

# Investigation Report

## Identification

Type of Occurrence:	Accident
Date:	12 June 2011
Location:	Reichelsheim
Aircraft:	Airship (Blimp)
Manufacturer / Model:	American Blimp Corporation / A-60+
Injuries to Persons:	1 person fatally injured, 3 persons suffered minor injuries
Damage:	Aircraft destroyed
Other Damage:	Minor crop damage
Information Source:	Investigation by BFU
State File Number:	BFU CX004-11

## Factual Information

### History of the Flight

An airship was stationed at Reichelsheim Airfield for several days so that sightseeing flights in the region could be conducted as part of a publicity campaign. On the day of the accident at 0830 hrs<sup>1</sup> the two pilots, who were taking turns conducting the sightseeing flights, met at the airfield for pre-flight preparation. It was determined that the gas volume of the airship had decreased somewhat compared to the day before.

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<sup>1</sup> All times local, unless otherwise stated.

The Load Sheet was compiled at 0930 hrs. The total gross weight was stated as 3,806 lbs and the maximum gross weight as 4,394 lbs. The total gross weight included a ballast of 475 lbs. The flights were split up so that pilot (1) would conduct five sightseeing flights between 0954 hrs and 1500 hrs and pilot (2) would conduct two sightseeing flights between 1510 hrs and 1745 hrs. At 1808 hrs, the airship took off for the eighth flight with pilot (2) and three passengers on board. The intent was to take aerial photos above Bad Homburg of the preparations for a concert which was to take place in regard to the "Hessentag". On both legs to and from Bad Homburg the pilot was in radio communications with Langen Information on frequency 119.15 MHz between 1813 hrs and 2005 hrs. After about two hours of flight time he reported to the Flugleiter (A person required by German regulation at uncontrolled aerodromes to provide aerodrome information service to pilots) at Reichelsheim Airfield his position as 5 Nautical Miles (NM) south-west of the airfield in 3,500 ft. The pilot received the information that there were no surface winds.

The passengers observed that the airship quickly descended during the approach and then flew in low-level flight towards the ground crew. At 2015 hrs, during the final approach in direction 18 about 470 m away from the anchor mast the airship suffered initial ground contact. The three passengers described this first ground contact as very hard. They unanimously stated that after the airship had come to a complete stop the pilot had said it was an accident. The passengers made the pilot aware of the increasing fuel smell and reported fire and heat development in the aft part of the gondola. They disembarked from the airship gondola; according to their statements the pilot supported them to do so.

The ground crew described the final approach of the airship as normal. They did notice a loud cracking noise during the initial ground contact. The ground crew observed that the airship did not move closer and smoke developed around the gondola. Then the ground crew members ran toward the airship to help. They saw three passengers disembark from the gondola and the airship ascending again. In a short period of time it reached a height of more than 20 m and the fire in the rear part of the gondola rapidly spread to the cabin area and the envelope. The ground crew could not reach the mooring ropes hanging from the nose of the airship.

The burning airship continued to ascend again up to about 100 m and thereby drifted slowly to the east. Deformation of the envelope began with the increasing fire. Later it caved in and at 2020 hrs the burning airship crashed to the ground about 400 m from the initial touch-down point. It burnt out completely and only the pilot's body could be recovered. The three persons who had left the airship suffered from shock.



Burning airship

Photo: Witness

## Personnel Information

The 52-year-old pilot held a Pilot's Licence Airships (Blimps) since 1985. Since 1977 he had acquired different licences and ratings for single and twin engine aircraft. He had a total flying experience on blimps of about 12,330 hours. He had a total flying experience on different single-engine aircraft of about 1,800 hours and on twin-engine aircraft of about 3,000 hours. Since 8 June 2011 the pilot had conducted sightseeing flights daily with the airship from Reichelsheim Airfield. At the day of the accident he conducted three flights with the airship. The pilot held a class 1 medical certificate. The last examination took place on 18 February 2011. When the class 1 medical certificate was issued it included the requirement to wear reading glasses.

## Aircraft Information

The airship A-60+ is a blimp. The airship had a length of 39 m and an envelope volume of 1,926 m<sup>3</sup>. Helium is used as filling gas. The airship is powered by two combustion engines. In normal operation it reaches a speed of about 30 kt in zero wind condition.

The airship had been registered in Great Britain and was commercially operated by an operator for sightseeing flights and sales promotions.



Luftschiff A-60+

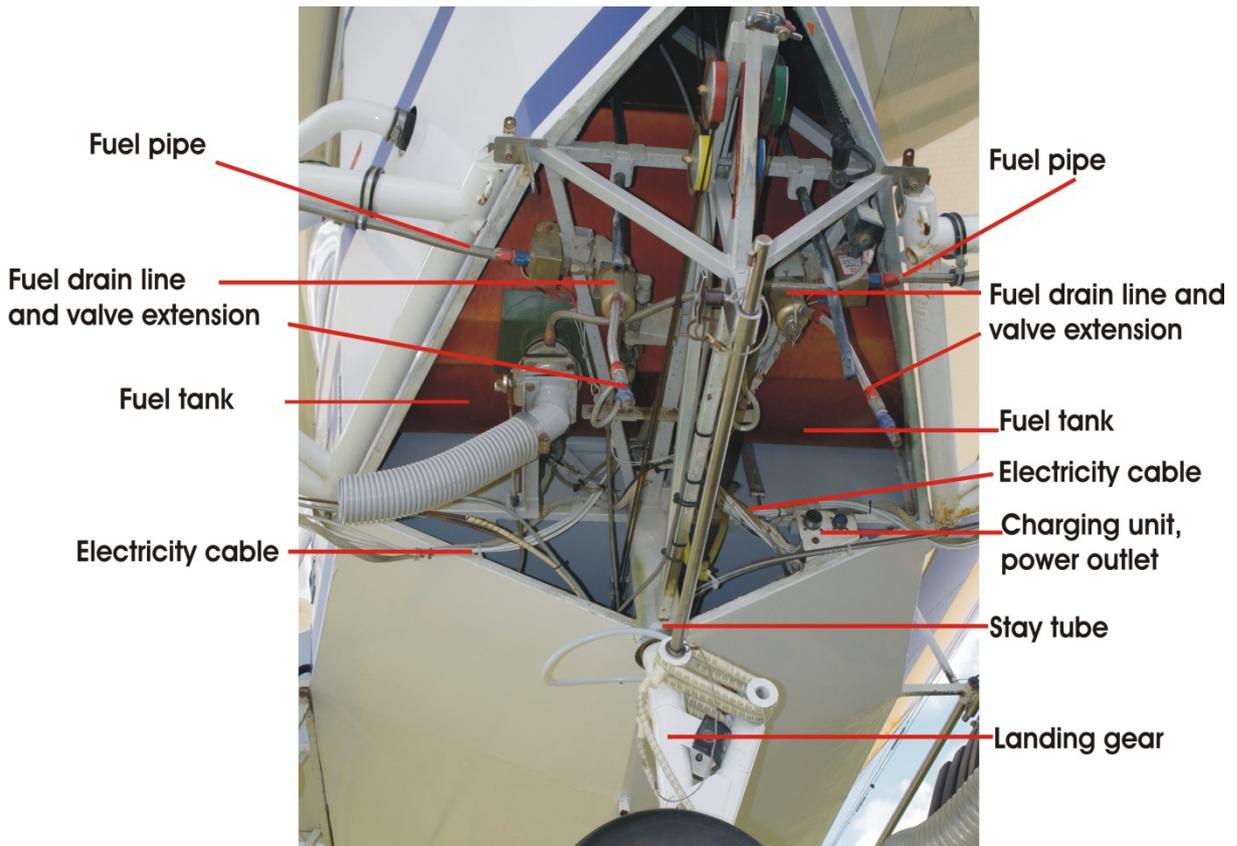
Photo: Good Year

Manufacturer:	American Blimp Corporation
Type:	A-60+
Year of manufacture:	1991
Manufacturer's serial number:	003
MTOM:	4,394 lbs, 1,993 kg
Engines:	Two Limbach L2000 EC1

On 7 March 1991 the aircraft received an US American certificate of registration. Since May 2002 the airship had a British certificate of registration. Total operating time was about 8,000 hours. The last annual inspection took place on 7 April 2011. The airworthiness certificate, the certificate of registration and the annual inspection certificate were available.

The gondola of the A-60+ consisted of a steel tube frame work and the compartment floor was covered by marine plywood which met the FAA burn test requirements per

Order P-8110-2 Paragraph 4.39. The upper part of the gondola's bulkhead also consisted of marine plywood which met the FAA burn test requirements per Order P-8110-2 Paragraph 4.39. The bulkhead below the rear seat consisted of aluminium. The steel tube frame work of the gondola was mainly covered by standard aircraft fabric (polyester). The pointed rear end of the airship was freely accessible from below.



The sister airship (same design)

Photo: AAIB

At the rear of the gondola behind the back seats a fuel tank holding 260.8 l fuel is installed. The tank was made of aluminium and was fastened to the steel tube frame work with metal straps. Fuel pipes lead from the tank to both engines. Two gascolators are mounted to the bottom of the fuel tank each of which is equipped with a 33 cm long flexible fuel pipe and one drain valve. Aircraft Flight Manual (AFM) excerpt:

*"1.2.3 FUEL SYSTEM Two fuel lines run separately from the bottom of the fuel tank and up to its respective engine. Each fuel line has a fuel drain sump (GASCOLATOR) at its lowest point, an On/Off fuel valve and electrical booster pump."*

A ballast compartment is located in front of the fuel tank in which additional ballast bags can be transported and where the starter battery is installed. On the bulk-head inside the compartment a special mounting for electrical wires and components is installed. Several wires run through the back wall of the ballast compartment into the open space below the rear end. These wires run on both sides of the fuel tank to the outside. Among other things, a charging station on the upper left is connected to it.



The sister airship (same design)

Photo: AAIB

The ballast compartment can only be accessed from the outside through a door. In the steel tube frame work below the ballast compartment the landing gear suspension is mounted.

## Meteorological Information

Visual meteorological conditions with few clouds prevailed at the time of the accident. There was no wind at Reichelsheim Airfield. Due to a slightly westerly wind the burning wreck was carried east when it ascended again. Air temperature on the ground was about 16°C. There were no special meteorological conditions.

## Communication

Pilot and Flugleiter at Reichelsheim Airfield were in radio communication on frequency 120.42 MHz. During the flight to Bad Homburg radio communication took place with Langen Information on frequency 119.15 MHz. In addition, the pilot had contact with the ground crew on frequency 130.570 MHz. Radio communications on the two frequencies 120.42 and 119.15 MHz were recorded. Pilot (1) stated that there were problems with the microphone button which often jammed mechanically.

During the last flight, the airship and the ground crew had contact via text messages. The pilot sent the following text message: "Its a heavy puppy 15 plus. Doesn't want to fly at 2200 rpm. I guess no hooked approaches today." The ground crew answered: "I reckon you need to use long grass...". The American Blimp Corporation and Lightship Europe Limited estimated in a letter dated 26 April 2013 sent to the BFU that the text message implies the airship was overloaded by 15 ballast bags or 375 lbs, respectively. This prompted the pilot to demand 2,200 rpm from the engines to hold the airship steady.

Pilot (1) stated that contact by text message only occurs when contact on the operating frequency is not possible.

## Aerodrome Information

Reichelsheim Airfield (EDFB) has one 1,300 m long asphalt runway, oriented 18/36 and one 250 m long grass runway, oriented 27/09, at the southern end of the airfield. At the time of the accident runway 18 was in use. The mooring mast for the airship was located about 132 m east of the asphalt runway, directly on the runway centreline of the grass runway. The approach of the airship occurred in the direction to runway 18 east of the asphalt runway above grass which was about 70 – 80 cm high.

## Wreckage and Impact Information

The initial ground contact of the airship occurred about 470 m north of the anchor mast and about 82 m east of the edge of the asphalt runway on a meadow with about 70 - 80 cm high grass. The airship came to a complete stop 38 m beyond the point of initial ground contact. On this path small pieces from the gondola were found. Torn-off rubber bands and metal parts of a landing gear ball bearing were found a few meters from the initial touch-down point. A cover cap of a lighting system was found about 18 m from the initial touch-down point. Distinctive traces of fire were found on a

grass area (approximately 0.5 m<sup>2</sup>) about 38 m from the initial touch-down point. The torn-off main landing gear was found about 4 m east of the fires traces in the grass.



Accident site airship

Photo: Witness

The accident site was located about 500 m east of the asphalt runway on a meadow. On the ground the entire airship construction had burnt almost completely. Only the metal construction of the envelope and the gondola protruded from the accident site. The steel tube frame work was severely deformed. A slit-shaped opening was found on the bottom of the fuel tank. The edges of the 23 cm long opening were clearly bent inwards. For further investigation, the torn-off landing gear and gondola components were taken to Braunschweig.

## Medical and Pathological Information

The responsible public prosecutor ordered to not perform a post mortem examination on the pilot. Due to witness' statements health problems were very unlikely.

## Fire

After the airship touched down hard there was fuel leakage which caught fire on the rear part of the gondola.



Source of the fire on the gondola

Photo: Witness

The fire expanded rapidly and within a short time spread to the cabin area. While the airship ascended again the fire spread to the outer skin of the envelope. Once the structure of the envelope failed, the envelope collapsed and the burning wreckage crashed to the ground.

## Survival Aspects

The landing of the airship occurred without injuries to persons. After the three passengers noticed the fuel smell they left the gondola. The passengers stated the pilot remained in his seat even though he had been made aware of the fuel smell and the heat development. After the passengers had disembarked, the burning airship ascended again which made it impossible for the pilot to disembark.

## Tests and Research

Parts of the landing gear and the fuel tank system were subject to technical examination. The determinations and conclusions are described below.

### Landing gear

#### Description and Function

The landing gear consists of a landing gear strut which is designed as a tube. It is inserted into a stay tube from below and its upper end is bolted down with a crown nut.



Sister airship

Photo: AAIB

The stay tube is welded into the supporting structure below the bulkhead (construction title STA 113) of passenger cabin and fuel tank. Within the stay tube the landing gear strut is pivot-mounted (360°) through ball bearings mounted to the upper and lower part of the tube. The landing gear leg, on which the axis with the wheels is located, is screwed with a bolt to the lower part of the landing gear strut. Brackets are welded to the landing gear strut below the stay tube and to the upper end of the landing gear leg. Shock rings which function as suspensions are wrapped around these brackets.

In the unloaded condition spring deflection is limited by a rubber-coated stop which is welded to the landing gear strut. This also keeps the axis centre behind the centre line of the strut and therefore ensures that the spring mechanism is triggered. Maximum spring deflection is limited by a steel cable; it begins at the brackets for the shock rings on the landing gear leg and goes around the strut. In addition, two centering bungees are stretched between the brackets for the shock rings and the gondola undercarriage; they align the landing gear with the flight direction.

## Damages on the Landing Gear

The landing gear fractured at the landing gear strut. The fracture is located 40 mm above the lower bearing ball. In this area was a shoulder where the outer diameter of the landing gear strut was reduced from 57 mm to 51 mm. Due to the shoulder the change in wall thickness causes a change in stiffness which increases the predisposition for fracture.



Fractured landing gear strut

Photo: BFU

At the fracture surface shear lips of 45° had formed. It was decided that the foremost point of the outer diameter of the strut is in the 12 o'clock position when landing gear and flight direction are aligned. Based on this decision the shear lips appear in two areas. One area extends from 7 to 5 o'clock. In this area the shear lips run 45° from outer to inner diameter. In the area between 5 and 7 o'clock they run 45° from inner to outer diameter.

This fracture pattern indicates a forced fracture which occurred with high tensile stress. There were no indications that the fracture occurred over a longer period of time. At the cross section, the fracture occurred abruptly from the front to the back. The landing gear was hit from the front during forward motion. Since the landing gear

strut was restricted in its movement by the position of the ball bearings in the stay tube bending was not possible and therefore the strut was strained to tension. Only after about two thirds of the strut were fractured the characteristic buckling of a bent tube appeared on the back of the upper fracture surface.



Fracture of the landing gear strut from the back with the buckling on the left fragment

Photo: BFU

The paint on the upper part of the landing gear strut fracture piece in the area of the shoulder between the 10 and 2 o'clock positions was abraded. The paint on the back side of the collar between the 4 and 8 o'clock positions was also abraded (crescent shaped).

At the lower seat of the ball bearings, the balls had indented themselves into the back side of the stay tube between the 4 and 8 o'clock positions. The cross section of the stay tube was pulled out to the rear and therefore somewhat oval instead of round.



Bottom fracture piece of the landing gear strut with ball bearing seat

Photo: BFU

The abraded paint is an indication that the front side of the lower fracture piece of the landing gear strut grated on the front side of the stay tube's inner side. The collar on the landing gear strut limits the lower ball bearing seat downward. Its back side was forcibly pressed back into the upper ball bearing seat, located on the stay tube. This caused the paint abrasion. Due to this forced indentation the balls mapped themselves on the upper ball bearing seat of the stay tube.

The steel cable ruptured on the left-hand side of the strut. The elastic ropes which served as suspensions were ruptured as well.

## Fuel Tank, Description and Examination

At the outside rear of the gondola a fuel tank holding 260.8 l fuel was installed. From the fuel tank, fuel pipes led to both engines.

Two gascolators were mounted to the bottom of the fuel tank, each of which was equipped with a 33 cm long flexible fuel pipe and one drain valve. Whenever the bottom of the gondola rests on the ground the valve extension of the drain valve inevitably has ground contact on a length of 8 - 10 cm.



Sister airship

Photo: AAIB

In the vicinity of the fuel tank several wires ran to both sides of the gondola through the bulkhead of the ballast compartment to the outside. Among other things, a charging station on the upper left was connected to it. At the accident site the fuel tank including parts of the steel frame work and the adjoining power unit were seized.



Steel tube frame work with stay tube and fuel tank parts at the accident site

Photo: BFU

Although the components were severely damaged the position of the gascolators could be determined. On one of the bowls the closing cap including extension hose and drain valve were missing.

The examination of the remaining parts of the fuel tank at the accident site revealed a gap of about 23 cm on the bottom part of the fuel tank. The investigation determined that as the burning wreckage crashed to the ground the tetragonal steel pipe construction was pushed into the bottom of the fuel tank.

## Organisations and their Procedures

Two pilots took turns conducting the advertising flights with the airship from Reichelsheim Airfield. Pilot (1) who had handed over the airship at 1500 hrs stated regarding the daily routine that he had conducted five flights and the lifting capacity of the airship had been below the optimum that morning. He also stated that the microphone button on the radio often got stuck. He estimated that due to the changed solar radiation conditions in the late afternoon the lifting capacity of the

airship had been reduced further. The estimated net lifting capacity was 608 lbs (276 kg) at the time of filling in the pre-flight preparation sheet. He estimated that at the time of the last flight the airship could have been operated about 175 lbs (79 kg) above the maximum allowable static heaviness. This assumption is confirmed by the text messages between the pilot and the ground crew during the last flight noting that the airship was overloaded by about 15 bags or 375 lbs. The exact lifting capacity and loading for the accident flight could not be determined. During the next to last flight a tail strike occurred and resulted in the loss of the wheel on the rudder. As a result the chief of the ground crew and the pilot talked briefly. The pilot was informed of the loss of the wheel and advised that the landing gear bungees were not in the best of conditions.

## Analysis

The aircraft had a British certificate of registration and a valid entry permit for German airspace. If an estimation of loading is even possible, given the information available, during the accident flight the airship was operated outside the limit value range for lifting capacity and loading. Prior to the last flight the condition of the landing gear bungees was criticized and the loss of the tail wheel indicated. The pilot was aware of the malfunction of the radio.

The pilot held valid licences issued in different countries and had acquired a substantial experience on airships in his more than 25 years as pilot. On this particular type his experience was substantial as well and he was well trained. At 0930 hrs the pre-flight preparation document was filled in for the day. At 1500 hrs when he took over, filling volume, lifting capacity, fuel quantity and loading were not documented. The pilot was aware of the loading condition in combination with the difficult landing conditions and sent a commensurate text message to the ground crew.

At the time of the accident good visual meteorological conditions prevailed. However, the wind situation at the airfield posed special demands on the pilot to land the airship safely. Because at the time of the landing there was no wind and the airship was operated above the maximum allowable static heaviness the pilot extended the final approach in order to reduce the approach speed in the high grass.

## Course of events

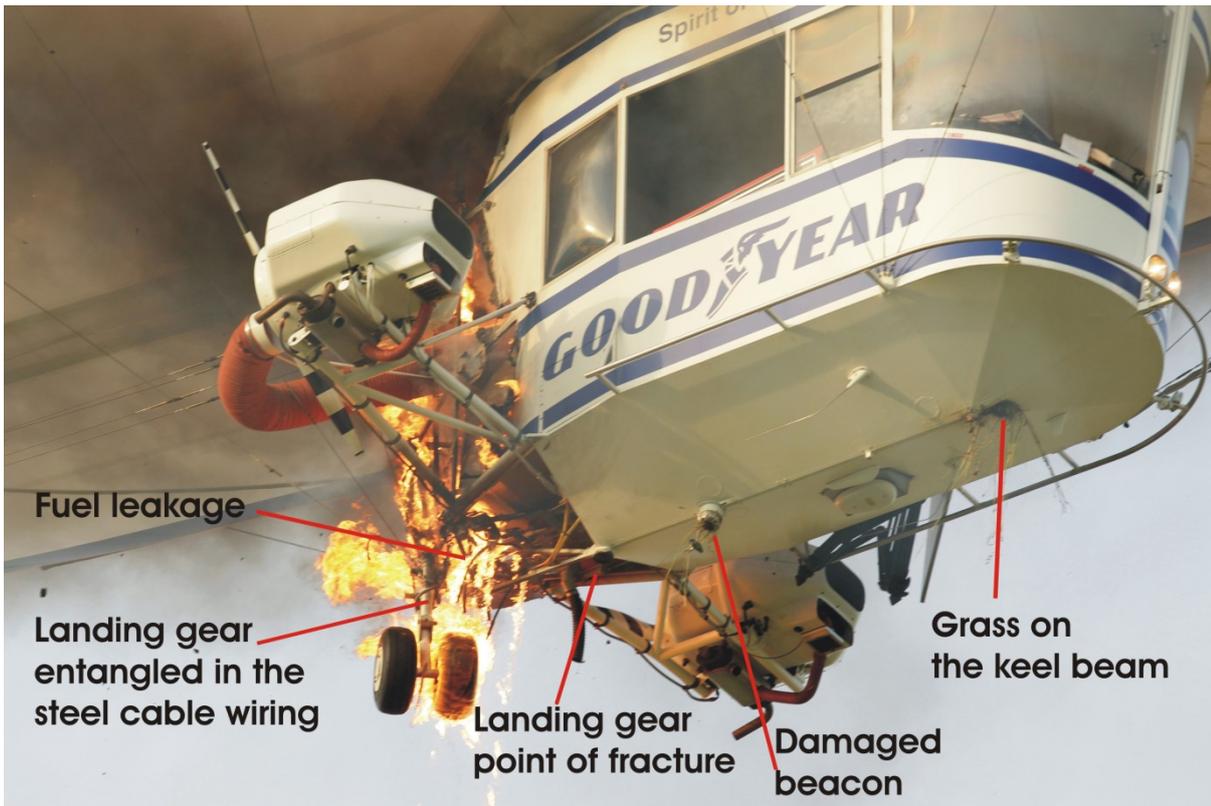
Due to the traces on the ground at the point of initial touch-down it is highly likely that the damages occurred as follows:

After the wheels had ground contact they moved so far back that the steel cable, which limits the maximum spring deflection, ruptured. Then the shock rings which serve as suspension ruptured. Therefore, it was possible for the landing gear leg to travel far back. Then the landing gear strut had ground contact at which point an immense backward effective force was passed into the strut because of the forward movement of the airship. This force caused the rupture of the ball bearing. Furthermore, this force resulted in a tensile stress on the landing gear strut due to the restriction in bending caused by the position of the strut in the stay tube. The landing gear strut fractured as a result.

Because of the missing landing gear the bottom of the gondola could touch down on the ground and slide across the meadow for about 38 m. The fractured cap of the Anti-Collision Light (ACL) and other small parts were found in this area. Tufts of grass found on the tip of the keel beam and on the mounting of the ACL are additional proof that the bottom of the gondola touched the ground.

It is highly likely that the fractured landing gear strut including landing gear leg had gotten entangled in the ropes which connect gondola and envelope in the rear part of the airship. It was turned by 180°, i.e. the back side of the landing gear strut pointed forward.

It is highly likely that after the gondola had touched down and slid across the ground, the fractured landing gear had pulled one hose of the drainage valve to such an extent that the cap on the gascolator shifted and subsequently caused the heavy fuel leakage. It cannot be ruled out that the pull on the hose of the drain valve occurred when the bottom of the steel pipe frame work and the landing gear jammed. The result would have been the opening of the gascolator. As a result of the slide across the ground the gascolator area of the fuel tank was either damaged by the fractured landing gear, or because components of the tank were jammed between the bottom of the gondola and the ground. A large amount of fuel leaked from the fuel tank. Witnesses in the gondola at the time confirmed that after the hard touch-down there was a strong smell of fuel.



Burning gondola

Photo: Witness

On photos taken at the time when the airship began to ascent again flames dripped down where the gascolators were located and burning liquid (fuel) is visible.

In the immediate vicinity of the fuel leak the central electrical supply, with different electro motors, electrical fuel pumps, servo valves, cables, and cable connections, was located.

It is highly likely that the fuel was ignited by arcing originating from the electrical system. It could not be determined with absolute certainty what had caused the electric arc. It is possible that due to the fractured landing gear, electrical equipment or connections were damaged which then caused a short circuit. It is also possible that evaporating fuel ignited on operating electrical equipment. At the time when the airship had come to a stop and all persons were still on board, the landing gear had either been beneath the rear part of the airship or was jammed between airship and ground. Evidence shows that during that period of time the airship rested on the ground with its keel beam.

The last trace on the accident site was a 1 x 1 m scorch mark in the grass. It was found 38 m away from the initial ground contact.

The analysis of the photo material witnesses had made available to the BFU shows that the fire propagation from the initial fire after the hard landing until the burning airship crashed to the ground took less than 12 minutes.

The American Blimp Corporation and Lightship Europe Limited estimated in a letter dated 26 April 2013 sent to the BFU that the fuel leakage could have been avoided if the pilot had closed the fuel valve controller after the hard landing as is stipulated in the airship manual. The position of the fuel controller could not be determined on the sized components of the airship.

The airship could ascend again because three passengers had left the gondola after they had noticed fuel smell and heat development. Due to the resulting decrease in weight (about 250 kg) the airship's lifting capacity was sufficient to ascend again.

The ground crew waiting at the mooring mast, about 400 m away, noticed smoke emanating from the airship and passengers disembarking. They rushed toward the airship but could no longer reach the mooring ropes. Therefore the continuous ascent could not be prevented.

## Conclusions

The air accident was due to the landing gear fracturing after a hard landing and as the gondola touched down fuel tank components were damaged which caused a fuel leakage and subsequent fire.

The fuel leakage was possible due to a damaged gascolator below the fuel tank. It is highly likely that while the gondola (without landing gear) was sliding across the ground the cover cap was forced open because the extension hose of the drain valve was jammed between components of the steel construction and the ground. It is also possible that the fractured landing gear forced the cover cap of the gascolator open because the extension hose had gotten entangled in it as the fractured landing gear moved to the rear.

In the immediate vicinity of the fuel leakage different wires were installed unprotected on the outer surface of the steel frame work. The fractured landing gear which had gotten entangled between components on the open rear of the airship could have caused an electric arc if it had damaged wires. Sparking caused by metal parts hitting the rear of the airship could also be an ignition source for the leaking fuel.

The fast fire propagation is due to the intense heat development caused by the burning of the leaking fuel. The intense heat caused the flame retardant material of the gondola's covering and fairing to reach their burning points within a short time period.

Contributory factors were the loading of the airship in connection with the wind conditions at the airfield. Together, both facts resulted in an extremely difficult landing situation for the pilot.

#### Safety Recommendation

The BFU abstained from issuing a safety recommendation because shortly after the accident the manufacturer published the Service Bulletins SB 169 "A-60 Landing Gear Strut Inspection", SB 170 "Gondola Station 113 Mod" and SB 171 "Lower Aft Cover", and the Service Letter 118 and had all airships inspected.

Investigator in charge:	Stahlkopf
Assistance:	Nehmsch
Field investigation:	Weigand, Eisenreich

Braunschweig, September 2013

This investigation was conducted in accordance with the regulation (EU) 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 and the Federal German Law relating to the investigation of accidents and incidents associated with the operation of civil aircraft (*Flugunfall-Untersuchungs-Gesetz - FIUUG*) of 26 August 1998.

The sole objective of the investigation is to prevent future accidents and incidents. The investigation does not seek to ascertain blame or apportion legal liability for any claims that may arise.

This document is a translation of the German Investigation Report. Although every effort was made for the translation to be accurate, in the event of any discrepancies the original German document is the authentic version.

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