CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL

Report IN–032/2014

Incident involving an Airbus A320-216 aircraft, registration EC-KCU (operated by Vueling), and a Boeing 737-800, registration EI-EKS (operated by Ryanair), in the vicinity of reporting point VULPE in the Seville (LEZL) TMA, Spain, on 30 October 2014

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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

ACAS	Airborne Collision Avoidance System
ACC	Area Control Center
ACS-RAD	Air Control Surveillance – Radar Control
AESA	Spain's National Aviation Safety Agency
APS-RAD	Approach Control Surveillance – Radar Control
AEMET	National Weather Agency
AP	Autopilot
ATC	Air Traffic Control
ATM	Air Traffic Management
ATPL (A)	Airline Transport Pilot License
CPL(A)	Commercial Pilot License (Airplane)
CRM	Crew Resource Management
DGAC	Spain's Civil Aviation General Directorate
EASA	European Aviation Safety Agency
EINN	ICAO code for the Shannon Airport (Ireland)
FA	Flight attendant
FD	Flight Director
FDM	Flight Data Monitoring
FDP	Flight Duty Period
FL	Flight level
FMGC	Flight Management and Guidance Computer
ft	Feet
ft/min	Feet / minute
g	Acceleration due to gravity
H	Hours
IAA	Irish Aviation Authority
ICAO	International Civil Aviation Organization
ILS	Instrumental Landing System
JAR-FCL	Joint Aviation Requirements for Flight Crew Licensing
kg	Kilogram(s)
Kt	Knots
LEBL	ICAO code for the Barcelona/El Prat Airport
LECS	ICAO code for the Seville Air Traffic Control Center
LEMG	ICAO code for the Malaga/Costa del Sol Airport

LEZL	ICAO code for the Seville Airport
LPC	Line Proficiency check
N/A	Not applicable
NE	Northeast
NM	Nautical miles
OPC	Operator Proficiency check
PAC	Conflict Alert Prediction
PALESTRA	Plataforma de Análisis y Estado del Tráfico Aéreo (Air Traffic Analysis and Study Platform)
PF	Pilot Flying
PFD	Primary Flight Display
PM	Pilot Monitoring
PNF	Pilot Not Flying
RA	Resolution Advisory
SACTA	Automated Air Traffic Control System
S/N	Serial Number
SERA	Standardised European Rules of the Air
SRA	Safety Risk Assessment
TA	Traffic Advisory
TCAS	Traffic collision avoidance system
TMA	Terminal Maneuvering Area
UTC	Coordinated Universal Time
VAC	Conflict Alert Violation
VSI	Vertical Speed Indicator

Synopsis

Owner and Operator 1:	Vueling
Aircraft 1:	Airbus A320-216, registration EC-KCU
Owner and Operator 2:	Ryanair
Aircraft 2:	Boeing 737-800, registration EI-EKS
Date and time of incident:	Thursday, 30 October 2014 at 20:57[1]
Site of incident:	Seville TMA - (vicinity of point VULPE)
Persons onboard aircraft 1:	2 flight crew, 4 flight attendants (FA) and 153 passengers, no injuries
Persons onboard aircraft 2:	2 flight crew, 5 flight attendants and 36 passengers, no injuries
Type of flight aircraft 1:	Commercial air transport – Scheduled – International - Passenger
Type of flight aircraft 2:	Commercial air transport – Scheduled – International - Passenger
Date of approval:	29 March 2016

Summary of the incident:

On 30 October 2014, an Airbus A320-216, registration EC-KCU, operated by Vueling, took off from the Barcelona-El Prat Airport (LEBL) en route to the Seville Airport (LEZL). Its callsign was VLG2226. At the same time, a Boeing 737-800, registration EI-EKS, operated by Ryanair, callsign RYR314Q, was on a flight between the airports of Shannon, Ireland (EINN) and Malaga-Costa del Sol (LEMG).

The aircraft with callsign VLG2226 was preparing to make an instrument approach to runway 09 at the Seville Airport (LEZL). The crew noticed that the wind from the west favored a landing on runway 27, so they asked Seville air traffic control (LECS) if they could land on this runway. After coordinating it, LECS authorized the runway change and, in different communications, successive descents from cruise level to flight level 170, at a descent rate of 2000 ft/min or less. In an effort to reach the ideal altitude to commence the approach, the crew increased their descent rate above 2000 ft/min.

[1] All times in this report are in UTC unless otherwise specified. To obtain local time, add 1 hour to UTC time.

The aircraft with callsign RYR314Q was cleared by Seville Control to descend from flight level 410 to flight level 150, at a descent rate of 2000 ft/min or higher.

In the vicinity of reporting point VULPE, and close to flight level 220, the separation between the aircraft fell to a minimum separation of 1.4 NM horizontally and 100 ft vertically. The TCAS systems in both aircraft issued first a TA (Traffic Advisory), and a few seconds later, due to the proximity between the two aircraft, an RA (Resolution Advisory). The crew onboard VLG2226 carried out a maneuver that was contrary to the one initially indicated by the TCAS RA ("Adjust Vertical Speed, Adjust"), until the system issued a reversal instruction TCAS RA to "Climb, Climb", which the crew followed properly.

No occupants on either aircraft were injured and the aircraft were undamaged.

The investigation focused on, among other aspects, the actions taken by the crew of VLG2226, both involving the increased descent rate and their reaction to the TCAS RA, since both crewmembers insisted that the system displayed different instructions.

It was concluded that the incident took place because the crew of VLG2226 did not comply with the descent rate instructions provided by the LECS controller. The following contributed to the event:

- The fact that the controller re-cleared VLG2226 to a lower flight level without explicitly including in the clearance the descent rate restrictions again.

- The controller instructed VLG2226 to proceed direct to reporting point ROTEX, indicating that the speed restrictions were still in effect. This part of the instruction was not acknowledged by the crew and the LECS controller did not insist on a full acknowledgment.

- The LECS controller did not have descent rate information on his radar display.

- The crew of VLG2226 did not follow the TCAS RA, instead increasing their descent rate.

As a result of the investigation, three safety recommendations were issued directed at Spain's DGAC, AESA and ICAO.

1. FACTUAL INFORMATION

1.1. History of the flight

On 30 October 2014, a B-737-8AS aircraft, registration EI-EKS and callsign RYR314Q, was flying from the Shannon Airport (Ireland) to the Malaga-Costa del Sol Airport (LEMG). Once in radio and radar contact with Seville Control (LECS), it was cleared to descend from FL410 to FL150.

At the same time, an A-320-216 aircraft, registration EC-KCU and callsign VLG2226, was flying between the airports of Barcelona-El Prat (LEBL) and Seville (LEZL). The first officer was the pilot flying (PF), while the captain was the pilot not flying/pilot monitoring (PNF/PM).

While preparing the instrument approach to runway 09 at the Seville Airport, the crew of VLG2226 noticed that the westerly wind favored a landing on runway 27, so they asked LECS to land on that runway. They were cleared to descend first to FL310, and then to FL250, maintaining a descent rate of 2000 ft/min or less. In the meantime, the crew of RYR314Q were instructed to descend at a rate of 2000 ft/min or higher. This way the LECS controller could ensure the vertical separation between the aircraft, which at that time was in excess of 2000 ft, since the aircraft were on converging trajectories.

After coordinating the runway change, the controller cleared VLG2226 to proceed to point ROTEX[2] under the same restrictions. After one minute, the aircraft's crew noticed they had to increase their descent rate to reach the ideal altitude profile, which they did, reaching a descent rate of up to 5000 ft/min. Shortly afterwards, VLG2226 was cleared to descend to FL170. This time, the LECS controller did not mention in his clearance that the descent rate restrictions were still in effect.

The vertical distance between the aircraft began to fall, as did the horizontal distance, due to the aircraft's flight paths. This resulted in TCAS traffic advisories in both cockpits, followed by resolution advisories. The crew of RYR314Q descended following the advisory. The first officer of VLG2226 disengaged the autopilot and increased the descent rate. A few seconds later, the aircraft had a reversal advisory indicated in the TCAS RA, which was giving the instruction to climb. At that point the captain moved the control stick, without pressing the priority button, to stop the descent and follow the instructions in the TCAS RA. The first officer also pulled on the stick in the same direction, causing both inputs to be added, which resulted in the aircraft's vertical acceleration reaching 2.02 g.

[2] Reporting point.

After several seconds with both pilots actuating the controls, the TCAS RA changed to "Do not Descend", with the TCAS eventually reporting "Clear of conflict". The aircraft crossed, separated by 1.4 NM horizontally and 100 ft vertically.

1.2. Injuries to persons

Aircraft EC-KCU/ VLG2226

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious				
Minor				N/A
None	2+4	153		N/A
TOTAL	6	153		

Aircraft EI-EKS/ RYR314Q

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal				
Serious				
Minor				N/A
None	2+5	36		N/A
TOTAL	7	36		

1.3. Damage to aircraft

Neither aircraft sustained any damage.

1.4. Other damage

There was no other damage.

1.5. Personnel information

1.5.1 Information on the crew of aircraft VLG2226

The captain of VLG2226, a 43-year old Spanish national, had a JAR-FCL airline transport pilot license (ATPL(A)) issued by AESA, with an A320 rating that was valid

and in force until 30 April 2015. He also had class-1 and -2 medical certificates valid and in force until 14 April 2015. He had 7254 flight hours, of which 5957 had been on the type.

The captain had taken the following training courses, as specified by the EU OPS regulations:

- Operator's conversion course, on 21 and 22 May 2009.
- Captain's course, on 4, 5 and 6 April 2011.
- OPC and LPC courses and simulator training, on 17 September 2014, which cover CRM and TCAS maneuvers.

Based on information provided by the airline, the captain's simulator training records for the past four years did not reveal any incidences related to captain's behavior involving TCAS.

Duty period of Captain had started at 10:55 h and finished at 21:37 h. The incident occurred at 20:57 h so the duty period accumulated was 10:02 h out of a total of 10:42 h. The Flight Duty Period (FDP) was 10:22 h[3]. The previous day to that of the incident he was on Home Standby from 3:55 h to 22:55 h[4]. The Flight Duty Period (FDP) was 00:00 h[5].

The first officer of VLG2226, a 29-year old Spanish national, had a JAR-FCL commercial pilot license (CPL(A)) issued by AESA, with an A320 rating that was valid and in force until 31 January 2015. He also had a class-1 medical certificate that was valid and in force until 13 April 2015, and a class-2 certificate that was valid and in force until 28 April 2018. He had 3550 flight hours, of which 1572 had been on the type.

The first officer had taken the following training courses, as specified by the EU OPS regulations:

- Operator's conversion course, from 11 to 18 February 2013.
- OPC and LPC courses and simulator training, on 5 June 2014, which cover CRM and TCAS maneuvers.

Based on information provided by the airline, since 2013, the first officer's simulator training records did not reveal any incidences related to first officer's behavior involving the TCAS.

[3] According to EU-OPS the maximum basic daily FDP is 13 hours.

[4] According to EU-OPS minimum rest won't be less than 12 h.

[5] According to EU-OPS the maximum basic daily FDP is 13 hours.

Duty period of first officer had started at 10:55 h and finished at 21:37 h. The incident occurred at 20:57 h so the duty period accumulated was 10:02 h out of a total of 10:42 h. The Flight Duty Period (FDP) was 10:22 h[6] . The previous day to that of the incident he started his activity at 05:00 h finishing at 11:18 h. The Flight Duty Period (FDP) was 05:58 h[7].

1.5.2 Information on the crew of aircraft RYR314Q

The captain of RYR314Q, a 33-year old Dutch national, had a JAR-FCL airline transport pilot license (ATPL(A)) issued by the IAA, with an B737 300-900 rating that was valid and in force until 31 March 2015. He also had a class-1 medical certificate that was valid and in force until 17 January 2015, and a class-2 certificate that was valid and in force until 17 January 2019. He had 8000 flight hours, of which 7800 had been on the type.

The first officer of RYR314Q, a 24-year old Spanish national, had a JAR-FCL commercial pilot license (CPL(A)) issued by AESA, with an B737-800 rating that was valid and in force until 31 May 2015. He also had a class-1 medical certificate that was valid and in force until 26 June 2015, and a class-2 certificate that was valid and in force until 26 June 2018. He had 1716 flight hours, of which 1500 had been on the type.

1.5.3 Information on ATC personnel

The executive controller had had an air traffic controller license since 1989 and had been working as an air traffic controller in the sector of the incident since 2002. He had the necessary ratings and the required unit endorsements (LECS APS/RAD and ACS/RAD), valid and in force until 16 October 2015. He had an English proficiency rating of 5, valid and in force until 16 May 2019, and a class-3 medical certificate, valid and in force until 26 March 2015.

The planning controller had had an air traffic controller license since 2004 and had been working in the sector of the incident since 2012. He had the necessary ratings and the required unit endorsements (LECS APS/RAD), valid and in force until 17 November 2015. He had an English proficiency rating of 4, valid and in force until 16 May 2016, and a class-3 medical certificate, valid and in force until 16 January 2016.

[6] According to EU-OPS the maximum basic daily FDP is 13 hours.

[7] According to EU-OPS the maximum basic daily FDP is 13 hours.

1.6. Aircraft information

1.6.1 Information on VLG2226

The aircraft with registration EC-KCU is an Airbus 320-216, serial number 3109. It is outfitted with two CFM56-5B6/P engines (S/N 697212 and 697215). The aircraft had valid and in force registration and airworthiness certificates.

The aircraft had 22,577 flight hours and 16,226 cycles.

It was equipped with a TCAS II, version 7.0.

Photograph 1. Photograph of the aircarft[8]

1.6.1.1 Maintenance records of aircraft VLG2226

The last check of the aircraft prior to the incident had been on 7 November 2014. It was a type-A check, and the aircraft had 22435 flight hours and 16147 cycles at the time.

1.6.1.2 Flight controls on the A-320

The control sticks of the captain and first officer move independently. They are not mechanically linked, and the captain and first officer can be commanding different maneuvers at the same time. The maneuver that the airplane assumes is being requested corresponds to the algebraic sum of the two inputs.

[8] Image taken from http://www.planespotters.net.

The force feedback in the controls provided by the system is independent of the aerodynamic forces on the control surfaces, and independent of the forces that the other pilot may be exerting on his control stick.

Either pilot can cancel the other pilot's actions by pressing a priority button on his control stick. The last pilot to press this button has control of the aircraft, and a light on the other pilot's instrument panel alerts him to this. The other sidestick's inputs are only cancelled while the button is pressed. A "DUAL INPUT" callout is issued by the system when both sidesticks are active.

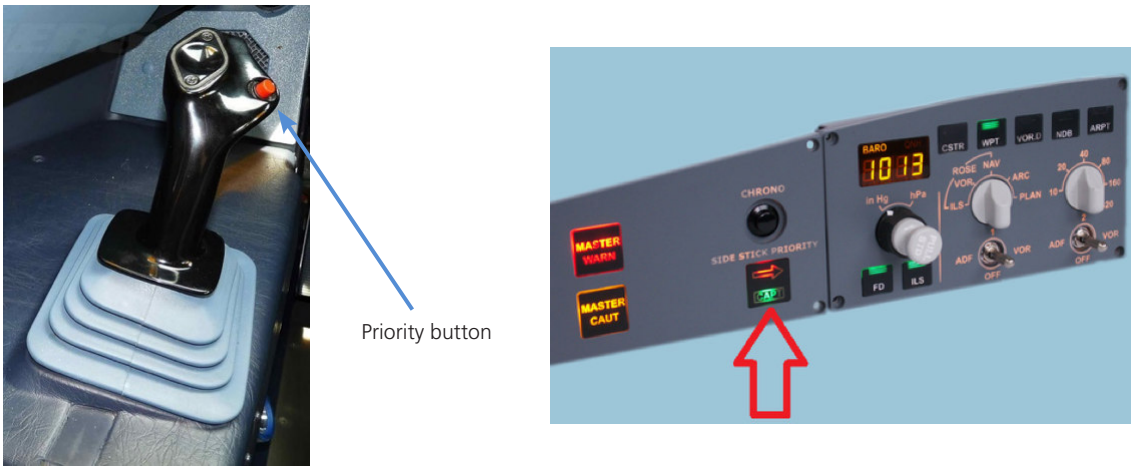

Figure 1. Sidestick on the A320 and control priority indicator

1.6.1.3 Monitoring and anti-collision system

The A320 (VLG2226) was equipped with a TCAS II (Traffic Collision Avoidance System), version 7.0, which is able to detect any aircraft in the vicinity that is equipped with a transponder. Depending on the proximity and track of intruding aircraft, the system will issue various alerts depending on the estimated time to the closest point of approach between the two aircraft.

A Traffic Advisory (TA) informs the crew of the presence of an aircraft that could pose a threat, alerting it to prepare for a possible evasive maneuver. A Resolution Advisory (RA) warns the pilot of the presence of a threat aircraft and recommends an evasive maneuver to ensure sufficient separation.

Depending on the situation, the system will generate various RA's. It can generate advisories that are not as abrupt as "climb" or "descend". For example, the system can generate advisories such as "Adjust Vertical Speed, Adjust" when the aircraft is maneuvering. This advisory is accompanied by a reduction in the climb or descent rate that the aircraft has before it is issued. The required rate is shown such that the crew of the aircraft has to move the climb or descent rate into the green area

on the vertical speed indicator. In some cases it can also be shown in the pitch cue on the aircraft's PFD[9].

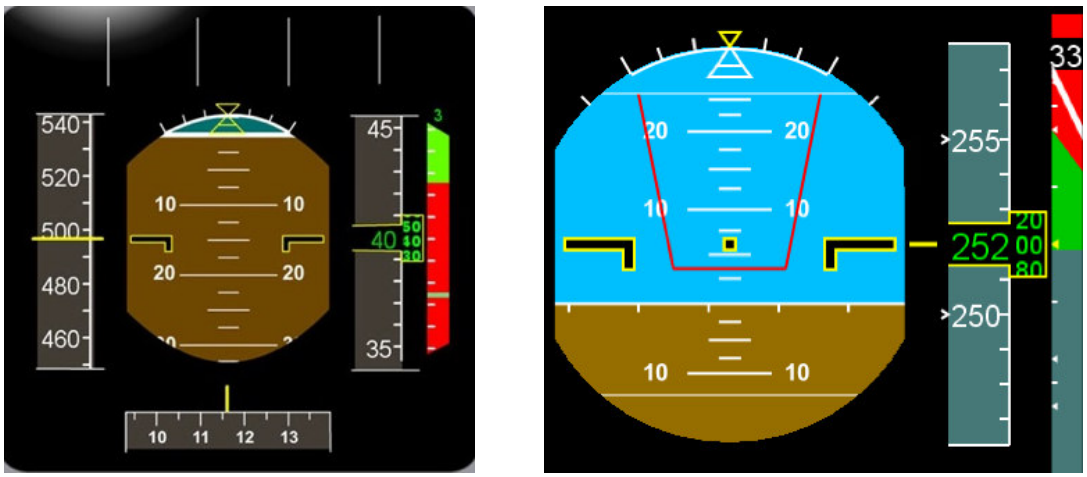

Figure 2. Vertical rate indicators from the TCAS

1.6.2 Information on RYR314Q

Aircraft EI-EKS is a Boeing 737-8AS, serial number 38504. It is equipped with two CFM56-7B engines (S/N 802903 and S/N 802906). The aircraft had valid and in force registration and airworthiness certificates.

It had 15188 flight hours and 8723 cycles.

Photograph 2. Photograph of the aircraft[10]

[9] Primary Flight Display.

[10] Image taken from http://www.allaircraft.net.

1.6.2.1 Maintenance records of aircraft RYR314Q

The last check of the aircraft prior to the incident had been on 7 August 2014. It was a type-A check, and the aircraft had 14293 flight hours at the time.

1.7. Meteorological information

According to information provided by Spain's National Weather Agency (AEMET), weather conditions in the area of the incident at around 21:00 were as follows: clear skies, good visibility at all altitudes, wind from the NE (30º-40º) at 50 kt. There was no significant precipitation or adverse phenomena warnings.

1.8. Aids to navigation

N/A.

1.9. Communications

The communications between the aircraft crews and the executive controller in the Seville TMA sector, where the incident took place, were available to investigators.

According to these communications, at 20:48:54 the controller cleared RYR314Q to start its descent to FL150, and a few minutes later he instructed its crew to maintain a descent rate of 2,000 ft/min or higher. These instructions were given in English.

At 20:54:19, the controller cleared VLG2226 to descend to FL250 at a descent rate of 2,000 ft/min or less. The crew acknowledged the clearance correctly. The controller then once more instructed RYR314Q to maintain a descent rate of 2,000 ft/min or higher, which the crew acknowledged, adding that at that time they were descending at 3,000 ft/min. At 20:54:50, the controller instructed the crew to expect runway 27 for landing (which the crew had requested earlier), and instructed them to proceed direct to point ROTEX and continue with the same restrictions for the time being. The crew did not mention continuing with the restrictions in their acknowledgment ("read-back"), and the controller did not require the crew to fully acknowledge his instructions ("hear-back"). This conversation was held in English.

At 20:55:30, VLG2226 reported reaching FL250, and the controller cleared its crew to continue to FL170. This time the controller did not inform the crew that the descent rate restrictions given earlier were still in effect. This exchange took place in Spanish. A minute later the controller informed the crew, in English, of traffic 9 NM away and 2,000 ft below. The crew acknowledged the information.

At 20:57:15, the controller asked the crew of VLG2226 if they had increased their descent rate and informed them of traffic at their 12 o'clock, 500 ft below them. RYR314Q then reported they had received a TCAS RA. The controller then asked RYR314Q what its descent rate was, to which the crew replied it was 2,500 ft/min. He then asked VLG2226 its descent rate, but received no reply. All of these conversations took place in English.

At 20:57:59, the crew of RYR314Q reported they were "Clear of Conflict" and were continuing to descend at 2,000 ft/min or higher. The executive controller explained that the traffic they had above them had increased its descent rate, and had been transferred to Malaga approach. This exchange took place in English.

The controller then asked the crew of VLG2226 what their descent rate was, to which the crew replied 2,200 ft/min. The controller then told them that he had clearly instructed a rate of 2,000 ft/min or less, and that by increasing their rate they had triggered the TCAS advisory. The crew of VLG2226 noted that the descent rate restriction was to their initial altitude, and that when they were cleared to descend to FL170, no limits had been imposed on their descent rate. The controller then cleared VLG2226 to descend unrestricted to FL130 and transferred it to the approach frequency. This conversation took place in Spanish.

1.10. Aerodrome information

N/A.

1.11. Flight recorders

Due to the time that elapsed between the date of the incident and when the CIAIAC became aware of it, it was not possible to preserve the flight recorder information, though the data downloaded by the operators for their internal FDM (Flight Data Monitoring) investigation was available.

1.12. Wreckage and impact information

The aircraft involved in the incident did not sustain any damage.

1.13. Medical and pathological information

There were no indications that the flight crews were incapacitated or that their actions were affected by any physiological factors.

1.14. Fire

There was no fire.

1.15. Survival aspects

No search and rescue activities were required as a result of this incident since the aircraft continued to their destinations with no further complications.

1.16. Tests and research

Ryanair provided the flight data downloaded by the airline. Both ENAIRE and Vueling (with help from the manufacturer, Airbus) conducted their own internal investigations into the incident and reported their conclusions to the CIAIAC. The main findings of these investigations are provided below.

1.16.1 Analysis conducted by Ryanair

According to the data provided by Ryanair, the descent rate used by the aircraft was 2000 ft/min or higher at all times [maximum of 3000 ft/min and minimum of 2000 ft/min]. The TCAS RA was activated as the aircraft was passing through FL222, and the clear of conflict notification was received as it reached FL204. During the TCAS activation, RYR314Q increased its descent rate from 2300 ft/min to 2800 ft/min.

1.16.2 Analysis conducted by the air traffic services provider (ENAIRE)

ENAIRE conducted an internal investigation and issued a report containing the following conclusions:

"The TCAS RA occurred because VLG2226 did not follow ATC's instruction to maintain a descent rate of 2,000 ft or less, an instruction that was clearly given by the controller.

RYR314Q did comply with its instruction at all times to maintain a rate of 2,000 ft or higher.

Both aircraft executed TCAS RAs, with RYR314Q increasing its descent rate and VLG2226 decreasing its rate, descending to FL214 and before subsequently climbing to FL219.

The radar separation was 1.8 NM and 0 ft, both aircraft at FL214.

This is a B-severity incident[11] with no ATM contribution."

1.16.3 Analysis conducted by Vueling

Vueling conducted an internal investigation with help from Airbus. An analysis of the FDM data revealed the following:

At 20:55:25, VLG2226 was descending to the selected altitude of FL250 at an established descent rate of 1800 ft/min. As it passed through FL302, the vertical speed was changed to -2400 ft/min and the magnetic heading set to 245º.

At 20:55:40, while crossing FL296, the selected altitude was changed to FL170 and the vertical speed to -5000 ft/min.

At 20:56:59, while crossing FL238, the vertical speed was reduced to -4000 ft/min. Then, at 20:57:03, while crossing FL234, a traffic advisory (TA) was received on the TCAS, after which the selected vertical speed was set to -1000 ft/min.

At 20:57:17, the aircraft was crossing FL226 at a descent rate of 3200 ft/min when a TCAS "Adjust Vertical Speed, Adjust" resolution advisory (RA) was received, along with an indication to maintain a descent rate of 1000 ft/min or less (green area on the vertical speed tape from -1000 ft/min to lower, or even positive, climb rates). The advisory was active for 14 seconds. Three seconds after the RA was received, the pilot flying (PF), who at the time was the first officer, disengaged the autopilot (AP) and increased the descent rate to 4400 ft/min. The descent rate shown in the RA changed at 20:57:29 to indicate a descent rate of 500 ft/min or less. At that point the crew disengaged both flight directors (FD).

At 20:57:33, while crossing FL216 at a descent rate of 4400 ft/min, the RA changed to "Climb, climb", showing a climb rate of 1500 ft/min or higher for 13 seconds. Data from that time showed that both pilots pulled up on the control stick, with neither one pressing the priority button, resulting in a vertical acceleration of 2.03 g. According to the report, the "Dual input" alarm was not activated since the system regards this alarm as having a lower priority than the TCAS advisory.

Both the captain and the first officer simultaneously actuated the stick for 10 seconds. The minimum altitude reached by the aircraft before it started to climb was 21340 ft.

[11] Severity B- Major Incident- incident as per Eurocontrol's ESSAR 2 event severity classification scheme. An incident associated with the operation of an aircraft, in which safety of aircraft may have been compromised, having led to a near collision between aircraft, with ground or obstacles.

At 20:57:45, as the aircraft was climbing through FL216, the TCAS RA changed once more to "Adjust Vertical Speed", which lasted 12 seconds. According to the data recorded, the first officer raised the pitch angle to 5º, and the climb rate increased to 2800 ft/min.

At 20:57:58 the onboard TCAS gave a "Clear of Conflict" indication. Based on the data from the first officer's sidestick, the aircraft's altitude stabilized at FL220.

This report states that the onboard TCAS was tested, the results of which were satisfactory and indicated that it had no faults.

The TCAS was also tested in place, which similarly indicated no problems.

The report also noted that no problems were identified with the crew when training on TCAS scenarios in the simulator.

The report included a series of recommendations directed at various departments at the airline to take the following actions:

- Provide refresher training to the incident crew on the procedure contained in the manufacturer's manual regarding evasive TCAS maneuvers, as well as on the process for transferring control between pilots.
- Remind all crews of the importance of complying with ATC instructions, using the common language (English) in aviation communications and in those situations where they may be using the same frequency as other crews that do not speak Spanish. Also, inform all crews of the conclusions drawn from this SRA (Safety Risk Assessment).
- Accelerate the timeline as much as possible and update TCAS II to version 7.1 in every aircraft.

According to information provided later by Vueling, the following mitigative measures were implemented:

- Information on the event was published on its Safety website for all crews to see.
- The case was reviewed in classroom training in both the 2014-15 cycle and the current 2015-16 cycle, reminding crews of the problem with the advisories, the event and the transition to TCAS 7.1.
- Information notes were published requesting that crews pay special attention to TCAS procedures and phraseology. The need to comply with ATC instructions and to lower the descent/climb rate when nearing the cleared flight level was also underscored.

- Simulator scenarios involving the TCAS RA "Adjust Vertical Speed, adjust" were also provided in those simulator models that supported it.

The airline confirmed that all of its aircraft had been upgraded to TCAS version 7.1 as of 1 December 2015, as required by the regulation.

1.17. Organizational and management information

1.17.1 Vueling procedures in the event of a TCAS RA

Vueling requires that the following steps be taken when a TCAS RA is received during a flight:

- The pilot flying (PF) must disengage the autopilot and adjust the descent rate into the green section of the VSI within 5 seconds, and ask the PNF/PM to disengage both FDs.

Both FDs must be disconnected once Aps are disconnected:

~ To ensure autothrust speed mode

~ To avoid possible confusion betwween FD bar orders and TCAS aural and VSI orders.

- The pilot not flying must disengage both FDs but will not attempt to locate the intruding aircraft.
- The PF will avoid abrupt maneuvers and keep the vertical speed outside the red area on the VSI and inside the green area. Never move in the opposite direction to the RA since the RAs on the aircraft are coordinated.
- The PNF must report the TCAS RA activation to ATC using standard phraseology (see table):

Circumstances	Phraseologies	
	Pilot	ATC
After a flight crew starts to deviate from any ATC clearance or instruction to comply with an airborne collision avoidance system (ACAS) resolution advisory (RA)	TCAS RA	ROGER
After the response to an ACAS RA is completed and a return to the ATC clearance instruction is initiated.	CLEAR OF CONFLICT, RETURNING TO (assigned clearance)	ROGER (or alternative instructions)
After the response to an ACAS RA is completed and the assigned ATC clearance or instruction has been resumed.	CLEAR OF CONFLICT, (assigned clearance) RESUMED	ROGER (or alternative instructions)
After an ATC clearance or instruction contradictory to the ACAS RA is received, the flight crew shall follow the RA and inform ATC directly.	UNABLE, TCAS RA	ROGER

Table 1. Standard radar phraseology taken from Vueling's procedures

1.17.2 Manufacturer's procedure for transferring control of the aircraft

The following procedure is required to transfer control of the aircraft between pilots:

PF/PM DUTIES TRANSFER
Ident.: PRO-NOR-SOP-90-00011914.0001001 / 23 DEC 14 **Applicable to: ALL**
To transfer control, flight crewmembers must use the following callouts: - To give control: The pilot calls out "YOU HAVE CONTROL". The other pilot accepts this transfer by calling out "I HAVE CONTROL", before assuming PF duties. - To take control: The pilot calls out "I HAVE CONTROL". The other pilot accepts this transfer by calling out "YOU HAVE CONTROL", before assuming PM duties.

Table 2. Airbus procedure for transferring control of an aircraft

1.18. Additional information

1.18.1 Statement from the crew of VLG2226

In statements after the incident, the crew of VLG2226 stated that while preparing for the ILS 09 approach to Seville, they saw that the wind (300/05) was more favorable for a landing on runway 27, so they asked Seville ATC if they could land there. At the same time they requested to descend to achieve the ideal profile since their distance to landing would now be reduced. ATC cleared them to descend from cruise level at FL310 at a maximum descent rate of 2000 ft/min.

Before reaching that level, ATC confirmed it was clearing them to proceed to runway 27. They changed the runway and approach in the FMGC (Flight Management and Guidance Computer) and saw that they were very high with respect to the distance to the runway, so they requested to continue descending and regain the optimal profile. ATC cleared them to continue descending to F250. A minute later they were cleared to fly direct to ROTEX, which worsened their distance/altitude ratio even more, so they increased their descent rate considerably. They again requested to descend more, since they were practically at FL250, and the controller cleared them to continue descending to FL170.

In the last three or four exchanges with ATC, the latter never reminded them that they were still limited to 2000 ft/min in their descent, so they (mistakenly) increased their descent rate thinking the limit had expired. Nearing FL220 they received a TCAS TA, followed by a "Descend" RA a few seconds later. The captain stated that they followed the procedure they had so often practiced in the simulator to the

letter, and adjusted the descent rate to within the green area. After a few seconds in the area, there was a sort of fast sweeping motion in the VSI that shifted the line separating the green and the red upward. At the same time they heard the "Climb, Climb Now" aural. This time he reacted before the first officer to start the climb maneuver as quickly as possible. The captain admitted that in that "very stressful moment" he did not apply the procedure specified by the manufacturer to address his fellow pilot and inform him, using the phrase "I have control", that he now had control of the aircraft, as his intention was to exit the red area as quickly as possible. He then saw the "Dual Input" caution and its associated green light. Shortly thereafter they heard the "Clear of Conflict" aural. They reported the event to ATC, which rebuked them for not having followed their instructions, to which the crew of VLG2226 replied that they thought the restriction was no longer in effect since ATC had not repeated it in its last four messages.

In his report the captain alluded to the possibility that he was fatigued since it was his fourth flight of the day.

1.18.2 Statement from the crew of RYR314Q

In statements given after the incident, the crew of RYR314Q said that after leaving FL410 while under Seville control, they had to maintain a descent rate in excess of 2000 ft/min, which they did by descending at approximately 2500 ft/min. A Vueling aircraft flying into Seville was instructed to descend at a maximum rate of 2000 ft/min. At around FL240 they received a TCAS RA. They followed the TCAS RA indication and shortly later the advisory changed to "Adjust Vertical Speed" and then to "Clear of Conflict".

1.18.3 Statement from the executive controller in Seville

The executive controller at the Seville Control Center (LECS) stated that RYR314Q was cleared to FL150 at a descent rate of 2000 ft/min or higher. VLG2226 was cleared first to FL250 at a descent rate of 2000 ft/min or lower, and then to FL170, with no mention being made of a change to this restriction. The controller also noted that VLG2226 was given information on the traffic affecting it when it was 2,000 ft below and some 7 NM away at its 2 o'clock position. In the vicinity of VULPE[12], on seeing that VLG2226 was only 1 NM above RYR314Q, the executive controller asked the crew of VLG2226 about their descent rate. They did not reply, and RYR314Q reported a TCAS RA. After the incident the crew of VLG2226 apologized, saying they thought that the restrictions did not apply to the descent to FL170. This statement was consistent with that given by the planning controller.

[12] Reporting point.

1.18.4 Conflict alerts and information taken from the SACTA system data[13]

Air traffic control stations have a predictive conflict alert system that uses data sent by the aircraft to detect situations in which two aircraft could come into conflict. The system generates aural and visual alerts based on the distance between the aircraft. The first alert is issued when the two aircraft are still at the prescribed radar distance, and is called Conflict Alert Prediction (PAC). If this distance is breached, another warning, called a Conflict Alert Violation (VAC), is generated. These PAC and VAC messages are shown on the screen and an audible signal is activated to alert the controller.

According to data from this system, before 20:55:39, VLG2226 maintained a descent rate below 2000 ft/min, while the descent rate of RYR314Q was in excess of 2000 ft/min. At that time RYR314Q was 3600 ft below the position of VLG2226. After that time, VLG2226 started descending at a higher rate and by 20:57:08, was descending at 5025 ft/min. RYR314Q maintained a rate slightly greater than 2000 ft/min at all times.

At 20:56:23, the controller's conflict alert system was activated. In this case, it was a PAC, since the minimum radar separation distance had not been breached. The descent rate of VLG2226 was 4475 ft/min[14] and the distance between the aircraft was 9.7 NM horizontally and 2800 ft vertically.

At 20:57:18 the conflict alert system issued a VAC. By this time the distance between the aircraft was 3.8 NM and 300 ft.

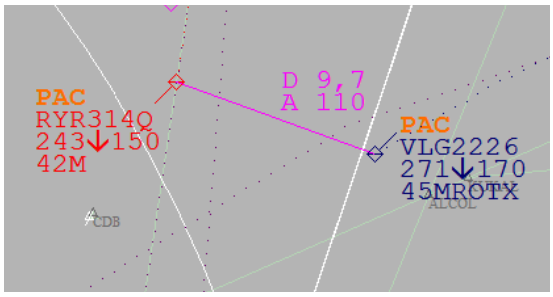

Figure 3. Aircraft positions at 20:56:23

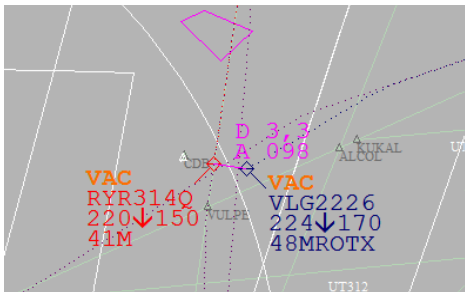

Figure 4. Aircraft positions at 20:57:23

At 20:57:23, RYR314Q was descending at 2,344 ft/min while VLG2226 was descending at 3,981 ft/min. They were separated by 3.3 NM horizontally and 400 ft vertically.

[13] SACTA- Sistema Automatizado de Control del Tránsito Aéreo (Automated Air Traffic Control System).

[14] Information not available to the controller. See Section 1.18.5.

The closest point of approach came seconds later, at 20:57:43, when they were separated by 1.4 NM horizontally and 100 ft vertically.

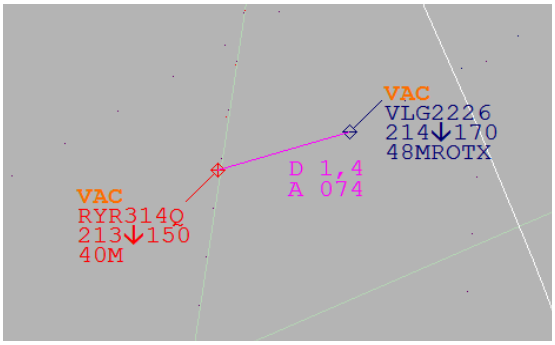

Figure 5. Aircraft positions at 20:57:43

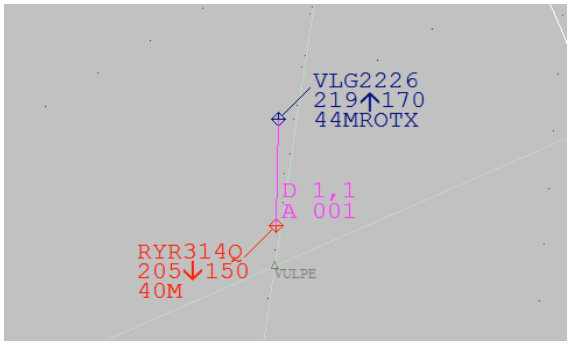

Figure 6. Aircraft positions at 20:57:58

The minimum horizontal distance between the aircraft was 0.9 NM, by which point the vertical distance had increased to 1100 ft.

1.18.5 Mode C and mode S radar. Information displayed on the SACTA radar screen.

The controller had the following information available on the radar screen displayed by the SACTA system:

- Aircraft position.
- Callsign.
- Current flight level.
- Aircraft's attitude, be it climbing, descending or established.
- Assigned flight level (this information is entered by the controller).
- Aircraft's ground speed.
- Point where the aircraft is headed. This information is also entered by the controller.

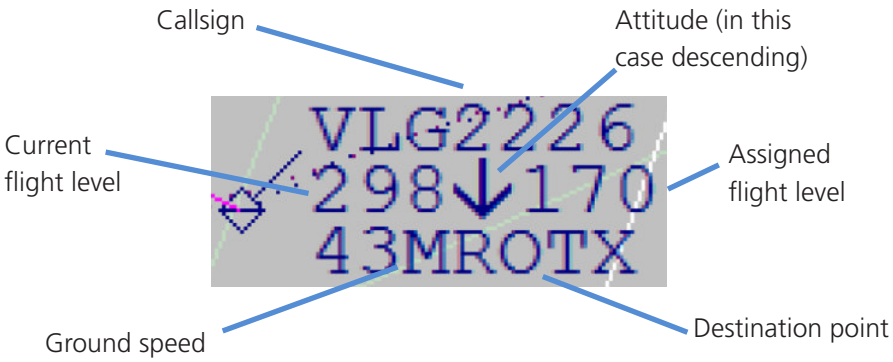

Figure 7. Radar tag shown on controller's display

There is no way for the controller to see the descent rate of aircraft.

Most secondary radars in mainland Spain are currently mode C. In this case, the aircraft transmits its barometric altitude but not its vertical speed or descent rate.

The system uses a tool called PALESTRA[15] to calculate a vertical speed with data obtained from the radar response, which allows ENAIRE to carry out the relevant internal analyses of any events.

According to information supplied by the air navigation services provider (ENAIRE), the Mode C radars are being replaced by Mode S radars[16]. This change will offer a series of technical advantages that will improve the identification of aircraft, which will, in turn, send a set of data that will include:

- Altitude selected
- Pitch angle, true track angle
- Indicated airspeed
- Ground speed
- Magnetic heading
- TCAS advisories
- Vertical rate

Since the vertical speed data sent by aircraft, which are based on barometric altitudes, are subject to significant variations for a variety of factors, including

[15] PALESTRA- Plataforma de Análisis y Estudio del Tráfico Aéreo (Air Traffic Analysis and Study Platform).

[16] Seventeen radars are scheduled for replacement in 2016 and 2017, and 12 radars from 2018 to 2023 at a rate of 2-3 radars per year.

turbulence and small but rapid vertical movements, the EASA[17] notes that vertical rates based on barometric altitudes are highly unstable. Some countries that are using the mode S transponder have decided not to display it on the controller's screen or have instructed their controllers not to use it due to the excessive sensitivity of this parameter.

As a result, ENAIRE, as part of its program to improve the SACTA system, has evaluated the most viable options for using the mode S data obtained from aircraft and displaying it to controllers. It has done so in consideration of established implementation timelines, the full replacement of mode S radars, migrating to other, already approved operating systems, the coverage of mode S radar and the prioritization of useful parameters. The current upgrade is focused on displaying reliable data that help controllers without saturating them, such as selected altitude and indicated airspeed. ENAIRE, in keeping with EASA and other countries where mode S is used, does not consider the display of aircraft vertical rate to be a priority, since the data must be exhaustively analyzed to confirm the viability of using this parameter before planning its implementation, both in the case of presenting the information to ATC and of improving the prediction of flight paths in safety networks.

1.18.6 Relevant regulation on controlling vertical speed

Spain's Air Traffic Regulations state that:

"4.2.22.1.2. The vertical speed between two aircraft that are climbing or descending can be controlled for the purpose of establishing or maintaining a given minimum vertical separation."

"4.2.22.1.6. An aircraft will be informed if a climb or descent vertical speed restriction is no longer applicable."

In the same way these paragrafs are related with those from the ICAO 4444 Document, 4.7.1.1 and 4.7.1.4.

4.7.1.1 In order to facilitate a safe and orderly flow of traffic, aircraft may be instructed to adjust rate of climb or rate of descent. Vertical speed control may be applied between two climbing aircraft or two descending aircraft in order to establish or maintain a specific vertical separation minimum.

4.7.1.4 Aircraft shall be advised when a rate of climb/descent restriction is no longer required.

[17] https://www.easa.europa.eu/system/files/dfu/NPA%202012-19.pdf.

1.18.7 Regulation on the use of ACAS II

The SERA (Standardised European Rules of the Air) specify the following in Article 4.2.19 on procedures applicable to aircraft equipped with airborne collision avoidance systems (ACAS): "The use and operating procedures for airborne collision avoidance systems (ACAS) shall comply with Regulation (EU) no. 1332/2011 of 16 December 2011, laying down common airspace usage requirements and operating procedures for airborne collision avoidance systems."

Regulation (EU) no. 1332/2011 specifies the actions for crews to take in operations involving the use of ACAS II:

"When an RA indication is produced by ACAS:

a) the pilot flying shall immediately conform to the indications of the RA indication, even if this conflicts with an air traffic control (ATC) instruction, unless doing so would jeopardise the safety of the aircraft;

b) the flight crew, as soon as permitted by workload, shall notify the appropriate ATC unit of any RA which requires a deviation from the current ATC instruction or clearance;

c) when the conflict is resolved, the aircraft shall:

i. be promptly returned to the terms of the acknowledged ATC instruction or clearance, or

ii. comply with any amended ATC clearance or instruction issued."

Pursuant to Regulation (EU) no. 1332/2011 of the Commission of 16 December 2011, laying down common airspace usage requirements and operating procedures for airborne collision avoidance, since 1 March 2012 all aircraft on routes toward, within or from the European Union with a certified takeoff weight in excess of 5700 kg, or those aircraft authorized to transport 19 passengers, must be equipped with ACAS II version 7.1. Those for which a certificate of airworthiness was issued before this date must be equipped with this version of ACAS no later than 1 December 2015.

Logic version 7.1 offers two fundamental improvements over 7.0. One involves the improved TCAS response to changing the direction of the RA when required, either because one aircraft is not equipped with TCAS or because one of the aircraft involved in the encounter did not adequately follow the TCAS RA. The other involves replacing the "Adjust Vertical Speed" RA, which requires reducing the climb or descent rate to 2000, 1000, 500 or 0 ft/min, by another RA indicating a "Level Off" instruction, which requires a rate of 0 ft/min. The aim is to eliminate the confusion exhibited by some crews in interpreting the "Adjust vertical speed" RA.

Attachment B of ICAO Document 8168 defines ACAS training for pilots, specifying two types of training: theory and simulator.

In the theory training portion, one of the points to train involves crew coordination and allocating tasks between the pilot flying and the pilot monitoring, including a clear definition of whether the pilot flying or the captain will fly the aircraft during the TCAS RA. It also emphasizes the use of standard phraseology in these cases to inform ATC that the aircraft is following a TCAS RA.

The practical training states that the simulator must mirror the TCAS display and controls onboard the aircraft as closely as possible, though it allows the use of computer displays that are similar in appearance if the operator does not have a flight simulator available.

The tasks specify verifying that the pilot can properly interpret and respond to TCAS RAs.

The training scenarios should include maneuvers involving initial RAs that require a change in vertical speed, initial RAs not requiring a change in vertical speed, maintain rate RAs, altitude crossing RAs, increase rate RAs, RA reversals, weakening RAs, RAs issued while the aircraft is at a maximum altitude and multi-aircraft encounters.

1.18.8 Eurocontrol ACAS Bulletin

The ACAS Bulletin is a Eurocontrol publication that focuses on the ACAS system. This specific issue reported on studies conducted on this system, discussed events that resulted from a conflict alert and provided best practices on how to use and react to the system.

The actions that a crew has to take to respond to a TCAS RA can be shown in three different displays (TCAS-VSI), depending on the configuration installed on the aircraft. In the case of this incident, the display on VLG2226 that showed the RA response was the vertical speed tape.

The TCAS "Adjust vertical speed" RA requires the crew to reduce the aircraft's descent or climb rate. Bulletin number 3 focused on faulty interpretations by crews of the "Adjust vertical speed" advisories, stating that this is the most frequent type of RA, meaning its instructions must be followed exactly. The bulletin noted that over just 14 months, 12 events were detected in which the crew maneuvered the aircraft in the opposite direction required by an "Adjust vertical speed" RA (other potential events were being analyzed). In the cases considered, the RA was shown

on the vertical speed tape or on the semi-circular VSI (vertical speed indicator). In one similar event, however, the RA was displayed on the pitch cue in the PFD.

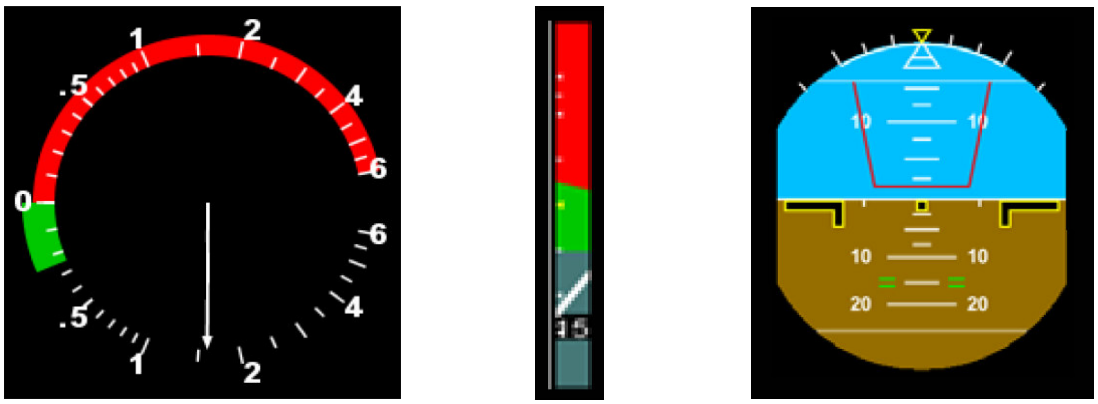

Figure 8. TCAS-VSI. From L to R: Semicircular VSI, Vertical Speed Tape and Pitch Cue

The Eurocontrol ACAS Bulletin states that the RA is sometimes difficult to interpret when it is shown on the vertical speed tape. An RA shown on the PFD can be similarly difficult to interpret for a weakening RA due to the absence of a green area. It also does not inform the crew of what vertical speed is required by the RA. Many aircraft operators and pilots regard the RA displayed on the pitch cue on the PFD as the most intuitive for other RA types. This means that if the RA is shown both on the PFD and on the vertical speed tape, it can improve the crew's interpretation of RAs of the "Adjust vertical speed" type.

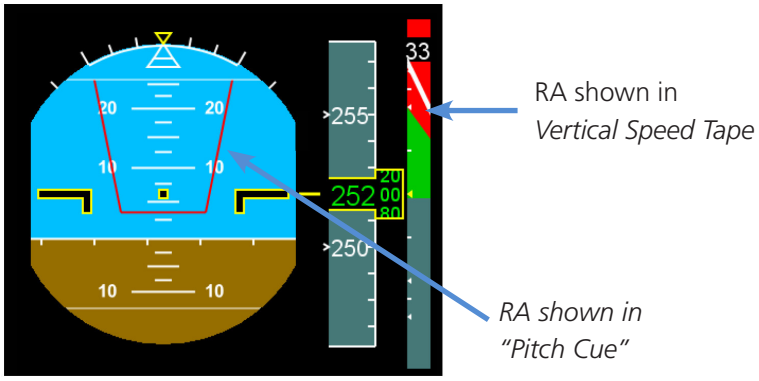

Figure 9. RA indications on the pitch cue and vertical speed tape

According to information from Eurocontrol, a European airline has been monitoring its crews' responses to RA indications and identified a problem involving the "Adjust vertical speed" RA.

- About 4% of the initial reactions were wrong and opposite to the RA.
- Most of the errors were quickly corrected, but a few resulted in serious events.

The operator identified some contributing factors:

- Only "Climb" and "Descend" RAs are practiced in simulator scenarios. The "Adjust vertical speed" RA is only generated after the initial reaction to the initial RA, but it is not itself generated initially.
- The "Adjust vertical speed" aural does not specify the direction of the maneuver required.
- Interpreting the RA displayed on the vertical speed tape is less intuitive than that shown on the pitch cue.

1.18.9 Consultation with Airbus

Airbus[18] was asked about the existence of additional cases in which crews executed the opposite maneuver required by the system, alleging that the color code on the VSI indicated said maneuver. Airbus replied that it had no knowledge of any operator reporting unusual behavior involving the colors on the TCAS-VSI display. Airbus also reported that any issue or report received from an operator, as well as any relevant communications, are archived, meaning that if any case existed that called into question the indication given by the TCAS VSI, it would be contained in the system.

1.18.10 Consultation with Eurocontrol

Along the same lines, and based on a Eurocontrol study that indicated that over a short 14-month period, 12 events were detected in which crews maneuvered the aircraft in the opposite direction to that indicated in an initial "Adjust vertical speed" RA, Eurocontrol was asked about the existence of additional cases or crew accounts involving possible errors in the TCAS-VSI displays. Eurocontrol offered to use its aircraft information tools to display the response of the aircraft and its crew in that particular case, as well as to evaluate different scenarios to demonstrate the effect of different potential crew responses ("What if" scenarios). In the end this was not necessary because the analysis conducted by Airbus after the Vueling report was similar, and Eurocontrol's analysis would have added nothing of any further value to the investigation.

[18] Airbus participated in the relevant standardization committees (RTCA SC-147 and EUROCAE WG-75) designing the change to version 7.1. Therefore they were aware of the issues with the "Adjust vertical speed, adjust" RAs.

One of the reasons for developing version 7.1 was the fact that the "Adjust Vertical Speed" aural was not intuitive and did not really tell the crew what to do (climb or descend), whereas the "Level Off" aural is not ambiguous and instructs the performance of a standard maneuver with no room for interpretation. In this new version, if a misleading indication is displayed on the TCAS-VSI (for example, the color code on the vertical speed tape), the crew also has the aural information to aid it in making the correct decision.

This type of confusion during "Adjust Vertical Speed" RAs had involved crews in all types of aircraft (and on all three display types), though it had been observed more frequently on Airbus aircraft. Unfortunately, Eurocontrol only had statistical information and not official reports with the corresponding crew statements.

1.19. Useful or effective investigation techniques

N/A.

2. ANALYSIS

2.1. General

On 30 October 2014, a B-737-8AS aircraft, registration EI-EKS and callsign RYR314Q, was flying between the Shannon Airport (Ireland) and the Malaga-Costa del Sol Airport. At the same time, an A-320-210 aircraft, registration EC-KCU and callsign VLG2226, was flying from the Barcelona-El Prat Airport to the Seville Airport. It was the aircraft's fourth flight of the day and the first officer was the PF and the captain was the PNF.

Both aircraft were in radar and radio contact with the same sector of the Seville air traffic control center (LECS).

The crew of VLG2226 requested a change in the landing runway due to more favorable wind conditions on the other runway. This was coordinated between the various sectors of the Seville ACC. The two aircraft were on converging flight paths, with RYR314Q below the position of VLG2226 and with RYR314Q having been cleared to descend to FL150, while VLG2226 had been instructed to maintain FL310 upon reaching it due to traffic.

2.2. Conflict generation

At 20:54:11, RYR314Q was instructed to maintain a descent rate of 2000 ft/min or more and to report any changes. The Seville ACC controller then cleared VLG2226 to descend to FL250 maintaining a descent rate of 2000 ft/min or less. The instruction was given in English so both crews could understand the information to aid in their situational awareness. VLG2226 correctly acknowledged the instruction. This way, even though VLG2226 had been cleared to descend to a flight level that had not been vacated by RYR314Q, the controller used the descent rate restriction to ensure that vertical separation was maintained during the crossing. This also favored the maneuver of VLG2226, which was able to perform a constant descent. The controller also repeated his instruction to RYR314Q to maintain a descent rate of 2000 ft/min or higher.

This kind of instruction is allowed by Spain's Air Traffic Regulations to provide vertical separation between two maneuvering aircraft (see Section 1.18.6).

Then, at 20:54:50, the Seville ACC controller instructed VLG2226 to fly direct to ROTEX and observe the same restrictions. The crew acknowledged the instruction, but not the part about observing the same restrictions. The controller did not request for an acknowledgment to maintain the vertical speed restriction. Both messages were sent in English.

According to radar data, RYR314Q used a descent rate that was higher than 2000 ft/min, while based on data provided by Vueling and taken from its FDM, VLG2226 had a lower descent rate as it descent speed was set to 1800 ft/min.

At 20:55:25, the crew of VLG2226 set the descent rate to 2400 ft/min and reported reaching FL250. The Seville ACC controller immediately cleared them to descend to FL170, at which point the crew selected a descent rate of 5000 ft/min. With this clearance the controller did not include the same descent rate restriction. From this time forward, the vertical distance between the aircraft, which was initially 3600 ft, began to decrease.

The captain admitted in his report that because the controller did not reiterate the vertical speed restriction, and because they were attempting to reach their optimum descent profile, they mistakenly selected a rate that was higher than authorized.

National and international regulation states that it is the controller who must inform the aircraft if a vertical climb or descent rate restriction is no longer in effect. In the absence of this information, speed restrictions continue to apply. However, if a controller clears an aircraft to a different flight level while the restriction remains in effect, this Commission believes it is necessary to reiterate and explicitly re-state the restriction to avoid possible misunderstandings or oversights. As a result, three safety recommendations are issued in this regard.

2.3. Conflict detection

At 20:56:23, the controller's conflict alert was activated by way of a PAC (Conflict Alert Prediction) warning. The controller then informed the crew of VLG2226, in English, of the presence of RYR314Q at its 11 o'clock position, 9 NM away and 2000 ft below them.

According to radar data from that time, the aircraft was descending at a rate of 4475 ft/min and the vertical distance between the aircraft was 2800 ft. The descent rate increased to 5025 ft/min a few seconds later.

According to FDM data extracted by Airbus from VLG2226, at 20:56:59, the vertical speed setpoint was reduced to -4000 ft/min. Then, at 20:57:03, while crossing FL234, a TCAS traffic advisory (TA) was received, after which the crew selected a vertical speed of -1000 ft/min.

The controller did not have descent rate information from the SACTA system on his radar display. As a result, it was not obvious that one of the aircraft was not complying with the vertical speed restrictions given. In mode C, vertical speed is not

sent by the aircraft, it is calculated after the fact by the system. ENAIRE was asked about the possibility of including descent rate data with the other information shown to the controller once the SACTA system is upgraded and mode S radars are implemented. This option was ruled out in the end because vertical speed is subject to large variations due to turbulence and to small, fast vertical motions of the aircraft. As a result, a safety recommendation is not issued in this regard to the service provider to upgrade the SACTA system to have it display this information on the controller's display as the transition to mode S radar is made.

2.4. Conflict management

A few seconds later, at 20:57:15, the controller asked the crew of VLG2226 if they had increased their descent rate, informing them that traffic was at their 12 o'clock position and 500 ft below them. The controller then received a VAC (Conflict Alert Violation) warning at his post. According to FDM data extracted by Airbus, a TCAS "Adjust Vertical Speed" RA was then received in VLG2226. Its crew did not respond and did not report that they were following a TCAS RA on the frequency, as required both by the regulation and by the airline's procedures.

The crew of RYR314Q, for their part, did report on the frequency that they were following a TCAS RA.

According to FDM data extracted by Airbus, a TCAS "Adjust Vertical Speed" aural RA was received, along with a maximum descent rate indication of 1000 ft/min, meaning the crew should have seen on the vertical speed tape a red area between -1000 ft/min and higher descent rates, and a green area from -1000 ft/min and lower, or even positive, vertical rates. The first officer, who at that time was the pilot flying, disengaged the AP within three seconds and increased the descent rate to 4400 ft/min, which was contrary to the TCAS indication. Twelve seconds after the TCAS RA activation, the FDs were disengaged by the crew. At that time the new descent rate calculated by the TCAS and shown on the vertical speed tape was decreased from -1000 ft/min to -500 ft/min or lower, while the aural continued to instruct "Adjust Vertical Speed". According to the airline's procedures, the AP must be disengaged by the PF after a TCAS RA is issued. The FDs must be disengaged by the PNF when requested by the PF once the AP is disengaged to avoid possible confusion when following the TCAS RA. It could not, however, be determined that the pilots misinterpreted the direction of the vertical rate indicated by the TCAS due to not disengaging the FDs, though too much time was allowed to elapse before this action was taken.

The captain confirmed in his statement that they increased their descent rate to adjust their speed to the TCAS indication, since as they stated, the green area

ranged from -1000 ft/min and higher descent rates (this is the opposite of what the FDM data show).

Vueling conducted an in-place test of the TCAS, with satisfactory results. A series of subsequent checks also failed to detect any problems with its operation. AIRBUS was also consulted, with the manufacturer stating that no cases had been reported involving a failure of the vertical speed indications coded in the TCAS-VSI.

Meanwhile the crew had made the pertinent TCAS simulator flight trainings, and no lack of knowledge had been detected in them.

According to information from Eurocontrol, it has analyzed several cases similar to the one involving the crew of VLG2226, in which a crew carried out the opposite instructions given by the TCAS RA when an initial "Adjust vertical speed" aural was activated. The studies into these events yielded a series of conclusions, most notably:

- Update the TCAS II software from version 7.0 to 7.1, in which the "Adjust Vertical Speed" aural is changed to "Level Off", along with the requirement to level the altitude instead of reducing the aircraft's climb/descent rate, as this is considered more intuitive for crews. European Regulation 1332/2011 requires that from 1 December 2015, all aircraft flying on routes into, within or from the European Union with a certified takeoff weight in excess of 5700 kg, or authorized to carry 19 passengers, must be equipped with ACAS II logic version 7.1. As of the time of this writing, the deadline for implementing version 7.1 has expired.
- In most cases, a TCAS "Adjust vertical speed" RA is practiced in simulators as a result of an initial climb or descend RA.
- The interpretation of the RA shown on the vertical speed tape is less intuitive than the one shown on the pitch cue of the PFO in some cases. As a result, it might be helpful to display the RA in both places.

After analyzing the crew's actions and statement, the FDM information and the existence of more cases in which the crew acted carried out the opposite instructions provided by the TCAS, the investigation was unable to accurately determine if the crew misinterpreted the RA indication, or if there was a fault in the color coding system in the TCAS VSI.

The airline reported that update 7.1 of the TCAS logic version has been implemented in all of its aircraft. As mitigative and preventive measures, the information relevant to this incident was provided to its crews, and the airline also published information bulletins on complying with TCAS procedures and phraseology. It also added scenarios in which "Adjust Vertical Speed" (now "Level Off") is the first RA, as well

as other advisories not requiring a sudden change to the aircraft's vertical speed (such as "Monitor vertical speed") to its simulator training. As a result, no safety recommendation is issued in this regard.

At 20:57:33, VLG2226 was descending at a rate of 4400 ft/min. The direction of the RA then changed to "Climb, climb now", indicating a climb rate of 1500 ft/min. The FDR recorded at that instant that both pilots pulled on their sidesticks to reduce the descent rate without either of them pressing the priority button. The captain stated that at that time, the speed indicator display on the PFD refreshed to reveal that the vertical speed needle was in the red area, and far from the green area. This caused him to react rapidly to adjust the speed to that required by the TCAS, although he did not intend to take control of the aircraft. As a result of the stressful situation, he did not apply the procedure for transferring control of the aircraft, as required by the operator. This caused the aircraft to increase its vertical acceleration to 2.03 g. The "Dual input" aural was not issued since the TCAS RA aural, which takes precedence, was also sounding. Both pilots were simultaneously actuating the aircraft's control for a period of 10 seconds.

The minimum altitude reached by the aircraft before climbing was 21340 ft, and the closest point of approach between the aircraft was 1.4 NM and 100 ft.

The TCAS onboard VLG2226 issued the "Clear of Conflict" aural at 20:57:58, which was not reported by the crew to ATC. The aircraft's altitude stabilized at FL220, at which point RYR314Q did report to ATC that it was clear of conflict.

An analysis of the event reveals that the VLG2226 crew's cockpit resource management was inadequate as they did not coordinate their actions and they did not properly apply the airline's or the manufacturer's procedures.

- The crew maintained the FDs engaged for 12 seconds following the TCAS RA activation.
- The crew did not report to ATC that they had received a TCAS RA or that they were clear of conflict.
- Finally, the crew did not follow the manufacturer's procedure for transferring control, as a result of which both the captain and the first officer provided simultaneous inputs to the flight control system for 10 seconds.

According to the report from the captain of VLG2226, these events took place on the fourth flight of the day, pointing to the possibility of fatigue, which could have affected the crew's actions. Although the duty and rest periods were according to EU-OPS regulation, it was checked that the incident occurred when the crew

accumulate 10:02 h out of a total of 10:42 h, that is, at the end of their total duty period.

The most recent simulator sessions carried out by the crew did not detect any weaknesses pertaining to CRM.

3. CONCLUSIONS

3.1. Findings

- The aircraft had their documentation in order and they were airworthy.
- The crews of RYR314Q and VLG2226 had valid and in force licenses and medical certificates.
- The crew of VLG226 accumulate 10:02 h out of a total of 10:42 h, that is, at the end of their total duty period.
- The executive controller had a valid and in force license, unit endorsements and medical certificate.
- VLG2226 requested to change the landing runway due to the wind. This was approved by LECS.
- The two aircraft were on converging flight paths.
- Both aircraft were in radar and radio contact with the same sector, the Seville ACC (LECS).
- RYR314Q was below the position of VLG2226.
- RYR314Q was cleared to descend to FL150 and maintain a descent rate of 2000 ft/min or higher.
- VLG2226 was cleared to descend to FL250 and maintain a descent rate of 2000 ft/min or lower.
- The crew of VLG2226 did not acknowledge ("read-back") the descent restriction during one of the transmissions and the controller did not correct this omission ("hear-back").
- The LECS controller cleared VLG2226 to descend to FL170 and the crew selected a descent rate of 5000 ft/min. The controller did not specify in his instructions that the rate restriction was still in effect.
- RYR314Q maintained a descent rate in excess of 2000 ft/min, in keeping with the instructions provided by the controller.
- The controller's SACTA display does not show the descent rate of aircraft.
- The control system displayed a PAC (Conflict Alert Prediction) advisory.
- The controller informed the crew of VLG2226 in English of the presence of RYR314Q.
- A VAC (Conflict Alert Violation) advisory was received at the control post.

- The controller asked the crew of VLG2226 if they had increased their descent rate and informed them that the traffic was at their 12 o'clock position 500 ft below them.
- The crew of the aircraft did not reply or report that they were receiving a TCAS RA.
- The crew of RYR314Q reported on the frequency that they had a TCAS RA.
- According to FDM data, an "Adjust vertical speed" TCAS RA was received in the cockpit of VLG2226, indicating a descent rate of 1000 ft/min or less.
- Three seconds later the first officer, who was the pilot flying, disengaged the autopilot and increased the descent rate to 4400 ft/min.
- The crew of VLG2226 disengaged the FDs twelve seconds after the TCAS RA was received.
- The RA onboard VLG2226 then indicated a change in direction, issuing a "Climb climb" advisory that required a climb rate of 1500 ft/min.
- The captain and first officer both moved the airplane's control stick without either one pressing the priority button.
- This caused the aircraft's vertical acceleration to increase to 2.03 g.
- Both pilots actuated their sidesticks simultaneously for 10 seconds.
- The minimum distance between the aircraft was 1.4 NM and 100 ft.
- The crew of RYR314Q reported on the frequency that they were "Clear of conflict".
- The crew of VLG2226 did not report to ATC that they were "Clear of conflict".
- The crew of VLG2226 larer reported that the TCAS advisory on the TCAS-VSI gave instructions that showed a green area that was opposite to that showin in the FDM data, which is why they increased the descent rate to adjust it to that area.
- The tests and analyses of the TCAS by the airline and the manufacturer did not reveal any faults in the system's operation.
- Eurocontrol detected the existence of more cases in which crews reacted opposite to the TCAS "Adjust Vertical Speed" advisories due to their potential ambiguity.
- This resulted in a revision to the TCAS and to the regulation that changed this advisory to a "Level off" instruction, which is more intuitive and concise and for crews to react to.

- According to the manufacturer, Airbus, there is no record of more cases of opposite reactions to the TCAS due to an error in the TCAS-VSI (Vertical Speed Tape).
- The CIAIAC did not have access to the accounts of crews in the cases studied by Eurocontrol, and was thus unable to ascertain the type of mistake made by these crews when carrying out instructions contrary to those supposedly given by the TCAS.
- Vueling conducted training activities with the incident crews and with all other crews involving TCAS and CRM.

3.2. Causes/Contributing factors

The incident occurred because the crew of VLG2226 did not comply with the descent rate instructions given by the LECS controller. The crew should have maintained a descent rate of 2000 ft/min or lower; however, they increased this rate, which resulted in an airprox event involving RYR314Q, which was on a converging path below VLG2226 and descending at a rate in excess of 2000 ft/min.

The following factors could have contributed to the incident:

- The controller instructed VLG2226 to proceed direct to reporting point ROTEX, indicating that the rate restriction was still in effect. This part of the instruction was not acknowledged by the crew and the controller did not demand a full acknowledgment.
- The controller then re-cleared VLG2226 to a lower flight level. This time, he did not explicitly state in his clearance that the descent rate restriction was still in effect, which led the crew to mistakenly select a higher descent rate.
- The controller did not have descent rate information for the aircraft on the radar display, which contributed to his inability to detect that VLG2226 was not complying with the descent rate instruction given.

The following contributing factor could have aggravated the incident:

- The crew of VLG2226 did not adhere to the TCAS resolution advisory "Adjust Vertical Speed, Adjust", and increased the descent rate instead of decreasing it. The investigation could not determine whether this was due to an incorrect maneuver by the crew, or to a fault in the descent rate indications shown on the onboard TCAS-VSI display.
- Although the duty and rest periods were according to EU-OPS regulation and fatigue is not prove enough it is consider that the fact the crew were at the

final of their flight duty time could generally affect the way the situation was managed.

4. SAFETY RECOMMENDATIONS

This incident revealed that one crew did not follow the descent rate restrictions imposed by ATC. These restrictions were provided at the same time as the descent clearance. The controller subsequently cleared the aircraft to continue its descent to a lower flight level, but did not include in this clearance the descent rate restrictions or indicated that they were still in effect. This could have resulted in a misunderstanding by the crew that caused them to violate the instruction, and as a consequence, to approach another aircraft in a way that encroached upon the minimum radar separation distance. National and international regulation in effect only states that the aircraft will be contacted if a vertical climb or descent rate restriction is no longer applicable. As a result, the following safety recommendations are proposed:

REC 63/16: It is recommended that Spain's National Aviation Safety Agency (AESA) take the regulatory initiative to have an article included in Spain's Air Traffic Regulations specifying that when an aircraft is cleared to climb/descend and climb/descend rate restrictions are imposed, controllers must repeat them if said restrictions still apply when the aircraft is cleared to a different flight level, or when communications are transferred between control sectors or stations.

REC 64/16: It is recommended that Spain's Civil Aviation General Directorate (DGAC) engage in the relevant regulatory proceedings required to include an article in Spain's Air Traffic Regulations specifying that when an aircraft is cleared to climb/descend and climb/descend rate restrictions are imposed, controllers must repeat them if said restrictions still apply when the aircraft is cleared to a different flight level, or when communications are transferred between control sectors or stations.

REC 65/16: It is recommended that International Civil Aviation Organization (ICAO) consider the need of including in the 4444 Document an article specifying that when an aircraft is cleared to climb/descend and climb/descend rate restrictions are imposed, controllers must repeat them if said restrictions still apply when the aircraft is cleared to a different flight level, or when communications are transferred between control sectors or stations.

During the investigation, Vueling reported that as a result of its internal analysis, it had taken actions involving crew training and refresher training. The TCAS and training simulators had also been updated to logic version 7.1, as required by the applicable regulation. These actions are regarded as satisfactory and sufficient, and thus no safety recommendations are issued in this regard.

ENAIRE, as part of its program to improve the SACTA system, is evaluating the evolution and upgrades of the SACTA system with a view to the complete

replacement of mode S radars, to changes in operating systems and to prioritizing the parameters provided by aircraft that are useful to controllers. In this case, since the reason why the descent rate is not being included in the next upgrade to SACTA as a priority parameter to display to controllers is because it is generally based on barometric information from the aircraft, which is not conducive to the stability of this parameter, it is not necessary to issue a safety recommendation in this regard.