Report 00-008

Aerostar S81A hot air balloon ZK-SKY

power line incident

near Methven

6 July 2000

Abstract

On Thursday 6 July 2000 at about 0915, Aoraki Balloon Safaris Aerostar S81A hot air balloon ZK-SKY was on a local flight in good weather near Methven with 13 passengers and 2 crew. During a go-around following a missed approach to land, the balloon descended to a position where a power line could not be avoided. After contacting the earth wire the balloon could not be climbed clear, so it was descended between the live power conductors underneath, to land without injury or damage.

The incident probably resulted from misjudgement by the handling pilot, and insufficiently close monitoring of his actions by the pilot-in-command.

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The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

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List of Abbreviations

°C	degrees Celsius
DC	direct current
kg	kilogram(s)
km	kilometre(s)
kV	kilovolt(s)
lb	pound(s)
m	metre(s)
nm	nautical mile(s)

Data Summary

Aircraft type, serial number and registration:	Aerostar S81A, 3008, ZK-SKY
Number and type of engines:	Aerostar 52950 HP III triple burners
Year of manufacture:	1997
Date and time:	6 July 2000, at about 0915[1]
Location:	3 nm west-south-west of Methven latitude: 43° 39.4' south longitude: 171° 34.5' east
Type of flight:	air transport, local scenic
Persons on board:	crew: 2 passengers: 13
Injuries:	nil
Damage:	nil
Pilots' licences:	commercial pilot licence (balloon)
Pilots' total flying experience:	pilot-in-command: 1822 hours (869 hours on balloons) (186 hours on ZK-SKY) handling pilot: 1283 hours (53 hours on balloons) (2 hours on ZK-SKY)
Investigator-in-charge:	J J Goddard

[1] All times in this report are New Zealand Standard Time (UTC + 12 hours) and are expressed in the 24 hour mode.

1. Factual Information

History of the flight

1.1 On Thursday 6 July 2000 Aoraki Balloon Safaris had bookings for 13 passengers for a normal morning balloon flight. At 0515 the chief pilot assessed the weather as suitable, and arranged to meet the passengers at 0700 in Methven. A new company pilot was to be the handling pilot on this flight, with the chief pilot, as pilot-in-command, supervising him.

1.2 The pre-flight passenger briefing, and other routine formalities, were completed in Methven before the ground crew drove the passengers, pilots and balloon to the chosen launch site 2 km north-west of Methven.

1.3 The balloon was prepared for flight and inflated normally in almost calm, frosty conditions at the launch site. The balloon lifted off without incident at about 0810 and was climbed up to about 5300 feet. During the climb the balloon passed from the very light northerly surface wind through a light south-westerly, then through a calm layer into a 4 to 5 knot north-easterly above 2000 feet. Flying conditions were locally clear and sunny, with coastal cloud 30 to 40 km to the east.

1.4 After about 35 minutes the balloon was descended so that the pilots could assess the lower wind before landing. This was found to be north-west at 1 to 2 knots, and because the area was not ideal for landing the balloon was climbed again into the upper north-east wind to reposition it towards a better area to the south-west.

1.5 The balloon was then descended towards a group of more suitable paddocks for landing. On the landing approach, the balloon's track changed to the south-east at 1 to 2 knots, as expected by the pilots, and towards a chosen paddock. The passengers were briefed to prepare for landing by stowing their cameras and adopting their landing positions in the basket.

1.6 As the balloon crossed the upwind boundary of the chosen paddock its descent was checked at about 30 feet above ground level, and it continued in level flight to track slowly along the paddock. As it approached half-way along the paddock, still not descending, the pilot-in-command instructed the handling pilot to go around. This decision was made because he wanted to avoid a firm landing which might have resulted from venting the balloon at that height to achieve a landing in the paddock.

1.7 The handling pilot promptly operated all 3 burners for sufficiently long to start the balloon climbing at a reported rate of 350 feet per minute. He observed that they had climbed above the top earth wire of the major power line ahead, which ran across their track just beyond the end of the paddock, and was able to select and point out another paddock ahead for their landing.

1.8 At about this time the balloon started to descend again. The handling pilot again operated all 3 burners, but failed to restore the climb in time for the balloon to avoid the earth wire of the power line.

1.9 The balloon contacted the earth wire with the bottom of its envelope, above the basket suspension cables. The balloon stopped, held against the wire by the light wind. Continued heating with the burners was not effective in lifting the balloon clear, and the pilot-in-command decided that they should shut off the fuel tanks and vent the balloon to descend between the power line conductors underneath them. Both pilots did these tasks, and the balloon landed upright under the power line, about one metre from the edge of the Rangitata Diversion Race canal which crossed at that point. The envelope squeezed between the conductors as it deflated, to fall clear without suffering or causing any damage.

1.10 No part of the basket or suspension cables contacted the conductors, but some passengers reported electrical noises and minor electric shock sensations.

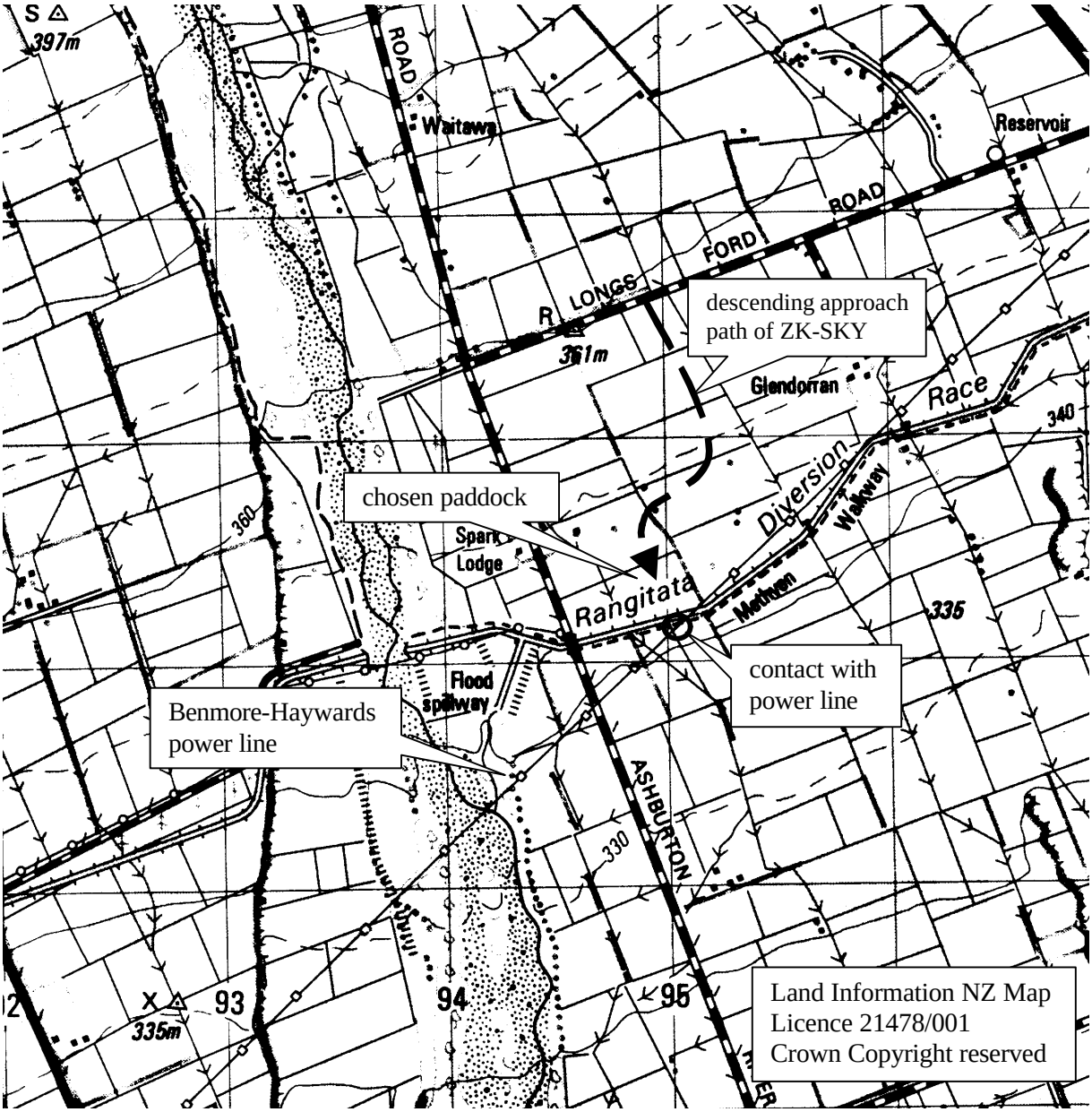

Figure 1
Descending approach path of hot-air balloon ZK-SKY

Personnel information

1.11 The pilot-in-command had been flying balloons with the company since completing his commercial pilot licence (balloon) in 1993. He was the company chief pilot and maintenance controller. He had flown 186 hours on ZK-SKY since the company acquired the balloon in 1998, of which 26 hours were in the last 90 days. The Class 1 medical certificate associated with his licence was valid to 16 April 2001.

1.12 The pilot-under-supervision had done his balloon flying training with the company, and had completed his commercial pilot licence (balloon) on 9 May 2000. Most of his 53 hours had been on small Aerostar balloons, with 2 hours on ZK-SKY, and 11 hours on intermediate sized balloons. The Class 1 medical certificate associated with his licence was valid to 24 August 2000.

Aircraft information

1.13 ZK-SKY was an Aerostar S81A balloon with an envelope volume of 245 000 cubic feet. It had flown 187 hours since new in December 1997. Maintenance records showed that the next routine maintenance was due at 220 flight hours or on 22 December 2000, whichever occurred first.

1.14 The balloon was fitted with an Aerostar 5-compartment basket and with triple burners, each with a 23 US gallon fuel tank. With this equipment, the aircraft flight manual specified a maximum gross weight of 3800 lb (1724 kg).

1.15 The load sheet prepared by the pilots before the flight showed that the lift-off weight of the balloon was 1902 kg.

Site information

1.16 The paddock chosen for landing was 225 m long in the landing direction, with a level grass surface and a hedge on the north-east boundary. There were no significant obstructions on the approach. The Rangitata Diversion Race and the Benmore-Haywards power line lay 30 m beyond the south-east boundary.

1.17 The Benmore-Haywards Line A was a major direct current (DC) electricity transmission line. It was supported on towers 80 feet high, with 312.5 m between the relevant towers. The balloon collided with the earth wire about 40 m north of a tower, where the wire was 66 feet high. At the same point the two conductors were 46 feet high and 8.2 m apart. At the time the operating voltages of the two conductors were +270 kV and -350 kV, and the operating current was 950 amperes.

Other information

1.18 During the flight the pilots noted that the maximum envelope temperature of the balloon was 94°C. The maximum continuous envelope temperature specified in the aircraft flight manual was 121°C.

1.19 The pilot-in-command described the balloon's transition from a climb to a descent after the go-around as something he had not experienced before, and the continued descent, with the burners going, as though the balloon "was being pulled in" to the power line. Both pilots had expected the balloon to climb clear of the power line easily, from their experience of the take-off and initial climb earlier in the flight.

1.20 The company subsequently arranged for some scientific tests to be carried out, using a 1.5 m diameter model balloon made of balloon fabric, to determine possible effects of an electrical field upon it. These tests were carried out in the high voltage laboratory of the Electrical Engineering Department of the University of Canterbury, and involved inflating the balloon with cold air and suspending it at various distances from a wire charged with 100 kV.

1.21 The tests initially showed no effect on the balloon, which was not electrically charged, at any distance from the wire. When an area of the balloon surface had been statically charged by rubbing, the balloon did respond to the voltage on the wire by rotating, but it was not perceptibly displaced to or from the wire.

1.22 The conclusion, based on the tests conducted so far, was that there was some effect, but no measurable force generated on the balloon. Further tests were being considered, using a tethered hot-air balloon near a DC power line.

1.23 Queries to overseas ballooning authorities disclosed no known research work or reference material on any effects of an electrical field upon a hot-air balloon.

1.24 The pilot-in-command believed that the descent of ZK-SKY occurred because of an "abnormal and unforeseeable force" associated with the power line.

1.25 Other types of hot-air balloons of the same size (245 000 cubic feet) had maximum gross weights of up to 2222 kg, based on a total permitted lift of 9.07 kg (20 lb) per 1000 cubic feet. The manufacturers of ZK-SKY, Aerostar International Inc, advised that the S81A envelope was capable of more lift, but the gondola (basket) had a limit specified because they, and US operators, wished to limit the capacity in the USA to an average of 12 passengers.

1.26 The power line company advised that if they were alerted by telephone to a situation such as this, they would be able to shut off the current very quickly.

2. Analysis

2.1 This balloon wire strike incident occurred in weather conditions which were good for hot air balloon operations. The sky was clear, with good visibility; ground temperature was low; low-level winds were light; and there was enough wind variation aloft to manoeuvre the balloon.

2.2 The paddock chosen for landing was suitable in most respects: it was sufficiently long for the wind conditions; it had no approach obstructions; the surface was suitable; and access from the road was available. However, the power line 30 m beyond the paddock did present a potential obstruction in the event that a landing within the paddock was not assured and a go-around was made.

2.3 The significance of the obstruction would have varied with the wind conditions. In the light wind of 1 to 2 knots the balloon should have been able to achieve a steep climb angle easily, to clear the line with a good margin. In a stronger wind the net climb angle on go-around would have been less, and the significance of the obstruction would have been more obvious to the pilots.

2.4 Factors which could have modified the climb angle and the extent of the climb during the go-around included:

- the use of the burners by the crew. A continued climb would have required longer or more frequent periods of burner use than that for level flight, while an intention to level off, for instance after climbing a few hundred feet, would have required an abatement in use of the burners in anticipation of the intended height
- the vertical temperature structure of the air. If the go-around climb was through a temperature inversion, i.e. climbing into a warmer layer above, the balloon would encounter reduced buoyancy which would reduce or negate the climb rate.

2.5 Because the pilot-in-command reported that the balloon's transition from a climb to a descent was outside his considerable experience, and that he suspected some electrical effect associated with the power line had affected the balloon, some scientific tests were conducted to explore the issue. The tests conducted so far did not reveal any results of significance to the flight path of ZK-SKY in this incident. These tests were not conclusive or definitive, however, and further work may be done in this regard.

2.6 In the absence of supportive test results, or relevant overseas reports, it was considered unlikely that any electrical effects from the Benmore-Haywards power line were a factor in the behaviour of the balloon during the go-around.

2.7 There probably was a temperature inversion present at low level. This would be a normal result of nocturnal cooling, and would persist on a clear, calm winter morning until appreciable solar heating had occurred. The light north-westerly surface wind, which was probably of katabatic origin caused by the cool surface layer of air sliding down the sloping Canterbury Plains, was a normal accompanying symptom. Another symptom was the balloon's descent being checked on the landing approach at about 30 feet. While this could have resulted from slight misjudgement by the inexperienced handling pilot, it probably also indicated that the balloon had descended into cooler air, thereby gaining some increased buoyancy. The general effect of an inversion is to temporarily check the descent, or climb, of a balloon moving vertically either way through it.

2.8 Coping with temperature inversions is a normal occurrence for a balloon pilot, and relies on developed skills of anticipation and observation as well as adept handling of the burners, gained from hands-on experience of the response of that balloon size and type. It was likely that the handling pilot, with his limited experience of large balloons, which included 2 hours on ZK-SKY, would have misjudged the response of the balloon to his burner inputs to some extent, both on the landing approach and on the go-around climb. It was also likely that the much more experienced pilot-in-command, had he been handling the balloon, would have more correctly anticipated the required burner inputs on the approach, and a normal landing would have eventuated.

2.9 The difference between the required burner inputs and those actually made could have been quite subtle and thus difficult for the pilot-in-command to monitor exactly, or to intervene with accuracy to ensure the approach to land was successful. On the go-around, however, it should have been possible and desirable for him to ensure that the climb was positively continued to a good margin of height above the power line before the balloon got close to it. While a large margin of height above the obstruction would have been unnecessary and unhelpful to a further landing approach, a margin of perhaps 200 feet above could have been an appropriate target to have set for the handling pilot.

2.10 The handling pilot probably started to level the balloon's climb as the balloon reached the height of the earth wire, and minor inaccuracies in handling and anticipation resulted in a descent with insufficient space to restore the climb before reaching the power line. In addition, the pilot-in-command probably did not monitor the handling pilot's actions sufficiently closely during the go-around to ensure that the balloon kept climbing until a safe height was reached.

2.11 The load sheet indicated that the balloon was 178 kg, or about 10% over the specified maximum weight at lift-off. While this operation beyond the limits of the aircraft flight manual was undesirable, it should not have significantly compromised the balloon's available climb performance. This was because the reported maximum envelope temperature of 94°C on the flight was well below the maximum continuous temperature of 121°C. This indicated that a large reserve of buoyancy was available if needed.

2.12 The maximum gross weight limit of ZK-SKY, which was almost 500 kg less than some other similarly sized balloons, represented an operational disadvantage to the company. However, even though the envelope was capable of more lift, the operator should not have allowed the aircraft flight manual limitation to be exceeded. An appropriate course of action would have been to determine with the manufacturer and with the Civil Aviation Authority what weight limit might be set for operation in New Zealand.

2.13 After the balloon contacted the earth wire and the crew found that it would not lift clear with more heat, the pilot-in-command decided that they would descend between the conductors below them. In the event this was successfully carried out, and may well have been the best option, but this course of action did carry unquantifiable risks from the 620 kV between the conductors. An alternative course could have been to keep the balloon above the live conductors, in contact with the earth wire, for a short time longer while making an emergency mobile telephone or radio call to get the power line company to shut off the current. While the viability of such a course of action might depend on additional factors such as weather, any opportunity to remove the electrical hazard before descending would have been advantageous.

3. Findings

Findings are listed in order of development and not in order of priority.

3.1 Both pilots were appropriately licensed for the operation.

3.2 The inexperienced handling pilot was under the supervision of the experienced pilot-in-command.

3.3 The balloon was serviceable and appropriately maintained.

3.4 The balloon was loaded in excess of the approved limit by about 10%.

3.5 The overloading was probably not a factor in the incident.

3.6 The weather was suitable for the balloon operation.

3.7 The adjacent power line presented an obstruction to a go-around from the chosen paddock.

3.8 There was no evidence that electrical effects from the power line were a factor in the behaviour of the balloon.

3.9 The missed approach to land probably resulted from minor handling errors and misjudgement as the balloon encountered a normal temperature inversion.

3.10 During the resulting go-around climb the balloon was similarly allowed to start descending at a position from which the power line earth wire could not be avoided.

3.11 During the go-around the pilot-in-command probably did not monitor the handling pilot's actions sufficiently closely to ensure that the balloon kept climbing to a safe height.

3.12 While the pilot-in-command's decision to descend the balloon between the live power line conductors was successful, the electrical hazard might have been avoided by taking time to arrange an emergency current shut-off.

4. Safety Actions

4.1 After this incident the chief pilot took the following steps:

4.1.1 Issued a verbal warning to all company pilots not to land closer than 300 m, and to avoid low-level flight over the Benmore-Haywards power line in light wind conditions.

4.1.2 Issued a written memo to all office staff and pilots requiring that passenger weights be ascertained when bookings were made, and that the balloons' maximum all-up weights were not to be exceeded.

Approved for publication 23 March 2001

Hon. W P Jeffries
Chief Commissioner