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Commission fédérale sur les accidents d'aviation
Commissione federale sugli infortuni aeronautici
Federal Aircraft Accident Board

Final Report No. 1950 by the Federal Aircraft Accident Board

concerning the accident

to the Boeing 737-33V aircraft, registration HB-III

of the EasyJet company, flight EZS 903

on 15 August 2003

in the region of Oyonnax (F),

approximately 35 km west of Geneva airport

This final report has been prepared of the Federal Aircraft Accident Board according to art. 22 – 24 of the Ordinance relating to the Investigation of Aircraft Accidents and Serious Incidents (VFU/SR 748.126.3), based on the Investigation Report by the Air Accident Investigation Bureau on 21 June 2007.

General information on this report

In accordance with Annex 13 of the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Law, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent future accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the French language.

All times in this report, unless otherwise indicated, follow the coordinated universal time (UTC) format. At the time of the accident, Central European Summer Time (CEST) applied as local time (LT) in Switzerland. The relation between LT, CEST and UTC is: LT = CEST = UTC + 2 hours.

For reasons of protection of privacy and simplicity, the masculine form is used in this report for all natural persons, regardless of their gender.

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Final report

Operator	EasyJet Switzerland S.A., CH-1215 Geneva 15, Switzerland
Owner	Lift EJ UK, LLC 1100 North Market Street, US-19890 Wilmington DE
Aircraft type	Boeing 737-33V
Country of registration	Switzerland
Registration	HB-III
Location	Region of Oyonnax/F Climbing through flight level FL 150
Date and time	15 August 2003 at about 08:00 UTC

Summary

Brief description

After taking off from runway 23 at Geneva airport, the flight crew of the Boeing 737-33V on flight EZS 903 destination Luton turned right in accordance with standard instrument departure "DIPIR 1A"; they were cleared to climb to flight level FL 150, then FL 180. When passing flight level FL 85 in a climb, they requested clearance to maintain heading 310 in order to avoid thunderstorm cells. A few minutes later, the aircraft passed through a shower of hail which seriously damaged it. After declaring a distress situation - "MAYDAY MAYDAY MAYDAY" - the flight crew were authorised to return to Geneva airport. The landing on runway 05 took place without any problems and the aircraft then reached its stand. None of the occupants was injured and passengers disembarked normally.

Investigation

The accident occurred at about 08:00 UTC and was notified at about 09:00 UTC to the Aircraft Accident Investigation Bureau (AAIB). The investigation was opened on the same day at about 12:00 UTC at Geneva airport, in collaboration with the airport authorities.

The accident was caused by the aircraft flying into a shower of hail embedded in a thunderstorm cell, following inadequate utilisation of the information provided by the onboard weather radar.

The following factors played a part in the accident:

- shortcomings in crew resource management (CRM);
- no specific meteorological information concerning this hazard was transmitted.

1 Factual information

1.1 History of flight

1.1.1 Preliminary

1.1.1.1 The aircraft

Flights made by aircraft HB-III in the 24 hours preceding the accident:

Date	Flight No.	Departure from	at (UTC)	Arrival at	at (UTC)
14.08.03	EZS 923	Geneva	04:50	Nice (F)	05:31
14.08.03	EZS 924	Nice (F)	06:15	Geneva	06:53
14.08.03	EZS 903	Geneva	07:53	Luton (UK)	09:17
14.08.03	EZS 904	Luton (UK)	10:07	Geneva	11:22
14.08.03	EZS 993	Geneva	14:40	Paris Orly (F)	15:30
14.08.03	EZS 994	Paris Orly (F)	16:15	Geneva	16:57
14.08.03	EZS 957	Geneva	17:41	Amsterdam (NL)	18:49
14.08.03	EZS 958	Amsterdam (NL)	19:48	Geneva	20:54
15.08.03	EZS 923	Geneva	04:35	Nice (F)	05:30
15.08.03	EZS 924	Nice (F)	06:10	Geneva	07:05

No significant defects were mentioned in the aircraft technical log.

1.1.1.2 Crew

On 14 August 2003, the commander and copilot were working together on a different aircraft from the one involved in the accident, on EasyJet flights departing Geneva, destination Amsterdam (NL) and London Gatwick (UK). They came on duty at 03:25 UTC and took off for Amsterdam about an hour later. After a stopover of approximately forty minutes, they returned to Geneva, whence they subsequently departed for London Gatwick in accordance with their schedule. They returned to Geneva at 12:35 UTC and at 13:05 UTC completed a period of flight duty of 9 hours 40 minutes.

1.1.2 History of flight

1.1.2.1 Flight preparation

On the day of the accident, the commander and the copilot were to make EasyJet flights together onboard the Boeing 737-33V, registration HB-III, departing Geneva, destination Nice (F) and London Luton (UK). According to the cockpit voice recorder (CVR) recordings, during the return flight from Nice (EZS 924) they had to avoid various thunderstorm cells between FL 150 and an altitude of 7000 ft during the Geneva approach phase. After landing, the aircraft taxied to stand 44.

Once the passengers had disembarked, the five crew members began the preparation for the next flight, destination Luton. An EasyJet company employee handed over to the pilots an envelope containing various items of information, including in particular the latest weather forecasts (TAF[1]) and meotological observations (METAR[2]) for the subsequent flight. The flight crew already had the meteorological charts in their possession. According to the commander, aircraft HB-III was parked too far away from the Geneva meteorological service office for them to go there during the stopover.

For the next scheduled flight, the commander was pilot not flying (PNF) and therefore was responsible for inspecting the outside of the aircraft and supervising refuelling. The minimum block fuel necessary for the flight to Luton (UK) is 6584 kg; the flight crew chose to depart with 7000 kg of fuel (actual block fuel).

Shortly before departure, 126 passengers embarked on the aircraft and 1547 kg of luggage was loaded into the holds.

1.1.2.2 Flight EZS 903 departing Geneva

The aircraft making flight EZS 903 took off at 07:54 UTC departing Geneva, destination Luton (UK), from runway 23 and initially followed the standard instrument departure (SID) “DIPIR 1A”. The copilot, as pilot flying (PF), was in control.

The settings of the onboard weather radar are not recorded on the digital flight data recorder (DFDR). The pilots stated that before departure it was set to WXR/TURB mode, AUTO gain and +2° tilt, 20 NM or 40 NM range. Analysis of the DFDR data revealed that the range of each pilot’s electronic horizontal situation indicator (EHSI) was set to a value of 10 NM.

After passing 7000 ft in a climb, the aircraft began a right turn, following the assigned departure route. At the beginning of this manoeuvre, the copilot set the range of his EHSI to 20 NM; he then remarked to the commander that it would be preferable to continue straight on. A little later, the latter changed the range of his EHSI from 10 to 40 NM; he remembered changing the tilt and range parameters, but could not give the exact values. The automatic pilot was switched on.

Six seconds after the copilot’s remark, the commander requested clearance from Departure control to “maintain” heading 310: “*Topswiss... nine O three, may we maintain flight level three... one zero to avoid, please.*” He received the reply: "*Er... you mean... the heading? – Sorry? – You mean heading three one zero? – Yes, I would like to maintain heading three one zero for a while, for about... fifteen nautical miles.*” This deviation from the standard instrument departure was granted and the flight was handed over to the INI NORTH radar control sector frequency.

At 07:58:37 UTC, the crew of flight EZS 903 was cleared to climb to flight level FL 180, on heading 310. A few seconds later, air traffic control (ATC) suggested him flying directly towards Dijon (DJL VOR), when convenient. The commander replied that he was expecting to proceed accordingly in approximately 10 NM. The crew stated that during this flight phase the aircraft was alternately under instrument meteorological conditions (IMC) and visual meteorological conditions (VMC).

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[1] *Terminal Aerodrome Forecast* – TAF

[2] *aviation routine weather report,* formerly *meteorological aerodrome report* - METAR

According to the CVR recordings, at 07:58:54 UTC the commander was busy using the flight management system (FMS) to determine the next heading which would allow him to turn towards DJL and increased the range of his EHSI to a value of 80 NM. Subsequently, the noise of the ATC radiotelephone exchanges masks the cockpit conversations and makes them impossible to understand.

Between 07:59:48 and 08:00:15 UTC, the conversations recorded between the two pilots are incomprehensible, as they are again masked by ATC radiotelephone exchanges.

In his statement, the copilot stated that at that time he was flying on heading 310: "*Es hatte auch ein kleines Echo auf der linken Seite. Ich vermute, wir flogen mit einem Abstand von ca. 10 Meilen. Auf der rechten Seite war ziemlich klar der rote Bereich sichtbar.*" – There was also a small echo on the left side (of the screen). I assume we were flying at a distance of approximately 10 nautical miles (from the storm cells). On the right side (of the screen), the red zone was clearly visible.

At 08:00:20 UTC, the CVR recording revealed about 5 seconds of the loud noise caused by a shower of hail which hit the aircraft as it passed FL 154 in a climb. A little later, the ground proximity warning system (GPWS) issued a voice alert "TOO LOW TERRAIN TERRAIN".

At 08:00:27 UTC, the commander said "*I've control... I take control*" to indicate that he was in control of the aircraft and took over radiotelephone communications. The copilot acquiesced, replying: "*Your controls*". At 08:00:31 UTC, the audible autopilot disengage warning sounded and remained audible for 38 seconds, until its autopilot disengage switch was pressed a second time to confirm the warning. The DFDR parameters reveal that at this instant the autothrottles were disengaged.

The commander noticed that the copilot's windscreen was badly damaged and declared a distress situation to INI NORTH control sector at 08:00:33 UTC, with the message: "*MAYDAY MAYDAY MAYDAY*"; he also asked for permission to return to Geneva and announced that he was maintaining flight level FL 160 and turning onto heading 270. The aircraft's speed was approaching maximum operating speed (Vmo) and the copilot drew attention to this trend by interjecting: "*Speed*".

At 08:01:23 UTC, the commander asked the copilot to don his oxygen mask and put on protective goggles. From this time onward, internal communications became more difficult because of the noise caused by breathing.

The commander informed ATC that he was having problems with the windscreens and asked for clearance to descend to the minimum safe flight level; he was immediately cleared to flight level FL 100 and then to an altitude of 7000 ft. The controller informed him that he could not see any conflicting traffic in the vicinity.

At 08:02:56 UTC, the commander asked the copilot to carry out the window damage checklist (*non-normal check-list 030 – window damage*).

The flight crew was then instructed to fly heading 090 and was then transferred to the Approach sector frequency, 120.3 MHz. They did not collate this message and did not answer back the consecutive calls of the INI NORTH sector controller.

The flight crew called on the frequency 121.3 MHz of the Departure sector DEP, which is another frequency than the one who was attributed to them. The DEP sector controller asked the flight crew to contact the Final sector FIN on the frequency 120.3 MHz.

The contact was finally established between the FIN sector and the flight crew of the EZS903 flight.

The copilot removed his oxygen mask and the commander then asked him to take over radiocommunications.

Taking into account the geographical position of the aircraft in distress at this time, the Approach radar controller proposed a direct approach on runway 05. The flight crew accepted this option and was then guided for interception of instrument landing system (ILS) 05. During the interception phase, the controller reported that the localizer 05 (LLZ) seemed to be out of order; the flight crew replied that he had the runway in sight and was subsequently cleared to land.

Approximately three minutes before landing, the commander communicated with the cabin crew and indicated that he was expecting a normal landing.

At 08:14 UTC, the aircraft touched down, then taxied to stand 66 under the surveillance of the Airport Safety Service (SSA). After the engines had been switched off, the passengers disembarked normally.

1.1.3 Departure from Geneva of two other aircraft

1.1.3.1 Flight EZS 995

At 07:58 UTC, 4 minutes after the take-off of EZS 903, an EasyJet Switzerland Boeing 737 making scheduled flight EZS 995, destination Paris-Orly, took off following the same standard instrument departure “DIPIR 1A”. At 08:01 UTC its flight crew requested clearance from the Departure controller to turn left onto heading 290 to avoid cloud formations, then 3 minutes later it resumed own navigation towards VOR DJL. This deliberate deviation from the initially envisaged route enabled the aircraft to avoid the thunderstorm activity area which affected EZS 903.

The commander stated that this avoiding route had been chosen because of the weather situation displayed on the onboard weather radar.

1.1.3.2 Flight VP-BKK

After the delay caused by the unexpected landing on runway 05 of the aircraft making flight EZS 903, a Hawker Siddeley 125 aircraft, registration VP-BKK, took off from runway 23. Its flight crew were cleared for destination Bournemouth (GB) on the same standard instrument departure as EZS 903, although ATC did not inform them of the meteorological problems which the latter had just encountered. The pilot stated that above the Jura his aircraft had encountered “*heavy rain*”; damage to the radome, leading edges and tail of the aircraft was confirmed by maintenance personnel on arrival in Bournemouth.

On 20 August 2003, its pilots complained in writing that they had not been informed by the ATC services of the particular weather situation which had affected EZS 903 even though they had followed the same departure route.

1.2 Injuries to persons

Injuries	Crew	Passengers	Other persons
Fatal	---	---	---
Serious	---	---	---
Slight/none	5	126	

1.3 Damage to aircraft

The hail damaged numerous parts of the aircraft, including:

- the leading edges of the wings, vertical and horizontal tail;
- the jet engine pods;
- the wing flaps and slats;
- the windscreens;
- the radome;
- the fuselage skin at cockpit level;
- various antennas and lights.

(see Annex 1).

1.4 Other damage

None.

1.5 Personnel information

1.5.1 Commander

Personal data	French citizen, born 1960	
Crew duty time	Start of duty on 14.08.03:	03:25 UTC
	End of duty on 14.08.03:	13:05 UTC
	Flying duty period on 14.08.03:	9:40 hours
	Rest period:	14:35 hours
	Start of duty on 15.08.03:	03:40 UTC
	End of duty on 15.08.03:	08:45 UTC
	Period of flight duty at the time of the accident:	5:05 hours
Licence	Airline Transport Pilot Licence ATPL (A) issued by the DGAC in France, valid till 21.02.2007	
Ratings	International radiotelephony RTI (VFR/IFR) Night flying NIT (A) Instrument flying IR (A)	

Ratings to be extended	Single-engined piston aircraft SE piston Multi-engined piston aircraft ME piston Type rating for Boeing B737 300-800 PIC obtained on 01.02.2001 Flight instructor FI (A) Instrument rating instructor IRI (A) Type rating instructor TRI (A)
Instrument flying ratings	SE piston, CAT I, valid till 30.06.2004 ME piston, CAT I, valid till 30.06.2004 Boeing B737 300-800 PIC, CAT III, valid till 31.10.2003
Last proficiency check	09.10.2002
Last line check	22.07.2003
Medical certificate	Class 1, valid till 30.09.2003; fit to fly, must wear spectacles
Last medical examination	03.03.2003
Flying experience	9742:00 hours in total
on powered aircraft	9742:00 hours
as commander	9147:00 hours
as copilot	291:00 hours
on the type involved in the accident	989:00 hours
during the last 90 days	61:35 hours
of which on the type involved in the accident	61:35 hours
the day preceding the accident	6:05 hours
the day of the accident	2:25 hours
Commencement of pilot training	1979

1.5.1.1 Pilot training

The aeronautical training of the commander involved in the accident has been analysed only for the period dating from when he took up his position with PARC Aviation, a company specialising in placing aeronautical personnel.

According to the documents made available to the investigation, the commander contacted PARC Aviation for the first time on 8 February 2000 with a view to being employed as a pilot. On the day of the accident, he had a total of 9742 flying hours, of which approximately 150 had been flown as copilot on aircraft of more than 20 tonnes. He accumulated almost 1400 flying hours on Mc Donnell Douglas MD81, 82 and 83 aircraft types and about 1100 hours on Boeing 737-300 and 400 aircraft.

From August 2003, EasyJet Switzerland launched a programme to rapidly replace its fleet of Boeing 737 aircraft by Airbus A319 type aircraft. To overcome the shortage of flight crews caused by regular pilots attending Airbus training courses, the company, among other things, had temporary recourse to using the services of the commander of the aircraft involved in the accident, via the PARC Aviation company.

The commander's skills were verified during four flight simulator sessions, each lasting four hours, in Luton (UK) on 2, 3, 5 and 6 July 2003. On this occasion, all the elements in EasyJet Switzerland's "*Short Refresher Exercises 1-4*" programme specified in the operation manual (OM) Part DF were covered.

On 4 July, he took part in a crew resource management (CRM) course[3], then took two courses within the company on 10 and 11 July in Switzerland, relating to safety-related aspects (safety equipment & procedures - SEP) and flight performance. On 15 July 2003, he began his line adaptation phase, completing it six days later after making the 16 flights required by the programme in his training dossier. The element which recurrently appears on the training reports is a lack of rigour about following new company procedures (standard operating procedures – SOP). No comment was made on the subject of using the onboard weather radar; the box "WX radar use, interpretation" in the training programme entitled "Line Flying Under Supervision Checklist – Aircraft Syllabus" was completed and signed by a company line instructor.

1.5.2 Copilot

Personal data	Swiss citizen, born 1967	
Crew duty time	Start of duty on 14.08.03:	03:25 UTC
	End of duty on 14.08.03:	13:05 UTC
	Flying duty period on 14.08.03:	9:40 hours
	Rest period:	14:35 hours
	Start of duty on 15.08.03:	03:40 UTC
	End of duty on 15.08.03:	08:45 UTC
	Period of flight duty at the time of the accident:	5:05 hours
Licence	Commercial Pilot Licence CPL(A)/JAR issued by the FOCA, valid till 21.07.2004	
Ratings	International radiotelephony RTI (VFR/IFR) Night flying NIT (A) Instrument flying IR (A)	
Ratings to be extended	Type rating for Boeing B737 300-900 COPI	
Instrument flying ratings	Boeing B737 300-900 COPI, CAT III, valid till 21.07.2004	
Last proficiency check	10.06.2003	
Medical certificate	Class 1, valid till 18.10.2003; fit to fly, no restrictions	
Last medical examination	07.10.2002	

3 CRM: training in the effective use of all available resources, i.e. equipment, procedures and personnel, in order to ensure the safety and efficiency of the flight.

Flying experience	3779:10	hours in total
on powered aircraft	3779:10	hours
on the type involved in the accident	2377:25	hours
during the last 90 days	165:25	hours
the day preceding the accident	6:05	hours
the day of the accident	2:25	hours
Commencement of pilot training	1989	

1.5.2.1 Pilot training

The copilot began his aeronautical training in the USA in 1989. He then continued it in Switzerland and obtained the same year his professional pilot's licence with an instrument flying rating.

In summer 1995, he began his aeronautical career as a copilot employed by a charter company in Zurich and flew for four years on Cessna Citation and Dassault Falcon aircraft types.

In 1997, he successfully completed his theoretical training as an airline pilot. In November 1999, he was successful in an EasyJet Switzerland pilot selection process and qualified in January 2000 on the Boeing 737.

1.5.3 Cabin crew

Not involved.

1.5.4 Air traffic controller A

Function	INI North (INN) radar regional controller from 07:50 to 08:10 UTC
Personal data	Swiss citizen, born 1970
Licence	Air traffic controller licence issued by the FOCA on 2 November 1995, renewed on 13 September 2002, valid till 11 October 2003

1.5.5 Air traffic controller B

Functions	Radar regional controller, INN C coordinator from 07:30 UTC onwards
Personal data	Italian citizen, born 1972
Licence	Air traffic controller licence issued by the FOCA on 30 June 2000, renewed on 9 July 2003, valid till 20 June 2004

1.5.6 Air traffic controller C

Function	INN radar regional controller from 08:10 UTC onwards
Personal data	Canadian citizen, born 1962
Licence	Air traffic controller licence issued by the FOCA on 23 October 2001, renewed on 1 November 2002, valid till 11 October 2003

1.5.7 Air traffic controller D

Function	FINAL sector (FIN) radar approach controller from 07:00 UTC onwards
Personal data	Swiss citizen, born 1972
Licence	Air traffic controller licence issued by the FOCA on 15 November 1996, renewed on 14 October 2002, valid till 23 September 2003

1.5.8 Air traffic controller E

Function	DEPART sector (DEP) radar approach controller from 07:30 UTC onwards
Personal data	Swiss citizen, born 1971
Licence	Air traffic controller licence issued by the FOCA on 2 November 1995, renewed on 14 October 2002, valid till 27 September 2003

1.6 Aircraft information

1.6.1 Aircraft HB-III

1.6.1.1 General

Aircraft type	Boeing 737-33V
Manufacturer	The Boeing Company
Registration	HB-III
Serial number	29 338
Year of construction	1999
Owner	Lift EJ UK, LLC 1100 North Market Street, US-19890 Wilmington DE
Operator	EasyJet Switzerland S.A., CH-1215 Geneva 15
Certificate of airworthiness	FOCA, 26 July 1999, IFR CAT 3A, B-RNAV (RNP 5)
Registration certificate	26.07.1999
Airframe flying hours	12 814
Number of airframe cycles	11 165
Engines	2 CFM International CFM56-3CI (operated at A rating)
Wingspan	28.88 m
Length	32.18 m
Height	11.13 m
Wing surface area	105 m^2
Thrust per engine	20 000 lb
Range fully refuelled	2590 km

1.6.1.2 Engine No. 1

Serial number	860 151
Period of utilisation since manufacture [hrs:min]	12 495:37
Number of cycles since manufacture	10 902
Period of utilisation on HB-III [hrs:min]	10 618:15
Number of cycles on HB-III	9368

1.6.1.3 Engine No. 2

Serial number	860 152
Period of utilisation since manufacture [hrs:min]	12 688:01
Number of cycles since manufacture	11 059
Period of utilisation on HB-III [hrs:min]	8833:59
Number of cycles on HB-III	7790

1.6.1.4 Avionics

The aircraft was fitted with the following avionics equipment:

- dual electronic flight information system (EFIS)
- dual flight management system (FMS)
- dual inertial reference system (IRS)
- dual VHF navigation system
- dual distance measuring equipment (DME)
- dual automatic direction finding system (ADF)
- dual air data computer (ADC)
- dual radio altimeter (RADALT)
- dual VHF communication system
- HF communication system
- integrated audio system
- intercommunication system (INTERCOM)
- public address system (PA - passenger communication)
- weather radar system.

1.6.2 Mass and centre of gravity

The mass and centre of gravity data on departure from Geneva were as follows:

Total traffic load	10 568 kg	
Dry operating mass	33 317 kg	
Zero fuel mass actual	43 885 kg	max. 47 627 kg
Actual block fuel	7000 kg	
Take off fuel	6800 kg	
Take off mass actual	50 685 kg	max. 56 472 kg

Trip fuel	3600 kg	
Landing mass actual	47 085 kg	max. 40 142 kg
Dry operating index	42	
Loaded index at zero fuel mass	52.1	
Loaded index at take off mass	48.4	
Stabilizer setting for take off	4.3	nose up

The mass and centre of gravity were within the permitted limits.

1.6.3 Description of the weather radar on aircraft HB-III

1.6.3.1 Introduction

Among other things, the Honeywell RDR-4B onboard weather radar enables the electronic horizontal situation indicator to display the precipitation zones on either side of the line of flight. In WX mode, their intensity is represented by three colours against a black background: red, yellow and green for heavy, moderate and low precipitation respectively.

In WX/TURB mode, in addition to normal precipitation, the system displays precipitation which is accompanied by turbulence: when it detects a relative variation in the longitudinal speed of precipitation greater than or equal to 5 m/s, it displays this in magenta. The zones shown in this colour represent major turbulence.

MAP mode displays the ground as a function of its reflectivity, again using the colours red, yellow and green. It also makes it possible to identify coastlines, regions of mountains or valleys, cities or other major structures.

The scale of the radar image is that of the range selected for the EHSI. However, turbulence detection is automatically limited to a distance of 40 NM.

The weather radar consists mainly of the transceiver, the antenna (common to these two functions) located in the nose of the aircraft inside a radome, and the control unit. Its high frequency is in the X band (8 to 12 GHz) in order to ensure optimal reflectivity of water particles, to minimise atmospheric attenuation and to limit the dimensions of the antenna.

1.6.3.2 Transceiver

In the transmitting part of the radar’s transceiver, pulses at the nominal frequency of 9345 MHz, of short duration but very high energy, are generated and then transmitted to the antenna to be radiated. Only a low proportion of the emitted energy is reflected by raindrops then received by the antenna before being routed to the receiver and then the video processor. The latter processes these signals for display on the EHSI. The distance and direction of the precipitation zones are determined by the duration of the outward and return travel of the electromagnetic wave and the instantaneous direction of the antenna.

The receiver part of the transceiver compensates for the low amplitude of the signals reflected by distant targets with the aid of automatic sensitivity regulation.

1.6.3.3 Antenna

Unlike traditional parabolic antennas, the one fitted in aircraft HB-III is a flat-plate phased array. The conical characteristic of the emitted radar beam (a pencil beam) is elaborated in the antenna by means of a specific arrangement of small dipoles placed on the surface; the beam angle is 3.3°.

The azimuth radar sweep over the line of flight is obtained by oscillations of the antenna around the vertical axis which is stabilised independently of the aircraft's attitude.

Antenna stabilisation is controlled by the IRS (inertial reference system) and is limited to ±25° in pitch and ±40° in roll. The sweep plane in relation to the horizon (±15°) is adjustable using the *tilt* button located on the control panel.

1.6.3.4 Control panel

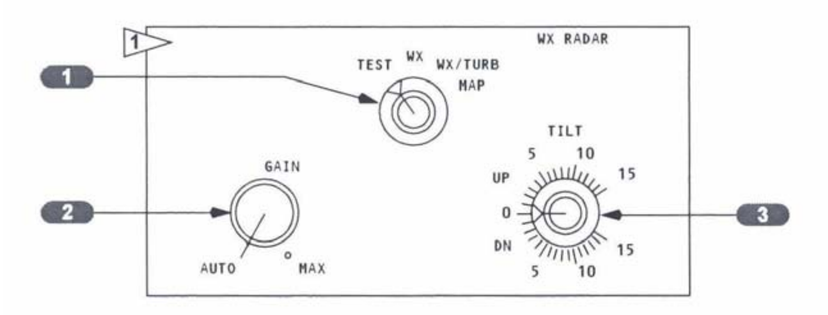


Fig. 1

There is only one control panel for the weather radar. It is located on the front of the central console and includes three control buttons, the functions of which are as follows:

(1) **Mode Selector** button, with four positions:

- TEST – the radar transmitter is triggered for a brief instant in order to check system operation; a test image is displayed on the EHSI, followed by confirmation of the test if it is conclusive.
- WX – displays the detected precipitation.
- WX/TURB – displays the precipitation and precipitation accompanied by turbulence; turbulence detection is limited automatically to a distance of 40 NM.
- MAP – displays the ground as a function of its reflectivity.

The selected mode is displayed in the upper right corner of the EHSI.

(2) **GAIN control** button: regulates amplification of the received signal. In the AUTO position this adjustment takes place automatically.

(3) **Tilt control** button: adjusts the sweep plane vertically in relation to the horizon (±15°).

1.6.3.5 EFIS control panel

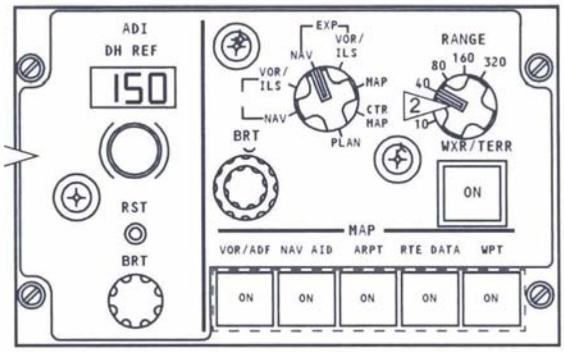


Fig. 2

Each pilot has an electronic flight information system (EFIS) control panel which is located on the central console.

The **RANGE** button selects the range of the EHSI and therefore the range of the weather radar. The possible options are 10, 20, 40, 80, 160 and 320 NM. Each of the pilots can independently select a range for his electronic horizontal situation indicator.

The weather radar display is switched on by means of the **WXR/TERR** pushbutton and is available for the EXP VOR/ILS, MAP, CTR MAP and NAV positions of the **RANGE** selector.

1.7 Meteorological information

1.7.1 General situation

A flat pressure pattern prevailed over central Europe. Moist, unstable air from the west was being transported towards Switzerland. A cold front was moving slowly from Germany towards the Alps and in the morning it was located in the northern region of the Alps. These masses of cold air moving south caused increased instability of the warm, moist air masses. Consequently, violent storms were already developing in the morning.

1.7.2 Weather conditions in the Oyonnax/F region at the time of the accident

According to the meteorological observations at Geneva airport, Ambérieu and Mâcon, as well as the radar and satellite images, the following weather conditions prevailed in the region of the accident:

- cloud cover:
  - 4-6 oktas, base approximately 10,000 ft AMSL
  - 2-4 oktas cumulonimbus, base between 6000-7000 ft AMSL, top approximately 40 000 ft AMSL
  - Cirrus
- weather: very isolated thunderstorms with heavy precipitation (hail)
- wind and temperature at 10 000 ft AMSL: 260 degrees, 20 kt, +05 °C
- wind and temperature at 14 000 ft AMSL: 260 degrees, 25 kt, -04 °C
- wind and temperature at 18 000 ft AMSL: 260 degrees, 30 kt, -13 °C

1.7.3 Hazardous weather phenomena

1.7.3.1 Thunderstorms

According to the Payerne radiosonde observation recorded at 00:00 UTC, a mass of extremely unstable air was situated in the area in question. In the thunderstorm cells, very strong updraughts favoured the formation of large hailstones.

On the MeteoSwiss radar image, in the region of Oyonnax, there appeared a thunderstorm cell of the greatest intensity, indicating the probability of heavy showers of hail.

1.7.3.2 Damage due to hail in the Oyonnax region

Synopsis of an article which appeared in the regional newspaper of the Ain département:

At the time of the accident, extremely violent thunderstorms accompanied by hail were observed at several locations. Major damage was reported in the villages of Condes, Dortan, Vescles and Arbent. According to eyewitnesses, the hailstones were as big as ping-pong balls (40 mm); some were even 50 mm in diameter. An angler, who was on the lake, suffered head injuries which needed treatment. A swan was even killed on this lake. A train was derailed because of trees falling on the track. In places, the roads were covered with a layer of hailstones up to 20 centimetres thick.

1.7.3.3 Size of the hailstones at the altitude of the aircraft at the time of the accident

The freezing level in the region of the accident was at an altitude of 3500 - 4000 m (11 500 – 13 000 ft). The localities in the Oyonnax region affected by the phenomenon are at elevations between 540 and 600 metres. The hailstones passed through a layer of a vertical extent of more than 3000 metres in which the temperature was above 0° C. As they passed through this layer, the hailstones melted slightly.

In the localities affected, the largest hailstones were between 40 and 50 millimetres in diameter. At the altitude of the aircraft, they must have been larger than 50 millimetres.

1.7.4 ATIS messages broadcast from Geneva

The content of the AUTOMATIC TERMINAL INFORMATION SERVICE (ATIS) message broadcast from 07:20 to 07:38 was as follows:

THIS IS GENEVA INFORMATION X-RAY

RUNWAY IN USE TWO THREE GRASS RUNWAY IN OPERATION FOR VFR TRAFFIC MET REPORT GENEVA ZERO SEVEN TWO ZERO VARIABLE THREE KNOTS VISIBILITY ONE ZERO KILOMETRES VICINITY SHOWERS FEW CB SEVEN THOUSAND FEET BROKEN NINER THOUSAND FEET BROKEN TWO ZERO THOUSAND FEET TEMPERATURE TWO ZERO DEW POINT ONE SIX QNH ONE ZERO ONE EIGHT QFE NINER SIX NINER NOSIG

TRANSITION LEVEL EIGHT ZERO

AIRMET ONE VALID BETWEEN ZERO SIX FOUR ZERO AND ZERO EIGHT FOUR ZERO SWITZERLAND FIR/UIR LINE OF THUNDERSTORM OBSERVED NORTH OF ALPS LINE BERN SAINT-GALLEN-ALTENRHEIN MOVING EAST SOUTH EAST NO CHANGE

GENEVA INFORMATION X-RAY"

The content of the ATIS message broadcast from 07:38 to 07:50 was as follows:

"THIS IS GENEVA INFORMATION YANKEE

RUNWAY IN USE TWO THREE GRASS RUNWAY IN OPERATION FOR VFR TRAFFIC MET REPORT GENEVA ZERO SEVEN TWO ZERO VARIABLE THREE KNOTS VISIBILITY ONE ZERO KILOMETRES VICINITY SHOWERS FEW CB SEVEN THOUSAND FEET BROKEN NINER THOUSAND FEET BROKEN TWO ZERO THOUSAND FEET TEMPERATURE TWO ZERO DEW POINT ONE SIX QNH ONE ZERO ONE EIGHT QFE NINER SIX NINER NOSIG

TRANSITION LEVEL EIGHT ZERO SPEED LIMITATION ACTIVE

AIRMET ONE VALID BETWEEN ZERO SIX FOUR ZERO AND ZERO EIGHT FOUR ZERO SWITZERLAND FIR/UIR LINE OF THUNDERSTORM OBSERVED NORTH OF ALPS LINE BERN SAINT-GALLEN-ALTENRHEIN MOVING EAST SOUTH EAST NO CHANGE

GENEVA INFORMATION YANKEE"

The content of the ATIS message broadcast from 07:50 to 08:20 was as follows:

"THIS IS GENEVA INFORMATION ZULU

RUNWAY IN USE TWO THREE GRASS RUNWAY IN OPERATION FOR VFR TRAFFIC

MET REPORT GENEVA ZERO SEVEN FIVE ZERO VARIABLE THREE KNOTS VISIBILITY ONE ZERO KILOMETRES FEW FOUR THOUSAND FEET SCATTERED NINER THOUSAND FEET BROKEN TWO ZERO THOUSAND FEET TEMPERATURE TWO ZERO DEW POINT ONE SEVEN QNH ONE ZERO ONE SEVEN QFE NINER SIX EIGHT NOSIG

TRANSITION LEVEL EIGHT ZERO SPEED LIMITATION ACTIVE

AIRMET ONE VALID BETWEEN ZERO SIX FOUR ZERO AND ZERO EIGHT FOUR ZERO SWITZERLAND FIR/UIR LINE OF THUNDERSTORM OBSERVED NORTH OF ALPS LINE BERN SAINT-GALLEN-ALTENRHEIN MOVING EAST SOUTH EAST NO CHANGE

GENEVA INFORMATION ZULU"

1.7.5 Meteorological information, forecasts and warnings

1.7.5.1 Meteorological observations (METAR), Geneva airport

150720Z VRB03KT 9999 VCSH FEW070CB BKN090 BKN200 20/16 Q1018 NOSIG

150750Z VRB03KT 9999 FEW040 SCT090 BKN200 20/17 Q1017 NOSIG

150820Z VRB03KT 9999 –SHRA FEW030 FEW060CB BKN100 20/17 Q1017 TEMPO 30010G20KT TSRA

1.7.5.2 Terminal aerodrome forecasts (TAF), Geneva airport

150300Z 150413 25007KT 9999 FEW050 SCT100 BKN200 PROB30 TEMPO 0413 8000 SHRA FEW050CB BKN050 PROB30 TEMPO 0413VRB15G30KT 5000 TSRA SCT020 BKN040CB=

150600Z 150716 25007KT 9999 SCT060 BKN100 PROB40 TEMPO 0716 8000 SHRA SCT060CB BKN080 PROB30 TEMPO 0716 VRB15G30KT 5000 TSRA SCT050CB BKN070=

1.7.5.3 Weather reports possibly affecting safety

AIRMET 1 VALID BTN 0640 AND 0840

SWITZERLAND FIR UIR LINE OF TS OBS N OF ALPS LINE LSZB LSZR MOV ESE NC=

LFFF SIGMET SST 1 VALID 150300/150500 LFPW-

UIR FRANCE ISOL CB OBS/FCST BLW FL340 E OF O3E N OF 45N AND S OF 50N MOV E 10 KT NC=

LFFF SIGMET SST 2 VALID 150500/150700 LFPW-

UIR FRANCE ISOL LOC OCNL CB OBS/FCST BLW FL380 E OF 05E N OF 44N AND S OF 50N MOV E 10 KT NC=

1.7.5.4 Warning of electrical discharges provided by the Geneva aerodrome meteorological office

15 August 2003, 03:25 UTC:

Warning of electrical discharges[4] associated with thunderstorms in the region of Geneva airport. Widespread thunderstorms.

Comment/remark: Extension of warning. A line of thunderstorms centred on a line Bellegarde-Ambérieu is moving east.

15 August 2003, 08:10 UTC:

Warning of electrical discharges associated with thunderstorms in the region of Geneva airport. Isolated thunderstorms.

Comment/remark: Broad echo of thunderstorms on the Valserine moving east.

1.7.6 Flight dossier

Flight dossier, provided by the Nice aerodrome meteorological office:

TEMSI BETWEEN SFC AND FL450, VALID FOR 15/08/2003 AT 06 UTC:

Data shown on the chart for the region of the accident: *SCT-BKN LYR, BASE 020-080, TOP 070-300, LOC RAIN* (see Annex 2)

1.7.7 Radar image

On the radar image of the station of La Dôle (MeteoSwiss) the thunderstorm activity in the Oyonnax region appears with the highest intensity (see Annex 3).

The recordings at the source of the ATC radar data show the same situation (see Annex 4).

The MeteoSwiss radar images were at the disposal of crews in the office of the Geneva aerodrome meteorological office.

[4] These warnings of electrical discharges are issued mainly to warn personnel working within the airport perimeter.

1.8 Aids to navigation

The air navigation aids used are DVOR/DME Geneva (GVA) and DVOR/DME Passeiry (PAS). In both cases, these are Doppler-effect omnidirectional beacons. Both are also equipped with distance measuring equipment (DME).

Air navigation aid	DVOR/DME GVA
Geographical position	46° 15' 14 10" N, 006° 07' 55 98" E
Elevation	1377 ft AMSL
Designated operational coverage (DOC) area	80 NM/50 000 ft
Frequency	DVOR 114.60 MHz (at the time of the accident), DME channel 93X
Period of operation	24 hours

Air navigation aid	DVOR/DME PAS
Geographical position	46° 09' 49 3" N, 005° 59' 59 7" E
Elevation	1415 ft AMSL
Designated operational coverage area	80 NM/50 000 ft
Frequency	DVOR 116.60 MHz, DME channel 113X
Period of operation	24 hours
Air navigation aid	ILS05 LLZ CAT I
Geographical position	46° 15' 05 27" N, 006° 07' 43 05" E
Frequency	110.90 MHz ID INE
Note	On 15 August 2003 between 08:09:00 UTC and 09:40:00 UTC, there was a failure of localizer 05 and the ILS was therefore out of order. The monitor input attenuator was defective.

1.9 Communication

1.9.1 Air traffic control units involved

1.9.1.1 General

ATC unit	Code	Frequency
Swiss Radar INI North	INN	134.025 MHz
Geneva Departure	DEP	121.300 MHz
Geneva FINAL	FIN	120.300 MHz
Geneva Tower	TWR	118.700 MHz

At the time of the accident, the Swiss Radar INI North frequency (134.025 MHz) was coupled with the INI EAST frequency (128.900 MHz).

1.9.1.2 Organisation of the Geneva Control Centre

The GENEVA ATC area of responsibility (AoR) is divided into two logical ATC units:

- UPPER AREA CONTROL CENTER (UAC) SWITZERLAND / WEST
- TERMINAL CONTROL CENTRE GENEVA (TCG)

UAC SWITZERLAND is responsible for providing ATC services in the UIR SWITZERLAND above FL 295.

ATS services for the TCG area and the UAC SWITZERLAND / WEST area are provided by one operational unit, designated GENEVA ATC.

The TCG unit is responsible for providing ATS services within the limits of the area defined in the Swiss AIP (section ENR 2) up to FL295.

Four control units handle air traffic control.

Each unit is subdivided into sectors as follows:

UNIT I	T: "TERMINAL"	SECTOR INI NORTH	Up to FL 264
		SECTOR INI EAST	Up to FL 264
		SECTOR INI SOUTH	Up to FL 264
UNIT II	E: "EN ROUTE"	MOLUS 3	FL 265 to FL 314
		MILPA 3	FL 265 to FL 314
UNIT III	E: "EN ROUTE"	MOLUS 4	FL 315 to FL 354
		MILPA 4	FL 315 to FL 354
UNIT IV	U: "UPPER"	MOLUS 5	FL 355 to FL 620
		MILPA 5	FL 355 to FL 620

Physically, the sectors INI North, East and South are located in the first unit of the TCG, situated in the North section of the Geneva Control Centre. INI North occupies the positions on the left within the unit, INI South the central positions and INI East the positions on the right.

1.9.1.3 Geneva Terminal Control Centre

Unit TCG: Control Tower (TWR) / Intermediate Approach (INT) / Initial Approach (INI) performs on a permanent basis (24 hours) the tasks assigned to it, whatever the operational status of the airport.

The INT control unit comprises 3 functions (DEP, APC, ARR).

These functions are spread over 5 workstations (DPC, DEP, APC, PRE, FIN), according to the time of day.

When a workstation is not occupied, its tasks are distributed among the occupants of the other workstations according to the workload at the time.

The occupant of each workstation performs the tasks assigned to him in accordance with the published regulations and using the instruments available to him.

The Approach supervisor is the most experienced controller present on the duty shift of the INT service. His tasks are delegated by the TWR supervisor (STR); the latter carries out his activity in the Control Tower building.

1.9.2 Recordings of conversations

The following TWR – APP – ACC data are continuously recorded by a digital recording system and are backed up onto DDS-format digital audio tape:

- all the VHF radio channels used; in addition, recording equipment is installed in the APP, ADC and INI sectors for recordings of short duration;
- all the cabled links between the workstations;
- all the telephone conversations taking place at the workstations;
- radiotelephone links with the police and rescue services.

Ambient conversations are not recorded in the radar room and in the tower observation room.

1.9.3 Communication systems

At the time of the accident, the TWR, APP and INI recordings and the systems management log (SYMA) do not mention any failure or fault in the ATC communication systems. The same applies to all internal links (intercom, telephone) within the air traffic control service.

1.10 Aerodrome information

1.10.1 General

Geneva airport is located at the western end of Switzerland. In 2002, the air navigation services company – Skyguide – handled a traffic volume of 143 470 landings and take-offs under instrument flight (IFR) rules.

1.10.2 Runway equipment

The data concerning the runway at Geneva international airport are as follows:

A single runway 23/05, 3900 x 50 m, reference elevation 1411 ft AMSL, geographical position 46°14´17"N, 006°06´32"E.

ILS23-LLZ CATIII / ILS05-LLZ CATI.

Runway 23 take-off run available - TORA 3900 m / landing distance available - LDA 3900 m

Runway 05 TORA 3900 m / LDA 3570 m

1.10.3 Operating regulations

Choice of the runway in operation:

Runway 23: wind calm or from the SW
Runway 05: wind predominantly from the NE

Deviations are authorised for the following reasons:

- safety measures;
- measures to improve traffic flow;
- noise abatement measures;
- particular weather conditions (storms).

The TWR may authorise movement on the opposed runway to the runway in operation, in so far as such a trajectory enables flight time and nuisance to be reduced.

1.10.4 Rescue and fire-fighting services

Geneva airport is equipped with category 9 fire-fighting resources in accordance with ICAO Annex 14. The airport's professional fire brigade is on duty 24 hours a day. In the event of an accident, the intervention forces are able to remain in permanent contact with the control tower and with the police thanks to the alarm centre and appropriate telecommunications equipment.

A paramedic section is integrated into the rescue and fire-fighting services; it is equipped with vehicles and qualified personnel and is also on duty 24 hours a day. The paramedic section has an advanced medical facility. It is permanently connected to the emergency paramedic exchange 144.

The entirety of Geneva International Airport's emergency plan is integrated into the cantonal system known as OSIRIS (organisation for intervention in exceptional situations).

1.11 Flight recorders

1.11.1 Digital flight data recorder (DFDR)

1.11.1.1 Technical description

The onboard recording system includes a digital flight data acquisition unit (DFDAU), a solid-state flight data recorder (SSFDR) and a tri-axial accelerometer.

The DFDAU is programmed to acquire data from the aircraft's various systems and sensors in a predefined order and to then transmit them to the SSFDR. All the data, analogue or digital, are converted by this module into a uniform format, then recorded digitally in the SSFDR in a predefined sequence.

The recorded parameters include the display types as well as the selected ranges on the EHSI (see Annex 5).

1.11.2 Cockpit voice recorder (CVR)

1.11.2.1 Technical description

The audio signals sent and received via the VHF equipment and the intercom conversations inside the cockpit are recorded automatically by the cockpit voice recorder (CVR). In addition, a cockpit area microphone (CAM) records the voices and noises inside the cockpit.

Aircraft HB-III was equipped with a solid-state cockpit voice recorder (SSCVR).

1.11.2.2 Recorder condition and read-out

The recorder was in perfect condition; the recordings could be used in their totality.

1.12 Wrackage and impact information

Not applicable.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

Fire did not break out.

1.15 Survival aspects

The damage suffered by the aircraft was considerable but not irremediable. The windscreens were cracked but not shattered, engine operation was not adversely affected and the lift surfaces and controls were not affected to the extent that they influenced control of the aircraft.

1.16 Test and research

Not applicable.

1.17 Organisational and management information

1.17.1 Airline company - EasyJet Switzerland

1.17.1.1 General

EasyJet Switzerland is part of the EasyJet group, known as one of the leading low-cost carriers in Europe. The first EasyJet aircraft took off in November 1995 and since then the company has enjoyed growth which has resulted today in the operation of a network consisting of more than 150 routes serving some forty European destinations (as of October 2003).

The company's development has been partly due to the acquisition of European airlines, such as the Basle charter company TEA Basel AG, absorbed by EasyJet in 1999; on 1 April 1999, it became the Swiss company EasyJet Switzerland S.A., based in Geneva. This company benefited from the authorisation issued by the FOCA to operate under JAR-OPS 1 and maintained the existing operation of TEA's five Boeing 737 aircraft. From August 2003, these aircraft were replaced in a short period of time by Airbus A319 aircraft.

1.17.1.2 Operational regulations

Regulations concerning operation in difficult weather conditions which represent a potential hazard.

The operating rules are defined in the EasyJet Switzerland operating manual OM Part A. At the time of the accident, the following regulations, among others, were applicable:

"Chapter 8.3.8 ADVERSE AND POTENTIALLY HAZARDOUS ATMOSPHERIC CONDITIONS

(...)

Air Traffic Control Considerations:

A Pilot intending to detour round observed weather when in receipt of an Air Traffic Service which involved ATC responsibility for separation, should obtain clearance from or notify ATC so that separation from other aircraft can be maintained. If for any reason the Pilot is unable to contact ATC to inform about his intended action, any manoeuvre should be limited to the extent necessary to avoid immediate danger and ATC must be informed as soon as possible;

- *Take-off and Landing*
  - *The take-off, initial climb, final approach and landing phases of flight in the vicinity of thunderstorms may present the Pilot with additional problems because of the aircraft's proximity to the ground and the maintenance of a safe flight path in these phases can be very difficult*
  - *Do not take-off if a thunderstorm is overhead or approaching;*

- *At destination hold clear if a thunderstorm is overhead or approaching. Divert if necessary;*
- *Avoid severe thunderstorms even at the cost of diversion or an intermediate landing. If avoidance is impossible, the procedures recommended in these paragraphs should be followed;*

Use of Weather radar – Guidance to Pilots

Flight Altitude (ftx1000)	*Echo Characteristics*			
	Shape	*Intensity*	*Gradient of intensity**	*Rate of change*
0-20	*Avoid by 10 miles echoes with hooks fingers, scalloped edges or other protrusions*	*Avoid by 5 miles echoes with sharp edges or strong intensities*	*Avoid by 5 miles echoes with strong gradients of intensity*	*Avoid by 10 miles echoes showing rapid change of shape, height or intensity*
20-25	*Avoid all echoes by 10 miles*			
25-30	*Avoid all echoes by 15 miles*			
ABOVE 30	*Avoid all echoes by 20 miles*			

Applicable to sets with Iso-Echo or a colour display. Iso-Echo produces a hole in a strong echo when the returned signal is above pre-set value. Where the return around a hole is narrow, there is a strong gradient of intensity.

NOTE:

1. *Storm clouds have to be overflown, always maintain at least 5000 ft vertical separation from cloud tops. It is difficult to estimate this separation but ATC or MET information on the altitude of the tops may be available for guidance.*
2. *The aircraft is not equipped with radar or it is inoperative, avoid by 10 miles any storm that by visual inspection is tall, growing rapidly or has an anvil top.*
3. *Intermittently monitor long ranges on radar to avoid getting into situations where no alternative remains but the penetration of hazardous areas.*
4. *Avoid flying under a cumulo-nimbus overhang. If such flight cannot be avoided tilt antenna full up occasionally to determine, if possible, whether precipitation (which may be hail) exists or is falling from the overhang.*

(...)"

1.17.2 Temporary aeronautical services company - PARC Aviation

1.17.2.1 General

The PARC Aviation company, headquartered in Dublin, is a division of the PARC Group, which since 1975 has specialised in placing qualified personnel in various areas of professional activity. It is divided into four sectors: flight crew, training, maintenance and consultancy.

Throughout the summer of 2003, EasyJet Switzerland used the services of this company to employ pilots on a temporary basis, within the framework of the programme to replace its Boeing 737 fleet by Airbus A319 aircraft. The commander of the aircraft involved in the accident was one of the pilots recruited on this occasion to overcome the shortage of flight crews caused by regular pilots attending training courses for the new aircraft type.

1.17.2.2 Selection procedure

PARC Aviation employs retired pilots and airlines pilots who are temporary leave from their full time job, as well as experienced pilots from airlines which have ceased activity.

An application is considered if it includes at least a curriculum vitae accompanied by documents attesting existing professional experience to a certain level, along with references from at least two previous employers. It is then examined and assessed by specialists who may request clarifications or complementary information from the candidate as well as the mentioned professional references.

When an airline has recourse to the services of PARC Aviation, it receives one or more pilot dossiers which meet the requirements for the position or positions to be filled; it may subsequently consult all the documents relating to the selected candidates and generally subjects them to additional tests on a flight simulator.

1.17.3 Air navigation service provider - Skyguide

1.17.3.1 General

In Switzerland, the Skyguide company is responsible for organising and providing air traffic control within Swiss airspace and foreign airspace for which the air navigation services have been delegated to Switzerland.

The Skyguide company evolved out of Swisscontrol on 1 January 2001. The Swisscontrol company was a limited company under private swiss law. Since 1996, the management of finances became independent from the Swiss Confederation.

1.17.3.2 INI North control sector

Four control units handle air traffic control and are staffed by controllers. Each unit is subdivided into sectors. Unit I "Terminal" consists of sectors INI North, INI East and INI South.

Each control sector is in principle staffed by two controllers, a radar controller (R) and a coordinator (C). These positions must be permanently occupied.

For operational reasons, for example, in the case of low volumes of traffic, the control sectors may be grouped together at certain positions.

1.17.3.3 Approach control sector

Take-off and landing control is managed within Approach control (APP). At Geneva airport, depending on the traffic volume, incoming traffic is handled by two control positions, Presequence control (PRE) and Final control (FIN). The totality of the “PRESEQUENCE” and “FINAL” positions constitutes the “ARRIVAL” (ARR) position. Outgoing traffic is managed by a single control position, Departure Control (DEP).

The FINAL controller is responsible, where applicable, for the control of aircraft in difficulty. At the time of the accident, the FIN control position was activated to provide control for the aircraft in distress.

1.17.4 Meteorological service provider - MeteoSwiss

1.17.4.1 General

MeteoSwiss, the Federal Office of Meteorology and Climatology, reports directly to the head of the Federal Department of Home Affairs (FDHA). The federal law on meteorology and climatology assigns it various public service tasks. In particular, it is responsible for providing weather information for flight operations and air navigation services over Swiss territory.

According to the ordinance of 18 December 1995 on the air traffic control service (OSNA), MeteoSwiss provides the meteorological service for civil aviation and is also the meteorological authority as defined in ICAO Annex 3. The Department of the Environment, Transport, Energy and Communications (DETEC) defines the conditions with the agreement of the FDHA.

The tasks of MeteoSwiss in the aviation sector are specified in the ordinance dated 26 May 1999 on the aeronautical meteorological service for civil aviation. Supervision of the provision of this service is the responsibility of the FOCA.

1.17.4.2 Organisation of the aeronautical meteorological service

At the time of its reorganisation in 1998, MeteoSwiss was provided with a “process-based” structure. The activities of the three divisions – Weather, Climate and Assistance – are supported by centres of competence and coordinating bodies.

The aeronautical meteorological process is integrated into the Weather division. It fulfils the functions of the aeronautical meteorological service over the entirety of Swiss territory in accordance with the standards and recommendations of the World Meteorological Organisation (WMO) and the ICAO.

1.17.4.3 The aeronautical meteorological service at Geneva airport

The activities of Geneva airport’s meteorological service are performed by an information unit and an observation unit. The operational centre’s information centre is staffed from 04:45 to 22:15 LT and the observation station is staffed 24 hours a day.

The main products of the information centre are:

- meteorological data for flight planning;
- customised information services;
- dissemination of local hazard warnings concerning airports (storms, thunderstorms, electrical discharges).

The task of the observation station is to continuously monitor the evolution of the weather at Geneva airport. It disseminates meteorological observation messages for aviation every 30 minutes in the METAR and QAM[5] codes. In the event of a significant change between two dissemination intervals, a special message is disseminated to the various airport services.

The observation station is located in the north-east sector of the airport. Meteorological parameters are recorded on the basis of visual observations and readings from the instruments installed on the airport perimeter and in its vicinity. Apart from the classical measuring instruments, for example thermometers, hygrometers, barometers and anemometers, the following equipment is also used:

[5] QAM: periodical local weather observation message, destined for dissemination to the concerned aerodrome

- three transmissometers distributed along the runway to determine the runway visual range;
- two ceilometers, to determine the height of the cloud ceiling;
- lightning detectors.

1.17.5 Standards and recommendations of the international civil aviation organisation ICAO

The arrangements governing processing of meteorological information transmitted by pilots (*pilots' reports* – PIREP) and hazard bulletins (*significant met report* – SIGMET) are described in document 4444 PANS-ATM and in Annex 3 of the ICAO standards and recommendations.

"ICAO Doc. 4444-ATM and Annexe 3

Air-report. *A report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting.*

11.4.3.2 MESSAGES CONTAINING METEOROLOGICAL INFORMATION

Note.— Provisions governing the making and reporting of aircraft observations are contained in Annex 3. Provisions concerning the contents and transmission of air-reports are contained in Chapter 4, Section 4.12 of this document, and the special air-report of volcanic activity form used for reports of volcanic activity is shown in Appendix 1 to this document. The transmission by ATS units, to meteorological offices, of meteorological information received from aircraft in flight is governed by provisions in Chapter 4, Section 4.12.6 of this document.

Provisions governing the transmission by ATS units of meteorological information to aircraft are set forth in Annex 11, 4.2 and in this document (see Chapter 4, 4.8.3 and 4.10.4; Chapter 6, Sections 6.4 and 6.6; Chapter 7, 7.3.1; and Chapter 9, 9.1.3). The written forms of SIGMET and AIRMET messages and other plain language meteorological messages are governed by the provisions of Annex 3.

4.12 REPORTING OF OPERATIONAL AND METEOROLOGICAL INFORMATION

4.12.1 General

4.12.1.1 When operational and/or routine meteorological information is to be reported by an aircraft en route at points or times where position reports are required in accordance with 4.11.1.1 and 4.11.1.2, the position report shall be given in the form of a routine air-report. Special aircraft observations shall be reported as special air-reports. All air-reports shall be reported as soon as is practicable.

4.12.3 Contents of special air-reports

4.12.3.1 Special air-reports shall be made by all aircraft whenever the following conditions are encountered or observed:

a) severe turbulence; or

b) severe icing; or

c) severe mountain wave; or

d) thunderstorms, without hail that are obscured,

embedded, widespread or in squall-lines; or

e) thunderstorms, with hail that are obscured, embedded,

widespread or in squall-lines; or

f) heavy dust storm or heavy sandstorm; or

g) volcanic ash cloud; or

h) pre-eruption volcanic activity or a volcanic eruption.

4.12.6 Forwarding of meteorological information

4.12.6.3 When receiving air-reports by voice communications, air traffic services units shall forward them without delay to their associated meteorological watch offices. In the case of routine air-reports which contain a Section 3, the air traffic services unit shall forward Section 1, sub-items 1 to 3 and Section 3.

6.4 INFORMATION FOR DEPARTING AIRCRAFT

Note.— See Chapter 11, 11.4.3, regarding flight information messages.

6.4.1 Meteorological conditions

Information regarding significant changes in the meteorological conditions in the take-off or climb-out area, obtained by the unit providing approach control service after a departing aircraft has established communication with such unit, shall be transmitted to the aircraft without delay, except when it is known that the aircraft already has received the information.

Note.— Significant changes in this context include those relating to surface wind direction or speed, visibility, runway visual range or air temperature (for turbine-engined aircraft), and the occurrence of thunderstorm or cumulonimbus, moderate or severe turbulence, wind shear, hail, moderate or severe icing, severe squall line, freezing precipitation, severe mountain waves, sand storm, dust storm, blowing snow, tornado or waterspout. (…)

7.3 INFORMATION TO AIRCRAFT BY AERODROME CONTROL TOWERS

7.3.1 Information related to the operation of aircraft

7.3.1.2.2 Prior to take-off aircraft shall be advised of:

a) any significant changes in the surface wind direction and speed, the air temperature, and the visibility or RVR value(s) given in accordance with 7.3.1.2.1;

b) significant meteorological conditions in the take-off and climb-out area, except when it is known that the information has already been received by the aircraft.

Note.— Significant meteorological conditions in this context include the occurrence or expected occurrence of cumulonimbus or thunderstorm, moderate or severe turbulence, wind shear, hail, moderate or severe icing, severe squall line, freezing precipitation, severe mountain waves, sand storm, dust storm, blowing snow, tornado or waterspout in the take-off and climb-out area.

8.6.9 Information regarding adverse weather

8.6.9.1 Information that an aircraft appears likely to penetrate an area of adverse weather should be issued in sufficient time to permit the pilot to decide on an appropriate course of action, including that of requesting advice on how best to circumnavigate the adverse weather area, if so desired.

Note.— Depending on the capabilities of the radar system, areas of adverse weather may not be presented on the radar display. An aircraft's weather radar will normally provide better detection and definition of adverse weather than radar sensors in use by ATS.

8.6.9.2 In vectoring an aircraft for circumnavigating any area of adverse weather, the radar controller should ascertain that the aircraft can be returned to its intended or assigned flight path within the available radar coverage, and, if this does not appear possible, inform the pilot of the circumstances.

Note.— Attention must be given to the fact that under certain circumstances the *most active area of adverse weather may not show on a radar display.*

8.6.10 Reporting of significant meteorological information to meteorological offices

Although a radar controller is not required to keep a special watch for storm detection, etc., information on the position, intensity, extent and movement of significant weather (i.e. storms or well-defined frontal surfaces) as observed on radar displays, should, when practicable, be reported to the associated meteorological office.

11.4.3 Flight information messages

11.4.3.2 MESSAGES CONTAINING METEOROLOGICAL INFORMATION

Note.— Provisions governing the making and reporting of aircraft observations are contained in Annex 3. Provisions concerning the contents and transmission of air-reports are contained in Chapter 4, Section 4.12 of this document, and the special air-report of volcanic activity form used for reports of volcanic activity is shown in Appendix 1 to this document. The transmission by ATS units, to meteorological offices, of meteorological information received from aircraft in flight is governed by provisions in Chapter 4, Section 4.12.6 of this document. Provisions governing the transmission by ATS units of meteorological information to aircraft are set forth in Annex 11, 4.2 and in this document (see Chapter 4, 4.8.3 and 4.10.4; Chapter 6, Sections 6.4 and 6.6; Chapter 7, 7.3.1; and Chapter 9, 9.1.3). The written forms of SIGMET and AIRMET messages and other plain language meteorological messages are governed by the provisions of Annex 3.

APPENDIX 1. INSTRUCTIONS FOR AIR-REPORTING BY VOICE COMMUNICATIONS

1. Reporting instructions

2. Special air-report of volcanic activity form (Model VAR)

3. Examples

4. Forwarding of meteorological information received by voice communications

4.1 When receiving routine or special air-reports, air traffic services units shall forward these air-reports without delay to the associated meteorological watch office (MWO). In order to ensure assimilation of air-reports in groundbased automated systems, the elements of such reports shall be transmitted using the data conventions specified below and in the order prescribed.

End PANS-ATM

ANNEXE 3 to the CICA: Meteorological Service for International Air Navigation

CHAPTER 5. AIRCRAFT OBSERVATIONS AND REPORTS

5.1 Obligations of States

Each Contracting State shall arrange, according to the provisions of this chapter, for observations to be made by aircraft of its registry operating on international air routes and for the recording and reporting of these observations.

5.5 Special aircraft observations

Special observations shall be made by all aircraft whenever the following conditions are encountered or observed:

a) severe turbulence; or

b) severe icing; or

c) severe mountain wave; or

d) thunderstorms, without hail, that are obscured, *embedded, widespread or in squall lines; or*

e) thunderstorms, with hail, that are obscured, embedded,

widespread or in squall lines; or

f) heavy duststorm or heavy sandstorm; or

g) volcanic ash cloud; or

h) pre-eruption volcanic activity or a volcanic eruption.

5.7 Reporting of aircraft observations during flight

5.7.1 Aircraft observations shall be reported by airground data link. Where air-ground data link is not available or appropriate, aircraft observations during flight shall be reported by voice communications.

5.7.2 Aircraft observations shall be reported during flight at the time the observation is made or as soon thereafter as is practicable.

5.7.3 Aircraft observations shall be reported as air-reports.

5.8 Relay of air-reports by ATS units

The meteorological authority concerned shall make arrangements with the appropriate ATS authority to ensure that, on receipt by the ATS units of:

a) routine and special air-reports by voice communications, the ATS units relay them without delay to their associated meteorological watch office;

b) routine air-reports by data link communications, the ATS units relay them without delay to WAFCs; and

c) special air-reports by data link communications, the ATS units relay them without delay to their associated meteorological watch office and WAFCs.

7.1 SIGMET information

7.1.1 SIGMET information shall be issued by a meteorological watch office and shall give a concise description in abbreviated plain language concerning the occurrence and/or expected occurrence of specified en-route weather phenomena, which may affect the safety of aircraft operations, and of the development of those phenomena in time and space.

7.1.2 SIGMET information shall be cancelled when the phenomena are no longer occurring or are no longer expected to occur in the area.

7.1.3 The period of validity of a SIGMET message shall be not more than 6 hours, and preferably not more than 4 hours.

7.2 AIRMET information

7.2.1 AIRMET information shall be issued by a meteorological watch office in accordance with regional air navigation agreement, taking into account the density of air traffic operating below flight level 100. AIRMET information shall give a concise description in abbreviated plain language concerning the occurrence and/or expected occurrence of specified en-route weather phenomena, which have not been included in Section I of the area forecast for low-level flights issued in accordance with Chapter 6, Section 6.6 and which may affect the safety of low-level flights, and of the development of those phenomena in time and space.

7.2.2 AIRMET information shall be cancelled when the phenomena are no longer occurring or are no longer expected to occur in the area.

7.2.3 The period of validity of an AIRMET message shall be not more than 6 hours, and preferably not more than 4 hours.

1.18 Additional information

1.18.1 Standard instrument departure (SID) DIPIR 1A

At the time of the accident, the standard instrument departure (SID) published in the Swiss AIP was the following (see Annex 6):

DIPIR1A: *Procedure Design Gradient 6.5 % to 7000 ft. Climb on R226 GVA (R046 PAS). When passing 7000 ft but not before D8 GVA (PAS), turn right to intercept R331 PAS via KELUK to DIPIR. Initial CMB CLR FL90.*

Notes: - Flights via DJL CLR FL200 or above: cross D25 DJL at MNM FL200.

- Flights via LERDU and ARBOS: cross LERDU at MNM FL200.

SID DIPIR is used for LSGG departures from runway 23, the exit points are DJL and ARBOS.

Sector INI North re-clears the aircraft at the exit point and assigns it a flight level.

1.18.2 Display of thunderstorm cells by weather radar

Weather radar operates on the same principle as typical air navigation surveillance radars, except that instead of detecting aircraft it is designed to detect precipitation, calculate its movement and determine its type. To this end, an antenna emits a beam of electromagnetic waves and in this way locates the presence and concentration of water particles, liquid or solid, falling or in suspension in the atmosphere (for example: rain, hail).

1.18.2.1 Radar backscatter of rain and hail

Among other things, these particles cause backscattering of the electromagnetic radiation emitted by the radar antenna, i.e. scattering in the opposite direction to emission; this phenomenon constitutes the physical basis of the process of radar detection of precipitation.

For a target located entirely within the radiation emitted by the antenna, the intensity of the reflected signal is given by the radar cross section (RCS) of this target. This depends on the geometry and material characteristics of the target, as well as on the radar frequency.

In a cloud, targets consist of raindrops and hailstones; in this case the signal intensity is defined by the concept of reflectivity, i.e. approximately the sum of the RCS of each particle of liquid and solid water in the volume of a radar cell[6]. Raindrops and hail can be modelled by dielectric spheres and their RCS calculated using the general theory of scattering of electromagnetic waves by Mie particles[7]. Considering the data shown in tables 1 and 2, the radar cross section of raindrops and hailstones are determined in relation to their diameter.

---

[6] Characteristic of the radar which corresponds to the product of the solid angle of the antenna beam and the pulse length (d = c x T / 2)

[7] Mie, G.: Beiträge zur Optik trüber Medien, speziell kolloidaler Metallösungen, Annalen der Physik, 25, 1908, p377ff.

Diameter of a raindrop	0.1 mm to 1 cm
Diameter of a hailstone	1 mm to 3 cm
Onboard radar frequency (X band)	9.4 GHz (3.2 cm wavelength)
MeteoSwiss weather radar frequency (C band)	5.4 GHz (5.6 cm wavelength)
Geneva Approach primary radar (S band) frequency	2.8 GHz (10.7 cm wavelength)

Table 1 Parameters for calculation of Mie scattering for different radar systems

	Water (at 0 °C)		Ice (at 0 °C)	
	ε	**n**	ε	**N**
9.4 GHz	44.5 - 50.0 i	7.25 - 2.83 i	3.19 - 0.0009 i	1.79 - 0.0003 i
5.4 GHz	65.7 - 36.4 i	8.39 - 2.17 i	3.19 - 0.0006 i	1.79 - 0.0002 i
3.2 GHz	78.4 - 23.2 i	8.97 - 1.46 i	3.19 - 0.0005 i	1.79 - 0.0001 i

Table 2 Dielectric characteristics: the complex permittivity **ε** and the complex refractive index **n** depend on materials, frequency and temperature

Table 1 shows that RCS generally increase with particle diameter. More precisely, for particles whose size is much smaller than the wavelength, the RCS is proportional to the 6^{th} power of target diameter (D^6) and the 4^{th} power of frequency. When a given quantity of water observed in a radar cell is distributed in a number N of drops, N is inversely proportional to the cubic power of diameter (D^3). The net effect of an increase in diameter is that the increase in the RCS dominates over the reduction in N.

For the special case of diameters smaller than 1 cm, the RCS increases with frequency: reflection is greatest for an onboard radar (9.4 GHz); it reduces for ground-based weather radar (5.4 GHz) and is lowest for ATC radar (2.8 GHz).

The table also reveals that the RCS is higher for raindrops than for hailstones of the same size. However, hailstones may attain greater dimensions than raindrops and their reflectivity is therefore also increased.

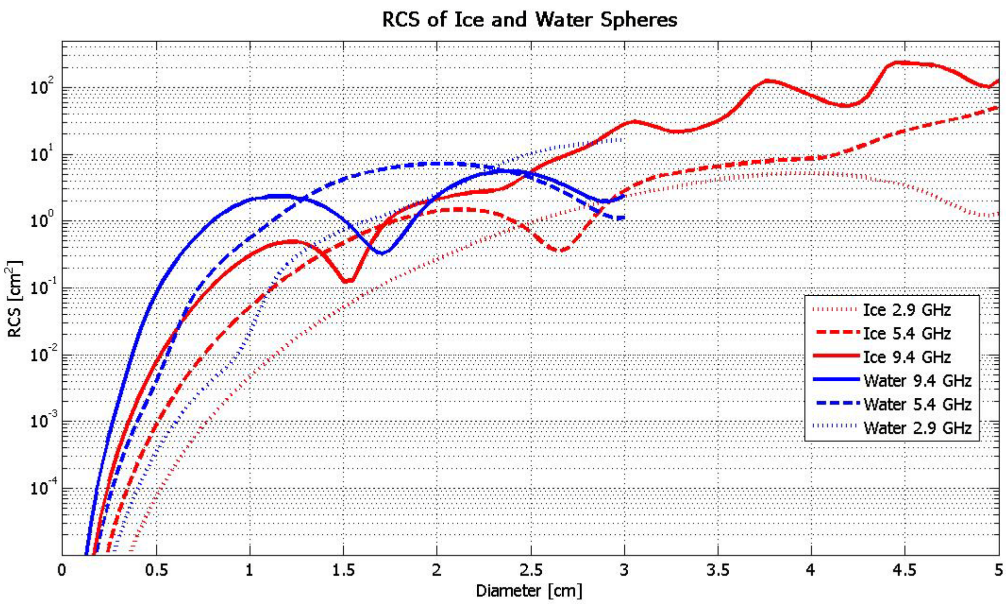


Fig. 3 RCS of water droplets and hailstones as a function of diameter, calculated using the Mie formulae for different radar frequencies

1.18.2.2 MeteoSwiss weather radar

MeteoSwiss operates 3 METEOR 360 AC type weather radars located at the sites of Monte Lema, La Dôle and Albis. They provide radar coverage of the whole of Switzerland as well as its frontier regions.

These radars operate in the C band, between 4 and 8 GHz. Over a 5-minute interval their antennas sweep a target volume with a maximum radius of 230 km at a frequency of 5.4 GHz, i.e. at a wavelength of 5.6 cm, and at an angle of elevation varying between -0.3° and 40°. They detect precipitation and calculate its movement.

Their receiver collects the echoes captured by the antenna and transmits them to the signal processor in data blocks containing the reflectivity and the Doppler velocity for volumes of targets sampled at 1/30th of a degree in azimuth and 1/12th km in length. The receiver eliminates ground clutter, then processes these data, extracting from them the average intensity of the precipitation exhibited on cells with a surface area of 1 km^2 (resolution 1 km x 1 km) and 4 km^2 (resolution 2 km x 2 km) respectively.

The reflectivity Z measured by the radar is related to the intensity of precipitation R according to the formula $Z = 316 R^{1.5}$. Expressed on a logarithmic scale (dBZ), it therefore makes it possible to determine indirectly the intensity of the precipitation from radar observations. This is divided into 16 classes:

Classes	Reflectivity Z [dBZ]	Intensity of precipitation R [mm/hr]
00	<13	< 0.16
01	13 - 16	0.16 - 0.25
02	16 - 19	0.25 - 0.40
03	19 - 22	0.40 - 0.63
04	22 - 25	0.63 - 1.00
05	25 - 28	1.00 - 1.60
06	28 - 31	1.60 - 2.50
07	31 - 34	2.50 - 4.00
08	34 - 37	4.00 - 6.30
09	37 - 40	6.30 - 10.0
10	40 - 43	10.0 - 16.0
11	43 - 46	16.0 - 25.0
12	46 - 49	25.0 - 40.0
13	49 - 52	40.0 - 63.0
14	52 - 55	63.0 – 100.0
15	> 55	> 100.0

Every 10 minutes, a composite image is produced on the basis of the data provided by the three radar stations; the one relating to the weather situation which existed at the time of the accident, i.e. on 15 August 2003 at 08:00 UTC, is given in Annex 3; its resolution is 2 km x 2 km and its scale, as well as the key for the colours corresponding to the 16 classes of precipitation, are shown on the left of the figure.

The weather radar images, resolution 1 km x 1 km, from the La Dôle radar station, relating to the periods before and after the accident, were saved.

1.18.2.3 Geneva airport approach radar

At Geneva airport, in conjunction with the secondary air traffic control radar, Skyguide operates an ASR10SS type primary radar in the S band (2 to 4 GHz) at frequencies between 2.7 and 2.9 GHz. It can be used up to flight level FL 310, its maximum range is 60 NM or 111 km, and the antenna rotation period is 4 seconds. Since it is of the bidimensional (2D) type, it measures only the azimuth and distance of a target. However, it cannot measure elevation. By combining the primary radar data with the secondary radar data, it is possible to calculate the 3D track by integrating altitude information (mode C).

The main process of the ASR10SS radar is MTD (moving target detection), dedicated to surveillance of air traffic. This radar is also able to detect precipitation, but with lesser quality and accuracy than those offered by weather radar. Its fan beam antenna emits an electromagnetic beam which is narrow in azimuth (1.4°) but broad in elevation, so as to allow detection of aircraft within a 40° angle. It is particularly sensitive to clutter, especially to ground clutter which interfere with the weak precipitation signal in the S band. The weather function of the ASR10SS radar consists in producing a precipitation image with 8 levels of intensity, every 24 seconds. Air traffic controllers have only four of them at their disposal. They can superimpose it on their ICWS (integrated controller workstation) radar screen. These four levels of intensity allow an identification of the intensity by comparison of the juxtaposed colors of blue. On this subject, the Geneva ATM manual [8] specified:

"*Les informations météorologiques fournies par le radar ASR 10 sont disponibles sur les ICWS. Ces données sont utilisables jusqu'au FL310 dans un rayon de 60 NM max. Le cycle de renouvellement est de 24 secondes. L'ASR 10 n'étant pas un radar météo, ces informations sont à utiliser avec précaution et constituent un complément au radar météo*"

Remarque:

"*Le radar secondaire associé au radar d'approche ASR10 est intégré dans le MRT, mais n'est pas validé pour les secteurs INI ni pour le DELTA. En conséquence il est interdit de l'utiliser seul à ces secteurs pour faire des séparations radar.*".

Translation:

The weather information provided by the ASR 10 radar is available on the ICWS. These data are useable up to FL310 within a radius of max. 60 NM. The refresh rate is 24 seconds. Since the ASR 10 is not a weather radar, this information must be used with caution and constitutes a complement to the weather radar.

Note:

The secondary radar associated with the ASR10 approach radar is integrated into the MRT, but is not validated for the INI sectors or for DELTA. It is therefore forbidden to use it on its own in these sectors to carry out radar separations.

End of translation.

[8] Extracts from GENEVA ATM - ACC Chap. Equipment 2.1.5. and APP Chap. Radar 2.6.1.

The part of the ICWS radar image represented in figure 4 shows the position of flight EZS 903 at 08:00:01 UTC, when it was entering a thunderstorm area with the highest intensity of precipitation.

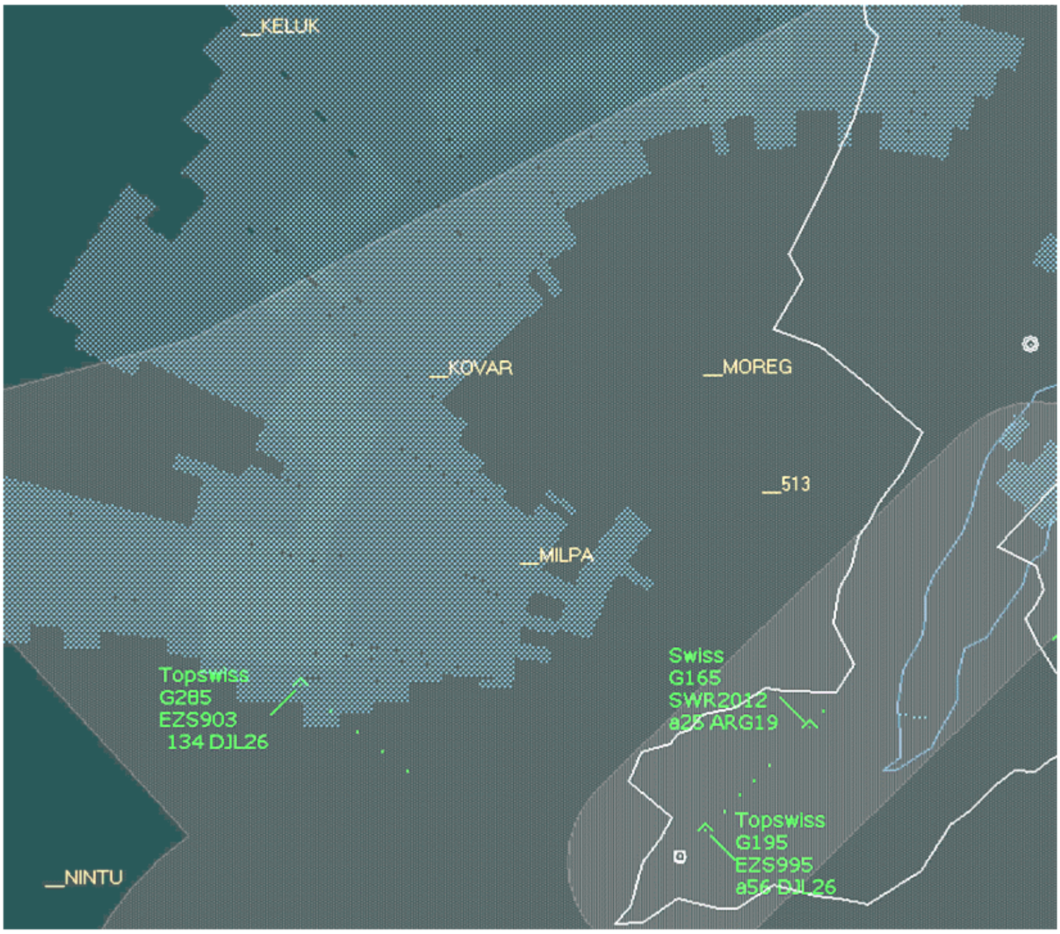


Fig. 4 Representation of part of the ASR10SS radar image as it would have appeared on the ICWS console at 08:00:01 UTC.

The tracks detected by Geneva Approach radar were recorded by the legal recording. The radar track of EZS 903, shown with a 4 second refresh rate, was archived by Skyguide.

1.18.2.4 Onboard Honeywell RDR-4B radar

The onboard RDR-4B radar, described in section 1.6.3, was designed to detect and display weather phenomenon on the line of flight, such as:

- rainfall;
- hail;
- turbulence associated with precipitation.

Ice crystals and dry snow produce weak radar returns; on the other hand:

- cloud, fog, wind;
- clear air turbulence (without precipitation);
- wind shear;
- thunder;

do not generate measurable returns.

It displays the following colours to represent intensity:

		Rainfall rate
Black	*Very light or no returns*	*Less than 0.7 mm/hr*
Green	*Light returns*	*0.7 - 4 mm/hr*
Yellow	*Medium returns*	*4 – 12 mm/hr*
Red	*Strong returns*	*Greater than 12 mm/hr*
Magenta	*Turbulence*	*N/A*

Honeywell RDR-4B User's Manual Rev 6

Since an aircraft may be at low or very high altitude, the radar must allow broad scope for adjustment in order to obtain an adequate display of the precipitation zones. In order to detect distant targets with sufficient sensitivity and adequate resolution, the instrument is equipped with a pencil beam antenna with an effective angle of only 3.3°; this implies that at approximately ±1.6° from the emission axis, the energy emitted or received is reduced to half of its maximum value, i.e. -3 decibels (dB).

Outside this part of the beam, the energy decreases rapidly and reaches a minimum at just over twice the -3 dB angle, which corresponds to the sensitive angle of the pencil beam of 6.6°. This is why it is essential to ensure that the angle of the sweep plane in relation to the horizon is correctly adjusted using the *tilt* control, in order to avoid the detection of clutter.

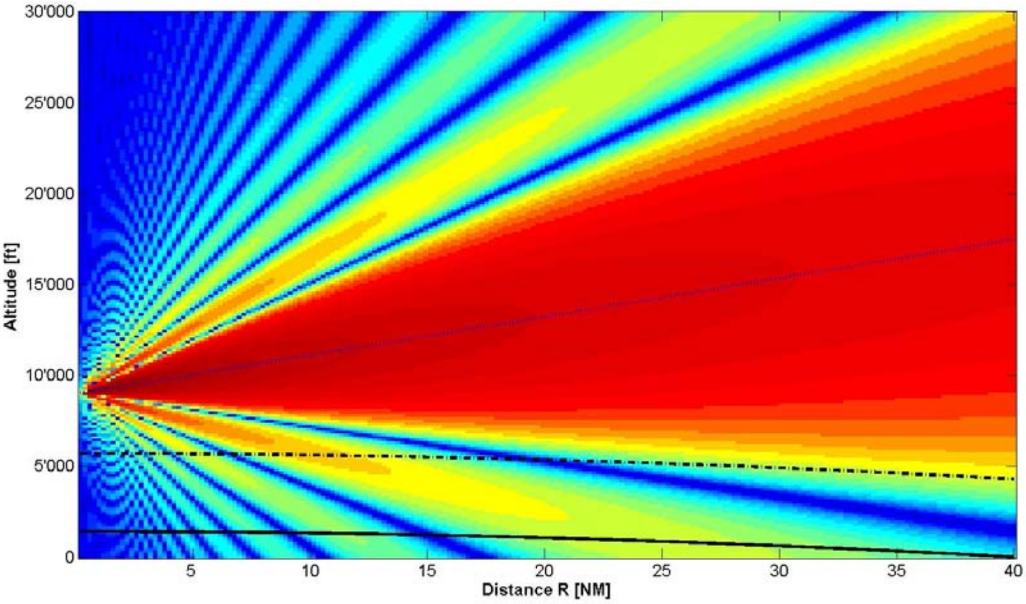


Fig. 5 Sensitivity diagram of the onboard radar for an aircraft flying at 9000 ft and a *tilt* setting of +2°

The radar equation applied to a weather target which is completely within the beam emitted by the antenna shows that the sensitivity of the radar is proportional to the square of the antenna gain and inversely proportional to the square of the distance to the object (G^2/R^2). In figure 5, showing the sensitivity diagram of the onboard radar for an aircraft flying at 9000 ft and a *tilt* setting of +2°, this sensitivity is represented using a logarithmic scale of colour intensities, in which red is assigned to the highest value and blue to the lowest. The dotted line is the *tilt* axis set at +2°, the dotted/dashed line delimits the summit of the Jura and the continuous line represents the elevation of Geneva airport, taking into account the curvature of the earth.

The onboard radar precipitation display depends on the following factors:

- the swept sector;
- the *tilt* setting,
- the selected range;
- the minimum detection distance;
- the antenna beam angle;
- the aircraft's altitude;
- the topography.

The flight crew controls the display of precipitation on the EHSI by adjusting:

- The mode of operation WX, WX/TURB on the weather radar control panel.

  This delimits the angle of the swept sector by the weather radar in azimuth on the line of flight; this is 180° (±90°) for WX mode and is reduced to 120° (±60°) for WX/TURB mode. In the AUTO position, the gain is adjusted automatically.

- The angle in relation to the horizon of the sweep plane (*tilt*) on the weather radar control panel.

  Just before take-off, it is advisable to search for precipitation zones by vertically sweeping the envisaged departure flight path using the tilt function of the onboard weather radar. During the initial climb phase, this angle must be adjusted upwards in order to avoid ground clutter and to correspond to the trajectory of the flight.

  As the aircraft climbs, the tilt angle must be gradually reduced to detect the most intense precipitation zones, whilst avoiding ground clutter. This adjustment, which amounts to ±15° in relation to the horizon, is therefore particularly delicate, as it depends on several factors: the local weather situation, the shapes of the surrounding relief and the aircraft's altitude.

  If the *tilt* is set too high ("*over scan*"), significant weather phenomena on the line of flight may not be detected, whilst if it is set too low ("*under scan*"), ground clutter may mask potentially hazardous precipitation zones.

- The range selected on the EHSI. During take-off and climb phases, the range selected on the EHSI must be such that trajectories to avoid storm cells can be planned and implemented correctly.

The accurate displaying of precipitation zones by the onboard weather radar is therefore essentially dependent on the *tilt* setting and the range selected on the EHSI. The Honeywell manual (Honeywell RDR-4B User's Manual Rev 6) gives a more detailed overview of the procedures to be followed depending on the different flight phases:

***BEFORE TAKEOFF** (page 20):*

1. *Perform TEST mode procedure.*
2. *Set Mode Selector to WX/TURB.*
3. *Set Range Selector to a range sufficient to display the area included in the planned flight path.*

4. *Adjust the antenna TILT control down until ground returns appear. This ensures that the radar system is operational.*
5. *While observing for weather returns, slowly adjust the antenna TILT control in 1 or 2 degree steps to +15 degrees.*
6. *Return antenna TILT control to +4 degrees.*

The amount of background noise is not critical unless it obscures targets.

CLIMB-OUT *(page 20):*

1. *Shortly after takeoff, slowly rotate antenna TILT control to +15, then down to where ground returns appear, and then back to +4 degrees while searching for weather targets.*

Maintain tilt setting of +4 degrees as long as aircraft's pitch attitude is approximately + 15 degrees nose up or greater.

2. *repeat step 1 if course changes of 45 degrees or more are made during climb-out.*

CRUISE *(page 20):*

1. *As soon as practical, after reaching cruise altitude, select the 40 NM range and set antenna tilt control to -10 degrees.*

The following exercise ensures that the radar beam is not overscanning any targets beginning at 30 or 40 miles out of the longest range.

2. *While scanning and observing display for weather targets, adjust antenna TILT control clockwise until a sprinkle of ground return appears.*
3. *Repeat step 2 for each intermediate range through the longest range intended for use.*

1.18.3 Weather radar images available to ATC

1.18.3.1 MeteoSwiss radar screens in the Geneva ATC units

In the Geneva ATC units, each work sector is equipped with a 15" monitor positioned near the air traffic control radar screen, displaying a MeteoSwiss weather radar image. This displays, over the entire territory of Switzerland and its vicinity, the precipitation zones as well as the thunderstorm cells which may give rise to wind gusts. The intensity of these weather phenomena is quantified using a colour representation.

1.18.3.2 Weather information on the IFREG ICWS control screens

The weather information available on the IFREG ICWS radar consoles (*weather data display*) comes from the ASR10SS radar installed at Geneva airport. It displays a projection of the precipitation strata on the horizontal plane only.

According to the controller's statements, the weather data display was not switched on at the INN sector control position at the time of the accident.

1.18.4 Procedures relating to the use of radar

1.18.4.1 Air traffic management manual (*ATM-M Sect 6 General radar procedures*)

The procedures relating to the use of radar contain, among other things, the following elements:

Note 1: The use of radar in the provision of flight information service does not relieve the pilot-in-command of an aircraft of any of his responsibilities, including the final decision regarding any suggested alteration of flight plan.

(…)

On the position of significant weather and, as practicable, advice to the aircraft on how best to circumnavigate any such areas of adverse weather;

To assist the aircraft in its navigation."

1.18.4.2 Air traffic management manual (*ATM-M Sect 11 Flight information service*)

The procedures provide for transmission of the following information in the event of weather conditions which constitute a hazard:

"When weather information is available, you should issue information that an aircraft appears likely to penetrate an area of adverse weather in sufficient time to permit the pilot to decide on an appropriate course of action, including that of requesting advice on how best to circumnavigate the adverse weather area, if so desired.

When vectoring an aircraft for circumnavigating any area of adverse weather, you should ascertain that the aircraft can be returned to its intended or assigned flight path within the available radar coverage and, if this does not appear possible, inform the flight crew of the circumstances.

Be advised that under certain circumstances the most active areas of adverse weather may not show on a radar display. An aircraft's weather radar will normally provide better detection and definition of adverse weather than radar sensors in use by ATS."

1.18.4.3 ATC procedures when cumulonimbus (CB) is present

According to the ATM-GE section ACC, when there is a probability that a thunderstorm front or a local development of cumulonimbus will occur, the ACC supervisor will in good time take the necessary measures to reduce the workload on the sectors concerned. He will monitor the development of weather conditions on the basis of the information provided in the INFONET, the aerodrome meteorological office and the managers of the adjacent centres. Depending on the situation, he will decide on the new traffic capacity to be allocated to the various sectors concerned.

2 Analysis

2.1 Meteorological aspects

2.1.1 Weather conditions on the day of the accident

The 00:00 UTC Payerne radio probe indicated extraordinary atmospheric instability. This was the cause of the development, in the morning, of heavy storms along the Prealps (Switzerland) and in the region of Oyonnax.

2.1.2 Weather situation in the region of the accident

The 08:00 weather radar images from the La Dôle site showed returns characteristic of supercell storms with a maximum intensity level in the Oyonnax region (see Annex 3). The aircraft entered a cumulonimbus cloud and passed through a shower of hail for about 5 seconds. At the altitude at which the accident occurred, the largest hailstones were probably more than 50 mm in diameter. In the vicinity of this type of cloud formation, it is possible for hail to be ejected outside the cloud.

2.1.3 Performance of the weather services

The 06 UTC charts of significant weather SWC and TEMSI did not show any thunderstorms expected in the Oyonnax region. The 09 UTC and 12 UTC TEMSI, i.e. those valid for the periods after the accident, forecast showers or thunderstorms, but not hail.

The flight crew had available the TAF forecasts for the period from 04 UTC to 13 UTC, the TEMSI chart valid at 06 UTC and the wind/temperature charts, as well as two SIGMET information messages for aircraft flying at supersonic speeds (SST), valid respectively from 03 UTC to 05 UTC and from 05 UTC to 07 UTC. The terminal aerodrome forecast for Geneva, which predicted moderate thunderstorms with no hail, with a PROB30 probability rating, was correct. The SIGMET SST reports did not mention showers of hail.

Finally, no forecast mentioned the possibility of showers of hail because the intensity of thunderstorm activity on the morning of the accident was underestimated by the meteorological services.

2.2 Technical aspects

2.2.1 Navigability

According to the data from the digital flight data recorder (DFDR), the cockpit voice recorder (CVR) and the aircraft technical log, no technical fault related to the accident was found on aircraft HB-III.

The instruments relating to the display of weather phenomena were operating correctly.

2.2.2 Ground-based technical equipment

The air traffic control and weather radars were operating correctly. The air traffic controllers had the possibility of informing crews of the particular weather conditions which prevailed in the Jura region.

Between 08:09 UTC and 09:40 UTC, there was a failure of localizer 05 and the ILS was therefore out of order. This failure had no effect on the progress of the approach, which was made visually.

2.3 Operational aspects

2.3.1 Analysis of the display of the storm cell

2.3.1.1 Analysis of the sequence of the accident

The accident sequence can be described by the events which took place at five significant points in time between the time of take-off and the time the aircraft entered the hail precipitation zone (figure 6).

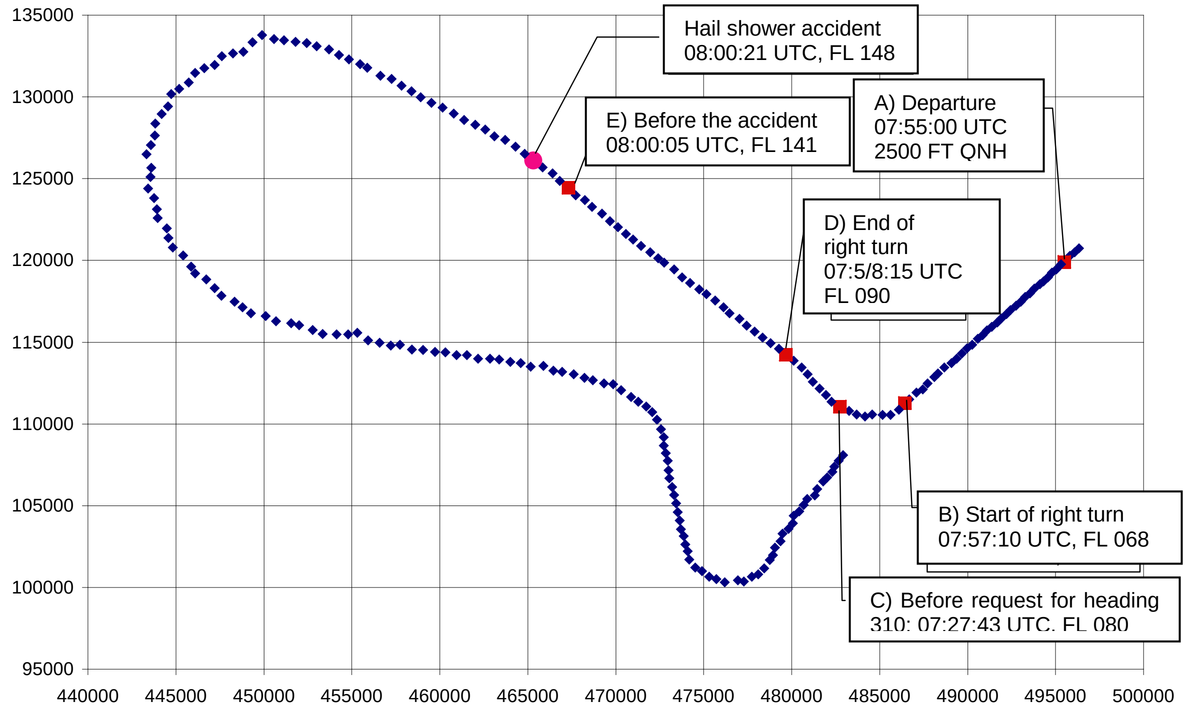


Fig. 6 Route of the aircraft based on Geneva Approach sector radar recordings, with a 4 second refresh rate

A) Position at 07:55:00 UTC: take-off

The aircraft took off from Geneva and at this time was at an altitude of 2500 ft, on heading 225. The point at which it would traverse the shower of hail which caused the accident was 16.8 NM away and 56° to the right of the current position. The DFDR recordings show that the range of each pilot's EHSI was set to 10 NM; at this moment, therefore, it was not providing sufficient visible area for the hail cell to be visible on the instrument.

According to the crew's statements, the weather radar *tilt* was set to +2°. At the range of 10 NM, the -1.3° line resulting from the *tilt* setting and the sensitive angle of the beam was 1300 ft below the flight altitude, i.e. at approximately 1200 ft. Since Geneva airport and the peaks of the Jura are at 1411 ft and 5700 ft altitude respectively, the radar was set to "*under scan*" and was mainly returning ground clutter.

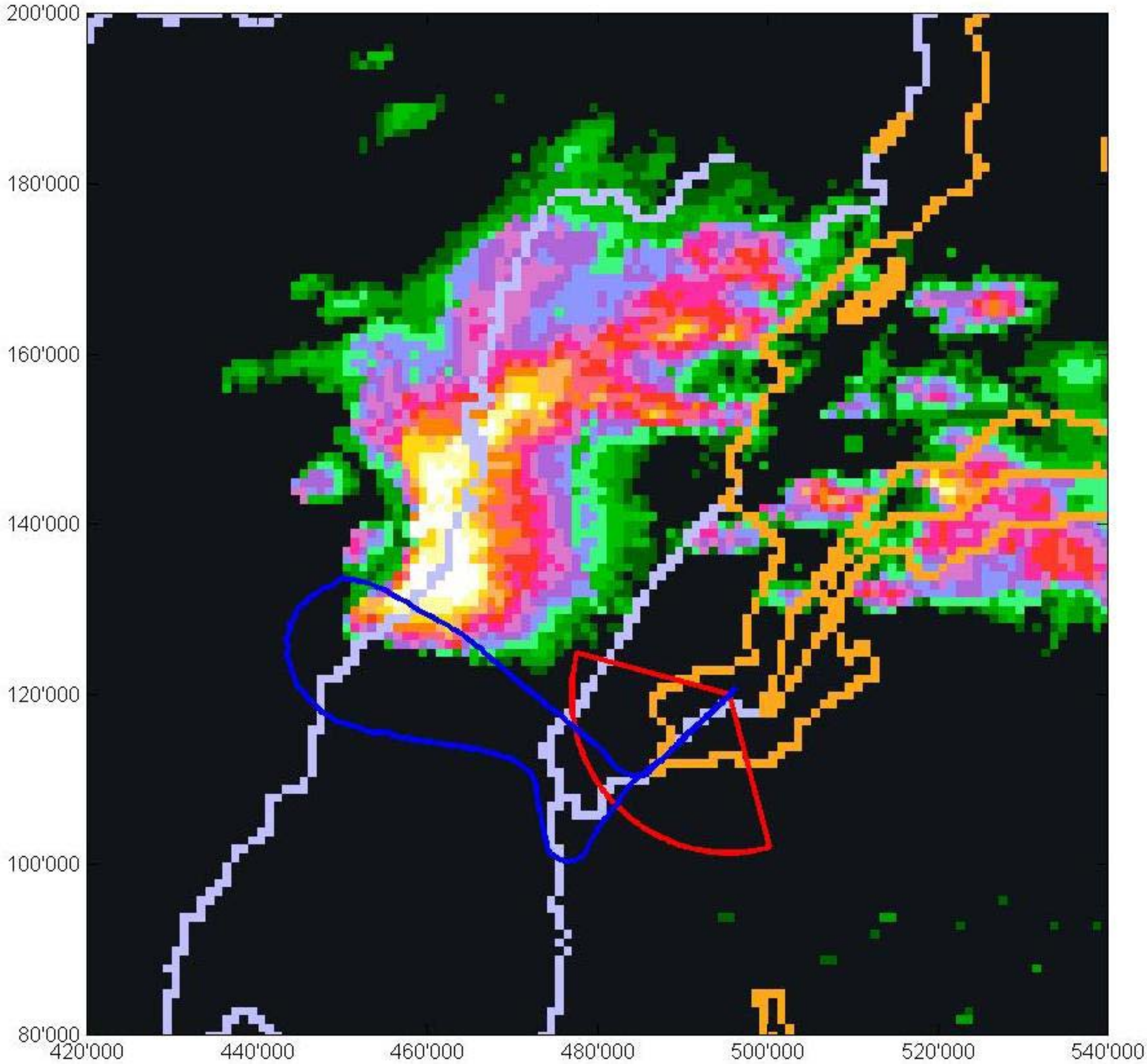


Fig. 7 Superimposition of the route of the aircraft (blue) on the La Dôle weather radar image at 07:55:00 UTC. The sector shown in red is the one being scanned by the onboard radar at the time of take-off, for the range of 10 NM. Abscissa and ordinate are relative to the Swiss national kilometric grid CH 1903.

B) Position at 07:57:10 UTC: start of the right turn

At this time the aircraft was at flight level FL 068 and on heading 227. The point at which it would traverse the shower of hail was 14 NM away and 78° to the right of the current position. The range of each pilot's EHSI was still set to 10 NM; at this moment, therefore, it was not providing sufficient visible area for the hail cell to be visible on the instrument.

The weather radar *tilt* was set to +2°. At the 10 NM range, the -1.3° line scanned the flight path at an altitude of approximately 5500 ft, corresponding to the peaks of the Jura. If the selected EHSI range had been greater, this setting would not have enabled the thunderstorm cell to be displayed, as it was outside the scanned sector.

C) Position at 07:57:49 UTC: request to maintain heading 310

At 07:57:26 UTC, 23 seconds earlier, the commander set the range of his EHSI to 40 NM. At 07:57:43 UTC the aircraft was at flight level FL 080, turning right through heading 304.

At 07:57:49, the commander requested clearance to maintain heading 310; the point at which the aircraft would traverse the shower of hail was 12.5 NM away and 15° to the right of the current position.

D) Position at 07:58:15 UTC: end of the right turn

At this time the aircraft was at flight level FL 090 and on heading 310. The point at which it would traverse the shower of hail was 10.1 NM in front. The EHSI ranges were set to 40 NM for the commander and 20 NM for the copilot; most of the storm zone should therefore have been visible on the right sector of the two instruments. The following factors reinforce this fact:

- The *tilt* settings of the onboard radar and the EHSI ranges set by the flight crew enabled the thunderstorm cell to be displayed;
- the radar cross sections (RCS) of the hail and rain permitted good detection in the X band of the onboard weather radar;
- the hail cell which caused the accident was part of a broad thunderstorm zone displayed with good resolution by the onboard weather radar;
- the hail cell which was traversed occupied a central position within the sector scanned by the onboard weather radar (figures 8 and 9).

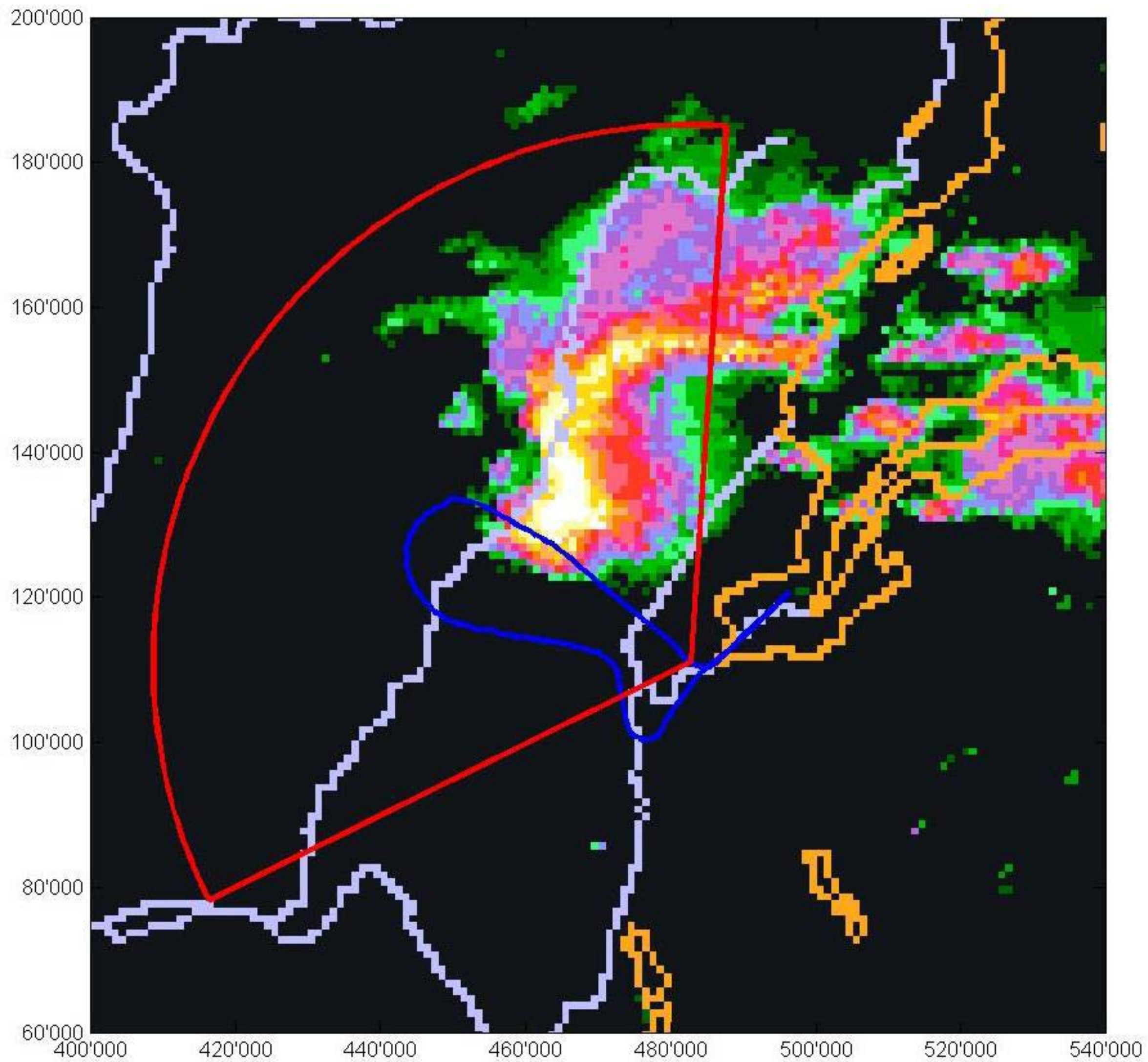


Fig. 8 Superimposition of the route of the aircraft (in blue) on the La Dôle weather radar image at 08:00 UTC. The sector shown in red is the one being scanned by the onboard radar at the end of the right turn, for the range of 40 NM selected by the commander.

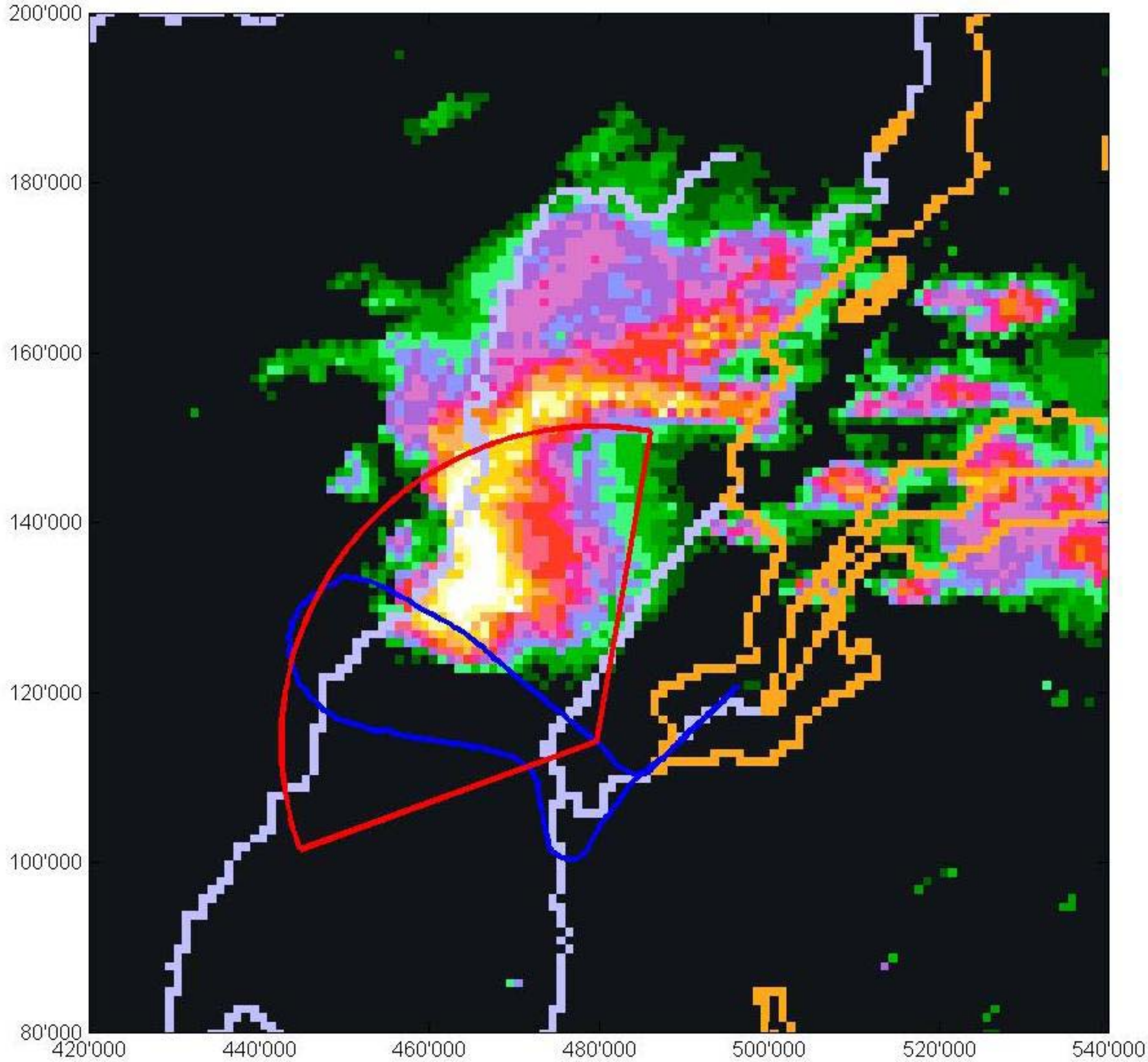


Fig. 9 Superimposition of the route of the aircraft (in blue) on the La Dôle weather radar image at 08:00 UTC. The sector shown in red is the one being scanned by the onboard radar at the end of the right turn, for the range of 20 NM selected by the copilot.

E) Position at 08:00:05 UTC: a few seconds before the accident

The commander set the range of his EHSI to 80 NM. At this time the aircraft was at flight level FL 129 and on heading 312. The point at which it would traverse the shower of hail was 1.4 NM in front.

2.3.1.2 Analysis of the display shown on the onboard radar

The following factors suggest that the display of the storm cells shown on the onboard radar was probably of better quality than that of the La Dôle weather radar used to analyse the history of the accident in the preceding paragraph:

- the EHSI range values recorded in the DFDR were such that the storm cell which was traversed occupied a central position within the sector scanned by the onboard weather radar. The analysis carried out in § 2.3.1.1 is based on a *tilt* setting of +2°. A voluntary change to this angle made by the flight crew would merely have resulted in an improvement in the display of the storm cell;

- in comparison with the ground-based weather radar, the higher frequency of the onboard radar ensured better reflectivity of the precipitation;
- another EasyJet aircraft, of the same type and equipped with similar weather radar deviated from the same departure route to avoid the storm cell. This avoiding action was taken by the flight crew because of the weather situation displayed on the onboard radar;
- the vertical development of the thunderstorm cell was such that an *over scan* situation was not possible.

Although the images from the onboard radar of the HB-III were not recorded, we can logically conclude that the hail cell which caused the accident was nevertheless perfectly visible on them.

2.3.2 EasyJet operational regulations

The investigation has shown that the EasyJet company's operational regulations include sufficient directives relating to flying in unfavourable weather conditions.

In general, the flight experience acquired in the company's specific operational context contributes to the correct application of these directives.

Compliance with the operational rules and in particular with the point entitled "*Use of Weather radar – Guidance to Pilots*" mentioned in section 1.17.1.2 of this report would have made it possible to prevent the accident.

2.3.3 Flight crew

2.3.3.1 The commander

The commander had approximately 2500 hours of flying experience on jet aircraft of more than 20 tonnes, of which less than 300 hours as a copilot. The brevity of this period on the right hand seat probably did not allow him to sufficiently take advantage of the experience of more experienced crew members in the use of the onboard weather radar.

Furthermore, the basic training in two-man cockpit working takes place at the beginning of a career, i.e. when a pilot is acting as copilot. Over the course of his professional life, the commander occupied this position for only a few hundred flying hours, leaving him only very little time to assimilate these basics.

On the avoiding heading, when he should have been prioritising operation of the weather radar in order to cope with the stormy ambient conditions, the commander was preoccupied using the FMS to determine the next heading which would allow him to turn towards DJL. The different ranges which he set consecutively on his EHSI were less suited to displaying precipitation than those chosen by the copilot.

2.3.3.2 The copilot

The copilot had been employed by the EasyJet airline on Boeing 737-300 aircraft since November 1999. With more than 2300 hours on this type of aircraft, he can be considered as experienced in systematic two-man working in an EasyJet cockpit, as well as compliance with company procedures.

In the flight phase which preceded the accident, it is surprising that he did not draw the commander's attention to the priority to be given to avoiding the thunderstorm cells.

2.3.3.3 Management of the flight

On the morning of the accident, the crew made the flights Geneva-Nice and back; during these flights, the pilots had to avoid thunderstorm cells. The unusual weather situation should already have made them attentive to the priority to be given to operation of the weather radar in the course of the next flight departing Geneva.

The investigation showed, on the contrary that just before the accident:

- priorities were handled inadequately; avoiding the thunderstorm cells should have taken priority over operation of the FMS;
- the information from the onboard weather radar was used inappropriately.

From a technical viewpoint and on the basis of the information provided by the pilots, the investigation revealed that the storm cell should have been visible on the two EHSI electronic horizon situation indicators at least 2 minutes before the accident. The reasons why the flight crew continued on a heading which brought the aircraft into the shower of hail remain unexplained.

After the accident, management of the subsequent flight phase and the associated decisions were adequate up to its completion.

2.3.4 The role of ATC

The thunderstorm cells located in the Oyonnax region were displayed in two locations:

- on the screens showing the MeteoSwiss weather radar image. On these screens, precipitation is shown at the scale of the country but the presence of heavy showers of hail could have been detected only by a meteorologist;
- on the ICWS control screens, provided that the weather function is activated on them. Precipitation is visible, but at poorer quality and accuracy than those offered by weather radar.

After notification of the accident at the latest, in accordance with section 8.6.10 of regulation doc. 4444 PANS-ATM, ATC should have indicated the presence of heavy showers of hail to the meteorological service, so that a SIGMET message could have been issued within the shortest possible time.

2.3.5 Issue of SIGMET messages

The meteorological services generally transmit SIGMET messages on the basis of information communicated to ATC by pilots.

The meteorological information relating to this significant situation, which should have led to the issuing of a SIGMET message, was not transmitted by ATC. Apart from SIGMET SST, no SIGMET information concerning the region of the accident was issued on that morning.

3 Conclusions

3.1 Findings

3.1.1 Meteorological aspects

- On the morning of the accident, the meteorological documentation handed over to the flight crew did not mention the risk of showers of hail in the region of the accident.
- The 08:00 UTC weather radar images from the La Dôle site showed returns characteristic of supercell storms with a maximum intensity level in the Oyonnax region.
- At the time and in the region of the accident, violent storms accompanied by hail were observed at several locations. According to eye witnesses, the hailstones were as big as ping-pong balls (40 mm); some were even 50 mm in diameter.

3.1.2 Technical aspects

- In terms of the aircraft's airworthiness, no technical fault associated with the accident was found.
- The localizer of the runway 05 ILS system was out of order.

3.1.3 Crew

- The documents supplied indicate that the pilots were in possession of valid licences.
- The flight crew consisted of a commander employed under a temporary contract; the copilot had been employed by EasyJet Switzerland since November 1999.
- After a rest period of 14 hours 35 minutes, the flight crew was making their third flight in a planned series of four.

3.1.4 Operational aspects

- Five minutes after the take-off of aircraft EZS 903, EZS 995 took off following the same standard instrument departure "DIPIR 1A". Its flight crew avoided the thunderstorm cell which caused the problem for flight EZS 903 by flying to the west of it; this avoiding route was chosen because of the weather situation indicated by the onboard weather radar.
- Neither the flight crew of flight EZS 903 nor the flight crew of flight EZS 995 received any weather information originating from ATC.
- The flight crew of flight EZS 903 was not able to explain in detail the way they used the onboard weather radar.
- Five minutes after the accident, the flight crew of flight EZS 903 transmitted the reasons for their declaration of a distress situation: "*very heavy hailstorm*", on frequency 120.3 MHz.
- After the delay caused by the unexpected landing on runway 05 of the aircraft making flight EZS 903, aircraft VP-BKK took off from runway 23 approximately 20 minutes after the accident. Its flight crew followed the same standard instrument departure as EZS 903. On arrival at the destination, damage to the radome, leading edges and tail of the aircraft was found by maintenance personnel.
- The weather conditions encountered by EZS 903 were not communicated by ATC to the flight crew of aircraft VP-BKK.

3.2 Cause

The accident was caused by the aircraft flying into a shower of hail embedded in a thunderstorm cell, following inadequate utilisation of the information provided by the onboard weather radar.

The following factors played a part in the accident:

- shortcomings in crew resource management (CRM);
- no specific meteorological information concerning this hazard was transmitted.

4 Safety recommendations

4.1 Introduction

From reading the various radar tracks and after verifying the workstations, it appears that no weather information was transmitted even though the means to do so existed and the situation at the relevant time demanded this.

4.2 Safety recommendation No. 281 (formerly No. 82)

The Federal Office for Civil Aviation should require the systematic use by the responsible air traffic personnel of the information provided by weather radar when the situation presents dangers.

4.3 Safety recommendation No. 282 (formerly No. 83)

The Federal Office for Civil Aviation should impose, on reception of specific weather information transmitted by crews, immediate transmission within the air traffic sectors concerned and should require that this information be forwarded to MeteoSwiss for a SIGMET to be issued.

4.4 Comment by the FOCA (21.11.2003)

We support the cited recommendations by the AAIB and to this end we have intervened with Skyguide (...).

We shall keep you informed as soon as Skyguide has sent us confirmation of its implementation of the above-mentioned recommendations.

Berne, 30 March 2010

Federal Aircraft Accident Board

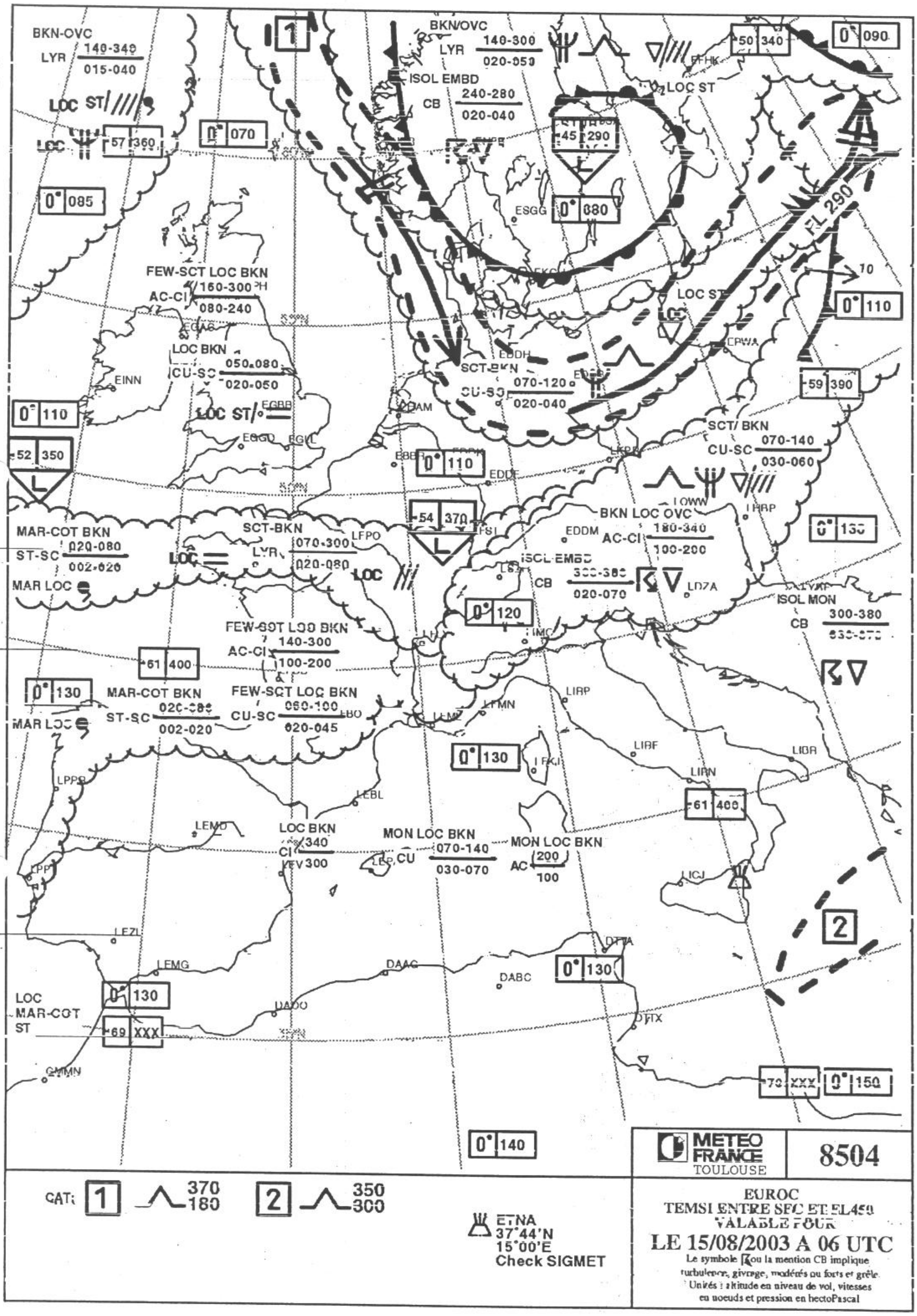
André Piller, President

Tiziano Ponti, Vicepresident

Ines Villalaz-Frick, Member

Annex 1

Annex 2


BKN-OVC
LYR 140-340 / 015-040
LOC ST
BKN/OVC
LYR 140-300 / 020-050
ISOL EMBD
CB 240-280 / 020-040
LOC ST
FEW-SCT LOC BKN
AC-CI 160-300 / 080-240
LOC BKN
CU-SC 050-080 / 020-050
LOC ST
SCT-BKN
CU-SC 070-120 / 020-040
SCT/ BKN
CU-SC 070-140 / 030-060
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ST-SC 020-080 / 002-020
MAR LOC
SCT-BKN
LYR 070-300 / 020-080
BKN LOC OVC
AC-CI 180-340 / 100-200
ISOL EMBD
CB 300-380 / 020-070
ISOL MON
CB 300-380
FEW-SCT LOC BKN
AC-CI 140-300 / 100-200
MAR-COT BKN
ST-SC / 002-020
MAR LOC
FEW-SCT LOC BKN
CU-SC 060-100 / 020-045
LOC BKN
CI 340 / 300
MON LOC BKN
CU 070-140 / 030-070
MON LOC BKN
AC 200 / 100
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8504
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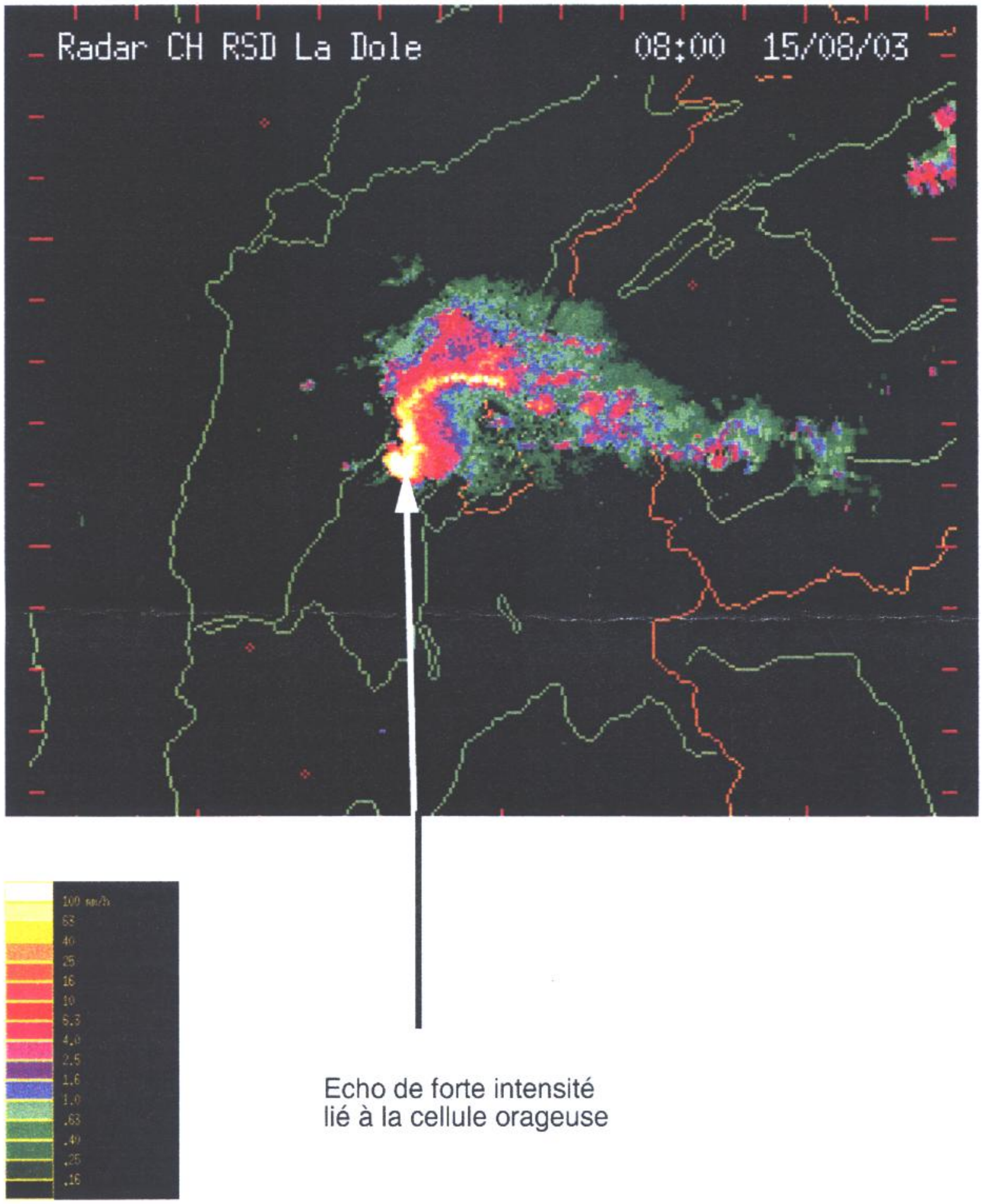
TEMSI ENTRE SFC ET FL450
VALABLE POUR
LE 15/08/2003 A 06 UTC
Le symbole ou la mention CB implique turbulence, givrage, modérés ou forts et grêle
Unités : altitude en niveau de vol, vitesses en noeuds et pression en hectoPascal

Annex 3

MétéoSuisse **5** Situation du 15 Août 2003 / Grêle

Images radar (Dôle) de 0800 UTC



Annex 4


08 : 00 : 15
138 KOR24
KELUK
MOLUS
KOVAR
MOREG
513
MILPA
Air Berlin
G395
BER8937
340 PDU
Topswiss
G300
EZS903
147 DJL26
Swiss
G160
SWR2012
a28 ARG19
G245
BZ921RW
130 SLV09
511
Topswiss
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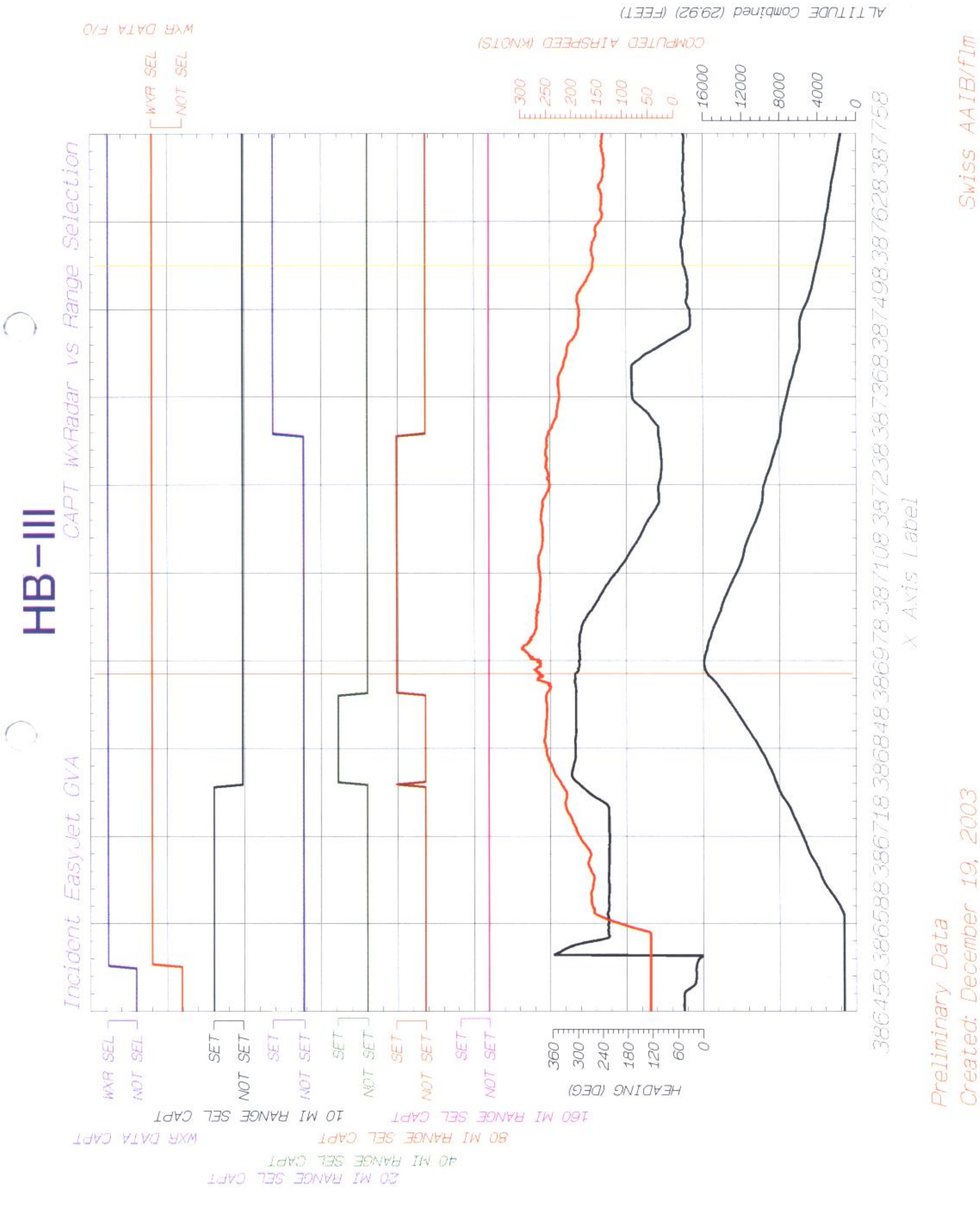
OMASI

Annex 5


HB-III
Incident EasyJet GVA CAPT WxRadar vs Range Selection
ALTITUDE Combined (29.92) (FEET)
COMPUTED AIRSPEED (KNOTS)
HEADING (DEG)
WXR DATA F/O
WXR DATA CAPT
10 MI RANGE SEL CAPT
20 MI RANGE SEL CAPT
40 MI RANGE SEL CAPT
80 MI RANGE SEL CAPT
160 MI RANGE SEL CAPT
X Axis Label
Swiss AAIB/flm
Preliminary Data
Created: December 19, 2003

Annex 6

SID CHART ICAO

STANDARD INSTRUMENT DEPARTURE SID RWY 23

NON RNAV

GENEVA