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Swiss Transportation Safety Investigation Board STSB

Aviation Division

Final Report No. 2261 of the Swiss Transportation Safety Investigation Board STSB

concerning the accident involving the Cameron Z-120 hot-air balloon, HB-QOW,

on 6 August 2013

at la Comba d'Avau
north of Montbovon
Haut-Intyamon / FR municipality

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Cause

L’accident est dû à la collision du ballon avec une ligne électrique à haute tension en raison d'une tactique de vol inappropriée consécutive à un oubli de la présence de cet obstacle en phase d’approche. La visualisation tardive de l’obstacle n’a pas permis son franchissement.

Un vent local soufflant dans le secteur d’approche a joué un rôle dans le déroulement de l’accident.

General information on this report

This report contains the Swiss Transportation Safety Investigation Board's (STSB) conclusions on the circumstances and causes of the accident, which is the subject of the investigation.

In accordance with Art 3.1 of the 10th edition, applicable from 18 November 2010, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944 and Article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of an accident or a serious incident causes and circumstances is expressly no concern of the investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the French language.

All information, unless otherwise indicated, relates to the time of the accident.

All times in this report, unless otherwise indicated, are stated in local time (LT). At the time of the accident, Central European Summer Time (CEST) applied as local time in Switzerland. The relation between LT, CEST and UTC is:
LT = CET = UTC + 2 hours.

Final report

Aircraft type	Cameron Z-120 HB-QOW				
Operator	Gstaad Fly S.à r.l., Wispilenstrasse 29, 3780 Gstaad, Switzerland				
Owner	Gstaad Fly S.à r.l., Wispilenstrasse 29, 3780 Gstaad, Switzerland				
Pilot	Swiss citizen, born in 1948				
Licence	Hot-air balloon pilot, according to the International Civil Aviation Organisation (ICAO), issued by the Federal Office of Civil Aviation (FOCA)				
Medical certificate	Class 2 for balloon pilot, issued 29 April 2004, with VNL restriction (*shall have available corrective lenses*)				
Flying hours	**total**	240:25 hours	**during the last 90 days**	8:30 hours	
	on the type involved	160:15 hours	**during the last 90 days**	8:30 hours	
Location	Comba d'Avau, approximately 500 m north of Montbovon, Haut-Intyamon / FR municipality				
Coordinates	569 655 / 149 092 (Swiss Grid 1903) N 46° 29' 32.83'' / E 007° 02' 36.21'' (WGS 84)		**Elevation**	853 m AMSL[1] 2798 ft AMSL	
Date and time	6 August 2013, 08:38				
Type of flight	VFR by day				
Flight phase	Landing				
Type of accident	Collision with a high-voltage power line				

Injuries to persons

Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	0	1	1	0
Serious	1	3	4	0
Minor	0	0	0	0
None	0	0	0	Not applicable
Total	1	4	5	0

Damage to aircraft	Envelope, burners and basket
Other damage	Electrical conductors of a high-voltage power line

[1] AMSL: above mean sea level.

1 Factual information

1.1 History of the flight

1.1.1 General

The information contained in this report is based on the statements of the pilot, the passengers and observers as well as on video and photographic recordings.

1.1.2 Pre-history

In April 2013, a family of foreign nationality had contacted a travel agency in their country in order to organise a trip to Switzerland. The latter had commissioned a Swiss travel agency to set up the tourist visit for the couple and their two children.

From 4 to 6 August 2013, the family stayed in Interlaken before continuing their tourist excursion to Lausanne.

As part of this stay, the Swiss travel agency had commissioned a Gstaad / BE company with which it collaborated regularly to organise a hot-air balloon[2] flight in the region. The date of 6 August 2013 had been chosen. On that day, the holiday-makers left their hotel in Interlaken early in the morning to travel to Gstaad by car, with a driver provided by the agency.

1.1.3 Flight preparations

At approximately 06:30, the family arrived in Gstaad, where the pilot of balloon HB-QOW and his team member were waiting for them. The pilot remarked to the agency driver that they were a quarter of an hour late according to the envisaged schedule. According to the driver's statements, the pilot seemed somewhat stressed. He informed him that because of the possible development of thermals, it was preferable not to delay too much, as the envisaged take-off site was at Château-d'Oex / VD. According to the pilot's statements, the flight was to last approximately one hour and his intention was to climb to 3000 m AMSL to benefit from the inversion of the winds. He therefore planned to travel in a north-easterly direction in order to land in the Boltigen area.

The vehicle with the passengers on board and the team's vehicle drove from Gstaad towards the take-off location at Château-d'Oex. On the way, they stopped at the pilot's residence to pick up the mobile telephone, which he had forgotten. Before arriving at Château-d'Oex, the balloon pilot made radio contact with a balloon pilot who had taken off from the same location at 06:37. The latter informed him of his altitude, speed and heading. This pilot later stated that the flight and the landing took place without any problems.

Once they had arrived at the take-off site at Château-d'Oex, at around 07:00, the pilot of HB-QOW informed his passengers that he would need approximately thirty minutes preparation time before take-off. During this time, the passengers went to the village for refreshment.

The team member driving the vehicle and trailer was responsible for following the balloon until it landed in order to recover the pilot and the balloon equipment. The agency driver's task was to pick up the passengers after the landing and then to take them on to Lausanne.

[2] Hot-air balloon: in this report the term hot-air balloon is replaced by balloon.

1.1.4 History of the flight during which the accident occurred

At the take-off site at Château-d'Oex, the pilot of the Cameron Z-120 balloon, registration HB-QOW, carried out the preparations for departure. He installed the burners and various items of equipment in the basket, including an altimeter-variometer. Among other things, this instrument emitted an audible signal when the balloon was descending. Four cylinders filled with propane gas were placed and fixed vertically in the basket. The envelope has been first inflated with ambient air using a fan and then set vertically by means of air heated by a burner. The pilot carried out the usual checks before take-off and switched on the on-board instruments. According to his statements, everything was working normally.

At approximately 07:45, in a calm wind, the balloon lifted off from the take-off site at Château-d'Oex, located at an elevation of 928 m AMSL. On board the basket, the family of four, speaking in English, accompanied the pilot, whose knowledge of this language was limited. No particular instruction in relation to safety instructions for the flight was issued to the passengers. The beginning of the flight proceeded normally and the balloon gained height travelling in a south-westerly direction. After 10 to 12 minutes of flight, the balloon reached an altitude of approximately 2100 m AMSL. Because of the fear of one of the passengers crouching down in the bottom of the basket, the father asked the pilot to stop climbing. On this subject, the balloon pilot stated the flight objective was to ascend to 3000 m AMSL, to set off towards Schönried but the passenger told me to stop the ascent at 2100 m AMSL.

The pilot then decided to make a descend in the valley in the direction of Montbovon-Albeuve. At approximately 08:00, the pilot called his team member, who was still at Château-d'Oex, to ask him to set off for Montbovon. The latter did this, followed by the travel agency vehicle.

After passing Rossinière, the flight continued over lake Vernex and La Tine, as far as the bend in the valley (see annex). Above La Tine, the pilot changed the supply connection of one burner to connect it to a full gas cylinder. After flying over the narrow part of La Tine, the balloon was travelling in a northerly direction. The balloon made a slight right turn to pass at low height over the area known as "Les Rafforts", located approximately 1 km south-west of Montbovon station. From “Les Rafforts” the flight continued in a northerly direction. The pilot noted in his statement that he did not encounter any turbulence during the flight and that the valley descent took place at an average speed of approximately 9 km/h.

Just before his arrival at Montbovon, the team member saw the balloon and stopped near the village station at approximately 08:35. At the same time, the pilot reported by radio his intention to land at La Comba d’Avau, in a field situated between Montbovon and d’Albeuve. The team member acknowledged with *“OK”*. From this time on, he no longer had visual contact with the balloon because of the hill, which separates La Comba d’Avau from Montbovon. Not knowing exactly the envisaged landing site, the team member again tried to make a radio contact with the pilot to obtain more precise details, but got no response.

A person who was on the balcony of a chalet located at La Comba d'Amont (see Annex) observed that the balloon was flying over dwellings at a low height, at constant speed, descending slowly and with no burner activated. When it passed the forest, which skirts L’Hongrin river separating La Comba d'Amont from La Comba d’Avau, the balloon accelerated appreciably. The pilot fired a burner several times, but the balloon did not rise. At that moment, the high-voltage power line crossing the valley was no more than approximately 250 m away. The balloon flew over a small cattle shed, a pasture occupied by cattle and then the first dwellings of La Comba d'Avau. The basket was lower than the power line. While the pilot

operated a burner, some passengers waved to some residents who were in front of their dwellings, then suddenly began to cry out, realising the proximity of the power line. Despite the activation of both burners, the balloon collided with the high-voltage power line at 08:38. The cables, which connect the envelope to the burner frame of the basket (figures 1 and 10), came into contact with the lower electric conductors of the power line, at a height of approximately 46 m. Electric arcs were observed by the passengers and by persons on the ground, causing the severing of several cables which connect the envelope to the burner frame of the basket.

The upper part of the envelope slid momentarily between the 60 kV upper conductor and the earth conductor cable of the power line (figures 7 and 8). The hot air rapidly escaped. The basket, with a pronounced tilt, attached to the few cables of the envelope, which were still in position in the pilot's compartment, fell violently into a garden located near a dwelling and tipped onto its side. None of the occupants was thrown out of the basket. The completely deflated envelope came to rest in front of the basket, partially on the access road to the hamlet and partially in the garden of the property. At the time of impact of the basket, a gas leak occurred. An observer, who arrived at the location shortly after the accident, closed the gas valves on the cylinders which remained open, on the pilot's instructions. This per didn't see the high-voltage lines son, an acquaintance of the pilot, reported his spontaneous statements that he didn't see the high-voltage lines.

Several inhabitants of La Comba d'Avau, witnesses of the accident, raised the alarm by telephone and tried to provide assistance to the balloon's occupants. To facilitate access and intervention by the emergency services, the envelope was detached from the basket and moved to the side of the house. The emergency services and the police were rapidly at the location of the accident.

One passenger was fatally injured and the other four occupants were seriously injured. They were evacuated by helicopter and by ambulance to the various hospitals in the region.

Fire did not break out. The balloon was badly damaged. Conductors of the high-voltage line were damaged but withstood the collision.

1.1.5 Information provided by the pilot and observers

1.1.5.1 Pilot's statement

The pilot noted in a statement that throughout the flight the burners functioned correctly, that he did not encounter any technical problem and that he had no recollection of the final moments before the collision.

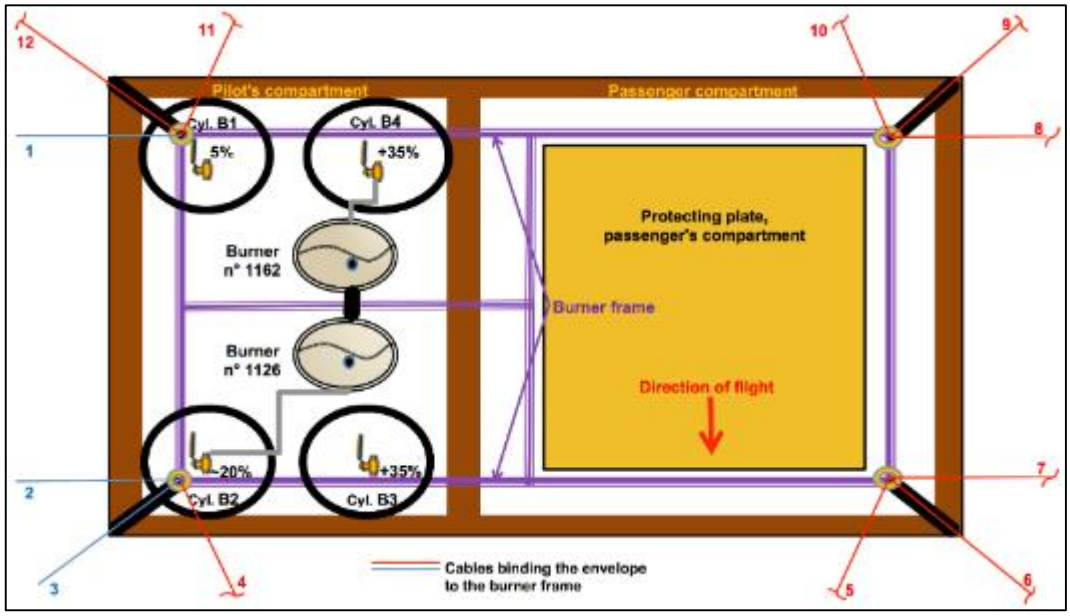


Figure 1: Diagram of the general layout of the basket, with the position of the cables which connect the envelope to the burner frame. The cables shown in blue were intact and the severed ones are shown in red.

1.1.5.2 Observers located in La Comba d'Amont

Observer A

" […] *je me trouvais au premier étage de ma maison* […] *fenêtre grande ouverte orientée au sud, quand j'ai été réveillé par une conversation (en anglais par ailleurs) perçue juste au-dessus du toit et immédiatement suivie d'un grand coup de tuyère. Ce passage ne m'a pas surpris en lui-même mais le fait que je puisse entendre distinctement les propos des occupants de la nacelle m'a paru anormal. Le ballon est passé à quelques mètres du toit de la maison, donc fort bas!* […] *".*

Translation:
[…] I was on the first floor of my house […] large south-facing window open, when I was woken up by a conversation (in English, moreover) just above the roof and immediately followed by a blast on the nozzle. This fly-past did not surprise me in itself but the fact that I could distinctly hear the remarks of the occupants of the basket appeared abnormal to me. The balloon passed a few metres above the roof of the house, i.e. very low! […].

Observer B

" […] *j'étais sur le balcon, on préparait le petit-déjeuner avec mon épouse. J'ai d'abord entendu le ballon en raison des coups de brûleurs. J'avais l'impression que le ballon était presque arrêté au-dessus du Plan aux Lièvres à une hauteur d'environ 20 m au-dessus des sapins. Puis le ballon est passé devant nous à une hauteur d'environ 50 m sans action de coups de brûleurs sur ce tronçon. Ensuite le ballon a accéléré en direction de la ligne en descendant avec des coups de brûleurs au niveau de L'Hongrin. J'ai eu peur et me suis tourné en disant : « il va s'envoyer la ligne ». Nous avons observé la collision du ballon contre la ligne et remarqué que la partie supérieure de l'enveloppe est passée par-dessus le conducteur supérieur de la ligne mais en-dessous des ballonnets du câble de protection. Il y a eu un éclair suivi d'une explosion. L'enveloppe s'est rapidement dégonflée et a glissé sur le conducteur suivi de la chute du ballon* […] *en été, on ne voit pas de ballon passer devant notre balcon, l'accélération du ballon était marquée et nous a impressionnés. On leur a fait signe de la main* […] ".

Translation:
[…] I was on the balcony, preparing breakfast with my wife. I first heard the balloon because of the noise of the burners. I had the impression that the balloon was almost stationary above the Plan aux Lièvres at a height of approximately 20 m above the fir trees. Then the balloon passed in front of us at a height of approximately 50 m without any burner noise on this section. Then the balloon accelerated in the direction of the power line while descending with operation of the burners to the level of L'Hongrin. I was afraid and turned round, saying: "He's going to hit the line". We observed the collision of the balloon with the power line and noticed that the upper part of the envelope passed over the upper conductor of the line but below the small spheres on the protection cable. There was a flash followed by an explosion. The envelope deflated rapidly and slid onto the conductor, followed by the fall of the balloon […] in summer, we do not see balloons pass in front of our balcony, the acceleration of the balloon was considerable and impressed us. We waved to them […].

1.1.5.3 Observers located in La Comba d'Avau

Observer C

« […] *j'étais sur l'escalier de l'entrée quand j'ai aperçu le ballon au-dessus de la ferme. J'ai appelé ma fille car sa présence était soudaine, les passagers nous ont fait bonjour, on voyait bien les visages la couleur blonde des cheveux. Le ballon m'a paru bas au passage de la remise, il allait vite* […] *il m'a paru voler à l'horizontale et il chauffait de façon soutenue avec de petits arrêts* […] *».* Son mari qui était dans la remise attenante précise: *«* […] *j'ai entendu d'abord le bruit des brûleurs puis vu le ballon à env. 30 m au-dessus du toit. J'ai fait la réflexion suivante à ma femme, tiens il va peut-être passer sous la ligne. Pour moi il allait trop vite pour poser. Le vent local (Ruchio) soufflait fort. Comme il chauffait toujours, j'ai réalisé qu'il tentait de passer par-dessus la ligne* […] *».*

Translation:
[…] I was on the entry staircase when I saw the balloon above the farm. I called my daughter because its presence was sudden, the passengers greeted us, we clearly saw their faces and the blond colour of their hair. The balloon appeared to me to be low as it passed the outhouse, it was travelling rapidly […] it seemed me to be flying horizontally and it was being fired continually, with small breaks […]. Her husband, who was in the adjacent outhouse, said: […] First I heard the noise of the burners then I saw the balloon approximately 30 m above the roof. I made the following remark to my wife: well, maybe he'll pass under the power line. I thought he was going too quickly to land. The local wind (the Ruchio) was blowing strongly. Since he was still firing, I realised that he was trying to pass over the power line […].

Observer D

« […] *j'étais assise sur l'escalier devant la porte d'entrée, j'ai entendu des coups de brûleur et vu un ballon qui m'a paru bas et j'ai réalisé qu'il ne pouvait pas passer au-dessus de la ligne à haute tension. Le ballon m'a semblé aller vite. J'ai entendu des coups de brûleur rapprochés et je pense que le ballon montait légèrement avant la collision* […] *».*

Translation:
[…] I was sitting on the staircase in front of the front door, I heard the noise of burners and saw a balloon which appeared to me to be low and I realised that it could not fly over the high-tension power line. The balloon seemed to me to be going quickly. I heard burners operated at shorter intervals and I thought that the balloon climbed slightly before the collision […].

Observer E

« […] *j'étais dans ma cuisine quand j'ai entendu un bruit de brûleur sans voir de ballon. Je me suis alors déplacée vers ma terrasse dont la porte était ouverte et aperçu un ballon très bas venant de la Comba d'Amont. Je me souviens d'avoir entendu plusieurs coups de brûleur. J'étais inquiète, car j'ai pensé qu'il était trop bas pour passer la ligne et trop haut pour poser avant. Pour moi le ballon venait vite contre moi sans s'élever. J'ai vu les passagers faire bonjour avec des signes de la main. Puis j'ai observé la collision du ballon et vu que l'enveloppe se trouvait au-dessus des fils alors que la nacelle était sous les fils. Il me semble que j'ai entendu deux déflagrations. J'ai entendu des cris et des jurons du pilote* […] *».*

Translation:
[…] I was in my kitchen when I heard the noise of a burner without seeing any balloon. I then went towards my terrace the door of which was open and noticed a very low balloon coming from La Comba d'Amont. I remember hearing several bursts of the burner. I was worried because I thought that it was too low to pass the power line and too high to land before it. For me, the balloon came quickly towards me without climbing. I saw the passengers waving hello. Then I observed the collision of the balloon and saw that the envelope was above the wires, whilst the basket was below the wires. It seems to me that I heard two explosions. I heard screams and the pilot's swearwords […].

1.2 Meteorological information

1.2.1 General meteorological situation

Switzerland was ahead of a thalweg[3], the axis of which extended from northern Spain to the North Sea.

1.2.2 Weather conditions at the time when the accident occurred

The sky was cloudless. A light mountain wind was blowing near the ground.

Cloud	None
Visibility	60 km
Wind	From 170° to 210° / 3 kt
Temperature / Dew point	18 °C / 14 °C
Atmospheric pressure QNH	1021 hPa
Hazards	None

1.2.3 Astronomical data

Position of the sun	Azimuth 88°	Elevation 22°
Lighting conditions	Daylight	

1.2.4 Meteorological information at Château d'Oex

The MétéoSuisse station at Château-d'Oex located at 1029 m AMSL permitted to record the values of wind, temperature and atmospheric pressure the 6 August 2013.

[3] Thalweg: barometric low between two areas of high pressure.

Time	Wind direction [degree]	Wind speed [kt]	Gusts kt	Temperature [°C]	Dewpoint [°C]	QNH [hPa]
08:00	165	0	2	15.9	14.2	1021.4
08:10	304	1	2	16.0	14.4	1021.4
08:20	341	1	3	17.2	14.9	1021.3
08:30	128	1	3	16.7	14.5	1021.3
08:40	125	1	2	17.4	14.8	1021.3

Table of meteorological data recorded between at 8 h and 8 h 40 min.

1.2.5 Local meteorological observations

At the time when the accident occurred, the inhabitants of La Comba d'Amont and La Comba d'Avau noted a wind coming from the narrow part of La Tine and L'Hongrin. This wind, which was light according to some of them, was estimated by others to have a speed between 20 and 25 km/h. This is actually a local wind called the *Ruchio* which occurs in good weather. This cold flow begins in early evening, blows all night and stops between 10:00 and 11:00. It generally reaches its maximum speed in the early morning.

1.3 Aircraft information

Registration	HB-QOW	
Aircraft type	Cameron Z-120	
Characteristics	Hot-air balloon	
	Total height:	23.2 m
	Envelope:	
	Maximum diameter:	19.5 m
	Volume:	3398 m^3
	Equipped with an RDS[4]	
	Equipped with turning vents allowing the envelope to rotate	
Manufacturer	Cameron Balloons Limited, Bristol, UK	
Year of construction:	2010	
Burners	Manufacturer: Cameron Balloons Limited, Bristol, UK	
	Characteristics: Stratus double burners	
	Total power: 5880 kW at a propane pressure of 6.9 bars	
	Type and serial no.: CB 8720, 1126 and 1162	
Basket	Manufacturer: Cameron Balloons Limited, Bristol, UK	
	Characteristics: Partitioned into two compartments	
	Type and serial no.: CB 3238, BH 1710	

[4] RDS: rapid deflation system.

Masses	Maximum take-off mass at 0 m AMSL: 1088 kg Maximum permissible take-off mass at the elevation of Château d'Oex (928 m AMSL): 882 kg Estimated take-off mass: 880 kg Estimated mass at the time of the accident: 825 kg At the time of the accident, the mass was within the prescribed limits.
Registration certificate	Issued by the FOCA on 10 December 2012 / no. 2
Airworthiness certificate	Issued by the FOCA on 3 March 2010
Airworthiness inspection certificate	Issued by the FOCA on 14 January 2013 Expiry date: 16 January 2014
Operating hours	Envelope: 157:28 h TSN[5] and 94 inflations Burners and basket: 157:28 H TSN
Maintenance	Annual inspection carried out on 9 January 2013 at 141:20 hours TSN and 77 inflations for the envelope
Fuel	Propane, liquid gas
Quantity of fuel on board	In total, approximately 110 kg of propane gas was on board the basket on take-off. The quantity of fuel measured after the accident was 54.7 kg. The quantity was sufficient for the planned flight.

1.4 Wreckage and impact information

1.4.1 Site of the accident

The accident occurred in the small valley of La Comba d'Avau located behind a hill approximately 500 metres north of Montbovon at an elevation of 807 m AMSL. This small valley is located in the extension of La Comba d'Amont at an elevation of 840 m AMSL. A farm and some buildings are in the hamlet of La Comba d'Avau, surrounded to the west by pastures and to the south by meadows. A high-voltage power line equipped with six conductors and one earth conductor cable fitted with orange marker spheres, crosses La Comba d'Avau perpendicularly, just before the last house located down the valley from the hamlet. The accident occurred approximately in the centre of the valley (figure 2).

[5] TSN: time since new.

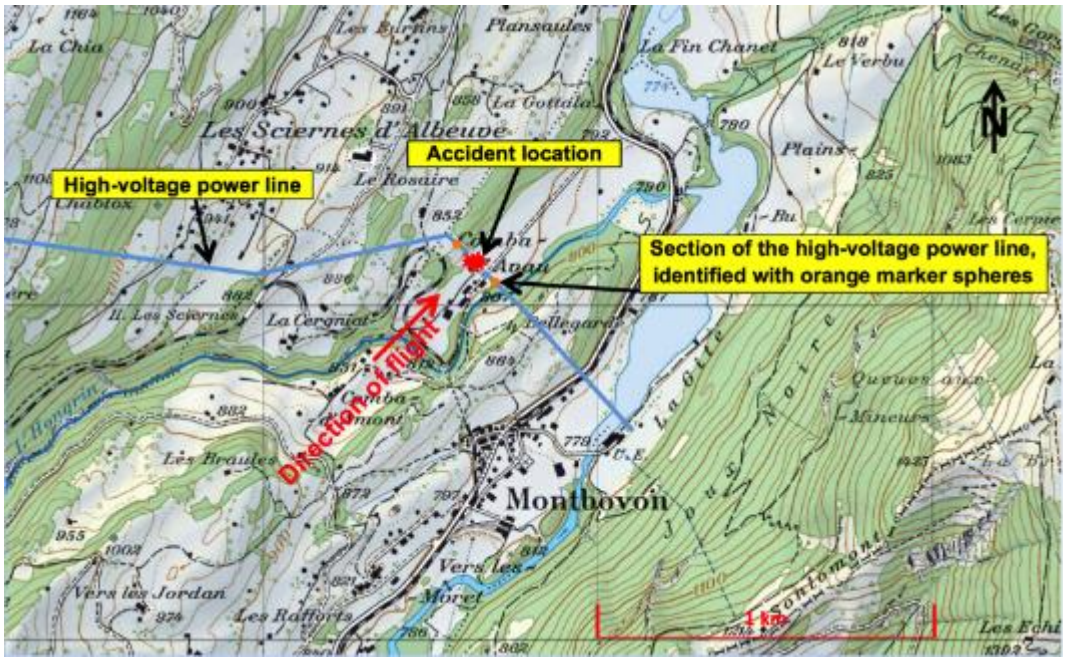


Figure 2: General situation of the accident site (map reproduced by permission of the Federal Office of Topography Swisstopo (JA150149)).

1.4.2 Impact

The collision occurred at 08:37:56 between the lower conductors of the high-voltage power line and the cables connecting the envelope to the burner frame (figures 9 and 10).

The fabric termed the scoop[6] was oriented towards the front in the direction of flight. The pilot's compartment with the propane cylinders was on the right and the passengers were in the left compartment (figure 1).

The various electric arcs caused nine of the twelve cables connecting the envelope to the burner frame to sever. The upper part of the equator of the envelope slid between the upper 60 kV conductor and the earth conductor cable (figure 8).

At the time of the collision, the hot air rapidly escaped from the envelope, when it was still hanging from the power line. The basket fell from a height of approximately forty metres into a garden, with a pronounced tilt because only three cables were still connecting it to the envelope.

Following the impact the basket tipped onto its side and then came to rest against a small fruit tree. The envelope, dragged by the fall of the basket, slid onto the conductors. It landed in the direction of flight, completely deflated, in front of the basket, partially on the access road to the hamlet and in the garden of the property.

[6] Scoop: fabric installed partially on the base of the envelope to improve the performance of the balloon in flight, in the event of turbulent winds (figure 10).

Figure 3: Envelope moved before the intervention of the emergency services.

Figure 4: Final position of the basket with the burner frame.

1.4.3 Wreckage

To enable the emergency services to intervene easily, the balloon's control lines were cut, with their ends remaining attached to the basket socket (figure 4) at the front right of the basket. The envelope was moved to the side of the house (figure 3). The positions of the RDS and the parachute valve (figures 5 and 6) could not be determined with certainty.

The gas leak caused at the time of impact by the rupture of a flexible supply pipe between burner no. 1162 (figure 1) and cylinder B4 was rapidly controlled. The liquid gas valves of the cylinders, which remained open, were closed by a third person known to the pilot.

Four propane cylinders were fixed vertically in the basket, two with a capacity of 23.8 kg (B1 and B2) and two of 31.5 kg (B3 and B4). Each cylinder was equipped with a gauge, the scale of which indicates only the last 35% available.

Cylinder B2 was connected to burner no. 1126; the gauge indicated an available capacity of approximately 20%. Cylinder B4 was connected to burner no. 1162; the gauge indicated an available propane quantity in excess of 35%. The gauges on the two off-line cylinders indicated less than 5% for cylinder B1 and more than 35% for cylinder B3.

An internal envelope temperature measurement transmitter (section 1.5.1.3) was found beside the basket. The multifunction instrument was on the ground in front of it. In the basket there was a box containing a communication device (very high frequency - VHF) switched to “OFF” and a transponder switched to “ALT” mode. A portable VHF radio, a portable GPS receiver[7] and aeronautical charts were among the equipment carried by the pilot.

[7] GPS: global positioning system.

1.5 Additional information

1.5.1 Envelope

1.5.1.1 General

The envelope of balloon HB-QOW, consisting of 24 gores, was equipped with turning vents and a RDS. It was also provided with a temperature probe and heat-sensitive tags.

1.5.1.2 Deflation system

The balloon is equipped with a deflation valve, which may be activated by two different manners by means of a white and red rope or a red rope (figures 5 and 6).

By pulling on the red and white rope in flight, the parachute valve opens and releases hot air in a conventional manner. It closes again as soon as the tension on the red and white line is released, as a result of the pressure of the hot air.

By pulling on the red rope, the rapid deflation system (RDS) is activated. The parachute gathers in a column in the middle of the opening in the shape of a tulip and causes the rapid deflation. This deflation action can be stopped by pulling on the red and white cord for closing the parachute valve.

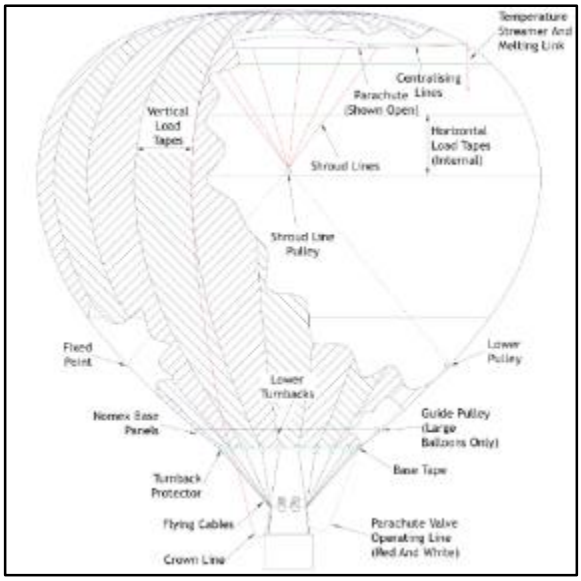


Figure 5: Description of an envelope without an RDS system.

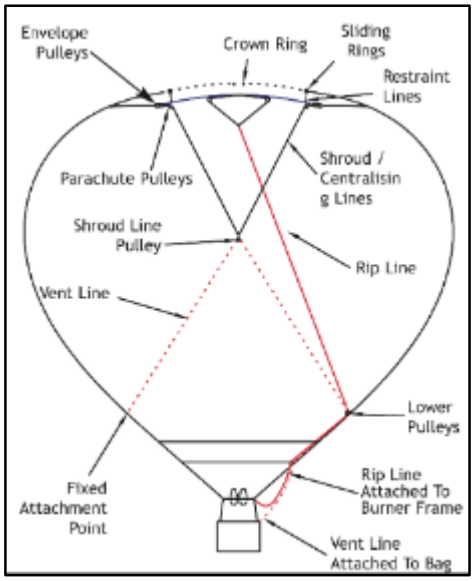


Figure 6: Description of an envelope with an RDS system.

1.5.1.3 Temperature probe and heat-sensitive tag

A melting link attached to a streamer is fitted inside the envelope, usually close to the top (figure 5). If the temperature in the envelope reaches 127 C (261 F), the link melts releasing the streamer which falls through the balloon mouth into the basket, warning the pilot of the danger of overheating.

A heat-sensitive tag is sewn onto the envelope close to the top on a load tape. It includes dots of heat-sensitive material which irreversibly change colour after exposure to temperatures between 90 °C and 150 °C (200 °F and 300 °F). These dots provide a permanent record of the maximum temperature attained by the fabric (figure 11). According to the manufacturer's handbook, it must not exceed 120 C (250 F).

The temperature transmitter equipped with a probe is fixed in the top of the envelope. This device transmits the internal temperature of the balloon by radio to the multifunction instrument; the latter also acts as a variometer and altimeter.

1.5.2 Basket

The basket, made from woven wicker and cane, is designed with two compartments, one for the pilot and one for the passengers (figure 1). It is 1.85 m long, 1.20 m wide and 1.37 m high. The floor is also woven and covered with a plywood panel. Eighteen rope handles are distributed on the sides so that the occupants can hold onto them during landings. The top of the basket is padded with foam and trimmed with leather. The weight of the structure is supported by four stainless steel cables passing under the floor of the basket and connected to the burner frame.

1.6 Information on the power line

1.6.1 Conductors and pylons

The high-voltage power line damaged at the time of the accident consisted of three 18 kV conductors on the northern row which supply Montbovon up to Prés-d'Albeuve and three 60 kV conductors on the southern row which supply Montbovon up to Châtel-St-Denis. An earth conductor cable fitted with orange marker spheres is fixed to the top of the pylons (figure 8). On the damaged section of the line, the conductors are supported by two reinforced concrete pylons 332 m apart and approximately 26 m high. On the earth protection cable, 10 orange marker spheres (section 1.6.3) are positioned between the two pylons. Those were replaced in September 2000.

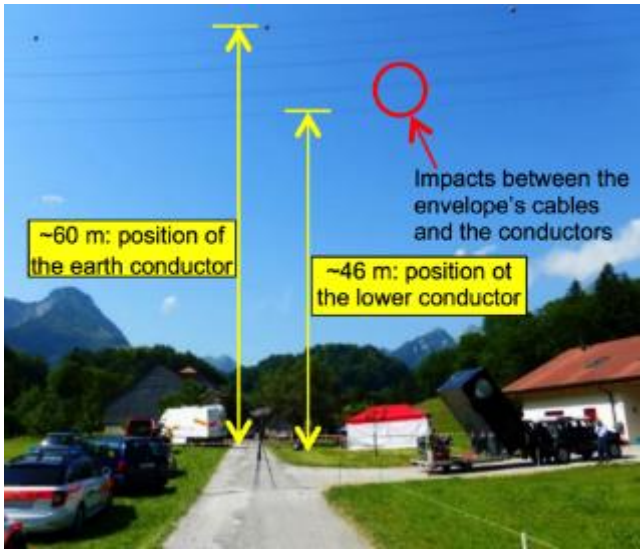


Figure 7: View towards La Comba d'Amont from the accident location with the position of the power line conductors.

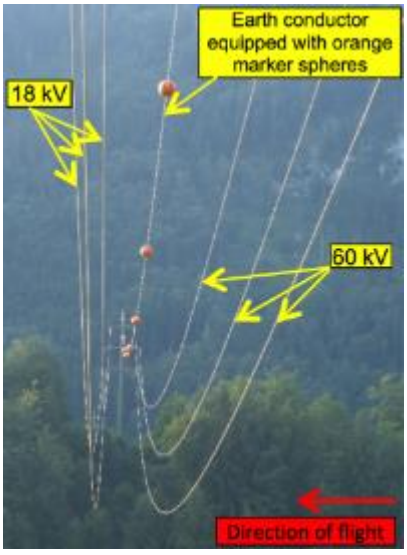


Figure 8: View of the conductors towards Montbovon.

The lower conductors are located approximately 46 metres above the ground. The earth protection cable is approximately 60 metres above the ground (figure 7).

A visual inspection by technicians found that the 6 phases were marked and blackened. These are Aldrey conductors[8]; they have a cross-sectional area of 300 mm^2.

[8] Aldrey is an alloy of aluminium (99 %), magnesium (0.5 %) and silicon (0.5 %).

The conductors were damaged but withstood the collision. The pylons were not damaged.

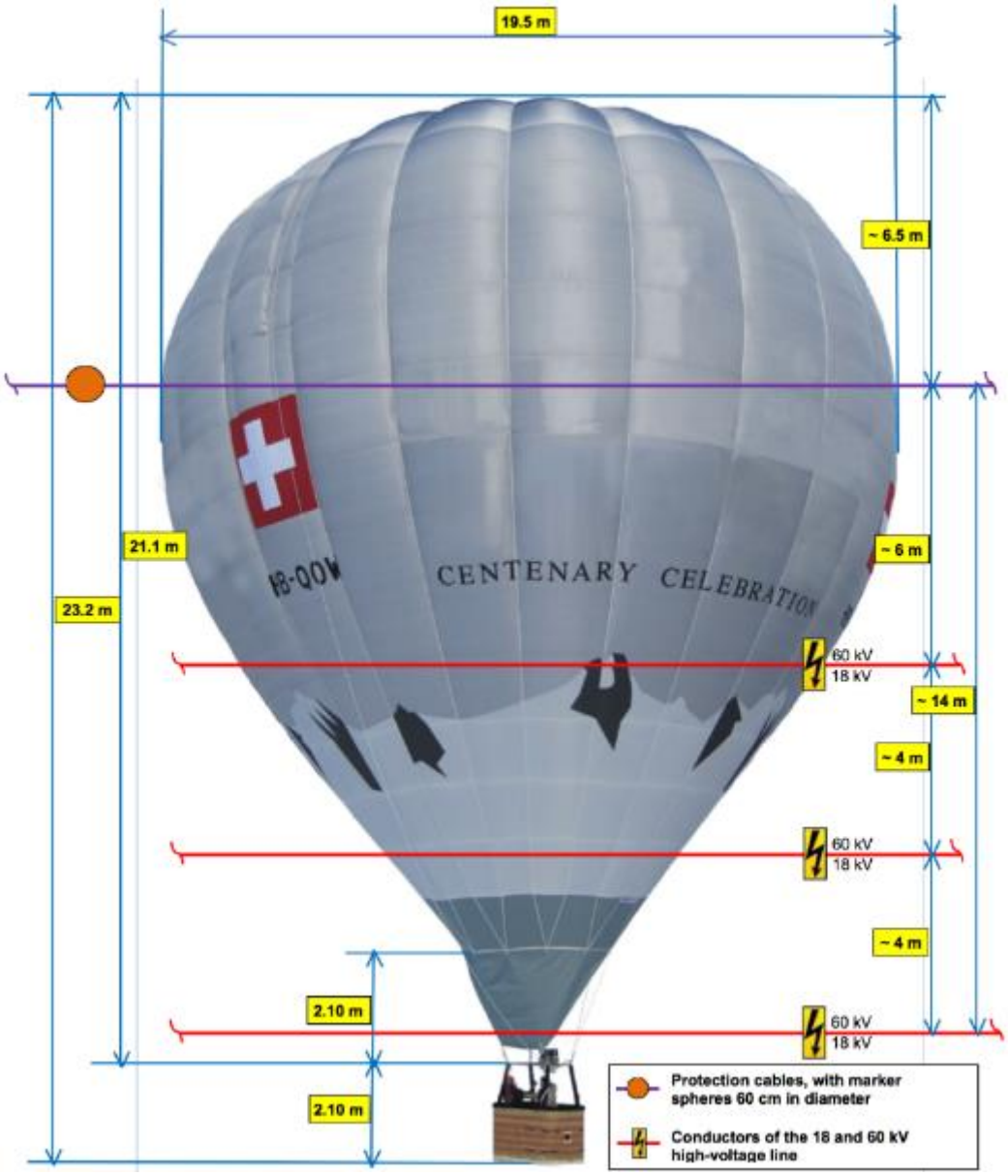


Figure 9: Dimensions of the balloon showing the positions of the conductors in red and the earth conductor cable in violet, at the time of the collision.

1.6.2 Circuit breakers

A circuit breaker is a protective device for electrical lines. In the event of a short-circuit, it interrupts the current and attempts to re-establish it approximately 300 ms later. If the short-circuit persists, the current is switched off.

The surveillance records for the 18 kV power line indicate an interruption of the current at 08:37:56, thus determining the exact time of the accident. The current was re-established at around 11:30.

The opening and automatic closing of the circuit breaker on the 60 kV power line caused only a brief interruption in supply.

1.6.3 Obstacle to aerial navigation

The section of the power line involved in the collision is recorded in the database of obstacles to aerial navigation. It is registered under number 262-HL-20 as shown on the 1:100,000 scale map no. 41, with a maximum height of 60 m AGL[9] and a length of 332 m.

1.6.4 Visibility of the obstacle

Reconnaissance, aerial and on foot, showed that the section of the power line identified by 10 orange marker spheres (RAL 2009) is visible from the locality known as "Les Rafforts", i.e. approximately 1 km up the valley.

1.7 Experience of the pilot

The pilot began his practical training in May 2004 and completed it in May 2007. His flying experience was 240:25 hours, including 35 hours of captive flights[10]. Out of a total of 150 completed flights, the majority were made in the region of Pays-d'Enhaut.

According to his statements, he was aware of the existence of the high-voltage power line at La Comba d'Avau because he had flown over it numerous times. His flying logs do not mention any landing at La Comba d'Avau. A flight made in August 2012 notes a landing at Montbovon and eleven landings were recorded in the region of Albeuve, Les Sciernes and Lessoc. The local wind known as the *Ruchio* was known to the pilot. However, he had not experienced its effects before the accident.

1.8 Organisational and management information

Based in Gstaad, the Gstaad Fly S.à r.l. company was the owner and operator of only one balloon. Its purpose was amongst other things the purchase, sale and leasing of sport and leisure items, in particular hot-air balloons, as well as the organisation of sporting events, entertainment events and tourist flights in balloons. The company's only pilot was the director.

No transport ticket was produced in the name of the passengers for the flight on 6 August 2013. The Gstaad Fly S.à r.l. company had no authorisation to make commercial flights. On 14 May 2013 the travel agency had drawn up a programme for the day specifying the number of people for the flight, the departure time and the balloon's landing time in order to allow for arrival in Lausanne at 10:00.

1.9 Medical and pathological information

1.9.1 Pilot

The pilot had an initial medical examination to acquire the hot-air balloon pilot licence in Switzerland on 29 April 2004. Since this date he had no further medical examinations. Renewal of the medical certificate is not mandatory for balloon pilots.

The family doctor attested to the pilot's good health. According to him, the pilot did not suffer from any chronic illness which might have influenced his physical or

[9] AGL: above ground level

[10] Captive flights: tethered to the ground by ropes, the balloon ascends between 20 and 30 metres into the air. After a few minutes at the top, the balloon descends to change passengers before carrying out the same exercise several times.

mental performance or which might have caused a sudden incapacity on the day of the accident.

The pilot suffered serious injuries and various traumas. No trace of electrocution was found. The toxicological analyses did not reveal the presence of any substance likely to diminish psychomotor, reaction or decision-making capabilities.

1.9.2 Passengers

The serious injuries noted on the three surviving passengers were various fractures and internal lesions.

No trace of electrocution was found on the passengers.

The death of the passenger is due to multiple serious lesions of vital organs, which were incompatible with survival.

1.10 Tests and research

1.10.1 General

The components of the balloon, i.e. the envelope, the basket, the burners and the cylinders were examined.

In addition, a Mode S transponder, a portable Garmin GPSmap 60CSx GPS and a Flytec 3040 multifunction instrument were on board the basket. No data from these devices could be used to determine with any accuracy the trajectory, altitude or speed of the balloon.

1.10.2 Inspection of the envelope

The envelope was inflated with ambient air. The control lines, as well as the pulleys and the centralising cords of the parachute valve and RDS, were all in position.

Apart from the cables severed at the time of the impact, the envelope did not undergo any major damage. Several small tears and friction marks were observed on the lower part and on the upper part of the envelope.

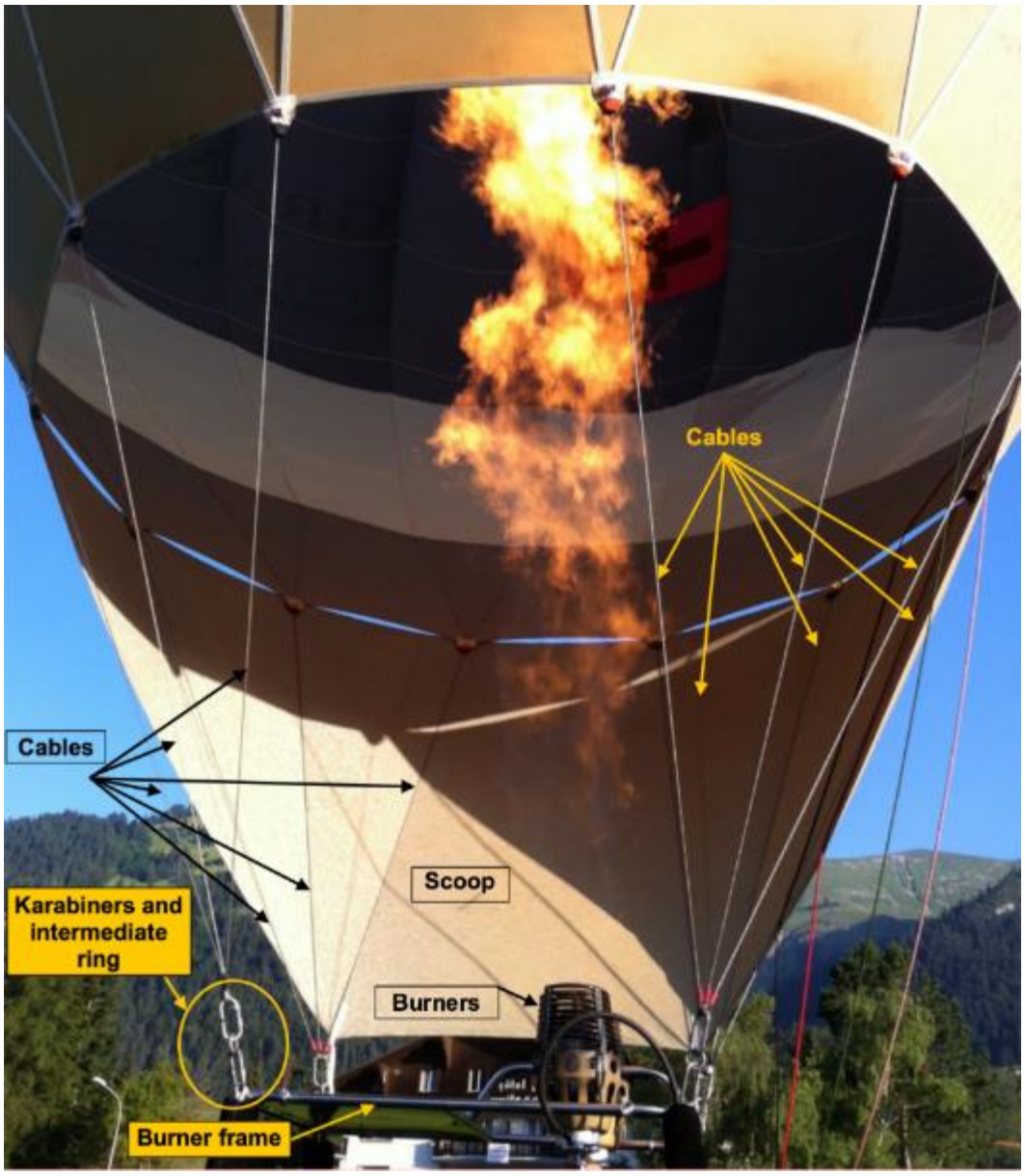


Figure 10: Photograph taken before the take-off of the accident flight, showing the scoop, the burners and the cables of the envelope connected to the burner frame.

Aldrey particles from the conductors of the high-voltage power line were found on all the cables connecting the envelope to the burner frame. Out of a total of twelve cables with a diameter of 4 mm (figure 10), only three located in the two corners of the pilot's compartment withstood the collision (figure 1). The other three cables on the side of the pilot's compartment and the six cables on the side of the passenger compartment were severed. Of the latter, five were severed in two different places. The breaks, mechanical or due to melting, are between 0.33 m and 1.68 m above the karabiners securing the envelope to the burner frame. The scoop (figure 10), fixed to the base of the envelope, was badly damaged. The two fasteners of the lower part fixed to the karabiners of the burner frame were torn off. Tears, segments of burnt fabric and traces of Aldrey were found on the outside of the scoop. It was not possible to determine the origin of these traces of burns, i.e. to know if they were due to the short-circuit or the flames from the burners. The fixings of the upper part were not damaged.

The internal melting link, attached to a coloured streamer, secured in the top of the envelope, was detached from its bimetallic tag (figure 12). The detached streamer

was not found at the site of the accident. The heat-sensitive tags sewn onto a strap in the top of the balloon indicated 149 °C for the original tag and 121 °C for the second added tag (figure 11).

According to the technical documentation, the second heat-sensitive tag was added at the time of the annual inspection carried out on 7 December 2010 at 31:40 hours TSN, whilst the original tag indicated 121 °C black. At the time of the annual inspection carried out on 9 January 2013 at 141:20 hours TSN, the two tags indicated a temperature of 121 °C.

In addition, the internal melting link was replaced at the time of the annual inspection carried out on 9 January 2013.

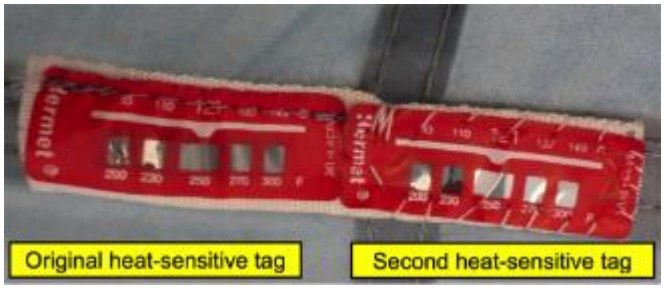


Figure 11: Heat-sensitive tags.

Figure 12: Part of the bimetallic tag, which remained fixed to the envelope.

1.10.3 Inspection of the basket

The structure and the partition of the basket compartment were deformed by the impact. The wooden skids fixed under the basket and the floors broke in several places. The rope handles fixed inside the basket were not damaged. Short-circuit marks are visible on some karabiners and on the forged steel intermediate rings installed between the burner frame's karabiners and those of the envelope cables.

1.10.4 Inspection of the burners

The break in the flexible feed pipe between burner no. 1162 and cylinder B4 occurred at the junction of the screw connection on the cylinder.

The burner frame and the burner mounts were deformed by the impact. The chrome-plated parts of the protective plate on the passenger side exhibited numerous traces of hot particles ejected by the electric arcs.

The propane pressure gauges were not indicating zero. After purging the gas circuit, the pressure gauge on burner no. 1126 indicated 1.5 bars; its glass was blackened, concealing the green sector of the indication. The pressure gauge of burner no. 1162 indicated 6.6 bars.

A function test of the burners did not reveal any defect, apart from the reading of the pressure gauges.

1.10.5 Inspection of the cylinders

The four stainless steel cylinders were protected on their cylindrical section by a foam cover surrounded by fabric. The valves for opening and closing the cylinders were activated by a lever system. An inspection of the cylinders, the bleed valves and the gauges did not reveal any defect. The stainless steel protective rings, welded onto the lower part of the four cylinders, were deformed by the impact.

1.11 Reconstruction of the final phase of the flight

1.11.1 General

The reconstruction of the final phase of the flight is based on photographs taken by the passengers. Eight of these were used to determine the various positions of the balloon in relation to the power line by photogrammetry. Position nine corresponds to the location of the collision, this being known with accuracy.

1.11.2 Summary of the positions of the balloon

Table 1 shows the positions of the balloon with the time, height, and altitude together with tolerances and metric co-ordinates.

Position	Time	Height AGL [m]	Vertical tolerance [m]	Altitude AMSL [m]	Coordinates (Swiss Grid 1903)
Pos. 1, Les Rafforts	08:34:12	~ 67	± 1.5	~ 926	~ 569 106 / 148 080
Pos. 2	08:35:52	~ 91	not defined	~ 948	~ 569 233 / 148 542
Pos. 3, Comba d'Amont	08:36:34	~ 118	± 6	~ 937	~ 569 303 / 148 712
Pos. 4	08:36:52	~ 99	± 1.5	~ 916	~ 569 350 / 148 799
Pos. 5, Comba d'Avau	08:37:28	~ 28	± 3	~ 838	~ 569 507 / 148 980
Pos. 6	08:37:32	~ 27	± 3	~ 835	~ 569 524 / 148 994
Pos. 7	08:37:34	~ 25	± 3	~ 828	~ 569 536 / 149 002
Pos. 8	08:37:38	~ 23	± 3	~ 824	~ 569 557 / 149 020
Pos. 9, collision HT line	08:37:56	~ 43	± 1.5	~ 845	~ 569 655 / 149 092

Table 1

Table 2 shows the average values established on the basis of the data in table 1. The parameters between positions no. 8 and 9 were estimated from the time of the first interruption in the power line.

Position of the balloon	Time difference [s]	Distance travelled [m]	Horizontal tolerance [m]	Height difference AGL [m]	Speed of travel [km/h]	Rate of ascent and descent [m/s]
Pos. 1 - 2	100	~ 479	± 1.5	+ 24	~ 17.3	~ + 0.22
Pos. 2 - 3	42	~ 183	not defined	+ 27	~ 15.7	~ - 0.26
Pos. 3 - 4	18	~ 102	± 6	- 19	~ 20.4	~ - 1.17
Pos. 4 - 5	36	~ 251	± 1.5	- 71	~ 25.1	~ - 2.15
Pos. 5 - 6	4	~ 24	± 3	- 1	~ 21.6	~ - 1.5
Pos. 6 - 7	2	~ 14	± 3	- 2	~ 26.1	~ - 2
Pos. 7 - 8	4	~ 28	± 3	- 2	~ 25.2	~ - 1.12
Pos. 8 - 9	18	~ 123	± 3	+ 20	~ 24.6	~ + 1.19

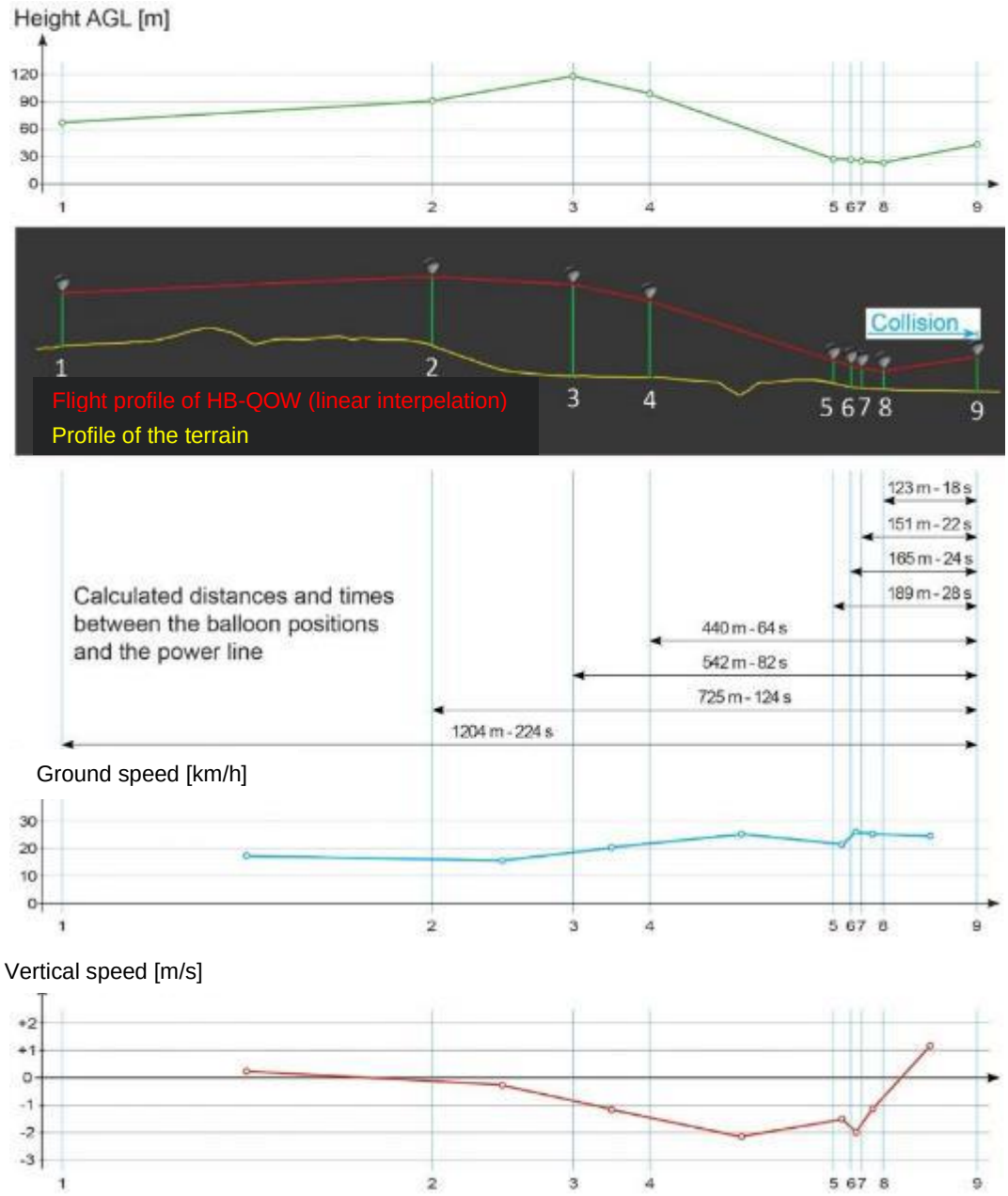
Table 2

1.11.3 Representation of the final flight phase

The different positions of the balloon in table 1 were entered onto the model three-dimensional map below.

Figure 13: Successive positions no. 1 to no. 8 of the balloon. The position no. 9 corresponds to the collision with the power line.

1.11.4 Profiles and graphs of the final flight phase



Profiles and graphs of the values for height, ground speed and vertical speed for positions no. 1 to no. 9.

1.12 Additional information

1.12.1 Extracts from the flight manual

Among the limitations and procedures related to the operation of a Cameron Z-120 balloon, the manufacturer's flight manual recommends the following:

1.12.2 Section 2 - Limitations

" […]

2.8 Envelope temperature and loading

1. The envelope temperature must not exceed 120 °C, (250 °F).

2. The envelope temperature must be controlled either by use of the envelope thermometer, or by loading according to the loading chart in Section 5.

[…]

2.12 Rapid deflation systems

1. The parachute valve of the rapid deflation system, when used for the controlled release of hot air during flight, must not be held open for periods longer than 3 seconds. The envelope must be allowed to re-inflate fully between operations of the vent.

2. Use of the rip line is not permitted at heights greater than 2m (6ft) above ground level, except in an emergency. "

1.12.3 Section 3 - Emergency procedures

" […]

3.2 Avoidance of dangerous obstacles at low level

The pilot must decide whether to climb or to make an emergency landing. "

3.2.1 Emergency Climb

[…]

Emergency climbs should be made by operating the main burner valve on each burner unit simultaneously.

Note: The operation of two burners from a single fuel supply using the crossflow valve will not give maximum burner power.

3.2.2 Emergency Landing

Emergency landings can be made by partially opening the parachute valve, Rapid Deflation System or Velcro rip panel at heights of 15m (50 ft) or less.

3.3 Contact with electric power lines

Contact with electric power wires is extremely dangerous and can result in serious or fatal injuries. It should be avoided at all costs.

If contact with power wires cannot be avoided, initiate a rapid descent so that contact with the wires will be made by the envelope instead of the basket assembly.

Shut off all the fuel supplies at the cylinder valves and vent the fuel hoses before con- tact.

If the balloon is caught in the power wires, do not touch any metallic parts.

[…] "

1.12.4 Section 4 - Normal procedures

" […]

4.5.2.1 Parachute Valve/RDS

To release hot air during flight the venting line should be pulled. "

[…]

4.6 Landing

Pre-Landing Checks

Powerlines	*Clear of approach path and overshoot.*
Passenger Briefing	*Silence during landing.* *Repeat landing part of passenger briefing.*

[…]

Fuel	*Enough fuel in cylinder(s) in use for landing and overshoot.*

[…]

Liquid Fuel Supply	*Check contents of cylinders in use.*

[…] “

2 Analysis

2.1 Technical aspects

The investigation did not reveal any technical factor which might have caused or contributed to the accident. In addition the pilot did not indicate any technical defect for this flight.

The damage noted on the feeder pipe and the pressure gauges of the burners is probably due to the impact of the basket with the ground.

The fact that the streamer fixed to the top of the envelope by the melting link was detached allows the conclusion that the pilot definitely made continuous use of the two burners just before the collision. The difference in indication between the two heat-sensitive tags can be explained by the relative reliability of these devices.

2.2 Operational aspects

2.2.1 Landing site

The flight was expected to be relatively short and the option of a landing after one hour of flight was a logical decision with regard to the programme drawn up by the travel agency. After flying over the area known as “Les Rafforts”, the pilot decided to land at La Comba d’Avau and logically informed his team member, who was following him.

The presence of the high-voltage power line was known to the pilot and was indicated on the chart of obstacles to aerial navigation. Its marking, by 10 orange spheres, made it visible from more than one kilometre away. On the basis of the calculated speeds at the various positions, the pilot had more than three minutes to cross this obstacle. This period of time was ample to adapt a flight tactic in order to avoid collision.

2.2.2 Flight tactic

The various values determined at the time the balloon passed positions no. 1 to no. 4 (see 1.11.4) allow the conclusion that crossing the power line was possible up to that point. In fact, the balloon was at a distance of approximately 440 m from the obstacle and at a height which was still higher than the power line. Maintaining the flight altitude would have made it possible to clear it.

After the balloon passed position no. 4, which corresponds to passing over La Comba d'Amont, the reconstructed profile shows a descent phase, which was stabilised at approximately 25 m above ground level. This situation was aggravated by the presence of the local wind known as the *Ruchio*, blowing in the lower strata, which caused the balloon to accelerate in the direction of the obstacle. At that moment, i.e. in the area of positions no. 5 and no. 6, the balloon was at a distinctly lower height than that of the earth conductor of the power line and in an acceleration phase, which constituted a dangerous situation. This inadequate flight tactic can be explained by a temporary lapse of memory concerning the position of the obstacle on the part of the pilot, the cause of which is difficult to explain. It may be that it was caused by the pilot's preoccupation with landing at this location in order to end the flight as soon as possible to comply with the passengers' schedule. This preoccupation may have caused a "tunnel vision" effect, i.e. a focus on a single factor or objective, in this case the landing manoeuvre, without taking account of the presence of the obstacle.

When the pilot became aware of the presence of the power line, probably around position no. 7, his decision was to try to cross it by constantly activating the two burners. This emergency manoeuvre could not succeed in this context. In fact, the

balloon was then only approximately 150 m from the power line, at an estimated height of 25 m, at a calculated speed of 25 km/h, with a rate of descent of approximately 2 m/s.

During this final flight phase, the late activation of the burners enabled a climbing phase of flight to be established; however, the following factors reduced the balloon's climbing performance:

- A mass close to the authorised maximum value.
- An outside temperature of 18 °C.
- The use of two burners, one of which was supplied by a cylinder containing only approximately 20% propane.

Consequently, the collision with the power line conductors was inevitable. The flight manual mentions in section 3 *"3.3 Contact with electric power lines"* descending as rapidly as possible so that the contact with the power line takes place at the level of the envelope and not of the basket. In addition, it recommends closing the valves of the cylinders.

Because of the pilot's lack of recollections just before the collision, it is not possible to analyse his manoeuvres at that time.

The fact that the envelope deflated immediately after the collision indicates that the pilot had probably operated the RDS cord. In fact, the envelope was only slightly damaged by the collision and consequently could only be deflated so rapidly and completely by the activation of the RDS.

2.3 Human aspects

2.3.1 Lapse of memory concerning the power line

The fact that the pilot forgot to take the proximity of the obstacle into account can be explained by stress related to the following factors:

- The modification of the envisaged flight trajectory because of the fear of one of the passengers.
- The intention to want to shorten the flight to suit the passengers.
- A lack of communication due to the language difference.

These stress factors probably created a "tunnel vision" situation, which caused this lapse of memory. Although he was aware of the existence of this power line, the pilot did not see it until very late. This fact is corroborated by the pilot's statement to one of the first persons present at the accident site that he had not seen the power lines.

2.3.2 Survival aspects

The fall of the basket in a tilted position resulting from the rupture due to melting of nine out of twelve cables with a deflated envelope generated high reaction forces on impact with the ground. The occupants were probably hanging onto the basket's internal handles, stopping them from being thrown out. On the other hand, the contact with the ground was very violent and resulting in serious injuries to the occupants, causing the death of one of the passengers at the site of the accident. No protective device could have prevented this fatal outcome.

The presence of many persons who responded contributed to the effectiveness of the emergency services and prevented a fire hazard or even the risk of an explosion.

2.4 Meteorological aspects

The weather conditions were adequate for making a balloon flight. The weather was clear and the wind light at altitude. The pilot experienced neither turbulences nor thermals. Despite his acquaintance with the local *Ruchio* wind in the area of La Comba d'Avau, the pilot was probably surprised by its presence.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The investigation did not reveal any defect which might have caused or contributed to the accident.
- The components of the balloon and the propane cylinders were damaged.
- No data concerning the flight trajectory, altitude and the speed of the balloon could be used from the on-board devices.
- Nine out of a total of twelve envelope cables were severed in the collision with the power line conductors, either mechanically or by melting.
- The internal melting link, attached to the top of the envelope, was detached from its bimetallic tag and could not be recovered.
- The conductors of the high-voltage power line were damaged but withstood the collision.
- The power line's protection circuit breakers functioned correctly.

3.1.2 Operational aspects

- The pilot was in possession of an adequate licence.
- The quantity of propane gas carried in the basket was sufficient for the planned flight.
- The majority of his flights were carried out in the Pays-d'Enhaut region.
- At the time of the accident the mass of the balloon was within the prescribed limits.
- The balloon was licensed for daylight VFR flight.
- No transport ticket for the passengers was issued.
- The Gstaad Fly S.à r.l. company had no authorisation to make commercial flights.
- The section of the high-voltage power line is identified by ten orange marker spheres 60 cm in diameter.
- The section of the power line is indicated on the chart of obstacles to aerial navigation no. 41, with a maximum height of 60 m AGL and a length of 332 m.

3.1.3 Human aspects

- The pilot was aware of the existence of the high-voltage power line because he had flown over it numerous times.
- The pilot's toxicological analyses did not reveal the presence of any substance likely to diminish psychomotor, reaction or decision-making capabilities.
- Communication between the pilot and the passengers was reduced because of the language difference.
- The fear experienced by one of the passengers caused the pilot to modify the altitude of the flight and consequently its trajectory.

3.1.4 History of the final phase of the flight

- At approximately 08:35, the pilot informed his team member by radio that he planned to land at La Comba d'Avau.
- The reconstructed flight profile demonstrates that the height maintained up to La Comba d'Amont permitted the crossing of the high-voltage power line approximately 440 m away.
- The altitude reached by the balloon at position no. 5 was lower than that necessary for the crossing of the power line.
- The burners were connected to two cylinders, one of which contained 20% propane.
- The balloon collided with the high-voltage power line conductors at 08:38.
- The envelope deflated rapidly after the collision with the high-voltage power line.
- The basket with its occupants fell from a height of approximately 40 metres.
- A gas leak occurred following the impact of the basket with the ground; it was dealt with by a third person who closed the valves on the cylinders.
- Fire did not break out.

3.1.5 General conditions

- The weather conditions were adequate for the flight to take place.
- The pilot experienced neither turbulences nor thermals during the flight.
- Observers located at La Comba d'Amont and La Comba d'Avau reported that a local wind known as the *Ruchio* was blowing at a speed estimated between 20 and 25 km/h at the time when the accident occurred.

3.2 Cause

The accident is attributable to the collision of the balloon with a high-voltage power line because of an inappropriate flight tactic following a lapse of memory concerning the presence of this obstacle in the approach phase. The late sighting of the obstacle did not allow it to be crossed.

A local wind blowing in the approach sector played a role in the evolution of the accident.

4 Safety recommendations, safety advices and measures taken since the accident

4.1 Safety recommendations

None

4.2 Safety advices

None

4.3 Measures taken since the accident

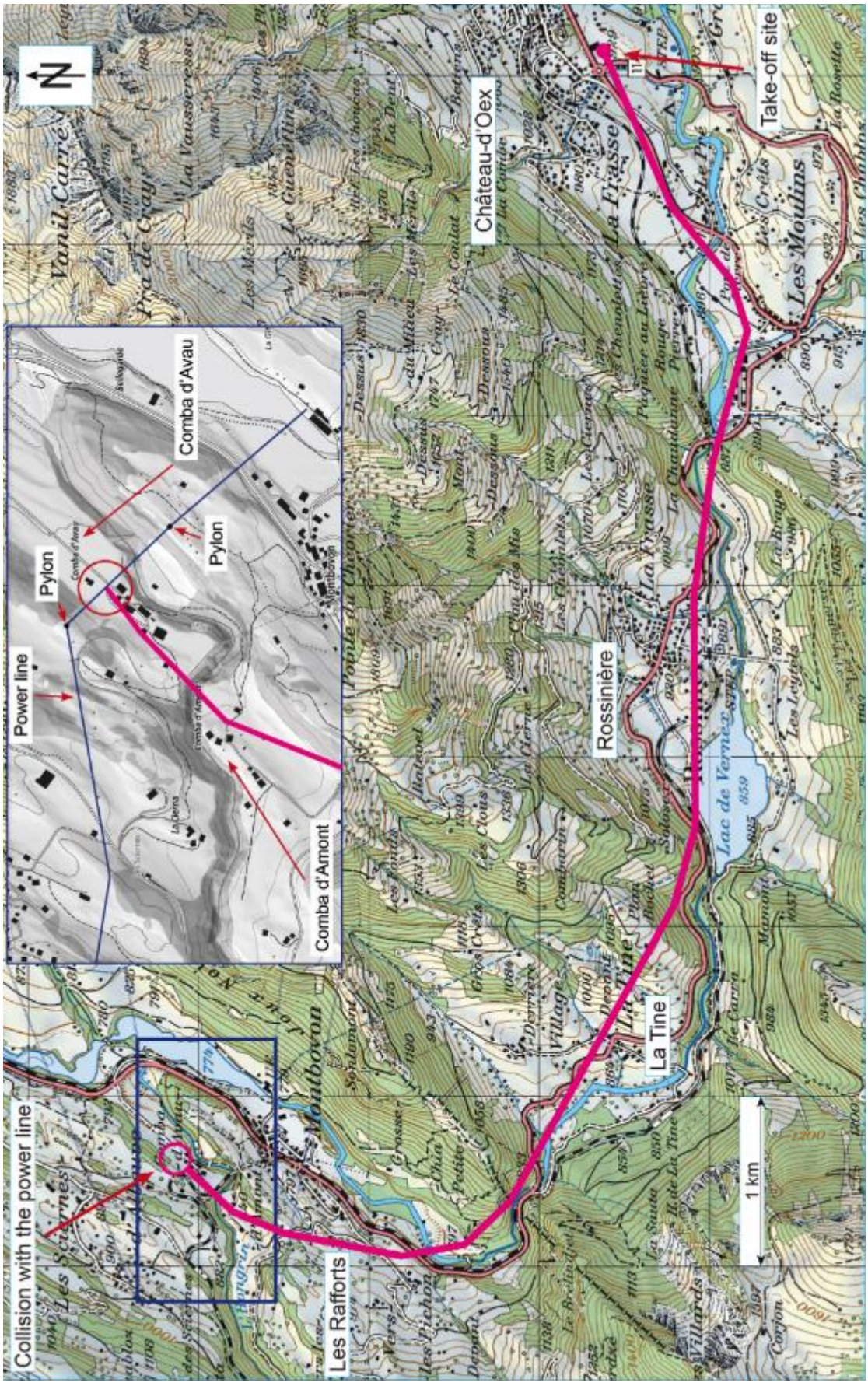
None

Payerne, 21 March 2016 Investigation Bureau STSB

This final report was approved by the Board of the Swiss Transportation Safety Investigation Board STSB (Art. 10 lit. h of the Ordinance on the Safety Investigation of Transportation Incidents of 17 December 2014).

Berne, 7 April 2016

Annex: plan view of the estimated trajectory of the balloon



Map reproduced by permission of the Federal Office of Topography Swisstopo (JA150149)