



**COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL**

Report IN-010/2010

Incident occurred on 14 May 2010, to aircraft Boeing 737-800, registration EI-DYX, operated by Ryanair during approach to Valencia Airport (LEVC), Spain



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DE ESPAÑA

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SUBSECRETARÍA

COMISIÓN DE INVESTIGACIÓN
DE ACCIDENTES E INCIDENTES
DE AVIACIÓN CIVIL

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Foreword

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) n° 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.

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Abbreviations

00°	Geographical degrees
00 °C	Degrees centigrade
A/T	Autothrottle
AENA	Aeropuertos Españoles y Navegación Aérea
AFE	Above Field Elevation
ALT	Altitude
APP	Approach
ATC	Air Traffic Controller
ATM	Air Traffic Management
ATIS	Automatic Terminal Information Service
ATPL	Airline Transport Pilot License
ATS	Air Traffic Service
CAS	Computed Airspeed
CIAIAC	Spain's Civil Aviation Accident and Incident Investigation Commission
CPL	Commercial Pilot License
CVR	Cockpit Voice Recorder
DALTA	Descent-Approach-Landing-Taxi-Apron
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
EDDF	Frankfurt airport (Germany)
EGPWS	Enhanced Ground Proximity Warning System
EGSS	Stansted Airport
ESKN	Stockholm airport (Sweden)
ETOW	Estimated Take-Off Weight
FA	Flight Attendants
FCTM	Flight Crew Training Manual
FL	Flight Level
FMC	Flight Management Computer
FPL	Flight Plan
ft	Feet
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
h	Hour(s)
IAF	initial approach fix
ICAO	International Civil Aviation Organization
ILS	Instrumental Landing System
IMC	Instrument Meteorological Condition
kg	Kilogram(s)
km	Kilometer(s)
kt	Knot(s)
lb	Libra(s)
LEAL	Alicante airport (Spain)
LECL	Terminal Area Control Center (TACC) Valencia
LELC	Murcia-San Javier airport (Spain)
LEMD	Madrid airport (Spain)
LEVC	Valencia airport (Spain)
LEVD	Valladolid airport (Spain)
LEVT	Vitoria airport (Spain)
LEZG	Zaragoza airport (Spain)
LOC	Localizer del ILS
LW	Landing Weight
m	Meter(s)
METAR	Meteorology Aerodrome Weather Reports
ND	Navigation Display
NM	Nautical mile

Abbreviations

NOTAM	Notice To Airmen
OFP	Operational Flight Plan
QNH	Atmospheric pressure at sea level
RA	Radio Altimeter
SPECI	Report with special remarks to be spread outside the aerodrome
TACC	Terminal Area Control Center
TAF	Terminal Aerodrome Forecast
TL	Transition Level
TOW	Take Off Weight
TREND	Landing forecast, tendency type, included in a METAR or a SPECI
TWR	Tower
UTC	Universal Time Coordinated
Vapp	Wind-corrected approach speed
VHF	Very High Frequency
VMC	Visual meteorological conditions
VOR	VHF Omnidirectional Radio Range
Vref	Reference speed
ZFW	Zero Fuel Weight

Synopsis

Owner and operator:	Ryanair
Aircraft:	Boeing 737-800, registration EI-DXY
Date and time of accident:	Friday, 14 May 2010, at 18:30 UTC ¹
Site of accident:	Approach to Valencia Airport (LEVC), Spain
Persons onboard:	2 flight crew, 4 flight attendants, 170 passengers
Type of flight:	Commercial Air Transport-Scheduled – International – Passenger
 Date of approval:	 30 March 2013

Summary of accident

On 14 May 2010, a Ryanair's aircraft B-737-800 callsign RY9ZC was flying from Stansted airport (EGGS, UK)² and Alicante Airport (Spain), was cleared to land first at 10 runway (Alicante Airport-LEAL)³ and made a go-around due to meteorological conditions (windshear). Then they tried a new approach this time on 28 runway but the wind conditions were similar and the crew finally decided to divert to Valencia airport (LEVC)⁴. They stated urgency (PAN-PAN) due to the fact that they were below the final fuel reserve and then, when they were in approach, they stated emergency (MAYDAY) and they landed at 12 runway in Valencia Airport uneventful. Once there, the fuel quantity was checked to be below final reserve fuel and the aircraft was refueled and the flight continued to Alicante, finally landing at 21:40 h UTC. CIAIAC started an investigation with reference IN-010/2010.

On 26th July 2012 thunderstorms occurred in the vicinity of Madrid airport (LEMD) that forced ATC to divert twelve flights towards Valencia Airport (LEVC). Four of these twelve flights declared emergency due to problems with fuel, when they were in approach to Valencia airport. Given the similarity with this incident occurred in 2010 and the advanced phase in which its corresponding report was, CIAIAC decided not to conduct an individual report for each one of those cases but proceed to incorporate them to the incident report ref. IN-010/2010, of similar characteristics. The similarity between those cases occurred 26th July 2012 with that report from 2010 entailed that no new recommendations, different from those established in that report, were going to be issued on this regard, although those 2012 cases reinforce the arguments in which the recommendations are based on.

¹ All times in this report are in UTC unless otherwise specified. To obtain local time, add two hours to UTC.

² EGGS Stansted airport (UK).

³ LEAL Alicante airport (Spain).

⁴ LEVC Valencia airport (Spain).

1. FACTUAL INFORMATION

1.1. Description of event

The Boeing 737-800 aircraft, registration EI-DYX and callsign RYR9ZC, was flying from Stansted (EGSS) to Alicante (LEAL) with a total of 176 people onboard: 170 passengers, two flight crew (hereinafter "crew") and four cabin crew (flight attendants – FA). At 17:51, on approach to the destination airport, the crew decided to go around just before landing on runway 10 due to, as they stated, windshear on the runway. The wind was highly variable at both runway thresholds (10/28) and the crew decided to attempt another approach, this time via runway 28, after checking the latest wind information. After approximately thirteen minutes, the crew was cleared for the second approach to runway 28 and, once on final, and in light of the latest wind information provided by ATC, decided to go around once again and divert to the alternate airport, Valencia (LEVC). While en route, the crew issued an urgency declaration (PAN-PAN) on the approach frequency due to low fuel. Eight minutes later, while on final approach, the crew declared an emergency (MAYDAY). The landing proceeded normally. The final fuel amount was 956 kg, 183 kg less than the calculated final reserve fuel.

1.2. Personnel information

1.2.1. Crew information

The captain, a British national, was 27 years old and had a valid and in force airline transport pilot license (ATPL) with a B-737 300-900 type rating. He also had a valid and in force class 1 medical certificate. He had a total of 6,835 flight hours, of which 5,426 were on the type.

The copilot, a British national, was 22 years old and had a valid and in force commercial pilot license (CPL) with a B-737 300-900 type rating. He also had a valid and in force class 1 medical certificate. He had a total of 2,057 flight hours, of which 1,902 were on the type.

Both had level 6 English language competency certificates and had taken the training courses approved for the operator in accordance with EU OPS.

1.2.2. Crew statement

According to the report filed by the crew, inbound Alicante Airport (LEAL) they were notified that the runway in use was 10 and that the wind was from 130° at 11 kt. The crew noted on the navigation display (ND) that there could be a tailwind on

approach but a headwind on landing. Since ATC had warned of windshear, the crew decided to land with 30° flaps. The approach was normal, but in the last 50 ft the Enhanced Ground Proximity Warning System (EGPWS) omitted the radio altitude calls and a gust of tailwind resulted in excessive speed. They performed a go-around in conditions of turbulence. Initially, ATC offered the crew another approach attempt on the in-use runway 10, but the crew requested wind for 28, which ATC reported as variable at 2 kt. The crew checked the fuel amount reading on the FMC⁵ for Valencia Airport (LEVC) and, believing it sufficient, decided to make an approach on runway 28 with variable wind. The necessary briefing⁶ was completed and they started the approach. When they changed to the tower frequency they were told the wind was from 90° at 15 kt. The crew requested a confirmation of the wind, since it had previously been reported as calm. The wind was beyond the limit for Alicante Airport, so the crew decided to abort the approach and proceed to the first alternate (Valencia Airport). On diversion, the wind reported to another airplane arriving at the Alicante Airport was from 310° at 20 kt for runway 10 and from 100° at 15 to 18 kt for runway 28, meaning both runways were outside the limits. The FMC indicated Valencia initially at 1.3 (1,300 kg of fuel) and then 1.2 (1,200 kg of fuel)⁷. The headwind on the diversion was nearly three times that specified in the Operational Flight Plan (OFP), resulting in the amount of fuel continuing to decrease. When the crew became aware that they might land with a fuel amount below final reserve fuel, they declared an urgency situation (PAN-PAN). The crew made the approach to runway 12 and, as they turned onto short final, the fuel amount fell below the final fuel reserve. As a result, the crew declared an emergency (MAYDAY) in keeping with Part A of the operator's Operations Manual. The approach and landing were normal. The captain stated that they had gone past the Valencia Airport en route and had noted the weather conditions, finding them suitable. He also referred to the fact that the Murcia-San Javier Airport was a military airport, and he was not sure if it was open. Since he was more familiar with the Valencia Airport and he had weather information available for it, he decided to divert there.

1.3. Aircraft information

1.3.1. General information

The aircraft, registration EI-DYX, is a Boeing 737-8AS model with serial number 37517, a maximum authorized weight of 66,990 kg and two CFM 56-7B26 engines. The aircraft had valid and in force registration and airworthiness certificates. It also had the corresponding noise limitation certificate.

⁵ Flight Management Computer.

⁶ Required by airline procedures and necessary to prepare for the second approach: Descent and Approach Setup and Briefing "DALTA" (Descent – Approach – Landing – Taxi – Apron).

⁷ The final reserve fuel amount specified in the Operational Flight Plan for LEVC was 1,139 kg.



Figure 1. Photograph of the aircraft⁸

1.3.2. Load sheet information

The following relevant data were reflected in the load sheet:

- Payload: 14,609 kg.
- Zero fuel weight (ZFW): 57,155 kg.
- Fuel at takeoff: 8,049 kg.
- Takeoff weight (TOW): 65,205 kg.
- Landing weight (LW): 59,605 kg.

On the same load sheet, handwritten by the crew, it stated that the reference speed, VREF, calculated for the first approach to Alicante Airport was 141 kt. This VREF was subsequently corrected to 139 kt for the approach to the Valencia Airport.

1.3.3. Fuel information in the OFP

The fuel calculation performed for the flight, as reflected in the Operational Flight Plan (OFP) used by the crew, is shown in the following figure.

This portion of the OFP shows the fuel calculated for each phase of the flight, including those aspects considered as per Part A of the company's Operations Manual and based on EU OPS 1.255 (see Appendix A). The Block Fuel amount was 8,123 kg, which was rounded up to 8,200 kg, as shown in the handwritten annotation. Note that the captain decided not to add any extra fuel.⁹

⁸ Image taken from www.airliners.net

⁹ The Commander may carry up to 300 kg more than FPL fuel without explanation. Where departure fuel is more than 300 kg in excess of flight plan fuel an explanation for the uplift shall be recorded on the voyage report. Commanders have a responsibility to adhere to target fuel loads subject to operational requirements.

*** PZFW 59199 ***									
FLIGHT PLAN					FUEL				
TAXI/APU	0:12				150KG	MTOW	74990	ETOW	67172
TRIP	2:11				5442KG	MZFW	61688	EZFW	59199
CONTINGENCY	0:07				272KG	MLWT	65317	ELWT	61730
RESV/HOLD	0:30				1139KG	S.H.	TTK	GOIST	MTC
LEVC	0:30				1120KG	7.9	003	103	M22
					2259				
FPL FUEL	3:30				8123KG				
TANK	0:00				0KG				
EXTRA	0:00				0KG				
BLOCK FUEL	3:30				8123KG				
FINAL FUEL				8200				
ALT	FUEL	TIME	MSA	TTK	DIST	COMP			
LELC	1100KG	0:30	7.5	202	73	P4			
LEAM	1398KG	0:33	10.9	226	159	M11			
LEAS	1892KG	0:46	7.9	024	240	M6			
TIME	FUEL	COMP	PROFILE						
2:11	5460	15	350						
2:09	5542	17	330						
2:09	5711	18	300 CPT	310					

Figure 2. Fuel calculation taken from the Operational Flight Plan

The first alternate aerodrome was the Valencia Airport (LEVC), for which the OFP showed a required fuel amount of 1,120 kg, a distance of 103 NM and a forecast headwind of 22 kt. There is no explicit reference to the parameters considered in determining the amount of fuel needed to reach Valencia or the remaining alternates. The second alternate aerodrome was the San Javier-Murcia Airport (LELC), for which the calculated fuel amount was 1,100 kg, a distance of 73 NM and a forecast 4-kt tailwind.

As per company policy, the amount of fuel shown for the second alternate airport (San Javier) was the established minimum of 1,100 kg.

The contingency fuel¹⁰ was 272 kg, equivalent to seven minutes of flight time and corresponding to the minimum required by law of 5% of the fuel to fly to Alicante (LEAL).

The alternate fuel represents the minimum amount of fuel needed to divert to the alternate airport and reach it with the required final reserve fuel¹¹. In this case, and based on OFP data, the amount needed to divert to the alternate was 2,259 kg, with the final fuel reserve being 1,139 kg.

Once the airplane landed at the Valencia Airport, airport officials requested that the fuel supply company measure the amount of fuel remaining in the aircraft's tanks. The results were as follows:

- Tank n.º 1: 440 kg
- Center tank: 0 kg
- Tank n.º 2: 470 kg

for a total of 910 kg.

¹⁰ OPS 1.192 Terminology: Contingency Fuel: The fuel required to compensate for unforeseen factors which could have an influence on the fuel consumption to the destination aerodrome such as deviations of an individual aeroplane from the expected fuel consumption data, deviations from forecast meteorological conditions and deviations from planned routings and/or cruising levels/altitudes.

¹¹ Fuel required to fly for 30 additional minutes with turbine engines at hold speed at 1,500 ft.

1.3.4. *Description of flight*

So as to provide a better understanding of the incident, this section combines the information obtained from Air Traffic Control (ATC) services with that obtained from the Digital Flight Data Recorder (DFDR).

1.3.4.1. **First go-around**

The aircraft was dispatched from Stansted Airport (EGSS) with 8,200 kg of fuel, which matches the rounded amount calculated in the OFP (8,123 kg) (see figure 2 above).

The airplane's expected takeoff weight shown in the OFP (67,172 kg) was above the actual weight calculated on the load sheet (65,205 kg)¹². This lower actual weight meant lower consumption and allowed the airplane to climb to FL 390, instead of the FL 370 planned in the calculation. Moreover, as noted on the OFP, the crew was authorized several detours en route. As a result, the aircraft arrived at the Alicante Airport with an extra 477 kg of fuel (which allowed for an additional 12 minutes of flight time, approximately).

On approach to Alicante Airport, the aircraft was cleared to proceed from point VILNA¹³ via the 20 NM arc on ALT (VOR/DME) and subsequently to complete the ILS approach to runway 10 (see Appendix B).

According to DFDR data, there was a tailwind during the approach (the controller had reported these conditions, as stated by other aircraft crews), but at about 200 ft the wind speed decreased rapidly almost to zero as its direction shifted to the south.

Although the wind data recorded on the DFDR during the landing are not completely reliable due to the aerodynamic influence of the ground effect and to changes in the airplane's attitude, they do offer an approximate idea of the prevailing wind conditions, which on this occasion warrant consideration, as they are consistent with the wind data reported by the control tower and other aircraft and by their agreement with the effect on the airplane's CAS (computer airspeed).

According to the DFDR, in the final 20 seconds before initiating the go around, coinciding with the last 180 ft of RA, the wind slowed gradually until it was almost calm on the surface of the runway.

This decrease in wind is consistent with the increase in the aircraft's CAS (see figures 3 and 4) and with the pilot's reaction to decrease thrust.

¹² The impact of this lower weight was a fuel savings of approximately 105 kg.

¹³ VILNA IAF (initial approach fix) for the runway 10 ILS approach LEAL.

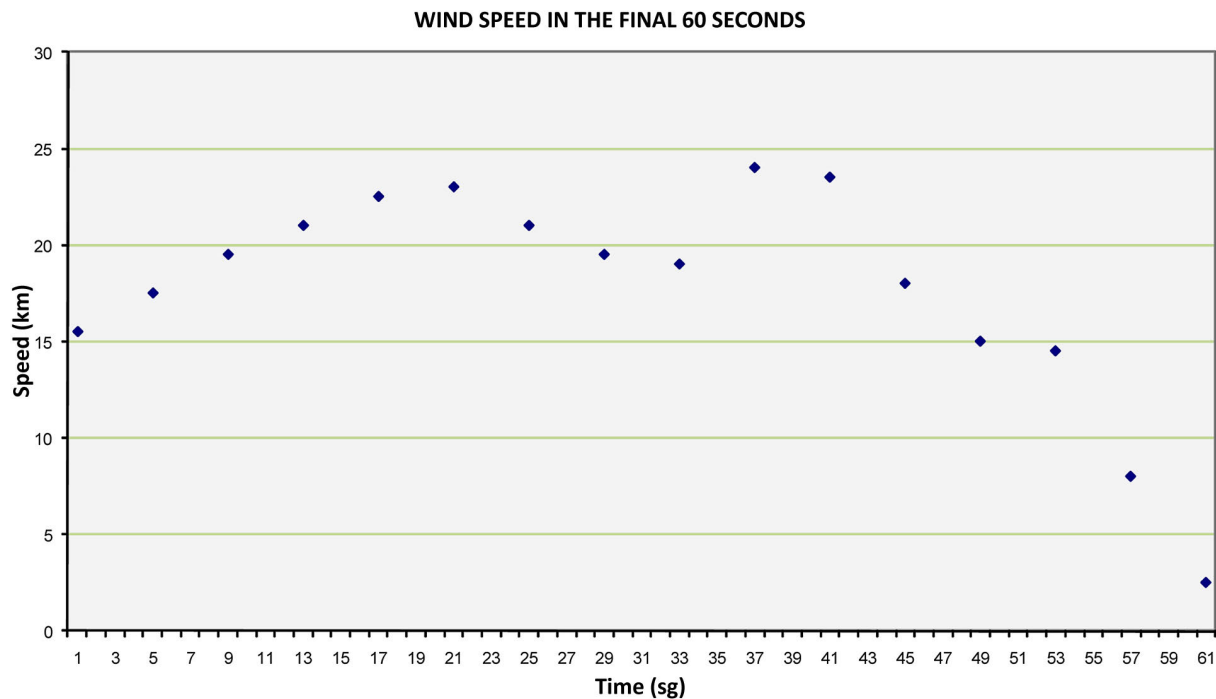


Figure 3. Change in wind speed in the final 60 seconds

Note how the CAS increased gradually over these last 20 seconds to a momentary maximum of 162 kt. The speed the pilot was trying to maintain, or V_{app} , was 146.

At 17:55:19, when the aircraft was at an altitude of 3 ft above the runway, the crew initiated a go around.

The GPS position recorded on the DFDR indicates that this maneuver was started some 580 meters past the runway 10 threshold.

It could not be determined whether there were aural warnings from the GPWS, since the CVR (Cockpit Voice Recorder) information was unavailable. The data taken from the DFDR do not show any windshear or GPWS warnings¹⁴, which confirms that the thresholds for activating these warnings were not exceeded.

The graph below shows the calculated airspeed (CAS) recorded on the DFDR in the final 60 seconds¹⁵ before the go around. The bold horizontal line represents V_{app} ¹⁶, that is, the speed that the pilot was attempting to maintain.

¹⁴ Windshear Caution-Windshear Warning & GPWS Warning.

¹⁵ Second 1 represents the start of the final minute. Second 61 represents the start of the go around.

¹⁶ V_{app} , or wind-corrected approach speed, refers to the speed selected by the pilot to be maintained by the A/T, in this case $V_{ref} + 5$ kt.

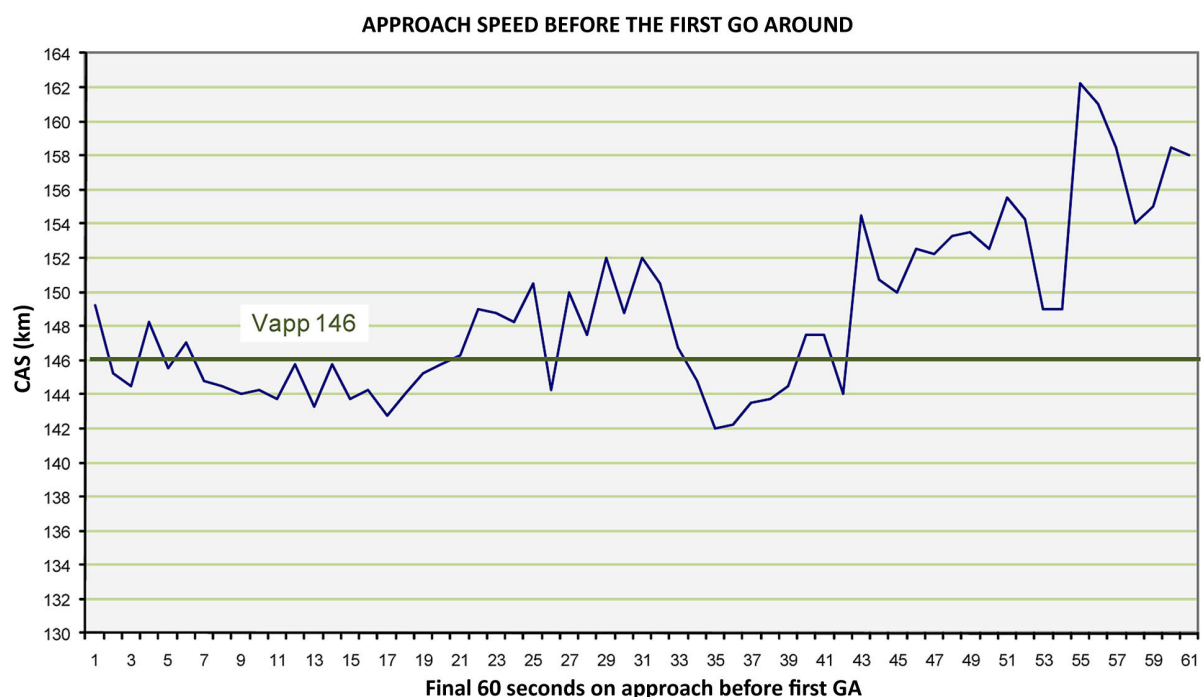


Figure 4. Approach speed before the first go around

1.3.4.2. Second go-around

Following the initial go around, instead of proceeding with the standard go-around maneuver, ATC vectored the crew to the right toward the west so as avoid having them reach slow-moving traffic that had departed shortly before the crew started its maneuver. The approach controller in Alicante offered radar vectors to the crew to proceed once more to runway 10, which the crew accepted. Some three minutes later, when the crew requested new wind information, ATC reported that at that time both thresholds had a tailwind. The crew then decided to attempt the approach on runway 28, but first they requested to proceed to point MAGAL and hold, reporting that they would establish contact when ready for the approach. The amount of fuel remaining at that time was 2,523 kg and the minimum alternate fuel¹⁷ to reach the alternate airport, Valencia, with the required final reserve was 2,259 kg.

The crew held the briefing required by company procedures to prepare for the second approach (VOR approach versus the previously attempted ILS approach). At 18:06:42, the crew reported that it was ready for the approach to 28. At that time the controller was busy giving instructions in Spanish to other traffic approaching on 10. A minute later, at 18:07:46, the crew reiterated to ATC that it was ready for the approach. The controller asked how long they could remain above MAGAL, to which the pilot replied

¹⁷ Alternate fuel: Minimum amount of fuel required to divert to the alternate airport and reach it with final reserve fuel.

they had to start the approach immediately or proceed to the alternate. The controller then asked the other traffic (again in Spanish) if it could circle a couple of times around VILNA so as to allow another aircraft that had just gone around to land, and that would have to go to the alternate otherwise. The other traffic agreed.

When, at 18:08:20, the aircraft was cleared to start the VOR approach maneuver to runway 28 from MAGAL, the amount of fuel remaining was 2,218 kg, that is, 41 kg below the minimum alternate fuel for LEVC.

At 18:17:18, the crew made its second go-around with 1,932 kg of fuel remaining and requested an "immediate diversion to Valencia with radar vectors due to fuel". A total of 22 minutes elapsed between the first and second go-arounds, with the amount of fuel remaining on board being 327 kg below the minimum alternate fuel required to proceed to Valencia.

1.3.4.3. Diversion to alternate airport

The OFP includes the data on the flight's alternate airports. These data include the fuel required (1,120 kg for Valencia, LEVC, and 1,100 for Murcia-San Javier, LELC), the distance to each (103 NM to Valencia and 73 NM to Murcia-San Javier) and the expected wind component (22-kt headwind for Valencia and 4-kt tailwind for Murcia-San Javier) (see figure 2).

As reflected by the DFDR data, the diversion flight to Valencia Airport was made on a direct heading at FL 80 and a speed of 220 kts, as the crew requested to ATC. En route they encountered an average wind from 315° at 25-30 kts, consistent with that forecast in the flight plan.

At 18:30:02, 31 NM away from Valencia, 12 minutes after initiating the second go-around, the crew declared an urgency situation, PAN-PAN, PAN-PAN, PAN-PAN due to fuel. The fuel remaining in the aircraft at that time was 1,250 kg.

At 18:38:15, as they were turning toward the runway 12 localizer 6 NM away from the ILS, the crew radioed MAYDAY, MAYDAY, MAYDAY, declaring a fuel emergency. The amount remaining then was 1,040 kg.

The flight finally landed at 18:41:44 on runway 12 at the Valencia Airport with 956 kg of fuel remaining, 183 kg below final reserve fuel.

1.4. Information on stabilized approach criteria

According to the B-737 Flight Crew Training Manual (FCTM), one of the elements recommended as part of a stabilized approach, based on the criteria published by the Flight Safety Foundation (see Appendix D), is that:

The aircraft speed is not more than $V_{ref}+20$ kts and not less than V_{ref} .

Based on these criteria:

An approach that becomes unstabilized below 1,000 ft above airfield elevation in instrument meteorological conditions (IMC) or below 500 ft above airfield elevation in visual meteorological conditions (VMC) requires an immediate go-around.

Ryanair's criteria concerning excess speed is consistent with the above, with an approach being regarded as unstabilized if the speed exceeds V_{ref} by 20 kt or is below V_{ref} . An airplane that is not stabilized at the "landing gates"¹⁸ is required to perform a go-around.

1.5. Meteorological information

1.5.1. *Information available to the crew*

The weather information available to the crew before the flight was as follows:

METAR LEAL 141430Z 09011KT 060V150 9999 FEW025TCU SCT 045 17/08
Q1009 NOSIG

FC: NO RECENT BULLETINS FOR LEAL

FT: TAF LEAL 141100Z 1412/1512 28808KT 9999 SCT030 TX22/1512Z TN12/1506z
PROB30 TEMPO 1412/1419 17010KT
TEMPO 1506/1512 30016KT

As regards wind information, the 14:30 METAR indicated that the wind was from 90° at 11 kt, varying in direction from 60° to 150°. The short-range (9-hour) Terminal Aerodrome Forecast (TAF) did not have any information for the Alicante Airport, and the long-range (24-hour) TAF indicated that at 11:00, the wind was from 288° at 8 kt with a moderate probability (30%) for occasional winds from 170° at 10 kts between 12:00 and 19:00.

1.5.2. *Meteorological information at the time of the incident*

The weather information for the Alicante Airport at the time of the incident was as follows:

METAR LEAL 141800Z VRB03G16KT 9999 SCT045 19/M01 Q1011 NOSIG

¹⁸ Ryanair defines the "landing gates" as passing through the final 500 ft in VMC or 1,000 ft in IMC.

In other words, the weather conditions at the Alicante Airport on the 14th at 18:00 were reported as wind from variable direction at 3 kt and gusting up to 16 kt.

The forecast weather conditions at the Alicante Airport (as specified on the long-range TAF – 24 hours) at 17:00 were as follows:

TAF LEAL 141700Z 1418/1518 31010KT 9999 FEW030 TX22/1512Z TN14/1505Z
TEMPO 1418/1512 33010G20KT=

This forecast was valid from the 14th at 18:00 until the 15th at 18:00, and had been issued on the 14th at 17:00. In terms of wind, the forecast was for 310°/10 kt with a visibility of 10 km, with occasional winds from 330° at 10 kt and gusting up to 20 kt from the 14th at 18:00 until the 15th at 12:00.

The weather information for the Alicante Airport on the 14th at 18:00 was as follows:

	Direction	Speed
Average value in the ten minutes prior to the time specified (17:50-18:00)	300	4.8 kt
Maximum average ten-minute value in the hour prior to the time specified (17:00-18:00) and the exact time of this value	120	14 kt
Maximum gust (at 17:10:50)	112	26 kt

The National Weather Agency issued a report on the possible cause of such highly variable winds at both thresholds:

«The weather situation on 14 May 2010 was characterized by the presence of a low-pressure area in the vicinity of the Balearic Islands, accompanied aloft by a large trough that extended from Iceland to beyond the peninsula. The strongest winds associated with the trough were present throughout the entire peninsula and the Balearic Islands, with the resulting situation being conducive to convective instability, especially in the area of the Mediterranean, where a very compact convective nucleus formed that gave rise to various storms, most of them over water. In the hours prior to the incident (17:50 UTC), most of the convective activity near Alicante took place in the vicinity of the island of Ibiza, and it is very likely that the gust front from said storm was responsible for the turbulent winds seen at the Alicante Airport, as well as for the prevailing northerly winds over one of the thresholds. In the area not affected by storm gusts, the wind was caused more by effects associated with the topography or with sea breezes. The synoptic wind in medium high layers was from the northwest. Although the storm activity was abating at the time of the incident (17:50 UTC), as evidenced by diminished wind speeds, it is probable that the difference in winds between the airport's

thresholds resulted from the fact that one threshold was affected by nearby convective activity, while the other was subject to local effects.»

1.6. Aerodrome information

The Alicante Airport (LEAL) is located 9 km southwest of the city at an elevation of 142 ft. It has one 3,000-meter long runway in a 28/10 orientation. Runway 10 has an ILS approach, while runway 28 has a VOR approach. Both plates are included in Appendix B.

The Valencia Airport (LEVC), first alternate specified in the OFP, is located 8 km west of the city at an elevation of 240 ft. It has one 3,215 m long runway in a 30/12 orientation. Both runways have an ILS approach.

The Murcia-SanJavier Airport (LELC), second alternate specified in the OFP, is 45 km southeast of the city at an elevation of 28 ft. It has two parallel runways in a 05/23 orientation measuring 2,320 and 1,577 m in length. Runway 05R has an ILS approach and 23L has a VOR approach. Runway 05L/23R is for military use only.

The second alternate airport, the Murcia-San Javier Aerodrome, is closer than the first alternate (Valencia) (73 NM versus 103 NM, according to the OFP).

According to the OFP, the fuel needed to reach the Murcia-San Javier Airport was 1,100 kg (minimum required by company policy, though the actual amount needed was lower, see Section 1.3.3 and Appendix A) and for the Valencia Airport it was 1,120 kg.

1.7. Air Traffic Services Information

1.7.1. NOTAM information

Included as part of the aircraft's dispatch information were the NOTAMs for the origin and destination airports, as well as those corresponding to the route to be flown.

1.7.2. ATIS information¹⁹

The ATIS C (Charlie) information checked by the crew before the approach was for 17:30 and specified the runway in use as 28, TL (transition level) 075, wind from 130° at 11 kt,

¹⁹ ATIS (Automatic Terminal Information Service) is the updated information on significant aspects at the airport that is broadcast constantly on an assigned frequency. The information includes runway in use, QNH, visibility, wind, transition level and other details. This information is transmitted in messages identified with a letter (A-Z) that changes with each update.

variable from 080° to 160°, visibility in excess of 10 km, few clouds at 025, scattered at 045, temperature 18°, dew point 05°, QNH 1011, NOSIG (no significant changes expected).

The ATIS C information on file and provided by AENA reflected the same data and likewise stated that no significant changes were expected. No SPECI²⁰ or TREND²¹ reports were issued on this regard.

In order to issue a SPECI or a TREND in light of significant changes, as the change in the wind direction, this has to be equal to or bigger than 60° with respect to the data of the last METAR (the wind direction changes are measured each 10 minutes). To issue a SPECI or a TREND report because of wind speed, this has to be at least 10 kt different from the medium wind speed obtained in the last METAR (10 minutes before).

1.7.3. *ATC communications*

Appendix E shows the most relevant exchanges that took place between the aircraft and the various ATC facilities: ALC APP (Alicante approach), ALC TWR (Alicante tower), VLC APP (Valencia approach) and VLC TWR (Valencia tower). This appendix shows the communications that took place as well as the activities of the crew during the two go-arounds, the deviation to the alternate airport, the urgency and emergency declarations and the response to said declarations by air traffic control services.

1.7.4. *Information on the ATC Update Log*

According to the Operational Update Log at the Alicante Airport, at the time of the go-arounds there were several entries regarding changes in runway configurations and several go-arounds made by aircraft due to windshear.

00:00	Configuration change to RWY 28 due to wind.
14:21	Configuration change to RWY 10 due to wind.
14:40	B737 go-around. Windshear.
14:58	Configuration change to RWY 28 due to wind.
16:03	B738 go-around. Traffic encountered windshear on short final.
17:22	B737/8 go-around. Wind shifting.
17:25	Aircraft reports strong windshear taking off from 10.
17:39	Aircraft go-around due to windshear.
17:57	Go-around of RYR9ZC due to windshear.
18:17	Go-around of RYR9ZC on runway 28 due to windshear. Diverting to alternate.
18:26	Change to runway 10.
19:42	Configuration change to RWY 28 due to wind.

²⁰ SPECI: Report with special remarks to be spread outside the aerodrome.

²¹ Landing forecast, tendency type, included in a METAR or a SPECI.

In the Operational Update Log for LECL (Valencia TACC²⁰) the following incident was recorded: *"Traffic RYR9ZC inbound from EGSS and after two landing attempts at LEAL diverts to LEVC. At 18:30 en route to Valencia it declares TAM TAM TAM, and at 18:38 MAYDAY. Lands at 18:43. The Airport's Emergency Protocol is cancelled at 18:45."*

1.7.5. Additional information on ATC experience with emergencies

Eurocontrol, in its internal document "Guidelines for Controller Training in the Handling of Unusual/Emergency Situations," admits that most of its controllers have no experience in handling serious emergencies and probably will not attain such experience during their years of service due to the quality of the air and ground equipment and to the overall safety levels attained in commercial aviation in our operational environment, and that this lack of experience makes it likely that when faced with a real emergency, deficient performance could result.

This document recommends promoting in various forums the use of transponder code 7700 and the appropriate use of the MAYDAY and PAN codes. It also recommends the use of checklists by controllers to better handle these emergency situations.

In this regard, AENA reported during the course of the investigation that it had written a procedure in March 2011 for handling urgency and emergency situations titled "Procedimiento de actuación en emergencias y situaciones especiales de las aeronaves" [Procedure for emergency and special situations in aircraft]. This document was an adaptation of a Eurocontrol document that included additional material and the proper English phraseology. This operating reference document was intended to be used by ATS personnel at various ATC stations (control towers, approach and control centers) to handle emergency and abnormal situations involving aircraft. The last revision of this document had been prepared with input from not only controllers, but also from pilots who provided a perspective from the cockpit.

1.8. Information on the emergency declaration

EU OPS 1.375 states that:

«The commander shall declare an emergency when calculated usable fuel on landing, at the nearest adequate aerodrome where a safe landing can be performed, is less than final reserve fuel.»

²² Terminal Area Control Center.

This EU OPS regulation is incorporated into Ryanair's own rules (see Appendix F).

- The commander shall make an urgency call (Pan x3) if he believes he will land with less than final reserve fuel (Ryanair policy).
- The commander shall declare an emergency when the calculated usable fuel on landing is less than final reserve fuel (EU-OPS).
- The commander shall make a mayday call (Mayday x3) when committed to making an approach and there is insufficient fuel to do a go-around.

The EU OPS regulations do not use the terms MAYDAY or PAN, nor is the "urgency" concept fully explained; therefore, emergency declarations are not associated with their use. The ICAO addresses urgency and emergency messages in Annexes 2 (Rules of the Air) and 10 (Aeronautical Telecommunications), an extract from which is shown in Appendix F. Annex 6 (Operations of Aircraft) does not explicitly cover these terms. It is this Annex that is transposed in the EU OPS, but only in connection to fuel in EU OPS 1.375.

During the comment phase, the ICAO reported that Amendment 36 to Annex 6 (Part I – International commercial air transportation – Airplanes) had gone into effect on 15 November 2012 and included a new item involving in-flight fuel management (4.3.7) that references the situation in which an aircraft has a minimum/critical amount of fuel and the actions that ATC should take (see Appendix H)²³.

1.9 Information on several cases that occurred in July 2012

On 26 July 2012²⁴, at around 20:00 UTC, seventeen airplanes from various airlines had to be diverted from the Madrid Airport (LEMD) to the Valencia (LEVC) and Alicante (LEAL) airports due to adverse meteorological conditions (hail storms). A total of twelve aircraft were diverted to Valencia and five to Alicante.

Of these seventeen flights, three Ryanair aircraft (RZR 2054, RZR 9VR, RZR 5389) and one LAN Chile aircraft (LAN 705) declared an emergency (MAYDAY) to TACC Valencia (approach control) due to fuel. According to ATC records, four airplanes diverted to LEAL (EZY483K, RZR7227, EZY7946, RZR5996) reported cuts in fuel flow without declaring an emergency. Appendix G shows a radar image with the locations of several of the aircraft involved in the incident.

The details of each of the flights that declared an emergency are presented below:

²³ See also: <http://www.ifalpa.org/downloads/Level1/Briefing%20Leaflets/Air%20Traffic%20Services/13ATSBL01%20-%20ICAO%20changes%20for%20minimum%20and%20emergency%20fuel.pdf>

²⁴ At that time this report was nearing final approval.

The aircraft with callsign **RYP 2054** (registration EI-EKK), flying to Madrid from Palma de Mallorca (LEPA) with 150 passengers onboard, performed a go-around on runway 18R at LEMD at 20:08 due to the storm. After proceeding to point RESBI, located northwest of the airport, with the intention of trying a new approach, it was finally diverted to LEVC at 20:19. At 20:55 the aircraft contacted the TACC Valencia (LECL), which provided descent instructions and, at 20:59, instructed the aircraft to hold. The crew of the aircraft replied that they could not hold as they did not have sufficient fuel. Valencia Approach asked if they were declaring an emergency, with the crew issuing a MAYDAY at 21:00 UTC.

The fuel data in the operational flight plan (OFF) did not list any extra fuel, though 613 kg of extra fuel was included in the final fuel amount. This amount was justified in the Voyage Log Report due to the weather forecast (storms).

The arrival fuel noted in this report was 910 kg (1,029 kg on touchdown), versus the 1,104 kg calculated for the final reserve fuel. In this case the aircraft landed with an amount below final reserve fuel.

As regards the A-340-300, registration CC-CQF and callsign **LAN 705**, flying from Frankfurt (EDFF) to Madrid and diverted to Valencia (LEVC) due to weather conditions, it was initially reported that its crew had declared an emergency due to the "loss of an engine" or an "Engine stoppage", presumably due to having been struck by lightning. It was subsequently confirmed that it had declared a fuel emergency and that the no. 3 engine had stopped due to fuel starvation.

The aircraft had made a go-around on runway 18R at 20:05 due to adverse weather conditions. After reaching the hold point RESBI (northwest of the runway) at 20:16 so as to make a new approach, the crew requested to divert to its alternate airport (LEVC). ATC authorized the diversion but kept the aircraft flying west for a few minutes. According to radar information, the aircraft initiated its diversion to the alternate at 20:28, though it first had to fly south to avoid a front of cumulonimbus clouds. At 21:05 the crew established contact with Valencia TACC, and at 21:04 the crew declared an emergency, reporting to ATC that they had "lost" an engine. According to the crew, thirty minutes before landing in LEVC, they had received a low fuel level alarm in the left tank. Eleven minutes before landing the low fuel level alarms in both wings were received, and a minute later the number 3 engine stopped. At 21:08 ATC cleared the crew to conduct an ILS approach to runway 30 at their discretion. According to the crew they had added 1,000 kg of extra fuel. When they diverted to the alternate they had 7,250 kg of fuel, 1,053 kg above the minimum alternate fuel. The fuel level dropped, causing an auto shutdown of the number 3 engine.

The final landing fuel was 2,365 kg (versus the 2,452 kg calculated for final reserve fuel). In other words, the aircraft landed with a fuel amount that was below the final reserve.

The aircraft with callsign **RYR 9VR** (registration EI-DHH), flying to Madrid from Stansted (EGSS) with 179 passengers onboard, did a go-around on runway 18R at LEMD at 20:11 due to the storm and was directed to hold point RESBI. Some 9 NM before reaching this point, at 20:15, the crew started to divert to LEVC. When the crew contacted Valencia ATC, they were instructed to hold over point MULAT (21:01). At that time, according to the crew, there were six aircraft on approach. Another aircraft's emergency declaration caused them to delay even more. At 21:04, the crew informed Valencia ATC that if they did not start their approach within 2-4 minutes, they would have to declare an emergency, which they eventually did at 21:11. At 21:12 the aircraft was cleared for an ILS approach to runway 30.

The fuel data in the operational flight plan did not list any extra fuel, though 283 kg of extra fuel was included in the final fuel amount. This amount was justified in the Voyage Log Report due to delays in Madrid.

The final arrival fuel listed in the report was 1,130 kg (1,160 kg on touchdown) versus the 1,119 kg calculated for final reserve fuel, meaning that the aircraft landed with a fuel amount that was above the final reserve.

The aircraft with callsign **RYR 5389** (registration EI-ENM) flying to Madrid from Stockholm (ESKN) with 140 passengers onboard, did a go-around on runway 18L at LEMD at 20:12 due to the storm. It then proceeded to RESBI but diverted south for a few minutes, some 14 NM before reaching it, and then proceeded to point LALPI, situated northwest of the runway. Finally, at about 20:30, the aircraft was diverted to LEVC. The crew declared an emergency at 21:14.

In this particular case the first alternate airport was Valladolid (LEVD), followed by Zaragoza (LEZG) and Vitoria (LEVT). LEVC was the fourth alternate and the most distant, and thus the one that was used in the dispatch fuel calculations when considering the amount of additional fuel to carry.

The fuel data in the operational flight plan did not list any extra fuel, though 892 kg of extra fuel was included in the final fuel amount. This amount was justified in the Voyage Log Report due to 20 minute delays expected in Madrid because of storms and due to the change of the alternate airport. The first alternate airport was Valladolid (LEVD), followed by Zaragoza (LEZG) and Vitoria (LEVT). LEVC was the fourth alternate and deemed the most suitable, with the fuel amount being increased based on the distance to LEVC.

The final arrival fuel listed in the report was 1,120 kg (1,228 kg on touchdown) versus the 1,090 kg calculated for final reserve fuel, meaning that actually the aircraft landed with a fuel amount that was above the final reserve.

2. ANALYSIS

2.1. Analysis of fuel calculation

The flight of the aircraft with registration EI-DYX and call sign RYR 9ZC, which was flying from Stansted to Alicante on 14 May 2010, was dispatched from the Stansted Airport with a fuel load of 8,200 kg, which, rounding, coincided with the amount recommended in the Operational Flight Plan (8,123 kg).

Available to the crew during the dispatch of the flight were the 14:30 Alicante Airport METAR and the 11:00 TAF, both the most recent versions and neither of which indicated any weather conditions of concern.

The fuel calculation was verified to be in accordance with EU OPS 1.255, and the details in Part A of the Operations Manual (see Appendix A) were applied: fixed 150 kg to taxi and 1,100 kg of fuel to the Murcia-San Javier Airport.

The calculation was also verified to have been performed assuming an Estimated Takeoff Weight (ETOW) of 67,172 kg, when in reality, as shown on the load sheet, the final weight was 65,205 kg, that is, 1,967 kg less. As a result, the fuel consumption was lower which, in combination with other favorable factors, resulted in the aircraft arriving at the Alicante Airport with 477 kg of fuel more than expected.

It was observed that the Captain decided not to add any additional fuel to that calculated in the flight plan. This decision was based, at least partially, on the fact that the forecast weather conditions and the information in the NOTAMs consulted did not suggest any difficulties ahead; that is, the Captain believed that there would be no setbacks or delays in the flight to Alicante and that if any did arise, the contingency fuel, 272 kg, equivalent to about seven minutes of flight time, would suffice.

Once the crew requested the second approach to the Alicante Airport (with the fuel close to the minimum diversion level), ATC asked another aircraft to hold over VILNA (with its ensuing fuel consumption) so as to allow the incident aircraft to proceed with the approach first.

Ryanair's fuel policy, as stated in its Operations Manual, is based quite specifically on minimizing the fuel load at the start of the flight. Since fuel consumption rises considerably with any additional weight that is transported, the goal of this policy must therefore be to reduce consumption by reducing the weight of the fuel transported as much as possible. As a result of this economic policy, Ryanair aircraft generally land with the minimum required fuel. This policy, which is in keeping with EU OPS 1.375, gives Ryanair a competitive advantage over other airlines that tend to fly with larger amounts of reserve fuel and that therefore use more fuel.

It is worth noting that market competition is forcing other airlines to reduce their costs by adopting fuel policies similar to Ryanair's. This could make it commonplace for airplanes to arrive at their destinations with the minimum required fuel and without reserves in the event of a delay or, as in this case, to attempt a second approach after being given preferential treatment by ATC at the expense of other traffic yielding its approach priority.

The arrival of several aircraft flying with minimum fuel at the same airport could give rise to several simultaneous emergency declarations for lack of fuel, especially if circumstances force deviating to the alternate airport.

In light of this, aviation authorities should establish expected typical average delay times at various airports that are specific to the circumstances present in each so as to provide guidelines to airlines on the increased fuel reserves needed to fly safely.

2.2. Analysis of first go-around

Before starting the approach, the crew had the ATIS C information for the Alicante Airport from 17:30. A handwritten note in the OFP said: runway in use 28, TL (transition level) 075, wind 130°/11 kt, variable from 080° to 160°, visibility in excess of 10 km, few clouds at 025, scattered at 045, temperature 18°, dew point 05°, QNH 1011, NOSIG (no significant changes expected).

At 13 NM on final, the tower controller reported that the wind was from 170° at 4 kts, that another aircraft had found wind from 300° at 15 kt at 1,300 ft and that the preceding aircraft had reported wind from 320° at 20 kts at 1,000 ft.

The crew noted in its report that it was anticipating a tailwind during the approach and a headwind during the landing. They were also aware of a windshear warning.

The pilot of the aircraft that landed immediately before RYR 9ZC's go-around told the controller at the Alicante tower once on the ground that the wind at 100 or 200 ft was a 20-kt tailwind, and from 250° at 7 kts on landing. He added that the approach was very cumbersome and that braking the airplane was very difficult, so he recommended changing the runway (see Appendix E). This conversation was held in Spanish and thus not understood by the crew of RYR 9ZC.

At a distance of 2.3 NM away, Alicante tower controller cleared the aircraft to land on runway 10, reporting wind speed varying from calm to 7 kt.

The DFDR shows that the indicated airspeed in the last 50 ft. oscillated between 149 kt and 162 kt, with 141 kt being the reference speed calculated by the crew based on the airplane's weight and its flap configuration. In the last 20 seconds, below 180 ft RA,

the speed increased gradually, briefly attaining the maximum of 162 kts (see Figure 4). Faced with this increase in speed, the crew decided to go around when at an altitude of 3 ft above the runway. They were 580 m past the runway threshold and over the normal landing zone at the time.

Based on established stabilized approach criteria (see Section 1.4 and Appendix D), one of the elements to consider is that the speed not exceed $V_{ref} + 20$ when below 1,000 ft, a situation that requires an immediate go-around. In this case, the speed reached 162 kt ($V_{ref} + 21$) and the go-around was started at 158 kt ($V_{ref} + 17$).

2.3. Analysis of second go-around

Instead of proceeding with the standard go-around maneuver, ATC vectored the aircraft to the right toward the west so as to avoid having it reach slower traffic that had taken off shortly before the maneuver. The approach controller offered the aircraft radar vectors to return to runway 10 and, with the pilot's consent, routed the airplane to a point near the base turn to intercept the ILS LOC for runway 10. It was then, at 17:59:38, some four minutes after the go-around, that the crew received new wind information, 320°/15 for runway 10 and 140°/15 for 28, that is, a tailwind at both thresholds.

The crew then decided to attempt the approach on runway 28 instead of 10. First, though, they requested to proceed to MAGAL and hold, informing ATC that they would contact again when ready to commence the approach. The fuel remaining at that time was 2,523 kg, still 264 kg above the minimum fuel required to reach the Valencia Airport with final reserve fuel.

The aircraft had arrived in Alicante with 477 kg of fuel above the alternate fuel required, which gave it 12 minutes of maneuvering time above the airport before proceeding to the first alternate, Valencia, sufficient to attempt a second approach. Between the first and second go-arounds, however, 22 minutes elapsed, which brought the fuel remaining onboard to 327 kg below the minimum diversion fuel quantity required for said alternate.

This delay was due in part to weather conditions and to traffic at Alicante, and in part to the briefing required by the change in approach type from ILS to VOR when changing from runway 10 to 28.

When the aircraft reported to Alicante approach that it was ready for the approach, the controller was busy giving instructions to other traffic. The fuel remaining on the aircraft at that time was the minimum diversion fuel to the alternate (Valencia). When the aircraft was cleared and started, one minute later, the VOR approach maneuver to 28 from MAGAL, its fuel remaining was 2,218 kg, or 41 kg below minimum diversion to Valencia. This decision to make a second approach with fuel just below the minimum

diversion is within the scope of regulation EU OPS 1.375 on in-flight fuel management (see Appendix A) considering prevailing conditions for making a safe landing with at least final reserve fuel.

In conclusion, the captain's decision to attempt a new approach in Alicante was based on the fuel remaining and on the wind information that he was given. Had he had a more accurate picture of the weather situation, he probably would have made a different decision, such as proceeding to the alternate without attempting a new approach.

The wind information received by the crew at 18:10:28 was 090°/6 to 9 kt; at 18:14:50, after being transferred to the Alicante tower frequency, it was 090°/10 kt and at 18:16:34, when cleared to land, 100°/15 kt. The pilot, confused, requested confirmation of the last wind information received and then stated his inability to land with that tailwind and started the second go-around at 18:17:18 with 1,932 kg of fuel remaining, 327 kg below the minimum diversion fuel. He requested an "immediate diversion to Valencia with radar vectors due to fuel."

2.4. Analysis of the weather information given to the crew

The METAR reports published between 14:00 and 19:00 did not reflect the unusual weather conditions present at the airfield in terms of windshear and the constant changes in wind direction and speed. This resulted in five aircraft having to execute go-arounds over this time period (two of them also operated by Ryanair). There was also a report of strong windshear from a departing aircraft, as noted in the Update Log extract shown in Section 1.7.4. This unusual situation is mentioned frequently in the conversations, reproduced in Appendix E, held between the approach controller in Alicante and the tower controller in Alicante during the time they were handling RYR 9ZC.

The ATIS information checked by the crew on approach made reference only to a variable wind direction (from 80° to 160°). No SPECIs or TRENDS reports were issued because of significant changes, as the limits established for such changes were not reached. This way it is avoided to constantly modify the notification to the crew due to sudden changes not prolonged in time. The ATIS records recovered from the East Control Region stated that no significant changes were expected, so reports from aircraft arriving in Alicante warning of changing wind conditions and windshear were not incorporated. These reports could have aided crews to plan their approaches and make any relevant decisions. The information provided prior to an approach should also include any data that can warn crews of significant weather conditions. A safety recommendation is issued in this regard.

The wind information that Alicante approach reported to RYR 9ZC as it was preparing for the approach to runway 28, though exact and correct in reporting a tailwind

component at the threshold of said runway, did not give the crew a clear idea of how strange and unpredictable the wind conditions were. Appendix E shows the conversations held between both controllers in this regard (example, 18:00:20). In contrast, the other crew that had agreed to let RYR9ZC through to make its second approach, and which was communicating in Spanish, received a more detailed explanation of what has happening that was more useful to its decision-making process (example, 18:06:31 and 18:09:42). The captain of RYR 9ZC stated in his report that he was expecting calm winds on 28, a clear sign that he did not understand the situation based on the reports he received.

The fact that English was not used in the communications kept RYR 9ZC from understanding the more explicit and colloquial information that was being given to the other aircraft. That is why it would be convenient that, when aircraft converge at the same airport and whose crews speak different languages, English be used so that all have the same information and all benefit from the information provided to other crews.

2.5. Analysis of alternate airport choice

Per company policy, regardless of how close the alternate airport is, the minimum fuel consumption assumed in the Flight Plan calculation to be needed to reach it is 1,100 kg. In this case the consumption to the Murcia-San Javier Airport was below 1,100 kg, which is why this amount was listed instead of the real one. The Valencia Airport is farther away from Alicante than the one in Murcia (San Javier), 103 NM versus 73 NM; moreover, going to Murcia-San Javier would have involved having a tailwind, not a headwind, and yet the amount of fuel required for both in the flight plan was almost identical. With alternates so close, as are both Murcia-San Javier and Valencia, the difference in consumption may not be much, but in this case it probably would have been sufficient to avoid landing below the final 30-minute reserve. If the crew had known the actual fuel amount needed to reach San Javier, it probably would have considered that alternate as better suited to their circumstances.

The captain stated that they had gone past the Valencia Airport en route and had noted the weather conditions there, finding them suitable. He also referred to the fact that the Murcia-San Javier Airport was a military airport, and he was not sure if it was open. Since he was more familiar with the Valencia Airport and he had weather information available for it, he decided to divert there. The Murcia-San Javier Airport has both military and civil operations, and since it was the second alternate listed in the OFP, the captain should have been familiar with its characteristics beforehand.

The flight to Valencia was direct at FL 80 and 220 kt, parameters far from those recommended by Boeing to maximize range for a given amount of fuel²⁵. The OFP

²⁵ According to the Boeing Flight Planning Performance Manual (FPPM) for short trip cruise chart.

reflects the fuel required for the alternates but makes no reference to the criteria, i.e. the optimum altitude and speed, used in this calculation, meaning the relevant parameters are not directly known to the crew. Had this information been included in the OFP, the crew could have made better decisions in terms of the optimal flight parameters. As a result, a safety recommendation is issued in this regard.

2.6. Analysis of the handling of the emergency

At 18:30:02, 12 minutes after going around for the second time in Alicante, the crew declared an urgency, radioing literally "PAN PAN, PAN PAN, PAN PAN Ryanair 9 Zulu Charlie errr... fuel... requesting, ummm, vectors immediately to land runway one two". The fuel remaining on the aircraft at that time was 1,245 kg. The urgency was declared in keeping with company regulations since the crew was expecting to reach Valencia with less than the final fuel reserve, as had probably been indicated on the Flight Management Computer (FMC) when it was reprogrammed with Valencia as the destination airport. This initial urgency communication was not fully understood by the controller at Valencia approach due to, among other factors, the speed and lack of clarity of the message. The controller then requested confirmation that an emergency was being declared, to which the crew reiterated it was an urgency, not an emergency, enunciating more carefully PAN PAN, PAN PAN, PAN PAN.

At 18:38:15, while turning toward the runway 12 localizer 6 NM away from the ILS, RYR 9ZC radioed "MAYDAY, MAYDAY, MAYDAY fuel emergency now". Its fuel remaining then was 1,040 kg, 99 kg below final reserve fuel.

EU OPS 1.375 (see Section 1.3.4.2) states that:

«The commander shall declare an emergency when calculated usable fuel on landing, at the nearest adequate aerodrome where a safe landing can be performed, is less than final reserve fuel.»

According to this regulation, the Captain should have declared an emergency following the second go-around in Alicante with 1,932 kg of fuel remaining, that is, 327 kg below the minimum diversion fuel to fly to Valencia and land there with at least final reserve fuel. The 2,259 kg figure was handwritten by the crew in the OFP.

This EU OPS is incorporated into Ryanair's own procedures, though the wording is ambiguous, as shown in Appendix C:

- The Commander shall make an urgency call (Pan x3) when he believes he will land with less than Final Reserve Fuel (Ryanair policy).

- The Commander shall declare an emergency when calculated usable fuel on landing is less than Final Reserve Fuel (EU-OPS).
- The Commander shall make a Distress call (Mayday x3) when he is committed to an approach from which he will not have enough fuel to conduct a Missed Approach.

In reality, there is no difference between conditions 1 and 2, and this can give rise to erroneous interpretations of EU OPS 1.375 by Ryanair pilots, who declare an urgency instead of an emergency. It can also create confusion in ATC about the real situation present on the aircraft, as happened in this case. The third item, which specifies when Ryanair pilots must use the MAYDAY message for reasons of low fuel, adds confusion regarding the use of MAYDAY, which seems reserved for a situation so unlikely and extreme as not having enough fuel for a go around. Given the ambiguity between the terms for urgency (PAN PAN), emergency and distress (MAYDAY), a safety recommendation is issued in this regard, as detailed later in this report.

In this case, the crew's urgency declaration through the use of the PAN PAN code was not understood by approach and tower controllers at Valencia, who even joked about whether he had said PAN PAN or TAM TAM, and who admitted not knowing what to do next.

A check of the ATC recordings shows that the pilots of RYR 9ZC spoke English fluently, since both were British, but it was difficult for controllers (whose native language was different) to understand. An analysis of the recordings reveals a high number of repeated transmissions and also more lack of precision than desired in the transcription of these recordings.

When the minimum English language skill requirements were established for pilots and controllers, a minimum level (4 out of 6), called an operational level, was defined as sufficient for ensuring communications in any airspace. Language skills involve not only knowledge of the English language, but the use of standard phraseology and a proper speaking speed and enunciation so as to avoid the dangers associated with possible misunderstandings between pilot and controller and to speed up communications.

In this regard, item 5.3.1.6 of Annex 10 to the ICAO Convention (see Appendix F) is relevant:

5.3.1.6. In cases of distress and urgency communications, in general, the transmissions by radiotelephony shall be made slowly and distinctly, each word being clearly pronounced to facilitate transcription.

The foregoing shows the need to issue a safety recommendation aimed at avoiding misunderstandings and erroneous interpretations in the communications between crews whose level of English is native and others involved in the aviation community

who possess the operational level required but whose native language is not English.

The EU OPS regulations make no mention of the words MAYDAY or PAN, nor is the concept of “urgency” considered. Therefore, declaring an emergency does not involve their use. The ICAO addresses urgency and emergency messages in Annex 2 (Rules of the Air) and 10 (Aeronautical Telecommunications), but not in Annex 6 (Aircraft Operations), which is transposed in the EU OPS, though only in EU OPS 1.375 in relation to fuel. Addressing these discrepancies would allow for defining common operating procedures in the event of an emergency and improving the understanding between pilot and controller in these situations. A safety recommendation is issued in this regard.

The ICAO reported that it had amended Annex 6 (valid as of 15 November 2012) that included a new item concerning in-flight fuel management (4.3.7) and that referenced the situation in which an aircraft has minimum/critical fuel and the actions to take involving ATC (see Appendix H). While this change is regarded as advancing the cause of standardizing this phraseology, it is not sufficient to address the ambiguity of the urgency (PAN PAN), emergency and MAYDAY terms in Annex 6 so that they can then be reflected in the EU OPS regulations, and thus in the Operations Manuals of companies. Section 4.3.7 also establishes the requirement to provide more precise and complete information to aircraft in a low fuel situation that has reported MINIMUM FUEL, but before reaching the extreme of declaring an emergency. Although Section 4.3.7 specifies that under no circumstances shall an aircraft be given priority over other aircraft, the crew of the aircraft would have much more information than other crews regarding expected delays and the situation of other aircraft. In addition, ATC personnel faced with a pre-emergency situation, would obviously have to make decisions that would unintentionally give priority to an aircraft reporting MINIMUM FUEL (as per Section 4.3.7.2.2). This modification, while far from resolving individual cases, could result in the appearance of more situations more often than desired, promoting, as noted in the first point in this analysis, the widespread use of crews “optimizing” their fuel calculations so as to reach their destinations with the minimum required fuel. The concurrence of several aircraft in this same situation could lead to simultaneous emergency declarations (as per 4.3.7.2.3) due to low fuel, with the ensuing risk to safety. As a result of this potential, a safety recommendation is issued in this regard to the ICAO.

Considering the information in Section 1.7.5, Eurocontrol acknowledges that most of its controllers have not experienced a serious emergency, and that this lack of experience makes it likely that when faced with a real emergency, deficient performance could result. This document recommends promoting in different forums the use of transponder code 7700 and the proper use of the MAYDAY and PAN codes, as well as the use of checklists by controllers to better handle these emergency situations. AENA reported that it had written a procedure for handling urgency and emergency situations along the lines of Eurocontrol’s recommendations, as a result of which no safety recommendation is issued in this regard.

2.7. Analysis of the incidents that occurred in July 2012

Before this report was approved, there were a series of missed approaches at Madrid Barajas due to storms and subsequent diversions to the Valencia Airport. During these diversions (seventeen in all), four emergency declarations were made due to fuel. Of these four emergency declarations, three involved the airline Ryanair. Following the initial evaluation, it was concluded that the fuel calculated by each of the Ryanair aircraft was the minimum required by law, and that all of the crews had added extra fuel, justifying this in the flight plan due to adverse weather or to weather-related delays. In fact two of the three Ryanair aircraft landed with a fuel amount in excess of final reserve despite having declared an emergency as per their Operations Manual, since they expected to land with an amount of fuel that was below final reserve.

According to TACC Valencia's report involving ATM safety events and incidents, four aircraft diverted to LEAL reported being low on fuel without declaring an emergency.

The incidents that occurred in July 2012 are thus regarded to be similar to those considered in this report. Since the recommendations in this report had not yet been published and therefore evaluated or implemented by the affected parties, it was concluded that an individual investigation into these cases would not lead to the formulation of different conclusions or recommendations than those noted in this report, though the presentation of said cases would further strengthen the arguments on which some of the recommendations issued herein are based.

3. CONCLUSIONS

3.1. Findings

After presenting and analyzing the information gathered on the incident, the following conclusions may be drawn:

- The crew had valid and in force licenses and medical certificates.
- The aircraft was dispatched from the airport of origin with a fuel load that, rounded up, complied with the minimum fuel required calculated in the OFP.
- After consulting the updated weather and NOTAM information, which indicated no delays or any problems of significance to operations, the captain decided not to take on any extra fuel.
- The weather information published, METARs and ATIS, both available at the time of dispatch and that received by the crew once airborne, did not reflect the reality of the frequent changes in wind direction and speed that were occurring at the LEAL airport.
- The crew was informed of the presence of tailwind gusts by the control tower at Alicante Airport when it contacted the tower; specifically, it was informed that preceding traffic had encountered wind from 320° at 20 kt.
- The first approach was made in tailwind conditions, just as the crew had anticipated.
- The indicated airspeed increased gradually in the last 180 ft, temporarily reaching a maximum of 162 kt ($V_{ref} + 21$).
- The crew decided to go around when at an altitude of 3 ft above the runway and approximately 580 m past the runway threshold, when over the normal landing zone.
- Strict adherence to stabilized approach criteria requires a go-around when any of the elements in question exceeds limits, particularly $V_{ref} + 20$.
- The lack of accurate wind information made the crew consider landing on the other runway (28) instead of proceeding to the alternate.
- The crew had to prepare for the new approach, which required additional time before they reported being "ready" to Alicante approach.
- The weather information provided by Alicante approach to the aircraft while preparing for the approach to runway 28 did not reflect the changing wind conditions.
- When cleared for the second approach, the amount of fuel in the aircraft was 41 kg below the fuel required to divert to Valencia and arrive with final reserve fuel (alternate fuel quantity).
- EU OPS 1.375 considers the captain's decision to make a second approach with less than minimum alternate fuel in light of the circumstances at the moment so as to make a safe landing.
- The wind conditions changed once more during the hold and approach to runway 28, and at the time the clearance was given were 100°/15 kt (15-kt tailwind for 28).

- The crew decided to go around a second time and divert to the first alternate, the Valencia Airport.
- The first alternate (Valencia) was further away than the second (Murcia-San Javier) (103 NM versus 73 NM).
- The fuel specified in the OFP for the two alternate airports (Valencia and San Javier) was almost identical due to the company's fuel policy.
- The characteristics of Ryanair's Operational Flight Plan (OFP) were such that the crew did not know that reaching the second alternate, San Javier, required less fuel and time than reaching the first, Valencia.
- Said flight plan does not specify the optimum flight parameters used to calculate the fuel needed to reach the alternates.
- The crew encountered a headwind en route to the first alternate (LEVC), but would have had a tailwind to the second (LELC).
- The crew proceeded to the Valencia Airport at an altitude and speed that were far from optimal in terms of reaching the alternate with the most fuel remaining.
- The crew declared an urgency (PAN-PAN) after detecting that it would reach the destination airport with less than minimum reserve fuel, 12 minutes after the second go around at LEAL.
- By the time the diversion to the alternate was started, the amount of fuel had dropped to 327 kg below the minimum required, meaning that, according to EU OPS 1.375, the crew should have declared an emergency at that point. Ryanair regulations instruct their crews to declare urgency (PAN PAN) when, according to EU OPS 1.375, they should declare an emergency.
- The aircraft's crew spoke in quick and poorly enunciated English in its communications instead of using an English that was understandable by all involved, resulting in frequent repetitions and exchanges that were hard for control personnel to understand.
- The declaration of urgency was not understood by control (Valencia approach) at first, but the crew clarified its meaning by enunciating the message better.
- Valencia approach did not understand the use of the urgency declaration and did not know how to proceed in such a case.
- The crew declared an emergency (MAYDAY) when the fuel amount fell below minimum reserve fuel.
- Ryanair's transposition of EU OPS 1.375 b3 on the requirement to declare a fuel emergency to the company's own regulations is confusing and specifies the use of urgency when the proper course of action is to declare an emergency.
- EU OPS does not consider the use of the MAYDAY or PAN-PAN phraseology.
- ICAO Annex 6, Aircraft Operations, does not consider the use of the MAYDAY or PAN-PAN phraseology for emergencies and urgencies.
- A modification to Annex 6 (Amendment 36) has been issued, in effect since November 2012, that refers to the declaration of a Minimum Fuel situation for reporting to ATC.
- The aircraft landed in Valencia with 956 kg of fuel, 183 kg below the minimum reserve fuel required.

3.2. Causes

The incident was caused by the crew's inadequate decision-making process in opting to make a second approach, in the choice of alternate airport and in the flight parameters used en route to that airport, which resulted in the fuel amount dropping below the required minimum reserve fuel and in the crew declaring an emergency (MAYDAY).

The company's fuel savings policy, though it complies with the minimum legal requirements, tends to minimize the amount of fuel with which its airplanes operate and leaves none for contingencies below the legal minimums. This contributed to the amount of fuel used being improperly planned and to the amount of fuel onboard dropping below the required final fuel reserve.

Another contributing factor was the wind information provided by ATC to the crew when preparing the approach to runway 28. This information, though accurate, did not give the crew a clear picture of the changing wind conditions, which would have facilitated their making more suitable decisions.

4. SAFETY RECOMMENDATIONS

This incident took place primarily due to the inadequate decisions made by the crew due, in part, to the prevailing conditions at the destination airport and to their lack of knowledge regarding their progression. For this reason, concerning the ATIS information issued, it is considered necessary that the significant variations resulting from sudden and relevant changes which do not generate a specific issue of a SPECI or TREND be incorporated to ATIS, in order to facilitate the crew their preparation of the corresponding approaches.

REC 18/13. It is recommended that AENA Air Navigation establish the necessary measures and procedures to facilitate the crews, by means of ATIS, the relevant and significant information that may be associated to sudden changes reported by aircraft, or those not important enough to have originated an SPECI O TREND, this way helping them to prepare their approaches and to take their decisions in the most appropriate way.

The choice of alternate airport and of which flight parameters to use were made without knowledge of the factors used to calculate the fuel shown on the OFP. This resulted in selecting parameters far from optimal and therefore in the wrong decisions being made.

REC 19/13. It is recommended that RYANAIR modify its Operational Flight Plan to show the real time and fuel data calculated for any alternate, regardless of its proximity, and the optimum parameters used in said calculations, so that these data may be referenced by its crews.

The terminology and situations considered in the RYANAIR Operations Manual for determining the possible cases of urgency-emergency are ambiguous and combine definitions from Annex 10 with its own (urgency (PAN-PAN)-emergency-distress (MAYDAY)).

REC 20/13. It is recommended that RYANAIR revise its Operations Manual to clarify the situations in which to declare urgency and emergency.

The native English used by the crew when declaring an emergency was difficult for controllers to understand due to unclear and hurried nature of the declaration. This resulted in frequent repetitions of messages and confusion among control personnel, which risked having said personnel misunderstand the needs of the crew.

REC 21/13. It is recommended that RYANAIR introduce as part of its practices and procedures that, at least when operating outside domestic airspace, and especially in emergency situations, its crews speak English adapted to the so-called "operational level", using standard phraseology as much as

possible and speaking slowly and clearly enough so that they may be easily understood by all of the parties involved.

On the other hand a lack of definition was detected in the ICAO reference regulations and a failure to incorporate the various emergency situations into the EU OPS regulations, resulting in a lack of uniformity and standardization of common criteria for airlines.

REC 22/13. It is recommended that the ICAO clarify and standardize the use of the PAN PAN and MAYDAY terminology in urgency and emergency declarations in Annex 2 (Rules of the Air), Annex 6 (Aircraft Operations) and Annex 10 (Aeronautical Telecommunications) so that the entire aviation community can use common criteria.

The ICAO reported that Annex 6 has been modified by means of Amendment 36, which includes a new item concerning in-flight fuel management (4.3.7). This item is not consistent with the emergency situations described in Annexes 10 and 2, and its improper use could lead to incorrect use by crews in an effort to obtain more detailed information from ATC.

REC 23/13. It is recommended that the ICAO reconsider the text in Section 4.3.7 of Annex 6 resulting from Amendment 36 in terms of both adapting the fuel-related emergency declarations to the generic emergency declarations listed in Annex 2 (Rules of the air) and Annex 10 (aeronautical Telecommunications), and of avoiding having the improper use of the "Minimum Fuel" status become a routine declaration in an effort to obtain better information or preferential treatment from ATC.

APPENDICES

APPENDIX A

Fuel information

Section 1.8.7 of Part A of the Operations Manual, on determining the amount of fuel, reads as follows:

«Every flight must be planned to ensure that every flight carries sufficient fuel for the planned operation and reserves to cover deviations from the planned operation.

The operating conditions under which the flight is to be conducted include:

- Fuel consumption data provided by the aircraft manufacturer.
- Standard masses.
- Expected met conditions.
- Air Navigation Services Provider(s) procedures and restrictions.

8.1.7.2. Flight Plan Fuel

The minimum fuel required for departure from any airport shall comply with EU-OPS 1.255, is called the "Flight Plan Fuel" and must include:

The minimum amount of fuel required to depart from any airport, referred to as "Flight Plan Fuel," must comply with EU OPS 1.255 and must include:

Flight Plan Fuel		
TAXI (TAXI/APU)		Average taxi fuel, equivalent to 150 kg (12 minutes) for the B-737-800 series
TRIP		Fuel for the trip, needed to reach the destination
RESERVE	CONTINGENCY ³²	No less than 5% of the trip fuel
	FINAL RESERVE (RESV/HOLD)	Final reserve fuel: to fly for 30 additional minutes in turbine engines at holding speed at 1,500 ft
ALTERNATE (IDENT. ALT)		To reach the alternate destination passing through the planned destination
FPL FUEL		Sum of all the above
EXTRA	TANK	As needed in addition to that specified above. Optional depending on operator's policy or by captain's decision for operational reasons
	EXTRA	
BLOCK FUEL		Sum of FPL and EXTRA
FINAL FUEL		Total sum

²⁶ OPS 1.192 Terminology: Contingency Fuel: The fuel required to compensate for unforeseen factors which could have an influence on the fuel consumption to the destination aerodrome such as deviations of an individual aeroplane from the expected fuel consumption data, deviations from forecast meteorological conditions and deviations from planned routings and/or cruising levels/altitudes.

As an exception, the company specifies that the calculated fuel to the destination shall never be below 2,000 kg, which may occur when nearby alternates are used. Achieving this minimum of 2,000 kg requires that the fuel to the alternate be at least 1,100 kg, even if the actual consumption is lower.

The fuel savings policy, as noted in Part A of its Operations Manual, emphasizes minimizing the fuel load when the flight is dispatched, in addition to the use of general fuel efficiency techniques recommended by Boeing and in transporting fuel when suggested by price differences at airports. Additionally, the policy notes that fuel consumption must be optimized through proper management, including in one of its points the use of the closest alternate due to weather conditions.

Ryanair asks its captains to load the fuel indicated by the computerized flight plan and allows the captain, at his discretion and for operational reasons, to increase this amount by 300 kg without providing any justification. Any fuel loaded in excess of 300 kg must be explained in the "Voyage Report."

EU OPS 1.375, In-Flight Fuel Management, specifies the following:

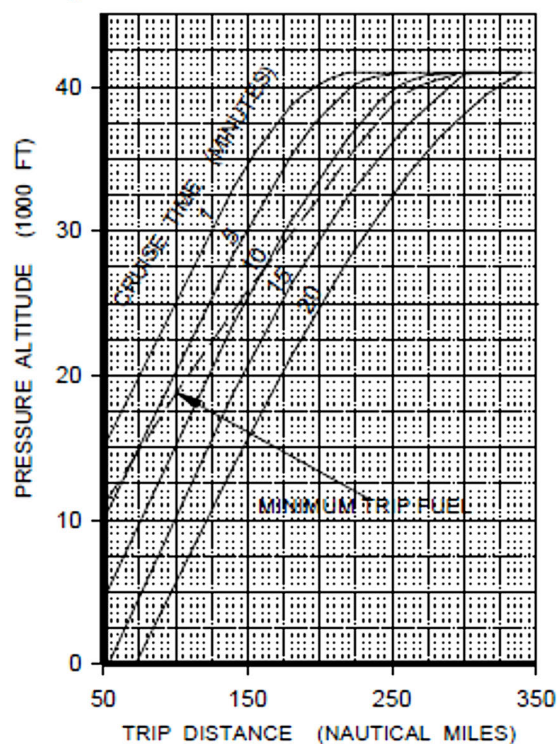
«however, if, as a result of an in-flight fuel check, the expected usable fuel remaining on arrival at the destination aerodrome is less than the required alternate fuel plus final reserve fuel, the commander must take into account the traffic and the operational conditions prevailing at the destination aerodrome, at the destination alternate aerodrome and at any other adequate aerodrome, in deciding whether to proceed to the destination aerodrome or to divert so as to perform a safe landing with not less than final reserve fuel,

[...]

The commander shall declare an emergency when calculated usable fuel on landing, at the nearest adequate aerodrome where a safe landing can be performed, is less than final reserve fuel.»

Boeing's Flight Planning and Performance Manual (FPPM) includes a graph for short distances that can be used to calculate fuel consumption for short-distance flights as a function of various parameters such as weight, altitude, wind and temperature. The graph also outputs the optimal, or lowest consumption, level (see figure). For a distance of 103 NM, the minimum fuel curve corresponds to an altitude of 18,000 ft.

Short Trip Cruise Altitude

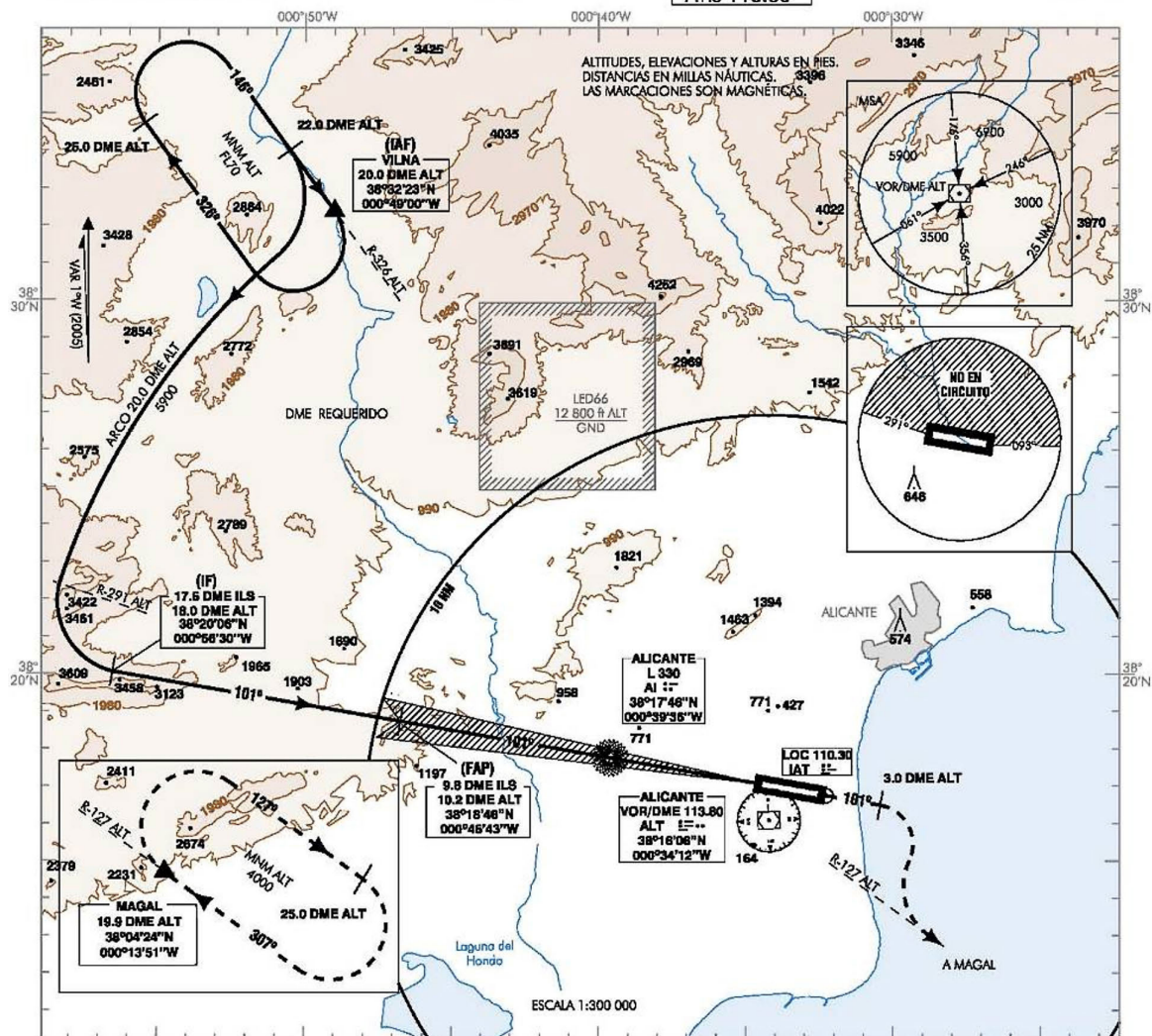


Altitude Adjustments

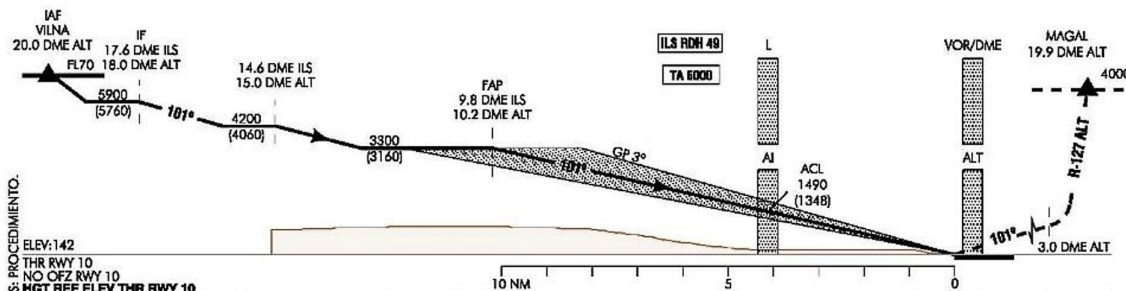
PARAMETER	ADJUSTMENT
WEIGHT	-220 FT/500 KG ABOVE 45000 KG
TEMPERATURE	-1300 FT/10°C ABOVE STD +700 FT/10°C BELOW STD
WIND	HEAD: -200 FT/10 KTS TAIL: -1500 FT/10 KTS
AIRPORT ELEVATION	ORIG: +100 FT/1000 FT ELEVATION DEST: +200 FT/1000 FT ELEVATION

APPENDIX B

LEAL approach plates used

CARTA DE APROXIMACIÓN
POR INSTRUMENTOS-OACIELEV AD
142APP 120.40
TWR 118.15
GMC 121.70
ATIS 113.80ALICANTE
ILS Z
RWY 10

FRUSTRADA: SUBIR EN RUMBO MAGNÉTICO 101° HASTA 3.0 DME ALT, VIRAR A LA DERECHA PARA INTERCEPTAR Y SEGUIR R-127 ALT DIRECTO A MAGAL SUBIENDO A 4000 FT PARA INTEGRARSE EN LA ESPERA.



CAMBIOS: PROCEDIMIENTO.

OCA/H	A	B	C	D
CAT I	356 (214)	366 (224)	376 (234)	386 (244)
STA				
En circuito (H) sobre 142	960 (820)	1090 (950)	1240 (1100)	1370 (1230)

WEF 30-JUL-09 (AIRAC AMDT 08/09)

GS	kt	80	100	120	140	160	180
FAP-THR: 9.8 NM	mins	7:19	5:51	4:53	4:11	3:40	3:15
FAP-MAPT:	mins						
ROD: 5.2 %	ft/min	425	531	637	743	849	955
ALT/HGT DME () FNA							
13 DME	12 DME	11 DME	10 DME	9 DME	8 DME	7 DME	6 DME
5 DME	4 DME	3 DME	2 DME	1 DME			

AIP-ESPAÑA

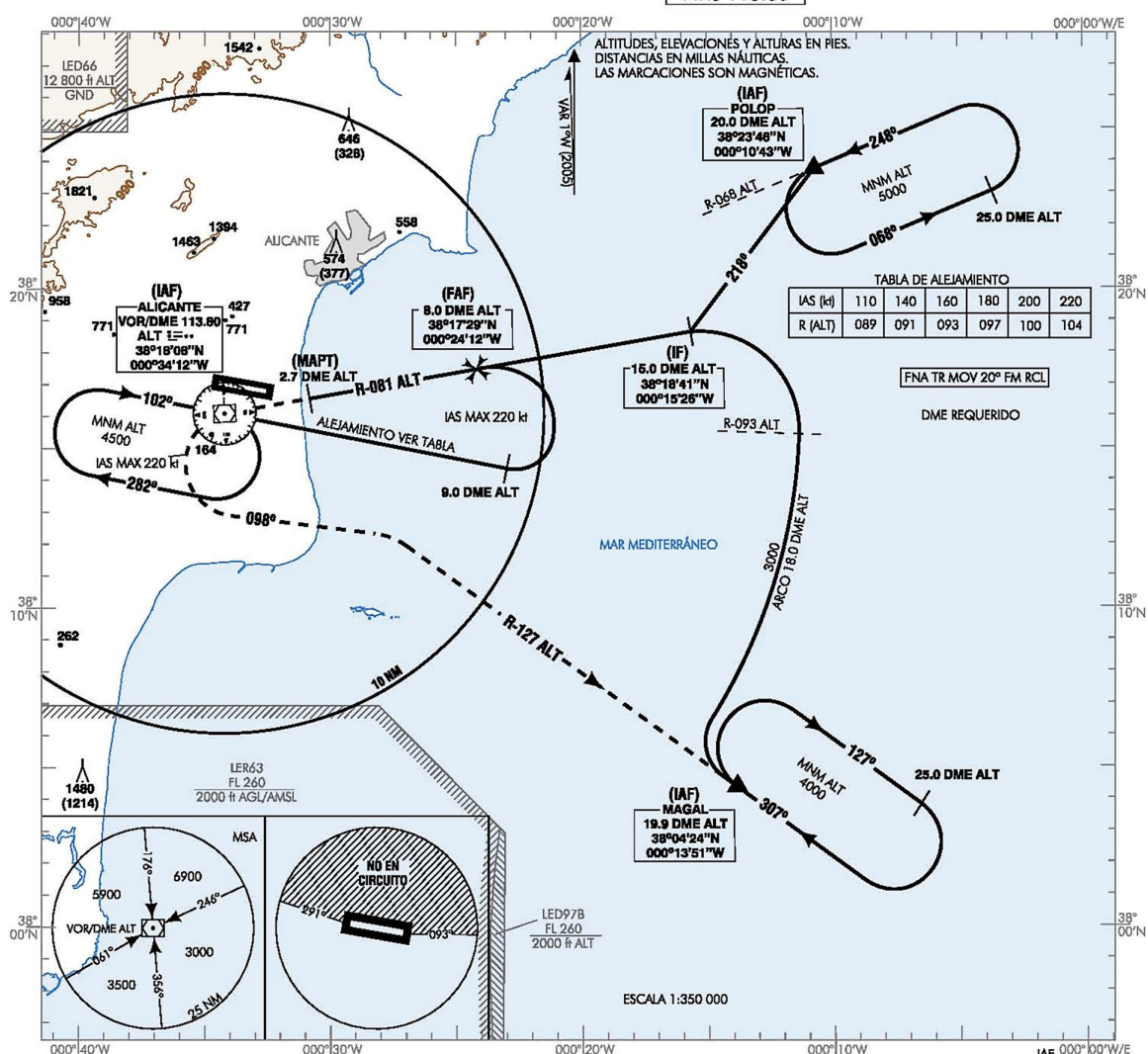
AD 2-LEAL IAC/1

CARTA DE APROXIMACIÓN POR INSTRUMENTOS-OACI

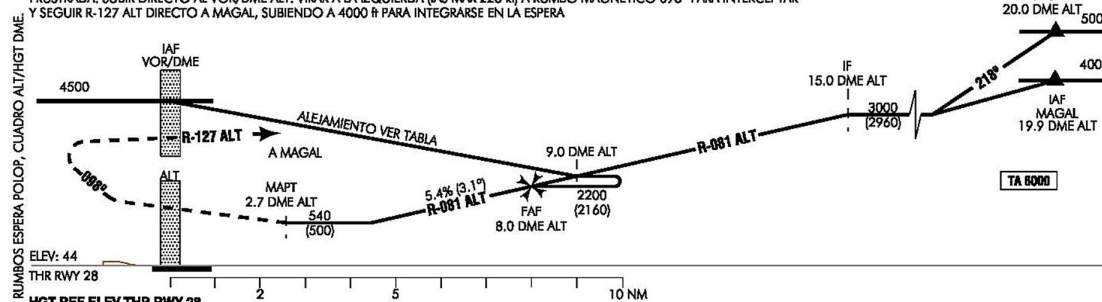
ELEV AD
142

APP	120.40
TWR	118.15
GMC	121.70
ATIS	113.80

ALICANTE
VOR Z
RWY 28



FRUSTRADA: SUBIR DIRECTO AL VOR/DME ALT. VIRAR A LA IZQUIERDA (IAS MAX 220 kt) A RUMBO MAGNÉTICO 098° PARA INTERCEPTAR Y SEGUIR R-127 ALT DIRECTO A MAGAL, SUBIENDO A 4000 ft PARA INTEGRARSE EN LA ESPERA



OCA/H		A	B	C	D
STA	2.5%	540 (500)			
En circuito (H) sobre 142		960 (820)	1090 (950)	1240 (1100)	1370 (1230)

GS		kt	80	100	120	140	160	180				
FAF-THR:		mins										
FAF-MAPT: 5.3 NM		mins	3:59	3:11	2:39	2:16	1:59	1:46				
ROD: 5.4 %		ft/min	439	549	658	768	878	988				
ALT/HGT DME (ALT) FNA												
13 DME	12 DME	11 DME	10 DME	9 DME	8 DME	7 DME	6 DME	5 DME	4 DME	3 DME	2 DME	1 DME
						1880 (1840)	1550 (1510)	1220 (1180)	890 (850)	560 (520)		

08-APR-10 (AMDT 195/10)

AIP-ESPAÑA

AD 2-LEAL IAC/7

APPENDIX C

Use of autothrottle

Information contained in the Boeing Flight Crew Training Manual on the use of A/T

(Reference FCT 737NG (TM) October 31, 2005, pg. 1.35)

"Autothrottle use is recommended during takeoff and climb in either automatic or manual flight. During all other phases of flight, autothrottle use is recommended only when the autopilot is engaged"

Landing:

When using autothrottle, position command to VREF + 5 kt. Sufficient wind protection is available with the autothrottle engaged because the autothrottle is designed to adjust rapidly when the airspeed drops below command speed while reducing thrust slowly when the airspeed exceeds command speed. In turbulence the result is that average thrust is higher than necessary to maintain command speed. This results in average speed exceeding the command speed.



737 NG Flight Crew Training Manual

Command Speed

Command speed may be set by the pilot through the MCP or FMC and is displayed by a magenta airspeed cursor on the airspeed indicator or by a magenta speed bug on the PFD airspeed display.

Takeoff

Command speed remains set at V_2 until changed by the pilot for acceleration and flap retraction. Manually select flaps up maneuver speed at flap retraction altitude.

Climb, Cruise and Descent

Command speed is set to the appropriate speed by the FMC during VNAV operation or manually using the MCP. The white airspeed bugs (if installed) are positioned to the appropriate airspeeds for approach and landing.

Approach

Command speed is set to the maneuvering speed for the selected flap position by the FMC during VNAV operation or manually using the MCP.

Landing

When using the autothrottle, position command speed to $V_{REF} + 5$ knots. Sufficient wind and gust protection is available with the autothrottle engaged because the autothrottle is designed to adjust thrust rapidly when the airspeed drops below command speed while reducing thrust slowly when the airspeed exceeds command speed. In turbulence, the result is that average thrust is higher than necessary to maintain command speed. This results in an average speed exceeding command speed.

If the autothrottle is disengaged, or is planned to be disengaged prior to landing, the recommended method for approach speed correction is to add one half of the reported steady headwind component plus the full gust increment above the steady wind to the reference speed. One half of the reported steady headwind component can be estimated by using 50% for a direct headwind, 35% for a 45° crosswind, zero for a direct crosswind and interpolation in between.

When making adjustments for wind additives, the maximum command speed should not exceed $V_{REF} + 20$ knots or landing flap placard speed minus 5 knots, whichever is lower. This technique provides sufficient low speed maneuver margin and reduces the possibility of flap load relief activation. Margin to load relief activation may also be increased by using a reduced landing flap setting. The following table shows examples of wind additives with a runway heading of 360° .

APPENDIX D

Stabilized approach criteria

The B-737 Flight Crew Training Manual (FCTM), and based on the criteria set out by the Flight Safety Foundation, specifies the following:

Stabilized Approach Recommendations

Maintaining a stable speed, descent rate, and vertical/lateral flight path in landing configuration is commonly referred to as the stabilized approach concept.

Any significant deviation from planned flight path, airspeed, or descent rate should be announced. The decision to execute a go-around is no indication of poor performance.

Note: Do not attempt to land from an unstable approach.

Any significant deviation from the flight path, airspeed or descent rate should be reported. The decision to go around is not indicative of bad performance.

Note: Do not attempt to land from an unstabilized approach condition.

Recommended Elements of a Stabilized Approach

The following recommendations are consistent with criteria developed by the Flight Safety Foundation.

All approaches should be stabilized by 1,000 ft AFE²⁷ in instrument meteorological conditions (IMC) and by 500 ft AFE in visual meteorological conditions (VMC). An approach is considered stabilized when all of the following criteria are met:

- The airplane is on the correct flight path.
- Only small changes in heading and pitch are required to maintain the correct flight path.
- **The airplane speed is not more than VREF + 20 kt indicated airspeed and not less than VREF.**
- The airplane is in the correct landing configuration.
- Sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted.
- Thrust setting is appropriate for the airplane configuration.
- All briefings and checklists have been conducted.

Specific types of approaches are stabilized if they also fulfill the following:

²⁷ Above Field Elevation.

- ILS and GLS approaches should be flown within one dot of the glide slope and
- Localizer, or within the expanded localizer scale during a circling approach, wings should be level on final when the airplane reaches 300 ft AFE.
- Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

Note: An approach that becomes unstabilized below 1,000 ft AFE in IMC or below 500 ft AFE in VMC requires an immediate go-around.

These conditions should be maintained throughout the rest of the approach for it to be considered a stabilized approach. If the above criteria cannot be established and maintained at and below 500 ft AFE, initiate a go-around.

At 100 ft HAT for all visual approaches, the airplane should be positioned so the flight deck is within, and tracking to remain within, the lateral confines of the runway edges extended.

As the airplane crosses the runway threshold it should be:

- Stabilized on target airspeed to within + 10 kt until arresting descent rate at flare.
- On a stabilized flight path using normal maneuvering.
- Positioned to make a normal landing in the touchdown zone (the first 3,000 ft or first third of the runway, whichever is less).

Initiate a go-around if the above criteria cannot be maintained.

Ryanair's criterion in terms of excess speed regards an approach as being unstable if the speed exceeds V_{ref} by 20 kt or is below V_{ref} .

A Ryanair entry in the Flight Crew Operations Manual (FCOM) states that:

The Landing Threshold ("Landing Gates")

The aircraft shall be stabilized by the Landing Gate.

The Landing checklist shall be completed to the "Landing lights".

If not, a go-around is **mandatory**.

The "Landing Gates" is defined in VMC as 500 ft AAL and in IMC as 1,000 ft AAL.

APPENDIX E

ATC communications

Communications between the aircraft and various ATC facilities

ALC APP (Alicante approach)
 ALC TWR (Alicante tower)
 VLC APP (Valencia approach)
 VLC TWR (Valencia tower)

- 17:45:12** ALC APP clears RYR9ZC to descend to 6,000 with QNH 1,011 and after VILNA to follow the 20 NM arc. Shortly thereafter ALC APP clears it to ILS 10.
- 17:51:05** ALC APP transfers RYR9ZC to ALT TWR frequency of 118.15.
- 17:51:12** Aircraft establishes contact with ALC TWR. Six seconds later tower informs aircraft to continue approach and that it is number two in the approach sequence, wind from 170° at 4 kt, and that other traffic has encountered wind from 300° at 15 kt at 1,300 ft. and the preceding traffic has encountered wind from 320° at 20 kt at 1,000 ft. At about 17:53, the aircraft that just landed reports to control for its information that 100-200 ft. before the threshold it encountered a 20-kt tailwind and on touchdown from 250° at 7 kt. The crew notes that the approach was cumbersome and that breaking the airplane was difficult.
- 17:54:21** ALC TWR clears RYR9ZC to land on runway 10. Wind calm gusting up to 7 kt.
- 17:55:40** ALC TWR tells RYR9ZC *"on visual contact turn right and proceed to MAGAL²⁸, there is a slow traffic in front of you"*.
- 17:56:50** ALC APP offers RYR9ZC vectors to the runway 10 localizer. RYR9ZC accepts.
- 17:57:10** ALC APP asks RYR9ZC to set course 270°.
- 17:57:21** ALC TWR informs (in Spanish) ALC APP *"right now I have 300°/15 kt on runway 10"*.
- 17:57:34** ALC APP asks RYR9ZC if it wants vectors to 6 NM on final of runway 10 at 2,500 ft.
- 17:58:06** RYR9ZC replies to ALC APP that it prefers standard vectors for the ILS procedure
- 17:58:11** ALC APP asks RYR9ZC confirmation of whether it wants vectors to mile 15 or to mile 6 and 2,500 ft. RYR9ZC replies 2,500 ft.
- 17:58:33** ALC APP asks RYR9ZC about the reason for the go-around, RYR9ZC replies gusting wind. The controller then asks if it had encountered windshear, and RYR9ZC replies *"...20, windshear, 15 kt"*.
- 17:58:57** ALC APP informs RYR9ZC of a tailwind at both thresholds, 230/15 on 10 and 140/15 on 28. RYR9ZC requests confirmation of more than 10-kt tailwind at both thresholds. The controller repeats wind information and confirms tailwind at both thresholds.

²⁸ MAGAL: On-request reporting point on a basic RNAV route at coordinates 380424N 0001351W.

- 17:59:38** RYR9ZC requests approach on 28 if possible, but first requests to go to MAGAL and hold. ALT APP clears it direct to MAGAL and to climb to 6,000 ft.
- 18:00:20** ALC APP reports RYR9ZC's intentions to ALC TWR, which requests (in Spanish) to ALC APP to inform the aircraft of the wind: *"020/13, which is rather from the north."* ALC APP notes: *"It looks like it's changing a lot, I have 330°, 10, 16 kt"*. TWR ALC in turn notes *"it's constant, this is exasperating, right now we have 020/10 gusting to 14 for 10 and for 28 the wind is practically the same as 10"*.
- 18:00:48** RYR9ZC call ALC APP to ask about surface winds on runway 28. The controller replies *"Roger, fly to MAGAL initially"*. RYR9ZC acknowledges and repeats question about the wind. Controller finally replies *"now is 190/10"*.
- 18:01:08** ALC APP controller asks ALC TWR (in Spanish) *"What wind do you have for 28? Ryanair is asking"*. ALC TWR replies *"for 28 right now I have 140/1 gusting to 8"*.
- 18:01:24** ALC APP calls RYR9ZC to inform that the wind reported by TWR is 140/1 gusting to 10.
- 18:01:40** ALC APP asks ALC TWR about the delay in landing on 28. ALC TWR replies it has no departures, it could enter on the right.
- 18:01:59** ALC APP informs RYR9ZC that it has room at the moment to make the approach on 28 if it wants. RYR9ZC replies that when it arrives at MAGAL it would call for the approach on 28.
- 18:03:03** ALC TWR informs ALC APP of wind: 300/7 for 10 and 120/6 for 28.
- 18:06:17** Another aircraft calls ALC APP and is cleared to 6,000 ft with QNH 1,011.
- 18:06:31** ALC APP tells (in Spanish) ALC TWR: *"I'm going to tell [the other traffic] what there is and let's see what he says, because now I'm seeing 320 here between 14 and 20 kt. Is that possible?"*.
- 18:06:36** RYR9ZC calls ALC APP and says *"RYR9ZC ready for approach"*.
- 18:06:40** ALC APP continues talking (in Spanish) to ALC TWR: *"OK, well I'll tell and he's going to ask for the other one for sure"*. ALC TWR replies: *"That's for sure"*.
- 18:06:42** RYR9ZC call ALC APP once more: *"Over MAGAL ready for approach"*. ALC APP replies *"Stand by sir"*.
- 18:06:52** ALC APP calls another aircraft and informs (in Spanish): *"The wind in Alicante is highly variable, the storm must be over the field. Right now we have wind from 320 between 14 and 20 kt at the threshold of 10. Several airplanes have gone around and right now at the 28 threshold it's from 090 between 6 and 10 kt"*.
- 18:07:24** The traffic replies (in Spanish) to ALC APP: *"We'll go to 10 and let you know..."* ALC APP replies *"as you prefer, as I said a couple of airplanes just went around. We were using 10, but the wind is shifting constantly and we've changed runways five or six times"*. The aircraft then asks about the cloud ceiling and the possibility of landing with a tailwind on 28.

- 18:07:46** RYR9ZC calls ALC APP saying *"request approach"*. ALC APP replies *"for how long could you hold over MAGAL?"*, to which RYR9ZC replies *"we need, we need the approach now or we have to divert"*.
- 18:08:06** ALC APP calls (in Spanish) another aircraft to ask: *"If you don't mind doing a couple of turns at VILNA²⁹ so that another aircraft that just went around can come in, if not he'll have to divert. let me know"*. The aircraft replies: *"OK, we'll hold at VILNA"*.
- 18:08:20** ALC APP clears RYR9ZC for runway 28 approach and shortly thereafter confirms VOR X procedure, QNH 1011 and that it is also clear to enter the visual circuit, if it wants.
- 18:09:24** RYR9ZC asks ALC APP for wind information for 28 threshold. ALC APP replies: *"I'm telling you that if you want circuit you are cleared for the circuit, any service you want... we can... avoid delay for the traffic behind you"*. RYR9ZC replies *"Roger"*.
- 18:09:42** ALC APP calls the other aircraft to inform that it can hold at level 90, 100 or 110. The other aircraft replies (in Spanish) *"if you want we'll go to 28, whatever is best for you"*, and ALC APP replies: *"Well, it depends a lot on the wind, sir, as I say, it's changing, it's rotating, there's an aircraft that's going to try on 28 after going around on 10 and now 10 looks pretty bad. In fact, we have 320 between 12 and 20 kt. I can't tell you why, as I said, the wind's been swirling all day"*.
- 18:10:25** RYR9ZC calls ALC APP to ask about the wind on 28. ALC APP replies: *"Yes the wind 090 between 6 and 9 kt"*.
- 18:14:27** ALC APP transfers RYR9ZC to ALC TWR frequency 118.15.
- 18:14:50** ALC TWR informs RYR9ZC that wind is 090°/10 kt.
- 18:16:34** ALC TWR calls RYR9ZC, *"You are cleared to land, runway 28, the wind is now 100 15 kt"*. RYR9ZC requests confirmation of wind and, upon receiving it, replies *"090... we are unable to approach due to tailwind"*.
- 18:17:08** ALC TWR informs RYR9ZC that if it goes around, to maintain runway heading and 5,000 ft.
- 18:16:40** While giving vectors to the other aircraft, ALC APP says (in Spanish): *"It's getting pretty ugly. At the 28 threshold the wind is from 100 between 13 and 18 kt and at the 10 threshold, 310 between 11 and 20 kt"*.
- 18:17:19** ALC TWR calls ALC APP to report (in Spanish): *"RYR9ZC can't touch down with this tailwind, right now 17 kt. I'm passing him to you on runway heading at 5,000 ft"*.
- 18:17:26** ALC TWR transfers RYR9ZC to ALC APP frequency on 120.4.
- 18:17:48** RYR9ZC contacts ALC APP again and says *"we need immediate diversion into Valencia due to fuel, immediate diversion with radar vectors"*.
- 18:18:02** ALC APP clears RYR9ZC direct to Valencia and asks about flight level requested, to which RYR9ZC replies FL 080.

²⁹ VILNA IAF: (initial approach fix) for the runway 10 ILS approach to LEAL.

- 18:19:15** RYR9ZC calls ALC APP to ask which approach to expect in Valencia and for radar vectors.
- 18:19:25** RYR9ZC insists: *"I request approach to Valencia now"*. ALC APP replies: *"OK, direct to Valencia, would you like visual over Valencia?"*. RYR9ZC replies: *"Radar vectors, radar vectors and the type of approach we can expect"*.
- 18:19:38** ALC APP replies: *"OK, initially fly direct Valencia, expect vectors with the next sector approach, if you need to climb you can climb until 120"*. RYR9ZC replies: *"We are happy at flight level 80"*.
- 18:20:30** RYR9ZC asks ALC APP: *"Could you give me the final runway in use Valencia, please?"*. ALC APP replies: *"Runway 12, sir"*.
- 18:23:53** ALC APP transfers RYR9ZC to VLC APP frequency on 120.1.
- 18:24:15** VLC APP clears RYR9ZC to proceed to OPERA, runway 12 and to notify when ready to descend. RYR9ZC acknowledges and requests radar vectors to runway 12. VLC APP gives course 345°. RYR9ZC adds that it would appreciate any reduction. VLC APP replies that when it is closer and in VMC conditions.
- 18:30:02** RYR9ZC radioes *"PAN PAN, PAN PAN, PAN PAN Ryanair 9 Zulu Charlie errr... fuel..."* *"requesting, ummm, vectors immediate to land runway one two"* *"PAN PAN, PAN PAN, PAN PAN"* ³⁰.
- 18:30:12** VLC APP asks RYR9ZC to repeat
- 18:30:13** RYR9ZC replies *"we would like to declare a pan due to errr... a pan emergency due to fuel"* *"urgency, PAN PAN, PAN PAN, PAN PAN"* ³¹ *Ryanair 9 Zulu Charlie"*.
- 18:30:21** VLC APP asks: *"Confirm you declare emergency?"*.
- 18:30:23** RYR9ZC replies *"urgency, PAN PAN, PAN PAN, PAN PAN"* ³², *Ryanair 9 Zulu Charlie"*.
- 18:30:28** VLC APP replies to RYR9ZC *"Copied, proceed own discretion to runway 12"*.
- 18:32:00** VLC APP informs VLC TWR that the RYR is arriving at the airport without fuel and that it just declared PAN-PAN, telling them to be ready because he does not know what to do in those cases. VLC TWR replies that it will report it to Coordination (CEOPS³³) and that they will know what to do.
- 18:32:04** RYR9ZC calls VLC APP to ask for the latest weather report for Valencia using the abbreviation *"met report"*. The controller does not understand and asks him twice to repeat. Finally RYR9ZC says *"we would like to request the weather at the field"*. VLC APP replies: *"OK, the weather is, the wind is 140/5 variable on direction from 110° 217° visibility 10 km or more, the cloud scattered 4,500 ft, QNH 1,011. Temperature 16, point 06"*.

³⁰ Sounded like FAN, FAN and very fast.

³¹ This time slower and more vocalized.

³² This time slower and more vocalized.

³³ Airport Operations Coordination Center.

- 18:33:49** VLC APP radioes (in Spanish) VLC TWR: *"Hello, look, we've dropped the RYR down to 5,000 ft. and it looks like he's proceeding on final, ok? You're ready, right?"*. VLC TWR replies that it has notified CEOPS. The planner controller at VLC APP reports that the aircraft said PAN-PAN. VLC TWR asks what exactly that means as he has never heard it before. VLC APP then rectifies and says that what the aircraft said was *TAM, TAM... TAM, TAM MEDICAL*³⁴, which surprises the VLC TWR controller who, while laughing, asks what that is and if the aircraft has really declared an emergency, which is not the same as PAN-PAN, to which VLC APP replies to stand by.
- 18:35:23** VLC APP contacts TWR again to confirm that *"the aircraft definitely said just TAM, TAM"*. A discussion ensues between them regarding whether it had reported airport in sight so as to initiate the emergency, since APP had reported the emergency and the airport has to be notified to undo the start of the emergency. VLC APP reports that the aircraft is declaring an urgency at that time, to which VLC TWR insists that they have been told emergency, not urgency, and as result have notified the airport.
- 18:35:38** VLC APP contacts the aircraft to request information on emergency declaration, to which the crew replies: *"We declared urgency, not emergency, RYR9ZC"*. A minute later VLC APP contacts again to request number of passengers onboard.
- 18:38:15** RYR9ZC transmits: *"MAYDAY, MAYDAY, MAYDAY, fuel emergency now"*.
- 18:38:40** VLC TACC³⁵ informs VLC TWR that the aircraft just reported an emergency, and VLC TWR replies that the two things were not the same and that they had the airport *"in chaos."*
- 18:39:02** RYR9ZC reports turning on final runway 12, and VLC APP transfers it to VLC TWR on frequency 118.55.

The aircraft landed at **18:43** without incident.

³⁴ This expression is not included in item 5.3, "Distress and urgency radiotelephony communication procedures" of ICAO Annex 10. See Appendix C.

³⁵ Terminal Area Control Center.

APPENDIX F
**Information on urgency and distress
communication (PAN-PAN and MAYDAY)**

As specified in Annex 10, Volume II, Communication Procedures

5.3. *Distress and urgency radiotelephony communication procedures*

5.3.1. General

5.3.1.1. Distress and urgency traffic shall comprise all radiotelephony messages relative to the distress and urgency conditions respectively. Distress and urgency conditions are defined as:

- a) **Distress:** a condition of being threatened by serious and/or imminent danger and of requiring immediate assistance.
- b) **Urgency:** a condition concerning the safety of an aircraft or other vehicle, or of some person on board or within sight, but which does not require immediate assistance.

5.3.1.2. The radiotelephony distress signal **MAYDAY** and the radiotelephony urgency signal **PAN PAN** shall be used at the commencement of the first distress and urgency communication respectively.

[...]

5.3.1.6. In cases of distress and urgency communications, in general, the transmissions by radiotelephony shall be made slowly and distinctly, each word being clearly pronounced to facilitate transcription.

Operations Manual Part A (item 8.9.3.2) Situations justifying declaration of an emergency

A situation in which the aircraft may not be able to reach a suitable airfield for landing is clearly a full emergency. Other cases where the Commander has cause to doubt the aircraft's serviceability to land, or where a warning circuit gives evidence of hazard, should also be treated as an emergency. Typical examples would be:

Typical examples might be:

1. Unsafe landing gear indications or wheel or tyre damage;

[...]

7. When it is established that there will be less than FINAL RESERVE FUEL (RESV/HOLD on the OFF) on board at landing.

Operations Manual Part A (item 8.3.7.1) Urgency (Pan x3) and Distress (Mayday x3) calls involving fuel

- The Commander shall make an urgency call (Pan x3) when he believes he will land with less than Final Reserve Fuel (RYR Policy).
- The Commander shall declare an emergency when calculated usable fuel on landing is less than Final Reserve Fuel (EU-OPS).
- The Commander shall make a Distress call (Mayday x3) when he is committed to an approach from which he will not have enough fuel to conduct a Missed Approach.

APPENDIX G
**Location of aircraft involved in the incidents
of July 2012**

APPENDIX H
**Amendment 36 to Annex 6, Part I – International
commercial air transport – Aeroplanes**

Amendment 36 to ICAO Annex 6 Part I (Chapter 4):

4.3.7. In-flight fuel management

4.3.7.1. An operator shall establish policies and procedures, approved by the State of the Operator, to ensure that in-flight fuel checks and fuel management are performed.

4.3.7.2. The pilot-in-command shall continually ensure that the amount of usable fuel remaining on board is not less than the fuel required to proceed to an aerodrome where a safe landing can be made with the planned final reserve fuel remaining upon landing.

4.3.7.2.1. The pilot-in-command shall request delay information from ATC when unanticipated circumstances may result in landing at the destination aerodrome with less than the final reserve fuel plus any fuel required to proceed to an alternate aerodrome or the fuel required to operate to an isolated aerodrome.

4.3.7.2.2. The pilot-in-command shall advise ATC of a minimum fuel state by declaring MINIMUM FUEL when, having committed to land at a specific aerodrome, the pilot calculates that any change to the existing clearance to that aerodrome may result in landing with less than planned final reserve fuel.

Note 1.—The declaration of MINIMUM FUEL informs ATC that all planned aerodrome options have been reduced to a specific aerodrome of intended landing and any change to the existing clearance may result in landing with less than planned final reserve fuel. This is not an emergency situation but an indication that an emergency situation is possible should any additional delay occur.

Note 2.—Guidance on declaring minimum fuel is contained in the Fuel Planning Manual (Doc 9976). It should be noted that Pilots should not expect any form of priority handling as a result of a “MINIMUM FUEL” declaration. ATC will, however, advise the flight crew of any additional expected delays as well as coordinate when transferring control of the aeroplane to ensure other ATC units are aware of the flight’s fuel state.

4.3.7.2.3. The pilot-in-command shall declare a situation of fuel emergency by broadcasting MAYDAY, MAYDAY, MAYDAY, FUEL, when the calculated usable fuel predicted to be available upon landing at the nearest aerodrome where a safe landing can be made is less than the planned final reserve fuel.

Note 1.—The planned final reserve fuel refers to the value calculated in 4.3.6.3 e) 1) or 2) and is the minimum amount of fuel required upon landing at any aerodrome.

Note 2.—The words “MAYDAY FUEL” describe the nature of the distress conditions as required in Annex 10, Volume II, 5.3.2.1, b) 3.

Note 3.—Guidance on procedures for in-flight fuel management are contained in the Fuel Planning Manual (Doc 9976).

