSTREAM 200	Aircraft Damage:	Minor
Defining Event:	Landing gear collapse	Injuries:	3 None
Flight Conducted Under:	Part 91 subpart k: Fractional		

Analysis

Prior to the incident flight, the flight crew performed an uneventful repositioning flight and did not experience any problems with the airplane's landing gear system. During the incident flight, the flight crew was performing a visual approach to the destination airport. The second-in-command (SIC) initiated a landing gear extension, and the landing gear extended but did not lock. The flight crew entered a holding pattern to perform the Landing Gear Down Lock Indication Failure checklist. Before the SIC reached the steps to cycle the landing gear, the flight crew was distracted by a hydraulic overheat condition and diverted to the Hydraulic System Overheat checklist to address that condition. When the SIC returned to the Landing Gear Down Lock Indication Failure checklist, he could not cycle the landing gear per the checklist instructions, because the hydraulic pressure was low. He then began the Emergency Landing Gear Extension checklist. The emergency extension resulted in all three landing gear remaining extended, but only the nosegear locked, and no further pertinent information remained in the checklist. The flight crew then performed an emergency landing at an airport with a longer runway. During the landing, the right main landing gear collapsed, and the airplane came to rest on the runway.

During postaccident examination of the airplane, the landing gear selector handle was found 1/8- to 1/4-inch from the full down position. Subsequent ground testing revealed that when the landing gear selector handle was positioned full up, followed by full down, the landing gear cycled successfully, indicating that, if the flight crew had placed the handle in the full down position, the landing gear would likely have operated normally. When the landing gear selector handle was positioned where it was found, the landing gear extended, but did not lock. A hydraulic bypass also occurred, with a resulting increase in hydraulic fluid temperature and decrease in hydraulic fluid pressure. The hydraulic bypass was most likely the reason that the

landing gear did not lock when the emergency gear extension procedure (blow down) was followed during the incident flight. Although, the rigging of the landing gear selector valve arm was found to be 2 degrees beyond specifications, the fact that the landing gear was successfully cycled numerous times with this discrepancy indicates that it was not a contributing factor to this incident.

After the incident, the airplane manufacturer revised several checklists by replacing the terms "normal" and "low" with actual numerical values. Additionally, the Landing Gear Down Lock Indication Failure and Emergency Landing Gear Extension checklists were revised to include more guidance on ensuring that the landing gear handle was positioned full down. Lastly, the Emergency Landing Gear Extension checklist was expanded to include a situation where the blow-down procedure failed to extend and lock all three landing gear.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be: The flight crew did not ensure that the landing gear selector handle was in the full down (extend) position. Contributing to the incident was inadequate checklist information.

Findings

Personnel issues	Incorrect action performance - Flight crew
Aircraft	(general) - Incorrect use/operation
Organizational issues	Policy/procedure development - Manufacturer

Factual Information

History of Flight

Approach	Miscellaneous/other
Landing	Landing gear collapse (Defining event)

HISTORY OF FLIGHT

On May 27, 2011, at 0928 eastern daylight time, an Israel Aircraft Industries Gulfstream 200, N749QS, managed by NetJets Inc., incurred minor damage when the right main landing gear collapsed during an emergency landing at Stewart International Airport (SWF), Newburgh, New York. The two certificated airline transport pilots and one passenger were not injured. The personal flight was conducted under the provisions of 14 Code of Federal Regulations Part 91K. Visual meteorological conditions prevailed and an instrument flight rules flight plan was filed for the flight destined to Westchester County Airport (HPN), White Plains, New York. The flight originated from Greenville Spartanburg International Airport (GSP), Greer, South Carolina, about 0730.

The pilot-in-command (PIC) stated that during approach to HPN, the landing gear lever was selected to the extend (down) position. Sounds associated with landing gear transit were heard; however, the landing gear cockpit indications displayed three red lights. He aborted the approach and entered a holding pattern to complete the appropriate checklist items. Approximately 20 to 40 seconds later, a "R HYD OVERHEAT" message illuminated on the engine indicating and crew alerting system (EICAS). At that time, hydraulic pressure was about 1500 psi (normal is 3000 psi), where it remained for the remainder of the flight. The flightcrew then completed the checklist items for a right hydraulic overheat.

The flightcrew subsequently performed the emergency gear extension checklist items and utilized the emergency gear blow-down bottle. The resultant cockpit indications were nose gear green, but the right and left main landing gear remained red. The flightcrew then declared an emergency and elected to divert to SWF due to a longer runway and less traffic. Before diverting to SWF, HPN tower personnel reported that they observed the airplane's three landing gear in the extended position. While enroute to SWF, the flight reviewed the right hydraulic system failure checklist. Upon landing on runway 27, the airplane remained level for 2 to 3 seconds and then began slowly tilting to the right. The airplane then settled on its right wing and slid to a stop on the runway.

PERSONNEL INFORMATION

The PIC, age 45, held an airline transport pilot certificate, with a rating for airplane multiengine land; and a commercial pilot certificate, with a rating for airplane single-engine land. He also

held a type rating for the Gulfstream 200. The PIC reported a total flight experience of 10,013 hours; of which, 3,244 hours were in the Gulfstream 200. He flew 105 hours and 25 hours during the 90-day and 30-day periods preceding the incident, respectively. The PIC's most recent Federal Aviation Administration (FAA) first-class medical certificate was issued on January 6, 2011.

The second-in-command (SIC), age 41, held an airline transport pilot certificate, with a rating for airplane multiengine land; and a commercial pilot certificate, with ratings for airplane single-engine land, rotorcraft helicopter, and instrument helicopter. He also held a type rating for the Gulfstream 200. The SIC reported a total flight experience of 5,800 hours; of which, 604 hours were in the Gulfstream 200. He flew 65 hours and 37 hours during the 90-day and 30-day periods preceding the incident, respectively. The SIC's most recent FAA first-class medical certificate was issued on December 30, 2010.

AIRCRAFT INFORMATION

The 11-seat airplane, serial number 165, was manufactured in 2007. It was powered by two Pratt & Whitney Canada PW306A engines, each capable of generating 6,040 pounds of thrust. The airplane was maintained under an approved inspection program. It's most recent inspection was completed on May 14, 2011. At that time, the airplane had accumulated 2,982 total hours of operation, and it had been operated an additional 23 hours since that inspection.

Additionally, maintenance work was performed on the airplane from May 22, 2011 to May 26, 2011. The maintenance work included inspection of the nosegear uplock actuator, cleaning the emergency gear blow-down valve mounting hardware, and replacing the landing gear selector valve rod end. Following the maintenance work, the landing gear was cycled twenty times with no anomalies noted. Subsequently, about 0500 on the day of the incident, the incident flightcrew departed Savannah, Georgia on a repositioning flight to GSP. They arrived at GSP uneventfully and did not report any problems with the landing gear system.

METEOROLOGICAL INFORMATION

The weather reported at SWF, at 0930, was: wind calm; visibility 15 miles; few clouds at 15,000 feet; temperature 24 degrees C; dew point 17 degrees C; altimeter 30.01 inches of mercury.

FLIGHT RECORDERS

The airplane was equipped with a cockpit voice recorder (CVR), which was forwarded to the NTSB Vehicle Recorders Laboratory, Washington, DC for readout. The CVR recorded 2 hours of audio data. A CVR Group convened and prepared a summary report of the most recent 30 minutes from the recording.

According to the summary report, at 0902, the flightcrew was performing a normal approach to HPN, with the PIC as the pilot flying in the left seat and the SIC as the pilot monitoring in the

right seat. The SIC had initiated a landing gear extension and sounds were heard consistent with landing gear travel; however, the SIC noted that the three green lights did not illuminate in the cockpit. Additionally, at that time, a master warning (red EICAS message, "GEAR NOT DOWN") activated along with a landing gear warning horn. The flightcrew then received radar vectors for a hold to perform checklist items.

At 0903, as the PIC continued flying, the SIC initiated the Landing Gear Down Lock Indication Failure checklist contained in the quick reference handbook. He completed items No. 1 and No. 2, pertaining to the flaps and airspeed, respectively. Item No. 3 pertained to right hydraulic pressure, to which the SIC noted that there was a problem. Additionally, before addressing item Nos. 4 and 5, which would have instructed the SIC to cycle the landing gear selector handle, a master caution (amber EICAS message, "R HYD OVERHEAT") activated due to a right hydraulic overheat condition. Seconds later, the SIC also noted a burning smell. The PIC then expressed the need to get the airplane on the ground.

At 0905, the SIC suspended the Landing Gear Down Lock Indication Failure checklist, to initiate the Hydraulic System Overheat checklist. That checklist included the instruction to reduce the affected engine to idle power and the PIC reduced the right engine thrust to idle power.

At 0907, the SIC returned to the Landing Gear Down Lock Indication Failure checklist, item No. 3, and noted that if hydraulic pressure is "normal," proceed to item No. 4 (cycle gear); however, hydraulic pressure was not "normal." Additionally, the SIC also noted that item No. 7 instructed that the emergency landing gear extension should be performed if the hydraulic pressure was "low."

At 0908, the flightcrew switched duties due to the location of the emergency landing gear extension controls. The PIC read the Emergency Landing Gear Extension checklist, including item No. 3, which stated that the landing gear lever is in the down position. He then performed item No. 4, which was the release, turn, and lift of the emergency gear extension handle. Although item No. 5 stated that the landing gear was down and locked with a three-light indication, the flightcrew noted that only the nosegear was down and locked. The checklist did not include any additional instructions pertaining to a situation where all three landing gear were still not down and locked.

At 0911, the flightcrew switched duties again and discussed diverting to an airport with a longer runway. They declared an emergency and the PIC flew toward SWF at 0915.

At 0912, the airplane flew past the HPN control tower and tower personnel advised that all three landing gear appeared to be extended.

At 0919, the SIC began to read the Right Main Hydraulic System Failure checklist, but the flightcrew agreed that the hydraulic system had not failed.

At 0922, the flight was cleared for the visual approach to runway 27 at SWF and the SIC

reported a left base leg at 0923 to the SWF tower.

At 0925, the PIC remarked that the hydraulic temperature was rising again and that they needed to get the airplane on the ground. At 0927, the flight was on short final approach at 1,000 feet. At 0928, about 3 seconds after touchdown, the right main landing gear collapsed.

WRECKAGE AND IMPACT INFORMATION

Initial examination of the airplane by FAA inspectors revealed minor damage to the right wing, consistent with ground contact. The inspectors subsequently examined the airplane with representatives from the airplane manufacturer, management company, and pilots' union.

The examination revealed that the landing gear selector handle was found approximately 1/8 to 1/4 inch from the full down position. The airplane was placed on jacks and supplied electrical power and hydraulic pressure from ground carts. The landing gear selector handle was then positioned full up, followed by full down, and the landing gear cycled successfully. During operation of the landing gear handle, there was no tactile feel of a detent as the make and model system utilized detents on the landing gear selector valve, rather than the landing gear handle. Subsequently, an emergency gear extension test (blow-down) was performed and all three landing gear moved to the down and locked position.

Examination of the hydraulic system did not reveal any failures. Additional tests were performed to attempt to simulate the in-flight event. When the landing gear selector handle was positioned to where it was found, a hydraulic bypass "hissing" sound was heard, accompanied by a rise in hydraulic temperature and reduction in hydraulic pressure. The main landing gear extended, but did not lock and the nose landing gear did not extend; however, when the emergency gear extension handle was activated, all three landing gear extended and locked.

The landing gear selector valve rigging was visually inspected, photographed, discussed, and no anomalies were noted at that time. The rigging was not further examined; however, the landing gear selector valve, landing gear emergency blow-down valve, and right main landing gear side brace actuator were forwarded to their respective manufacturer's facilities for testing and examination under government supervision. Utilizing the individual component acceptance test procedures, testing of the units did not reveal any mechanical malfunctions, nor did the subsequent teardown examinations. According to a representative of the airplane manufacturer, most of the Gulfstream models had a landing gear selector handle that must be moved left out of a detent, then down, then right into a detent to extend the landing gear. However, the Gulfstream 200 was formerly an Israel Aircraft Industries Galaxy, and the detent mechanism was not located on the handle itself, but on the landing gear selector valve instead. The representative added that the hydraulic bypass from an intermediate position of the landing gear selector valve would result in the failure of the landing gear down locks to engage due to back pressures; however, the examinations could not positively determine why the emergency landing gear extension (blow-down) worked during the ground test, but not during

the incident flight. One possibility was that a hydraulic mule was used for the ground test, whereas the actual airplane hydraulic system was used in flight.

ADDITIONAL INFORMATION

Checklists

After the incident, the airplane manufacturer revised several of its normal and abnormal checklists. Specifically, terms such as "normal" and "low" were replaced with actual numerical values. Additionally, the Landing Gear Down Lock Indication Failure and Emergency Landing Gear Extension abnormal procedures were revised to include more guidance on ensuring the landing gear handle was at the full extent of its downward travel. Lastly, the Emergency Landing Gear Extension abnormal procedure was expanded to include a situation where an emergency blow-down procedure failed to extend and lock all three landing gear.

Landing Gear Selector Valve Rigging

Subsequent to the on-scene examination, manufacturing drawings were obtained of the landing gear selector valve. Review of the drawings and specifications revealed that when positioned to the full gear down position, the landing gear selector valve arm must be rigged within plus 10 degrees to minus 5 degrees from the zero reference point to prevent hydraulic bypass. Teardown testing of the incident valve revealed a larger design margin of plus 20 degrees to minus 5 degrees from the zero reference. Comparison of the drawings to photographs of the landing gear selector valve as found revealed that when the landing gear selector handle was placed in the full down position, the landing gear selector valve arm was approximately plus 12 degrees from the zero reference point.

Pilot Information

Certificate:	Airline transport; Commercial	Age:	45, Male
Airplane Rating(s):	Single-engine land; Multi-engine land	Seat Occupied:	Left
Other Aircraft Rating(s):	None	Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 1 Without waivers/limitations	Last FAA Medical Exam:	January 6, 2011
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	November 17, 2010
Flight Time:	10013 hours (Total, all aircraft), 3244 hours (Total, this make and model), 105 hours (Last 90 days, all aircraft), 25 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Co-pilot Information

Certificate:	Airline transport; Commercial	Age:	41, Male
Airplane Rating(s):	Single-engine land; Multi-engine land	Seat Occupied:	Right
Other Aircraft Rating(s):	Helicopter	Restraint Used:	
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 1 Without waivers/limitations	Last FAA Medical Exam:	December 30, 2010
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	March 4, 2011
Flight Time:	5800 hours (Total, all aircraft), 604 hours (Total, this make and model), 65 hours (Last 90 days, all aircraft), 27 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	ISRAEL AIRCRAFT INDUSTRIES	Registration:	N749QS
Model/Series:	GULFSTREAM 200	Aircraft Category:	Airplane
Year of Manufacture:		Amateur Built:	
Airworthiness Certificate:	Transport	Serial Number:	165
Landing Gear Type:	Retractable - Tricycle	Seats:	11
Date/Type of Last Inspection:	May 14, 2011 AAIP	Certified Max Gross Wt.:	35600 lbs
Time Since Last Inspection:	23 Hrs	Engines:	2 Turbo fan
Airframe Total Time:	3010 Hrs at time of accident	Engine Manufacturer:	P&W CANADA
ELT:	Installed, not activated	Engine Model/Series:	PW306A
Registered Owner:	NETJETS SALES INC	Rated Power:	6040 Lbs thrust
Operator:	NETJETS AVIATION INC	Operating Certificate(s) Held:	On-demand air taxi (135)
Operator Does Business As:		Operator Designator Code:	DXTA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	Condition of Light:	Day
Observation Facility, Elevation:	SWF,491 ft msl	Distance from Accident Site:	0 Nautical Miles
Observation Time:	09:30 Local	Direction from Accident Site:	0°
Lowest Cloud Condition:	Few / 15000 ft AGL	Visibility	15 miles
Lowest Ceiling:	None	Visibility (RVR):	
Wind Speed/Gusts:	/	Turbulence Type Forecast/Actual:	/
Wind Direction:		Turbulence Severity Forecast/Actual:	/
Altimeter Setting:	30.01 inches Hg	Temperature/Dew Point:	24°C / 17°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Greer, SC (GSP)	Type of Flight Plan Filed:	IFR
Destination:	White Plains, NY (HPN)	Type of Clearance:	IFR
Departure Time:	07:30 Local	Type of Airspace:	

Airport Information

Airport:	Stewart International Airport SWF	Runway Surface Type:	Asphalt
Airport Elevation:	491 ft msl	Runway Surface Condition:	Dry
Runway Used:	27	IFR Approach:	None
Runway Length/Width:	11817 ft / 150 ft	VFR Approach/Landing:	Full stop;Precautionary landing

Wreckage and Impact Information

Crew Injuries:	2 None	Aircraft Damage:	Minor
Passenger Injuries:	1 None	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	3 None	Latitude, Longitude:	41.503887,-74.104721(est)

Administrative Information

Investigator In Charge (IIC):	Gretz, Robert
Additional Participating Persons:	Daniel Spera; FAA/FSDO; Saddle Brook, NJ Paul McClaskey; NetJets Aviation; Columbus, OH Suzanne Danielson; NJASAP; Columbus, OH Rick Trusis; Gulfstream Aerospace; Savannah, GA
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Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.nts.gov/Docket?ProjectID=79231

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