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INVESTIGATION REPORT

Accident to Schroeder Fire Balloons G50/24
registered **F-HCCG**
on 5 October 2014
at Cazes-Mondenard (82)
operated by **Quercy Pluriel**

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

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Safety investigations

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SPECIAL FOREWORD TO ENGLISH EDITION

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.

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Glossary

AAIB	Air Accidents Investigation Branch (British counterpart of BEA)
AMC	Acceptable Means of Compliance
AOC	Aircraft Operator Certificate
ARC	Airworthiness Review Certificate
ARO	Authority Requirements for air Operation
BFU	Bundesstelle für Flugunfalluntersuchung (German counterpart of BEA)
CAC	Civil Aviation Code
CAT	Commercial Air Transport
CNPPA	National council of aerostation professionals and partners
CPB	Commercial Passenger Ballooning
CRS	Certificate of Release to Service
CT	Code of Transport
DGAC	French civil aviation authority
DSAC	Civil aviation safety directorate
DSAC-EC	Civil aviation safety directorate - Headquarters
DSAC-IR	Civil aviation safety directorate - Regional office
EASA	European Aviation Safety Agency
FFAÉ	French aerostation federation
GM	Guidance Material
MCT	Technical Inspection Manual
METAR	Aviation routine weather report
NCC	Non-Commercial air operations with Complex motor-powered aircraft
NOTAM	NOtice To AirMen
OM	Operations Manual
OSAC	Civil aviation safety organization
PT	Public Transport
REX	Voluntary and confidential event reporting system
SPO	SPecialized Operations

TAF	Terminal Aerodrome Forecast
TEMSI	Significant weather charts
TSB	Transportation Safety Board of Canada (Canadian counterpart of BEA)

Synopsis

Hard landing, basket upset, fire

Time	Around 16:30[(1)]
Operator	Quercy Pluriel
Type of flight	Commercial Air Transport - Passenger
Persons on board	Pilot and 10 passengers
Consequences and damage	One passenger fatally injured, three passengers seriously injured, six passengers and pilot slightly injured, balloon destroyed

[(1)]Unless otherwise stated, all times given in this report are in UTC. One hour should be added to obtain the legal time applicable in Metropolitan France on the day of the event.

Near the end of cruise, the balloon was flying in a convective atmosphere generating wind variations. The pilot made the decision to land. In accordance with his instructions, the passengers adopted the safety position. During the descent, the vertical speed became high despite burner inputs by the pilot. Near the ground, the balloon's flight path turned to the left by several dozen degrees. The pilot activated the turning vents to position the long side of the rectangular basket perpendicular to the flight path and then activated the rapid deflation system. The pilot lights were on. The balloon struck the ground hard, then regained height. On the second impact, the basket turned over completely. A fire broke out during the evacuation of the occupants.

The investigation showed that the accident was due to the combination of the following factors:

- inadequate consideration given to the meteorological conditions, which exposed the balloon to turbulence and variations in the force and direction of the wind, probably of a convective nature, which in the end caused the basket to turn over;
- the failure to turn off the pilot lights before the first impact. This could be due to the pilot focusing his attention on controlling the balloon's rate of descent and orientation, during a hard and fast landing, generating stress.

The following factors may have contributed, though it was not possible to determine the degree to which they contributed:

- the practice, the extent of which could not be precisely assessed, of landing with one or more pilot lights lit, which makes it unlikely that the pilot will instinctively react and turn them off in a fast or hard landing situation;
- the use of a "double-T" installation - unauthorized by the manufacturer - that may limit the available heating power;
- an overestimation of the safety offered by the pilot carrying out the actions specified in the Flight Manuals for an emergency landing, which must by nature be carried out under stress;
- techniques and means of oversight of operators by the authority which are mainly concerned with regulatory compliance, poorly adapted to detecting risky practices.

The BEA issued recommendations to:

- study the development of emergency "*fuel shut-off*" devices on board balloons;
- homogenize the operational documents regarding the practice of turning off the pilot lights;
- clarify the safety objectives for commercial balloon flights;
- reinforce feedback from operators.

ORGANIZATION OF THE INVESTIGATION

The BEA was informed of the accident on 5 October. In accordance with European Regulation No 996/2010, the BEA opened a safety investigation and notified the BFU and AAIB, respectively State of Manufacture of the envelope and State of Manufacture of the basket and burners. The BFU and the AAIB each appointed accredited representatives, who were advised by technical advisers from the German manufacturer Schroeder and the British manufacturer Cameron.

EASA, the DGAC, the FFAé and the CNPPA also provided the BEA with useful information for the investigation.

1 - FACTUAL INFORMATION

1.1 History of the flight

Note: F-HCCG was equipped with a video system filming the basket and the occupants. Videos made by a passenger were also analysed. The description which follows is principally based on these videos, supplemented by the pilot's statement. T is denoted arbitrarily to represent the moment when the basket came to rest upside down in the field.

Two groups of passengers who purchased their flight on a shopping website had an appointment with the pilot in the morning. The pilot cancelled the flights planned for the morning due to the wind which he considered was too turbulent[2] . He suggested to the passengers who could, that they stay until the afternoon when a lighter wind was expected.

The pilot said that when he had to make a decision as to whether or not to fly the afternoon flight, the weather conditions, estimated visually and by releasing a ballonnet, seemed to him satisfactory. He also consulted meteorological information by Internet.

On take-off at approximately 15:45, the wind indicated by the ground windsock was about 5 kt and numerous cumulus or stratocumulus were observable (coverage of about 4/8). They were there for the duration of the video.

During the flight, no technical anomaly occurred. The pilot was attentive to the conduct of the flight and gave technical and tourist information to the passengers.

At about T-10 min, the pilot reminded the passengers of the safety position to adopt for landing, knees bent, back to the direction of travel of the balloon, holding onto the handles.

The pilot said that after about 35 minutes of flight, significant wind variations, deforming the balloon's envelope, led him to decide to land. This decision cannot be given a precise time on the video. However, signs of wind variation can be seen several times on the video (changes in ground speed, hair and clothes of occupants moving, sound of blowing in the microphone, deformation of the balloon's shadow on the ground).

At about T-2 min the pilot picked up the valve line and kept it taut for about one minute. The video does not make it possible to quantify the effective opening of the valve, but it can be considered that the line is simply kept taut without opening the valve, in preparation for this. The pilot briefly heated several times during this minute.

At T-1 min 45 s, the pilot asked the passengers to adopt the safety position.

At approximately T-1 min, the pilot released the valve line and continued the heating inputs (including one of about 15 seconds). He grasped the rapid deflation line[3] without pulling on it. The balloon continued to advance in a direction perpendicular to the long side of the basket. The pilot said that he had identified a field for landing. The vertical speed appeared to be high.

[2]The pilot said that the general conditions of sale of the tickets stated that the flight could be cancelled if the pilot did not consider the flight possible.

[3]The top of the F-HCCG envelope is equipped with a system called PARAQUICK in the Flight Manual and which has two functions: a "*parachute*" function (measured release of hot air via the valve) using the white valve line and a *"rapid deflation"* function activated by a red line. This function is used to rapidly deflate the envelope by gathering the panel into a column in the centre of the envelope. It is only to be used for landing.

From T-1 min, at a low height, a change of wind direction by several dozen degrees to the left directed the flight path towards a field of maize. The pilot heated again for eight seconds while activating the turning vents to try to orient the basket correctly again. When he stopped his inputs on the burners, a few meters from the ground, he pulled the rapid deflation line, with a view to landing. He made no attempt to turn off the pilot lights.

At T-38 s, the basket hit the ground hard shortly before the maize field then rebounded. Two passengers fell to the bottom of the basket and no longer adopted the safety position up to the second impact.

At T-34 s, the basket tilted and was dragged into the crops. The pilot, unattached, was almost thrown out. The balloon regained a little height while the pilot was still pulling on the rapid deflation line. Passengers briefly left the safety position.

At T-11 s, on the second impact in a field further on from the maize field, the basket tipped over onto its short side and was then dragged along the ground for a few metres.

At T-2 s, the basket turned completely over. The burner frame uprights bent under the weight of the basket. The burners were directed towards the ground. Some of the occupants were in contact with the frame. A brief but large flame was visible from the burners.

Figure 1: photo of situation of basket at T
the maize field overflown is in background

At T+8 s, a flame briefly appeared on the burners, while the first of the passengers trapped between the basket and the burner frame got out.

From T+10 s, a fire started at the burners and spread rapidly to the wicker basket, while passengers evacuated by helping each other. Aided by passengers, the pilot also evacuated. They put the basket back on its side. One passenger was unable to get out and could not be evacuated.

At about T+1 min, the pilot closed the fuel cylinder valves. The burner flames were extinguished. The basket was still on fire. The pilot and a passenger then tried to extinguish the flames with the balloon fire extinguisher, but did not succeed, then attempted to rescue the victim.

A few minutes later, the retrieve vehicle arrived with a second fire extinguisher which the pilot used against the blaze, without being able to extinguish it. The basket and its equipment burnt up completely due to the fire, fuelled several times by the gas from the tanks released by the safety valves.

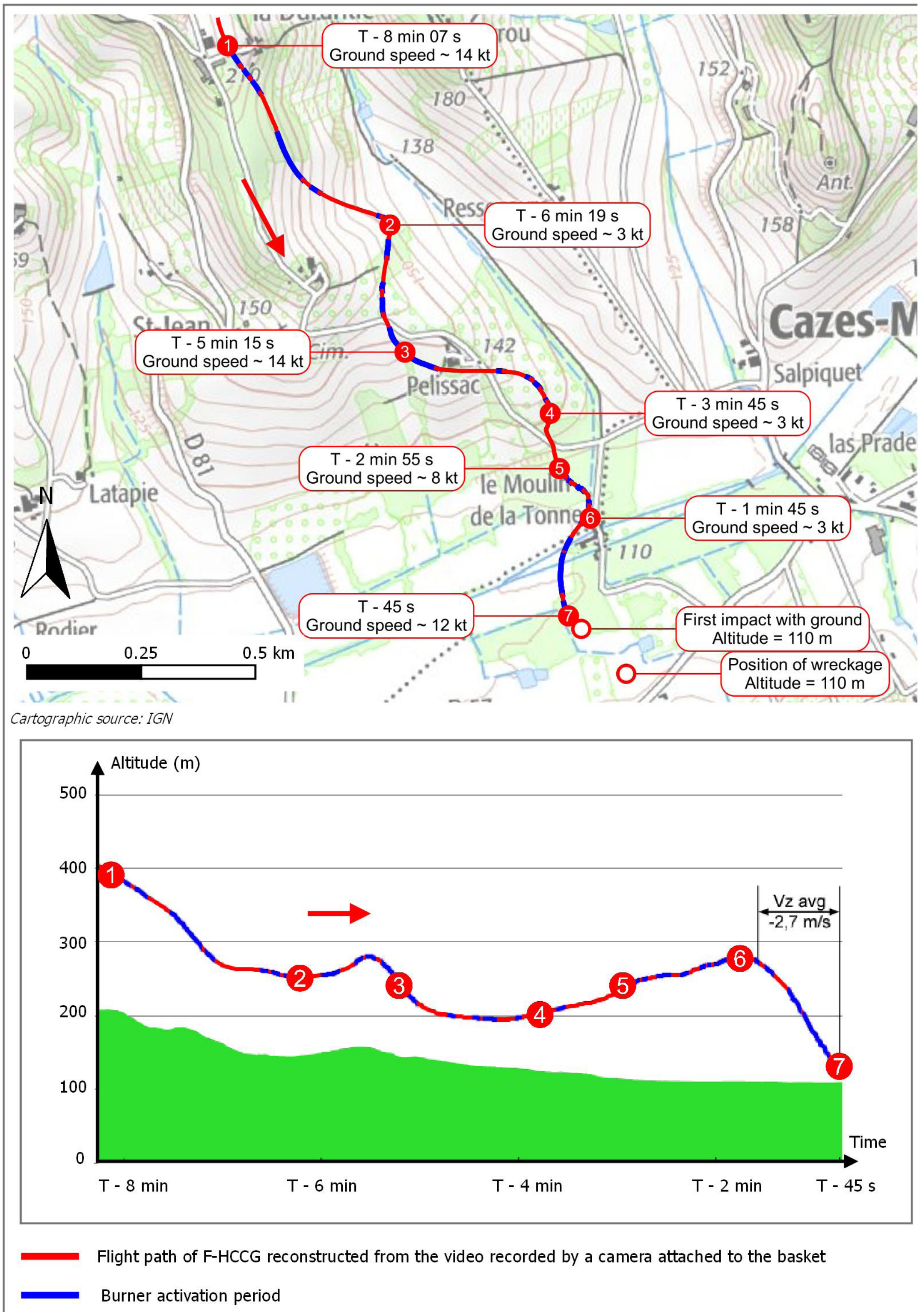

Figure 2: last part of flight path obtained from analysis of video recorded by camera

1.2 Injuries to persons

	Injuries		
	Fatal	**Serious**	**Minor**
Crew	-	-	1
Passengers	1	3	6

1.3 Damage to aircraft

Aircraft destroyed.

1.4 Other damage

There was no other damage.

1.5 Personnel information

The pilot, aged 66, held a hot air balloon pilot's licence issued in December 2010 in accordance with the provisions of the French decree of 31 July 1981[(4)] and a valid Class 2 medical certificate. He had started his training in July 2010 at the FFAé school. The training progress log shows a change of instructor after the first solo flight on 19 November 2010. The rest of the training was undertaken by another instructor who noted in the log in the part on "summary of the training”:

- ❒ level of theoretical knowledge quite good;
- ❒ level of flying proficiency somewhat above that expected for issuance of the certificate;
- ❒ frequent tendency of the pilot to contest his own mistakes and to attribute them to external causes, which was a problem for his instructors.

This instructor was also the tester for the flight to ratify the training on 22 December 2010.

On 5 May 2014 the same instructor had performed a proficiency check on the pilot, as required by the operator's procedures in accordance with the regulations in force, on board the balloon that was subsequently involved in the accident. The result of this check was satisfactory.

On 25 April 2014 the pilot had participated in a "Training Day -- Exchanges" organised by the FFAé at Blagnac (Haute-Garonne). The programme included some regulatory subjects on training, safety issues relating to handling liquid propane, electric power lines, human factors associated with incidents or accidents, and one subject on controlled air space.

The pilot estimated that he had logged about 375 flight hours and 350 flights at the time of the accident.

[(4)]Civil aviation non-professional crew licences and qualifications (aircraft flight crew), see paragraph1.17.3.3.

During the investigation, the pilot provided video recordings of the flights made with the instructor during which the landings were carried out with the pilot lights lit[5]. These videos did not allow the content of the debriefing of these flights to be documented.

1.6 Aircraft information

F-HCCG had belonged to the operator since June 2013. It was made up of a Schroeder Fire Balloons envelope and Cameron Balloons basket and burners. The airworthiness certificate is attributed to the envelope that carries the registration. The association of components from different manufacturers is made possible under regulations by a series of documents from EASA, and a supplement in the envelope manufacturer's Flight Manual[6].

The DGAC stated that in the case of a balloon made up of parts coming from different manufacturers, the envelope Flight Manual is the reference for the operator and for any person in charge of the maintenance or continuing airworthiness. In this case the Schroeder Flight Manual for F-HCCG states that the fire balloon's Flight Manual will be taken into account, as well as the corresponding manual for other foreign parts. In case of any doubt, the shortest maintenance interval will be taken into account, the lowest weight or the most restrictive limitations on use. The maximum usable weight should not be exceeded, nor should the number of persons on board indicated by the basket manufacturer. Equally, the maximum weight indicated by the envelope manufacturer shall not be exceeded.

The ARC, valid for one year, was renewed on 16 April 2014 after an annual maintenance inspection by a workshop, which holds approval to manage continuing airworthiness issued by OSAC and a maintenance approval issued by the DGAC.

1.6.1 Envelope

Manufacturer	Schroeder Fire Balloons
Type and volume	G50/24, 5000 m3
Serial number	1056
Year of manufacture	2003
Registration	F-HCCG
Airworthiness certificate	No 124443 of 21 May 2012 issued by DSAC
Date of last annual inspection and subsequent use	16 April 2014, 307 flight hours and 270 flights
Date of last maintenance operation and subsequent use	10 September 2014, 358 flight hours and 326 flights

[5] Issues related to landings with pilot lights lit, see paragraphs 1.16.2, 1.17.1 and 1.17.2.

[6] TCDS EASA.BA.016, Technical Note TM EASA.BA.016-42 and supplement C.1.1 in the Schroeder Fire Balloons Flight Manual

Reports on the maintenance operations performed in April 2014 and in September 2014 state that a new tempilable and a new melting link were installed at each of these maintenance operations[7]. These devices monitor the envelope operating temperature, which is limited. Examinations of the envelope did not reveal any anomalies, the tear tests on the envelope were satisfactory[8] and the CRS was signed.

1.6.2 Basket, burners and propane tanks

The basket was of the CB3314 type. The manufacturer's drawing indicates that it was designed for ten occupants and one pilot. Its serial number was BB1573. The basket was mainly made of wicker, as is the case for the vast majority of balloon baskets. This material provides good shock damping but can contribute to sustaining a fire. It was divided into two passenger compartments and one compartment for the pilot, which included the equipment required for the flight and four fuel tanks (Thunder & Colt V30 type, serial numbers 949, 950, 995 and 1010).

Each tank had:

- ❒ a quarter-turn valve to open or close the supply of liquid propane;
- ❒ a valve to supply propane gas (not used on F-HCCG);
- ❒ an overflow valve;
- ❒ a safety valve to prevent excessive pressure in the tank.

The tanks supplied three burner blocks with liquid propane through hoses installed in the burner frame uprights.

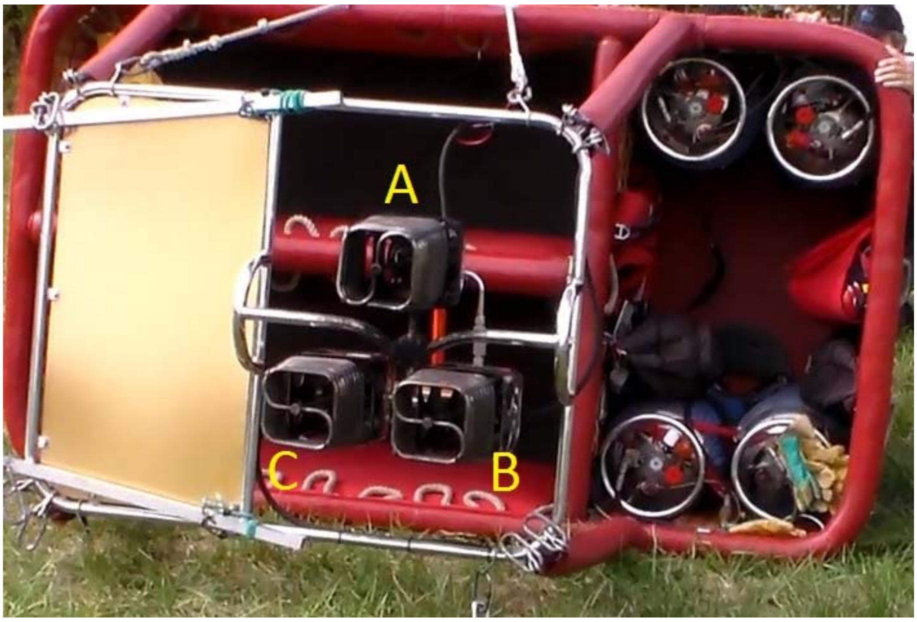

Figure 3: general view of basket

[7]Tempilables show a temperature above 110°C. The workshop specified that the melting link had been replaced in September 2014 as the former link had melted. The reason for the replacement in April 2014 was not found.

[8]The Maintenance Manual produced by the manufacturer states that a tear test must be carried out if the internal temperature has exceeded 140 °C. This test is recommended if the internal temperature has temporarily exceeded 135 °C. The workshop carried out this test after having noted a temperature above 110°C indicated by the tempilable attached to the envelope.

In figure 3:

- the lower left burner (called C in this report) was supplied by the two lower tanks through a T-coupling system;
- the two other burners (called A and B) were supplied by the two upper tanks through a double T-coupling (*figure* 4). This configuration is not proposed by Cameron Balloons, the manufacturer. The DGAC and OSAC stated that this type of assembly is not in accordance with the type certificate[(9)]. Cameron Balloons considered that it was possible that this assembly reduced the heating power of the two burners when activated simultaneously, according to the characteristics of the couplings and the simultaneous opening or not of the two tanks. The pilot said that he had bought the balloon in this configuration from the previous owner and that it was in place when he asked for the renewal of the ARC in April 2014. He had never observed abnormal operation linked to this assembly.

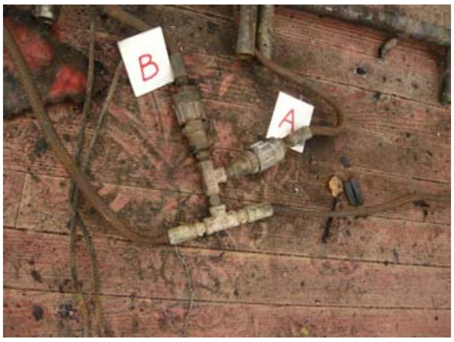

Figure 4: double T-coupling supplying burners A and B

The inspection report and ARC renewal report do not provide confirmation as to whether this was the configuration on that date. The workshop stated that according to the various manufacturer maintenance documents, these additional connections [author's note: between the bottles] are not officially part of the aircraft which meant that it is not able to require a specific assembly during the ARC renewal inspection. The DGAC and OSAC stated that they did not support this point of view.

The three "upper" fuel hoses, that is to say connecting the burners to the T-couplings, had been changed in April 2013 (the balloon then belonged to the previous owner).

The frame for the three burners was attached to the basket by uprights and to the envelope by a series of cables. The uprights are designed to keep the burners in position above the occupants when the basket is vertical.

Each burner block (Cameron Balloons CB2467, serial numbers 5361, 6617 and 6623) had a pilot light control valve (gold in colour), a whisper burner control valve (blue) and a main burner control valve (or heating valve)[(10)]. The three burner blocks were placed at the three ends of a T-support as illustrated in Figure 3.

[(9)]The Cameron Flight Manual states that "*In double, triple or quad burners, each burner unit has its own independent fuel supply*" (chapter 6.3.6) and that "*The manifold must not be used to connect two or more burner fuel supplies together to reduce the number of independent fuel supplies […]. Only one cylinder at a time should be open to each burner.*" (Chapter 4.5.3.1).

[(10)]The "*whisper burner*" mode and the "*main burner*" mode differ in the circulation and supply of gas. The former is used occasionally and makes less noise than the latter, making it possible to abate the noise when flying over animals.

The A and B burner blocks were connected to each other by a connecting valve that allowed their main burners to operate simultaneously. The heating valves on burners B and C could be activated simultaneously by an input on a "*double-action*" control bar located on the red support bar that links blocks B and C. Without a pilot input on this bar, the main burners remain inactive. As a result of this assembly and when the coupling valve between burners A and B was open, an input on this control bar caused the three main burners to light.

The pilot lights and the whisper burners were controlled independently via their quarter-turn type controls.

The heating valve on burner A could also be activated via a control identified as 1 in Figure 5. This control had two "*closed*" positions: that shown in Figure 5, where the control is at 45 degrees to the red support bar, and the "*straight*" position where the control is aligned with this bar. All other control positions were unstable and caused the ignition of the main burner, as did the application of pressure on the control in the 45 degree position.

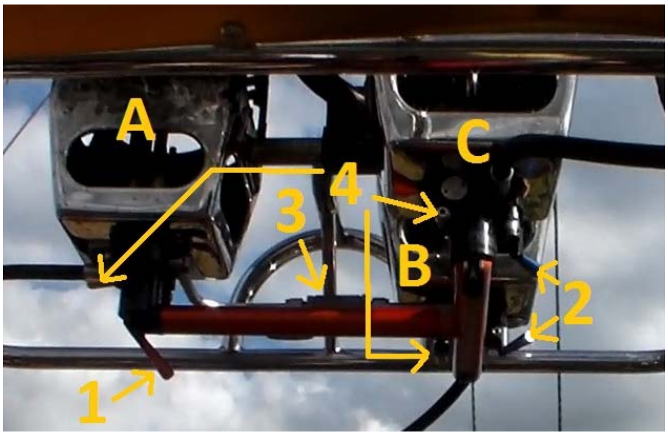

Figure 5: installation of the burner blocks on F-HCCG. Item 2 indicates the whisper burner controls on blocks B and C (not visible for block A) and item 4 indicates the pilot light controls. Item 3 indicates the connecting valve (partially visible) of main burners A and B. The "*double-action*" control bar is not visible, being located on the upper part of the small red bar on the T support, between blocks B and C.

In accordance with regulations, there was a fire extinguisher in the pilot's compartment of the basket[(11)].

[(11)]See paragraphs 1.14 Fire and 1.15 Survival aspects

1.6.3 Flight Manuals

The Flight Manual of the Schroeder Fire Balloons envelope includes a loading chart that allows the pilot to calculate the maximum weight that the balloon can lift, according to the conditions on the day. Application of this calculation to the accident flight is discussed in 1.16.1.

The Flight Manual also states:

- that generally one should avoid a flight in thermal activity;
- a balloon flight is to be cancelled when the wind velocity on the ground exceeds 15 knots at the take-off site, gusts occur with velocities of more than 10 knots above the average wind velocity and that the upper limit should be 10 knots for standard passenger flights (part E.9 "Significance of meteorological phenomena" and Part B.5 “Limitations on use - wind speed”);
- that immediately before “landing”, the pilot light and cylinder valves must be closed for a normal landing;
- that for an emergency landing it is essential to turn off the pilot lights, close the cylinder valves and vent the pipes of residual gas.

It should be noted that translations into French and English of the latest updates to the Flight Manuals, originally written in German, are not available on the manufacturer’s website. This does not affect the aspects studied during this investigation.

The Cameron Flight Manual indicates similar wind and aerological limits without stating if the presence of passengers should lead to the application of lower limits. For a normal landing, the pilot lights "*Should be turned off when the pilot is satisfied that no further burner operation will be required*." It is also stated that "*If the wind speed is high, or the landing field poses a fire risk, the pilot lights should be turned off immediately prior to touchdown and the main fuel supply turned off, if time allows*." In the emergency procedures associated with a hard or fast landing, it is necessary to "*Extinguish the pilot light(s), shut the fuel off at all cylinders in use and empty the hoses if time permits*."

1.7 Meteorological information

Note: the site of the accident is located at six kilometres from the take-off site. The two sites are at the same altitude (around 110 metres).

1.7.1 Estimated conditions on accident site

The accident site was to the rear of a disturbance which was moving towards the east of France.

There was still some convection at the time of the accident, evidenced by cumuli and wind peaks of 15 kt, that might cause local turbulence.

Météo France forecast the following for the site at the time of the accident:

- cloud cover: 3 to 4 octas of cumulus based at about 650 metres with tops at about 1,250 metres;
- visibility above 10 km;
- ground wind: from 330 to 360° at 5 to 7 kt with a maximum between 13 and 15 kt;
- ground temperature: 15 °C;
- QNH: 1,018 hPa.

1.7.2 Pre-flight planning information

The pilot gave the BEA a printout of the pages from the website that he used to consult the weather forecast on the morning of the accident flight.

Consultation made in morning
An initial document, dated the morning, showed evolutions in various parameters, updated at 6:30, at Lauzerte, the take-off site:

- cloud cover shown as a pictogram: decreasing during the day;
- temperature: 12 °C forecast at 8:00 increasing to a maximum of about 17 °C from 14:00 to 18:00;
- wind: from 15 to 20 km/h (i.e. 8 to 11 kt) decreasing from the beginning of the afternoon down to close to zero at 21:00/22:00.

This document also stated that sunset was at 19:32. It did not include any METAR or TAF.

Consultation made in afternoon
A second document, from the same website, dated the middle of the day, gave the same forecasts and had the same update time (06:30).

Other documents consulted gave similar temperature, wind and cloud cover forecasts.

The pilot said that before take-off, he had visually observed the conditions and released a helium balloon. He had observed a temperature of 13°C measured with the balloon thermometer.

1.7.3 Météo-France forecasts and observations

The forecasts given above are close to those in the forecast made by Météo France apart from the cloud cover which Météo France forecast as being greater.

The METAR of 15:30 and the TAF for Agen aerodrome (50 km west of the accident site) and Toulouse aerodrome (70 km south) at 13:00 mentioned cloud cover between FEW and BKN with clouds based between 2,500 and 4,300 ft (between 760 and 1,300 m). The forecasts indicated a wind from the north-west at 5 to 7 kt. Observations in the afternoon at Agen indicated that the wind remained between 5 and 8 kt. It was stronger at Toulouse, between 9 and 12 kt.

On the TEMSI France chart valid at 15:00 UTC the flight is in a region characterized by cumulus or stratocumulus cloud cover which is SCT to BKN based between 3,000 and 4,000 ft and situated behind the most disturbed areas in the east of France.

1.8 Aids to navigation

Not applicable.

1.9 Communications

The pilot had a VHF radio. He communicated with the retrieve vehicle. He did not communicate with an air traffic services organisation, the flight having been made in Class G air space where radio contact is not mandatory.

1.10 Aerodrome information

Not applicable

1.11 Flight recorders

The regulations do not make the installation of recorders mandatory for this type of flight. F-HCCG was not equipped with one. It was however equipped with a camera and microphone, attached to a metal support, itself attached to the burner frame. It filmed the basked and its occupants for commercial reasons. This video was used for the investigation.

1.12 Wreckage and impact information

Examination of the envelope was limited by the fire damage. It did not bring to light any anomaly that might have contributed to the accident. The envelope's temperature indicator showed that the temperature was between 93°C and 110 °C since it was installed. The melting link[12] was in place.

Examination of the burners showed that the three pilot light controls were open. The whisper burner controls were partially open on the B and C burner blocks, and closed or slightly open on block A. The control of main burner A, item 1 on Figure 5, was in the "*straight*" position, aligned with the T-support bar, that is to say closed.

The gas pipes were in place and showed no breaks.

Examination of the four tanks, limited by the fire damage, showed that:

- the "*overflow*" valves were closed;
- three propane gas supply valves were closed, the position of the fourth being impossible to determine;
- three "*quarter-turn*" liquid propane supply handles were in the closed position or near to this, the position of the fourth being impossible to determine.

Two fire extinguishers were found at the site. The one near the basket was burned. That was the on-board extinguisher. The second, a 1-kg powder extinguisher for Class ABC fires was found a little further away, emptied. This was the extinguisher carried by the retrieve vehicle.

1.13 Medical and pathological information

The death and the injuries were mainly caused by the post-impact fire.

[12]It is marked 25 °C and is not supplied by the manufacturer Schroeder, the latter nevertheless considers that it should be understood as 125 °C.

1.14 Fire

The video recording as well as the examination of the wreckage and of the burner controls allowed the following fire scenario to be identified.

The basket struck the ground while the pilot lights were still lit. When it turned over, the main burners and the whisper burners were off. The examination of the wreckage showed that the fuel supply pipes had not been broken and that the positions of several burner controls were modified between the second impact and the end of the evacuation. The control of main burner A was "*straight*", and the valves of the whisper burners B and C were partially open.

The occupants fell towards the burner frame, and it is likely that one of them made contact with a burner control, causing the first temporary flame. It is possible that temporary pressure was exerted on the control of main burner A.

At the beginning of the evacuation, a second temporary flame appeared. This could correspond to the control moving from the 45° position to the straight position. According to the video recording, the foot of the first passenger to evacuate the basket could have made contact with this control.

The burners then became active again, in a continuous manner, until the basket was set on its side and the pilot shut down the gas bottles. This could have been the consequence of the whisper burner valves being opened by the passengers evacuating the basket. The video recording does not make it possible to ascertain this hypothesis.

The fire that started as a result of the burners being activated rapidly spread to the leather covering the inside of the basket and then to its wicker. The wind fanned it after the burners were extinguished.

According to the video recording, a passenger and then the pilot discharged the balloon powder extinguisher with the intention of protecting the victim's immediate environment. This clearly did not reduce the size of the fire, even in the area targeted.

The retrieve vehicle arrived about four minutes after the accident. The pilot got a second extinguisher from the vehicle, which he then discharged onto the fire with no significant effect.

Around thirty seconds later, when the survivors had moved away, a safety valve on a bottle of gas opened and violently reignited the blaze. This phenomenon was repeated several times for about ten minutes. The fire had more or less stopped when it was put out by the fire brigade about 25 minutes after the accident.

1.15 Survival aspects

The balloon configuration, after it had turned over, made it difficult to evacuate the occupants, blocked by the basket and hampered by the burner frame and its burners.

The applicable regulation[13] requires the presence of on-board safety equipment including a hand-held extinguisher in the pilot compartment. It does not specify the characteristics required for the extinguisher. The current certification regulation, CS31HB amendment 1, also requires the presence of an extinguisher (see paragraph 1.17.4). The AMC 31HB.72 (a) (4) associated with this requirement mentions a minimum capacity of 2 kg for powder extinguishers.

(13)French decree of 6 March 2013 on the conditions of use of untethered hot air balloons operated by a public transport company

An aviation fireman, when asked by the BEA, indicated that small powder extinguishers are effective if they are used in the first few seconds after a fire starts, and at an appropriate distance. When the fire has become established, these means are more or less ineffective.

For example, the American manufacturer Firefly Balloons has designed an optional fire extinguishing system in which the content of a fire extinguisher bottle attached to the basket is simultaneously discharged onto each burner and each fuel cylinder using a system of hoses connected to the extinguisher. The bottle is discharged by the pilot pressing the extinguisher button after having first removed the safety pin[14]. This system is rare in France.

(14)The manufacturer specified that the safety pin should be removed immediately before activating the extinguisher and not during the pre-flight preparation to avoid inadvertent activation during the flight which would lead to the burners being temporarily out of operation.

Figure 6: installation of fire extinguisher in accordance with option proposed by FireFly Balloons

The extinction of the flame is only provisional, since the gas can catch fire again on contact with hot surfaces or incandescent particles. Control of a propane fire thus depends on cutting off the fuel supply which is done in theory by applying the emergency procedure before landing.

1.16 Tests and research

1.16.1 Weight sheet

The weight sheet filled out by the pilot before the flight made it possible to estimate the total weight of the balloon as about 1,500 kg on take-off. This document does not refer to the loading chart in the Flight Manual that indicates the weight that the balloon can lift with an interior temperature in the envelope of 100°C in relation to the altitude and the temperature. The Flight Manual states that the maximum continuous operation should not be above 100 C, the maximum temperature is 110 C. The pilot said that he did not refer to the loading chart as he considered that he was in his usual operating envelope.

When applied to the flight conditions (altitude of about 500 m and ground temperature of 15°C) this curve leads to a maximum value of about 1,360 kg to comply with this limit of 100°C. If we take the temperature of 13°C given by the pilot, a value of around 1,410 kg is obtained. The manufacturer Schroeder supplied a method of calculation that made it possible to estimate that an interior temperature of 111°C made it possible for the balloon to rise with a weight of 1,500 kg. The Flight Manual states that a temperature above 110°C leads to a deterioration in the porosity and the strength of the envelope fabric. The latter would deteriorate more quickly if 110°C was exceeded for long periods. Consequently, the envelope operating limit was fixed at 110°C. In other words, operating the balloon at a temperature slightly higher than the planned 100°C, has an influence on the envelope's service life and its performance (specifically its gas consumption) but not on its immediate airworthy condition.

Influence of weight on balloon behaviour

The Hot Air Balloon Flight Training Manual[15] recalls that the pilot has only a few kilos of force available to fly (or modify the flight path of) a machine whose weight is of the order of a few tons !

In general, for a given balloon, a heavier balloon (thus hotter) requires more heating actions than a lighter balloon (thus cooler) to stop descent[16]. This must be taken into account when anticipating flying inputs.

On the other hand a lighter balloon is more vulnerable to turbulence due to the lower tension of the envelope.

The envelope manufacturer estimated that the effectiveness of the turning vents is not greatly affected by a balloon's heavy weight.

[15] Work of reference for pilots. Published by Cépaduès.

[16] The heat of the air in the envelope mainly dissipates through infra-red radiation, in proportion to its temperature (in Kelvin) to the power of 4. To cancel the balloon's vertical speed of descent, a heavier balloon (hot) has to be heated more than a lighter balloon (cold) which will dissipate less heat.

1.16.2 Study of documentation

Without claiming to carry out an exhaustive review of the technical and regulatory literature applicable to balloons, the following points are worthy of mention:

- the Hot Air Balloon Flight Training Manual states that, for a normal landing, the pilot lights must be turned off before contact with the ground. If there is enough time, it is advisable to shut the bottles and vent the burners. It is further stated that turning off the pilot light before contact with the ground can prevent any accident that might occur if, on impact with the ground, a passenger or you instinctively grab the handle and start the burner. In case of a very hard landing, the pilot lights must always be turned off and if possible the valves on the bottles closed. The pilot must also ensure that he cannot be ejected. This document also describes the phenomenon of convection and states that flight in thermal activity conditions is very difficult and is dangerous in character (turbulence, updrafts). The effects of turbulence are recalled, with possible deformations in the envelope (see Figure 6 below). These deformations push the hot air out of the base of the balloon, thus reducing its lift. It is also stated that turbulence of convective origin is often dreaded by the balloon pilot, because not only can it not "be seen" but it can be so strong that flight becomes uncomfortable or even dangerous;

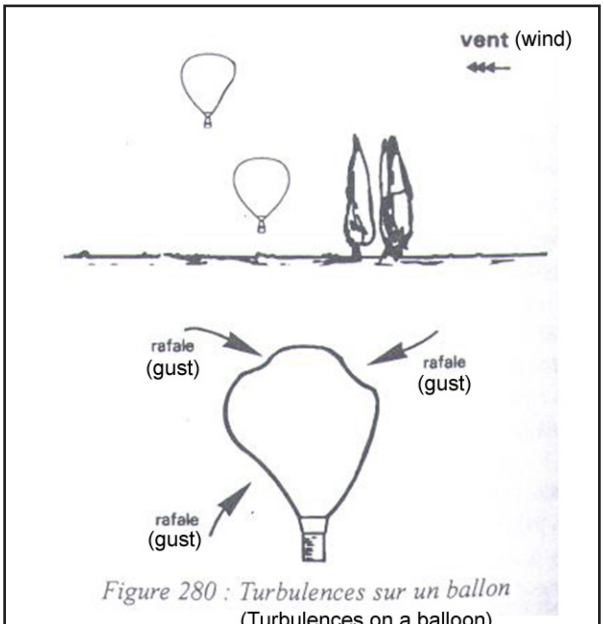

Figure 6: Illustration from "Hot Air Balloon Flight Training Manual ", published by Cépaduès

- Flight Manuals from various manufacturers were consulted[17]: they systematically call for the turning off of the pilot lights in case of a hard or fast landing, without however defining the thresholds to characterise such events. Two of them give the possibility of not turning off the pilot lights for a normal landing, according to the pilot's assessment of the landing conditions (mainly the wind);

- a few Operations Manuals were considered. The majority mentioned turning off the pilot lights during a normal landing. Some do not mention this or give vague wordings or leave it to the pilot's judgement in relation to landing conditions. For emergency landings (fast or hard), almost all mention actions aimed at preventing a fire: turning off the pilot lights, closing the tanks and venting the fuel pipes.

[17] Lindstrand, Schroeder, Cameron, Ultramagic

1.17 Organizational and management information

1.17.1 Operator

The company, Quercy Pluriel, in which the pilot was the Accountable Manager and sole pilot, held an AOC issued by DSAC-South regional office on 22 June 2012. It operated two hot air balloons: a Lindstrand hot air balloon of 3,400 m3 and a Schroeder hot air balloon, F-HCCG, acquired later. It had produced an Operations Manual. Many paragraphs in part B: Use were cut and pasted from the Lindstrand Flight Manual. This part does not show the differences in procedures between the two balloons.

The emergency actions to adopt during a "fast" or "hard" landing are mentioned: turning off the pilot lights, closing the tank valves, venting the fuel pipes if there is time, and that the pilot must take care not to be ejected.

Use of the harness is not specified. During the investigation, the pilot said that he considered that the harness limited movements in the basket and would have made his evacuation more complicated.

The normal landing procedures state: Immediately before touchdown, if the conditions allow it, turn off the pilot lights and if possible close the liquid valves and vent the fuel lines. Note: "if the conditions allow" does not appear in the Lindstrand manual from which this paragraph is copied.

The "Limitations" section of this manual is an almost complete copy-paste of the Lindstrand Flight Manual. The limitations are thus relevant for the first balloon but do not correspond entirely to the limitations described in the Schroeder Flight Manual and in the Cameron Flight Manual, relevant for F-HCCG. For example, the wind limitations indicated are consistent for both envelopes, as is the necessity to respect the maximum weight determined from the loading chart. On the other hand, the description of damage to the envelope that is acceptable for a flight differs between the Lindstrand and Schroeder envelopes, as do the temperature limits. These differences do not appear in the Operations Manual.

This manual has some inconsistencies on the technical description of the F-HCCG balloon and on the applicable maximum number of occupants (The envelope with a capacity of 9 passengers, including the pilot [..]; The basket with a capacity of 10+1 [..], certified capacity: 8 people + 1).

It contains several mistakes relating to paragraph numbering and repetitions of paragraphs relating to the quantity of fuel to take on board.

Recurrent training is ensured through annual theoretical training courses. The content of these courses is not described. A practical proficiency check is planned once a year with a pilot named by the operator, who is not necessarily an instructor.

Flight preparation must include consulting TAFs and METARs of NOTAMs and low altitude areas, filling out a weight sheet and studying the loading chart. The pre take-off check list specifies checking that the maximum weight is not exceeded according to the conditions at that time.

1.17.2 Hot air ballooner representatives

The FFAé and the CNPPA explained that systematically turning off the pilot lights has always been the reference procedure when conducting a landing. They stated that in practice pilots do not act in such a systematic manner. The reasons for this deviation are probably a combination of:

- training that was sometimes less strict about this point, in past decades;
- pilot recurrent training little formalised;
- inadequate risk awareness.

Videos can be found on Internet showing hot air balloon landings with the pilot lights lit, in calm to moderate wind conditions. The FFAé and the CNPPA explained that using burners on the ground kept the balloon inflated and upright, thus making it easier for the teams to find and retrieve it. This could encourage pilots to leave the pilot lights on when landing so as not to have to relight them with the piezoelectric system.

The FFAé stated that it had reinforced its messages on the necessity to systematically turn off the pilot lights before landing. In particular, the federal school now requires that its instructors make the student turn off the pilot lights before any contact with the ground. In the past, training flights were not always as strictly carried out. The FFAé underlines the fact that systematically turning off the pilot lights, even in very light winds, leads pilots to make this an automatic action. The reflexes thus developed are more likely to be repeated in a stressful situation, during a landing in a strong wind, for example.

Hot air balloon flights are usually carried out early in the morning or at the end of the afternoon in order to avoid periods of significant thermal convection, particularly for landing. It is thus common practice to take off between 2 h and 2 h 30 min before sunset. In winter, take-offs can occur earlier.

The FFAé also has a reporting system that makes it possible for each pilot to anonymously share all incidents that he has experienced.

The FFAé organises, in various regions, flight safety seminar days, open to all pilots. Attending these days can be used by a PT pilot as a means of complying with the theoretical recurrent training requirements which the operator must have defined, in accordance with the regulations.

The CNPPA has also recently started organising this type of day. Its aim is to bring together balloon professionals in order to represent them to the authorities. The CNPPA has stated that it is in favour of maintaining an AOC type system and developing training adapted to the professional activity, including technical and commercial aspects.

During discussions with the BEA, the CNPPA and the FFAé expressed their reservations about organising two successive morning flights, due to equipment and time constraints that would be generated. This level of performance by an operator seemed to them not to be compatible with maintaining acceptable safety margins.

1.17.3 DGAC

Note: this paragraph describes the regulatory context in force at the time of the accident and in the preceding period. It is defined by national regulations.

1.17.3.1 Balloon public transport

Balloon public transport (CAT) requires that the operator holds an AOC whenever the carrying capacity, including crew, is greater than four persons or 400 kg in weight[18].

The decree of 4 January 2011[19] introduced requirements applicable to an operator wishing to perform balloon PT flights, including those relating to the issuing of an AOC. Its provisions were changed with the decree of 6 March 2013[20] (applicable on 21 September 2013). These regulatory changes specifically made it mandatory for the pilot to be strapped in throughout the flight[21].

Oversight of balloon operators is undertaken by the DSAC-regional office according to the directives defined by the DSAC-HQ. Before September 2012, oversight inspectors referred to the Public Transport Technical Inspection Manual (MCT TP) which had been written for helicopter and aeroplane PT. This document contains an introduction to the Guide for examining an Operations Manual, in which the following points are mentioned:

- in the introduction to the manual, the operator undertakes that the manual complies with the terms of the regulations and its AOC and contains the operational instructions that its personnel must abide by. The Operations Manual is therefore one of the main means by which the operator ensures operating safety;
- the DSAC-regional office should be capable of correctly dividing its time between this examination and the other actions it must carry out as part of the issuing of the AOC and continuous oversight of all the operators for which it is responsible.
  The role of the DSAC-regional office, when it declares its acceptance of the manual, is not to carry out an exhaustive, detailed examination of the content of the manual, given the work load that this represents as well as its legal inability to check some parts or aspects of the manual, not governed by the operational regulations. Acceptance of the manual does not thus guarantee for the operator that the manual presents no non-conformity with the regulations. It is necessary to make operators aware that they alone are responsible for conformity. On the other hand, acceptance of the manual by the administration must attest, for the operator, that the administration's non-exhaustive examination, within the limits of its own means and taking into account the operational regulations currently in force, did not identify non-conformities that might compromise operating safety.

In order to standardize the examination of AOC's, the following part of this text defines some elements that must systematically be checked, including procedures that have a direct impact on safety.

On 4 September 2012, DSAC-HQ officially sent the Public Transport Technical Inspection Manual to the DSAC-regional office, this being the product of an internal working group to take into account the specificities of this activity.

[18]PT with fewer passengers is possible without an AOC according to article R330-1 of the Civil Aviation Code. EU regulation No 965/2012 eliminates this difference and requires an AOC for any CAT operation (application in 2017).

[19]French decree on the conditions of use of untethered balloons operated by an air transportation company.

[20]French decree on the conditions of use of untethered hot air balloons operated by a public air transportation company.

[21]The 2011 French decree made it mandatory for the pilot to be attached for a landing with wind of more than 8 kt. The 2013 French decree extended this requirement for the duration of the flight. The operator had benefited from a series of waivers. The last one was valid until 31 December 2013. These waivers were intended to cover the transitional phases between the enforcement of the French decrees and the availability of approved harnesses.

This document specifically states that:

- to be acceptable, the Operations Manual must comply with the structure stated in the previously mentioned French decrees or, if the operator chooses a different structure, include a certain number of mandatory points. The Operations Manual is not subject to approval (unlike the Flight Manual produced by the manufacturer in the context of the certification of an aeroplane). It is nevertheless studied by DSAC-regional office and the issuing of the AOC means that it is acceptable. The DSAC-regional office can impose modifications that it may judge necessary (part 3.4 of the annexes to the decrees of 2011 and 2013 mentioned above). It must be provided with the amendments. The DSAC stated that it provided an Operations Manual model to operators wishing to obtain an AOC, while specifying that they had to adapt it to their specific situation;
- the oversight inspector carries out a minimum of one audit every two years from the initial AOC being issued;
- the oversight inspector may undertake ground checks before a flight in some cases (serious or chronic failings on the part of the operator, accidents or incidents that have occurred during operations, reinforced oversight).

Ground checks outside of the situations previously described are also possible but in practice they are difficult to organise. The variability of the take-off places and times, which depend on meteorological conditions, make it difficult for an inspector to organise a check.

Deviations or comments[(22)] made during audits are ranked according to their importance and the operator must put in place the required corrective measures. Audits generally take place once every two years.

(22)Deviations are noted if a non-conformity with the applicable regulation is noted. Comments are observations with respect to points to be improved that are not a regulatory non-conformity.

At this time, a dozen agents from the DSAC-regional office undertake oversight of around a hundred balloon operators. They take a training module on hot air balloon operations (since October 2013) in their training course for the position of oversight inspector. The same agents also ensure or participate in the oversight of other types of operator (aeroplane or helicopter PT, aerial work, etc.).

Follow-up on technical, operational and regulatory questions on balloons is divided between five agents of the DSAC-HQ. Two of them have a balloon pilot's licence. There are no in-flight inspections for balloons similar to those that exist for aeroplanes or helicopters operated in PT.

Balloon PT operators are exempt from the aircraft operator's fee as defined by article 5 of the French decree of 28 December 2005[(23)] which became applicable with the introduction of the oversight associated with an AOC. The DGAC agents contacted during the investigation said that the discussions with the representatives of the operators revealed that the calculation method specified by this decree led to a fee that would be economically unrealistic for the majority of operators. They specified that for operators other than balloon operators an in-flight check was not specifically billed by the DGAC and that the latter did not pay the operator for transporting the inspector for this check.

(23)Relating to fees for services rendered by the State for civil aviation safety and security and implementing articles R.611-3, R.611-4 and R.611-5 of the civil aviation code.

1.17.3.2 Oversight of Quercy Pluriel

Within the previously-defined context, the oversight inspector who dealt with the AOC request at the beginning of 2012 had at his disposal the decree of 4 January 2011 quoted in paragraph 1.17.3.1 above and the MCT TP, the MCT TP for balloons not yet being available at that time. He stated that he had not received any specific training on balloon operations. He thought that this lack of knowledge may have contributed to not noting errors or ambiguities in the Operations Manual. DSAC-regional office agents expressed a desire to take advantage of such a training course. The AOC was issued on 22 June 2012.

Quercy Pluriel was subject to an audit on 28 June 2013. The operator was then using only one balloon registered F-HCJC. The deviations noted were in:

- ❒ composition of the flight file (no centralisation of flight preparation information, no specific weight sheet);
- ❒ composition of the pilot's log;
- ❒ presence of technical waivers on board the balloon;
- ❒ validity of the on-board extinguisher on F-HCJC.

Comments were also recorded with respect to:

- ❒ Operations Manual (method for filling in the weight sheet to be defined, list of crew);
- ❒ obtaining an attendance certificate for the recurrent training course;
- ❒ division of balloon documents between the balloon and the retrieve vehicle;
- ❒ approval of a take-off site.

The company supplied an update of its Operations Manual in October 2013. In November 2013, the DSAC-regional office closed the audit, considering that the modifications of this update were satisfactory.

At the time of this audit, balloon F-HCCG was in the process of being added to the operational specification sheet (fleet list), associated with the AOC (registration effective on 8 August 2013). A check for conformity[24] of this balloon was carried out without any anomalies being identified.

[24]This type of check verifies the presence of equipment required by the French decrees mentioned. It is different from airworthiness checks intended to renew the ARC.

1.17.3.3 Licences

The balloon pilot licensing system is defined by the decree of 31 July 1981, mentioned above, in paragraph 1.5. It provides that after acquiring the certificate, a pilot can renew his licence on the basis of a declaration of his recent experience. The privileges of the licence make it possible to undertake this PT activity after having performed at least 35 flight hours of which 20 as pilot-in-command and for balloons with a volume of more than 3,400 m3, a minimum number of hours in relation to the volume of the balloon, defined by the decree of 6 March 2013, mentioned above, in paragraph 1.17.3.1. A PT pilot's recurrent training and proficiency check must be defined by the operator according to the provisions of the latter decree, which does not make a flight with an instructor mandatory, but simply with a "peer" hot air balloon pilot. The people contacted by the BEA during the investigation stated that when this regulation was prepared the number of instructors recorded was not adequate to ensure the systematic presence of an instructor during an annual proficiency check flight.

This decree states that the qualification as instructor gives its holder the right to give and approve in-flight instruction relating to a balloon pilot's licence. There is no examiner qualification, as is the case in other types of aviation. However a list exists, drawn up by the DSAC, approving a few instructors for the training and examination of instructors.

The future European regulations regarding balloon pilot's licences will be applicable on 8 April 2020. It provides for the creation of an examiner qualification but not for a balloon commercial pilot's licence. Nevertheless, the holder of a private pilot's licence (BPL) will be able to undertake commercial activity after having logged 50 flight hours, 50 take-offs and landings and successfully passing a proficiency check with an examiner.

1.17.3.4 Age limit for pilots in public transport

The pilot was 64 years old at the time the AOC was issued, and 66 at the time of the accident.

The DGAC stated that there had been internal discussions as to whether the age limit specified in the CAC, then in the TC, that's to say 60, was applicable to balloon pilots undertaking public transport activities, at least since 2009. Various considerations, sometimes contradictory, had to be taken into account in this debate: the non-professional nature of balloon pilot's licences, the reference to the professional flight crew register in articles in the CAC and the TC, evolutions in French and European regulations, and the pilot age distribution (it was estimated in 2009 that the 50-65 age class represented 42.5 % of balloon pilots).

The "Public Transport Technical Inspection Manual" did not contain any information on this subject.

In response to this situation, the DSAC-HQ licence centre formalised a note in February 2016 intended for DSAC-regional office agents in charge of licences: it considers that in accordance with the code of transport (articles L6521-1 and L6521-4), activity as a balloon pilot holding a French licence cannot be undertaken in public transport beyond the age of 60[(25)]. European regulations on pilot's licences, modified in 2015, brought this limit up to 70 years specifically for balloon pilots. This provision will apply in France from 8 April 2020, the date at which French licences will no longer exist. Pending this, pilots over the age of 60 can apply to the DGAC for the conversion of their French licence into a European licence in order to benefit from this higher age limit.

[(25)]According to article L6521-4, the activity of pilot […], mentioned in paragraph 1 of article L6521-1, cannot be carried out in public transport beyond the age of sixty years. Article L6521-1 states: A civil aviation professional crew member is any person who for themselves or for others, for commercial gain or in return for payment, regularly and principally carries out one of the following functions: 1 The command and conduct of aircraft […]. The DGAC considers that operating with an AOC is an activity carried out regularly and principally, the burden of proof being on the pilot over sixty years to prove that he does not carry out this activity regularly or principally.

1.17.4 EASA

1.17.4.1 Certification

In the context of its attributions, EASA undertakes the tasks of defining the criteria for certification applicable to balloons, which were previously undertaken by the European states. The current reference text is CS31HB.

The CS31HB does not explicitly refer to a basket turning over. Nevertheless it states that:

- "*The balloon must be safely controllable and manoeuvrable without requiring exceptional piloting skill. Associated operational limitations must be established and included in the Flight Manual*" (CS31HB.20);
- "*The basket must be of a generally robust design and afford the occupants adequate protection during a hard or fast landing*" (CS31HB.27(d))[26];
- "*Where basket proportions and compartmentation are such that more than one occupant may fall on top of another during landing, there must be means to minimise this possibility*" (CS31HB.59(e)), such as "*Alignment of the basket for landing using turning vents* [...]" (AMC 31HB.59(e));
- "*Guards must be fitted to all fuel cells to protect the valves and other fittings from fuel leakage in case of: (1) Inadvertent operation* [...]" (CS31HB45(e));
- "*Controls must be so arranged and identified to prevent confusion and inadvertent operation*" (CS31HB.49(a)) or *"unintended interference from passengers* [...]" (CS31HB.49(b)). There are no acceptable means of compliance associated with these requirements nor any description of situations to be taken into account.

This regulation also requires the presence of an extinguisher. AMC 31HB.72 (a) (4) associated with this requirement mentions a minimum capacity of 2 kg for powder extinguishers.

Lastly, it states that the "*heater system must be designed so that in the event of any single failure, it will retain sufficient heat output to maintain level flight*." (CS 31HB.47(f)).

Schroeder balloons were certified for the first time in 1987, before EASA was set up, based on the LFHB regulations[27] issued by the German authority. Equally the type of Cameron basket used on the day of the accident was certified in September 2001 in accordance with British BCAR 31 requirements, then in January 2013 in accordance with the requirements of CS-31 HB amendment 1. The burner type was certified in January 1993 (BCAR). The frame was certified in May 1996 (BCAR).

1.17.4.2 Air operations

Note: this paragraph describes the new regulatory framework defined by the European legislation (Commission Regulation (EU) No 965/2012 modified by Commission Regulation (EU) No 2018/395 of 13 March 2018 laying down detailed rules for the operation of balloons pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council). This regulation is applicable from 8 April 2019.

The new regulatory framework modifies the requirements regarding air operations and licences for balloon operation. This evolution is based, in particular, on the Opinion[28] published by EASA on 6 January 2016 following the consultation of various actors.

[26] An acceptable means of compliance is associated with this requirement. It defines test conditions and recalls the qualities of the traditional construction in wicker.

[27] Lufttüchtigkeits-forderungen für Heißluftballone.

[28] https://www.easa.europa.eu/document-library/opinions/opinion-012016

The new regulation takes into account the "*the less complex nature of commercial operations with balloons as compared to other forms of commercial aviation*" and is consistent with the production of rules which are "*proportionate and founded on a risk-based approach*" (point 6).

It defines a new category of commercial air transport: commercial passenger ballooning (CPB) which is "*a form of commercial air transport operation with a balloon whereby passengers are carried on sightseeing or experience flights for remuneration or other valuable consideration.*" The new regulatory framework requires, for operators, a declaration of activity as defined in Regulation (EU) No 965/2012 instead of an AOC as for other CAT activities.

In summary, a declaration is based on the operator sending to the oversight authority, before the start of operations[29], a form found in the appendix of the Regulation in force[30] in which it undertakes to comply with the applicable regulations. Unlike the steps required to obtain a certificate, the authority does not have to receive and study, before the start of operations, a file describing the operator's structure, the equipment used and its procedures.

According to EASA, this declarative approach was initially introduced for NCC and SPO activities.

The declared and certified organizations are subject to an oversight defined by the requirements of the ARO part of Regulation (EU) No 965/2012, which is the same for all types of air operation. In the context of this oversight, inspections by the competent authority are based on audits and inspections, including ramp and unannounced inspections (ARO.GEN.300 (b)), or any information deemed useful (ARO.GEN.300 (f)). The scope of oversight shall take into account the results of past oversight activities and the safety priorities (ARO.GEN.300 (c)) and be based on the assessment of associated risks (ARO.GEN305 (b) and (d)).

For organisations certified by the competent authority an oversight planning cycle not exceeding 24 months shall be applied (ARO.GEN.305 (c)).

The AMC1 ARO.GEN.305 (d) relates to the declared organisations. As such, CPB operators should be included in the oversight planning no later than 12 months after their declaration and be subject to at least one inspection every 4 years. This is a minimum rate and the competent authority should programme additional oversight actions in relation to a risk assessment, including random inspections.

As indicated in the Opinion published by EASA, during the preliminary consultation, experts expressed their reservations as to the benefit, for balloon operators, of a management system as initially required by ORO.GEN.200 of Regulation (EU) No 965/2012. In accordance with annex IV to Regulation (EU) No 216/2008, EASA kept the requirement of a management system. However, adjustments are proposed through AMC and GM associated with BOP.ADD.030 and BOP.ADD.040 of the new regulation concerning balloon operations. These adjustments concern the organisation for the check for conformity (in terms of frequency, content and independence) as well as the personnel qualification and experience criteria.

[29] As things stand at present, the regulation does not specify a minimum notification period to be complied with.

[30] The declaration form is available at https://eur-lex.europa.eu/resource.html?uri=uriserv:OJ.L_.2018.071.01.0010.01.FRA.xhtml.L_2018071FR.01003402.tif.jpg and https://eur-lex.europa.eu/resouhttps://eur-lex.europa.eu/resource.html?uri=uriserv:OJ.L_.2018.071.01.0010.01.FRA.xhtml.L_2018071FR.01003501.tif.jpg

The balloon operator management system like those for other operators, must include risk identification and management, as well as reporting on events to the competent authority.

During the work presented in the Opinion quoted above, an assessment of the foreseeable impacts of this new regulation had been carried out, in particular with respect to safety.

From the safety point of view, the choice of a declarative approach was based on the following argument: "*It should be noted that concerning commercial operations, the Agency's balloon safety analysis did not give any clear indication in favour of either an AOC or a declaration as regards the impact on safety.*" It was also specified that the debate between the experts consulted did not produce a majority in favour of one or other of the systems.

In parallel, the Opinion specified that the fatal accident rate in Europe was estimated over the period 2010-2014 at $6x10^{-5}$ per commercial flight (that's to say six fatal accidents per 100,000 flights). For non-commercial flights, this rate was estimated as being approximately double. It was recalled that the fatal accident rate for CAT operations on commercial transport aeroplanes was estimated at $1.8x10^{7}$.

The published Opinion also referred to another EASA document entitled "*European General Aviation Safety Strategy*"[(31)] dated August 2012 which substantiated the choice of a proportional regulatory approach for general aviation safety in contrast with the more extensive regulation for CAT. This document, still in force, proposes a hierarchy in the acceptance of accident risks according to the various categories of persons, from those who are least likely to accept the risk of an accident to those who accept it more naturally.

[(31)] http://easa.europa.eu/system/files/dfu/European%20GA%20Safety%20Strategy.pdf

To summarise, the safety objectives must be higher for the former, uninvolved, than for the latter, directly involved in their own safety:

"*1. Uninvolved third parties*
2. Fare-paying passengers in CAT [Commercial Air Transport]
3. Involved third parties (e.g. air show spectators, airport ground workers)
4. Aerial work participants / Air crew involved in aviation as workers
5. Passengers ("participants") on non-commercial flights
6. Private pilots on non-commercial flights".

This hierarchy does not detail how paying passengers, taking part in operations that are not formally classed as commercial air transport (CAT), are considered.

As this document was earlier than the Opinion and the new regulation, the new category proposed, CPB, did not appear. EASA specified, during the investigation, that CPB passengers were to be considered at the same level as "*CAT balloon*" passengers, which it distinguishes from the "*CAT*" category. EASA did not specify how the "*CAT balloon*" should be inserted in the hierarchy above. It was specified that the modifications to the regulations should not lead to a safety rate which is lower than the current estimated rate. However, EASA did not contest waiting for advances in safety but without specifying a quantified target.

Apart from this principle of proportionality, the new regulation "*[is] founded on a risk-based approach*" (point 2 of regulation) to direct and size its actions, specifically in relation to regulation and oversight. To this end, EASA now relies on its Safety Risk Management (SRM) process. This process progressively integrates the drawing up and updating of risk portfolios by area of activity. In its document "Annual Safety Review – 2016"[32], EASA had already presented a balloon risk portfolio for the period 2011-2015 (see appendix 1). This table grouped together the "*Safety Issues*" and their consequences ("*Key Risk Areas - Outcomes*"). In this version, the possibility that a fire may result from a failing in the operational management of the flight was not identified.

[32] https://www.easa.europa.eu/system/files/dfu/209735_EASA_ASR_MAIN_REPORT.pdf

Lastly, EASA is leading normalisation inspections to check on application of the European regulation within Member States, in accordance with Regulation (EU) No 628/2013. EASA stated that these inspections made it possible, for example, to check if oversight of the declared organisations is in compliance with regulatory requirements.

These inspections also contribute to the harmonisation of the implementation of these oversights between the various European countries.

1.18 Additional information

1.18.1 Similar accidents and incidents

The following accidents were the subject of safety investigations. They have similarities with the accident to F-HCCG :

- the accident on 1 June 2003 to the Schroeder Fire Balloons G (8,500 m3) balloon at Dorfen (Bavaria, Germany)[33]: the pilot was undertaking a commercial flight with thirteen passengers on board. During the landing (wind around 10 kt) on a narrow track that had a sloping camber, the balloon pivoted and turned over onto the smaller side of the basket. The basket turned over completely and came to a stop on the burner frame, trapping the occupants, who nevertheless managed to escape when a fire broke out. Two fuel tanks exploded. Six occupants were injured. The BFU investigation report stated that the pilot lights had probably not been turned off and that, according to witnesses, the burners had been activated after the basket had turned over;
- the accident on 16 April 2007 to the Cameron Z 350 hot air balloon registered F-GPLV at Villaines-les Rochers (Indre-et-Loire)[34] : the pilot was making a commercial flight with eighteen people on board. On landing in a field, the basket bounced several times and came to a stop at the end of the field on the edge of a ditch. It fell into the ditch. Eight persons were burned by two successive flames. The BEA report stated that the flames resulted from unintentional actions on the burner controls while the pilot lights had not been completely extinguished;

[33] Available in German on the BFU site http://www.bfu-web.de/DE/Publikationen/Untersuchungsber-ichte/2003/Bericht_03_3X086-0.pdf

[34] Report available on the BEA website: http://www.bea.aero/docspa/2007/f-lv070416/pdf/f-lv070416.pdf

- the accident on 11 August 2007 to the FireFly 12B hot air balloon registered C-FNVM north-east of Winnipeg (Manitoba, Canada)[35]: the pilot was making a commercial flight with twelve people on board. During a landing in a strong wind, the basket bounced several times and then came to a stop upside down on the burners. There was a propane leak and a fire broke out while the passengers were starting to evacuate. Two gas bottles and an extinguisher exploded. Seven people were injured. The TSB report indicated that the fire was fed by fuel leaking from the pipes damaged during landing. The valves had not been closed and the pilot lights had not been turned off. TSB Canada issued two recommendations: one aimed at strengthening the oversight of balloon operators by the Canadian civil aviation authorities so that paying passengers on board balloons benefited from the same level of safety as paying passengers using other aircraft with the same carrying capacity, the other aimed at developing an emergency fuel shut-off device;
- the accident on 21 April 2013 to the Cameron hot air balloon US Z-225 registered N65625 at Chester Springs (Pennsylvania, USA)[36]: the pilot was carrying out a sightseeing flight with ten passengers. The pilot planned a hard landing because of the wind. The basket struck the ground and turned on its side while the pilot lights were lit. The burners were briefly activated, probably unintentionally by passengers thrown towards the outside of the basket. The pilot, in his witness statement, mentioned the time it took to turn off the three pilot lights which is longer than the time required to turn off a single burner on a smaller balloon. The NTSB used this report and another to recommend that the FAA increase oversight of balloon operators carrying out sightseeing flights[37] so that it is comparable to that applied to operators of aeroplanes and helicopters undertaking the same type of flights.

The FFAé has been using a reporting system (REX)[38] since 2011. At the time of writing this report it contained about forty entries. These events were not the subject of a safety investigation:

- entry 6338 describes a flight made by a pilot with fifteen passengers. On landing, the pilot noticed a ditch at the last minute when he had just pulled the rapid deflation line and could no longer go around. The basket slowly tipped into the ditch. The pilot turned off the pilot lights and closed the cylinder valves. During the evacuation the burners were activated, causing burns to some passengers. The pilot thought that the control of one of the burners, still hot, was inadvertently activated while the passengers were exiting. The entry mentions that the meteorological conditions were somewhat unstable;
- entry 6307 describes a solo flight made by a student pilot. During the approach, the balloon touched a tree. The student pilot used the heat then the valve. The balloon hit the ground near a ditch and some bushes. The pilot lights had not been turned off. One burner lit up, probably on its control coming into contact with a branch. A fire started, which was brought under control by firemen who arrived a short time later. The text of the entry mentions the effect of stress which led the student to make excessive flying inputs and to forget to turn off the pilot lights.

Note: These two events seem to correspond to the regulatory definition of an accident. Accidents must be the subject of a declaration to the authorities and be the subject of a safety investigation by the BEA.

(35) Available in English on the TSB website: http://www.tsb.gc.ca/fra/rapports-reports/aviation/2007/a07c0151/a07c0151.asp

(36) Available in English on the NTSB website: https://www.ntsb.gov/_layouts/ntsb.aviation/brief2.aspx?ev_id=20140615X80021&ntsbno=ERA14LA290&akey=1

(37) https://www.ntsb.gov/safety/safety-recs/RecLetters/A-14-011-012.pdf

(38) The reporting system portal for aviation federations is accessible at: http://rex.isimedias.com

The decrees of 2011 and 2013 mentioned in paragraph 1.17.3.1 include, for PT operators, an obligation to report events to the authorities. As of the date of the writing of this report, the DGAC database contained 43 event reports received over the 2011-2016 period, of which 31 came from the BEA (28 accident and three incident or serious incident summaries) and 12 from operators or air navigation services.

1.18.2 Statement from an operator concerning commercial aspects

Another operator explained that a ticket can be sold either directly by the operator or via commercial partners such as on-line shopping sites offering tickets at reduced prices. In the latter case, the operator offers a product (for example a flight in a given region of interest for tourists) to the shopping site whose reputation and visibility reach a wider public. If the latter believes that the product on offer is commercially good, it registers it on its site by proposing a significant reduction in comparison to the direct sales price posted by the operator. Passengers buy a reduced price ticket-coupon from the site, then contact the operator to organise the flight. After the flight, the operator presents the passenger coupons to the site and receives the sum corresponding to the reduced price less the site's remuneration. The sales conditions state that the flight may be postponed owing to weather conditions. In this case the passengers make another booking before the end of the ticket-coupon validity.

The sum received by the operator through this system is thus much lower than the price of a direct sale. Nevertheless an economic balance can be achieved by mixing the two types of sale and by adapting the organisation and the commercial strategy of the operator. In general this supposes an increase in the load capacity of the aircraft to reduce the cost per passenger. It is also necessary to be ready to handle a significant increase in activity.

The operator consulted thought that it was difficult to reach economic balance with a balloon with about a dozen places through this system of website booking.

The pilot of the accident said that this factor did not play a part in his decision to undertake the flight and that his activity was economically balanced.

1.19 Useful or effective investigation techniques

Not applicable.

2 - ANALYSIS

2.1 Scenario

The pilot undertook the flight in the middle of the afternoon after having decided not to make the planned flights in the morning because of wind. The meteorological forecasts that the pilot had in his possession did not specifically mention the presence of convection. It was, however, possible to deduce such a presence by consulting the available aviation reports and forecasts (TAF, METAR, TEMSI). These would have allowed the pilot to acquire a wider, up to date and global view of the situation (similar to a rear sky) which would have supplemented the earlier and more local forecasts obtained on Internet. The pilot stated that he looked at the sky to decide on making the flight. The video of the preparation of the balloon and the start of the flight shows that clouds generally associated with these convective phenomena were present. The investigation showed that balloon pilots generally fly early in the morning and at the end of the afternoon in order to avoid the phenomena of aerological convection that have risks associated. The pilot's decision to undertake the flight thus appears to be questionable. It may have resulted from an incorrect interpretation of this sign or from an under-estimation of the risks run.

It is also possible that he may have wanted to avoid cancelling another commercial flight. The organisation of two flights in the morning was an ambitious objective, which ballooner representatives judged unfavourable for calm and safe organisation, due to the constraints that it imposed.

The taking into account of the meteorological forecasts when preparing the flight constitutes the main barrier against hard or fast landings. It should be recalled, however, that the pilots' need for detailed forecasts is not always met, on the scale of the short distances covered by balloons, sometimes at a significant distance from the usual aviation observation sites (aerodromes). This often leads pilots to check that information from various sources (e.g. websites, call to a forecaster) tallies. The pilot's local assessment before departure is not always valid on the landing site.

The flight took place normally until the first signs of turbulence. When a balloon pilot encounters convective and turbulent meteorological conditions, he may possibly delay the decision to land until the convection stops due to the diminishing sunlight, on condition that he has enough fuel. Because of the mid-afternoon take-off, the accident pilot did not have enough fuel to ensure the possibility of continuing the flight until after the end of the convection. He may also have feared that the turbulence might increase in strength and thus judged it preferable to land without further delay.

The video recording shows that the pilot had difficulties in controlling the rate of descent during the landing despite significant heating inputs in the last part of the descent. The investigation was not able to clearly determine the factors that contributed to this high rate of descent:

- the condition of the envelope does not seem to be in question since:
  - it had been inspected in April and September 2014 and had passed the tear tests following signs of operation at high temperatures, close to the limits published by the manufacturer;
  - the heating cycle during the climb and cruise does not appear excessive;
- the basket manufacturer considered that using the coupling shown in Figure 4 could decrease the heating power of the burners. The investigation was not able to determine if this phenomenon had in fact contributed. The videos do not show any evidence of obviously abnormal burner behaviour;
- the balloon's weight, although slightly lower than on take-off, given the gas consumption during the flight, theoretically required a more sustained heating cycle than a lighter balloon due to the greater heat losses. This may have made it more difficult to rapidly correct an excessive rate of descent (see paragraph 1.16.1);
- the presence of an aerological downdraft and/or windshear seems likely, particularly since the balloon's flight path near the ground turned through several dozen degrees, indisputable evidence of a local irregularity in the wind, also shown by the previous changes in direction and ground speeds (see figure 1). These wind irregularities are compatible with the convection phenomena indicated by Météo-France. The turbulence previously encountered during the end of the cruise and the descent may have led to a loss of hot air and thus lift, due to deformations of the envelope which may have been caused by this turbulence (see paragraph 1.16.2).

This difficulty in controlling the flight path would require high levels of attention by the pilot whose actions were concentrated mainly on the main heating control and the turning vents, then on the rapid deflation system just before the first contact with the ground. The pilot stated that his main concern at that time was to reposition the balloon on its long side to prevent it turning over on the short side. The change in direction caused by wind rotation exceeded the possibilities of repositioning the basket before impact. In this context, the turning off of the pilot lights and shutting of the gas cylinders, specified in the procedures, were not performed.

The first impact was brutal. Two passengers were unable to stay in the safety position. The video recording also illustrates the risk for an unharnessed pilot of being thrown out, leaving the balloon and its passengers to fend for themselves. The balloon bounced and took off again, moving on its short side while the pilot continued to pull the rapid deflation line.

On the second impact the balloon turned over onto the short side. The basket came to a stop on its back, in contact with the burner frame whose uprights were deformed by the weight. The occupants fell towards the frame, came into contact with a burner control, causing the first brief flame. During the evacuation, the burners were reactivated again, probably due to inadvertent inputs on the burner controls.

When the fire spread to the basket and became uncontrollable, the occupants helped each other to complete the evacuation.

After having righted the basket on the short side, some occupants tried to limit the fire and to help the victim. The pilot, in particular, shut the gas tank valves which completely stopped the burner flames. The fire was then mainly fuelled by the basket wicker. The balloon extinguisher used by a passenger and then by the pilot was not adequate to put it out.

2.2 Fire

As previously indicated when a propane fire breaks out, the hand-held balloon fire extinguisher has limited effectiveness.

The provisions to prevent a fire mainly reside in complying with the piloting procedures that prioritise turning off the pilot lights, then closing the cylinder valves and venting the gas pipes. These actions prevent a fire in the event of the basket tipping or turning over. These situations can in fact cause damage to the pipes and the burners associated with a gas leak which catches fire or lead to involuntary inputs on the burner controls, as this accident and those listed in 1.18 demonstrate. These procedures and these risks are known and documented (see paragraph 1.16.2).

These accidents show that this barrier may be weakened by:

- an incorrect estimation of the landing conditions leading to a landing accepted with at least one pilot light lit, during a landing judged to be normal;
- a stressful situation, which reduces pilot performance, associated with a degraded situation ending with a hard or fast landing.

The efforts made by the FFAé to systematise the actions to prevent a fire, in particular the systematic turning off of all pilot lights before contact with the ground, whatever the conditions may be, reinforces this barrier in the first case. These efforts will be all the more effective if the community adopts unambiguous documents about turning them off, in particular in Flight Manuals and Operations Manuals where some phrases allow the pilot to exercise his own judgement on the appropriateness of leaving the pilot lights lit in view of the landing conditions.

Equally, in the second case, making actions "*automatic*" by repeating them during normal landings should facilitate repeating them in a stress situation. However the accident showed that one difficulty is to correctly identify priorities when time is short. This does not always make it possible for a pilot in a state of stress to systematically carry out all the specified actions during an emergency landing: turning off all the pilot lights, closing all the cylinders and venting the pipes when he also has to control the flight path, the orientation of the balloon and look after the passengers.

A supplementary approach would be to study the use of a single emergency control whose application would only require reduced mental effort for a pilot in a state of emergency, such as the fuel shut-off handles that are installed on aeroplanes with turboshaft engines.

Furthermore, the investigation showed that at least one manufacturer (see paragraph 1.15) proposed an optional system which discharges the content of a extinguisher on the burners and cylinders when the pilot presses the extinguisher button. This type of system is rare in France. A similar centralized system to shut off the gas supplies could advantageously supplement the operational provisions, which are today dominant in the prevention of a fire on landing, subject to it not causing other risks which would make the disadvantages of this system greater than the advantages.

2.3 DSAC oversight of operator

Oversight of French operators in balloon PT is undertaken by the DSAC. It concentrates on the balloon, operator and pilot documentation. The investigation showed that it did not, in this case, detect then have corrected all of the inconsistencies, ambiguities or omissions in the Operations Manual (for example the content of recurrent training courses, turning off the pilot lights in a normal landing, temperature limitations, the maximum number of people on board, the description of the equipment and the use of a harness). Specifically, it seems that adding F-HCCG to the fleet list did not lead to the operator being questioned about the updating of applicable procedures and limitations, previously aligned with the first balloon's Flight Manual. It should be noted that the use of material from different manufacturers complicates, for the operator and for the oversight inspector, the identification and strict verification of applicable procedures and limitations, if possible to all the fleet, in the different Flight Manuals whose updates are not systematically available in English or in French.

A widespread principle in aviation is to take advantage of an external view to question and correct the practices and choices of a pilot, operator or manufacturer by an instructor, oversight authority or certification authority. The regulatory requirement of an Operations Manual formalises this principle by encouraging the operator to think about the manner in which it handles safety during the writing of the manual. Through re-reading proportionate to the complexity of the operator and to the means available to the authority, the latter provides the operator with an additional view of the safety procedures. Thus it is supposed that pilots, complying on a daily basis with this document, will remain within the safety envelope, which is the fruit of collective thinking based on regulatory and operational references from experience accumulated by the community.

This principle has weak points, however, as illustrated below:

- the introduction of Operations Manuals for balloon activity is recent. Balloon pilots are still in an "*adoption*" phase. The necessity of writing this document, using it and updating it is sometimes considered a constraint by the operators, without any real usefulness for operations;

- the authority's check of this document is not intended to be complete, given the resources available and the fact that the agents for the majority, are not ballooners. Regulatory compliance with targeted points, rather than searching for signs of risky practices, seems to be favoured. Retrospectively, the wording that allowed landing with the pilot lights lit, except in an emergency situation, was not noted though the associated risks are documented, for example, in the Hot Air Balloon Flight Training Manual, and confirmed by some reports of incidents and accidents. The following factors made it difficult for the oversight inspector to identify this risk and then to modify the Operations Manual:
  - the DSAC agent had not received any specific training and applied the specified methods that were not yet completely adapted to balloon PT, which meant that he was not capable of detecting this point;
  - even with access to better expertise, either internally within the DSAC or in partnership with ballooner representatives, it is possible that the fact that the practice of landing with the pilot lights lit effectively existed may have diminished the specialist's perception of this risk;
  - if this risk had in fact been identified, its enforceability on an operator was made difficult by the ambiguity or the contradiction in the applicable reference works (practices, Flight Manual, Flight Training Manual);
- finally, events reported to the DSAC by operators are few in number, which deprives its agents of an additional source of information on the reality of risks during operations;
- the differences between the practices described in the manual and daily reality are not observable by the authority between two scheduled checks which are programmed several months apart. This accident illustrates that these differences are possible: the pilot did not consult the TAF or the METAR, for example, or refer to the loading chart when creating his weight sheet, even though the completion of a weight sheet was the subject of a deviation noted by DSAC in June 2013. The replacement on two occasions of the tempilable and melting link during the seven months before the accident tends to show that the balloon was operated at temperatures close to or exceeding those defined by the manufacturer. Finally the configuration of the balloon fuel system did not comply with the manufacturer's recommendations and the point of view of the workshop which renewed the ARC, with respect to the requirements applicable to couplings had not been detected by the OSAC or the DGAC.

The external view of line operations is made by peers, not necessarily instructors, once a year, in a planned manner. It is not supplemented by programmed or random line checks by a DSAC inspector. The proficiency of the peer pilot who undertakes this line check and that of the person giving the theoretical recurrent training are not checked by the authority. Thus the DSAC has no reliable and direct means to appraise practices in actual operation. It should be noted that introducing this type of check would involve two difficulties:

- the activity being seasonal and strongly dependent on meteorological conditions, this would complicate an intervention by a DSAC inspector;
- in the context of current fee practices, the place, not billed, occupied by an authority inspector in a basket for a dozen people would represent a more significant loss of earnings for the operator than for an operator of an aircraft with a higher passenger capacity.

Lastly, the current regulatory framework allows an instructor to also act as an examiner during a test of the student that he has trained. This situation means that, again, there is no systematic external view of a candidate's proficiency. One might wonder about the appropriateness of this practice for pilots intending to undertake a commercial activity. It should be noted that this intention may not exist or not be expressed during the initial training, which makes it impossible for instructors to adapt the requirements of the training to the type of activity targeted, even more so since these requirements are not formalised in the regulations. From this perspective, the development of appropriate training for future professionals, approved in an independent manner, would clarify the role of instructors and the additional proficiency expected in public transport.

In general, the insertion of the scope of "*Public Transport*" through the French decrees of 2011 and 2013 quoted above seems to have resulted in a compromise between the requirements of aeroplane and helicopter PT, and the historic and traditional operation of balloons in the context of "*General Aviation*". The low level of complexity of balloons, the limited size of operators and the reduced number of instructors were probably factors that led to relaxing the traditional PT requirements in the regulation of balloon flight commercial activity. This new regulation required, however, that operators use operational methods that were supposed to guarantee an acceptable level of security for paying passengers, who cannot be expected to assess and accept the risks inherent in this activity. A balloon, which is lighter than air, can give an uninformed passenger the impression that the energy used, and consequently the risk of injury, is low. In reality, the kinetic inertia of a balloon which has to be absorbed on landing by scraping the basket on the ground, may be considerable due to the weight of the moving volume of air.[39]

[39] Movement tends to be maintained by the envelope deflating, which exerts traction on the basket, like a yacht sail ("spinnaker" effect).

Commission Regulation (EU) No 2018/395 of 13 March 2018 setting out the detailed rules concerning balloon operation, applicable from 8 April 2019, specifies the setting up of a declaration system for balloon public transport.

In the absence of any objective elements, in particular statistical, that would make it possible to assess any potential safety benefits of a certification system compared to those of a declaration system, this choice has been guided by the principle of proportionality of regulatory requirements, applicable to an activity undertaken with non-complex aircraft by organisations that are themselves non-complex.

It should be noted that the declaration system was introduced in Regulation (EU) No 965/2012 for NCC and SPO activities (equivalent to aerial work) where it was considered that a higher risk level was acceptable compared with CAT operations. As an example, in comparison to certification, the declaration system has the following characteristics:

- the competent authority is not associated with the preparation of operations by a new operator, unlike the analysis of a request for a certificate. The involvement of a third party or an organisation accompanying a new operator in its preparation is not required. The declaration renders the operator responsible but, in case of any deviations, deliberate or accidental through ignorance of a requirement, this deviation could only be detected during the first inspection by the competent authority. It is more difficult for the competent authority to require immediate corrective actions of an operator which has already started its operations whereas it is easier for the authority to make an authorization to start operation subject to the correction of similar deviations;
- the minimum regulatory frequency for oversight actions is lower.

Thus, in general, even if EASA emphasizes the similarity of oversight tools between the two structures, the declaration system does not propose quite the same guarantees as the certification system for prior checks and operational follow-up.

For EASA, these differences in treatment are part of a wider evolution in the philosophy of oversight, which it has started to develop. For the competent authorities, this philosophy consists of both optimising resource allocation according to risks and in envisaging the study of both operator safety performance and their regulatory compliance. In this context, EASA considers that the declaration system offers more flexibility for the oversight authorities to more closely oversee the organisations considered the most exposed to the risk of an accident.

Logically, as it was drawn up at a later stage, the case of CPB was not explicitly mentioned in the documents that define EASA policy, specifically in the hierarchy of acceptable risks for persons, unchanged since its creation in 2012. During the investigation, EASA did not clarify how paying passengers should be considered in the hierarchy of acceptable risk of an accident. Nor did EASA give a quantified safety objective for this type of operation. In the Opinion prior to the new regulation, balloon CAT was considered around 300 times less safe than aeroplane CAT but it was not stated whether this difference was considered acceptable. A clear position from EASA could have been a structuring factor for the impact on safety study which is detailed in it.

According to the logic set out by the Agency, the authorities must divide the oversight resources between the various operators. Among the criteria for distributing resources may be the number of passengers transported, the complexity of the organization or even the maturity of the management system. But in the absence of a safety objective for CPB, at least with respect to other types of commercial operation, a basic criterion is missing, namely the difference between the safety level measured and that targeted.

This matter of arbitration is all the more relevant in that:

- the limited resources available are a strong constraint on developing oversight plans over several months. Consequently, in the context of oversight that could be considered as already being based on risk, the competent authorities could have some difficulty in releasing the resources necessary to take into account, sufficiently quickly, the effective start of a newly declared activity;
- this new oversight philosophy supposes that the competent authorities take greater account of practices and feedback, including observation in the field, planned and unplanned. However, the investigation showed that these tools were little used up to that time. Once again, resource management is a critical issue. Firstly, such an oversight mode for this type of activity requires specific availability (places, times, etc.) which necessarily affects the oversight plan for other activities. Secondly, this oversight mode is based on the development of a form of expertise that must be maintained even though the activity figures cannot justify, locally, the specialisation of some inspectors.

More insidiously, the absence of a safety objective when the regulations were modified can give rise to different interpretations.

Without more detail, the provisions adopted in the regulation on balloon operation could be considered by the competent authorities, and even by the operators concerned, as a signal indicating that it is acceptable that the safety level for the CPB activity is not the same as for the traditional CAT activity.

The declaration system would place a dozen (or more) passengers[40] in a basket in a system administratively different from those of other activities transporting an equivalent number of paying passengers, and based on lower minimum oversight regulatory requirements.

In France, in practice, these changes leading to a reduction of these requirements could even be perceived as the acceptance of a lower safety objective with respect to the current rate.

In the future, an impact study such as that presented in the Opinion may advantageously include a more qualitative analysis of the risks incurred, beyond the inventories carried out. For this purpose, EASA will be able to use the risk portfolios it develops and updates gradually. In the case of balloon activity, an upcoming update may include the results of this investigation. Thus, a fire may be the consequence of an "*operational*" management failing, or even associated with "*human*" and "*organizational*" factors, according to the categorization of the safety issues adopted by EASA.

[40] The largest balloon baskets can transport several dozen passengers. A major accident can lead to significantly more victims than in a major light aircraft accident where there is limited passenger capacity. For information, the accident in Egypt on 26 February 2013 led to fatal injuries to 19 of the 21 occupants. The accident in Texas in the USA on 30 July 2016 led to fatal injuries to all 16 occupants. This is the accident with the highest number of fatalities since 12 February 2009 (50 fatalities in the DHC-8 accident operated by Colgan Air at Clarence Center, in the state of New-York).

3 - CONCLUSIONS

3.1 Findings

- The pilot had the licences required to undertake the flight. The airworthiness review certificate had been renewed on 16 April 2014. It was valid up to 16 April 2015;
- the "double-T" installation of the fuel pipes that was in place on the day of the accident did not comply with the manufacturer's recommendations;
- the pilot had completed a weight sheet which did not refer to the loading chart in the Flight Manual. The estimated weight of the balloon on take-off was greater than the weight obtained by using the loading chart in the conditions of the day;
- the pilot had consulted the weather forecasts;
- meteorological convection was active in the area of the accident, leading to turbulence;
- the take-off and cruise took place without any notable events;
- the wind was irregular at the end of the cruise and during the approach, exposing the balloon, on several occasions, to a relative wind;
- at the request of the pilot, the passengers adopted the safety position;
- during the approach, the balloon's descent rate was high despite the heating inputs by the pilot;
- near the ground, the flight path turned to the left by several dozen degrees as a result of a change in wind direction;
- the pilot used the turning vents to try to turn the basket onto its long side then activated the rapid deflation system;
- the pilot lights were on during the landing;
- the pilot was not attached by harness;
- the first impact was hard. The basket climbed a little then struck the ground again and turned over completely;
- a fire broke out during the evacuation of the occupants and was then fuelled by the basket wicker and the gas escaping from the bottles via the safety valves;
- assisted by some passengers, the pilot tipped the basket onto its side, closed the gas tanks and tried to extinguish the fire with the balloon extinguisher, then with the extinguisher brought by the retrieve vehicle;
- the turning off of the pilot lights is required by various documents relating to flying hot air balloons. In practice sometimes they are not turned off by pilots before landing;
- the oversight of the operator by the authorities did not bring to light the errors contained in its Operations Manual;
- the specific nature of this activity (place and time of take-off being dependent on the weather, for example) makes it difficult to organise random checks.

3.2 Causes of the accident

The accident was due to a combination of the following factors:

- inadequate appreciation of the meteorological conditions, which exposed the balloon to turbulence and variations in the wind force and direction, probably of a convective nature, which in the end caused the basket to turn over;
- the failure to turn off the pilot lights before the first impact. This could be due to the pilot focusing his attention on controlling the balloon's rate of descent and orientation, during a hard and fast landing, generating stress.

The following factors may have contributed, though it was not possible to determine the degree to which they contributed:

- the practice, the extent of which could not be precisely assessed, of landing with one or more pilot lights lit, which makes it unlikely that the pilot will instinctively react and turn them off in a fast or hard landing situation;
- the use of an unauthorised "double-T" installation that may limit the available heating power;
- an overestimation of the safety provided by the pilot carrying out the actions specified in the Fight Manuals for an emergency landing, which must by nature be performed under stress;
- techniques and means of oversight of operators by the authority which are mainly concerned with regulatory compliance, poorly adapted to detecting risky practices.

4 - SAFETY RECOMMENDATIONS

Note: in accordance with the provisions of Article 17.3 of Regulation No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation in no case creates a presumption of fault or liability in an accident, serious incident or incident. The recipients of safety recommendations report to the authority in charge of safety investigations that have issued them, on the measures taken or being studied for their implementation, as provided for in Article 18 of the aforementioned regulation.

4.1 Systematic shutting down of pilot lights on landing

The investigation showed that the main defence against fire lay in the pilot repeating the actions specified in most of the writing available on piloting hot air balloons (flight training, flight and operating manuals) including, specifically, the shutting down of the pilot lights. This accident and those mentioned in this report show that this defence may be diminished by:

- an incorrect estimation of the landing conditions leading to a landing with at least one pilot light lit being accepted, during a landing judged to be normal;
- a stressful situation, which reduces pilot performance, associated with a degraded situation ending with a hard or fast landing.

Efforts made by hot air ballooner representatives to systematize shutting down all of the pilot lights before contact with the ground, whatever the conditions, will be made more effective if the community will adopt unambiguous documents on this aspect. The investigation showed that a certain tolerance on the compliance with this principle could trickle down from some flight and operating manuals.

Consequently, the BEA recommends that:

- **EASA ensures that the flight manuals are updated to underline the need for pilot lights to be shut down before contact, whatever the landing conditions may be. [Recommendation 2018-004]**

- **DSAC, without waiting for the flight manuals to be updated as specified in the recommendation [Recommendation 2018-005] ensures that the procedures and operational limitations, described in the operating manuals, stipulate shutting down the pilot lights before contact with the ground. [Recommendation 2018-006]**

4.2 Studying a system for quick shut-off of fuel system and protection of burner controls

The investigation illustrated the possibility of deterioration in the pilot's abilities due to the stress of an emergency situation that makes successful performance of the safety actions on the fuel system of a balloon less likely. Mechanisms such as *fuel shut-off handles* exist in public transport aeroplanes and make it possible to group several actions in one to isolate an engine from all of the systems (hydraulic, fuel, pneumatic). However, this approach would have the disadvantage of creating a device common to the various burners which, in case of a failure of the device, could make it impossible to continue heating the balloon. Equally, the problem of involuntary inputs on a control is known to the aviation community and solutions for protecting the controls could, for example, be imagined. In this case too, the undesirable effects need to be taken into account.

It thus appears to be appropriate that thought be given to assessing the safety compromise provided by these types of technical and ergonomic solutions, so that fire prevention takes greater account of the deterioration in pilot performance and his involuntary actions in an emergency situation where the consequences can be catastrophic (see paragraph 1.17.4).

Consequently, the BEA recommends that:

- **EASA, working with balloon manufacturers and pilot representatives, studies the possibilities of an emergency fire-prevention shut-off and protection of burner control system that could be required in public transport, and possibly in general aviation. [Recommendation 2018-007]**

4.3 Oversight of public transport operators

The investigation showed that the means of oversight currently used by DSAC are essentially aimed at checking regulatory compliance by operators, through programmed audits or through document checks. Few DSAC agents have any practical experience of commercial balloon flights which would allow them to bring a peer's view to these oversight techniques. These agents may also have difficulties in identifying the main areas of risks specific to this type of operation and in targeting their oversight actions around these risks. This oversight also does not allow for line checks to be organised to check for systematic compliance with the practices described in the operating manual.

With this in mind, the BEA takes note of the recent regulatory changes which include the use of a system of declarations for Commercial Passenger Ballooning (CPB), published in 2016 by EASA and then adopted in Commission regulation (EU) No 2018/395 of 13 March 2018 laying down detailed rules for the operation of balloons. In the absence of a clarification of the acceptable risk in CPB, in particular compared to other CAT activities, the BEA fears that these changes will further undermine the oversight of these operators.

The issue is all the more critical in that the trend towards an increase in the size of balloons and their carrying capacity (more than twenty passengers), that may be encouraged by economic pressure on operators, may result in an increase in risks, due to the greater inertia of these balloons and the number of individuals exposed. In addition, balloon flight may be perceived by unwary passengers as being an activity as such which holds little danger whereas experience shows that the safety level is very much below the commercial air transport safety level to which the general public has become accustomed.

Consequently, the BEA recommends that:

- **EASA, working with the competent authorities and commercial passenger ballooning professionals, clarifies the position of CPB in the hierarchy of acceptable risks defined by the European General Aviation Safety Strategy document. [Recommendation 2018-008]**

- **EASA carries out a targeted assessment of the effects of the European regulation for commercial passenger ballooning on the safety level, once it has become applicable, with specific attention paid to the oversight procedures expected of the competent authorities. [Recommendation 2018-009]**

- **EASA uses the results of the assessment specified by the recommendation above [2018-009] and ensures that the CPB oversight methods are commensurate with the targeted risk level and the ability of operators to reach this risk level. [Recommendation 2018-010]**

4.4 Feedback

The investigation showed that the risk situations encountered by the pilot of the accident (the influence of the commercial aspects during decision-making, flying in turbulent conditions, fast and hard landing with basket overturning, pilot being thrown out, fire) are documented in the various technical documents usable by balloon operators (articles on human factors, flight training, flight and operating manuals). In this respect, and as the existence of similar previous accidents indicates, the investigation did not bring to light any fundamental new risks. It would thus seem useful to strengthen feedback initiatives taken by ballooner representatives so that pilots share better knowledge of the risks in commercial operations.

Consequently, the BEA recommends that:

- **DSAC furthers improvement in the awareness of the risks specific to commercial passenger ballooning and the best management of these risks by operators. [Recommendation 2018-011]**

APPENDICES

Appendix 1

*Risk portfolio produced by EASA (*Source: "EASA Annual Safety Review – 2016")

Appendix 2

Declaration in accordance with Commission Regulation (EU) 2018/395

Appendix 1

Risk portfolio produced by EASA (Source: *"EASA Annual Safety Review – 2016"*)

Table 38: Balloons safety risk portfolio

Balloons											
Outcome Percentage of Fatal Accidents (2011-2015)		11			36%	27%	27%	18%	9%	9%
Outcome Percentage of Non-Fatal Accidents (2011-2015)		101			36%	15%	11%	5%	3%	2%
Safety Issues		Total number of occurrences in 2011-2015 per safety issue			Key Risk Areas (Outcomes)					
		Incidents (ECR data)	Serious Incidents	Total Accidents	Aircraft Upset in Flight	Terrain Conflict	Glider Towing Events	Other System Failures	Airborne Conflict	Abnormal Runway Contact and Excursions
Operational	Control of manual flight path through control of balloon inertia	2	27	9	■	■	■	■	■	
	Weather planning	2	39	4			■		■	
	Use or presence of Pilot restraints	–	5	4						■
	Loss of separation – Particularly during mass balloon launches	–	2	2					■	
Technical	Propane system fire	–	2	2					■	■
	Exterior Colour Schemes and Markings – Visibility of Balloon Registration	–	2	2					■	
Human	Perception, Decision making and planning	4	55	10	■	■	■	■	■	
	Commercial and competitive pressure to initiate flights	–	7	5	■	■	■			
	Pilot knowledge of balloon physics	–	12	3	■	■	■	■	■	
	Communication and situational awareness during mass balloon launches	–	2	2		■			■	
Organisational	Passenger safety knowledge	–	3	4	■		■			
	Availability of operational documentation – e.g. Map Marking with Power Wires	–	5	3	■	■				

Appendix 2

Declaration in accordance with Commission Regulation (EU) 2018/395

Appendix

DECLARATION

in accordance with Commission Regulation (EU) 2018/395

Operator

Name:

Place where the operator has its principal place of business.

Name and contact details of the accountable manager:

Balloon operation

Starting date of commercial operation and, where relevant, date of change to existing commercial operation.

Information on balloon(s) used, commercial operation(s) and continuing airworthiness management ([1]):

Balloon type	Balloon registration	Main base	Type(s) of operation ([2])	Continuing airworthiness management organisation ([3])

Where applicable, list of AltMoC with references to the associated AMC (annex to this declaration):

Statements

☐ The operator complies, and will continue to comply, with the essential requirements set out in Annex IV to Regulation (EC) No 216/2008 and with the requirements of Regulation (EU) 2018/395.

In particular, the operator conducts its commercial operations in accordance with the following requirements of Subpart ADD of Annex II to Regulation (EU) 2018/395:

☐ The management system documentation, including the operations manual, comply with the requirements of Subpart ADD and all flights will be carried out in accordance with the provisions of the operations manual as required by point BOP.ADD.005(b) of Subpart ADD.

☐ All balloons operated either have a certificate of airworthiness issued in accordance with Regulation (EU) No 748/2012 or meet the specific airworthiness requirements applicable to balloons registered in a third country and subject to a wet lease agreement or a dry lease agreement, as required by points BOP.ADD.110 and BOP.ADD.115(b) and (c) of Subpart ADD.

☐ All flight crew members hold a license and ratings issued or accepted in accordance with Annex I to Regulation (EU) No 1178/2011, as required by point BOP.ADD.300(c) of Subpart ADD.

☐ The operator will notify to the competent authority any changes in circumstances affecting its compliance with the essential requirements set out in Annex IV to Regulation (EC) No 216/2008 and with the requirements of Regulation (EU) 2018/395 as declared to the competent authority through this declaration and any changes to the information and lists of AltMoC included in and annexed to this declaration, as required by point BOP.ADD.105(a) of Subpart ADD.

☐ The operator confirms that all information included in this declaration, including its annexes, is complete and correct.

Date, name and signature of the accountable manager

(1) Complete the table. If there is not enough space to list the information, it shall be listed in a separate annex. The annex shall be dated and signed.
(2) 'Type(s) of operation' refers to the type of commercial operation conducted with the balloon.
(3) Information about the organisation responsible for the continuing airworthiness management shall include the name of the organisation, the address and the approval reference.

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