AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/9577		
Aircraft registration	**ZS-HAH**	**Date of accident**	25 October 2016		**Time of accident**	0455Z	
Type of aircraft	Cameron A-415 (Hot Air Balloon)		**Type of operation**		Hot Air Balloon (Part 136)		
Pilot-in-command licence type		Hot Air Balloon	**Age**	58	**Licence valid**	Yes	
Pilot-in-command flying experience		Total flying hours	863.3		Hours on type	69.9	
Last point of departure	Skeerpoort Balloon Field, North West province						
Next point of intended landing	Agricultural field on the farm Little Waters, North West province						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
On the farm Little Waters near Buffelspoort dam (GPS position: 25°48'10.58" South 027°30'09.66" East)							
Meteorological information	Probable strong surface wind, Temperature; 11°C, Visibility; + 10km, CAVOK						
Number of people on board	1 + 14	**No. of people injured**	2	**No. of people killed**	1		
Synopsis							

This was a commercial hot air balloon flight with an intended flying time of around one hour. Prior to take-off a young girl, age four, who got a fright when the pilot activated the burners, was off loaded and they took off at 0349Z. After the balloon lifted, the young girl asked to join her mother and this message was passed by radio to the pilot one or two minutes after take-off. The wind was sufficiently calm that the pilot was able to land the balloon close to the launch point, allowing the girl to re-board. According to the pilot, he gave the passengers a safety briefing prior to take-off. During the flight they ascended over the Magaliesberg Mountain range and climbed to a height of 8 731 feet above mean sea level (AMSL) while flying in a north-westerly direction.

Upon fast landing the balloon basket struck the ground three times, with one bounce between the first and the second ground strikes and a second bounce between the second and third ground strike, where after the balloon came to rest against a tree, 228.3m from the first ground strike. Three of the passengers were ejected from the basket during the landing sequence and sustained serious injuries. One of the injured passengers succumbed to her injuries later the same day following emergency surgery. The investigation found that the balloon was operated in high wind conditions, which resulted in the balloon drifting away from the Magalies Valley area, and a high-speed landing followed.

Probable cause

The pilot opted to execute a landing onto an open agricultural field with the prevailing wind from the east at approximately 22 knots, which was above the safe landing speed for hot air balloon operations, resulting in a high-speed landing.

SRP date	13 November 2018	Release date	27 November 2018

AIRCRAFT ACCIDENT REPORT

Name of Owner	**:** Bill Harrop's Balloon Tours (Pty) Ltd
Name of Operator	**:** Bill Harrop's Original Balloon Safaris
Manufacturer	**:** Cameron Balloons Ltd
Model	**:** Cameron A-415
Nationality	**:** South African
Registration markings	**:** ZS-HAH
Place	**:** Farm Little Waters near Buffelspoort dam
Date	**:** 25 October 2016
Time	**:** 0455Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (2011) the purpose of investigation of an aircraft accident or incident is to determine, in terms of the provisions of this Part, the facts of an accident or incident in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents, and ***not to apportion blame or liability****.*

Disclaimer:

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1. FACTUAL INFORMATION

1.1 History of flight

1.1.1 The passengers arrived at the Skeerpoort Balloon field to the west of the Hartebeespoort dam from about 0245Z on the morning of 25 October 2016. The balloon was prepared for the commercial flight with the assistance of the ground support crew and was cold inflated. Prior to the flight two weather balloons were released by the pilot, these balloons drifted slowly up and in an Easterly direction and started moving slowly to the West while ascending. The balloon was visible for approximately two minutes with light winds observed from the northwest at an

altitude of approximately 1 000 - 1 500 feet above ground level (AGL). The balloon did not indicate any change from the forecast weather and the weather conditions were assessed as calm and safe for flight by the pilot.

1.1.2 Once the hot-air balloon was fully upright, the passengers were invited to board the balloon basket in their allocated compartments. Prior to take-off, the pilot briefed the passengers with regard to the safety on board the flight as well as the posture and positions they should assume during the landing. He stated that he had fully instructed, described and checked that the passengers understood and could adopt the fast-landing position, which was company policy before every flight. The passengers were then requested to demonstrate the position and were visually checked by the pilot and the ground crew.

1.1.3 Prior to lift-off, a four-year-old girl passenger became frightened by the noise/flames caused by the burners and was off-loaded. This was after the pilot safety briefing. The pilot states that in view of the child's initial fear, he was absolutely sure that he would not have overlooked giving the briefing to the mother of the child as it was something he always did when small children were on board. After the balloon lifted, the young girl asked to join her mother and this message was passed by radio to the pilot one or two minutes after take-off. The wind was sufficiently calm that the pilot was able to land the balloon close to the launch point, allowing the girl to re-board. The balloon then lifted-off at 0349Z. As they ascended the pilot briefed the mother of the young girl on the preferred landing position with the child. He said that she should be seated between her mother's legs and the mother should place her arms in the 'cross-arm' position over the young girl's shoulders, and both should hold onto the rope handles directly in front of them. The mother of the young child stated that she never received a briefing to cross her arms over the shoulders of the child during a 'fast' landing. During the briefing she recalls the pilot mention that the child should sit between her legs and hold onto the handles in case of a 'fast' landing. No demonstration to this effect took place as the mother was seated in the right (starboard) rear corner of the basket and the pilot in the centre of the basket at the burner. Instructions were given and observed by the pilot to have been understood.

1.1.4 The flight progressed in calm weather conditions with the pilot deciding to ascend and climb in a westerly direction at a height of approximately 1 000 feet AGL. He observed the speed to be approximately 10 knots on the GPS. He continued to ascend and at a height of approximately 1 500 feet AGL he observed the speed to be approximately 20 knots with a change in heading towards the west-northwest. At

this altitude he observed another two hot air balloons in the air. One of them was over the Hartebeespoort dam area and the second in the Magalies Valley. He then decided to descend to gain a more favourable south-westerly direction to avoid the Magalies Mountain range. No change in direction was achieved and he then opted to ascend to an altitude of 7 500 feet AMSL at which stage they were directly approaching the mountain range. The pilot then remarked that "this is a first for me" which was audible to a number of passengers. This meant that he had never flown over these mountains in that direction. He then contacted his ground crew by radio and informed them that he was probably going to fly over the mountain range to the North. The prevailing winds at time did not allow flight back to the Magalies Valley, and the pilot opted to ascend to 8 500 feet, to look for faster winds, with the potential to get back into the valley. At this stage the pilot informed the passengers that he is going to fly over the mountain to the north. However, no change in wind velocity was apparent and therefore the balloon's track could not be altered. At about 0435Z he started to descend and spotted a potential landing site, the wind speed increased again and they were drifting in a northwesterly direction. He then contacted his ground crew and indicated that they were heading in the direction of the Buffelspoort dam. The pilot stated that he was constantly looking for landing sites as the wind had picked up again, and the GPS indicated a ground speed of approximately 20 knots.

1.1.5 After being airborne for approximately one hour the pilot had identified a large open agricultural area, which encompassed a harvested maize field ahead of their track. At this stage of the flight he had not yet spotted the perimeter of the maize field and was aiming for a large open area, which included an area of open veld around the maize field. He then instructed the passengers to stow away their cameras, cell phones and glasses as per the passenger safety briefing and to prepare for landing. From the video footage that was made available to the Investigator that was taken by one of the passengers on board it could be determined from the vegetation on the ground that the wind was blowing at a substantial speed/strength from the east. The passenger stopped the recording when the pilot instructed the passengers to stow their cameras and cell phones and as a result the landing sequence was not captured on video.

1.1.6 The pilot continued to descend the balloon as they were approaching the landing zone while crossing trees over some high ground. At this stage the pilot observed the speed on the GPS indicating 25 knots, he also saw the fence dividing the maize field from the veld, and delayed his landing until he had crossed the fence. He then instructed the passengers to brace for a bumpy landing. The pilot stated that he had

conducted a visual check on the passengers that they had adopted this position, both during the initial approach to the field and again just prior to landing. Just before ground impact the pilot shouted “Brace brace brace”. The pilot further stated that the fence was at an angle with the flight path and contact with the fence could have twisted the basket onto a corner or the short edge of the basket, which could have had a potential risk, which might have resulted in injury to the passengers.

1.1.7 The balloon basket first made contact with the ground firmly on the leading edge (front long edge) of the basket 108.7m past the barbed wire perimeter fence. One of the passengers that were seriously injured in the accident described the first impact as excessive and indescribably painful. The balloon then bounced and was airborne for 26.2m. From this point onwards the balloon was dragged over the field by the wind for a distance of 72.5 m. The balloon and basket then bounced a second time and was airborne for 52.8 m, and then again landed firmly on the leading edge of the basket,and tipped over onto its side. From this point onwards the basket remained on the ground. As the basket was dragged over the rocky terrain three of the passengers were ejected from the basket. The one passenger that was seriously injured could recall seeing the bottom of the basket for a brief period (split second) while she was lying on the ground amongst the rocks and bushes. The basket remained in contact with the ground until it came to rest against vegetation and trees.

1.1.8 The total distance covered from the first time the balloon basket made contact with the ground until the balloon came to rest was 228.3m. At the end of the maize field was a barbed wired perimeter fence and from there the impact path became very rocky and bushy. According to the pilot, he had deployed the Rapid Deflation System (RDS), and continued to deploy the RDS even after the balloon bounced for the 1st time. The balloon envelope then started to spinnaker, and the balloon basket was being dragged on its side (leading edge). The deployment of the RDS system was essential as it would have reduced the likelihood of the balloon becoming airborne again as well as the distance the balloon was dragged across the surface.

1.1.9 The three passengers that were ejected from the basket were seriously injured. Emergency services were notified of the accident by two of the critically injured passengers’ family members, who were also passengers on the flight. The pilot also contacted the operations manager via his cell phone advising him of the accident, who in turn contacted the emergency services. The pilot was unable to broadcast a distress call via the VHF (very high frequency) radio that was on board the balloon as the signal was blocked by the high ground. The pilot didn’t know his position

because the portable GPS unit was damaged during the landing and he asked some of the passengers with GPS enabled cell phones to assist him with the location of the accident site.

1.1.10 The injured passengers were treated with bottled water that was on-board the basket, and did receive limited medical treatment from the pilot who was a qualified First Aider from the United Kingdom (UK) Fire Services, while they waited the arrival of the emergency medical personnel/paramedics. The pilot was assisted in this process at the request and under the supervision of the pilot by one of the passengers who also had some basic First Aid knowledge. It was confirmed by the operator that there was a standard Medical Kit on-board the balloon, which was stowed in a flight bag in the pilot compartment. The injured passengers could not recall that there was an advance medical kit on the accident scene, prior to the arrival of the emergency vehicles. It took emergency services approximately 2 to 2½ hours to arrive at the scene of the accident. The two adult female passengers were transported from the scene to a private hospital in Brits via two road ambulances. According to available information the two female adults arrived at hospital approximately 4 hours after the accident occurred. The young girl was airlifted by an Emergency Medical Services (EMS) helicopter to a private hospital in Johannesburg which was equipped with a specialized pediatrics unit. The pilot had recommended in all his communications that two of the injured passengers were to be airlifted but that authority was with the emergency personnel (paramedics) that responded to the accident. One of the adult female passengers that was admitted to hospital succumbed to her injuries during emergency surgery that was performed on her shortly after she was admitted. She was a British citizen and had flown for a large United Kingdom registered airline as a cabin crew member for fifteen years.

1.1.11 The accident occurred during daylight conditions on the farm Little Waters near Buffelspoort dam in the North-West province at a geographical position determined as 25°48’10.58” South 027°30’09.66” East at an elevation of 4 287 feet (1 307m) above mean sea level (AMSL).

1.2 Injuries to persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	1	-
Serious	-	-	2	-
Minor	1	-	11	-
None	-	-	-	-

1.3 Damage to the hot air balloon

1.3.1 The balloon basket was damaged beyond economical repair. The fuel cylinders, which contained liquid propane gas (LPG) remained secured inside the basket during the landing sequence. According to the load sheet there was 160 kg of LPG in the cylinders that was on board the balloon before take-off and approximately 30 kg of LPG remained in the four cylinders after the accident.

1.4 Other damage

1.4.1 Approximately 50m of the perimeter fence was flattened when the balloon basket was dragged over the fence prior to coming to rest. Minor damage was caused to vegetation.

1.5 Personnel information

1.5.1 Pilot-in-command (PIC)

Nationality	British	Gender	Male	Age	58
Licence number	0272548041	Licence type	Hot Air Balloon		
Licence valid	Yes	Type endorsed	Yes		
Ratings	None				
Medical expiry date	30 November 2016				
Restrictions	*Must wear corrective lenses (see note below)				
Previous accident(s)	None on record with the SACAA prior to the accident in question.				

The pilot licence number entered in the table above was his South African Hot Air Balloon licence number. He was also the holder of a valid Commercial Hot Air Balloon licence that was issued by the United Kingdom Civil Aviation Authority. At the time of this accident South Africa had not incorporated different levels of hot air balloon pilot licences as was the case in some other countries around the world.

*NOTE: According to available information obtained from the pilot's last medical examination he conducted in South Africa, his long distance vision was very good, he would have benefit from readers glasses should he needed to read a map (i.e., reading small print). For that purpose, he had two pairs of glasses that he carried with him during the flight.

Conversion onto the Cameron A-415 Balloon:

According to the pilot's logbook copy he flew two dual training flights on the Cameron A-415 balloon. The first dual flight was on 27 February 2016, where he had flown for 1 hour and the second flight, which include the practical flight test were conducted on 29 February 2016. The duration of the second flight was 1 hour and 10 minutes. The practical flight test report for a free balloon pilot's licence (form CA 61-153) was then submitted to the SACAA. According to his logbook he had flown his first two commercial flights on the Cameron A-415 balloon as pilot-in-command under supervision. The Cameron A-415 type of balloon was endorsed in his pilot logbook as well as on his South African hot air balloon pilot licence.

Flying experience:

Total hours	863.3
Total past 90-days	30.5
Total on type past 90-days	11.5
Total on type	69.9

1.6 Aircraft information

Figure 1: Photograph of the balloon prior to the flight (courtesy of one of the passengers)

Airframe:

Type	Cameron A-415	
Serial number	10326	
Manufacturer	Cameron Balloons Ltd	
Year of manufacture	2002	
Total airframe hours (at time of accident)	106.3	
Last inspection (hours & date)	94.4	4 October 2016
Hours since last inspection	11.9	
C of A (issue date)	4 March 2003	

C of A (expiry date)	3 March 2017
C of R (issue date) (present owner)	5 April 2011
Operating categories	Standard Part 136

NOTE: A new envelope was fitted to the hot air balloon on 20 April 2016 that was purchased from the original equipment manufacturer (OEM) in the United Kingdom.

1.7 Meteorological information

1.7.1 The weather information entered into the table below was obtained from the pilot questionnaire and relates to the launch point.

Wind direction	NW	Surface wind speed	Calm	Visibility	CAVOK
Temperature	11°C	Cloud cover	Clear	Cloud base	N/A
Dew point	N/A				

1.7.2 An official weather report was requested from the South African Weather Services (SAWS) with special emphasis on the winds in the area of the accident site.

Buffelspoort Automatic Weather Station (AWS)

The Buffelspoort AWS was located 2.8 nm (5.3 km) northwest of the accident site. The information as displayed in the wind speeds and wind gust chart as depicted in Figure 3 of this report was obtained from the AWS. The average wind speed table, provide the average wind speed measured in metres per second (m/s) in hourly intervals over a 24-hour period.

Satellite image:

The satellite image in Figure 2 shows clear skies over the accident site and surrounding areas during the morning of the 25 October 2016. The satellite image was captured at 0445Z, which was 15 minutes before the accident occurred.

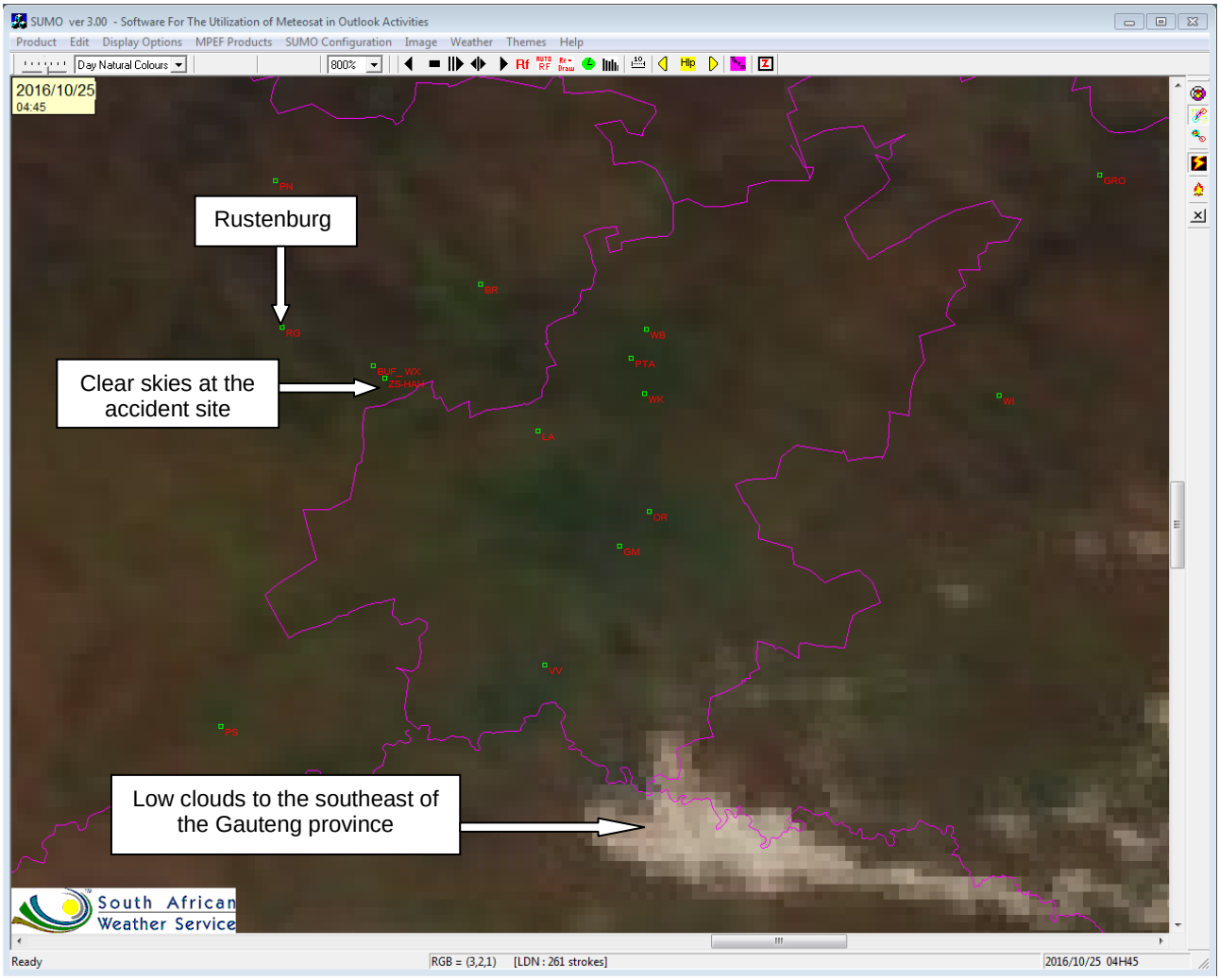

Figure 2: Satellite image shows clear skies over the accident area

Surface observations:

The surface wind data obtained from the automatic weather station, Buffelspoort, which was located close to the accident site, can be viewed in Figure 3. This data shows light winds during the time of the accident (0500Z), with no significant wind gusts. *NOTE: The time line in both tables in Figure 3 on the next page is in South African Standard Time (SAST).

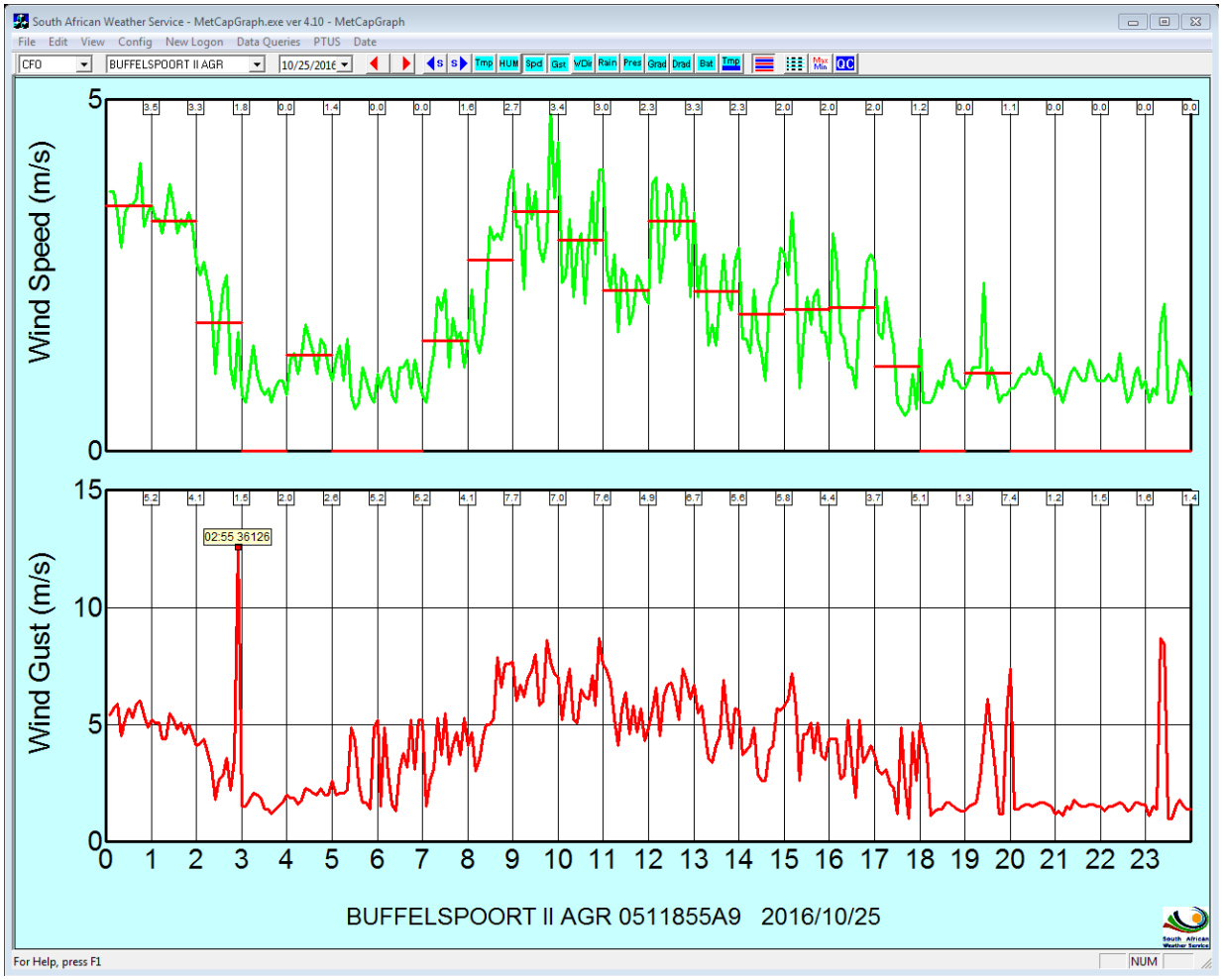

Figure 3: The 24-hour wind speed chart from the Buffelspoort automatic weather station

HOURLY DATA : Average Wind Speed (m/s) - 25 October 2016

BUFFELSPOORT II AGR - Climate Number:0511855A9 Lat:-25.7530 Lon:27.4820 Height:1230 m (Extracted 2016/10/26 13:46)

DD	h01	h02	h03	h04	h05	h06	h07	h08	h09	h10	h11	h12	h13	h14	h15	h16	h17	h18	h19	h20	h21	h22	h23	h24	avg	mx	tm
25	3.5	3.3	1.8	0.0	1.4	0.0	0.0	1.6	2.7	3.4	3.0	2.3	3.3	2.3	2.0	2.0	2.1	1.2	0.0	1.1	0.0	0.0	0.0	0.0	1.5	12.6	0255
Max	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		12.6	

Figure 4: The 24-hour average wind speed table from the Buffelspoort automatic weather station

Vertical wind and temperature profiles from Irene (FAIR) and OR Tambo International Airport (FAOR):

A Skew-T diagram recorded at midnight (0000Z) at Irene weather office (FAIR), in Pretoria, which was the closest recording station, is included in Figure 5. This diagram shows the vertical profile of winds and temperatures overhead Irene and is normally used to approximate conditions covering a wide area (covering a radius in excess of 50 kilometres from Irene). The vertical profile recorded south-easterly winds with an increasing speed between the surface level and the approximate pressure level of 810hPa. This area of an increasing wind speed with height

corresponded with that of an increase in temperatures with height (temperature inversion).

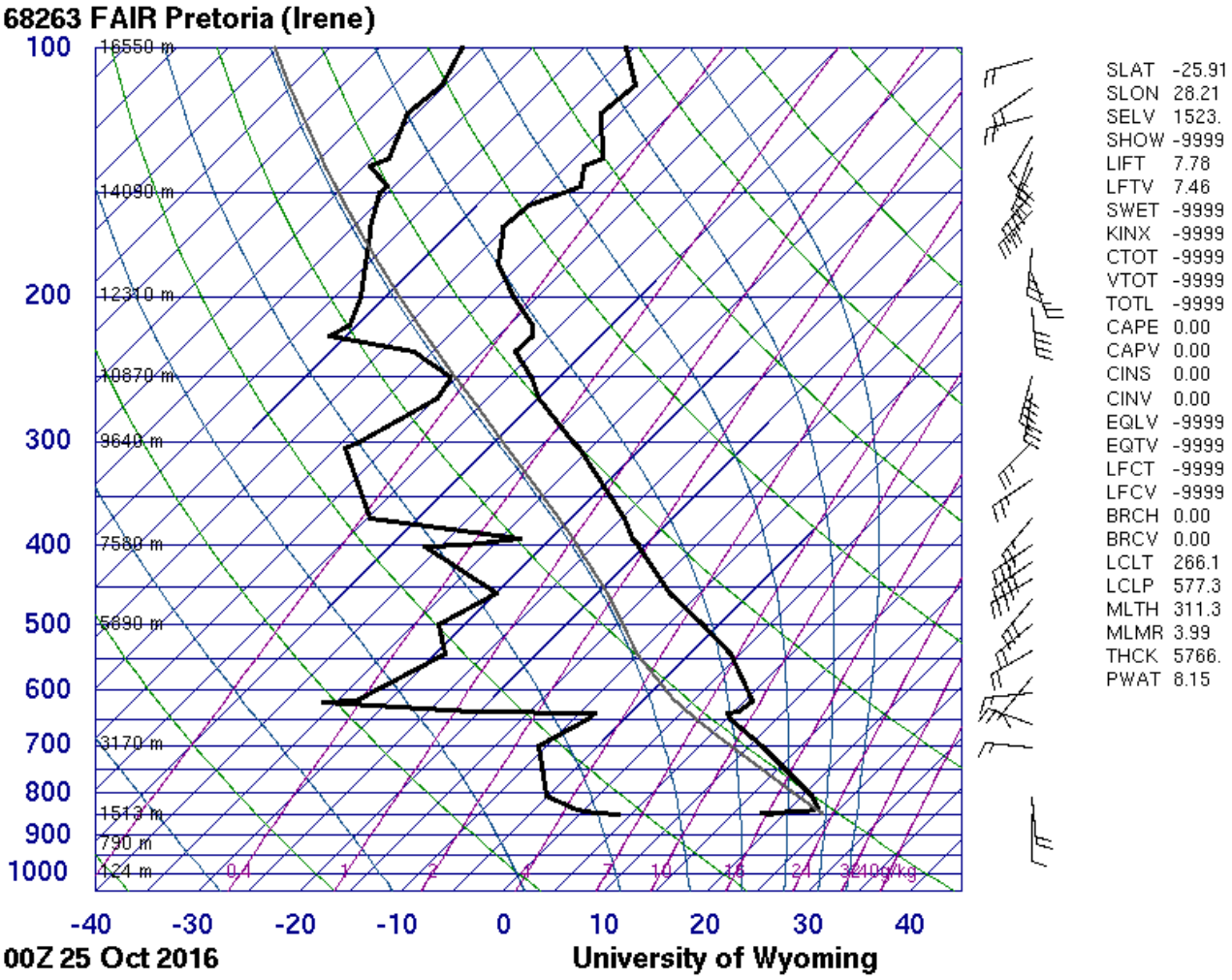

Figure 5: Wind data for 25 October 2016 from the SAWS

Also included in Figure 5 was the aircraft generated vertical wind and temperature profiles, the AMDAR data, obtained from OR Tambo International Airport. The aircraft data was used to validate the Irene ascent and allowed the investigator to identify and establish the evolution of and changes of the vertical structure that were indicated by the Irene profile. The aircraft data indicated easterly winds, as well as an increase in wind strength in the vertical, and a temperature inversion between the surface level and a pressure altitude of approximately 6 900 ft (FL069). The two ascents were validated against each other and similar characteristics were observed, especially in the upper levels where the impact of friction between the surface and the free standing atmosphere become minimal. The structure of the two ascents indicated that all the areas whose data were used were affected by a similar air-mass, allowing for a conclusion that that the vertical profiles were indeed

representative of the most likely conditions at the accident site - with the aircraft ascent being more useful as it provided not only the latest conditions, but a finer detail due to its high resolution.

The weather scenario that can be depicted from the two upper ascents is that of a low-level jet, which is described theoretically as a thin, narrow concentration of momentum in the lowest two kilometres of the atmosphere - i.e., the boundary layer. The jet, only a few kilometres wide, may move twice as fast as layers several meters below or above it. Theory relays that although the direction of the jet is fairly constant (in this case south-easterly to easterly), the jet speed has a large diurnal variation, with the early morning maximum likely to be double or more than the afternoon minimum.

Some research in aviation define this phenomenon as the region of maximum wind speed of at least 12 m/s (23.4 kt or 43.2 km/h) at some altitude in the boundary layer, with the wind speed at surface and below the 700hPa pressure level decreasing to at least half of the maximum wind speed.

Comparison of the available observational data (vertical profiles) with this meteorological theory makes it appropriate to suggest that this phenomenon occurred on this day. The strengthening of the speed of the jet in the early morning also observed from the two ascents presented and further confirms this theory. This allows one to come to a suggestion that wind shear may have been experienced by the weather balloon under investigation as a result of the low level jet, and this can only be confirmed with a vertical profile launched in close proximity of the site and closer to the time occurrence of the accident due to the limiting factors such as the topography.

The elevation of the accident site, being somehow lower than that of the weather stations used – i.e., the elevation of the accident site was approximately 1 248 m (4 093 ft) above mean sea level. The Irene's weather station (FAIR) elevation was 1 513 m (4 962 ft), and a distance of approximately 35 nm from the accident site. The elevation of OR Tambo International aerodrome (FAOR) was even higher at 1 761 m (5 777 ft), and was approximately 42 nm from the accident site.

1.7.3 Aeroden Aerodrome weather information

Aeroden aerodrome was a private aerodrome that was located 5.2 nm (9.7 km) to the North of the balloon launching site, and was located on the northern side of the

Magalies Mountain range. Weather information from this aerodrome was available via cell phone, by sending a short message service (SMS) to the number 36010 followed by entering the capital letters “AD”. A return SMS would then have been sent with the weather information at the aerodrome, which will contain the following;

Place	: Aeroden Airfield
Date and time	: The local date and time the SMS was send
Wind	: Direction and speed in knots as well as in km/h
Temperature	: In Celsius
Dew point	: In Celsius
Humidity	: In percentage (%)
Pressure altitude	: In milli-bar (QNH)
Density altitude	: In feet
Sunrise	: South African Standard time
Sunset	: South African Standard time

During an interview with the pilot he was asked if he was familiar with this SMS service, to which he replied, he was not aware of it and therefore could not make use of it prior to or during the flight. This information did not form part of his familiarisation training, nor was it communicated to him at any stage during his stint with the operator. Aeroden aerodrome was located 13.7 nm (25.3 km) to the northeast of the accident site. The weather information from this source was thus more relevant prior to take-off from the launch site and after becoming airborne. The aerodrome was a considerable distance from the actual accident site.

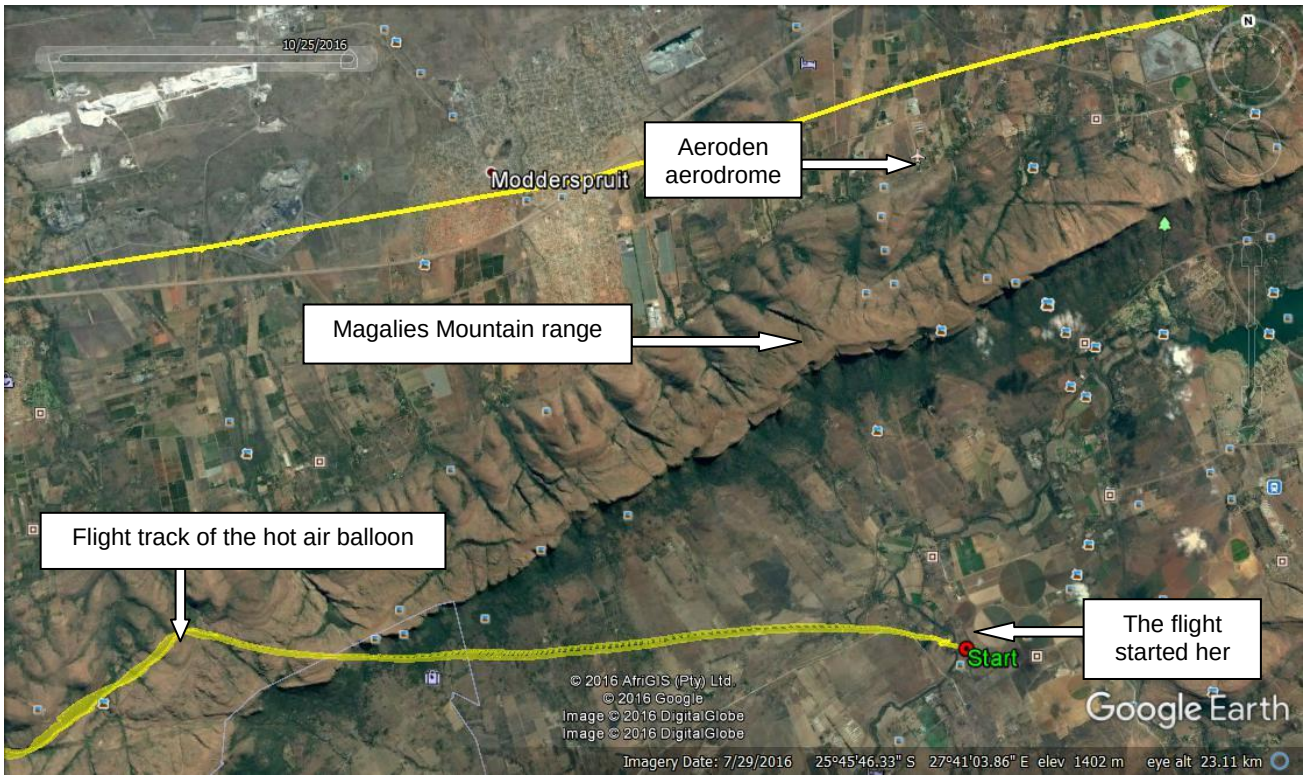

Figure 6: Google Earth overlay indicating points of interest with relation to the flight

Figure 7: A photograph that was taken by one of the passengers while flying on the lee side of the mountain range

1.8 Aids to navigation

1.8.1 The pilot was in possession of a set of aeronautical maps of the area, which he showed to the investigator during an interview with him. He was however not familiar with the area where they landed as he had never flown there before, nor was it part of his familiarisation training of the area. The pilot was well able to interpret map information especially where it shows areas of safety or danger. This information was used in the decision-making process to mitigate the situation and get the best landing site under the dynamically changing circumstances.

1.8.2 There was also a Garmin III Plus global positioning device (GPS) on board and he also made use of an application on his iPhone called 'Hot Air' that recorded his flight profile. The information from the GPS as well as his iPhone was downloaded and the flight profile from the Hot Air application was transferred onto a Google Earth overlay.

1.9 Communication

1.9.1 The pilot did not communicate with air traffic control (ATC) at Lanseria prior to take-off nor thereafter, but he maintained a listening watch on the VHF frequency 124.80 MHz below the terminal control area (TMA), which had a vertical platform of 7 500 feet AMSL.

1.9.2 The hot-air balloon was not equipped with a transponder, nor was it a regulatory requirement

1.9.4 He was also in two-way radio communication with his ground crew as well as the operational manager who was also the safety manager. Radio communication was lost during the accident when the radio was ejected from the balloon basket.

1.9.5 The pilot did not broadcast a distress call on the VHF frequency 124.80 Mhz, below the TMA or the standard distress frequency of 121.50 MHz as he had no reason to do so prior to touchdown. Following touchdown the radio was ejected from the balloon basket.

1.9.6 The pilot had two cell phones with him. The first time the basket made contact with the ground, his mobile phone fell out of his shirt pocket. At 0503Z the pilot phoned the operation/safety manager informing him of the accident. He made use of his

second cell phone, which was undamaged. He managed to retrieve his iPhone, which was still in a working condition by walking back along the impact path.

1.10 Aerodrome information

1.10.1 The accident did not occur at or close to an aerodrome.

1.11 Flight recorders

1.11.1 The hot air balloon was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required by regulations to be fitted.

1.11.2 The pilot's iPhone had an application (App), which recorded GPS derived position, altitude and ground speed once every 10 seconds and it is apparent that when it was at 50 ft agl, the recorded speed was 22 kt. By the next data point the phone's ground speed was 12 kt and it was at ground level, indicating that the balloon touched down between 12 kt and 22 kt. The phone, along with the pilot's radio and his GPS unit were ejected from the basket at the first or second point of impact. From the two graphs, Figures 8 and 9 it could be seen that the balloon went up to an altitude of 8 731 feet AMSL, and the maximum speed was 30 kt (56 km/h). The average rate of descent (ROD) from 135 ft AGL until ground impact was calculated to be approximately 250 feet per minute (fpm), which was regarded as a reasonable rate of descent by the operator.

1.11.3 The pilot made use of a Garmin III Plus GPS unit during the flight. This device sustained damage when it fell out of the basket during the first impact with the ground. It was found to be still in a working condition after it was recovered. The unit was taken to an approved service provider that specialise in these devices and who assisted AIID on a regular basis with the download of information. The GPS captured the flight track as well as the speeds the balloon was travelling at. The GPS recording stopped when the unit was ejected from the basket.

1.11.4 One of the passengers on board the flight took video footage of the approach flown prior to the landing, which resulted in the accident. The video footage was made available to the AIID. The passenger stopped the recording before the basket impacted with the ground, as he followed the instructions of the pilot by stowing all cameras and brace for landing. From the video footage it can be seen by looking at

the vegetation on the ground that a substantial wind was blowing from the south-east at the time.

1.11.5 Several of the passengers that were on board the hot air balloon that took photographs made it available to AIID, which was used in compiling the report.

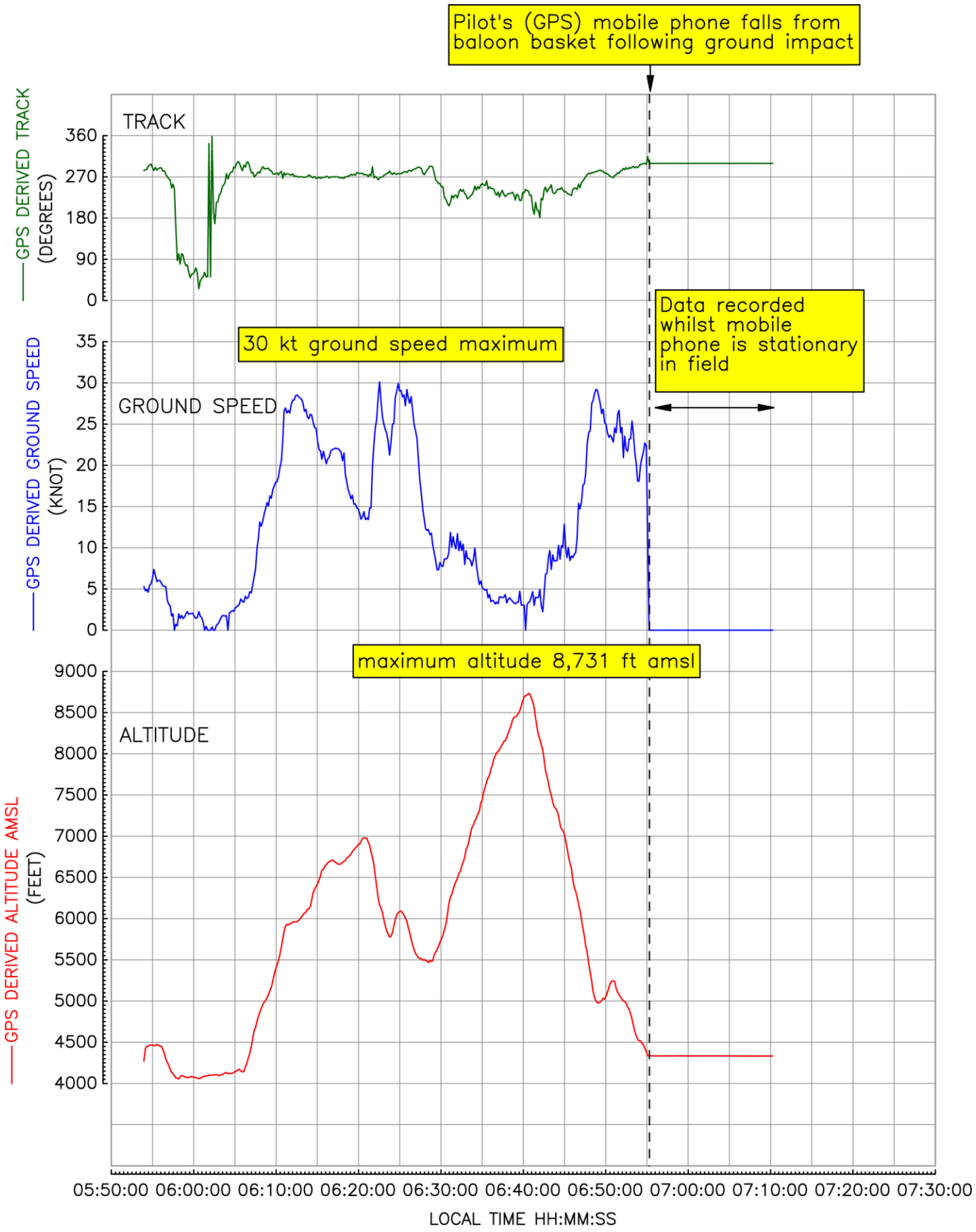

Figure 8: Graphs based on GPS data

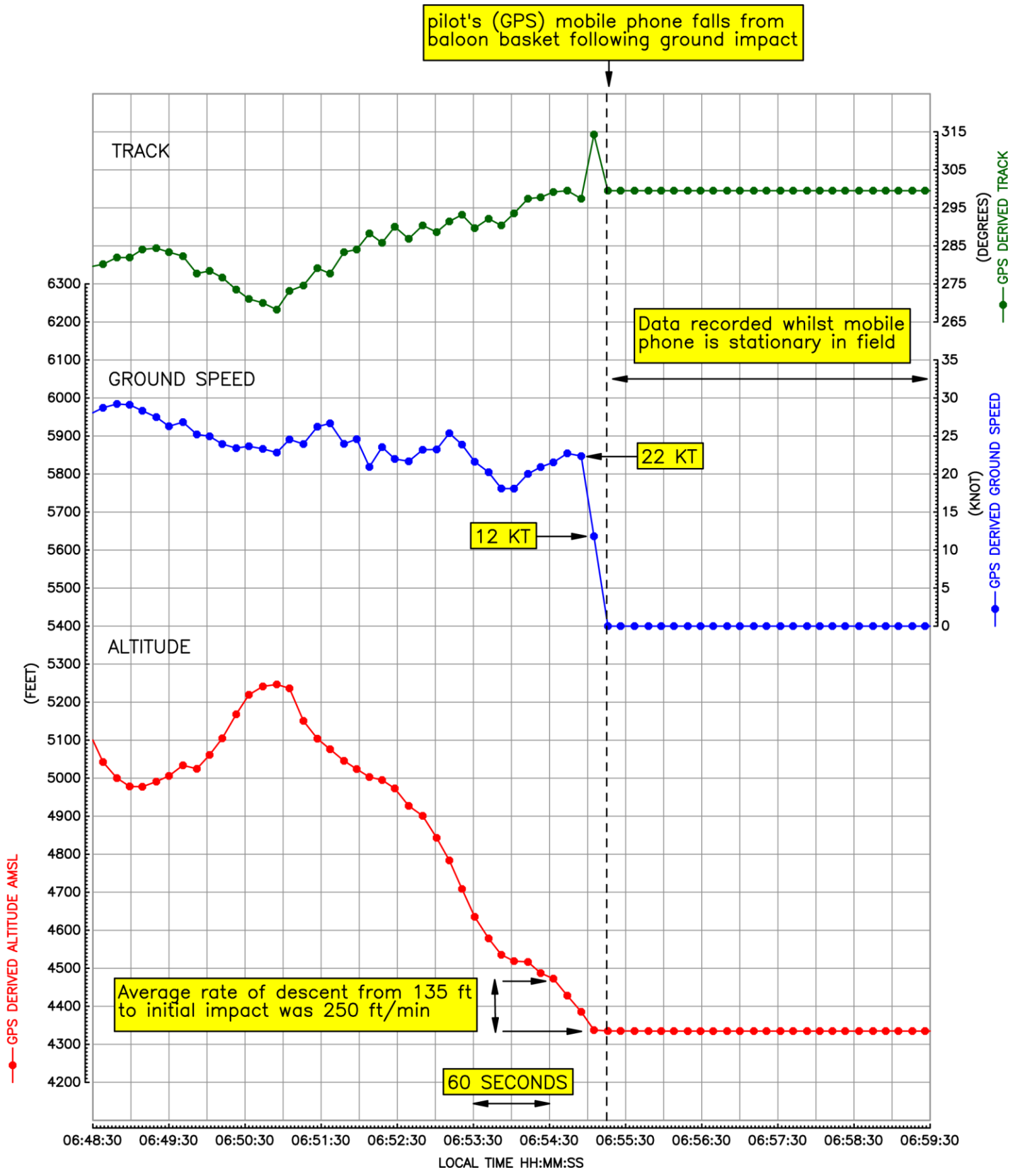

Figure 9: Graphs based on GPS data

1.12 Wreckage and impact information

1.12.1 The pilot stated: *"Prior to crossing the mountain range, at 7 500 ft I had made an assessment of the wind direction and speed. At 7 500 ft I felt a wind change and the GPS indicated a SW direction of 4-5 knots, I felt that this was not sufficient to achieve a flight back into the Magalies Valley, so I climbed to 8 731 ft to look for a faster wind on the SW track to potentially get back into the valley. No change in speed was achieved. I then commenced a decent, at which time I was constantly looking for an appropriate landing site. It was [not] until I had crossed the mountain range that I identified the harvested maize field as an option".*

From the flight profile (yellow vertical lines) as depicted in Figure 10 below it could be seen that the pilot ascended the balloon to a height of 8 731 feet and then commenced with the descent towards the open harvested maize field. The flight profile data was obtained from the GPS unit that was on board.

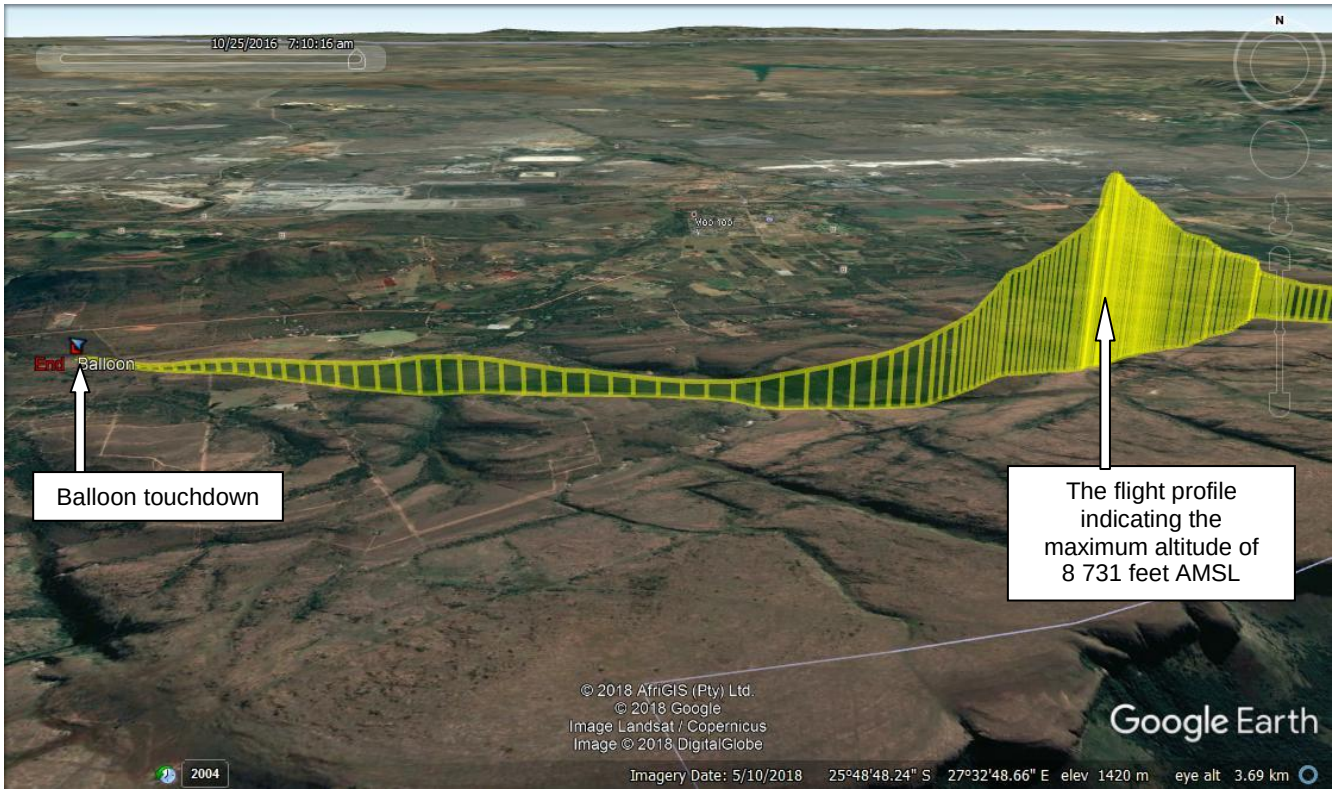

Figure 10: Google Earth overlay of the last phase of the flight until first ground impact

1.12.2 In Figure 11 the field is visible straight ahead. This was a snapshot taken from video footage that was obtained courtesy of one of the passengers that was on board the flight. The balloon basket first made contact with the ground 108.7m past the maize field perimeter fence, on a heading of 320°M. Ground markings indicated that the balloon then bounced a first time, contacting the ground a second time after a

distance of 26.2 m. The basket remained in contact with the surface of the field for a further 72.5 m, before bouncing a second time and it travelled 52.8 m on the second bounce. Following its third touchdown, the basket remained in contact with the ground until it came to rest against some trees 76.8m further on. The total distance covered from first ground contact until the balloon and basket came to rest was 228.3m.

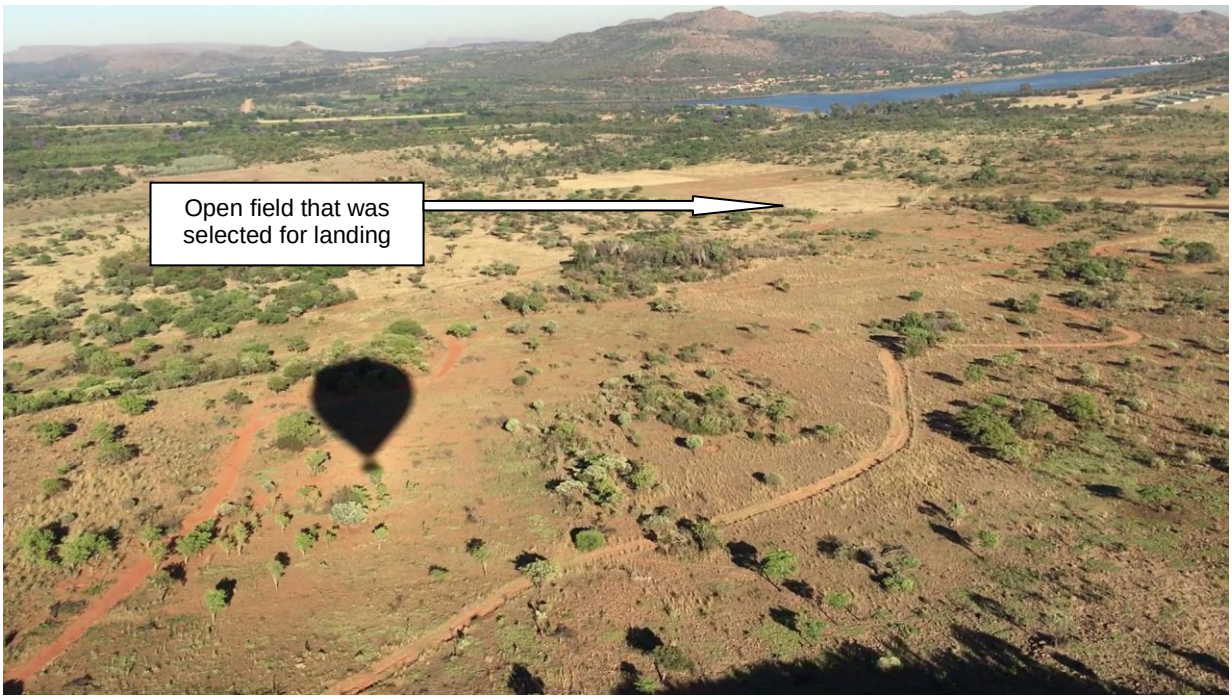

Figure 11: A snapshot from video footage with the open field visible

1.12.3 The two photographs below, Figures 12 and 13 were obtained courtesy of one of the passengers that were on board the flight. Figure 11 was taken just prior to the basket impacting with ground for the first time, and Figure 12 was taken when the basket impacted with ground for the second time.

Observation by the operator: In order for the passenger(s) to have taken these photographs they must have dis-obeyed the pilot's instructions for the landing position by not showing their camera's, or cell phones.

Figure 12: Photograph was taken just before the first ground contact was made by a passenger

Figure 13: The photograph was taken the second time the basket made ground contact

1.12.4 Over the last 30 to 40m before the balloon/basket came to a rest against trees and shrubs. The basket flattened a barbed wired fence that was approximately 1.5 m in height. The basket was then dragged over rocky terrain before coming to rest on its side as can be seen in Figure 14. The photograph below was obtained courtesy of one of the passengers that was on board the flight.

Figure 14: The balloon and basket as it came to rest prior to recovery (photograph courtesy of a passenger)

1.13 Medical and pathological information

1.13.1 The pilot, suffered from minor cuts and bruises.

1.13.2 The pilot notified the operations/safety manager of the accident via his cell phone at 0503Z. The operations/safety manager then informed the local emergency services, which in turn dispatched to the scene, which was on the farm Little Waters near Buffelspoort dam.

1.13.3 Mooinooi in the Northwest Province was the closest town to the accident site; it was a very small town and did not have any emergency medical facility (i.e., clinic or a hospital). Emergency medical personnel responded from different locations in the area, and had to travel a substantial distance to get to the accident site. An EMS helicopter was dispatched by emergency medical personnel that were on the accident scene following an assessment of the young girl injuries. She was airlifted to a private hospital in Johannesburg, which was equipped with a specialised paediatric care unit. The pilot, who was trained as a First Aider from the United Kingdom (UK) Fire Services, would be authorised to call for an EMS helicopter. The delay in the response by the emergency medical services was something neither the pilot nor the operator had any control over.

1.13.4 The young girl sustained severe internal injuries when she fell out of the basket during the impact sequence some distance before the balloon/basket came to a halt. She was admitted to intensive care unit (ICU) and was placed under sedation following surgery. She spent two weeks in hospital.

1.13.5 Two adult female passengers, one being the mother of the young girl, also sustained serious internal injuries. They were transported individually by road ambulances to a private hospital in Brits, which was approximately 65 km from the accident site. Following admission to the hospital and an assessment of their injuries, the one passenger was admitted to theatre for emergency surgery; she succumbed to her injuries later the same day. She suffered from a raptured spleen, and had incurred extensive internal bleeding. She was a British citizen and was visiting South Africa on holiday with her family.

1.13.6 The mother of the young girl remained in hospital in Brits for two weeks. During this period, she underwent surgery where her spleen was removed as it burst and she also suffered from bleeding from her liver, which also required surgery. She also tore a muscle in her left upper arm and her back was bruised. After she was discharged from the hospital in Brits she developed some complications and was again admitted to a private hospital in Pretoria for a further two weeks. She was then discharged from hospital but had to remain bed-ridden for another few weeks at home.

1.13.7 The passenger that succumbed to her injuries in the accident unabridged death certificate that was issued by the South African Department of Home Affairs state her cause of death to be – *Unnatural*. The post-mortem report that was compiled by a Forensic Pathologist indicates the cause of death to be; *Multiple injuries.*

1.13.8 Several of the other passengers also sustained minor injuries during the landing sequence. One passenger suffered from a torn muscle in his left arm, as well as a broken rib. Several of the passengers suffered from bruising especially from the neck and lower back as well as muscular pains.

1.14 Fire

1.14.1 There was no pre- or post-impact fire.

1.15 Survival aspects

1.15.1 The accident was considered to be survivable; however, three of the passengers were ejected from the basket during the landing sequence and suffered from serious injuries, which required hospitalisation and emergency surgery. One of the adult passengers succumbed to her injuries several hours after the accident while in hospital during emergency surgery where her spleen was removed as it had ruptured during the accident sequence.

Figure 15: Damage visible to the basket

Figure 16: The spiral-twisted rope handles for passengers to hold onto inside the basket

1.15.2 The two adult female passengers that were seriously injured were transferred to private hospital in Brits via two respective road ambulances. The young girl was airlifted to a private hospital in Johannesburg via an EMS helicopter. Figure 17 is a photograph of the helicopter that landed at the accident scene and transferred the young girl to hospital.

Figure 17: The EMS helicopter that landed at the scene (photograph courtesy of one of the passengers)

1.15.3 One of the adult female passengers succumbed to her injuries several hours after the accident while in hospital during emergency surgery, where her spleen was removed as it had ruptured during the accident sequence.

1.15.4 Two of the passengers that were on the left side of the basket when looked at from behind during flight sustained the following injuries; Person 1: Bruises, left arm's teared muscle, broken rib and muscular pains. Person 2: Bruises, rotator cuff, neck and lower back strain. These two passengers did not receive any immediate medical attention and went for a medical assessment after the ordeal.

1.15.5 The pilot compartment with his restraining harness temporarily hooked to one side of the basket as can be seen in Figure 18. When the harness is worn by the pilot during flight it is attached to a secure bracket on the floor structure of the basket. The primary purpose of the harness is to prevent the pilot from falling out of the basket during a fast landing, as he would not be able to hold onto the rope handles to remain in the basket because he would be handling controls and pulling deflation ropes.

Figure 18: The pilot compartment with his restraining harness hooked to the basket

1.15.6 The balloon was not equipped with an emergency locator transmitter (ELT), or any other type of tracking device. This was not a CAA requirement.

1.15.7 All post-accident communication between the pilot and the operations/safety manager was conducted via cell phones.

1.16 Tests and research

1.16.1 None considered necessary.

1.17 Organizational and management information

1.17.1 The operator was in possession of a Class II Air Service Licence. The licence with number N/146D was issued by the Department of Transport on 26 June 1992. The type of air service was indicated as N1, and the category of aircraft was indicated as A4.

1.17.2 The operator was in possession of an Air Operating Certificate (AOC) that was issued by the South African Civil Aviation Authority (SACAA) on 13 April 2016, with AOC number CAA/N146D. The AOC was valid until 31 March 2017 and the hot air balloon with registration markings ZS-HAH was duly authorised to operate under the AOC.

1.17.3 Tickets were issued to the passengers prior to the flight and the pilot gave a safety briefing before departure, which included instructions on the seating position for landing and to hold onto the rope handles. He also requested the passengers not to touch or pull on any of the ropes in the pilot's compartment of the basket. The pilot briefed the passengers on the required fast landing position and the passengers demonstrated this position to the pilot and the ground crew members. The pilot also told the passengers to hold onto the rope handles throughout the landing. The passengers were instructed to remain in the basket in the landing position until instructed otherwise by the pilot. There was no passenger briefing cards handed to the passengers prior to the flight to demonstrate these positions. The safety briefing for flying with a young child had to be given verbally by the pilot, which was given by the pilot to the adult in charge of the child, which were observed, corrected and approved as understood by the adult. With reference to the carriage of children the operators, operations manual did not contain any section or any specific requirements therein with regard to children.

1.17.4 Passenger Safety Briefing: was the headline printed on the back of the passenger ticket(s). The page contains several safety guidelines for passengers, with special emphasis on not to smoke in or near a Balloon, the landing position, as well as some additional information "for landing in slightly faster winds". It was noted that neither of the safety guidelines on this page makes any reference to children or the person/passenger responsible for the safety of a young child on board. (See attached to this report Annexure A, Copy of the Passenger Safety Briefing).

1.17.5 The hot-air balloon was maintained by an approved maintenance facility and the last mandatory inspection prior to the accident flight was certified on 4 October 2016 by AMO 1115. The AMO was in possession of a valid AMO certificate that was issued by the SACAA on 29 March 2016 with an expiry date of 31 March 2017. The envelope of the balloon was replaced on 20 April 2016 with a new one that was purchased from the original equipment manufacturer (OEM) in the United Kingdom by the owner.

1.18 Additional information

1.18.1 Notification of an accident.

AIID became aware of this accident via the social media several hours after it

occurred. Neither the pilot nor the operator had reported the accident to the investigating authority or any other person as referred to in Part 12.02.1 of the Civil Aviation Regulations (CARs) of 2011 as amended. Once the relevant information was obtained by the investigator on call who followed up on the media reports it was determined that a Hot Air Balloon was involved in an accident, and several passengers were seriously injured. It was established that the Balloon was recovered from the accident scene several hours after the accident by a ground crew team of the operator.

The Civil Aviation Regulations of 2011, Part 12.02.1 state the following with regard to the notification of an accident;

"(1) The PIC of an aircraft involved in an accident within the Republic, or if he or she is killed or incapacitated, a flight crew member, or if there are no surviving flight crew members or if they are incapacitated, the operator or owner, as the case may be, shall, as soon as possible but at least within 24 hours since the time of the accident, notify-

(a) the Director of Investigation;

(b) an ATSU; or

(c) the nearest police station,

of such accident.

(2) If an ATSU or police station is notified of an accident in terms of subregulation (1), such ATSU or police station shall, immediately on receipt of the notification, notify-

(a) the Director of Investigation;

(b) where such accident occurs on an aerodrome, the aerodrome manager".

1.18.2 Interference with objects and marks at the scene of an accident

The Civil Aviation Regulations of 2011, Part 12.04.4 state the following with regard to interference with objects and marks at the scene of an accident;

(1) Subject to the provisions of this Part, no person shall interfere with an aircraft which has been involved in an accident, the wreck or wreckage, a part or component thereof or anything transported therein or any marks resulting from the accident which may be of assistance in an investigation-

(a) until authorised to do so by the investigator-in-charge; and

(b) until, in the case of an aircraft which must be cleared by a customs officer by virtue of the provisions of the Customs and Excise Act, 1964 (Act No. 91 of 1964), clearance has been issued or permission granted by such officer.

(2) The provisions of sub-regulation (1) shall not prevent any action necessary for-

(a) the rescue or extrication of persons or animals from the aircraft or the wreck;

(b) the reasonable protection of the aircraft, the wreck or wreckage from destruction by fire or other causes;

(c) the safeguarding by the owner, operator or police guard of precious metals, jewellery or valuables;

(d) the prevention of danger or removal of an obstruction to the aircraft, other means of transport or to the public; and

(e) the removal of the aircraft, any part or component thereof or anything therein to a safe place, when in water or otherwise endangered.

1.18.3 Carriage of children

The Civil Aviation Regulations of 2011, Part 136.07.8 state the following with regard to the carriage of children in a balloon:

"The operator of a commercial air transport free balloon shall ensure that a child younger than seven years is only carried when all the conditions as prescribed in the operations manual have been met".

The Operator's Manual conditions were not met with regards to carriage of children, disabled and challenged passengers who all must be accompanied by a capable adult carer.

1.18.4 Briefing of passengers

Part 136.07.13 of the CARs of 2011

(1) The PIC shall ensure that passengers are given a safety briefing in accordance with Document SA-CATS 136.

(2) Where the safety briefing referred to in sub-regulation (1) is insufficient for a passenger because of that passenger's physical, sensory or comprehension limitations or because that passenger is responsible for another person on board the balloon, the PIC shall ensure that the passenger is given an individual safety briefing that is appropriate to the passenger's needs.

(3) The PIC shall ensure that, in the event of an emergency and where time and circumstances permit, all passengers are given an emergency briefing in accordance with the Document SA-CATS 136.

(4) In the event of a flight crew incapacitation, the PIC shall ensure that at least one passenger is briefed with the basic understanding of the balloon operating procedures for landing. The operator shall ensure that this is prescribed in the operations manual.

With reference to sub-heading (4) above, the pilot was not incapacitated in the flight. The pilot did not brief the passengers on what to do in the event of incapacitation of the pilot.

1.18.5 Weather

Source: Cameron Balloons, Flight Manual Issue 10 Amendment 16, Section 2, Limitations

"(1) The balloon must not be flown free, if the surface wind at the time and place of take-off is greater than:

Balloons ≤ 600,000 ft³ (16 992 m³): 15 knots (7.7 m/sec)
Balloons > 600,000 ft³ (16 992 m³): 12 knots (6.2 m/sec)

(2) The balloon must not be flown free if the forecast for the planned time and place of landing indicates a significant probability of the surface wind exceeding the limitations in paragraph (1) above.

(3) The balloon must not be flown free if there is extensive thermal activity, any cumulonimbus (thunderstorm) activity in the vicinity of the flight path, or any turbulence which is giving rise to gusts of 10 knots (5.1 m/sec) above mean wind speed."

1.18.6 Preparation for a hard landing

Source: Cameron Balloons, Flight Manual, Section 3, Emergency Procedures

"3.8 There are two possible hard landing situations. A burner or envelope failure results in a heavy landing where the speed is almost vertical, whereas a weather emergency may cause a 'fast' landing where the speed is mostly horizontal.

In a heavy landing the occupants should brace against vertical compression, with their knees only slightly bent. The rope handles or cylinder rims should be firmly held.

In a fast landing the basket may tip forward violently on impact, tending to throw the occupants out. The occupants should adopt a low down position (knees well bent) with their back or shoulder pressed against the leading edge of the basket, head level with the basket edge and rope handles or cylinder rim firmly held.

Remind passengers not to leave the basket until told to do so.

Extinguish the pilot light(s), shut the fuel off at all cylinders in use and empty the hoses if time permits.

The parachute operating/rip line should be firmly gripped before touchdown."

1.18.7 Rapid Deflation System (RDS)

According to the pilot he had used the RDS system and had activated it before the basket made contact with the ground for the first time. If the RDS system is deployed it allows hot air to exit the balloon and to force the balloon to remain in contact with the ground. Due to the fact that the balloon was recovered from the accident site prior to the investigating authority being informed of such, this action by the pilot could not have been verified on the accident site. There was no conclusion reached regarding whether the deflation system was correctly deployed. The dusty conditions in the harvested maize field where they landed could also had an effect on the RDS system. The RDS system was released and tested before take-off by the pilot, it was a standard procedure before any flight.

One of the passengers state the following; *"I'm not a pilot and I know nothing about flying balloon but I noticed that the pilot made important maneuvers in order to stop the hot air balloon as fast as possible, understand that without his attempts to "close" the rapid balloon when we landed increase the severity accident and we could all have died."*

"When landed the wind was very strong was the moment we realized the seriousness of the situation."

Source: Cameron Balloons, Flight Manual, Section 6, System Description

"The RDS system is similar in appearance to a parachute valve. However, the centralising and shroud lines are replaced by a single length of line running through pulleys.

Pulling the red line gathers the parachute panel into a column in the centre of the circular opening for final deflation.

The action of the red line can be reversed by pulling the red and white venting line. Pulling the red and white venting line opens the parachute in a similar way to a parachute valve for in-flight venting of hot air.

1.18.8 Pilot restraint harness

Source: Cameron Balloons, Flight Manual, Section 6, System Description

"The pilot restraint harness prevents the pilot from being thrown from the basket during a heavy or fast landing. The harness fastens around the pilot's waist, and is attached securely either to or close to the basket floor. A quick release buckle is fitted to allow the pilot to leave the basket in an emergency." As the pilot is activating the controls, such as the parachute rip line, which requires both hands, and he is pulling downwards on this line he would in effect be pulling himself out of the basket. The harness is designed to be used as a purchase point for the pilot in these conditions. However, the passengers do not have to exert such negative activity, and the rope handles inside the basket are considered to be more that adequate. With reference to the photographs that was taken by a passenger(s) as per Figures 12 and 13 it must be stated that this passenger(s) were in contravention

to the pilot safety briefing as; (1) they did not hold onto the rope handles with both hands and (2) they did not stow their camera(s) or whatever device he or she used to take these photographs.

1.18.9 The looped rope handles in the basket

In Figure 16 on page 27 of the report, the traditional spiral-twisted type looped rope handles can be seen from the basket that was involved in the accident. The primary purpose of these handles were for the passengers to hold onto during landing (depending on whether the operator endorses this type of procedure) or during landing; holding onto the handles should be compulsory during a fast or high wind landing. Figure 19 shows a close-up view of the woven rope handle, this photograph was obtained courtesy of the balloon manufacturer. Also visible were two attachment harnesses, (black in colour), the pilot is not allowed to secure his safety harnesses to these attachments as there is a special attachment on the floor structure of the basket for that. In the accident flight, the pilot was the only person that was secured to the basket with a restraining/safety harness.

Figure 19: Close up view of a woven rope handle (photograph courtesy of Cameron Balloons)

1.18.10 Interview of passengers

The passengers contact details were obtained from the operator. The investigator interviewed four of the passengers in person. Another five passengers, who were foreign citizens were corresponded with via e-mail and statements were obtained

from three of them, as two of them were still minors who were travelling with their parents. The other three passengers were contacted telephonically but did not answer the calls nor did they return a call. Contact was established with two of them via e-mail, and they responded to a list of questions the investigator had send them.

1.18.11 International protocol

The Air Accident Investigation Branch (AAIB) in the United Kingdom was notified of the accident and they had appointed a non-travelling Accredited Representative in accordance with the provisions as contained in ICAO Annex 13, Chapter 5.

The United Kingdom was the State of Design and they were also the State of Manufacture. A citizen of their country was fatally injured in the accident, which also allows the State to be granted participation status into the investigation.

1.19 Useful or effective investigation techniques

1.19.1 No new methods were applied.

2. ANALYSIS

2.1 Man (Pilot)

The pilot was the holder of a valid South African Hot Air Balloon pilot licence as well as Commercial Hot Air Balloon pilot licence from the United Kingdom. He was flying in South Africa on a three-month contract and this was his third flying stint with the operator in South Africa. While flying for the operator he converted onto the Cameron A-415 type of balloon on 29 February 2016. The Cameron A-415 had a substantial larger envelope than the balloon model he used to fly. By the time the accident occurred he had accumulated 69.9 flying hours on this type of balloon.

During his flying in the Magalies Valley he had never flown over nor had never crossed the Magalies Mountain range. However, as an experienced pilot, he was able to read the relevant maps and other data to assess the area for surface and atmospheric safety issues. This was the first flight he conducted that took him over the mountain range and along with that they encountered moderate wind conditions, which allowed the balloon to drift to the west while still positioned over

the mountain range. During the flight the pilot attempted to probe winds that would either have taken them to the south, back towards the Magalies Valley, or towards the north of the mountain range, where the terrain was fairly flat again and where the winds would be more gentle. In an attempt to access such winds, the pilot ascended to a height of 8 731 ft AMSL, however this had no effect on the direction of flight. The pilot influenced the height of the balloon. The balloon did not and could not ascend of its own accord. It was the weather conditions which changed to significantly differ from the official forecasts, which were the factors over which no one had any control.

After being airborne for approximately one hour the pilot had identified a large open agricultural field, which encompassed a harvested maize field from the air as a landing zone. He descended towards the field and proceeded to land. The ground speed of the balloon was between 12 kt (22 km/h) and 22 kt (41km/h) when the basket first made contact with the ground. The pilot indicated that he had activated the RDS system. It could not be determined if this action was performed, nor to what percentage did the system deployed, as the balloon was recovered from the site by the operator before the accident was reported to the investigating authority.

The decision by the pilot to land was also greatly influenced by the fuel status of the balloon during the flight as they had been airborne for over an one hour. Although it was difficult because of the unauthorized removal of the balloon from the accident site the remaining fuel status was requested from the operator, which stated that approximately 30kg of fuel remained at the time of the accident. The selection of the landing site did not allow the pilot with much time before he was committed or forced to land. With the terrain being very hostile towards hot air balloon landings', the pilot made the decision to land in the open agricultural field ahead.

The selection of the landing site was most probably further influenced by the projected track of the balloon, as observed by the wind direction and speed assessed by the pilot and the potential options of landing sites were considered non-existent due to the terrain and the residential built-up area and the dam that was on the balloons track. In addition the track was heading towards another mountain range (see Figure 11 for reference). These were all of concern to the pilot with regard to safety of the passengers and fuel management of the balloon. The open agricultural field was also chosen due to its size and terrain, being the best option to land the balloon in.

2.2 Machine (Hot Air Balloon)

The hot air balloon was maintained in accordance with the provisions as contained in the Regulations. A new envelope was use, and all systems were functional. There was adequate space in the basket for all the occupants that were on-board as well as a sufficient number of rope handles to hold onto during the landing sequence. The inside handles became the passenger's primary survival aid during the landing sequence as it was the only object that they could hold onto inside the basket during the fast landing. None of the handles were observed to have failed. The basket displayed substantial damage especially on the one side but remained intact. The radio, GPS and cell phone used by the pilot fell out of the basket during ground contact. These units were not secured to such an extend that it remained secured to the basket during the landing sequence and fell or was ejected from the basket.

2.3 Environment

It seems that when planning the flight the pilot seems to have thought that he would stay south of the mountain range. That certainly seems to have been what he tried to achieve. If he had no upper wind information it could be that he expected that with a southeast low level wind the upper winds would have backed with height (flying in southern hemisphere) and that should have given a more westerly or even south-westerly track to remain in the Magalies Valley (to the south of the mountain range). It seems from the graph in Figure 8 that the wind stayed steadily, south-easterly, giving a track to the northwest until he got up to 8 731 ft, but at that height the wind speed had dropped of so that he could not have got back into the southern valley before his fuel ran out. He therefore opted to come lower and resumed the track that crossed the mountains. The next problem he encountered was at low level a low-level jet had formed. There was an inversion layer at about 6000 to 7000 ft. What probably happened was that the air was squeezed between the inversion layer and the mountain tops creating a much faster band of wind. It then seems that the low-level jet followed the surface down on the leeward side of the mountain. There is no suggestion that the low-level jet had been forecast. This situation presents a real dilemma for a balloon pilot. Even if he knew what was happening (sometimes cloud formation gives a clue but during this flight the sky was clear) the pilot would have to decide whether to fly on hoping that the jet would lift off the surface giving slow air beneath it. However, usually wind and turbulence increases with temperature as the morning progresses, so the normal reaction would have been to land as soon as possible. The pilot had what looked to be a good landing

site on track and the decision to land was understandable.

From the available data that was retrieved by on board devices (i.e., cell phones, GPS) it was determined that the ground speed of the balloon was 22 knots prior to ground contact. The wind speed exceeded the limitations as contained in section 2 of the flight manual for this balloon, which was 15 knots. This value was not only applicable to the point of departure but also the point of intended landing. It was observed from the official Aviation Meteorology forecast and thus considered to be credible, as 5 to 10 kt at the time of landing, that the wind directions to be encountered during the flight would give sufficient latitude to fly the balloon to a safe landing site, and that even allowing for a safety margin the wind speed at that point would be well within relevant safety requirements. The pilot ascended to a height of 8 731 feet AMSL in an attempt to try and encounter any change in wind direction possible, as flying over the mountain range was not ideal. There was no change in the wind direction or speed. After being airborne for approximately one hour the pilot had identified a large open agricultural area, which encompassed a harvested maize field and he prepared his approach as such that he could land in the open field. Due to the prevailing wind conditions, the pilot instructed the passengers to stow any loose objects (i.e., cameras, cell phones, etc.) and to prepare for a fast landing. He also, checked that the passengers had complied.

2.4 Operator and passenger tickets

The operator was in possession of a valid air operating certificate. The tickets were issued to the passengers on the morning of the flight at the check-in desk, prior to them being served pre-flight refreshments and snacks, which allowed reasonable time for them to read the information therein, well before the boarded the balloon at the launch field. The tickets did contain a “Passenger Safety Briefing” section, which provided safety tips to the passengers; however, the sub-heading on the ticket did not contain any safety briefing information related to an adult passenger that was accompanied by a young child (<7 years of age). This was found to be important information that was lacking under the passenger safety briefing section. This was dealt with as a separate briefing that the pilot had to present to the mother of the young child. The briefing was conducted verbally (as are all approved briefings), as the pilot was unable to physically demonstrate the fast landing position to the mother from the pilot compartment, due to limit space being available. No physical demonstration took place prior to getting them on board the basket. The adult was adequately and reasonably told, and actually demonstrated, the “child” landing position to the pilot’s approval.

2.5 The carriage of children (age 7 years and younger)

Part 136.07.8 of the CARs of 2011

"The operator of a commercial air transport free balloon shall ensure that a child younger than seven years is only carried when all the conditions as prescribed in the operations manual have been met."

This part in the Civil Aviation Regulations was found to be lacking content as it provides no clear guidance in this regard, nor could any reference be found with regard to how the age of *seven years* and younger was considered to be of relevance.

2.6 Safety briefing and crash survivability

The passengers were given a safety briefing prior to the flight by the pilot, they were verbally briefed, fully instructed, described and the pilot checked that the passengers understood and could adopt the landing position, including the mother and her young child. He was also assisted by ground crew personnel at the launch site. It could not be determined if all the passengers were paying attention when the briefing and demonstration were given.

According to available information the pilot did deploy the RDS system in order to bring the balloon to rest in the shortest possible distance. One of the passengers state the following; *"I'm not a pilot and I know nothing about flying balloon but I noticed that the pilot made important maneuvers in order to stop the hot air balloon as fast as possible, understand that without his attempts to "close" the rapid balloon when we landed increase the severity accident and we could all have died".*

On the right-hand side of the basket with the balloon in-flight looking at it from behind there were eight passengers, of which five were male, two were adult females, as well as the young girl (age; 4-years). The three female passengers, were ejected from the basket and came to rest in close proximity to one another. The hard impact could have winded them and caused them to let go. It also could have been that they were most probably not physically strong enough to hold onto the rope handles throughout the ordeal. The forces that affected that part of the basket were most probably greater than those felt in other parts of the basket. The

basket remained in contact with the ground after the second bounce and from there onwards it was dragged over rocky terrain. It was during this phase that they most probably could not hold onto the rope handles any longer, lost their grip and were ejected from the basket.

The pilot also uttered *"brace, brace, brace"* for a fast landing prior to impact. The female passenger that perished in the accident had been employed for many years as a cabin attendant with a large airline. Throughout her professional career she would have demonstrated to passengers how they should "brace", when so – instructed in the event of an emergency landing, by placing their hands behind their heads and leaning forward. The possibility that this passenger adopted this position was possible, in which case she would have removed her hands from the rope handles.

There was a first aid kit on board in the balloon basket, which was used by the pilot to render medical assistance to the three injured passengers. He was a qualified First Aider and was assisted by some of the other passengers, of whom some had suffered from minor cuts and bruises.

Once the pilot notified the operator of the accident, emergency personnel took approximately 2 hours before the first two ambulances arrived at the scene. This was a crucial phase for the seriously injured passengers as timeously medical care during trauma was of the essence.

3. CONCLUSION

3.1 Findings

The Pilot

3.1.1 The pilot was the holder of a valid Hot Air Balloon licence that was issued by the SACAA. He was also the holder of a valid Commercial Hot Air Balloon pilot licence that was issued by the United Kingdom CAA.

3.1.2 He was the holder of a valid aviation medical certificate that was issued by a SACAA approved Aviation Medical Examiner.

3.1.3 He conducted his conversion onto the Cameron A-415 type balloon in South Africa

on 29 February 2016.

3.1.4 The pilot stated, that he gave the passengers a safety briefing, including the stowing away of cameras and phones (prior to landing) and the landing position were given to the passengers by instruction and demonstration by the passengers prior to take-off. The pilot did not physically demonstrate the 'fast landing position' or 'down position.

3.1.5 The pilot stated, that he briefed the mother with the young child on the emergency position with the child during a fast landing. The mother stated that the pilot never briefed her to keep her arms crossed over the child shoulders in the event of a fast landing.

3.1.6 The pilot was not familiar with the area while he was ascending over high mountainous terrain or where he attempted to land. As an experienced pilot he has the ability to assess the conditions by reference to maps and sight of the area. He had been flying hot-air balloons in South Africa on a three-month contract with the operator.

3.1.7 The RDS system was released and tested before take-off by the pilot.

3.1.8 The pilot did not broadcast a distress call after the accident when he retrieved the radio.

3.1.9 The pilot was not aware that he could obtain the weather information for Aeroden aerodrome, which was located 5.2 nm to the north of the Skeerpoort Balloon field, by sending an SMS to 36010 (AD).

3.1.10 The pilot was the only occupant that was secured to the basket by making use of a restraining harness.

3.1.11 The GPS unit that was on board the balloon was damaged during the fast landing. The pilot had to ask the passengers to assist him by making use of the GPS facility on their cell phones.

3.1.12 The pilot sustained minor cuts and bruises during the accident sequence.

3.1.13 The pilot was a qualified First Aider and he attended to the injured passengers until the emergency personnel arrived on the scene.

The Balloon

3.1.14 The last maintenance inspection (MPI) that was certified on the balloon prior to the accident flight was certified on 4 October 2016.

3.1.15 A new envelope was purchased from the original equipment manufacturer (OEM) in the United Kingdom by the owner and was used for the first time on 20 April 2016 according to the logbook entry.

3.1.16 It could not be determined if the rapid deflation system (RDS) was fully deployed by the pilot as the hot air balloon was recovered by a ground team from the operator before AIID became aware of the accident.

3.1.17 A section of the balloon basket sustained substantial impact damage.

The Passengers

3.1.18 The pilot did not physically demonstrate to the passengers for the 'fast landing' or 'down position' or fast landing position as it was not possible for him to do so due to the layout of the pilot's compartment, which was not the same as the passengers compartments, nor was it a physical requirement. The passengers demonstrate the 'fast landing position', which indicate the instruction given was fully understood.

3.1.19 The passengers received their tickets on the morning of the flight before they got on board the balloon/basket. The tickets did contain a "Passenger Safety Briefing" printed format (see Annexure A).

3.1.20 Three of the passengers were seriously injured when they were ejected from the basket during the fast landing.

3.1.21 Emergency services were informed of the accident but took several hours to reach the scene of the accident.

3.1.22 The pilot who was a trained First Aider was assisted by one of the passengers in rendering first aid to the three injured passengers. There was a first aid kit on-board the basket in the pilot compartment.

3.1.23 One of the passengers succumbed to her injuries while she during emergency surgery. She was admitted to hospital approximately 4 hours after the accident occurred.

3.1.24 The young child, who was seriously injured was airlifted from the accident scene by EMS helicopter and was transferred to a private hospital in Johannesburg where she underwent surgery.

3.1.25 A third female passenger was seriously injured and on arrival at the hospital underwent two emergency operations to her vital organs. Her back and arm had fractures.

3.1.26 Several of the passengers received medical and trauma therapy/counselling.

The Operator

3.1.27 The operator was in possession of a valid air operating certificate (AOC).

3.1.28 All the passengers were issued with tickets on check-in at the launch site before they got on board the balloon basket.

3.1.29 The operators, operations manual did not contain any content on the carriage of children.

The Weather

3.1.30 The prevailing weather conditions at the time of take-off presented calm conditions and clear skies, which was conducive to hot air balloon flying. This assessment was made by the pilot, the operations/safety manager as well as another pilot that was at the launch field.

3.1.31 The wind speed, which was predominantly from the east had increased once the balloon crossed the Magalies Mountain range. The wind drifted the balloon towards the west and had a direct influence on the *fast landing*.

3.1.32 According to the information that was downloaded from the pilot iPhone, 'Hot Air App', the wind speed was approximately 22 knots (41km/h) when the balloon/basket made contact with the ground for the first time.

On-site investigation

3.1.33 The balloon was recovered by the operator before the accident investigating authority was notified of the accident. The intervention by the operator hampered the investigation as they tampered with evidence on the scene of an accident.

3.2 Probable cause:

3.2.1 The pilot opted to execute a landing onto an open agricultural field with the prevailing wind from the east at approximately 22 knots, which was above the safe landing speed for hot air balloon operations, resulting in a high-speed landing.

3.3 Contributory factors:

3.3.1 The pilot received inadequate familiarisation training from the operator. He was not familiar with the area where he landed. He was a foreign pilot/citizen on a three month contract with the operator.

3.3.2 Once they crossed the Magalies Mountain range the wind speed started to increase. While over a mountainous region with an excessive wind it was very difficult for the pilot to land early, before the wind strengthens more.

3.3.3 The pilot did not physically demonstrate the 'fast landing or down position' to the passengers during the safety briefing as the pilot compartment in the basket does not allow adequate space for such a demonstration.

3.3.4 Apart from the pilot's safety briefing there was no safety placards inside the basket or safety cards (hard copies) being available to the passengers to acquaint themselves with the emergency procedures, which should have reflected the correct down position, similar as to what is found on board an airliner.

3.3.5 The Passenger Safety Briefing as contained/printed on the passenger ticket (see Annexure A) does not contain any safety content for an adult passenger that was accompanied by a young child of 7 years or younger.

3.3.6 The regulatory guidelines contained in Part 136 of the CARs of 2011 with reference to the carriage of young children were found to be lacking content, leaving the part open to interpretation, thereby shifting the responsibility to the operator.

4. SAFETY RECOMMENDATIONS

4.1 It is recommended to the Director of Civil Aviation that the SACAA implement a Commercial Hot Air Balloon pilot licence. This licence should be in line with international best practises. South Africa is one of the few countries in the world that does not have a Commercial Hot Air Balloon pilot licence, yet we have a substantial number of commercial Balloon operators in South Africa, who are flying thousands of passengers annually.

4.2 It is recommended to the Director of Civil Aviation that the provisions with regard to Part 136.07.8, which dealt with the carriage of children on board commercially operated hot air balloon be reviewed as it was found to be lacking content. This accident has illustrated that young children (under the age of seven as referred to by the regulation) are not physically strong enough to hold onto the rope handles during an emergency/fast landing over uneven/rough terrain. It is further recommended that the regulations should make clear provisions in this regard and that an operator that wishes to take young children on board should be able to demonstrate that they have the necessary safety measures in place to ensure the child is properly restraint during the flight to prevent a re-occurrence of this accident, whereby the child fell out of the basket during a 'fast or wind landing'.

4.3 It is recommended to the Director of Civil Aviation to amend the current regulations as contained in Part 136 to address adult passengers travelling with children on board a commercial hot air balloon flight. These passengers should be properly briefed prior to such a flight and should be clearly aware of the risks and safety requirements when accompanied by young child.

4.4 It is recommended to the Director for Civil Aviation that a review of Part 136 of the CARs of 2011 as amended be conducted as it was found to be lacking critical safety content.

The information listed below should be incorporated under this part;

(i) The term *young children* as used in Part 136 of the South African Civil Aviation Regulations should be clearly defined.

(ii) Part 136 of the South African Civil Aviation Regulations should clearly define the minimum age whereby a *young child* should NOT be allowed on board a hot air balloon.

(iii) Part 136 of the South African Civil Aviation Regulations should clearly state that women who are pregnant should not take to the skies. However not all pregnant women should be ban from flying, but the risk and potential stresses associated with this flying should be clearly stipulated. The stage of pregnancy whereby flying should not be undertaken should be clearly defined.

(iv) Part 136 of the South African Civil Aviation Regulations should consider helmets being carried on board a balloon, and it should be used during a *"fast or high wind landing"*.

4.5 Part 136.07.8 of the CARs of 2011 address the carriage of children very briefly and mention the age of seven years. The investigator could not find supporting evidence that explain how the authority derives at the age of seven years being an adequate or safe age for a young child to be carried safely on board a Hot Air Balloon.

***"Part 136.07.8** The operator of a commercial air transport free balloon shall ensure that a child younger than seven years is only carried when all the conditions as prescribed in the operations manual have been met."*

It is recommended that this age limit be reviewed in line with internationally best practises, a minimum age of ten years is recommended for consideration as well as a minimum height of 1.20m. The requirements for allowing *young children* on board should however not only be age and height dependant but the young child should display the ability whereby he or she will be able to take up the 'fast landing' position himself/herself without assistance from an adult passenger. He or she should be able to hold onto the support handles in the basket without being physically ejected from the basket during a fast landing.

The height of a child/person 1.20 m and taller allows a child/person to stand on the floor of the basket and look over the basket edge. Children/people shorter than 1.20 m at this stage need to stand on the seat cushions, which is elevated from the floor level in order to be able to look out of the basket edge. This practise is considered hazardous.

An additional safety method for young children is recommended whereby they should be secured to the basket by means of a safety harness, similar to the harness used by the pilot.

Essential passenger information

It is essential that passengers, including young children can hold onto the rope handles inside the basket during a landing in faster winds, or during a fast landing without falling or being ejected from the basket. If this provision could not be met, the use of a safety harness should be made available as an alternative, or the person should abstain from making the flight in the interest of his/her safety, and that of the other occupants on board.

Passengers and pilot(s) falling out of the basket during the landing sequence were not restricted to this accident, there have been many recorded accidents / serious incidents where passengers as well as pilots fell out of the basket during landings, that being the primary reason as to why pilots must wear safety/restraining harness that is attached to the basket during flight.

The option of wearing a safety harness should not be limited to the pilot(s) alone, and or young children, or people with disability, but all passengers should be allowed the opportunity to opt for a safety harness should they feel to do so. The harness should be worn during the take-off, approach and landing phase of the flight. The writer is aware of the fact that should every passenger wear a safety harness there is the possibility that these harnesses might became entangled. However, the benefit associated with wearing a safety harness far outweigh the possibility that a passenger or passengers might become entangled as it will prevent passengers, just like the pilot(s) being ejected from the basket as was the case in this accident.

4.6 It is recommended to the Director of Civil Aviation that the safety information placard (similar to what is used on board airliners and charter operator aircraft) be included in the Part 136 of the CARs as a compulsory item. No such safety placards were available on board the hot air balloon, yet we have seen passengers of different nationalities, for which English is not their first language, and they might not have grasped the safety briefing or all aspects of it.

4.7 It is recommended to all hot air balloon operators to ensure that all essential equipment used by the pilot during flight (i.e., Radio(s), GPS devices, cell phones, etc.) are stored in a secure location within the pilot compartment to ensure these devices does not fall out of the basket or get ejected from it during a fast landing.

4.8 It is recommended to the Director of Civil Aviation that Part 136 of the CARs be reviewed in its totality as it is not only lacking content but also contain content that is not clear for interpretation and might lead to confusion that might result in an unsafe action or actions by the pilot and or the operator.

5. APPENDICES

5.1 Annexure A (Passengers Safety Briefing as displayed on the ticket)

5.2 Annexure B (Conditions of carriage as displayed on the ticket)

PASSENGER SAFETY BRIEFING
BILL HARROP'S "ORIGINAL" BALLOON SAFARIS

- ***Your safety is of paramount importance to us throughout every facet of our operation.***
- ***Please be aware and pay attention to the instructions of your Captain and Crew at all times.***
- ***Your Captain has been trained regarding the correct procedures to follow for the collective safety of all involved.***
- ***Please feel free to ask for advice if there is anything that you do not understand in this regard.***

SMOKING (BANG!) - It is Illegal to Smoke in or Near a Balloon

LANDING POSITION - Most Often (Mary Poppins Type)

1. Stand with FEET TOGETHER, KNEES TOGETHER, and SLIGHTLY BENT, MUSCLES TENSED.
2. HOLD onto the internal HANDLES firmly WITH BOTH HANDS and FACE BACKWARDS AND SLIGHTLY SIDEWAYS looking over your shoulder towards the CAPTAIN and the direction of travel.
3. Cameras and small loose objects must be either slung around your neck to the front and tucked inside your clothing (to ensure they do not get caught between the basket and the ground) or around your wrist. Large bags and heavy objects should be placed on the floor underneath your buttocks. High-heeled shoes should be removed.
4. Keep all parts of your body, long hair and clothing inside the basket.
5. DO NOT GET OUT OF THE BASKET UNTIL YOU ARE INDIVIDUALLY INSTRUCTED BY YOUR CAPTAIN TO LEAVE.
6. ONLY THE PERSON INSTRUCTED TO LEAVE THE BASKET MUST DO SO (NO OTHER).

DOWN POSITION - Occasionally (Quite Sporty, Lots of Fun!)

For landing in slightly faster winds.

DO NOT ASSUME THE "DOWN POSITION" UNLESS INSTRUCTED TO DO SO BY THE CAPTAIN.

1. From the "Landing Position" bend the knees further to a squatting position keeping your head level with the top of the basket.
2. Press your back or shoulder firmly against the leading edge of the basket.
3. Hold the rope handles firmly with both hands.

PLEASE DO NOT SMOKE AFTER DISEMBARKING (WOOSH!) in the interest of safety, and in consideration and politeness to the landowner UNLESS YOU HAVE RECEIVED THE SPECIFIC PERMISSION OF A QUALIFIED CREW MEMBER.

N.B. Please save your applause for the pilot 'till after landing!

****SEE OVERLEAF FOR CONDITIONS OF CARRIAGE, TICKET AND PASSENGER INFORMATION***

CONDITIONS OF CARRIAGE

(Passengers and their Baggage)

CONDITIONS OF CARRIAGE
(Passengers and their Baggage): Must not contain compressed gases (aerosols, oxygen bottles), explosives (fireworks, ammunition), flammable solids or liquids (lighter fuel, matches), radioactive materials, oxidising material (bleach, corrosives, acids, alkalis, mercury, wet cell batteries), magnetised material, poisons and infectious material, briefcases with alarm devises, medicines and toilet articles for use on board are exempt from these restrictions.

1. The Carriage of passengers and their baggage is subject to any Special Conditions and Regulations of the Carrier/s displayed for inspection at their booking offices, insofar as the Conditions and regulations are not inconsistent with the Conditions and provisions referred to or stated below.
2. IMPORTANT NOTICE TO INTERNATIONAL PASSENGERS
   "Passengers on a journey including an ultimate destination or stop in a country other than the country of departure, are advised that the Warsaw Convention may be applicable. The Warsaw Conventions governs and in most cases limits the liability of carriers for death or personal injury and in respect of loss or damage to baggage and personal effects".
3. In all cases in which the carriage is not governed by the said Convention, carriage is only accepted at the passengers risk and upon the specific condition that the Carrier/s their servants and agents shall be under no liability for any damage of any kind whether caused or occasioned during carriage by air or in connection with auxiliary services incidental to the carriage by air or whether or not caused or occasioned by the act, omission, neglect, gross neglect or omission or default of the carrier/s their servants or agents. The passenger hereby indemnifies the Carrier/s against any claim or claims for compensation for any damage, loss or injury whether sustained on board the aircraft or in the course of any of the operation of flight embarking or disembarking caused directly or indirectly to him or his belongings which indemnity shall extend to the passenger's dependants, estate or any person whomsoever.
4. The Carrier/s are not obliged to accept luggage or baggage with a "Special Declaration of Value".
5. Delivery of baggage will be made to the bearer of the baggage ticket.
6. In the event of the Conditions and Regulations stated or referred above or any part thereof relating to the exclusion of limitation of liability of the Carrier/s being contrary to the law of State or territory in the Court of which an action is brought, the liability of the Carrier/s shall be excluded or limited insofar as the law permits, and the Carrier/s shall be entitled to the benefit of every exclusion or limitation of liability permitted by such law.
7. Any action against the Carrier/s shall be brought only in the Court of the State or territory in which the principal place of business of the Carrier/s is situated.

THE CARRIER, hereby warrants that it is insured in accordance with the Regulations promulgated in terms of the AIR SERVICES LICENSING ACT, 1991 (ACT No.115 OF 1990) and more specifically REGULATION 5 thereof.

SOME TIPS & HINTS

NB: Samsung Note 7 Devices are banned from carriage on all our flights.

DRESS:	Casual, warm but peelable, and "country" footwear.
BRING:	Spare film for your camera, batteries for the video and binoculars.
PHYSICAL CONDITION:	Participants should be nimble enough to climb in and out of the basket, to stand for the duration of the flight and be able to jump unassisted from a height of 60cm.
PLEASE BE PROMPT:	You may keep others waiting.
TOILET FACILITIES:	Please ask our staff for directions.
SMOKING:	***IT IS ILLEGAL TO SMOKE IN OR NEAR A BALLOON.***

- ***Your safety is of paramount importance to us.***
- ***Please be aware and pay attention to the instructions of your Captain.***
- ***Your Captain has been trained regarding the correct procedures to follow for the collective safety of all involved.***
- ***Please feel free to ask for advice at any time.***

BILL HARROP'S "ORIGINAL" EST. 1981 BALLOON SAFARIS

South Africa's most experienced Licensed Balloon Airline

EST. 1981