DATA SUMMARY

LOCATION

Date and time	**Saturday, 29 May 2010; 11:45 local time[1]**
Site	**San Luis Aerodrome (Menorca)**

AIRCRAFT

Registration	**N-554RB**
Type and model	**BEECHCRAFT E55 BARON**
Operator	**Private**

Engines

Type and model	**TELEDYNE CONTINENTAL IO-520-C**
Serial Number	**2**

CREW

Pilot in command

Age	**60 years old**
Licence	**Private Pilot's License**
Total flight hours	**2,255 h**
Flight hours on the type	**138 h**

INJURIES

	Fatal	Serious	Minor/None
Crew	**1**		
Passengers	**1**		
Third persons			

DAMAGE

Aircraft	**Destroyed**
Third parties	**50 square meters scorched by fire**

FLIGHT DATA

Operation	**General Aviation – Other – Airshow**
Phase of flight	**Maneuvering**

REPORT

Date of approval	**28th June 2012**

[1] All times in this report are local. To obtain UTC, subtract two hours from local time.

1. FACTUAL INFORMATION

1.1. History of the flight

The pilot of the aircraft was scheduled to take place in an air race that same afternoon. He had run through the course that morning (see Appendix 1), and he was planning to continue practicing. After fully refueling the aircraft with 207 l, he prepared everything for taking off from runway 02 at the San Luis Aerodrome in Menorca.

Onboard the aircraft were the pilot and a passenger.

After taking off, the aircraft turned left to follow the scatter points on the course at an approximate altitude of 200 ft above ground level (see figure 1). The pilot then turned left again to line up with the second scatter point on the ground (see Appendix 2). During this turn, the aircraft's left bank angle was close 90º, and the aircraft crashed to the ground, resulting in an explosion that engulfed the aircraft in flames.

The aircraft was completely destroyed by the impact and the subsequent fire. Both occupants were fatal injured.

Emergency personnel at the aerodrome immediately reported to the scene to extinguish the fire.

The fire consumed an area measuring some 50 m^2.

Figure 1. Flight path taken by the aircraft

Based on data gathered from video of the accident, the aircraft made a 180º turn over a span of eight seconds.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total on aircraft	Third persons
Fatal	1	1	2	
Serious				
Minor				N/A
None				N/A
TOTAL	1	1	2	

1.3. Personnel information

The pilot of the aircraft, an English national, had a private pilot's license issued by the British Civil Aviation authority (CAA). He had a multiengine piston rating that was valid until 27 April 2011.

He had a flying experience of 2,255 h, of which 138 had been on the aircraft type. In the previous month he had flown 28 h.

He had a valid and in force class 2 medical certificate and a FAI (Fédération Aéronautique Internationale) license.

In order to take part in this type of competition, pilots must have a license issued by the FAI, as well as a private pilot's license. They must have over 100 h of flight time as pilot in command and 5 h on the aircraft to be used in the competition. They must also have demonstrated the ability to accurately fly the aircraft in any orientation.

This ability is shown by way of a ground and practical exam. The handling check flight will require the aircraft to take off and land using only half the width available of the runway, flown on a precise track during take-off and landing and to be able to fly left level turns at full power. A chosen level must be maintained for entry, during and rolll out from such turns, which must of course be flown with a very good lookout and not on instruments. The aircraft must also be flown straight and level for two minutes whilst a lookout from the left tail plane round to the right tail plane is continually maintained. They also have to make a 360º turn at a 60º bank angle with a maximum vertical deviation of 40 ft and 180º turn at a 70º bank angle with a maximum vertical deviation of 40 ft.

1.4. Aircraft information

1.4.1. *General*

The aircraft, a Beechcraft E55 Baron, was registered in the United States though the owned was an English national. It had been manufactured in 1978. The current owner had purchased the aircraft in July 2007.

The aircraft's time since new was 2,292 h. The airplane was powered by the same two CONTINENTAL I0-520-C engines that had been installed on it at the time of manufacture.

Its cruising speed at maximum power was in excess of the 100 statute miles per hour required to take part in handicapped races.

1.4.2. *Condition of aircraft and maintenance*

The last annual inspection had been conducted on 22 April 2010 with 2,264 h on the aircraft. During this inspection, performed by AeroTech, an English maintenance company, the maintenance tasks specified for the aircraft, engines and propellers were performed.

1.5. Meteorological information

According to eyewitnesses, the visibility on the day of the accident was good and the wind was from the north at about 10 kt.

1.6. Aerodrome information

The San Luis Aerodrome is located in the city of Mahón. It has one 1,850 m long asphalt runway in a 02/20 orientation and at an elevation of 167 ft.

The aerodrome is private and is used primarily for sports aviation.

1.7. Wreckage and impact information

The aircraft impacted the ground 250 m away from the runway centerline and immediately exploded. The main wreckage was along the north-south flight path followed by the aircraft. It had been affected by the fire that broke out after the impact (see diagram of debris field in Appendix 3).

Due to the explosion, instruments and parts from the aircraft were found in shrubs on either side of the aircraft's flight path that were not affected by the fire.

Figure 2. Main wreckage and image of a part of the fuselage in a nearby shrub

1.8. Fire

The aircraft exploded and burst into flames as a result of the impact against the ground. The rapid response by emergency personnel contained the fire to a 50 m^2 area.

1.9. Tests and research

1.9.1. *Tests conducted*

Fuel

After the accident, fuel samples were taken from the tanker from which the airplane had last been refueled. An analysis of these samples showed that the 100 LL fuel was not within specifications[2], although the out-of-specification parameters (distillation residue and loss) were not considered significant.

The fuel sample did not show any sign of microbiological contamination.

1.10. Additional information

1.10.1. *Eyewitness interviews*

Private pilot and member of the Menorca Aeroclub

This eyewitness reported that the aircraft flew over the first scatter point and then made a very sharp turn. The second turn was made at a bank angle in excess of 45° (almost 90°), after which the aircraft started to descend until it impacted the ground.

[3] ASTM D-910-07a and DCSEA 118/B, which specify the composition, volatility, combustion, and other parameters for this fuel type.

Vicepresident of the Menorca Aeroclub

According to this eyewitness, the aircraft fully refueled with 207 l of fuel. As regards the flight, he reported that the aircraft was at a very low altitude, approximately 200 feet, during the first two turns. In his opinion, the wind could have played a role since it was from the north when the aircraft was turning toward the south.

He also reported that on a previous flight of the same aircraft conducted earlier in the day by the pilot, the maneuver had been very similar. In that flight, the pilot completed the second turn, during which he lost some altitude by leveling the wings abruptly.

Participant in the air race

He knew the pilot and had been with him in the days before the accident. At no time did the pilot mention any problems with the aircraft. He knew he had refueled because the air race was in the afternoon and they had to return to their country the next day.

Emergency services personnel

Arrived at the accident site two minutes after the crash. They started fighting the fire and, upon finding the occupants, confirmed that they had died.

They focused on fighting the fire to keep it from spreading.

1.10.2. *Handicapped Air Races*

Handicapped air races are a type of air race for propeller-driven aircraft.

This type of race takes into account the wind in the area and the various characteristics of the participating aircraft (maximum speed, weight, power, and glide ratio) to arrange the aircraft based on their ability to complete the circuit in the least amount of time. The participants then take off in order from slowest to fastest. By staggering the departures, the idea is to have all of the airplanes arrive at the finish line almost simultaneously, the winner being the one to cross it first.

1.10.3. *Information on regulations developed by national civil aviation authorities regarding air races*

FAA

In the United States, the FAA provides information on the altitudes, speeds and design of circuits for this type of competition in point 3-151, AIR RACES, of volume 3, chapter

6, section 1 of FAA Order 8900.1, Flight Standards Information Management System "Issue a Certificate of Waiver or Authorization for an Aviation Event".

This regulation divides air races into cross-country and closed-course races. Both require obtaining an authorization for the race. Closed-course races[3] further require that the course design be approved prior to the race. Closed-course races feature spectators.

This regulation pays particular attention to the separation between the spectators and the area where the flight or the show is going to be held.

In terms of the altitude, it specifies that it must never be below 500 ft. For the design of the course, it emphasizes the importance of factors such as the top speed of the aircraft and the acceleration (g) forces to which they might be subjected while flying in the circuit.

The speed is limited depending on the type of air race. The maximum acceleration force allowed is 3.5 g. These two factors are used to calculate the minimum turn radii for each type of race.

This regulation states that prolonged course changes are to be avoided, and specifies a maximum of 65º.

CAA

The British Authority (CAA) issued CAP 403 on air shows, which regulates the procedures to be followed by organizers and participants of air shows. This regulation is specific to spectator events.

It also states that national air races, including the issuance of permits and competitors' licenses, are organized and controlled by The Racing, Rally and Records Association of the Royal Aero Club (RRRA). Also specified is the fact that rules for air races, which can be obtained from the RRRA on application, are designed to ensure a high standard of safety. Organizers of air races are recommended to seek the advice of the RRRA.

According to the information provided by the RRRA every air race courses are sent to the CAA.

AESA

The Spanish Authority issued Royal Decree 1919/2009, of 11 December, which regulates aviation safety at civil air shows. This document includes the safety conditions that are applicable to civil air shows open to spectators. Specifically excluded are "air races".

[3] Examples of races of this type are the Reno Air Race and the Red Bull World Air Race.

This document does not include recommendations or guidelines for air races or other types of competition.

1.10.4. *Organization of the competition*

The second handicapped air race was organized by The Royal Aero Club-Racing, Rally and Records Association, in concert with the Real Federación Aeronáutica Española, Spain Real Aero Club and the Mahón Menorca Real Aeroclub.

The rules[4] used to organize the event was that of the Royal Aero Club-Records, Racing and Rally, as this organization had more experience in organizing this type of competition.

According to the rules provided by this organization prior to every competition, a pre-flight briefing must be held with an organization official. Compliance with certain key rules involving the crew, the aircraft, the design of the circuit, etc., is also required in order to guarantee safety. Especially it is reminded to operate with the limitations of the aircrafts and it is also specially mentioned the turns that required a heading change over 120º.

The circuit is a closed loop of between 20 and 25 miles in length and which is flown 4 or 5 times, normally to the left and over control points that are usually marked by orange pylons on the ground.

The altitude required above the first such point on the circuit is 500 ft, though this is normally increased to 700 ft for noise abatement purposes.

According to information contained in the organization's manual and confirmed by a pilot with experience in this type of competition, when an aircraft takes off opposite to the race course, it is necessary to leave two or more of these control points, known as scatter points, to the left.

The purpose of these scatter points is, on the one hand, to ensure that that aircraft have sufficient distance in which to accelerate to a speed at which they can then safely turn without the fear of stalling and on the other, to line up with the circuit course after a series of left turns. Having more than two scatter points allows the pilot to line up on the desired course after several turns.

The organization's manual pays special attention to aircraft performance in the turns, and in particular to the increased stall speed that results when bank angles are increased above 70º.

[4] Royal Aero Club Records, Racing and Rally Association. Rules 2011 and Air Racing Handbook. Issue 1 (20/01/2011).

One of the examples given is that the stall speed for an aircraft with an approximate stall speed of 80 kt[5] in level flight increases to 137 kt at a bank angle of 70º. It also specifies that an aircraft in a turn at a 70º bank angle is subject to an acceleration of 3 g's.

This manual does not include explicit bank or acceleration limits for the design of courses.

2. ANALYSIS

2.1. Analysis of the flight

The aircraft took off from runway 02 at the San Luis aerodrome in Mahón. In keeping with the requirements for the race, it had to take off and fly left of two scatter points placed in the vicinity of the aerodrome before heading to the Isla del Aire point at the south of the island. This maneuver required making a 180º turn.

Based on video footage of the accident, the aircraft made the turn in 8 seconds. For level flight at a constant altitude, making a steady turn from the runway centerline to the second scatter point requires a bank angle of 67º[6] and a speed of 107 kt. At this bank angle, the stall speed increases by 55% with respect to the level flight stall speed, meaning that for the configuration of the aircraft in the turn (gear and flaps up), the stall speed would have been 128 kt, in excess of the airplane's actual speed.

The turn was not in fact steady, with even higher bank angles being observed when passing above the two scatter points. During the last turn, a bank angle of almost 90º was observed before the aircraft lost control and impacted the ground.

This maneuver was also conducted at a low altitude and probably at a low speed, since the aircraft had just taken off. It was therefore close the ground as it made a very sharp turn. Eyewitnesses reported that the aircraft was flying some 200 ft above the ground, though as a general rule, the minimum altitude for this type of competition is 500 ft.

Figure 1 shows how at the end of its flight path, the aircraft started to level out but was unable to complete the recovery maneuver due to the low altitude available.

It is reasonable to think that had there been more scatter points, the maneuver required to follow the course would not have been as demanding and could have been completed using a shallower bank angle.

[5] According to the aircraft flight manual, the stall speed for the Beechcraft E55 is 83 kt.
[6] This assumes a uniform circular motion.

There are precedents in regulations formulated by aviation authorities (FAA) that propose examples for the design of courses. Specifically, the FAA's regulation stipulates a maximum course change of 65º in a single turn and maximum accelerations of 3.5 g's. The manual used by the organization to design the course did not specify this limitation, nor was it taken into account in said design. Had these limitations been enforced in this case, the 180º course change would have taken place over three or four segments, resulting in shorter turns and less pronounced bank angles.

Also, if the aircraft had been at a higher altitude above the ground, it is possible that the pilot, given his skill as demonstrated by the tests that must be completed to take part in this type of competition, could have regained control of the aircraft and avoided the accident. Spacing the scatter points further apart would also have given the pilot more time to gain altitude.

Taking part in an air race poses an obvious challenge to participants, who must outdo themselves and improve on their previous times, with the risks that entails. However, rules must also be put in place to ensure that the risks that are taken are acceptable.

Although the national regulations reviewed involving the design of circuits refer to air shows intended to be viewed by spectators, the criteria and findings presented therein could be expanded to include other types of competition, such as air races, if doing so would result in improved safety.

As a result of the above, a recommendation is issued that air race circuits be designed to ensure that course changes do not require pilots to make abrupt maneuvers and that a certain minimum altitude above ground is attained before a pilot is required to make a turn to remain in the circuit.

3. CONCLUSION

3.1. Findings

- The aircraft was properly licensed and certified for flight.
- The pilot was properly licensed and certified for flight.
- The aircraft had been fully refueled.
- Airplanes took off in the opposite direction from the start of the circuit.
- Entering the course required the aircraft to make a 180º turn.
- The pilot started a sharp turn to the left immediately after takeoff, a turn he eventually leveled.
- He made another turn to the left, increasing the bank angle until he lost control of the aircraft.

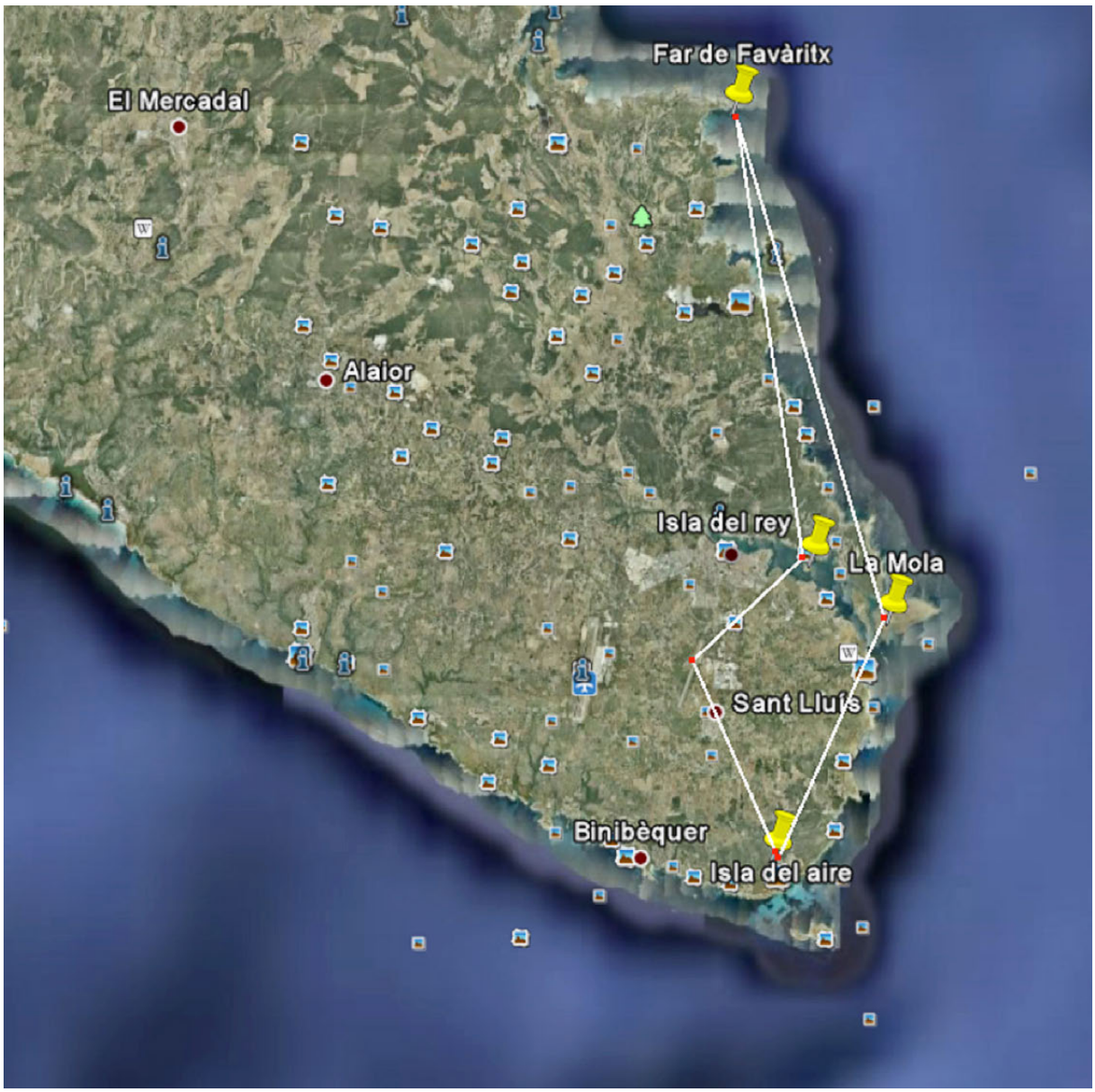
3.2. Causes

The accident was caused by a loss of control resulting from a loss of lift during a steep turn at a low altitude. As contributory factor is considered the first turn point was very close to the end of the runway which didn't allow the aircraft to gain enough energy to turn safely.

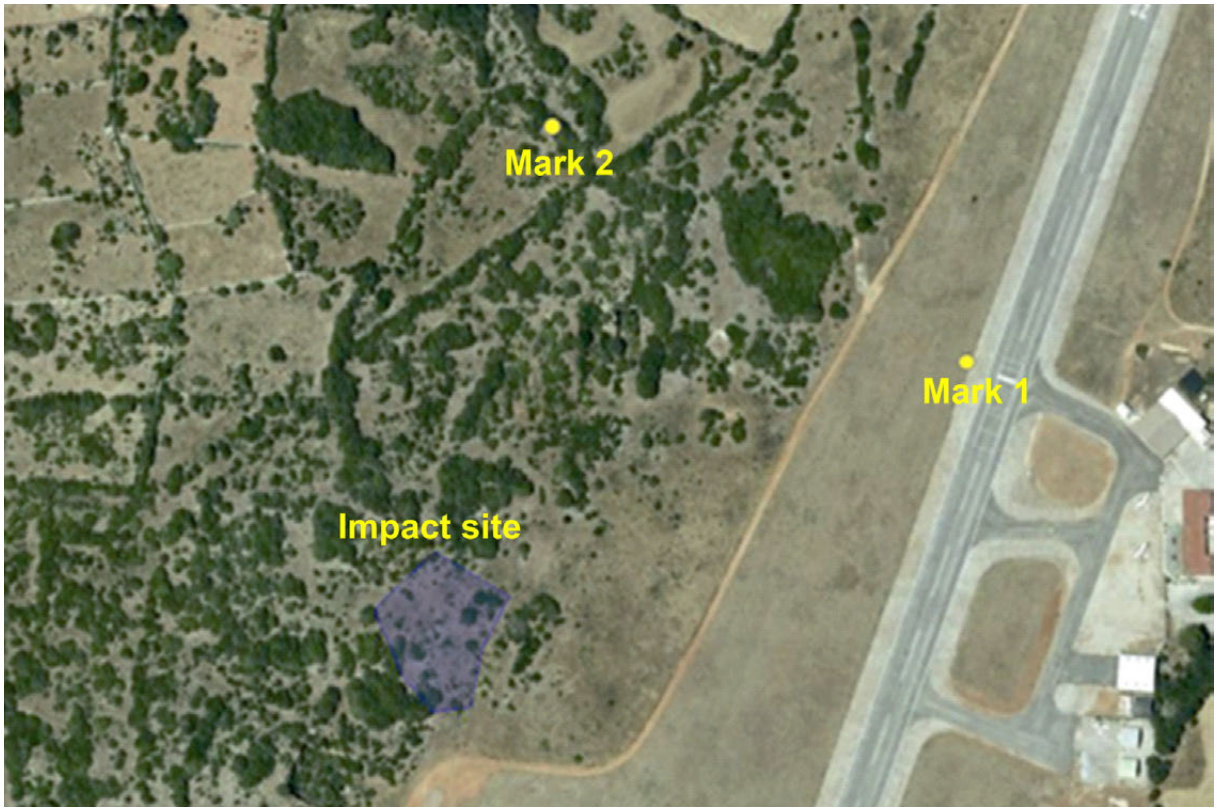
4. SAFETY RECOMMENDATIONS

REC 15/12. It is recommended that the Royal Aero Club-Records, Racing and Rally Organization and the Real Federación Aeronáutica Española include, as part of their internal instructions on the design of air race circuits, criteria that are similar to those specified by the FAA in its Order 8900, establishing specific limits on course changes and paying particular attention to the low-altitude, low-speed maneuvers required after takeoff to enter the circuit.

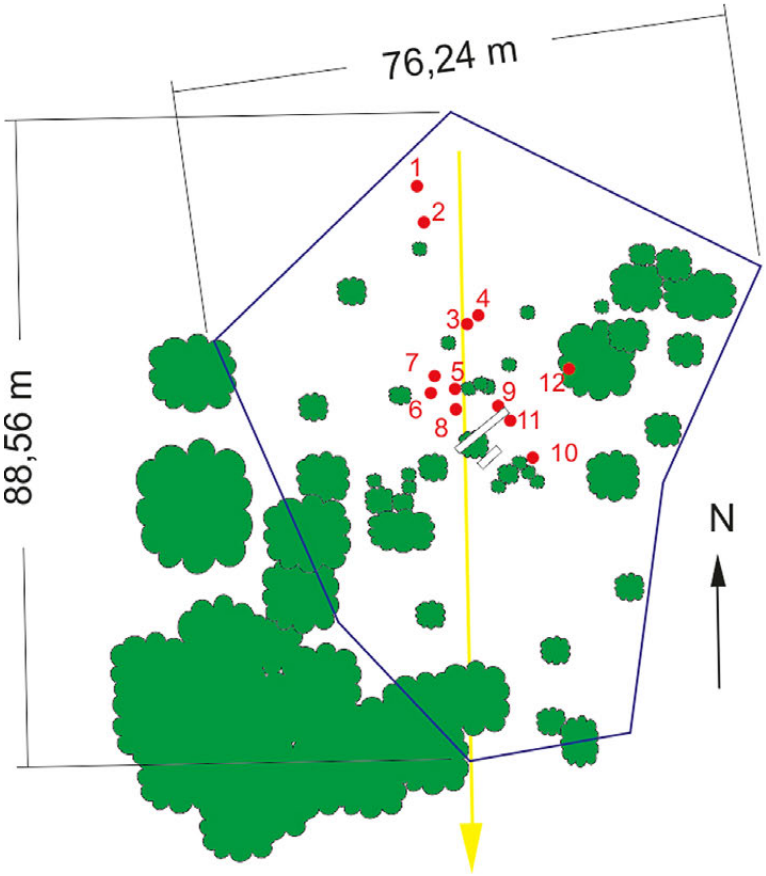
APPENDIX 1
Circuit planned for the event


Far de Favàritx
El Mercadal
Alaior
Isla del rey
La Mola
Sant Lluís
Binibèquer
Isla del aire

APPENDIX 2
Location of scatter points on the circuit


Mark 2
Mark 1
Impact site

APPENDIX 3
Debris field



1 Initial aircraft impact

2 Left propeller hub

3 Propeller blade

4 Propeller blade

5 Propeller blade, hub and left aileron

6 Instruments

7 Propeller blade

8 Left and nose gear, tail section

9 Main wreckage

10 Left engine

11 Right engine

12 Altimeter