ACCIDENT

Aircraft Type and Registration:	Lindstrand 105A hot air balloon, G-RIMB
No & Type of Engines:	None
Year of Manufacture:	2002
Date & Time (UTC):	11 December 2005 at 1455 hrs
Location:	Darwen, Lancashire
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 3
Injuries:	Crew - None Passengers - 1
Nature of Damage:	Basket and burner support structure bent, arcing damage to burner
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	950 hours (all on type) Last 90 days - 20 hours Last 28 days - 20 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and information provided by the Met Office

Synopsis

The balloon encountered an unexpectedly strong wind during an attempt to land at the crest of a hill and collided with power cables. It was dragged along the cables until one set of flying wires broke and the basket fell about 12 ft onto a road. It was then dragged across the road by the envelope until finally coming to rest against a high stone wall.

History of the flight

The commander reported that after a normal takeoff in calm conditions the flight proceeded uneventfully in an easterly direction, with ground speeds between 7 and 20 kt at altitudes between 500 and 1,500 ft. The ground speeds were indicated on a handheld GPS carried in the basket. The commander was accompanied by the holder of a PPL (Private Pilot's Licence (Balloons)) and three fare-paying passengers.

After a flight of approximately 40 minutes the balloon approached a wooded area at the head of a valley running north to south at the foot of Darwen Moor. The commander was aware that the terrain beyond Darwen Moor was less favourable for landing. He had hoped that the local topography would cause the wind to veer sufficiently to carry the balloon into this valley for a landing in open ground. As the balloon descended,

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however, it became clear that it would not enter the valley and would instead need to climb over Darwen Hill (at the northern tip of Darwen Moor, one mile south-west of Darwen town centre) for a landing further to the east. Once clear of Darwen Hill, a descent was initiated into the next valley, during which the ground speed dropped from 20 kt to approximately 8 kt.

A landing site was chosen on ground which sloped gently upwards in the direction of flight towards the crest of the next hill. However, the presence of several power and telegraph lines prevented an approach at hedge height to the chosen landing site and, after clearing all of them, a final descent was initiated from approximately 150 ft agl with a ground speed of 10 kt. The commander reported that the descent seemed slow at first and was "encouraged" with a very short pull on the parachute line[1], but on passing 25 ft agl the descent accelerated and a short burn was used to slow the approach. Immediately afterwards, the balloon, which was then descending "positively", encountered a strong wind which carried it 50 m further up the landing field than intended. The pilot opened the parachute vent and estimated that the balloon touched down at a speed of 25 to 30 kt, causing it to drag across the ground for a further 50 m. The strong wind then picked up the partially deflated envelope which, acting as a sail, carried the entire aircraft another 100 m downwind at a height of approximately 8 ft, over two substantial wooden fences and across a narrow road.

Initially, the basket came to rest against a telegraph pole supporting a set of insulated power cables which ran north-west to south-east along the west side of the road. The envelope, which had drifted beyond the cables, pulled the basket upwards until the burner frame rested against them. At first, there was no electrical arcing and the pilot was able to isolate the burner fuel supply. However, the balloon was dragged along the power cables in a south-easterly direction until the basket came to rest against the next telegraph pole. Chafing of the balloon's flying wires during this motion resulted in arcing, which caused one set of flying wires to break. The subsequent sudden movement of the balloon caused the power cables themselves to break which in turn allowed the basket to fall approximately 12 ft to the road. It was then dragged across the road by the envelope until finally coming to rest against a high stone wall. The envelope was draped over trees and the roof of a nearby house.

Injuries to persons

The PPL holder and the two younger passengers, one of whom may briefly have been unconscious, sustained bruising. The older passenger, contrary to the commander's briefing, had put his arm outside the basket and had sustained cuts to his hand and elbow, both of which required stitches. The commander sustained bruising and scratches, some of which were caused when the spectacles he was wearing broke during the accident sequence. Police, fire and ambulance services arrived shortly afterwards and the air ambulance was called to take the older passenger to hospital. The two younger passengers were taken to hospital by road. The commander stated that he and the PPL holder did not require medical assistance.

Damage to the balloon

Members of the emergency services assisted with the recovery of the balloon envelope which was severely damaged. The basket top-tube was twisted and the burner sustained damage from the various impacts and from electrical arcing. The commander stated that the basket and envelope were repairable but that the burner required replacement.

Footnote

[1] The parachute line opens a section of the envelope, which allows hot air to escape, thus reducing the buoyancy of the balloon.

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Other damage

The location of the second touchdown of the basket was indicated by a rectangular impact mark in the field adjacent to the power lines and by scraping of the grass corresponding to the direction of subsequent drift of the balloon.

A power line and a telephone cable running to the house were broken but no other damage to property was evident.

Meteorological information

Pilot report

The commander reported that he obtained a weather forecast prior to the flight, which indicated a surface pressure of 1036 hPa. He extracted from Form F214[1] information for position 52°30'N, 002°30'W, which indicated a 10 kt wind from 270° at 1,000 ft and a variable wind of 5 kt at 2,000 ft. He recalled that the North and Central regional ballooning wind forecasts obtained from the Met Office indicated a westerly surface wind of 2-7 kt.

Met Office report

An aftercast provided by the Met Office indicated an area of high pressure centred over south-west England feeding a moderate to fresh westerly flow over northern England, becoming stronger further north. Radiosonde ascents from locations around the accident site indicated a marked inversion between 1,000 and 3,000 ft amsl. The estimated wind at the accident location was from 270°, with a speed of 15-18 kt both at sea level and at 500 ft amsl. The accident occurred near position 53°41'N, 002°26'W. Inspection of Form F214 valid for 1500 hrs on 11 December 2005, interpolating between data for position 52°30'N, 002°30'W and position 55°N, 002°30'W, suggested that the local wind at 1,000 ft amsl would have been from 260° at 17 kt.

The regional ballooning forecast for the North area, valid from midday to dusk on 11 December 2005 predicted a surface wind from 230° at 7-10 kt, increasing to 12-15 kt locally and 8-12 kt generally in the north of the area. In discussions with the AAIB, the Met Office commented that stronger winds would be likely over higher ground due to topographical forcing which may have existed between the Pennines and the inversion.

Operator's limitations

The operator's Operations Manual, approved by the Civil Aviation Authority, stated that:

> *'The balloon shall not normally be operated in a wind speed exceeding 8 kt at the surface, and not in wind speeds between 8 kt and the flight manual limit of 15 kt without the specific approval of the Chief Pilot'*

Because the commander was the operator's sole commercial pilot, he was in effect the Chief Pilot and able, therefore, to authorised himself to operate in a wind speed up to 15 kt.

Landing site information

The landing site was on gently rising ground near the top of a ridge whose summit is at 1,063 ft amsl. Upwind, approximately 2 nm to the west of the landing site, the northern tip of Darwen Moor rises to almost 1,300 ft amsl. This promontory is visible in the background of the photograph in Figure 1. The area is dominated by numerous hills and valleys, aligned broadly north-south, with typical gradients of approximately 7%.

Footnote

[1] UK low level spot wind chart, produced by the Met Office, which showed forecast winds at various levels at intervals of 2°30' of latitude and 5° of longitude.

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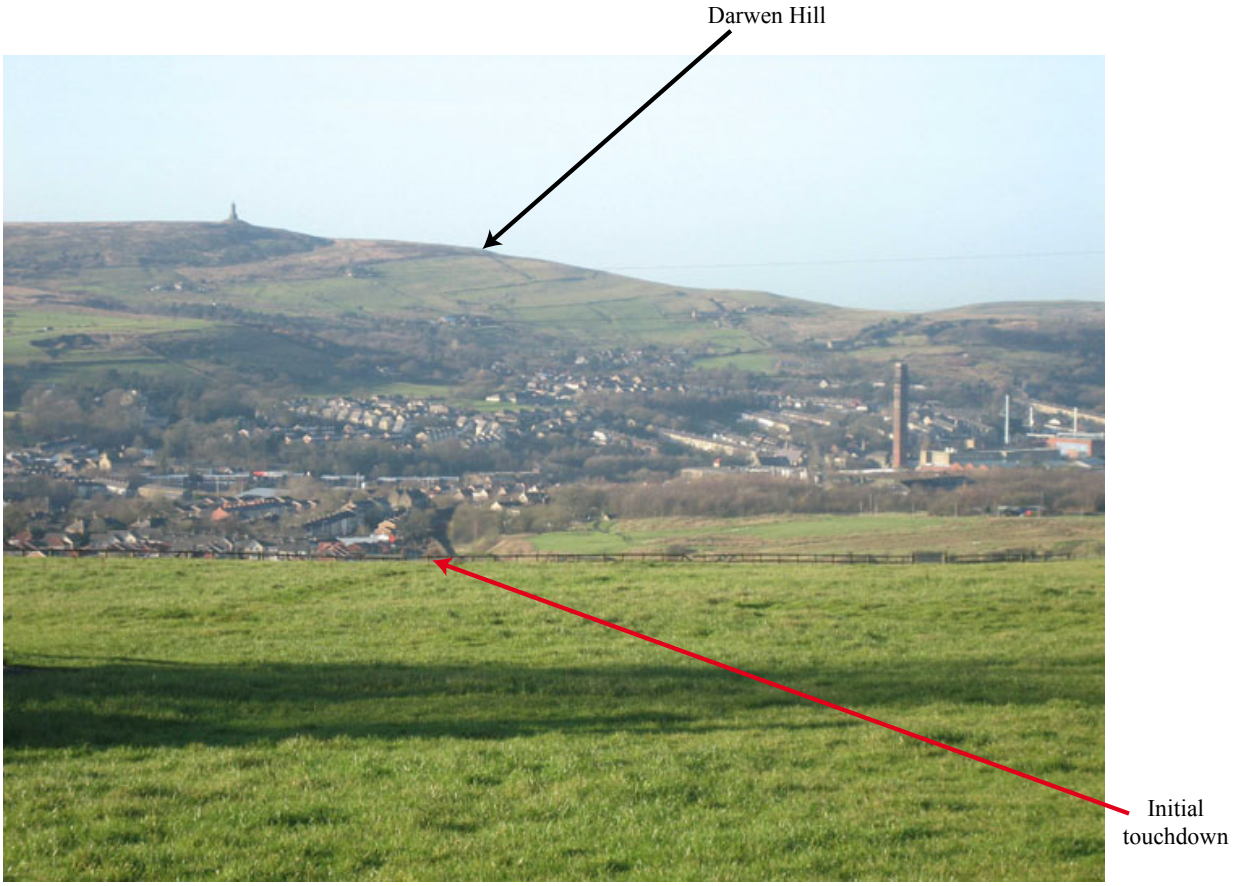

Figure 1

View west towards Darwen Hill

The touch down area was crossed by two sets of telegraph wires running north to south. A line of high tension cables and associated pylons, whose path is marked on the relevant Ordnance Survey "Explorer" 1:25,000 map (one of which was carried in the balloon), was aligned with the ridge downwind of the road and garden wall where the balloon finally came to rest. The surface was predominantly rough grass which was damp and flattened. During the approach, most of the visible trees were deciduous and had no leaves.

Recorded data

A handheld GPS, carried in the balloon and switched on during the flight, was successfully downloaded. The data points recorded provided Latitude, Longitude and GPS time but no altitude information. The difference between the locations of the data points and the time taken to travel between them was used to generate an average speed between the points. Similarly, the bearing of the line between data points was used to calculate mean track direction.

The flight recorded on the day of the accident started at 1402 hrs UTC, lasted 52 mins and covered 12 nm. The flight path of the accident flight is shown in Figure 2. Figure 3 shows a plot of the average ground speed of the GPS unit between the recorded track points. Figure 4 shows the end of the flight overlaid on an aerial photograph, aligned by reference to photographs of the landing points provided.

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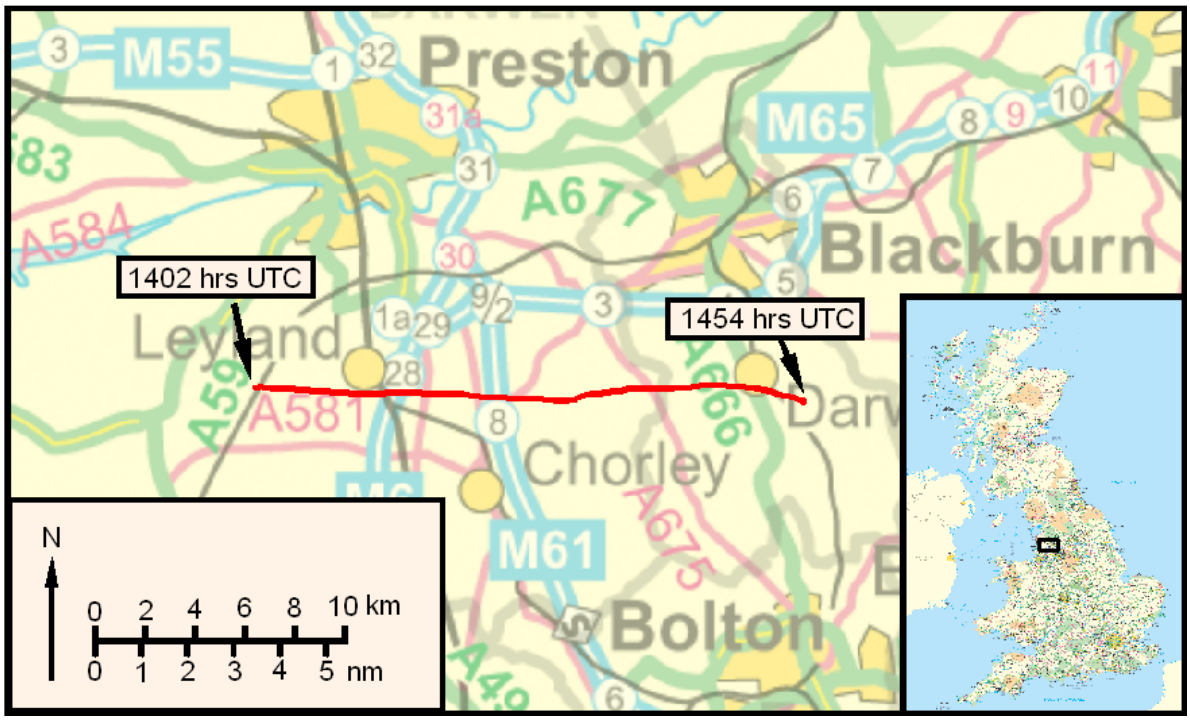

Figure 2

Flight path overview

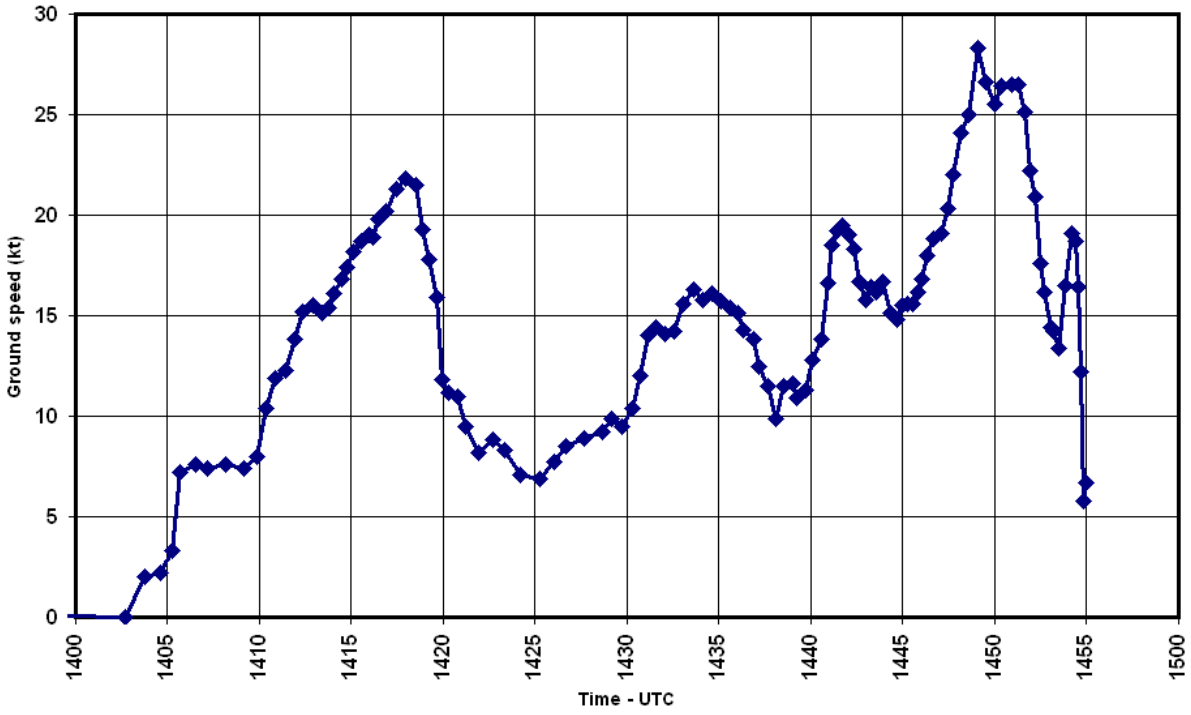

Figure 3

GPS speed

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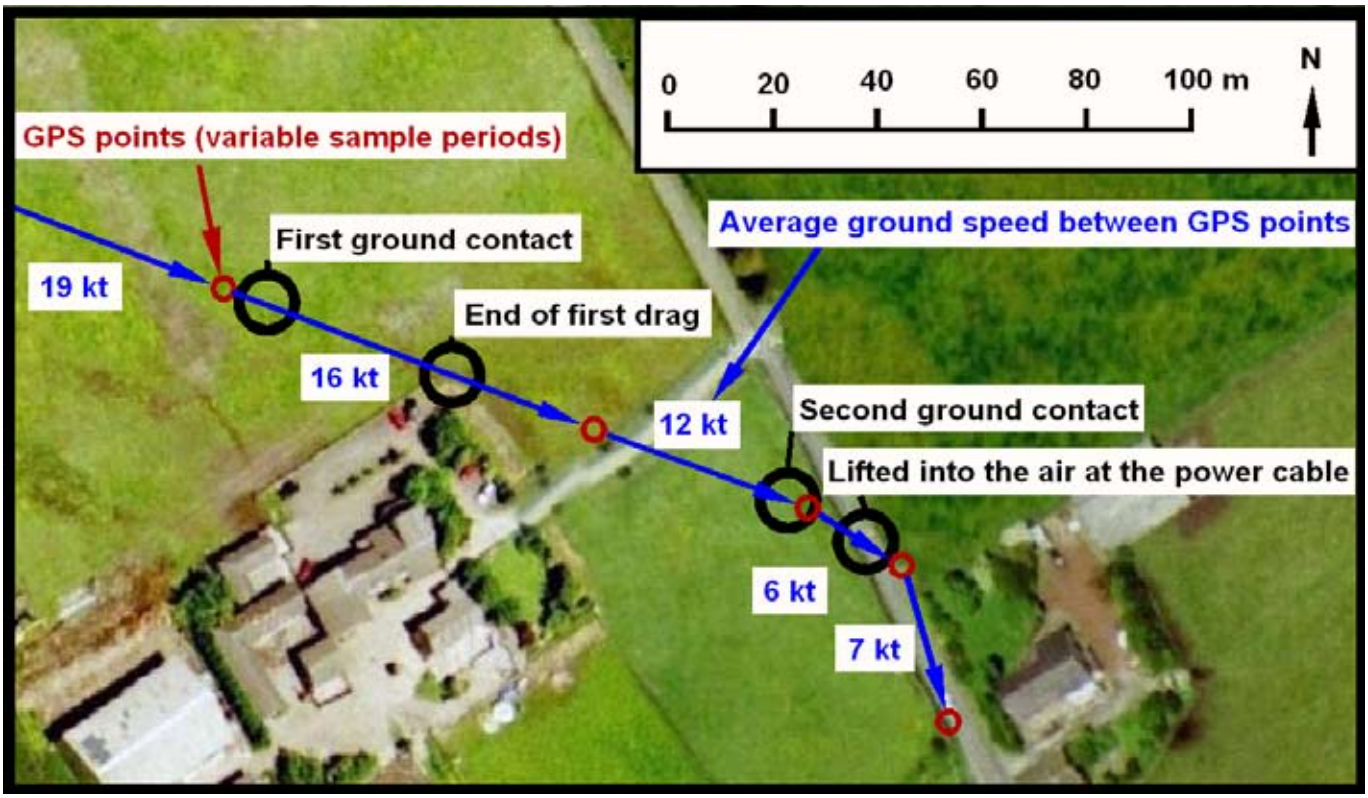

Figure 4

Final flight path

The ground speed of the balloon rose to approximately 22 kt during the first 15 minutes of flight. It then dropped to about 7 kt during the next 7 minutes and then climbed again, peaking at just over 28 kt, 5½ mins before the first touch down. The average ground speed between points then reduced to a minimum of just over 13 kt and climbed again by 6 kt in less than a minute, with an average 19 kt ground speed in the 21 seconds before the first touch down.

Survival aspects

Hand holds were provided inside the basket for each passenger in accordance with the requirements of CAP 494 – *British Civil Airworthiness Requirements, Part 31 – Manned Free Balloons*, published by the CAA. There was no requirement for additional passenger restraints, such as harnesses. The passengers stated that they received a safety brief, in accordance with the provisions of CAP 611 – *AOC Operation of Balloons*, prior to departure. This included the instruction to make use of the hand holds and to keep all parts of the body within the basket during landing. Those occupants who complied with the safety brief appeared not to have suffered serious injury.

Other information

The pilot of the air ambulance that attended the scene stated that he was surprised to encounter a marked increase in wind strength at 200 ft agl. He aborted his first attempt at landing and flew a clover leaf pattern in order to assess the lower wind strength and direction. He commented that during his second approach he had to use an unexpected amount of tail rotor thrust to turn against the wind.

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Analysis

The '*Handboook of Aviation Meteorology*', published by the Met Office, suggests that the wind speed at the surface, over land, will be "about one third to one half of the geostrophic value[1]. The widely accepted practical application of this statement is that the wind speed at the surface over land will be approximately half that at 2,000 ft. The commander's interpretation of meteorological information available before the flight indicated that surface wind speeds would not exceed 10 kt during the intended flight. On that basis, he had a reasonable expectation of operating the flight within the provisions of his Operations Manual. An estimate for the latitude at which the flight was conducted, based on data for position 52°30'N, 002°30'W and position 55°N, 002°30'W, would have indicated that the wind speed might be higher. The regional ballooning forecast for the North area, valid for the duration of the flight estimated a maximum surface wind speed of 15 kt.

Local topography can have a significant effect on surface wind speed, however. For example, an air mass will accelerate as it approaches the crest of an isolated hill and decelerate on the other side. The presence of an inversion will exaggerate this effect because it acts as a barrier and forms, with the hill, a venturi in which pressure decreases locally but wind speed increases. The air mass will also accelerate around the nose of a promontory. Strong winds, steep slopes and the presence of other hills and valleys will complicate this process greatly. The terrain over which the accident flight passed comprised a series of hills and valleys and, immediately downwind of the landing site, a promontory. The wind encountered in the valley preceding the touchdown was relatively calm but it accelerated as it approached the crest of the hill upon which the landing was attempted. Textural evidence of local wind conditions, such as the movement of leaves and grass, was not available because of the season and recent weather. Recorded evidence suggested that indications of ground speed provided by the GPS would have confirmed the commander's assessment that wind speed was reducing to acceptable levels as the balloon approached the landing site, but that very shortly before touchdown, it increased to a speed at which a normal landing could not be accomplished.

Footnote

[1] The wind speed calculated from pressure gradient, air density, rotational velocity of the Earth and latitude.

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