Report
IN-017/2017

Serious incident involving a Boeing B787-900, registration N825AA, and a Cessna 172-M, registration EC-IEO, in the Madrid TMA on 8 August 2017

Please note that this report is not presented in its final layout and therefore it could include minor errors or need type corrections, but not related to its content. The final layout with its NIPO included (Identification Number for Official Publications) will substitute the present report when available.

MINISTERIO DE FOMENTO
SUBSECRETARÍA
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Notice

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) nº 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1., 4. and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

CONTENTS

ABBREVIATIONS

° ‘ “	Sexagesimal degrees, minutes and seconds
°C	Degrees Celsius
3D	Three dimensions
AC	Conflict alert
ACAS	Airborne collision avoidance system
ACP	Area control procedural rating
ACS	Area control surveillance rating
ADF	Automatic direction-finding equipment
ADI	Aerodrome Control Instrument rating
ADV	Aerodrome Control Visual rating
AESA	Spanish National Aviation Safety Agency
AIP	Aeronautical information publication
AIR	Air Control endorsement
AMC	Acceptable means of compliance
APP	Approach Control Procedural Rating
APS	Approach Control Surveillance rating
ARO	Air traffic services reporting office
ATC	Air traffic control
ATCO	Air Traffic Controller
ATPL	Airline Transport Pilot License
ATS	Air traffic service
ATZ	Aerodrome traffic zone
CAVOK	Visibility, cloud and present weather better than prescribed values or conditions
CB	Cumulonimbus
CDR	Conditional route
CFL	Cleared Flight Level
COM	Communications equipment
CPL	Commercial pilot license
CRI	Class rating instructor
DEN	East takeoffs in north configuration
DME	Distance measuring equipment
DSH	Horizontal safety distance
DSV	Vertical safety distance
DVOR	Doppler VHF omnidirectional radio range
DWN	West takeoffs in north configuration
EASA	European Aviation Safety Agency
ELT	Emergency locator transmitter
ENR	En route

FI	Flight instructor
FIR	Flight information region
FL	Flight level
ft	Feet
ft/min	Feet/minute
GMC	Ground Movement Control endorsement
GMS	Ground Movement Surveillance endorsement
GND	Ground
h	Hours
hPa	Hectopascals
IFPS	Integrated initial flight plan processing system
IFR	Instrument flight rules
ILS	Instrument landing system
IR	Instrument Rating
kg	Kilograms
KIAS	Knots indicated airspeed
km	Kilometers
km/h	Kilometers per hour
kt	Knots
L.D.	Dedicated line
LAD	Feature of the SACTA system used to determine headings, as well as distances between runways, between points and runways to predict minimum separation and time
LC	Hotline
LEBG	Burgos airport indicator location
LECM	Madrid FIC/ACC indicator location
LECU	Madrid/Cuatro Vientos Airport indicator location
LEGT	Madrid/Getafe Airport indicator location
LEMD	Madrid/Barajas Airport indicator location
LEVS	Madrid/Cuatro Vientos Airport (military) indicator location
m	Meters
m^2	Square meters
MEP	Multi-engine piston rating
METAR	Aviation routine weather report (in aeronautical meteorological code)
min	Minutes
N	North
NAV	Navigation equipment
NDB	Non-directional radio beacon
NIGHT	Night flight rating
NM	Nautical Miles
NW	Northwest
PAC	Conflict alert - prediction

PF	Pilot flying
PPL	Private pilot license
P-RNAV	Precision area navigation
QNH	Altimeter sub-scale setting to obtain elevation when on the ground (pressure setting to indicate elevation above mean sea level)
RA	Resolution advisory
RAD	Aerodrome Radar Control endorsement
RD	Radio
RNAV	Area navigation
RVR	Runway visual range
RWN	West master sector
SACTA	Automated air traffic control system
SEP	Single-engine piston rating
SFC	Surface
SID	Standard instrument departure
STCA	Short-Term Conflict Alert
TA	Alert time
TAI	Immediate alert time
TCAS	Traffic Collision Avoidance System
TCL	Terminal Control endorsement
TCU	Towering cumulus
TMA	Terminal control area
TRM	Team Resource Management
TWR	Control Tower (TWR) endorsement
TWR	Control tower
UTC	Coordinated universal time
V_A	Maneuvering speed
VAC	Conflict alert - violation
V_{FE}	Maximum flap extended speed
VFR	Visual flight rules
V_{NE}	Never exceed speed
W	West
WDN	Sector resulting from union of DWN and WNN
WNN	West north sector in north configuration
WSN	West south sector in north configuration
Z	Flight initially made under VFR that undergoes one or more changes in its flight rules

Synopsis

.

Operator:	AMERICAN AIRLINES	AEROCENTER
Aircraft:	Boeing B787-900	Cessna 172-M
Date and time of incident:	Tuesday, 8 August 2017 at 09:35 UTC	
Site of incident:	Madrid TMA	
Persons on board:	228 passengers, 12 crew	2 crew
Type of flight:	Air transport – Scheduled – – International – Passenger	General aviation – training – dual
Phase of flight:	En route	En route
Flight rules:	IFR	Z[1]
Date of approval:	7 June 2018	

Summary of event:

The Boeing B787-900 aircraft, registration N825AA, had taken off from runway 36L at the Madrid-Barajas Airport to make flight AAL37 to the Dallas-Fort Worth Airport (United States).

The Cessna 172M aircraft, registration EC-IEO, had taken off from the Madrid-Cuatro Vientos Airport on a Z flight plan to the Burgos Airport. Its callsign was ACR31. After taking off, and in IFR conditions, it had been cleared by ATC to fly direct to Burgos at 11000 feet. It was leveled at that altitude at the time of the incident.

The Boeing B787 aircraft had been cleared to climb to FL240 and to follow standard instrument departure (SID) ZMR1L.

Shortly after passing point MD44 in procedure ZMR1L, the traffic collision avoidance system (TCAS) on the Boeing B787 aircraft issued a resolution advisory (RA) due to a reduction in separation with the Cessna 172. At that moment, the B787 was at 10900 ft and climbing to FL240.

The crew of the B787, AAL37, reported the situation to the control center while operating the controls to initiate a descent. For their part, the crew of the other aircraft, ACR31, had visual contact with the B787, realized it was descending and decided to make an evasive climb maneuver.

[1] Flight initially made under VFR that undergoes one or more changes in its flight rules.

These actions resulted in a quick resolution to the conflict situation, after which both aircraft continued their flights, reaching their destinations without further incident.
The investigation has determined that this incident occurred because the executive controller focused his attention on resolving a conflict in another part of the airspace under his control, while forgetting to track and resolve a potential conflict that he had previously identified.

The following factors are deemed to have contributed to this incident;

- A conflictive flight plan for aircraft ACR31, which violated restrictions on the airway and that brought it into conflict with takeoffs and landings at LEMD.
- Poor reception on the dedicated line to LEGT, which forced the executive controller to take over the tasks that the planning controller had been doing.
- The conflict alert on the SACTA system did not activate early enough for the executive controller to take action before the conflict situation involving the aircraft occurred.

1. FACTUAL INFORMATION

1.1. History of the flight

The ACR31 aircraft took off at 09:08:45 from the Madrid-Cuatro Vientos Airport en route to the Burgos Airport on a Z flight plan, which is characterized by starting out under visual flight rules (VFR) before transitioning to instrument flight rules (IFR).

It was a training flight to obtain an instrument rating. On board the aircraft were the instructor and a student.

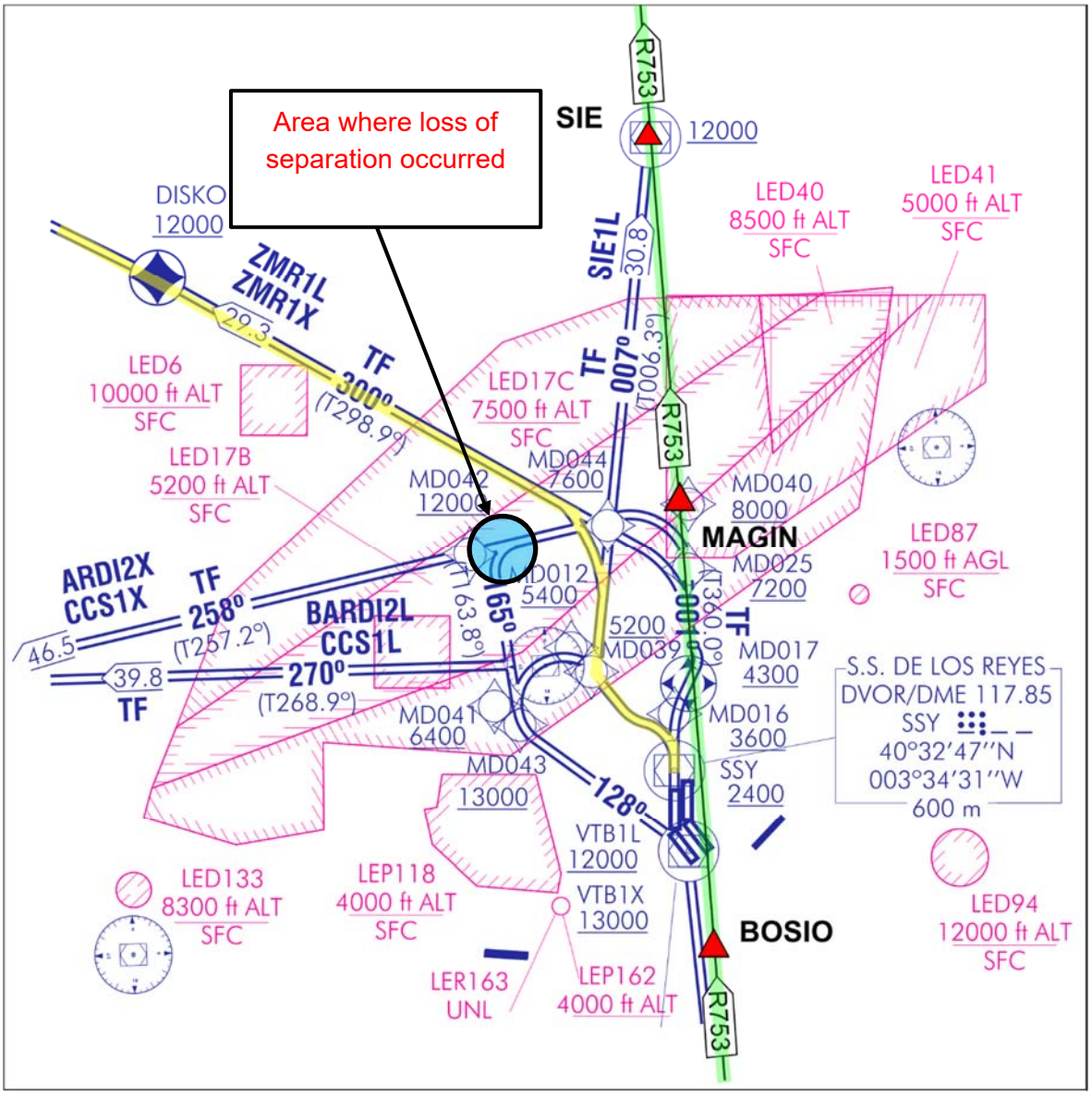


Figure 1. Section of P-RNAV chart for standard instrument departure, runway 36L daytime, with the route taken by aircraft AAL37 shown in yellow and the route indicated in the flight plan for aircraft ACR31 shown in green. Also shown in the blue circle is the area where the loss of separation took place.

The instrument part of this flight started at point BOSIO, with the next points on the instrument route being MAGIN-SIE-XERMA-ARLUN-BUR, which are part of lower ATS route R753.

In order to have both routes on the same chart, the initial part of the instrument route of aircraft ACR31 is shown atop the RNAV chart of the standard instrument departures for runway 36L from Figure 1. The first three points on the route, BOSIO, MAGIN and SIE, are indicated using red triangles, and the route proper is highlighted in green.

The sector charged with controlling these aircraft was WDN, which was the sector that resulted from combining the DWN (West takeoffs in North configuration) and WNN (West North North Sector) sectors.

At 09:10:35, the sector WDN controller at the Madrid control center called the controller in the tower at the Madrid-Cuatro Vientos Airport to ask him to quickly transfer him aircraft ACR31 because it “had a terrible route”.

The crew of ACR31 established radio contact with the WDN sector controller at 09:10:55. At that time, the aircraft was some 2 km south of the Madrid-Cuatro Vientos Airport, flying at 4000 ft on an easterly heading.

The controller instructed the crew to turn north when they reached 5000 ft.

At 09:12:43, once ACR31 had reached an altitude of 5000 ft, the crew started the turn to the north.

At the same time, the WDN controller once again called ACR31 to instruct the crew to continue turning to heading 330, and that he would advise them to proceed to Burgos.

The aircraf was subsequently cleared to climb to 7000 ft and then to 10000 ft.

At 09:23:30, the controller cleared the aircraft to proceed direct to Burgos, instructing the crew to climb to 11000 ft, as the minimum radar altitude in this area is 10500 ft. At that point the aircraft was northwest of Madrid, practically over the El Pardo reservoir.

As a result of the instructions provided by the controller, the aircraft was some 20 km west of the route specified in its flight plan.

The Boeing B787 aircraft with callsign AAL37 took off from runway 36L at the Madrid-Barajas Airport at 09:29:48 en route to the Dallas-Fort Worth Airport (United States).

It had been cleared to climb to FL240, following standard instrument departure (SID) ZMR1L (shown in yellow in Figure 1).

Shortly after flying over point MD44 in the ZMR1L procedure, the traffic collision avoidance system (TCAS) on the Boeing B787 with callsign AAL37 issued a resolution advisory (RA)

due to its reduced separation with the Cessna 172 aircraft with callsign ACR31. At that time, the B787 was at 10900 ft and climbing to FL240.

The crew of the B787 reported the situation to the control center while at the same time operating the controls to start a descent, which quickly caused the conflict situation to clear. After that, the two aircraft continued their flights, reaching their destinations without further incident.

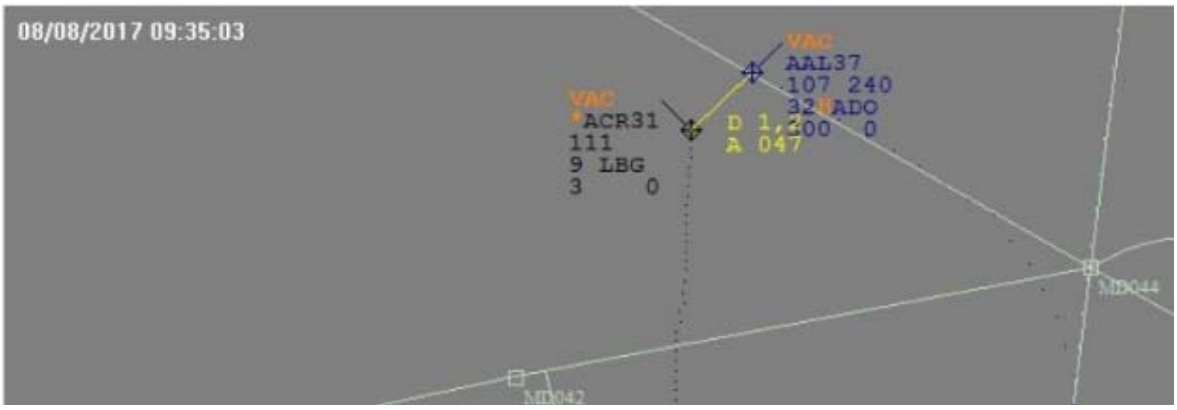


Figure 2. Image of the closest point of approach between the aircraft

The minimum separation between the aircraft during the event occurred at 09:35:03, when they came within 1.2 NM horizontally and 400 ft vertically of each other (see Figure 2).

1.2. Injuries to persons

1.2.1. Aircraft N825AA (AAL37)

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious				
Minor				N/A
None	12	228	240	N/A
TOTAL	12	228	240	

1.2.2. Aircraft EC-IEO

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious				
Minor				N/A
None	2		2	N/A
TOTAL	2		2	

1.3. Damage to aircraft

Neither of the aircraft involved in the event sustained any damage.

1.4. Other damage

There was no other damage.

1.5. Personnel information

1.5.1. Aircraft N825AA

1.5.1.1. Captain

- Age: 61
- Nationality: American
- License: ATPL (airplane)
- Ratings:
  - Super-80
  - B737
  - B767
  - B787
- Medical certificate: class 1, valid until 24/11/2017
- Total flight hours: 13214
- Flight hours on the aircraft type: 741
- Duty hours:

Previous 90 days:	184:37
Previous 7 days:	37:46
Previous 24 h:	10:23
Rest prior to flight:	25:03

1.5.1.2. Copilot

- Age: 56
- Nationality: American
- License: ATPL (airplane)
- Ratings:
  - Super-80
  - Fokker-100
  - B767
  - B787
- Medical certificate: class 1, valid until 22/08/2017
- Total flight hours: 11408
- Flight hours on the aircraft type: 973
- Duty hours:

Previous 90 days:	270:54
Previous 7 days:	38:19
Previous 24 h:	10:23

Rest prior to flight: 25:03

1.5.1.3. Relief pilot

- Age: 60
- Nationality: American
- License: ATPL (airplane)
- Ratings:
  - Fokker-100
  - B737
  - B767
  - B777
  - B787
- Medical certificate: class 1, valid until 15/11/2017
- Total flight hours: 11797
- Flight hours on the aircraft type: 1142
- Duty hours:

Previous 90 days:	276:41
Previous 7 days:	30:39
Previous 24 h:	10:23
Rest prior to flight:	25:03

1.5.2. Aircraft EC-IEO (ACR31)

1.5.2.1. Instructor

The instructor pilot, a 49-year old Spanish national, had private pilot and commercial pilot licenses (airplane) initially issued by the National Aviation Safety Agency (AESA) on 09/05/2001 and 24/06/2004, respectively, as well as the following ratings:

- SEP, single-engine piston land: valid until 30/06/2018
- MEP, multi-engine piston land: valid until 31/03/2018
- IR, instrument rating (airplane): valid until 31/03/2018
- CRI, class-rating instructor (MEP): valid until 31/03/2020
- FI, flight instructor (PPL/CPL/SEP/MEP/IR/FI/NIGHT): valid until 28/02/2020

He also had a class-1 medical certificate that was valid until 22 June 2018.

According to the information provided, at the time of the incident he had a total of 4175 flight hours, of which 2000 had been on the aircraft type involved in the event.

1.5.2.2. Student

The student, a 25-year old Spanish national, had a private pilot license (airplane) initially issued by the National Aviation Safety Agency (AESA) on 29/01/2014, as well as a single-engine piston (SEP) land rating, which was valid until 31/01/2018.

He had a class-1 medical certificate that was valid until 03/10/2017.

He had a total experience of 200 flight hours.

1.5.3. Air Traffic Controlers (ATCOs)

1.5.3.1. Executive controller

The executive controller in LECM sector WDN, a 60-year old Spanish national, had an air traffic controller license issued by Spain's National Aviation Safety Agency (AESA), with the following ratings and endorsements:

Rating	Initial issue date	Rating endorsement	Initial issue date
ADV	9/05/1986		
ADI	9/05/1986	AIR GMC TWR GMS RAD	9/05/1986 9/05/1986 9/05/1986 9/05/1986 9/05/1986
APP	9/05/1986		
APS	9/05/1986	TCL	9/05/1986
ACP	9/05/1986		
ACS	9/05/1986	TCL	9/05/1986

He also had an LECM-TMA1-APS unit endorsement that was valid until 19/05/2018.

As for his language proficiency, he had a level 6 in Spanish and 5 in English, which was valid until 16/05/2019.

He also had a medical certificate that was valid until 23 September 2018.

As for TRM (team resource management) training, he had not received any nor was he scheduled for it.

1.5.3.2. Planning controller

The planning controller in LECM sector WDN, a 52-year old Spanish national, had an air traffic controller license issued by Spain's National Aviation Safety Agency, with the following ratings and endorsements:

Rating	Initial issue date	Rating endorsement	Initial issue date
ADV	1/09/1992		
ADI	1/09/1992	AIR GMC TWR GMS RAD	1/09/1992 1/09/1992 1/09/1992 1/09/1992 1/09/1992
APP	1/09/1992		

APS	1/09/1992	TCL	1/09/1992
ACP	1/09/1992		
ACS	1/09/1992	TCL	1/09/1992

He also had an LECM-TMA1-APS unit endorsement that was valid until 16/10/2018.

As for his language proficiency, he had a level 6 in Spanish and 5 in English, which was valid until 16/05/2019.

He also had a medical certificate that was valid until 7 November 2018.

On the date of the incident, this controller had not yet done any TRM training, though he was scheduled for one session on 30/01/2018, which he attended.

1.6. Aircraft information

1.6.1. Aircraft N825AA

This was a Boeing B787-900 aircraft that had been manufactured in 2017, with serial number 40644. Its main characteristics are as follows:

- Wingspan: 60.7 m
- Length: 63.0 m
- Height: 17.0 m
- Wing surface: 325.0 m^2
- Empty weight: 118000 kg
- Maximum takeoff weight: 250836 kg
- Engines: two (2).
    - Manufacturer: General Electric.
    - Model: GEnx-1B74/75.
    - Serial number:
        - #1: 956857
        - #2: 956858
- Total flight hours: 2595
- Total cycles: 275

It had a transport category certificate of airworthiness that had been issued on 26 January 2017.

1.6.2. Aircraft EC-IEO

This was a Cessna 172-M, a single-engine aircraft with a braced high-wing and a tricycle landing gear. It had been manufactured in the United States in 1975 and had serial number 172-65632.

Its general characteristics are as follows:

- Wingspan: 10.97 m
- Length: 8.20 m
- Height: 2.67 m
- Wing surface: 16.20 m^2
- Empty weight: 612 kg
- Maximum takeoff weight: 1043 kg
- Fuel capacity: 191 liters
- Engine: Lycoming O-320-E2D, s/n:L-42373-27A
- Never exceed speed (V_{NE}): 293 km/h
- Maneuvering speed (V_A): 180 km/h
- Maximum flap extended speed (V_{FE}): 161 km/h
- Service ceiling: 13100 ft

It had a normal category certificate of airworthiness, issued on 20 June 2005.

Its airworthiness review certificate had been issued on 11/06/2017 and it was valid until 12/06/2018.

As for navigation and communications equipment, it was outfitted with the following:

- COM 1: TKM MX-170C
- COM 2: TKM MX-170C
- NAV 1: TKM MX-170C
- NAV 2: TKM MX-170C
- Transponder: Bendix King KT-76
- DME: Bendix King KN-65
- ADF: Bendix King KR-85
- Marker beacon: Bendix King KMA-20
- ELT: Bendix King KT-76ex ME-406

The table below contains information on the most recent maintenance performed on the aircraft:

Date	Type of inspection	Aircraft hours
6/06/2017	200-h	6215 h 35 min
4/07/2017	50-h	6265 h 00 min
26/07/2017	100-h	6314 h 55 min

1.7. Meteorological information

The following METARs were issued for the Madrid-Barajas and Madrid-Cuatro Vientos airports between 07:00 and 10:30 UTC on the day of the event:

- Madrid-Barajas Airport

0700Z 05004KT 340V120 CAVOK 21/09 Q1015 NOSIG=
0730Z 02006KT 310V100 CAVOK 22/09 Q1016 NOSIG=
0800Z 36010KT 340V040 CAVOK 22/09 Q1016 NOSIG=
0830Z 35007KT 300V040 CAVOK 23/09 Q1016 NOSIG=
0900Z 01006KT 330V070 CAVOK 24/09 Q1016 NOSIG=
0930Z 35008KT 290V040 CAVOK 25/08 Q1016 NOSIG=
1000Z 35007KT 290V030 CAVOK 25/08 Q1016 NOSIG=
1030Z 36006KT 290V090 CAVOK 26/08 Q1016 NOSIG=

- Madrid-Cuatro Vientos Airport

0700Z VRB01KT CAVOK 22/08 Q1016=
0730Z VRB02KT CAVOK 22/09 Q1016=
0800Z 00000KT CAVOK 23/08 Q1016=
0830Z VRB01KT CAVOK 23/07 Q1017=
0900Z VRB02KT CAVOK 24/08 Q1017=
0930Z 00000KT CAVOK 26/07 Q1017=
1000Z VRB03KT CAVOK 25/05 Q1017=
1030Z 16004KT 070V200 CAVOK 26/05 Q1017=

The above data show that the weather conditions at around the time of the incident were fairly uniform. The wind direction was variable and its speed low. The term CAVOK was present in every METAR message. The temperature was between 21º C and 26º C, rising during the morning, and the dew point was between 5º C and 9º C. The QNH was between 1015 and 1017 hPa.

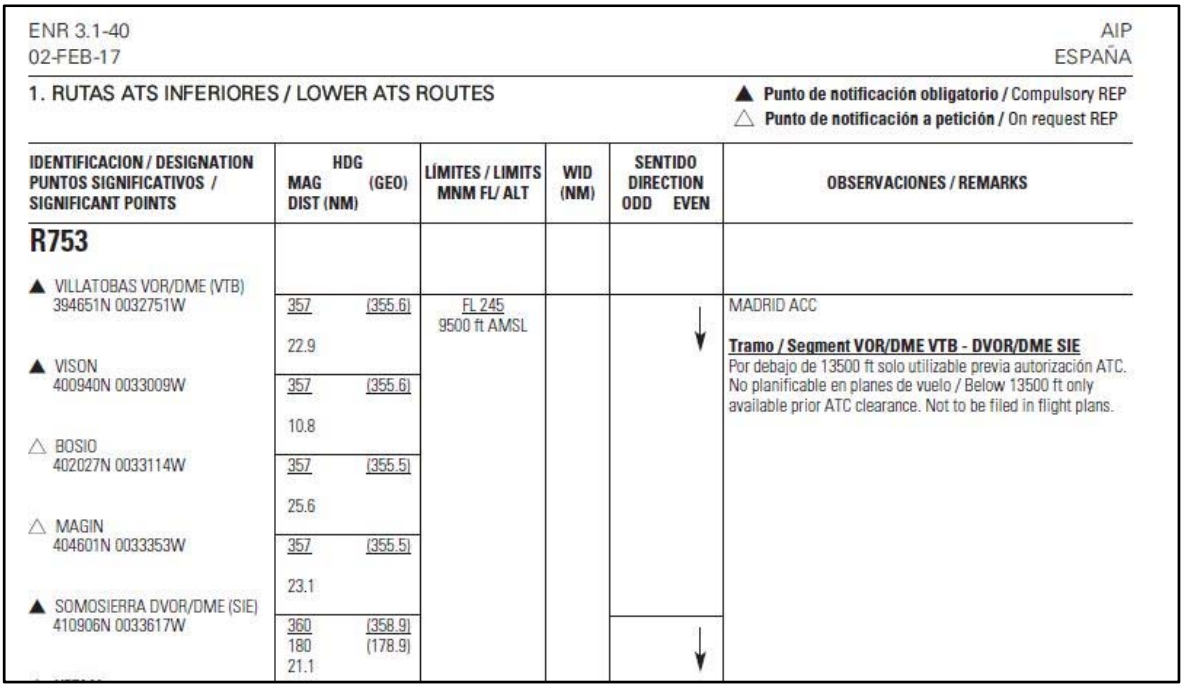
1.8. Aids to navigation

1.8.1. Lower ATS routes – R753

According to the approved flight plan, the aircraft with callsign ACR31 started the instrument part of its flight at point BOSIO where it joined airway R753, flying through points MAGIN, SIE, SERMA and ARLUN.

Point ENR 3.1 of the Spain AIP contains the information on lower ATS routes, including R753. The figure below provides an extract of the data from this airway that was in effect at the time of the incident:

As the remarks section shows, the segment between the VTB and SIE VOR/DMEs is only available below 13500 ft with prior approval from ATC and cannot be filed in flight plans. The published information does not contain any details regarding the airway category (CDR).



ENR 3.1-40 AIP
02-FEB-17 ESPAÑA

1. RUTAS ATS INFERIORES / LOWER ATS ROUTES

▲ **Punto de notificación obligatorio /** Compulsory REP
△ **Punto de notificación a petición /** On request REP

IDENTIFICACION / DESIGNATION PUNTOS SIGNIFICATIVOS / SIGNIFICANT POINTS	HDG MAG (GEO) DIST (NM)	LÍMITES / LIMITS MNM FL/ ALT	WID (NM)	SENTIDO DIRECTION ODD EVEN	OBSERVACIONES / REMARKS
R753					
▲ VILLATOBAS VOR/DME (VTB) 394651N 0032751W	357 (355.6) 22.9	FL 245 9500 ft AMSL		↓	MADRID ACC
▲ VISON 400940N 0033009W	357 (355.6) 10.8				**Tramo / Segment VOR/DME VTB - DVOR/DME SIE** Por debajo de 13500 ft solo utilizable previa autorización ATC. No planificable en planes de vuelo / Below 13500 ft only available prior ATC clearance. Not to be filed in flight plans.
△ BOSIO 402027N 0033114W	357 (355.5) 25.6				
△ MAGIN 404601N 0033353W	357 (355.5) 23.1				
▲ SOMOSIERRA DVOR/DME (SIE) 410906N 0033617W	360 (358.9) 180 (178.9) 21.1			↓	

Figure 3. Extract from ENR 3.1-40 in the Spain AIP containing information on airway R753

Conditional routes (CDR) are routes or segments of routes that can be filed or used in specific circumstances. They are divided into three categories (CDR1, CDR2 and CDR3) depending on their availability for flight plans.

Category 3 (CDR) – not plannable CDR: routes in this category cannot be filed in flight plans and can only be used with ATC clearance after coordinating with military controllers.

1.8.2. Current airspace configuration for departures toward N from LECU/LEVS.

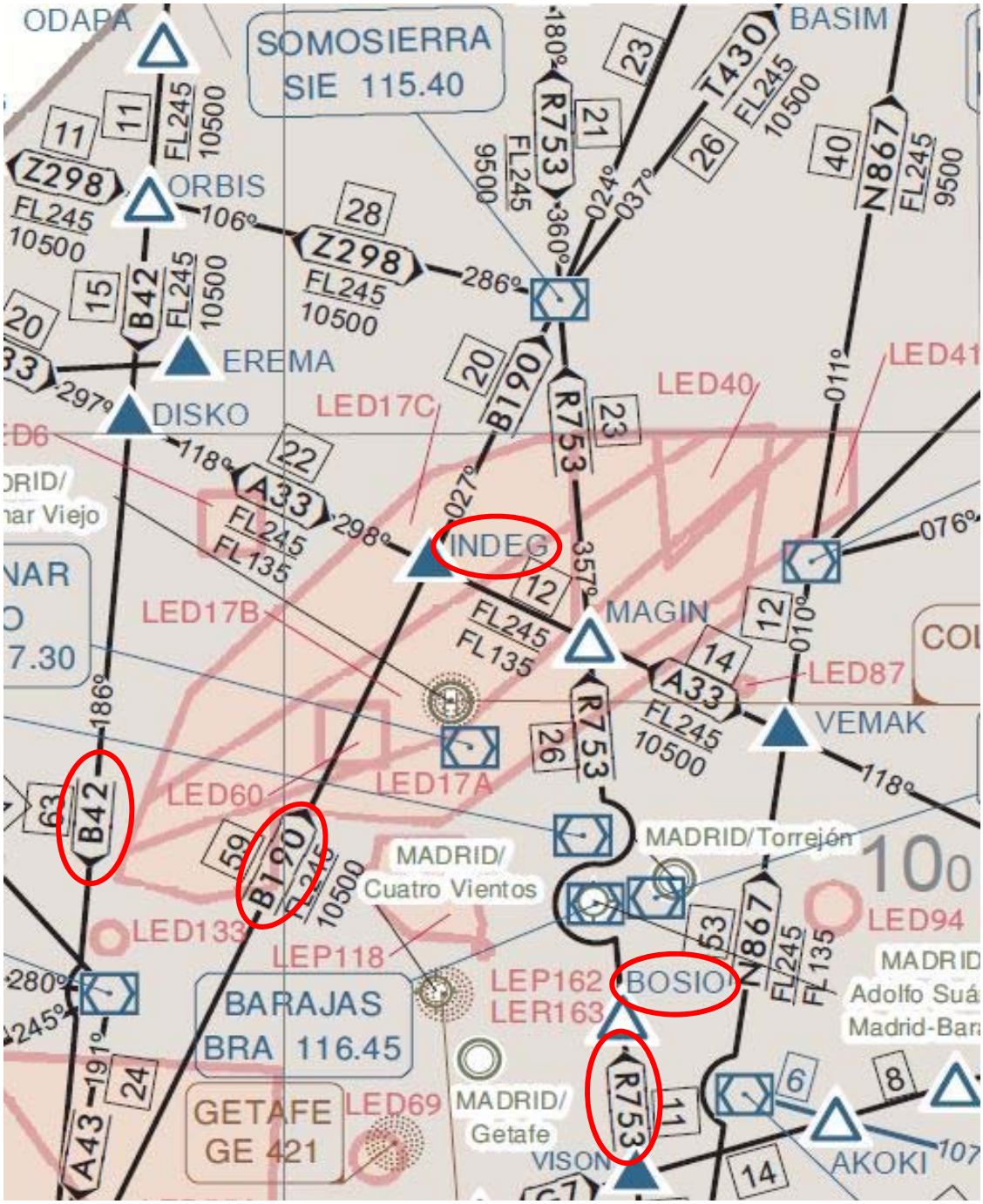


Figure 4. Extract from lower airspace chart (ENR 6.1-1), with airways B42, B190 and R753 and points INDEG and BOSIO circled in red

Aircraft taking off from LECU wishing to proceed under IFR to the N have the following options:

- Proceed direct to point INDEG and join airway B190.
- Proceed direct to the SIE DVOR/DME.

In both cases they must fly at VFR altitudes to that point, or under IFR with ATC clearance.

Aircraft cannot use airway B42, as it is a southbound airway.

The flight plans that are presented to and approved by the ARO office at LECU/LEVS for aircraft with Z flight plans proceeding to the north were checked, and all were verified to indicate that after takeoff, the aircraft proceeds direct to the SIE DVOR/DME (first IFR point).

In its investigation report, the service provider, ENAIRE, issued a recommendation in which it stated that Z flight plans from LECU to the north should be analyzed in order to keep their initial segment from conflicting with arrivals and takeoffs at LEMD.

1.9. Communications

Aircraft AAL37 had taken off from the Madrid-Barajas Airport at 09:29:48, while aircraft ACR31 had done so from the Madrid-Cuatro Vientos Airport at 09:08.

The crew of both aircraft were in radio contact with the control towers of the departure airports and with the WDN control sector.

The communications with the control towers were entirely routine, and thus no further information about them is included in this report.

As concerns the WDN control sector, the most significant ground-air radio communications with the aircraft under its control are provided below, along with those held on hotlines with other control stations.

Time	Freq.	Station	Message
9:10:35	HL[2]	WDN (executive)	Asks controller at Cuatro Vientos to transfer him ACR31 quickly, since it is on a bad route and he wants to turn it north.
9:10:43	HL	LECU	Acknowledges.
9:10:55	RD[3]	ACR31	ACR31 establishes radio contact.
Between 9:10:58 and 9:15:37	RD	WDN(executive)/ACR31	The controller gives several heading and altitude instructions to aircraft ACR31. Finally, after asking the crew about their desired altitude, he clears them to 10000 ft.

[2] HL - hotline

[3] RD - radio

From 9:16:37 to 9:17:15	RD	WDN (executive)	Communicates with aircraft ANGEL11M.
From 9:17:33 to 9:17:55	DL[4]	WDN (planning)	The planning controller coordinates aircraft ANGEL 11M with LEGT
From 9:18:03 to 9:18:29	RD	WDN (executive)	Communicates with ANGEL 11M
9:20:30 to 9:20:42	DL	WDN (planning)	Communicates with LEGT to coordinate aircraft ANGEL 11M and ANGEL 35M
9:23:33	RD	ACR31	The crew ask controller about possibility of flying direct to the Somosierra VOR
9:23:40	RD	WDN (executive)	Controller clears ACR31 direct to Burgos
Between 9:23:46 and 9:24:04	RD	WDN (executive)	The controller informs ACR31 that it will be passing through an area with a minimum altitude of 10500 ft, and thus instructs it to climb to 11000 ft
From 9:27:03 to 9:29:23	RD	WDN (executive)	Coordinates with ANGEL11M and CONDOR31
From 9:29:41 to 9:30:10	DL	WDN (planning)	Coordinates with LEGT (already in this exchange there are reception problems)
From 9:30:35 to 9:30:38	RD	WDN (executive)	Coordinates with CONDOR31
9:30:48	RD	AAL37	AAL37 reports passing 4300 ft climbing to 13000 ft
9:30:54	RD	WDN	Controller confirms radar contact with AAL37 and clears it to climb to FL240
9:30:59	RD	AAL37	The crew acknowledge the instruction
From 9:32:23 to 9:32:59	RD	DWN (executive)	Coordinates with ANGEL11M
9:33:00	DL	WDN (planning)	Cannot listen to the communications of Getafe, states will call using another method
Between 9:33:11 and 9:33:33	HL	WDN (executive)	Executive controller calls LEGT several times on hotline with no response
9:33:39	HL	LEGT	Reply received from LEGT

[4] Dedicated line

9:33:40	HL	WDN (executive)	The controller explains to LEGT the planning he has arranged for the arrivals of ANGEL11M and CONDOR to LEGT
From 9:33:52 to 9:34:33	RD	WDN (executive)	Coordinates with CONDOR31 its approach to LEGT
9:34:34	DL	WDN (planning)	Coordinates with LEGT the details of final approach phase of CONDOR21
9:34:44			Sound of PAC-VAC alert activation heard[5]
9:34:49			Sound of PAC-VAC alert activation heard
9:34:56	RD	AAL37	Crew of AAL37 report TCAS RA
9:34:57	RD	WDN (executive)	Controller acknowledges
9:35:25	RD	AAL37	Crew of AAL37 report clear of conflict and inform resuming climb to FL240

1.10. Aerodrome information

Not applicable.

1.11. Flight recorders

Since the investigation into this event was initiated several days after it occurred, it was not possible to access the relevant information that would have been recorded on the flight recorders, since the units continued to record during this time, resulting in the information on the incident being overwritten by subsequent information.

1.11.1. Radar information

The radar tracks for both aircraft were reviewed, from the time of takeoff until the crew of AAL37 reported clear of conflict after the TCAS RA.

ACR31 took off from the Madrid-Cuatro Vientos Airport at 09:08:45.

At 09:10:58, when the executive controller in sector WDN instructed the crew of ACR31 to “turn left heading north when you reach 5000 ft”, the aircraft was about 2 km south of the Madrid-Cuatro Vientos Airport flying to the east.

It continued flying east until 09:12:43, when it reached 5000 ft and it began turning north, reaching this heading 30 seconds later.

[5] The alert consists of three quick beeps repeated every five seconds.

The aircraft continued flying north as it climbed. It flew over the city of Madrid to the west (leaving the city to the east of its position). The flight path taken by the aircraft was some 25 km west of airway R753.

When the TCAS RA was received, this aircraft was over the town of Miraflores de la Sierra.

AAL37 took off from the Madrid-Barajas Airport at 09:29:53.

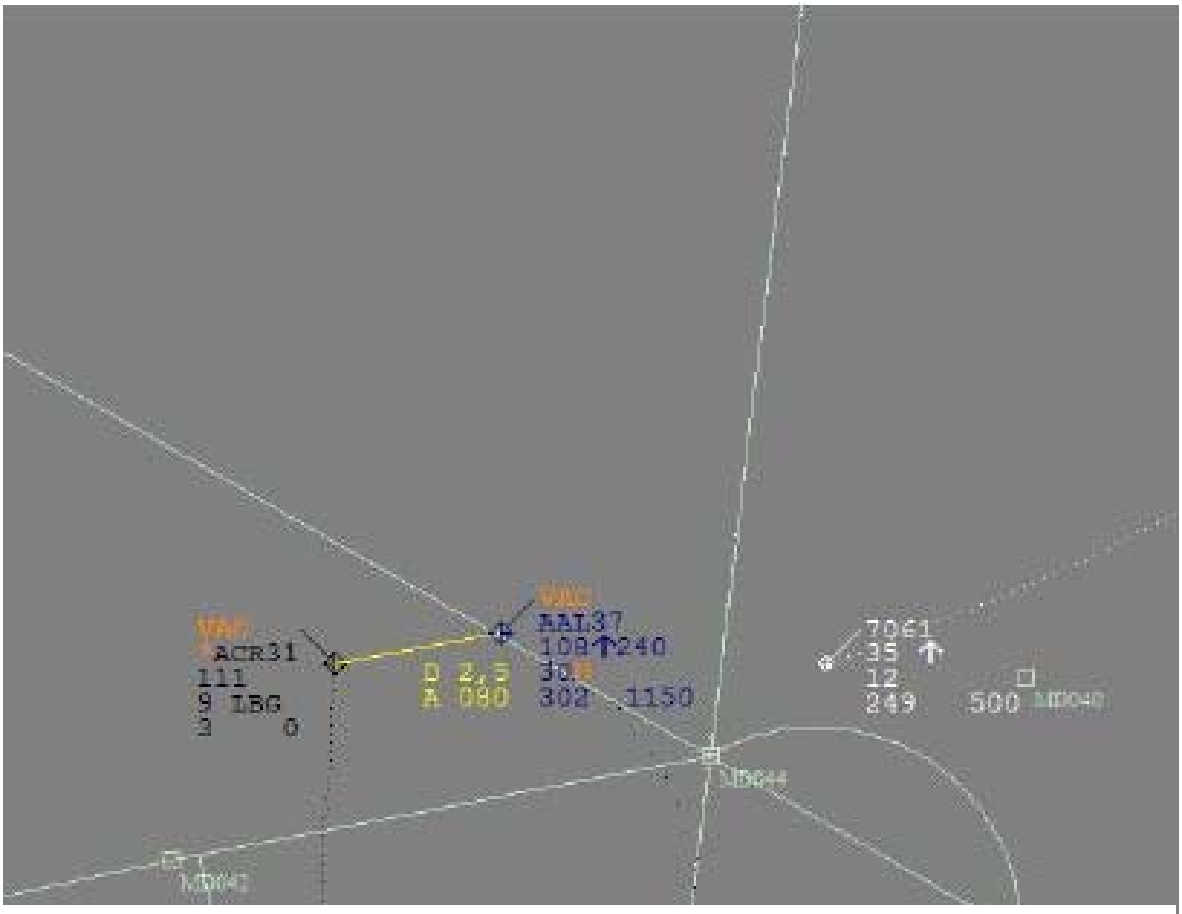


Figure 5. Image of the moment when the VAC conflict alert occurred

The radar track shows that the aircraft correctly followed SID ZMR1L. In the 2 minutes before receiving the TCAS RA, its climb rate had been 1900 ft/min.

At 09:34:43, the SACTA system issued a STCA VAC conflict alert (see Figure 5).

At 09:35:16, AAL37 generated a message that the RA was clear. This message was sent with the mode-S data packet. The information sent included the kind of maneuver indicated by the on board equipment, which was a descent maneuver.

1.12. Wreckage and impact information

Not applicable.

1.13. Medical and pathological information

Not applicable.

1.14. Fire

There was no fire.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

1.16.1. Statements from crews and controllers

1.16.1.1. Aircraft N825AA

1.16.1.1.1. Captain

The captain stated that they were flying American Airlines flight 37 from Madrid to Dallas-Fort Worth. They had taken off from runway 36L and were following P-RNAV departure ZMR1L.

Once above 10000 ft, they started to accelerate from 250 kt to approximately 340 kt, in keeping with standard operating procedure.

They saw “another traffic” on the TCAS, located to their left, which quickly became “close traffic”.

When they were at about 12500 ft, the TCAS issued a traffic advisory (TA), which changed to a resolution advisory (RA) when they were at about 13000 ft.

The copilot, who was the pilot flying (PF), executed the descent maneuver instructed by the TCAS. He disengaged the autopilot and auto-throttle and followed the instructions.

He informed Madrid Control that they were descending due to a resolution advisory. During the descent, they were in visual contact with the other airplane, which was a small high-wing, single-engine airplane.

When the TCAS indicated clear of conflict, he called Madrid Control to report this and that they were resuming their climb. The controller’s reply to both the RA report and to the clear of conflict report was “roger”.

1.16.1.1.2. Copilot

He stated that he was the pilot flying (PF).

They were climbing, following SID Zamora 1L, after having taken off from runway 36L at the Madrid-Barajas Airport.

As they were about to reach 12500 ft, they received a TCAS traffic advisory, which changed to a resolution advisory some 15 seconds later, with the TCAS instructing them to descend.

He disengaged the autopilot and followed the TCAS instructions while the captain reported the event to Madrid Control.

Once the conflict cleared, they resumed the flight, which ended uneventfully.

1.16.1.1.3. Relief pilot

The copilot was the pilot flying. The autopilot was engaged.

They realized there was a Cessna climbing and heading north. A little later he saw that this aircraft was some 15 NM away. At that point they received the first TCAS traffic advisory, which a short time later became a resolution advisory.

The copilot did a great job, disengaging the autopilot and gently carrying out the instructions issued by the TCAS. They informed ATC that they were taking action in response to a TCAS RA, to which the controller replied “roger”.

When the conflict cleared, they resumed climbing to their assigned altitude. He added that at no point did they deviate from their previous heading.

1.16.1.2. Aircraft EC-IEO

The instructor pilot who was in command of the aircraft stated that it was a training flight. They had a Z flight plan, meaning that it was initially conducted under visual rules and then under instrument rules. They had taken off from the Madrid-Cuatro Vientos Airport en route to the Burgos Airport.

After taking off they were transferred by the control tower at Madrid-Cuatro Vientos to Madrid Control.

They contacted this station, which instructed them to head north direct to Burgos and to climb to 11000 ft. He added that the first point on the instrument part of the route was BOSIO, but that Madrid Control diverted them by instructing them to head north.

They were flying in visual contact with the ground. They saw an aircraft at a lower altitude that was climbing and heading toward them, flying west.

They then saw the aircraft stop its climb and start to descend. They, in turn, attempted to climb, though they only managed to climb 200 ft, since they were flying practically at the aircraft’s service ceiling.

Seconds later the other aircraft passed beneath them, after which they continued their flight normally.

1.16.1.3. Control service

1.16.1.3.1. Executive controller

He stated that when the incident occurred, he had been working in that sector for about 90 minutes, for the first 37 minutes as the planning controller and then as the executive controller.

He stated that he was aware from the start that ACR31 could conflict with departures from runway 36L, so he set an LAD[6] between that aircraft and every departing aircraft.

In an effort to minimize potential conflicts with departures from Madrid, he decided to give it instructions to proceed to the west of the Madrid-Barajas Airport before later giving it a heading toward its destination.

His first instruction was to turn it to heading 330º and, at the crew's request, to climb to 10000 ft. Later he noticed that the aircraft would fly in an area with a minimum radar altitude of 10500 ft, so he asked the crew to climb to 11000 ft.

After this, they had to coordinate a series of approaches to Getafe. He recalled that while making the arrangements, a Ryanair aircraft had taken off from runway 36L, which he linked to ACR31 using an LAD to monitor their separation.

As they transferred the sequence of approaches to Getafe, that they had arranged through the planning controller, they noticed problems hearing the communications with Getafe.

When he received the first call from AAL37 after taking off from 36L, he linked it to ACR31 using an LAD. At that time he considered two options: stop the ascent of AAL37 at 10000 ft or let it continue and establish on the segment between MD093 and MD044, leave it on that heading until it cleared 12000 ft and then turn it toward ZMR. He decided to opt for the latter so as not to stop the traffic's constant climb.

With part of this task still pending, a change came up involving a request from a traffic in the sequence for Getafe that forced him to make a series of arrangements, which the planning controller started over the dedicated line, though he could not complete them due to the reception problems. As a result, the planning controller asked him to coordinate over the hotline.

[6] Feature of the SACTA system used to determine headings, as well as distances between runways, between points and runways to predict minimum separation and time

He recalled that it was hard to make contact, which made him lose more time. Once contact was established, he focused on giving instructions to keep the two aircraft en route to Getafe adequately separated.

He thought he had focused too much of his attention on this task and forgot the pending issue involving AAL37 and carrying out the plan he had set up to separate it from ACR31. He stated that the fact that he had a plan laid out could have made him feel that the task had been resolved.

When he received the call from AAL37 reporting the TCAS RA, all he could do was reply “Roger”.

He did not recall receiving any previous alerts warning of a loss of separation.

As for the workload, he deemed it to have been high, not so much due to the traffic volume, but rather because of the types of operations that were taking place at the various airports under the sector’s responsibility: many visual calls, coordinating with LECU and LEGT, etc. It was reminiscent of the workload basically associated with sector DW, more than WN. Although he did not think that combining the sectors was a relevant factor in how the event played out, he did think that the shift in focus required could have influenced his failure to detect the conflict. In this regard, he recalled changing his focus when he concentrated on the approach sequence to LEGT.

When asked about potential areas of improvement to reduce the complexity of the operation, he stated that it might be beneficial to analyze the possible conflicts caused by Z flight plans for departures from LECU toward the north, and involving both arrivals and instrument departures at LEMD.

1.16.1.3.2. Planning controller

The incident occurred 50 minutes into his shift as planning controller. He had made a complete rotation at the same combination of sectors first thing in the morning.

He agreed with the executive controller that the workload was high, not so much due to the traffic volume as due to the types of operations, coordinating with LECU and LEGT, etc. Although he did not think that combining the sectors was a relevant factor in the event, he thought that the type of operation that this combination entails leads to “wear” in situations like the ones that converged on that day.

He recalled that they had coordinated previously with the DEN sector, without using the hotline, for an approach to LEGT.

Over the course of the event, he had to update flight plans on several occasions at the request of the Getafe tower in order to forward the flight strip for ANGEL11M. This task was complicated by the potential confusion over another helicopter’s callsign (ANGEL35M).

He verbally asked the executive controller to handle coordinating the sequence of arrivals with LEGT, since he was unable to hear the controller at that station over the telephone.

He added that both he and the executive controller focused their attention on the conflict involving the LEGT sequence.

1.17. Organizational and management information

1.17.1. Control center

The WDN sector was in charge of controlling these aircraft.

Sector WDN is the result of combining two elementary sectors of the TMA (see Figure 6): DWN (west takeoff in a north configuration) and WNN (west north in a north configuration).

Sector DWN is responsible for aircraft departing from runway 36L at LEMD from the time they take off until they are transferred to other sectors in the TMA, WNN or WSN (west south in a north configuration). It is also responsible for aircraft executing a go around on runways 32R and 32L.

The controller in this sector is responsible for handling both inbound and departing traffic for LEGT, LECU/LEVS and LECV, as well as for making the necessary arrangements with the corresponding control towers.

Figure 6. Sectors DWN and WNN of the Madrid TMA

The sector's vertical limits are:

- Sector A: FL160/SFC.
- Sector B: FL160/3000FT
- Sector C: 6500FT/SFC except ATZ for LEGT, LECU/VS, LECV and LEMD.

As for sector WNN, it handles climbing traffic outbound from the Madrid TMA, from the time it is transferred by DWN until it is transferred to route sectors. It must also descend inbound traffic into the TMA from the time it is transferred by route sectors until it is transferred to

the West Master Sector (RWM), with which it must coordinate traffic from/to LEGT and LECU/LEVS.

The vertical limits of sector WNN range from FL245 (TMA limit) to the ground, except for the airspace belonging to the West Master and West Takeoffs sectors. The horizontal limits are shown in Figure 6.

Therefore, the controller of sector WDN, formed by combining the two sectors described above, has on his frequency all of the aircraft outbound from runway 36L at LEMD, from the time they take off until they are transferred to the route sectors, and inbound traffic to the TMA, until it is transferred to sector RWN. This controller also handles traffic from/to LEGT, LECU/LEVS and LECV. The vertical limits under his control were from FL245 to the ground.

1.17.2. Team resource management (TRM)

TRM (Team Resource Management) is defined as the strategies for improving the use of available resources (information, equipment and personnel) in order to maximize the safety and efficiency of air traffic services.

TRM training was developed in recent years when it was noticed that the causes of many incidents lay in human errors both in terms of performance and teamwork. TRM training, therefore, seeks to reduce the impact of errors in the air traffic management system that result from working in a team, as well as to develop strategies that allow for the better use of all the resources available in order to maximize safety and efficiency.

In light of the above, ENAIRE, the services provider, implemented a TRM course in December 2016 as part of its refresher training. The course lasts approximately four hours and is expected to be taught every three years.

The course is taught in person and the content features a theoretical part with an introduction to TRM and TRM “Facilitation”. This latter part describes teamwork and conducts an analysis and evaluation of this work. Finally, a case study is presented involving an analyzed incident whose cause was determined to be improper teamwork. Once presented, the course attendees debate the incident in order to identify the sources of individual and group errors and develop individual and group strategies to prevent the types of mistakes identified and mitigate their effects. These strategies include:

- Develop and maintain good situational awareness.
- Problem solving.
- Decision-making techniques.
- Effective communications.
- Creation of synergies.
- Efficient teamwork.

The services provider’s internal investigation report contained a recommendation issued to its own Regional Training and Evaluation Department to have it consider including this incident in its TRM training courses.

The acceptable means of compliance issued by the EASA for complying with regulation 2015/340 lays out requirements involving TRM training. Specifically, AMC1 ATCO.D.045(c)(4) states:

(a) Training organisations should train the applicant during OJT in team resource management, fatigue management and stress management.
(b) Training organisations should develop performance objectives for team resource management training.
(c) TRM training may also make use of synthetic training devices.

1.18. Additional information

1.18.1. Flight plan of aircraft ACR31

This flight plan was filed by the aircraft's crew with the ARO at 14:00 on the day prior to the event.

It specified the following:

- Time of takeoff: 08:30
- Speed: 90 KIAS
- Level: 100
- Route: the visual part, from takeoff to the "CVT" NDB, with the instrument part commencing at this point. From "CVT", it proceeded direct to the "SIE" VOR/DME, at which point it joined airway R753.

- The remarks section stated, among other things, that any changes proposed by the IFPS would be accepted[7].

The message was sent to the IFPS and a reply message from that system was received at 14:10. The reply made changes to the crew's proposal that primarily affected the route but kept the speed (90 KIAS) and flight level (100) unchanged.

The change in route affected the first part such that from the "CVT" NDB, it was to continue under VFR direct to point BOSIO instead of doing so under IFR to SIE, as proposed. With this change, the instrument part would begin at BOSIO, at which point the aircraft would join airway R753.

These changes were made by the IFPS based on the crew's previous acceptance to any changes made, as indicated on the flight plan they initially filed.

BOSIO is a point on airway R753 that is in the segment between the VTB VOR/DME and the SIE DVOR/DME, and is not to be filed in flight plans (see 1.8). As a result, the change made to the flight plan by the IFPS was in violation of this restriction.

[7] Eurocontrol's Integrated Initial Flight Plan Processing System

Investigators looked into this situation and came to the conclusion that this restriction was not entered into the IFPS because restrictions for airways that are not categorized, as was the case with R753, are not automatically incorporated into this system; rather, they are only entered if requested by the national coordinator.

The request was made and resolved by issuing a EURO restriction.

The remaining airways in the Madrid FIR were also checked to see if there were additional cases involving airways that were not categorized. It was concluded that R753 was the only case.

1.18.2. Operation of the conflict alert

A conflict alert (CA), also known as a STCA (short-term conflict alert) is a feature of the SACTA system that is intended to give controllers short-term information on potential losses of separation between aircraft based on previously defined criteria for horizontal and vertical separation.

The conflict alert relies on radar data (radar tracks) and on various locally defined parameters (volumes with different horizontal separation parameters, inhibition volumes, etc.)

The most usual mechanism for identifying a conflict is to use the so-called “linear prediction filter”. This filter extrapolates the future 3D position of each radar track to determine if, for a pair of candidate radar tracks, the lateral (HSD) and vertical (VSD) separation criteria will be simultaneously violated within a certain time. The system also uses cleared flight levels (CFL) entered manually to filter conflicts and thus avoid nuisance alerts.

The final step in the CA process is called “alert confirmation stage”, the goals of which are to:

- Verify if a conflict is imminent and requires an immediate alert.
- Delete an alert if deemed to result from incorrect information.
- Verify if an alert is needed immediately or if it can be delayed while waiting for the conflict situation to clear before the alert becomes necessary.

In this stage, the CA feature determines whether to display the alert or not based on whether the criteria for displaying the alert persist over three consecutive updates of the radar tracks and on the time remaining before the separation criteria are violated.

To do so, it uses the alert time (AT) and immediate alert time (IAT) parameters:

- If the CA feature detects a loss of separation before the AT, it will wait for the track to be updated three times (15 s) to confirm the conflict, and if it persists, it will display the alert.
- If the CA feature detects a loss of separation before the IAT, it will not wait for confirmation of the conflict and will display the alert immediately.

A conflict alert can have the following states:

- PAC (conflict alert prediction): displayed if the system detects that the specified separation parameters (horizontal and vertical (HSD and VSD)) will be violated within the specified time periods (AT and IAT).
- VAC (conflict alert violation): displayed when the specified separation parameters (HSD and VSD) are violated.

The alerts are reported on the screen visually, in color for both the PAC and VAC, and acoustically with a beeping sound.

For the airspace volume where the aircraft were located, the following parameters had been entered into the system:

- Immediate alert time (IAT): 55 s.
- Alert time (AT): 85 s.
- Horizontal safety distance (HSD): 2.5 NM
- Vertical safety distance (VSD): 800 ft

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1. Analysis of flight plan of aircraft ACR31

The initial flight plan filed by the crew of ACR31 included an entry in the remarks section in which they stated their acceptance of any changes proposed by the IFPS.

This practice is fairly common, as this ensures that the flight plan will be accepted. In contrast, if this is not done and the flight plan is not accepted, the crew must file a new proposal, wait for the reply from the IFPS and if rejected, start the process again until the flight plan is approved.

The changes made by the IFPS to the flight plan indicated that ACR31 would have to proceed to point BOSIO to join R753 at an altitude of 10000 ft. This change violated the altitude restrictions in place for this airway in that area. According to the Spain AIP, the airway cannot be included in flight plans at altitudes below 13500 ft without ATC clearance.

The controller quickly noticed that the routed planned for ACR31 was not suitable and could cause a conflict with aircraft inbound to or outbound from the Madrid-Barajas Airport. As a result, he decided to vector the aircraft to the NW (heading 330º) to move it away from the area.

This created an additional workload in the sector. Not only that, but the new route given to the aircraft could, and eventually did, create a conflict with aircraft taking off from runway 36L at LEMD. As a result, the approved flight plan is deemed to have been a contributing factor in this incident.

During the investigation, this restriction was found not to have been reported to the IFPS, because restrictions for airways that are not categorized, as was the case with R753, are not automatically incorporated into this system; rather, they are only entered if requested by the national coordinator.

The services provider took two actions as a result of this finding:

- It filed a request to have the restrictions of airway R753 registered, which was done by issuing a EURO restriction.

- The remaining airways in the Madrid FIR were also checked to see if there were additional cases involving airways that were not categorized. It was concluded that R753 was the only case

The measures taken by the provider are deemed adequate and no further recommendations are issued.

2.2. Analysis of takeoffs from LECU toward the north

According to the restrictions for airway R753, it cannot be filed in flight plans and it cannot be used below 13,500 ft without prior approval from ATC. Many aircraft outbound from LECU cannot comply with this restriction because their service ceiling is below this altitude.

Investigators asked the ARO office about the flight plans filed and approved for IFR aircraft flying to the N following the EURO restriction issued for airway R753. It was determined that aircraft proceed to the SIE DVOR/DME to join the airway at this point.

This route could cause aircraft to conflict with departures from runway 36L at LEMD, and specifically with instrument departures ZMR1L and ZMR1X. As a result, it would be prudent for aircraft departing LECU to the north to proceed to the W before joining one of the northbound airways.

The best thing would be to join airway B42 at the NVS DVOR/DME; however, this is a southbound airway.

The other option is to proceed N to point INDEG at 11,000 ft (due to altitude limitations) and there proceed to airway B190. This route, like the one in which an aircraft proceeds direct to the SIE DVOR/DME, could cause a conflict with takeoffs from 36L at LEMD.

In its internal investigation report, ENAIRE, the services provider, included a recommendation in this regard that called for Z flight plans from LECU to the north to be analyzed to ensure that their initial segment does not conflict with arrivals or departures at LEMD.

To complement the above, a safety recommendation is issued to ENAIRE to have it modify the airspace such that a route is provided for aircraft taking off from LECU and flying north under IFR that prevents them from conflicting with other aircraft in the Madrid TMA.

2.3. Considerations involving the control station

2.3.1. Airspace considerations.

The simple sectors DWN (west takeoffs in north configuration) and WNN (west north in north configuration) had been combined into a single sector, WDN. As a result, it was responsible for the following:

- Ascending aircraft taking off from runway 36L at LEMD until they were transferred to the corresponding route sector.
- Descending aircraft entering the Madrid TMA from the W until they were transferred to the master sector.
- Managing both inbound and outbound traffic for the LEGT, LECU/LEVS and LECV airports.

The WDN sector is large, both horizontally and vertically, since its vertical limits span from GND to FL245.

The workload was verified not to have been high, and at no time was the sector's stated capacity exceeded. The controller stated that the workload was increased due to calls from visual traffic and to the arrangements that had to be made, though he did not consider it a relevant factor in the event.

The possibility that controlling a large area, and therefore working with a rather broad radar display range, could have affected the detection of the conflict was considered during the investigation, though in the end this was deemed not to have been a contributing factor since the controller had correctly identified the potential conflicts far enough in advance. It was the fact that he focused his attention on one conflict that made him forget about the other one, something that could have happened in a smaller control area.

2.3.2. Actions taken by sector WDN controllers.

The executive controller had been working at the same post for about 50 minutes, and in the sector for 90 minutes (he started the shift as the planning controller), meaning his situational awareness was adequate. He noticed that the route contained in the flight plan for ACR31 would conflict with approaches to LEMD, and subsequently with takeoffs from LEMD. After contacting the aircraft on the frequency, he decided to divert it to the W, instructing it to turn to heading 330º. He also cleared it to climb to 10000 ft first, and then to 11000 ft upon noticing that it would be entering a sector where the minimum altitude was 10500 ft.

At 09:23:23, the crew of ACR31 requested to proceed direct to the SIE DVOR/DME, and the controller instructed them to proceed direct to LEBG. The controller knew the entire time that ACR31 could conflict with takeoffs from runway 36L at LEMD. He first realized this with a takeoff that in the end did not result in a conflict, and then with AAL37. According to the controller's statement, after contacting AAL37 on the frequency (09:30:54), he considered two options: halting the climb of AAL37 at 10000 ft until the potential conflict cleared, or letting AAL37 continue to fly SID ZMR1L and see if its climb rate caused it to clear 12000 ft, and if not, to keep it on the heading indicated by the procedure upon leaving point MD039 until it was past point MD044 on that same heading (instead of turning left, as indicated in the procedure) until it cleared 12000 ft, and then instructing it to resume the SID. He decided on the latter option so as not to interrupt the climb of AAL37. The controller left the LAD for the two aircraft set on the radar display to monitor the progress of the aircraft and to remind him that he needed to take action with AAL37.

Prior to this, the controller had handled an approach to LEGT. He had cleared ANGEL11M (a helicopter) to make the ILS approach to runway 05, and CONDOR31, number 2 in the sequence, to descend to 5000 ft, thus maintaining the vertical separation between the aircraft.

However, at 09:32:23, he contacted the crew of ANGEL11M, which offered to change the sequence order, since it was a slower aircraft, and to come in second behind CONDOR31,

so as not to hold it up. The executive controller thought the change appropriate and instructed ANGEL11M to turn left and maintain 4000 ft to take it out of the approach. For his part, the planning controller attempted to report the change to the controller in the LEGT TWR, but was unable to due to a reception problem on the dedicated line. This forced the executive controller to take over this task, which resulted in a delay in giving instructions to CONDOR31. As a consequence of this, the executive controller was focused on this conflict (coordinating with the LEGT controller and giving instructions to ANGEL11M and CONDOR31 to ensure the separation between them was maintained) from 09:32:23 until the acoustic conflict alert sounded at 09:34:44 (2 minutes and 21 seconds), which caused him to forget about the pending action involving AAL37.

As a result, the bad reception on the dedicated line to LEGT is considered a contributing factor in this incident. The services provider stated that it was a one-time malfunction, as there were no faults after the incident and no additional repair actions were needed.

By the time the conflict alert was received, the controller was unable to take any actions to avoid the conflict. Based on the oral communications, the first time the conflict alert was activated, the controller was communicating with another aircraft.

After the second aural alert, the executive controller identified the conflict, but the crew of AAL37 immediately informed him that they had received a TCAS RA.

2.3.3. Considerations involving the conflict alert

According to the radar data available, at 09:34:43 the SACTA system issued a visual alert by way of a VAC, since the minimum separation distance specified for that area (3 NM – 1000 ft) was being violated. The system also has an aural alert, which was activated one second after the visual alert.

The lead time provided by this conflict alert was not useful in this case since it did not allow the controller to take measures to avoid the conflict or increase the separation between the aircraft.

In the 40 seconds before the violation alert (VAC) was issued by the SACTA system, aircraft ACR31 flew a straight path and kept a practically constant altitude of 11,000 ft.

As for AAL37, it followed SID ZMR1L, which traces out a curve near point MD044 before continuing direct to point DISKO. The aircraft was gaining altitude steadily during this entire time.

Figure 7 contains a graph showing the radar targets for both aircraft during this time period. In yellow to the left are the targets for ARC31, while to the right in red are those for AAL37. The gap between each target is 5 s. As this figure shows, after the target from 09:34:18, AAL37 flew in a straight path.

Even before this, the path, though curved, is fairly gradual and clearly shows it is converging with the path of ACR31. Another fact to consider is that the path of AAL37 reflected the standard departure it had been assigned and that was listed in its flight plan, meaning the system had information on the future positions of this aircraft, in addition to those derived solely by the linear extrapolation.

In addition to the linear prediction, the system also has an alert confirmation phase. This uses two values, AT (alert time) and IAT (immediate alert time). For the area where the aircraft were flying, these values were set at 55 s for the IAT and 85 s for the AT. If the system calculates that the minimums will be violated within 55 s, it provides a direct alert. If the time to the violation is longer, it allows the radar data to be refreshed three times in order to confirm that the alert is real. In this case, the minimum distance entered into the system was 2.5 NM (horizontally) and 800 ft (vertically).

In this case a PAC alert was not issued, even though the characteristics of the 3D flight paths taken by the aircraft seem like they should have led to the conclusion that a conflict would occur within the IAT period, in which case the alert should have been displayed immediately without the need to confirm the conflict by waiting for three radar updates.

The certainty of the conflict would have been reinforced had the system used the information included in the flight plan, in particular that pertaining to the SID being followed by the aircraft.

For this reason, issued with this report is a recommendation directed at the control services provider, ENAIRE, to have it revise the conflict alert prediction algorithm (STCA) in an effort to improve its ability to detect future conflict scenarios. This recommendation also includes the suitability of evaluating the viability of improving the capability of the system to use flight plan data.

2.3.4. Considerations involving TRM training

When the dedicated line failed, the executive controller had to take over the coordination activities that the planning controller had been doing, in addition to keeping the aircraft separated in that area. Both the executive controller and the planning controller focused their attention on that part of the airspace for a long period of time, and as a result the executive controller was unable to monitor another potential conflict he had identified earlier. Therefore, it is deemed that the executive controller did not apply proper team resource management during the incident.

In 2017, the services provider started teaching TRM courses, though neither the executive nor the planning controller had taken any of the courses prior to the date of the incident.

In its internal investigation report, the services provider issued a recommendation to its own Regional Training and Evaluation Department to have it consider including this incident in its TRM training courses. This action taken by the services provider is considered to be sufficient, and therefore no additional safety recommendations are issued in this regard.

2.4. Actions taken by the flight crews

AAL37 was flying standard departure ZMR1L. After turning left at point MD044, as indicated in the procedure, the crew noticed the presence of an aircraft on the screen. Some time later a TCAS TA was received, followed by a descend RA. The copilot, who was flying the aircraft, disengaged the autopilot and followed the instructions in the RA by making the aircraft descend. According to radar data, the TCAS RA lasted until 09:35:16 and the aircraft descended to 10,200 ft. The TCAS RA was not coordinated since ACR31 did not have a TCAS system.

For its part, ACR31 was flying level at 11,000 ft on heading N. The crew were in visual contact with AAL37 and noticed it had initiated a descent (in keeping with its TCAS advisory), so they decided to climb. The radar data show they climbed to just 11,200 ft because, as the crew stated, they were close to their operational ceiling.

3. CONCLUSIONS

3.1. Findings

- The crews of both aircraft had valid licenses and medical certificates.
- The controllers with whom they were in contact during the incident had valid licenses and medical certificates.
- Both aircraft's documentation was in order and they were airworthy.
- ACR31 did not have an on board ACAS system.
- The crew of ACR31 filed their flight plan and stated that they would accept any change made by the IFPS.
- The flight plan proposed by the IFPS indicated they would have to join airway R753 at point BOSIO and 10,000 ft, which violated the airway's altitude restrictions.
- Sectors DWN and WNN were combined into sector WDN.
- The controllers had adequate situational awareness of the sector.
- The workload was not high and was not in excess of the sector's stated capacity.
- The executive controller noticed that the flight plan of ACR31 could cause conflicts and gave vectors to the aircraft to divert its flight path to the west.
- The controller noticed that the new path of ACR31 could cause it to conflict with AAL37.
- The controller set the LAD on the SACTA system on the aircraft to monitor their approach. He planned actions to take to avoid the conflict, to be executed later.
- The crew of ACR31 followed ATC's instructions.
- AAL37 followed standard departure ZMR1L after taking off from runway 36L at the Madrid-Barajas Airport.
- There was a change in the approach sequence to LEGT.
- There were reception problems on the dedicated line between LEGT and the planner, and so the executive controller had to take over coordinating with this station.
- Both the executive and planning controllers focused their attention on solving this conflict, forgetting about the situation between ACR31 and AAL37.
- The conflict alert resulted in a VAC when the separation between the two violated the minimum radar separation distance.
- The crew of AAL37 received a TCAS descend RA.
- The PF followed the established procedures and the aircraft, which had been climbing, executed a descent.
- The PNF reported the TCAS RA activation on the frequency, and then clear of conflict.
- The executive controller was unable to give instructions to the aircraft to avoid the conflict, or traffic information, since the crew of AAL37 immediately reported the TCAS RA.
- During the approach, the crew of ACR31 were in visual contact with AAL37, noticed it was descending, and decided to perform an evasive climbing maneuver.
- The aircraft only climbed 200 ft since it was near its operational ceiling.
- The services provider has started to provide TRM courses to controller.
- The services provider has issued a recommendation to have this incident included in its TRM courses.

3.2. Causes/Contributing factors

The incident occurred because the executive controller focused his attention on resolving a conflict in another part of the airspace under his control, while forgetting to track and resolve a potential conflict that he had previously identified.

The following factors are deemed to have contributed to this incident:

- A conflictive flight plan was approved for aircraft ACR31, which violated restrictions on the airway and that brought it into conflict with takeoffs and landings at LEMD
- Poor reception on the dedicated line to LEGT, which forced the executive controller to take over the tasks that the planning controller had been doing.
- The conflict alert on the SACTA system did not activate early enough for the executive controller to take action before the conflict situation involving the aircraft occurred.

4. SAFETY RECOMMENDATIONS

REC 34/18. It is recommended that ENAIRE establish a route for aircraft taking off from the Madrid-Cuatro Vientos Airport (LECU) on northerly routes under IFR, to facilitate its incorporation to an airway and to minimize possible conflictswith other traffics in the Madrid TMA.

REC 35/18. It is recommended that ENAIRE revise the conflict alert prediction algorithm (STCA) in an effort to improve its ability to detect future conflict scenarios. This recommendation also includes the suitability of evaluating the viability of improving the capability of the system to use flight plan data.