DATA SUMMARY

LOCATION

Date and time	**Friday, 15 April 2005; 14:44 UTC**
Site	**Murcia San Javier Airport**

AIRCRAFT

Registration	**EI-DAC**
Type and model	**BOEING 737-800**
Operator	**Ryanair**

Engines

Type and model	**CFM INTERNATIONAL, CFM56-7**
Number	**2**

CREW

	Pilot in command	Copilot
Age	**41 years**	**50 years**
Licence		**ATPL**
Total flight hours	**12,000 h**	**9,000 h**
Flight hours on the type	**650 h**	**350 h**

INJURIES

	Fatal	Serious	Minor/None
Crew			**6**
Passengers			**59**
Third persons			

DAMAGE

Aircraft	**None**
Third parties	**None**

FLIGHT DATA

Operation	**Commercial Air Transport – International – Passenger**
Phase of flight	**Taxiing**

REPORT

Date of approval	**26 September 2007**

1. FACTUAL INFORMATION

1.1. History of the flight

Aircraft EI-DAC, of Irish registry and operated by the company Ryanair, was on a commercial passenger flight on 15 April 2005 from Stansted Airport (London) to Murcia San Javier Airport.

The aircraft, whose maximum capacity was 189 persons, was carrying 59 passengers, 2 pilots and 4 cabin crew on the incident flight. The flight was proceeding normally until 14:44 UTC when, seconds after landing, while the aircraft was leaving runway 23 at Murcia airport, a wheel well fire warning alarm was received.

The crew, after stopping the aircraft on taxiway H and unable to get external confirmation of the existence of a fire, decided to evacuate the aircraft. The slides were deployed from the four main doors and, according to the purser’s estimate, the evacuation took some 30 seconds.

By the time emergency personnel arrived, almost all of the passengers had already been evacuated from the aircraft and it was not necessary to apply any agent to the aircraft since no fire, smoke or elevated temperatures were detected. Once the airplane was fully evacuated, the fire brigade stabilized the four slides with ballast, which were moving because of the wind.

The fire warning turned out to be false and the aircraft was returned to normal operation the same night of the incident, after the slides deployed during the evacuation were replaced.

Following the incident, the company pulled the CVR from the aircraft and downloaded its contents. The only flight data available was the information from the OFDM (operational flight data monitoring), which provided data on the approach and landing.

1.2. Aircraft information

The Boeing 737-800 is fitted with 8 emergency exists, two at the front and two at the rear that incorporate integral escape slides in the doors and four self help emergency exists located over the wing, two on the left and two on the right.

1.2.1. *Information on the fire warning*

Information provided by the company confirmed that a wheel well fire warning was received, and that said warning turned out to be false and that there was no actual fire.

This aircraft model, according to the crew operations manual, is equipped with a wheel well fire protection and detection system, consisting of a sensor installed in said compartment. When the temperature exceeds a set value, the sensor interprets this as a fire condition and sends a signal to a control unit or module which, in turn, triggers the following fire alarms in the cockpit:

- Aural warning.
- Visual notification by means of two red master fire warning lights.
- Visual warning by means of a red wheel well fire warning light, located on the engine and APU fire panel. This light remains lit until the sensor temperature drops below the limit.

The wheel well fire protection and detection system does not include any fire extinguishing devices.

The inspection made of both the sensor (main wheel overheat element, P/N 35610-4-400, S/N 0228) and the control module (compartment overheat module, P/N 35008-307, S/N 1182), which were replaced by new parts, did not reveal any problems or defects. The fire warning system's electrical connections, continuity and insulation were likewise checked. No abnormal conditions were detected.

1.2.2. *Previous fire warnings*

According to information provided by the company, a check of the aircraft's maintenance history for the previous six months revealed that the day before, Thursday, 14 April 2005, the same wheel well fire warning was received while the aircraft was parked. As with the incident covered by this report, the warning was false and no evidence of an actual fire was found.

Both the control module and the sensor were checked and inspected. Since no faults or damage were found, the aircraft was returned to service. Between the time of the fault on the 14th until the incident flight on the 15th, the aircraft had completed 12 uneventful medium-haul flights.

Since the first incident of spurious fire warning, the company performed maintenance actions focused on the inspection, protection, cleaning and replacement of the wheel well fire detector connectors. In adition, the company took measures regarding the APU remote control pannel in wheel well. According to information provided by the manufacturer concerning the effects of certain substances found in the fluids used to deice runways that can lead to fase fire warnings, the company inspected all its 737-800 aircraft as a preventive measure.

1.2.3. *Fire and evacuation procedures*

The company's crew operations manual includes the following fire and evacuation procedures in its chapter on abnormal in-flight procedures.

Should a wheel well fire warning be received, lower the landing gear and land at the nearest airport.

The passenger evacuation procedure, detailed below, defines the different actions to be taken by the captain and the first officer, as well as a brief explanation of the reasons for each.

- For the captain:
  - Parking brake: set.
  - Speed brake lever: down detent. (Prevents possible interference or injury to passengers evacuating through the overwing escape hatches.)
  - Engine start levers: cutoff. (shuts down the engines reduces the possibility of slide damage or injury.)
  - Evacuation: initiate. Notify flight attendants.
  - Engine and APU fire warning switches: override, pull and rotate. (Reduces risk of fire and injury.)[1]
- For the first officer:
  - Flap lever: 40. (Aids in evacuating passengers over the wings.)
  - Pressurization mode selector: man.
  - Outflow valve (if required): open. (Ensures airplane is depressurized for opening exists.)
  - Tower: notify.

1.3. Meteorological information

Meteorological conditions at Murcia San Javier Airport at the moment of initial contact between the aircraft and Murcia TWR, 11 minutes before landing, were as follows: temperature: 20°, QNH 1,007 hPa, CAVOK, winds at 18 kt out of 320° and runway in use: 23.

Except for the wind, which varied in intensity and direction, the other parameters were unchanged during the approach.

[1] After the incident, Boeing modified the procedure and removed the need to rotate the fire switches with only a wheel well fire warning.

- 9 minutes before landing, the wind direction was unchanged but the speed had decreased to 16 kt. The runway in use was 23. The tail wind component was 0 kt.
- 3 minutes before landing, the wind was at 15 kt out of 330°. The runway in use was 23. The tail wind component was 2.60 kt.
- 90 seconds before landing, the wind was at 17 kt out of 340°. The runway in use was 23 but the controller was offering approaching aircraft the option of using runway 05. The tail wind component was 5.81 kt.
- 1 minute before landing, the wind had picked up to 18 kt and was still out of 340°. The tail wind component was 6.15 kt.

1.4. Flight recorders and communications

Information concerning the in-flight communications of aircraft EI-DAC comes from two sources: the Murcia control tower's ATC communications recording and the cockpit voice recorded (CVR).

Murcia-San Javier control tower has two frequencies assigned, 130.30 MHz and 121.60 MHz. All communications involving the incident were recorded on the former.

The transcription and recording of the ATC communications held between Murcia control tower and the aircraft began at 14:31:42 UTC, when the aircraft first established contact with this facility after being transferred from Valencia TACC, and ended at 14:46:47 UTC. The cockpit voice recorder, once synchronized with ATC data, had communications from 14:14:26, at which time the aircraft was under Barcelona ACC control, until 14:44:43 UTC.

Flight data was obtained from the OFDM and encompasses from 14:35:00 UTC until 14:44:28 UTC. The aircraft's flight profile during the approach and landing was reconstructed based on information form the CVR, ATC communications and the OFDM, which yielded the times at which ATC communications took place.

At 14:40:42 UTC, the aircraft notified ATC that it was 5 miles away from the runway and cleared to land on runway 23, with the wind at 15 kt from 330°. At this time the aircraft was at an altitude of 1,494 ft.

Starting at 14:41:38 UTC, at 1,000 ft AGL, a series of exchanges between the controller and the aircraft took place in which the controller informed the pilot that the wind was at 17 kt out of 340° and offered him the choice of circling around to land on runway 05. The communications dragged on since the controller did not seem to understand the pilot until, at 14:42:15 UTC at an altitude of 597 ft, the pilot told him they were landing on runway 23: "disregard, we are landing at runway 23" (Table 1).

Time UTC	EI-DAC (RYR 8022)	Murcia TWR
14:40:51		RYR8022 roger, cleared to land runway 23, the wind 330 at 15.
14:40:51	Cleared to land runway 23, RYR 8022	
14:41:38		RYR8022 wind now 340 at 17. Confirm is good the runway 23 or do you prefer circling to runway five?
14:41:52	340 at 17, Ahh…just what´s downwind, sir?	
14:41:57		I confirm wind 340 at 18 now
14:42:02	340-18 what´s the down wind component?	
14:42:07		Right hand then, if you prefer circling right hand down wind
14:42:11	Eh, just what´s the downwind component?	
14:42:14		Say again
14:42:15	Disregard, we are landing at runway 23	
14:42:18		Ok, no problem

Table 1. ATC communications 38 seconds before landing

Seconds later, at 14:42:53 UTC, the aircraft landed with a ground speed of 150 kt and a maximum vertical acceleration of 1.5 g's. The aircraft was on the runway for 37 seconds before exiting via taxiway H, which is to the right of the runway on a heading of 316°. It was during this turn onto the taxiway, at 14:43:31 UTC, that the cockpit fire warning was first received which led to the first mayday from the aircraft 8 seconds later.

The mayday at 14:43:39 UTC requesting emergency services would be repeated once more at 14:44:02 UTC, after the controller on that frequency informed that the communication was cutting out and to make any requests to the marshall. At 14:44:26 UTC, the aircraft requested help from emergency services once more. Subsequent conversations with the tower focused on trying to get an outside confirmation from the firefighters of the actual existence of a fire. Once again the controller reported reception problems. Moreover, he believed the fire was in an engine and not in the wheel well.

Throughout this process the pilot of another aircraft located behind EI-DAC intervened, and was the first to transmit the mayday to ATC. Later, after the pilot of aircraft EI-DAC requested a visual confirmation of the fire, this pilot informed him that no signs of fire were visible from his position.

The last operation recorded by the OFDM was the retraction of the flaps after the second mayday.

In the ATC communications recorded at the Murcia control tower, the maydays made by aircraft EI-DAC after landing, as well as all the other communications from other aircraft at the airport, could be clearly heard. The quality of the communications degraded starting at 14:46:32 UTC.

The cockpit communications stopped at 14:44:43, which precluded having communications made during the evacuation available.

Time UTC	EI-DAC (RYR 8022)	Murcia TWR	Other aircraft
14:43:39	Mayday mayday mayday, wheel well fire warning, request emergency services to the aircraft		
14:43:54		RYR8022 Unable to read you at this time, your transmission is coming very broken, please follow the marshall, any request to the marshall, please	
14:44:02	Mayday mayday mayday we have a fire within the wheel, we are requested the engine fire services now		
14:44:11		Unable to read you, sir	
14:44:14			It´s a mayday call, RYR is on fire, request... bombers
14:44:20		Ok, RYR8022, mayday, is an engine on fire?	
14:44:26	Request, we have a fire engine, fire, wheel well indication we are requesting fire services now		
14:44:36		Ok, fire indicating fire engines, the bombers... the fire extinguisher is going to you	
14:44:43	Thank you		
14:45:56	RYR8022 could the fire services confirm if we´ve got a fire on the wheel well, please on the wheel?		
14:46:11		RYR8022 say again, please	
14:46:16	Could the fire services confirm if we´ve got a fire with the wheels?		
14:46:26		RYR 8022, please confirm you don´t have fire, is that correct?	
14:46:32	Wheel, wheel fire, appears appears it´s on fire		
14:46:39		Excuse me, but in that position communications I´m unable to read you	
14:46:47			RYR, from our position back of you, look OK

Table 2. ATC communications during the emergency

1.5. Statements

In his statement following the incident, the captain described how, after leaving runway 23 at Murcia airport, a wheel well fire warning was received. They stopped the aircraft, applied the parking brake and sent a mayday twice without receiving any acknowledgement from the controller.

Since the cockpit fire warning stayed lit and they had limited outside information on the status of the aircraft, they decided to perform an emergency evacuation, which was carried out using the four main exits.

As for the procedure, the pilot eventually concluded the fire risk was non-existent and that the aircraft and passengers were safe and he decided not to actuate the engine fire switches. After powering down the electrical systems, the captain abandoned the aircraft via slide L1 and the first officer used the R1 slide.

2. ANALYSIS

An analysis of the flight sequence of aircraft EI-DAC during the last 11 minutes yields the following considerations:

- The appearance of a wheel well fire warning.
- The interaction between the airport's control services and the aircraft during its approach phase and subsequent emergency.
- The evacuation procedure carried out by the crew.

The information supplied by the communications and the flight data indicate that the aircraft was making a VOR-DME approach to runway 23 at Murcia San Javier airport. The last 8 minutes of the flight place the aircraft nearing Ditre, 15 miles away from the airport, and from there on an approach and descent course to the runway. The entire approach was carried out in accordance with instructions provided by the Murcia San Javier control tower, with no deviations.

During the final 11 minutes prior to landing, when the aircraft was in contact with Murcia TWR, the wind shifted in direction and intensity. In the minute and a half before landing, wind direction changed from 330° (crosswind using runway 23) to 340° (tailwind component from the right using runway 23 of 6.15 kt). This is why the controller offered the aircraft the choice of circling so as to change the approach runway. The conversations, held in English, show an exchange of several phrases over the course of a minute during which the aircraft was on final approach and descended from 1,000 ft to 597 ft AGL. The communications were eventually ended by the pilot 38 seconds before touchdown.

Although the change in wind direction suggested the use of runway 05 and the controller's offer to change runway was appropriate, the controller's inability to understand the pilot prolonged the communications, which took place at a critical juncture due to the aircraft's altitude and flight phase.

The wheel well fire warning turned out to be false, just like the warning received the day before while the aircraft was in its parking stand. Based on information provided by the manufacturer, the operator took measures in order to inspect and guarantee appropiate condition of the wheel well fire detection not only on aircraft EI-DAC, but in the rest of the fleet. No anomalies were detected and the cause of the false fire warning received in the aircraft, therefore, remains unknown.

When the cockpit fire warning was received 38 seconds after landing, the aircraft was leaving runway 05-13 via taxiway H. Communications with Murcia TWR were being maintained on a frequency of 130.30 MHz and had not changed since first contacting the facility 11 minutes prior. Communications during this time took place normally without any reception problems.

The mayday made by the aircraft at 14:43:39 UTC, 8 seconds after the cockpit warning was received, took place while the aircraft was on taxiway H. It was after this point that the controller reported reception problems. A check of the ATC communications allow the maydays, as well as all other communications held with the aircraft following the incident, to be clearly heard and identified without any interference. The quality of the recording does deteriorate from 14:46:32 UTC on, with the appearance of static, but even then the communications are intelligible.

In this regard, it is unlikely that coverage problems exist between the control tower and the airport or the taxiway on the control frequency used. Communications between the tower in the 11 minutes prior to landing and the involvement of the other pilot, repeating the maydays, allow any transmission problems on the part of the aircraft to be dismissed.

A transcript of the communications indicates that the controller experienced certain confusion in understanding the maydays, since the controller believed, and relayed to emergency services, that a fire had broken out in one of the engines. Then, when the pilot tried to get an outside confirmation on the status of the landing gear, he also failed to receive any information from the tower. This lack of information influenced the crew's decision to evacuate the passengers.

The evacuation procedure was not carried out in full since the last item, actuating the engine and APU fire control switches, was not completed. The captain's justification for not performing this step was based on the same reasons that had led him to carry out an evacuation. In both cases, he had incomplete information regarding what was happening in the wheel well.

Likewise, retracting the flaps was contrary to procedures, which recommend extending them to aid in the evacuation. Lastly, the passengers were disembarked using the main exit slides, the emergency exits atop the wings not being opened. Even though the number of passengers (59) was below the aircraft's maximum capacity (189), there is no provision in the procedures to limit the number of exits used as a function of the aircraft's occupancy.

3. CONCLUSIONS

After a false wheel well fire warning was received the previous day, on 15 April 2005, a new false warning was received 38 seconds after landing at Murcia's San Javier Airport.

Checks and tests of the operation, connections, continuity and insulation of the aircraft's fire warning detection and control systems did not reveal any problems or deterioration of their condition which should have resulted in the appearance of these two warnings.

The slides on the four main exits were used to carry out the evacuation. The wing exits were not used. The evacuation procedure steps regarding the flaps and actuating the engine and APU fire warning were not completed even though the existence of a fire in the wheel well could not be completely ruled out.

There was a lack of understanding on the part of the control tower at Murcia-San Javier airport which affected the final phase of the approach. Moreover, during the emergency, reception problems with communications from the aircraft located on taxiway H affected the performance of the emergency services.

4. SAFETY RECOMMENDATIONS

None.

DATA SUMMARY

LOCATION

Date and time	**Thursday, 8 February 2007; 2:30 h UTC**
Site	**At FL410 over the Atlantic Ocean, 130 NM from the Canadian coast (approximate coordinates 48N 50W)**

AIRCRAFT

Registration	**EC-KBC**
Type and model	**GULFSTREAM G-200; S/N 145**
Operator	**TAG Aviation España (TAG Aviation E.)**

Engines

Type and model	**PRATT & WHITNEY PW-306A (LH S/N CC0299; RH S/N CCC0298)**
Number	**2**

CREW

	Pilot in command	Copilot
Age	**34 years**	**30 years**
Licence	**ATPL(A)**	**CPL(A)**
Total flight hours	**4,700 h**	**1,900 h**
Flight hours on the type	**55 h**	**30 h**

INJURIES

INJURIES	Fatal	Serious	Minor/None
Crew			**2**
Passengers			**2**
Third persons			

DAMAGE

Aircraft	**None**
Third parties	**None**

FLIGHT DATA

Operation	**Commercial air transport – Non revenue services – Ferry flight**
Phase of flight	**En route**

REPORT

Date of approval	**26 September 2007**

1. FACTUAL INFORMATION

1.1. History of the flight

1.1.1. *First intended flight Dallas-St. John's on 7 February 2007*

On 7 February 2007, a Gulfstream G-200 aircraft, registration EC-KBC, was to be flown from Dallas Love (KDAL), Texas, to St. John's (CYYT) in Canada, as the first leg of a delivery flight with final destination Valencia Airport (LEVC), in Spain.

This aircraft was the first Gulfstream G-200 being delivered to the operator, which already had other high performance corporate and business aircraft. The operator was a part of a large international corporate, business and charter commercial air transport group.

The aircraft had the "increased operating weight" MOD 10082, i.e. the MTOW according to the type certificate data sheet was 35,650 lb.

The operator assigned the only type-rated pilot and the only type-rated copilot they had for the delivery flight. Both crew members had obtained the G-200 type rating in October 2006.

The manufacturer usually assigned one of its own pilots to be on board during delivery flights, to provide additional assistance to the company pilots. In this case, no manufacturer pilot was available, so a mechanic was appointed to be on board during the delivery flight. This mechanic was also going to conduct training with the operator's maintenance personnel after his arrival in Spain.

The aircraft started the take-off run with the pilot in command (PIC or CM-1), the copilot (CM-2), a mechanic from the operator and a mechanic from the manufacturer on board. When the aircraft was accelerating at around 70 kt, an L FADEC FAULTY caution appeared in the cockpit. The CM-1 continued the take off and the caution angle of attack heat (AOA HEAT (L/R)) was displayed during the climb. The mechanic recommended returning to the airport, which they did.

During the landing the AOA probe heat fail message went out and the L FADEC FAULTY message remained lit.

They parked the aircraft and, after some discussion, started the engines again and carried out ground engine run tests with satisfactory results. Then they took off again for the intended flight to CYYT and during the climb the message "AOA HEAT (L/R)" appeared again. They returned to the airport and waited for the manufacturer's maintenance personnel to carry out the corresponding corrective actions. No discrepancy was found.

1.1.2. *Flight Dallas-St. John's on 8 February 2007*

Next day, with the same people on board, they took off again from Dallas without further incident or messages. The weight of the aircraft was approximately 31,600 lb.

On approach to St. John's, the amber "R AOA HEAT", "L AOA HEAT" and "TAT PROBE HEAT" indicators appeared and the circuit breakers for both pitot heaters tripped. The flight crew selected OVERRIDE on the probe switch, as required by operational procedures. After landing, the switch was put in auto and then in override again, as part of the troubleshooting activities. The mechanic from the manufacturer checked the pitot heaters and other systems. During the refueling of the aircraft, the L FADEC and R FADEC MAJOR messages appeared. The mechanic checked the Maintenance Data Computer (MDC) for faults. No fault codes were present. Both A channel and B channel circuit breakers were cycled for each engine. This extinguished the FADEC MAJOR indications for both engines.

Since the messages were no longer present, the aircraft was dispatched for flight again.

1.1.3. *Incident flight, St. John's-Madrid on 8 February 2007*

The flight crew had the following two documents for load and balance computation (weight in pounds):

	Operational flight plan (prepared by dispatchers and approved by the PIC)	Load and balance sheet
Basic operating weight (BOW)	19,000	
Basic empty weight		19,844
Crew, documents, etc. (weight of mechanics not included)		624
Payload	400	
Dry operating weight		20,468
Fuel	10,500 (actual at take-off)	10,000 (at take-off)
Take-off weight	29,900	30,468
Cg		36.6% of mean aerodynamic chord (MAC)

None of the documents was correct. The manufacturer's actual airplane weighing record dated 6 December 2006 showed an empty weight of 19,773 lb.

The Operational flight plan form had an error in the BOW, which was considered equivalent to the dry operating weight and therefore should have been 20,468 lb. The load and balance sheet did not include the weight of the mechanics and their baggage (around 400 lb) and missed 500 lb of fuel actually loaded (10,500 was the real value of fuel on board at the time taxiing was initiated).

The actual take-off weight was probably around 31,368 lb (adding 500 lb of fuel and 400 lb of the mechanics and baggage and documents) to the load and balance sheet. This compares with the MTOW of 35,650 lb.

The aircraft had spent approximately 1 h parked. The engines were started at around 1:56:16 h and they took off 10 min later.

The co-pilot was the pilot flying, the CM-1 was handling ATC communications and monitoring the flight. The mechanics were seated in the passenger cabin.

Air traffic control (ATC) cleared them to climb and to be established in 48N 50W (which is located 140 NM away from St. John's) at FL330 or FL440. The CM-1 used a rule of thumb and, thinking that their weight was approximately 29.9 thousand pounds, calculated they could climb to 40,700 ft and therefore he asked ATC for clearance to climb to FL410.

However, the crew later thought they would not reach the geographical point at the assigned altitude. The CM-2 asked whether to reduce climb rate or speed and the CM-1 instructed him to do whatever he wanted but not to drop below Mach 0.66, based on the performance chart, Page IV-70, of the Operational Planning Manual (see Figure 4).

The pilots recalled that the climb was made with the autopilot with the thrust levers at the maximum climb detent at a Mach number of around 0.7 or 0.69. When they were approximately 200 ft below FL410, at a static air temperature (SAT) of –55 °C, both crew members noticed a lateral shaking of the rear part of the aircraft (as if the left engine "dragged behind" in a sort of Dutch roll), and shortly afterwards the stall warning sounded. The autopilot disengaged and the disconnection warning started sounding. This warning continued sounding for more than 4 minutes during the incident sequence until it was silenced by the crew. The pilot stated that he tried to mute the warning earlier but he did not succeed.

They pushed the control column forward to reduce the pitch angle and the CM-1 said "Mine, mine," meaning "I have control." He advanced the thrust levers to the take off detent and was surprised because he did not see any increase in thrust. He then retarded the levers towards idle and moved them forward in a series of quick movements before leaving the levers in idle.

The flight crew did not apply standard stall-correcting procedures since there were inadequate pitch changes.

He told the CM-2 that the engines were not working and instructed him to declare an emergency through the radio.

The CM-2 started handling communications and 24 s after the start of the stall warning (this is the time reference used from now on in the following paragraphs of this section) he said on the radio: "We have had a flame out. We declare emergency." ATC instructed them to descend.

The conversations between the pilots recorded on the cockpit voice recorder (CVR) showed that the crew was confused about the possible cause of the situation.

The CM-2 asked whether to read off any checklist. The CM-1 thought the engines were not running. He then pushed the engine cutoff switches of both engines at the same time for one second. He did not advise the CM-2 of this action.

These switches cut the fuel flow to each engine and are intended to be used on the ground only. Their use in flight is not included in any of the aircraft's operational procedures.

The LH engine fuel flow (see Figure 2 below) went to zero and that of the RH engine dropped, though it did not reach zero. The core engine RPM (N2) also dropped for both engines but recovered shortly afterwards and the CM-1 said "Ok they are restarting," but around 20 s afterwards he said, "They are not working, they are not working." He thought they might have ice and switched on the engine anti-ice.

They turned towards St. John's and the CM-1 requested the CM-2 to enter that destination in the FMS.

At second 102 after the first stall warning, the CM-1 said they were going to restart one engine only to think once again that it was working, though he did not have control over the engine.

At second 145 he pushed the LH cutoff switch for 3 s, without advising the CM-2. The LH engine fuel flow went to zero at 2:30:11 h. The N2 of this engine reached a minimum of 41.59% at 2:30:54 h. After the LH engine cutoff switch was released its fuel flow and N2 recovered.

The RH engine continued operating normally during that sequence because its cutoff switch was not pressed.

The CM-2 again asked what checklist he could read off. The mechanic from the manufacturer went to the cockpit at that time and was asked by the flight crew about the possible causes of the engine behavior they were noticing. He said he did not know.

The aircraft continued its descent and return to St. John's. There were two further stall warning activations (at seconds 237 and 248, with the aircraft at 31,954 ft and 31,481 ft).

At second 285 the autopilot aural disconnect warning went out. At second 319, the CM-2 informed ATC that they had "the engine working, a little bit but working".

The aircraft approached St. John's Airport with the autopilot engaged until it was around 200 ft AGL. It finally landed normally 2,024 s (33 min and 44 s) after the initial stall warning appeared.

Canadian authorities provided the radar track data of the flight, together with a graph of the trajectory followed by the aircraft compiled from these data (see Figure 1).

Over the following days, the aircraft was inspected by personnel from the aircraft and engine manufacturers. No mechanical discrepancy related to the engines or engine control was found. When the aircraft returned to Savannah, the TAT probe 102AU1AG was replaced by another supplied by the customer. An operational check did not show any defect of the probe heaters.

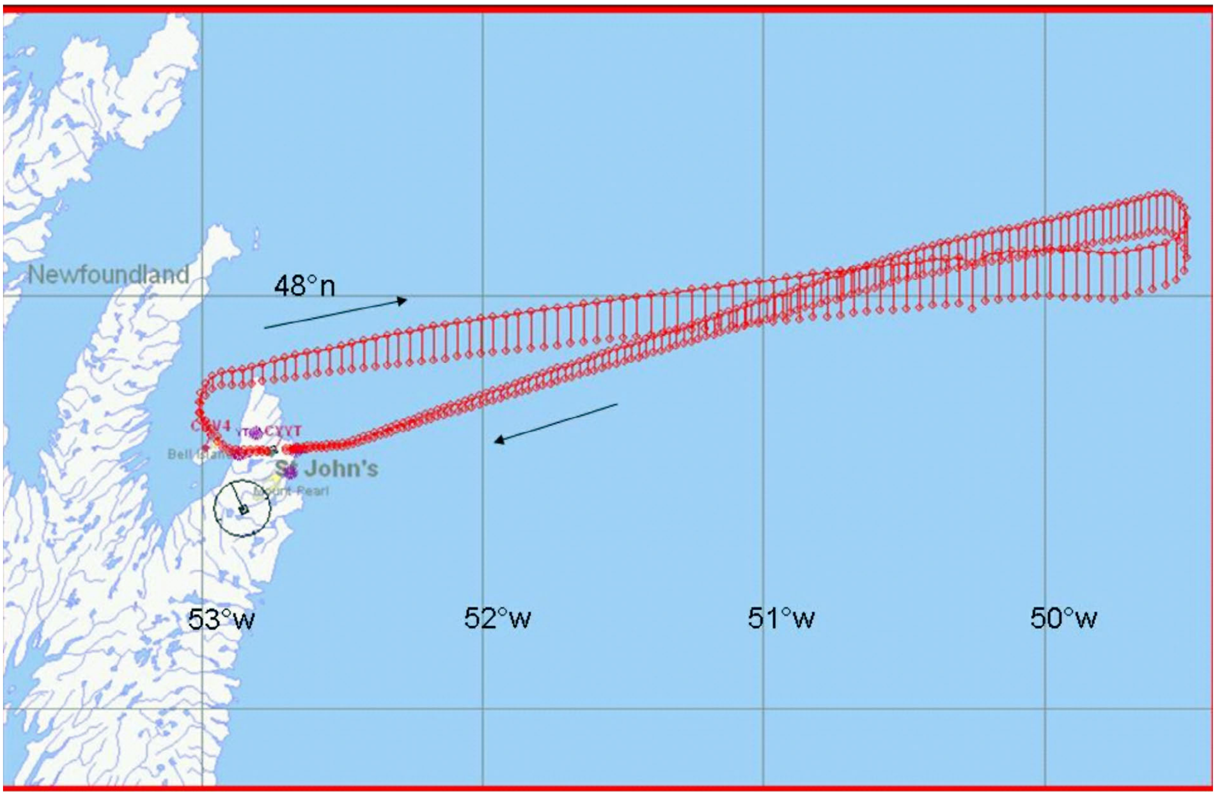

Figure 1. Flight path of the aircraft prepared by Canadian authorities using radar data

1.2. Personnel information

1.2.1. *Pilot in command*

Sex, age:	Male, 34
Nationality:	Spanish
License:	ATPL(A), obtained in 2006
Type rating:	PIC G-200 (only Spanish aircraft)
Previous type ratings:	Boeing B707, Falcon 20/200, CASA CN-235, CASA C-212
Total flight time:	4,700 h
Flight time on type:	55 h (approximately 52 h as pilot in command under supervision and 3 h as PIC)
Hours last 30 days:	9:40 h
Hours last 7 days:	6:25 h
Hours last 72 h:	6:25 h
Start of the flight duty period:	19:30 h on 7-2-2007
Previous rest:	16 h
Last course of crew resource management (CRM):	24-11-2006

The PIC had a military background and had crossed the Atlantic Ocean several times as PIC of a Boeing B-707.

He obtained his civil ATPL on 8-11-2006, and then attended the Gulfstream G-200 type rating course at Flight Safety Dallas, where he did 28 h in a flight simulator. He passed the corresponding skill test/proficiency check on 28-9-2006. He then received 1 h of actual flight training in Geneva, Switzerland, including 6 take-offs and 6 landings.

Afterwards, the PIC flew as PIC under supervision for around 25 FH and then another 30 FH as PIC without restrictions. The incident flight was the first high altitude, transatlantic flight he was to carry out with this type of aircraft.

The PIC stated he had not received any training or specific information on the behavior of the Gulfstream G-200 at high altitude. He found this behavior different from that of other turbojet aircraft flying at high altitude.

1.2.2. *First officer*

Sex, age:	Male, 30
Nationality:	Spanish
License:	CPL(A) obtained in 1999
Type rating:	Co-pilot G-200 (only Spanish aircraft); Class rating instructor (CRI(A)) Cessna single engine turbine
Previous type ratings:	Cessna 208 Caravan
Last medical examination:	12-07-2006; valid until 29-07-2007
Total flight time:	1,900 h
Flight time on type:	30 h (as first officer under supervision)
Hours last 30 days:	6:25 h
Hours last 7 days:	6:25 h
Hours last 72 h:	6:25 h
Start of the flight duty period:	19:30 h on 7-2-2007
Previous rest:	16 h
Last course of crew resource management (CRM):	24-11-2006

The copilot had received his training on the G-200 on the same dates as the PIC. He attended initial training at Flight Safety Dallas, where he passed the skill test/proficiency check on 30 September 2006 and then received 1:15 h of flight training in Geneva on 18 October 2006. Then he flew approximately 30 FH as copilot under supervision.

The copilot was used to flying the Cessna Caravan turboprop, and this was the first time he was to cross the Atlantic Ocean as the copilot of an actual flight.

1.3. Aircraft description

The engines of the G-200 aircraft have a Full Authority Digital Engine Control (FADEC) system. This system regulates the high pressure rotor speed (N2) and low rotor (fan) speed (N1) to apply a certain level of thrust to the engine depending on several factors like phase of flight, ambient conditions, aircraft discrete inputs, and thrust lever angle (TLA) position (i.e., the input from the pilot). The FADEC filters or dampens quick TLA movements to make the engine respond slowly to avoid surges at altitude.

The AFM contains a specific abnormal procedure for ENGINE SLOW RESPONSE (page. III-22, 8-3-2006) that states:

> "Possible ice contamination to engine sensor probes. FADEC has reverted to conservative acceleration/deceleration schedule to mitigate the risk of engine surge/stall and potential associated engine damage.
>
> 1. ENGINE ANTI-ICE pushbutton - ON
> 2. ENGINE SYNC switch - OFF
> 3. Thrust levers - OPERATE INDIVIDUALLY"

However, there are no instructions on when to apply this procedure.

The thrust levers have detents for certain flight conditions like flight idle, maximum cruise, maximum climb, take-off, automatic power reserve and reverse. According to Gulfstream, above an altitude of 20,000 ft, the amount of thrust provided with the TLA in the take-off detent is the same as that provided with the lever placed in the max climb position. Therefore, above 20,000 ft, moving the thrust lever from max climb position to take-off position will not produce any increase in thrust and therefore there will be no change in the engine parameters N1, N2 and fuel flow displayed to the crew.

The aircraft has a centralized system to display warnings and cautions (EICAS). One of those cautions is FADEC MAJOR (L/R), which means that the Full Authority Digital Engine Control computer has a malfunction. According to page III-19 of the Aircraft Flight Manual (AFM) dated 8 March 2006, this is a "failure in engine control that may have minor effect on engine operation. This message appears on ground only." There is a note that says that in this case, "Dispatch is not authorized." Another caution affecting the FADEC is the "FADEC FAULTY" message, which means "Failure in engine control that affects engine operation." The thrust levers must be operated gently and the engine indications must be monitored. The engine's back-up capability is reduced when this caution message appears and dispatch is not authorized.

The angle of attack (AOA), total air temperature (TAT) and pitot probes are heated to protect them against ice build-up. All heaters are controlled by a single PROBES HEAT switch on the overhead panel. This switch has two positions: AUTO and OVERRIDE. The nose gear oleo switch interrupts power to the heaters when the switch is in AUTO and the aircraft is on the ground. In OVERRIDE, the probes' heaters are powered in flight and on the ground.

The caution messages associated with the probe heaters are:

AOA HEAT (L/R). In flight. Discontinuity in power line. Corrective action: PROBES HEAT switch - OVERRIDE, as applicable.

PITOT HEAT (L/R). In flight. Power supply failure. Corrective action: PROBES HEAT switch – OVERRIDE, as applicable.

TAT PROBE HEAT. In flight. Power supply failure. Corrective action: PROBES HEAT switch - OVERRIDE, as applicable.

If the override position has been selected for the PROBES HEAT SWITCH, it has to be placed back to auto on the ground, and this is an item in the normal cockpit preflight checklist (reference AFM Normal Procedures, Page IV-10, 8 March 2006).

If this action is not carried out, heat is applied on the ground to the probes and during aircraft power up on the ground a FADEC MAJOR (L/R) message could be displayed. This was the subject of a Customer Support article published by Gulfstream on 13 October 2006. However, the display of the FADEC MAJOR message due to this reason would normally generate a fault code to be recorded on the MDC.

NOTE: As stated in 1.1.2 above, after the FADEC MAJOR messages appeared on the ground in St. John's, no fault code was recorded in the MDC. The engine manufacturer mentioned that this absence of recorded fault codes could be due to the EICAS switch being in the maintenance position or a power interruption to the FADECs after engine shutdown.

1.4. Flight recorders

1.4.1. *Cockpit voice recorder (CVR)*

The aircraft had a solid state cockpit voice recorder (CVR) P/N 1603-02-12, S/N 1656. It records 30 minutes of digital sound on four channels (CM-1, CM-2, CM-3 and cockpit area microphone) and two hours of digital sound in two additional files. One of those files ("mixer") jointly records the last two hours of the CM-1, CM-2 and CM-3 channels, and the other file ("area") records the last two hours of sounds from the cockpit area microphone.

The CVR was downloaded and found to have recorded the moments when the incident happened. The sound of the stall warning was recorded after 11 min and 36 sec of recording.

The relevant information of the CVR is as follows:

CVR recording elapsed time (hh:mm:ss)	Seconds after the start of the stall warning	DFDR UTC time (hh:mm:ss)	DFDR comment	Station talking	Text (not literal, only a summary of the conversations, when relevant or applicable, is included)
00:11:36	0	02:27:42		Sound	Clicker, stall warning.
00:11:38	2			CM-1	It is the stall.
00:11:47	11			CM-1	Ok, Ok.
00:11:50	14			CM-1	Mine, mine (meaning "I have control").
00:11:51	15			CM-1	What´s happening with the engines?
00:11:53				CM-1	[Exclamation]. They are not working!
00:11:56				CM-1	Tell ATC we have an emergency.
00:12:00	24			CM-2 (radio)	We have had a flame out. We declare emergency
00:12:14	38			CM-1	I am already descending.
00:12:16	40			CM-2	What do I do (name of the CM-1)?
00:12:25	49			CM-1	We do not have the engines running
00:12:35	59			CM-1	Ok, they are restarting.
00:12:48	72			CM-1	Tell him we are descending to level 330.
00:12:58	82			CM-1	They are not working, they are not working.
00:13:45	89			CM-1	Put me direct to Saint John's.
00:13:58	102			CM-1	We are going to try to restart one engine.
				CM-1	No, wait, it's working.
00:14:06	110			CM-1	What I don't have is control.
00:14:45	149			CM-2	What do I read off to you, (name of the CM-1)?
00:14:50	154			CM-2	What can it be?
00:14:52	156			Mechanic	I do not know
00:15:24	188			Mechanic	They are running
00:17:15	299			CM-2 (radio)	We have four people on board
00:17:35	319			CM-2 (radio)	We have the engine working, I little bit but working
00:18:00	344			CM-2	Engine working again

1.4.2. *Digital flight data recorder (DFDR)*

The aircraft had a solid state DFDR. The data was downloaded and the relevant information is as follows:

DFDR UTC time on 8 Feb 2007 (hh:mm:ss)	Seconds after the first stall warning		Airspeed (KIAS)	Altitude (ft)	Comentario
00:44:05	N/A	Master warning active	169	2.570	While on approach on the flight Dallas-St. John's. Master warning active for three seconds.
00:46:22	N/A	Weight on wheels on	118	903	Touchdown at St. John's after the flight from Dallas.
00:54:53	N/A	Engines shutdown after landing and taxi			
01:56:16	N/A	Engines started again			
02:06:52		Weight on wheels off	139	952	Lift-off during take off from St. John's.
02:27:42	0	Stall warning and shaker active	199	40.875	Master warning active. Autopilot disengages at the same time. Autopilot disengage warning sounds.
02:27:47	5	Stick pusher active for 1 s	198	40.874	Autopilot disengage warning continues sounding. It remains active until 02:32:27 h.
02:27:52	10	Stick pusher active for 1 s	200	40.776	
02:28:17	35	Stick shaker and stall warning disappear	200,5	36.698	
02:28:25	43	Stick shaker and stall warning active again for 4 s	218,5	38.869	
02:28:38	56	Engine cut off LH and RH active for 1 s	230,5	37.444	LH engine fuel flow goes to zero at 2:28:41 h. RH fuel flow engine reaches a minimum of 208 at 2:28:47 h. LH engine N2 reaches a minimum of 64.9% at 2:28:38 h. RH engine N2 reaches a minimum of 66.75% at 2:28:39 h.
02:30:07	145	Engine cut off LH active for 3 s	221,5	34.473	LH engine fuel flow goes to zero at 2:30:11 h. LH engine N2 reaches a minimum of 41.59% at 2:30:54 h.
02:31:31	229	LH thrust lever advanced in two seconds to 10° of TLA and then immediately returned to 0° (flight idle)	205	31.970	
02:31:37	237	Stall warning active for 2 s	203	31.945	

DFDR UTC time on 8 Feb 2007 (hh:mm:ss)	Seconds after the first stall warning		Airspeed (KIAS)	Altitude (ft)	Comentario
02:31:50	248	Stall warning active for 1 s	202	31.481	
02:32:09	267	Thrust levers advanced to around 17°	208	30.665	
02:32:27	285	Autopilot disengage warning disappears	228	29.654	
02:33:36	354	Autopilot is engaged again	237	28.500	Thrust levers at around 9° of TLA.
03:01:02	2.000	Autopilot disengages	146	1.188	The autopilot is disconnected during final approach at 160 ft AGL.
03:01:26	2.024	Weight on wheels on	133	920	Landed again at St. John's.

Regarding the moments when the actual incident happened during the flight from St. John's, the DFDR data showed that after the stall warning sounded at 02:27:42 h (at which time the autopilot automatically disconnected upon activation of the stick shaker), the flight crew advanced the thrust levers to the take-off detent (33° of thrust lever angle (TLA)) and maintained them in this position for about 7 s. The N2 and fuel flow for both engines did not vary, because (see Section 1.3) above an altitude of 20,000 ft the thrust delivered by the engines with the thrust levers located in the take-off detent is the same as when the levers are in the maximum climb detent.

After approximately 7 s, there was a series of quick movements of the thrust levers back and forward until they were left close to idle (0° of TLA) 21 s following the stall warning. When the levers were retarded, the N2 and the fuel flow of the engines fell after a lag of several seconds as per design.

At second 42, coincident with a new triggering of the stall warning, the levers were advanced slightly (TLA of 1.9°) for 5 s and retarded again to 0°. The fuel flows stopped decreasing and the values of N2 for both engines suffered a less noticeable variation (due to a higher lag) as a result of these inputs.

At second 56 the engine cut-off switches for both engines were pushed for 1 s. This caused the LH engine fuel flow to go to zero and the RH engine fuel flow to decrease noticeably also. Both N2 also fell. The manufacturer interpreted those values as meaning both engines were shut-down.

After a few seconds the engines recovered fuel flow and N2 and afterwards there were three movements of the thrust levers forward and backwards in what seemed to be a check of the status of the engines.

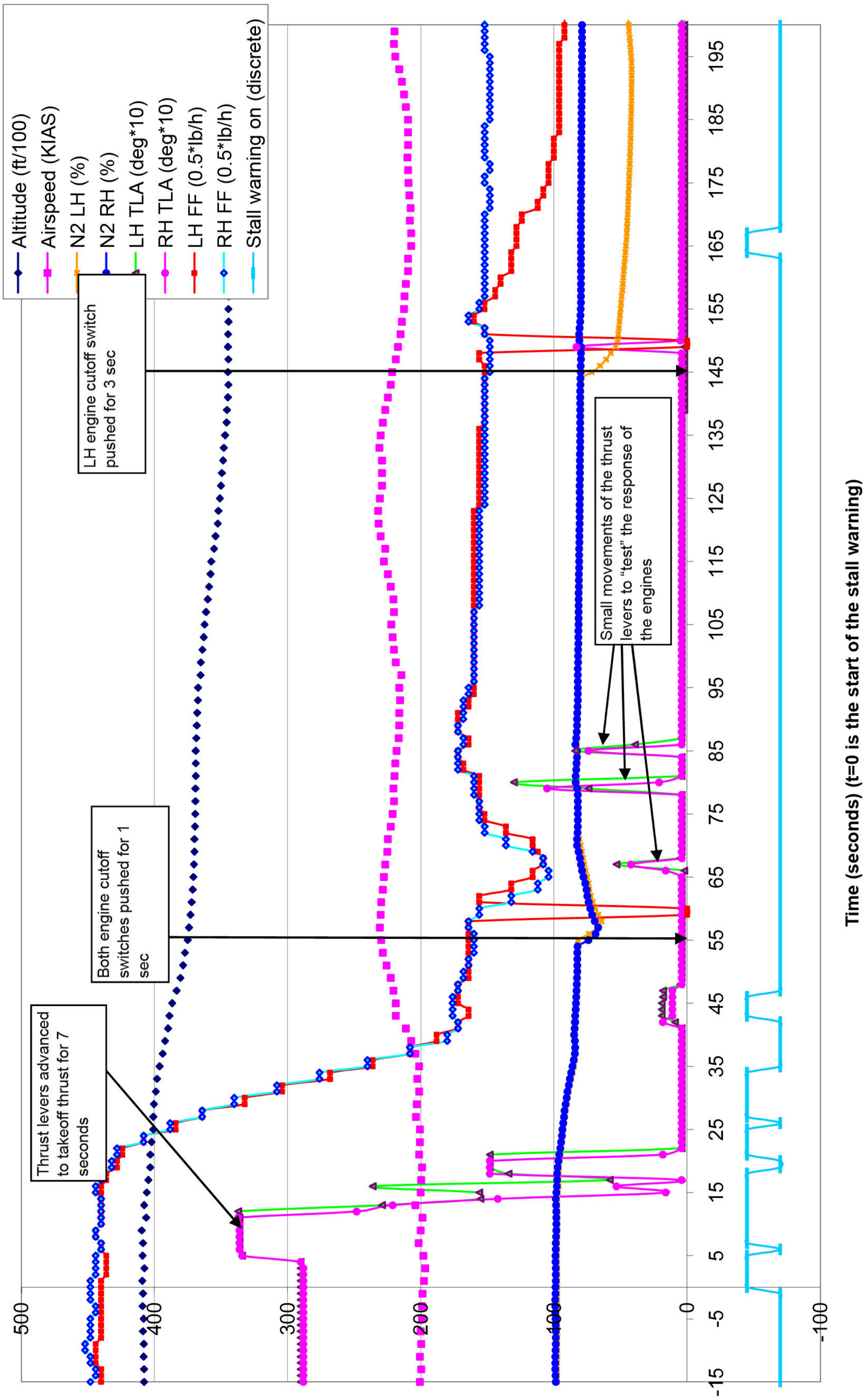

Figure 2. Qualitative variation of various DFDR parameters after the start of the stall warning. The scale of the curves has been adjusted to have all the data on the same graph

At second 145, with both thrust levers still at idle, the LH engine cut-off switch was pressed for 3 s, which caused the LH fuel flow to go to zero and the LH N2 to drop down to 41.7% in what was considered a complete shut-down of the engine. After several seconds, the fuel flow and N2 recovered and the engine re-started again.

There were no further manipulations of any engine cut-off switches. The stall warning sounded twice more. At 2:32:09 h the thrust levers were advanced to around 17° and the N2 of both engines returned to approximately 90%.

The autopilot disconnection warning remained active until 02:32:27 h (i.e. it had been sounding in the cockpit for almost 5 minutes while the flight crew was dealing with the stall warning situation). The pilot stated he tried to disconnect it earlier but he did not suceed. The reason for this could not be determined.

The aircraft continued descending back towards St. John's. Sixty nine seconds after the autopilot warning was muted, the autopilot was connected again and remained engaged until the aircraft was close to the runway during the final approach to the airport. No relevant incidents were recorded on the flight back to St. John's. The thrust levers were moved within the 4°-12° range as needed during the descent and approach. After touchdown the TLA reached –13.7° when reverse thrust was applied.

1.5. Operational procedures

The new model was included in the operator's "Manual de Operaciones" (Operations Manual) dated 6 November 2006. Part B of this manual had some G-200 aircraft information translated into Spanish but the reader was directed to the original AFM issued by the manufacturer for most of the procedures and performance information.

Part A (General) of the Operations Manual contained information and procedures for preparing the weight and balance of the aircraft and assigning flight crews to each flight. The procedures contained enough information to appropriately carry out these tasks. The operational flight plan was normally prepared by the operator's dispatchers and approved by the pilot in command.

The operator had also prepared a document of "Standard Operating Procedures" for their only G-200 aircraft. This document was based on the manual of the parent operating company, and was in a draft format effective 9 January 2007 (i.e. approximately one month in advance of the airplane delivery date). These procedures assigned detailed tasks to the PF and the PNF, as well to the pilot in command and copilot.

The procedures and aircraft information, contained in the different manuals issued by the manufacturer or by the operator, reviewed after the incident, did not include the information that, above 20,000 ft, the thrust delivered by the engines with the TLA in the max climb detent was the same as that delivered with the TLA located in the takeoff detent.

They also did not include signs to identify an "engine slow response."

2. ANALYSIS

2.1. General

The analysis of the factual information available shows that the St. John's-Madrid flight was initiated with an aircraft weight above the value calculated by the flight crew, and planned at an excessive cruise altitude for the actual weight. The climb schedule was not optimum in terms of speed but was within limits. As a result, the aircraft stalled upon reaching the planned cruise altitude and the flight crew could not adequately identify the response of the engines to the situation. They misinterpreted the available information and the CM-1 traced the inputs they were receiving to an engine problem, believing they had no control over the engines, and in order to solve this incorrect assessment, he took actions outside the approved operational procedures of the aircraft without advising the CM-2 or the mechanic that was on board of those actions, which led both engines to lose thrust simultaneously. Later on he took the same action (to push the engine cutoff switch) for the left engine.

The following paragraphs try to assess the influence of different factors on the actions carried out by the flight crew that put the operation at risk.

2.2. Previous flights

The information gathered shows that several cautions had appeared in the cockpit of this new aircraft during three flights carried out on the day of the incident and on the previous day. These cautions had included L FADEC FAULTY, L and R AOA HEAT and TAT PROBE messages. The Dallas-St. John's flight was cancelled twice as a result. When the flight was finally conducted, the AOA HEAT (L and R) and TAT PROBE messages appeared again on the approach to St. John's. During the three flights there was a mechanic from the manufacturer on board.

Finally, before the take-off of the incident flight, an L and R FADEC MAJOR message appeared in the cockpit while on the ground.

It was not possible to determine whether this latest appearance was due to the PROBE HEAT switch being left in the override position after the landing as a part of the troubleshooting activities.

This discrepancy had been the subject of a technical article issued by the manufacturer in one of their customer support publications. The cause of the AOA HEAT and TAT

PROBE messages could not be exactly determined. They were checked after the incident and no malfunction was detected. When the aircraft returned to Savannah, the TAT probe 102AU1AG was replaced. An operational check did not show any defects.

The analysis carried out by the aircraft and engine manufacturers shows that none of those faults was related to a malfunction of the engines or their control. However, it is probable that the different caution messages displayed led the flight crew, which was not familiar with the details of the possible malfunctions, to be prone to believe that some problem could be present when they finally took off from St. John's en route to Madrid.

2.3. Crew composition

The captain had experience in North Atlantic flights at high altitude with Boeing 707 aircraft as part of his military background. He also had experience in short haul "business type" flights in Falcon 20s, but his experience with the G-200 was very limited. He had around 30 FH as CM-1 without restrictions on this type.

The copilot had no experience in high performance, high altitude jet aircraft, or on long haul or North Atlantic flights.

According to their statements, the type rating training of the flight crew did not include extensive training on engine-related emergencies. They had not received specific training related to the high-altitude performance of the aircraft. They did not know that the thrust delivered by the engines with the thrust levers at maximum climb was the same as that delivered with the levers at take-off detent when the aircraft was above 20000 ft. For this reason, a safety recommendation is issued to Gulfstream to include this information in the G-200 training programs.

It is considered that the composition of the crew was not adequate for the type of flight being conducted. Although the Operations Manual had procedures in place to assure that the assignment of flight crews was studied and prepared in advance, this did not happen in this case. These were the only pilots type rated for the G-200 that the operator had at that time, and therefore there was no option for another crew composition, unless pilots outside the company were considered. They tried to locate pilots from the operator's parent company, but none were available.

On other delivery flights, the manufacturer usually assigned one of their own company pilots to be on board, but in this case none were available and a mechanic was assigned instead. In any case, this should be considered as an additional safety measure provided for that kind of flight, not to replace the need for a suitable and balanced flight crew being provided by the operator. Therefore, a safety recommendation is issued in this regard. Because it is considered that the coordination in the cockpit was not optimum during the management of the emergency, even though the crew attended a course of CRM on 24-11-2006, the recommendation includes the need to improve CRM training.

2.4. Flight planning

The flight planning was not adequate because the flight crew used the wrong load sheet data. The load sheet take-off weight was 30,468 lb, which did not reflect the payload (passengers' weight plus baggage) and also did not reflect the final actual fuel on board (500 lb of additional fuel). The estimated error of the load sheet was at least 900 lb below the actual weight.

The operational flight plan (29,900 lb) had an estimated error of 1,468 lb below the actual weight (31,368 lb). The empty weight values for the aircraft were not correct. A safety recommendation is issued to the operator to review their weight and balance dispatch procedures in order to assure that correct and updated information is being used every time.

On the other hand, the crew used the take-off weight from the flight plan (29,900 lb, which had the biggest error) to calculate the optimum flight level.

The CM-1 used a rule of thumb (that was inadequate in this case because of its inaccuracy) and the result was that the aircraft could climb to 40,700 ft. When ATC requested them to be established at FL330 or FL410 by waypoint 48N50W, he chose FL410.

The CM-1 assigned the copilot the role of pilot flying during the takeoff and climb, which was initially a good decision because the copilot was not familiar with North Atlantic communication and navigation procedures, which were going to be handled directly by the pilot in command.

However, he did not provide appropriate monitoring of the climb carried out by the copilot. ATC had requested them to be at FL330 or FL410 before reaching the waypoint at 48N50W (located around 140 NM away from St. John's). The climb speed was around 0.7 M, instead of the optimum value of 0.75 M (or 290 kt). The copilot said at the time that at that speed they would not reach the assigned flight level at the requested position, and asked what to do, whether to reduce the speed or increase the climb rate. The CM-1 answered "do what you want, but do not go below Mach 0.66," which was in accordance with the manufacturer's performance chart.

The flight crew did not have an adequate means to accurately check the capability of the aircraft to reach FL410 at the waypoint requested by ATC, especially given the SAT in the area. The operational flight plan, considering a take-off weight almost 2,000 lb below the actual weight of the aircraft, called for reaching FL410 after 02:37 h and 1,415 NM of flight.

The DFDR data show that the flight profile differed significantly from the best profile after leaving FL250. From FL350 to FL370, the Mach number was maintained steady at 0.72 M, below the optimum 0.75. This Mach value was a significant departure from Cruise mode for Long Range Settings (0.76) and from the flight plan computed cruise speed of 0.80 M.

From FL370 to FL400, it was 0.70, significantly below the optimum of 0.75. Finally, the last 1,000 ft were more critical. The speed progressively decreased down to 199 KIAS in a short period of time given the high altitude at which they were flying. As a consequence, the aircraft experienced low speed buffet onset.

2.5. Management of the stall warning situation

The first sign that the aircraft was too high was a sort of asymmetric Dutch roll experienced at around 40,700 ft. When the aircraft was at 40,900 ft the stall warning sounded. The crew correctly recognized the warning and the CM-1 took the flight controls. The actions to recover the stall were not ideal. Pitch oscillations went from +5.4° to –0.4° in 3 s and from –4.9 to +7.4° in 2 s. AOA oscillated from –7.7° to +14.4° in 3 s and from +14.4° down to 1.9° in 3 s.

The master warning was active intermittently for 6 s. The stick pusher was active for 2 s. The stall warning lit up to 7 times. Speed recovery was very slow (from 196.5 kt up to 211 kt in 37 s). Altitude loss was 2,530 ft in 48 s before stabilizing the descent.

In an attempt to regain control, the CM-1 advanced the thrust levers to the take-off detent. Because there was no change in engine parameters, he thought there was an erroneous interface between both FADEC and the thrust levers or some sort of engine control failure. The levers were put at idle, then shortly moved forward, and finally left at idle. This produced quick changes in fuel flow and slower RPM variations in the engines.

The CM-1 probably had in mind the previous FADEC MAJOR messages seen in the cockpit before the start of the flight.

However, at the time of the stall warning, no Master Caution was activated and no FADEC EICAS message was shown.

The CM-1 probably misinterpreted the following two engine behavior conditions as being caused by a faulty FADEC or a malfunction of another part of the engine control system:

- lack of increase in thrust when the TLA was increased to the take-off detent,
- slow response of the engines to thrust lever rapid movements.

The first condition was because the aircraft was above 20,000 ft, in which case the thrust delivered by the engines at maximum climb is the same as when the levers are at take-off. It seems the pilots were not aware of this fact, and had never been instructed about this important characteristic of the power plant system. The manufacturer manuals reviewed as a result of this investigation did not contain any reference to this condition. Therefore, a safety recommendation is issued to Gulfstream to include this information in the corresponding parts of the manuals.

The second condition was due to the design of the FADECs, which prevents the engines from surging in response to rapid throttle movements. It seems from the recorded data that the engine response was normal and in accordance with their design. In any case, the AFM contains a specific procedure for "Engine slow response" that was never resorted to or mentioned by the crew. However, the procedure does not include signs for identifying slow engine response, and a safety recommendation is issued to Gulfstream in this regard.

In these conditions, the activation of the engine anti-ice, with no external visible moisture conditions, was an isolated action and not a part of any procedure. The engine anti-ice reduces both maximum and optimum altitudes, and therefore its activation at that time could have made the situation worse.

Later on, both engine cutoff switches were pushed simultaneously, which reduced both fuel flows to near zero. This action was against the approved operational procedures and was taken without advising the copilot (PNF at those moments). At this time the aircraft was in descent, passing through 37,450 ft at 230 KIAS. This altitude is beyond the Air Start Envelope (Windmilling and Starter-Assist) (Figure 3-2, Section III, Abnormal Procedures, page III-24 of the AFM). Nevertheless, the engines restarted without any problem once the fuel flow was re-established.

After the accident, the CM-1 acknowledged that he should not have taken this action, but did so in the belief that the engines were not responding and as the only action he could think of at the time that could make the engines react.

The crew was worried and under great pressure at the time. They coped with the situation and the CM-1 decided to declare an emergency and return to St. John's shortly after the stall warning was activated.

Almost two minutes later, the CM-1 activated the "L FUEL ENGINE CUT OFF" for 3 seconds. The aircraft was still descending, passing through 34,473 ft at 221 KIAS, which is at the limit of the envelope for a wind milling air start, but it was not yet in good conditions for an air start, due to a slow speed deceleration and an excessive pitch angle (+4.2°). However, the engine restarted without any problems.

2.6 High altitude flights

One conclusion of the whole event is that the flight crew was not very familiar with low speed buffet onset and high altitude stalls and associated recovery actions, or with the conditions under which engine response may be slow. They also had a lack of information concerning high altitude aircraft performance. It is necessary that the the operator assure that their crews are provided with enough training in high altitude flights with high performance aircraft. The operator has informed that they send their crews to approved flight training centers that teach the complete airplane course in flight simulators. Nevertheless, they will take it into account in the future to further reinforce this kind of training.

The performance information of the G-200 provided by the manufacturer was reviewed. The buffet boundaries are provided in Figure 7-19 of the AFM. However, the curves on this graph are closely spaced and are very difficult to read. The graph does not show bank angle (only load factor, which is less intuitive to the flight crews) (see Figure 3). Additionally, it would be useful for operational purposes if this graph were also included in the Quick Reference Handbook. A recommendation is issued in this regard.

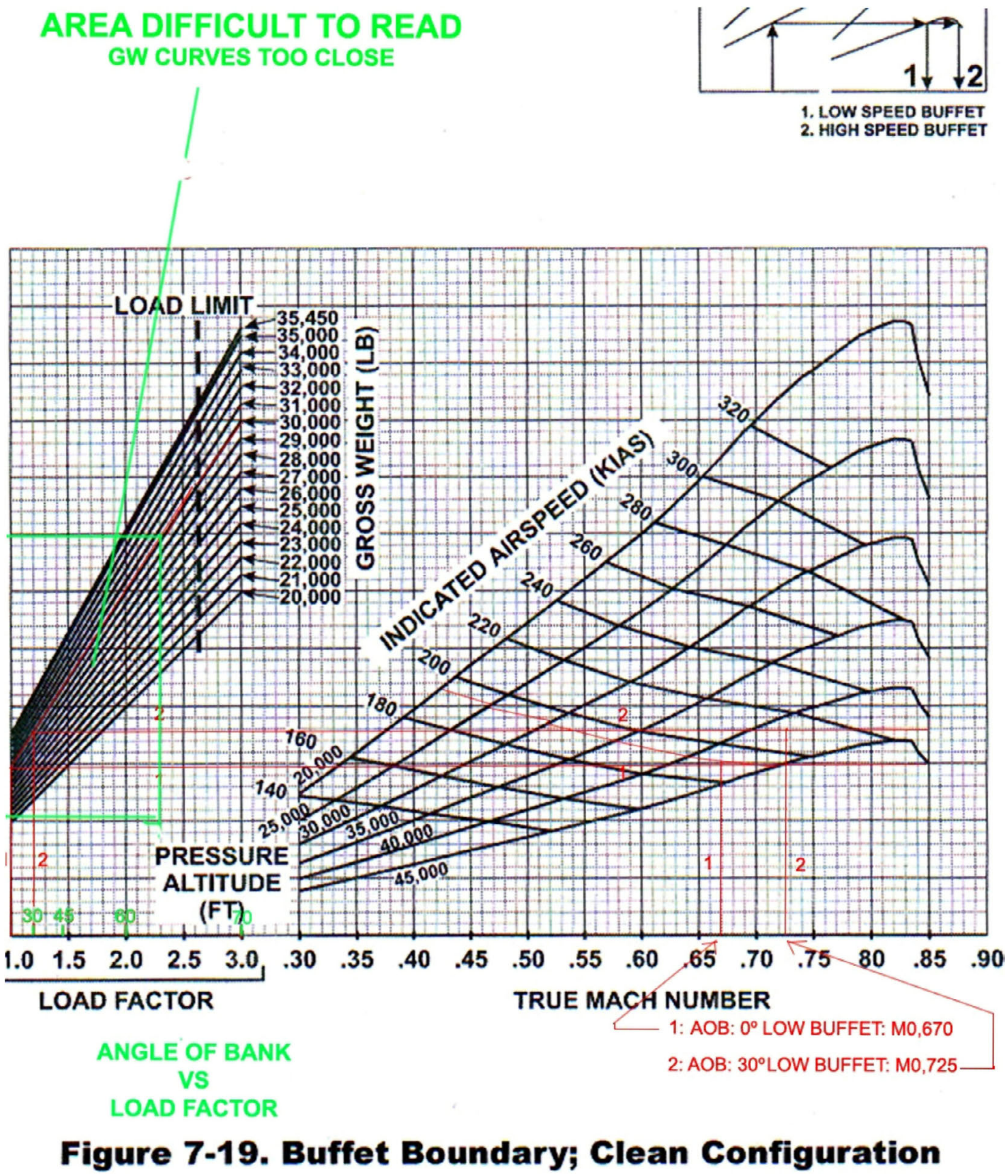

Figure 3. Modified composition of the buffet onset graph from the G-200 AFM

According to the Operational Planning Manual, page IV-70 (18 September 2004, see Figure 4 attached) at 30,000 lb the aircraft could theoretically fly at FL410 with constant speed cruise parameters at Mach 0.66 and N1 101.4%. However, this value is lower than the low speed buffet value shown in figure 3 (0.67 Mach with 0° of bank angle). Therefore, this table should be reviewed by the manufacturer and a safety recommendation is issued in this regard.

Section IV

Constant Speed Cruise

TOC Local

41,000 FT PRESSURE ALTITUDE

			0.66 M						0.68 M			
	-76	-66	-56	-46	-36	OAT (°C)	-76	-66	-56	-46	-36	
	-20	-10	0	10	20	ISA DEV	-20	-10	0	10	20	
30,000	97.0	99.3	101.4			%N1	97.4	99.6				30,000
30,000	1577	1628	1678			LB/HR	1601	1652				30,000
30,000	0.228	0.227	0.225			NM/LB	0.228	0.227				30,000
31,000	99.2	101.4				%N1	99.7					31,000
31,000	1681	1735				LB/HR	1714					31,000
31,000	0.214	0.213				NM/LB	0.213					31,000
32,000						%N1						32,000
32,000						LB/HR						32,000
32,000						NM/LB						32,000

Figure 4. Extract of page IV-70 of the Operational Planning Manual. Flight at FL410 is permitted at Mach 0.66 with 30,000 kg of gross weight

3. CONCLUSION

It is considered that the incident probably happened because, after the aircraft entered a high altitude stall due to inadequate flight planning in terms of aircraft weight and to the wrong acceptance of the ATC altitude restriction, the pilot in command simultaneously pushed the left and right engine fuel cut-off switches, which momentarily shut down both engines.

Contributing factors were:

- Execution of the final climb that resulted in a quick loss of airspeed.
- Lack of detailed knowledge of aircraft and engine behavior at critical high altitude, because this information was not a part of the manuals or the type rating training programs. This precluded the detailed checking of the capability of the aircraft to comply with the ATC altitude restriction (FL410 at 48N50W).
- Appearance in previous flights of several caution messages of undetermined origin involving the FADECs and the probe heaters, which probably misled the crew into thinking that there could be a latent problem with the engine control.

4. SAFETY RECOMMENDATIONS

REC 36/07. It is recommended that TAG AVIATION E. establish suitable practical procedures to assure that adequate flight crews are assigned for every planned flight, as described in their Operations Manual. These flight crews should have adequate training in crew resource management (CRM).

REC 37/07. It is recommended that TAG AVIATION E. review their weight and balance dispatch procedures in order to assure that the correct and updated information is being used every time.

REC 38/07. It is recommended that Gulfstream include in the appropriate parts of the aircraft manuals information regarding the variation with altitude of the maximum thrust delivered by the engines depending on the position of the thrust levers. This information should also be a part of the type rating training program.

REC 39/07. It is recommended that Gulfstream revise the engine slow response abnormal procedure of the airplane flight manual to provide flight crews with information to determine when they need to apply this procedure.

REC 40/07. It is recommended that Gulfstream revise the buffet boundaries graph provided in Figure 7-19 of the AFM in order to improve readability of the gross weight curves and to include the bank angle in addition to load factor. Additionally, it is recommended that this graph also be included in the Quick Reference Handbook.

REC 41/07. It is recommended that Gulfstream revise the table on page IV-70 (18 September 2004) of the Operational Planning Manual to assure that the Mach, gross weight and flight level values provided are consistent with the buffet boundary margins of the aircraft.