FINAL REPORT

AAIU Synoptic Report No: 2007-027
AAIU File No: 2006/0070
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The Inspector-on-Call (IOC) for the 23 September 2006, Mr. Graham Liddy responded to this particular notification and attended the scene. In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Air Accidents, on 7 May 2007, appointed Mr. Frank Russell as the Investigator-in-Charge (IIC) to carry out an Investigation into this Serious Incident and prepare a Synoptic Report.

Aircraft Type and Registration:	AS 350B, G-JESI
No. and Type of Engines:	1 x Turbomeca Arriel 1B
Aircraft Serial Number:	1205
Year of Manufacture:	1980
Date and Time (UTC):	23 September 2006 @ 18.10 hrs (19.10 hrs Local)
Location:	Dunkerrin, Co. Offaly
Type of Flight:	Public Transport
Persons on Board:	Pilot - 1 Passengers - 4
Injuries:	Pilot - None Passengers - None
Nature of Damage:	None
Commander's Licence:	UK ATPL (Helicopter)
Commander's Details:	Male, aged 59 years
Commander's Flying Experience:	15,000 hours (including 43 hours on type)
Notification:	Station Manager, ATC Shannon.
Information Source:	AAIU Incident Report Form submitted by Pilot.

SYNOPSIS

During "hot refuelling"[1] the Pilot observed a slight rise in his fuel gauge to 20% fuel before it stopped increasing. In the belief that his gauge was faulty, the Pilot requested, over his radio, that the refueller operator continue refuelling up to 300 litres. The Pilot then signed the presented fuel docket for 302 litres and re-positioned his helicopter to the parking area. Later that day, G–JESI took off from the K Club at 18.35 hrs (L) with 4 passengers onboard for the intended return flight to Adare, Co Limerick. At approximately 19.10 hrs (L), the Pilot became concerned about his fuel state and, following a slight engine surge, made a precautionary landing in a farm field near the village of Dunkerrin, on the Offaly/Tipperary border.

[1] Hot refuelling is a term used to describe a refuelling operation, which is conducted while the engine and rotors are running and the Pilot remains on the controls.

Both Pilot and passengers exited the aircraft safely. An examination of the helicopter the following morning by an Inspector of Air Accidents determined that the fuel tank contained a total of 6.5 litres of fuel. Furthermore there was no evidence of the helicopter having suffered a leak and no fuel staining was evident on the ground. There was no damage.

It was later determined by the Investigation that the helicopter fuel gauge was fully serviceable and that no leak had occurred through the entire fuel system. The Investigation notes that only 2 % of the fuel requested by the Pilot (approximately 10 litres of 302 litres) was apparently uploaded during the hot refuelling at the K Club but the Investigation was unable to reconcile this serious anomaly.

1. FACTUAL INFORMATION

1.1 History of the Flight

G-JESI was one of several dozen helicopters engaged to provide a shuttle service to and from the K Club in Co. Kildare, during the 2006 Ryder Cup Golf competition. At 09.05 hrs (L), on arrival from Adare, Co. Limerick, the Pilot of G-JESI, after dropping off his four passengers, was directed by local ATC to the "hot refuelling" line up point (**Photo 1**). On landing, and prior to this refuelling, the helicopter fuel gauge was reading 18 % (97 litres). Prior to commencement of refuelling, the Pilot told the refueller on the dedicated frequency (VHF 121.85 MHz) that he would call to stop the refuelling from his helicopter fuel gauge indicator reading. It was his intention to fuel to 70% (377 litres) indicated (as he did on the previous days identical shuttle operation). During refuelling the Pilot who was seated in the right-hand seat of the helicopter, observed his fuel gauge rise to 20 % (108 litres) and then it stopped increasing. Believing this to be *"a temporary sticking"* the pilot allowed the refuelling to continue with no communications, as he was able to see the fuel meter digits on the Bowser continue to increase. While noting that the mobile Bowser meter was indicating an increase, he could not read the actual figures due to the distance between the mobile Bowser and the helicopter (15 - 20 metres).

After about one minute the Pilot asked the refueller (over the radio) if he was still refuelling and the refueller replied, "Yes". The Pilot then asked the refueller to check how much fuel had been loaded. To do this, the refueller had to move from where he held the nozzle in the fuel tank to the mobile Bowser and read the meter. The reply was "246 Litres". This figure was read from the Bowser delivery meter (**Photo 2**). The Pilot surmised that his fuel gauge was sticking and therefore unreliable, so after a brief calculation he asked the refueller to uplift a total of 300 litres. The refueller dispensing the fuel (radio equipped) called over a second refueller as he could not refuel and read the meter at the same time. This colleague took charge of the nozzle while the original radio equipped refueller positioned himself by the meter. The refueller at the meter gave a thumbs-up to the nozzle man indicating that the meter had reached 300 litres. The Pilot concurred with this amount as it looked like the figures he could see on the meter. The refuelling overran slightly and the Pilot was presented with a manually generated fuel docket for 302 litres, for which he duly signed, as is the routine practice. The helicopter fuel gauge remained at 20%. The helicopter then took off and air-taxied to a parking site nearby. It remained parked at this location all day. Strict security was in force at all times in this helicopter parking area.

At 18.30 hrs (L) the helicopter started up and the four passengers were embarked for the return flight to Adare Co. Limerick. As the helicopter departed the K Club at approximately

18.35 hrs (L), the fuel gauge was still reading 20%. In spite of the fuel gauge reading, the Pilot reckoned that he had about 380 litres on board, based on what he had on arrival and the subsequent docketed fuel uplift. This fuel amount would have been sufficient for about 2 hrs 25 minutes flying time. The actual flight time to Adare is less than 1 hour. While the Pilot doubted the serviceability of the fuel gauge system, he felt secure in the knowledge that he had uplifted fuel and thus proceeded on his flight to Adare. As the flight progressed, the gauge level reduced and eventually the low fuel warning light flickered. In his submitted Incident Report Form the Pilot stated that, *"Because of my doubt of the gauging system and knowledge of the fuel uplift, I erroneously ignored the gauge and the low fuel warning".*

At approximately 19.10 hrs (L), when the gauge was almost reading empty and with the amber low fuel warning light on, the Pilot "*felt a twitch in yaw"* and had his first doubt about the fuel uplift for which he had earlier signed. He decided '*to make an immediate run-on landing in case any thing happened on the approach and landing'*. In fact, a successful autorotational landing was carried out, with a run-on of some 45 metres on a slightly wet downslope field. On landing in this farm field, the Pilot shut down the engine and rotors and disembarked with the four passengers normally and without injury. There was no damage.

The Pilot relayed his situation to a colleague on VHF frequency who, in turn, advised ATC Shannon of the situation. The Station Manager, ATC Shannon, then advised the Air Accident Investigation Unit (AAIU).

1.2 On Site Helicopter Fuel System Inspection

The following morning an Inspector of Air Accidents inspected the helicopter and determined that the fuel tank of G-JESI contained only 6.5 litres of fuel (approximately 3 minutes running time) and that there was no evidence of a leak or ground staining. During the subsequent refuelling, the tank contents were added to incrementally, and it was noted that the fuel gauge reading increased in accordance with the additions of fuel and that the fuel gauge indications agreed with the bowser gauge. This indicated that the gauge was not faulty. The helicopter was released back into service and routed back to the K Club. The Investigation was subsequently informed that the fuel gauge operated normally for the entire flight and no evidence of any fuel leaks were found.

The site at the K Club, where the helicopter had been parked after refuelling for approximately 8 hours, was also inspected. No evidence of a fuel leak, or of the characteristic grass burning that would result from a significant fuel leak, was found.

1.3 Pilot Information

The Pilot is the Chief Pilot of a UK based Helicopter Company contracted to operate a shuttle service to and from the K Club. He has held this position since 1988. His UK Civil Aviation Authority (CAA) licence and helicopter currency were valid. He is also a Qualified Flying Instructor (QFI) on eight (8) helicopter types, including the AS 350B, the subject helicopter of this Report. The Pilot has accumulated circa 15,000 flying hours on helicopters over a long career, including 41 hours 20 minutes on the incident helicopter type.

The Pilot returned to his helicopter at about 18.00 hrs (L) and, on checking the fuel gauge, he noted that it was still indicating 20%. He also noted that there was no sign of any fuel leakage from the helicopter. After passenger embarkation, take-off was at about 18.30 hrs (L). Shortly after take-off, the Pilot noted that the fuel gauge was reducing but in the belief he uplifted 302 litres, he was satisfied that he had sufficient fuel on board for the 0.9-hour flight to Adare. However, after about 5-10 minutes of the flight at above 1,700 feet the fuel low-level warning light started flickering and, a short time later it came on permanently. The Pilot said that he was still convinced at this time that he had a fuel gauge indication problem rather than a lack of fuel. He recalled that, with the warning light steady, the fuel gauge was reading about 13%. He said that he remained unconcerned, as he was satisfied with the fuel uplift.

However, after about 35 minutes flight time, he believed that he felt a yaw motion in the helicopter, which might have been an engine malfunction. It was at this point, with the fuel gauge indicating close to zero and the low fuel light on, that doubts were raised in his mind as to the accuracy of the fuel uplift. Regardless of these thoughts, the Pilot reacted as trained by making an autorotative descent into a farm field, carrying out a run-on landing. He said that he was not aware of any warnings during the descent but that he may have heard the low Rotor RPM warning towards the end of the run on. After shutdown and rotors stopped at 19.10 hrs, the passengers exited the helicopter in the normal manner where they were immediately looked after by the farm owner and his family. The aircraft was undamaged.

In his frank post incident de-brief statement the Pilot recounted that the minimum company landing fuel is 10%, with unusable fuel being about 2 litres. Normal fuel consumption is about 30 % (of tank capacity) per hour at max continuous cruise power. The fuel light comes on at a quantity of 60 litres (approximately 13 %). He ended his statement by saying that there is no visible check of the fuel quantity possible, unless the tank is almost full, when the fuel is then visible in the filler area.

1.4 Passenger Statement

The passengers were contacted by the investigation. One passenger stated*:" The light* (low fuel contents warning light) *was on and flashing amber/red on a panel, which was left of the pilot. This panel was just to my right. In fact my wife who was a passenger in the back gestured to me just after we took off about the light and I pointed it out to the pilot who dismissed it as faulty. Later he explained that this sometimes happens but since he had a docket for 320(sic) Lts of Fuel he considered the gauge to be faulty".*

1.5 Helicopter Fuel System

The AS 350B fuel quantity indication system utilizes a fuel quantity gauge that is supplemented with a fuel low-level warning light. The system comprises a float-operated resistor-type fuel quantity transmitter and a separate low-level detector that activates an amber, low-level fuel warning light on the instrument panel. The maintenance manual states that when the low-level fuel warning light illuminates, the fuel quantity indicator pointer should be above 10 % and that there must be more than 60 litres of fuel remaining in the tank. The manual also states that 1.25 litres of fuel is unusable. In addition, the fuel contents can be verified on the ground by opening the side cowling and internal panel and visually checking the level, through the transparent side of the fuel tank.

G-JESI had a new fuel sender installed in November 2006 and, as such, the system was check calibrated, including the low level warning light, which comes on at 60 litres.

1.6 Refuelling Operation

1.6.1 General

Celtic Helicopters managed the helicopter fuelling operation for the Ryder Cup event at the K Club.

Due to the high frequency of helicopter movements "hot refuelling" was provided for helicopters seeking fuel. The refuelling operation consisted of a small towable Bowser, which was located at a refuelling point. (**Photo 3**) The capacity of this particular Bowser was approximately 2000 litres. As the contents of the Bowser were dispensed, a large fuel tanker, which was positioned several metres away from the Bowser, would refill the Bowser as it emptied. A helicopter requiring fuel would line up in turn (with rotors running) and wait for the refuelling pad to be clear. On arrival at the pad, the nozzle man who was radio equipped would commence refuelling and await a "stop refuelling" command from the Pilot. The "stop refuelling" command comes when the Pilot sees his fuel gauge has reached the required amount of fuel load.

A second refueller man prepares a fuel invoice by taking the re-settable counter reading from the Bowser delivery meter. This invoice is presented to the Pilot and the Pilot signs as fuel received.

1.6.2 Mobile Fuel Bowser

The mobile fuel Bowser used on the subject helicopter was subsequently calibration checked by an Inspector of the Irish Aviation Authority (IAA) on 27 September 2006 at the Celtic Helicopters base in Dublin. The transparent container used was graduated in units of 5, 10, 15, 20 and 25 litres. The Inspector observed that the fuel dispensed was accurate in measurement of the 5 units of volume taken.

Subsequent to this inspection the Bowser was taken to a specialist refuelling company near Dublin Airport, where it was further checked for serviceability and underwent three specific tests, under the supervision of an AAIU Inspector.

In the first test the company examined the Bowser and attempted to simulate various refuelling conditions to determine if fuel could register on the Bowser meter but not actually deliver to the aircraft. The following was noted, *"the bowser is fitted with a recirculation system whereby the fuel is pumped and returned to the tank, but the return line is fitted before the meter and the fuel pumped and recirculated is not recorded on the meter."*

The second test conducted was to determine if the Bowser was empty of fuel and the meter was recording airflow while the pump was running. The fuel supply to the meter was disconnected and a delivery was simulated but the meter did not record during this exercise, which determined that the Bowser meter would not increase when the bowser was pumping air.

The third test carried out was a timed rate of flow check. Fuel delivery over a one-minute period was recorded and a flow rate of approximately 150 to 160 litres per minute was achieved. This output is in accordance with the Bowser specification

1.7 Regulatory Oversight

From time to time the IAA issues Aeronautical Information Circulars (AIC'S) to ensure the continuing safe operation of aviation in Ireland. One such AIC is **"Fuel at Aerodromes and Heliports,"** Nr 12/00, and another is **"Loading of Aviation Fuel"**, Nr 38/98.

Nr 12/00 applies to aviation fuel installations located at any place where aircraft, including Rotorcraft, may land or take-off within the state, other than an aerodrome or place under the control of the Minister for Defence. Paragraph 4 states that the management of any aviation fuel installation *"shall keep a written record in respect of each installation which record shall include*, inter alia, *(d) Particulars of the grade and quantity of aviation fuel dispensed to particular aircraft by time and date".*

There is no explicit reference in this AIC to mobile refuelling facilities. Paragraph 6 **"Aviation Fuel Installations at Places used by Aircraft including Rotorcraft and Airships, other than Aerodromes"** states that *"the management of the aviation fuel installation and the dispensing of fuel into aircraft are properly complied with in such cases"* (i.e. compliance with Paras 3 and 4 of the AIC).

Nr 38/98 states in Paragraph 1, **"Refuelling Procedures"***; "It is the responsibility of the pilot-in-command to ensure that the aircraft is refuelled with the correct type, quality and quantity of fuel and refuelling crews should not commence to refuel an aircraft until they have established the precise requirements from the pilot-in-command or his authorised representative".*

There is no explicit reference in this AIC to mobile refuelling facilities or indeed, to the much-practised "hot refuelling" technique at such facilities. The temporary helicopter operation at the K Club was established under Para 5 of this AIC *"Controlled installations may also be established by Operators under direction from the Irish Aviation Authority (IAA)".*

However, hot refuelling, while speeding up the flow of helicopters in and out of a designated landing and refuelling zone had the serious limitation (in the subject event) that it was impossible for the helicopter's Pilot to check the fuel contents independently of the fuel gauges, without shutting down the aircraft. This of course, would negate the purpose of the exercise, as the Pilot must remain on the flight controls of the helicopter during hot refuelling. Thus, the practice of hot refuelling makes it difficult for the pilot of single pilot helicopters to adhere to the requirements of Para 1 of Nr 38/98.

1.8 Fuel Accountancy

Celtic Helicopters, who was responsible for dispensing the fuel, informed the Investigation that they managed over 400 fuelling uplifts during the period of the Ryder Cup event. All went according to plan, except for the subject event.

The Investigation reviewed the handwritten *"Fuel Delivery Daily Sheet"* which is a running total of fuel delivered into the mobile Bowser from the main fuel tanker and which in turn is dispensed into the various helicopters. There are five (5) such sheets for the 23rd September 2006, accounting for forty-six (46) uplifts/deliveries of fuel.

On the event days the primary recording of each fuel delivery was done on the Operator's *"Fuel Delivery Notices/Invoice"*. This is a very important document as it is the one signed by pilots in acknowledgement of fuel uplifted. This document is then used for subsequent billing of the Helicopter Operators involved. Invoice No. 4413 shows that the Pilot of G-JESI signed for an uplift of 302 litres at 09.15 hrs (L) on 23 September 2006. This manually written invoice book had in some cases, the *"Meter Reading" Finish and Start*, scratched out by biro so as to be illegible, while in the subject event, the Meter Readings, *Finish and Start*, were left blank. This meter reading would normally be read from the 'Totaliser' gauge, which is a smaller running total fuel usage gauge located above the Bowser delivery gauge and which is non re-settable (**Photo 4**). The main delivery gauge is always zeroed before each uplift and this was the one seen by the Pilot (**Photo 4**). Thus, the paper trail of invoicing and meter readings was incomplete in places and impossible to reconcile the daily total used on the 23 September 2007. This is contrary to the Operator's Manual, Section 8.2.1.2. (e), and AIC Nr 12/00.

It was noted that in the case of most refuelling dockets, the Totaliser start and finish readings, for each refuelling, where either left blank or scratched out by heavy biro marks so as to be totally illegible. It was also noted that there were no records kept of the fuel put into the main Bowser, or of the fuel transferred from that Bowser to the dispensing bowser. It was further noted that neither the initial nor the final contents of this Bowser were recorded. Consequently the Investigation was unable to perform a reconciliation of total amount of fuel delivered to the K Club against total fuel dispensed.

1.9 Additional Information

1.9.1 Interim Report

The AAIU issued a Preliminary Report[2] on this incident on 26 October 2006. This Preliminary Report contained six Safety Recommendations that were directed to the Irish Aviation Authority and, one of which, was also directed to the UK Civil Aviation Authority.

1.9.2 Supplementary Report

During the course of this investigation, the AAIU has found that a standard refuelling bowser was being used to "hot" refuel turbine-engined helicopters. The AAIU has been advised by the UK manufacturer of the Bowser that a special nozzle specifically designed for hot refuelling should have been fitted, and not a standard refuelling nozzle designed solely for refuelling with the engine/s shut down. Using a standard nozzle, the fuel displaces vapour in the tank, causing the vapour to exit through the filling point. The filling point is invariably located high on the side of the helicopter, close to the engine. Consequently, flammable vapour exiting at the filling point can be ignited by the hot engine exhaust, or by ingestion into the engine(s), if the helicopter is refuelled while the engine is running.

[2] The Interim Report can be seen at http://www.aaiu.ie/AAIUviewitem.asp?id=8358&lang=ENG&loc=1280

The special nozzle is fitted with a seal that prevents fuel vapour exiting the tank at the filling point. This safety feature causes the fuel vapour to vent through the normal fuel tank vent, which is safely located in a position remote from the engine, during refuelling.

In light of this information, the AAIU issued a Supplementary Report[3], which contains another Safety Recommendation. The Safety Recommendation is included in the Safety Recommendations to this Report**. (SR 15 of 2007)**

2 ANALYSIS

What started as a routine helicopter refuelling operation at the K Club led to a chain of events that culminated in a Serious Incident, with the helicopter making an emergency landing in a field only moments before the engine would have flamed out in flight due to fuel starvation.

It was the final day of the otherwise successful 400 plus helicopter refuelling operations. Central to the success of this particular operation, to ensure a quick turnaround of helicopters and passengers, was the use of the "hot refuelling" technique. For this, the engine and rotors remained running while fuel was uplifted, with the pilot on the flight controls at all times. This practice of hot refuelling has evolved over the years, notably at major horse race meetings and other such events where large numbers of helicopter shuttle flights occur. However, the Investigation notes that there is no reference to hot refuelling in the IAA AIC's and whether this practice is permissible or not is unclear. Similarly, helicopter manufacturers do not refer to hot refuelling in their Flight Operations Manuals (FOM's). Thus, the practice seems to be more of an ad hoc arrangement to maximize commercial helicopter movements, which probably would have been set to continue had not the serious safety aspect of the subject event brought the practice sharply into focus.

It was also noted that Celtic Helicopters operating manual did not contain any special instructions or actions to be taken with regards to fuel accountancy when hot refuelling procedures where being used.

The highly experienced Pilot became part of a chain of events in a manner that he probably could never have envisaged. He spoke to the refueller on VHF radio with his refuelling requirements. He observed what he thought was a fuel gauge problem during the refuelling, so he gave further instructions to the refueller, and he recalled that he saw the numbers on the Bowser gauge moving. From his point of view, he assumed that the refuelling operation was complete when the refueller presented him with an invoice for the uplift. However, the apparent fuel gauge problem was a separate matter and, once the helicopter was parked for the day, the Pilot did not pursue the matter any further until pre take-off that evening, when he again noted that the fuel gauge was still reading 20%. This apparently unserviceable fuel gauge should have been a no-go item, as per the aircraft's Minimum Equipment List (MEL). He did not visually check the fuel tank for contents, as he should have done when the obvious fuel gauge problem persisted. At the very least, physical verification of the fuel contents would have been a prudent course of action. Once airborne, the pilot continued to believe that his fuel situation was satisfactory, in spite of the now decreasing fuel gauge reading, leading to the low fuel warning light and engine surge.

[3] The Supplementary Report can be found at www.aaiu.ie

The Pilot's realisation, however late in the day, that he had a fuel problem came just in time to carry out an autorotation before the engine flamed out. It was fortuitous that the Pilot finally reacted to his real-time lack of fuel when he did.

Another link in this Serious Incident was the refuelling operation and inexplicable events that followed which led the Pilot to believe, incorrectly, that all was well. And, perhaps, not surprisingly so, as the refueller apparently uplifted the amount of fuel as requested by the Pilot. He shut off the refuelling at 302 litres and presented the Pilot with the invoice. He had carried out a similar operation with the preceding and subsequent helicopter refuellings; to him all these operations were routine. However, what was not known to the Pilot and the refueller, but for different reasons, was that the uplift only went from 18% to 20% (a miniscule movement of the fuel gauge needle) and stopped or, in other words, less than 11 litres of fuel were apparently uplifted. While the Pilot and refueller saw the Bowser gauge move as expected, no fuel went into the tank on that occasion, other than the amount the Pilot thought he saw on the aircraft fuel gauge. What the Pilot did not, and could not have known without verifying for himself during the day, was that his gauge was reading accurately and that no more than 10 litres of fuel were uplifted, as he recalled. The subsequent flight time of some thirty-five minutes on the return to Adare represented the approximate amount of fuel in the tank on take-off, i.e. circa 108 litres and not the 302 litres, which the Pilot unwittingly believed he had on board.

The co-relation between the helicopter fuel gauge and the Bowser gauge during the refuelling at Dunkerrin shows that the helicopter gauge was not faulty. The absence of any evidence of a leak, while parked at the K Club, or during the flight to Dunkerrin or subsequent operations of the helicopter, shows that a fuel leak was not a factor in this serious incident.

It is clear that an emergency existed in the subject event, as the fuel remaining *"was reduced to an amount where an approach to land should be started without delay*". In this case, the "Final Fuel Reserve", per Para 7.3.2 of the Operator's Helicopters Operations Manual is 10% Gauge Indication (52 Litres). The Investigation found 6.5 litres in the tank on landing.

The advantage of hot refuelling is that the helicopter can position directly to the fuel Bowser, refuel and then reposition to a parking site or continue it's onward flight without having to shutdown. This expedites refuelling and negates against the Bowser having to be repositioned to each parked helicopter. A disadvantage of hot refuelling is that the Pilot has to remain at the controls and, if solo, is not in a position to verify the Bowser meter reading. The Pilot can only verify uplift by reconciling the docketed fuel with an equivalent increase in the helicopter fuel gauge reading.

3. CONCLUSIONS

(a) Findings

1. G-JESI was fully serviceable in accordance with UK CAA requirements.
2. The Pilot was fully licensed and qualified to carry out his functions in accordance with UK CAA requirements.
3. The designated refuelling area at the K Club was properly established by Celtic Helicopters under the direction of the IAA.

4. The Pilot assumed, incorrectly as it turned out, that he had a fuel gauge problem when it did not continue to rise but stopped at 20%.

5. Having instructed the refueller to uplift 300 litres, the Pilot assumed that this instruction was carried out and he signed the invoice for 302 litres. In addition, the Pilot believed that this tallied with what he could see on the Bowser meter. Otherwise, all appeared normal to the Pilot, except for the apparent fuel gauge problem.

6. This fuel gauge problem was not addressed by the Pilot throughout the day and, on before take-off checks the Pilot did not verify the status of his fuel contents by the simple expediency of opening the side cowling and internal panel and visually checking his fuel contents level, through the transparent fuel tank. This omission, and his continuing belief in the veracity of the fuel uplift, led the Pilot to continue with his mission, in spite of the fact that the unserviceable fuel gauge (*as he thought*) was a no-go item. He should have so informed his passengers and cancelled the flight.

7. Thus, unknown to the Pilot, he commenced his flight to Adare with only enough fuel on board to complete about half of his intended journey. This led to the emergency landing at Dunkerrin.

8. Tests undertaken on the evening of 23 September 2007 and the following morning showed that there were no leaks from the helicopter fuel system and that the fuel gauge was serviceable.

9. With this in mind, the whereabouts of the 302 litres fuel at the K Club remains a mystery. The refuelling of G-JESI was but one of the scores of such refuellings undertaken over the days of the event. There were no reports from any other helicopter Operator of refuelling problems.

10. The refueller himself was convinced that the fuel was uplifted and that he stopped his filling at 302 litres, as requested by the Pilot. The refuelling area was very noisy and he cut off the refuelling on the Bowser gauge reading, as requested by the Pilot.

11. Final verification of this fuel uplift would normally be made by subtracting the Meter Reading Finish from the Meter Reading Start. However, these figures were not inserted in the Fuel Delivery Notices/Invoice and thus it not possible for the Investigation to be absolute in this case. In addition, the Start and Finish readings were not taken down in either the immediately previous or the subsequent helicopter refuelling to G-JESI. As a result, there was no continuity of Totaliser readings. Nor was there a carryover Totaliser reading from the last flight on the previous evening. Thus, it can be seen that this wholly manual method of recording uplifts was clearly deficient.

12. The Pilot carried out a successful autorotative landing near Dunkerrin. However, that the flight came to such a premature and potentially dangerous ending reflects a serious and inexplicable lapse of airmanship on the part of the experienced Pilot.

13. The IAA issued AIC's, Nr 12/00 and Nr 38/98, are inadequate in that they do not explicitly cover mobile refuelling operations. This needs to be addressed, particularly in the context of single pilot hot refuelling operations.

(b) Cause

This Serious Incident was caused by incipient fuel starvation that led the Pilot to carry out an emergency landing in a farm field. Factors associated with this Serious Incident were a fuel gauge that was erroneously believed to be unreliable by the Pilot, but which was serviceable, and a fuel uplift docket of 302 litres, which was thought by three people to have been pumped into the tank, when, demonstrably, it was not. The cause of this non-delivery cannot be positively determined due to the absence of sequential fuel delivery figures.

4. SAFETY RECOMMENDATIONS

The Investigation is now re-issuing the 6 *Interim* Safety Recommendations made in the Preliminary Report and an additional Safety Recommendation made in the Supplementary Report. The fifth Safety Recommendation is jointly addressed to the IAA and the UK CAA.

1. The IAA should consider rewording AICs Nr 12/00 and Nr 38/98 to ensure that they explicitly cover mobile refuelling installations. **(SR 9 of 2006**)

2. The IAA should ensure that the hot refuelling of helicopters should only be provided where the provision of this service is explicitly covered in the refuelling provider's exposition. **(SR 10 of 2006)**

3. The IAA should ensure that the hot refuelling of helicopters, and associated safety procedures, should be explicitly covered in the Operations Manual of all refuelling providers who supply such a service. **(SR 11 of 2006)**

4. The IAA should ensure that the procedures covering hot refuelling of helicopters engaged in Public Transport and Aerial Work operations should be clearly laid down in the helicopter operator's Operations Manual. **(SR 12 of 2006**)

5. The IAA in conjunction with the UK CAA should ensure that all helicopter Operator's Operation's Manuals require the pilot to reconcile the initial fuel contents, and the added fuel, as per the refuelling docket, with the contents indicated by the helicopter's fuel gauge at the end of refuelling. This is particularly required where hot refuelling is permitted. If such reconciliation is not achieved, the helicopter should be shut down until the fuel contents are independently verified. **(SR 13 of 2006)**

6. The IAA should ensure that providers of fuel to Public Transport and Aerial Work helicopters, who are authorised to provide hot refuelling, should be required to present the pilot with meter-generated (printed) fuel dockets when a helicopter is hot refuelled. On this docket, the initial and final fuel meter readings, and the quantity of fuel dispersed, should be clearly printed. Exemption from such a requirement may be issued to individual operators to cover specific situations such as helicopter SAR operations. **(SR 14 of 2006)**

7. The IAA should review the possible danger associated with the practice of using standard nozzles for hot refuelling of helicopters, with a view to considering a requirement for the introduction of vapour sealing nozzles for this operation. **(SR 15 of 2007)**

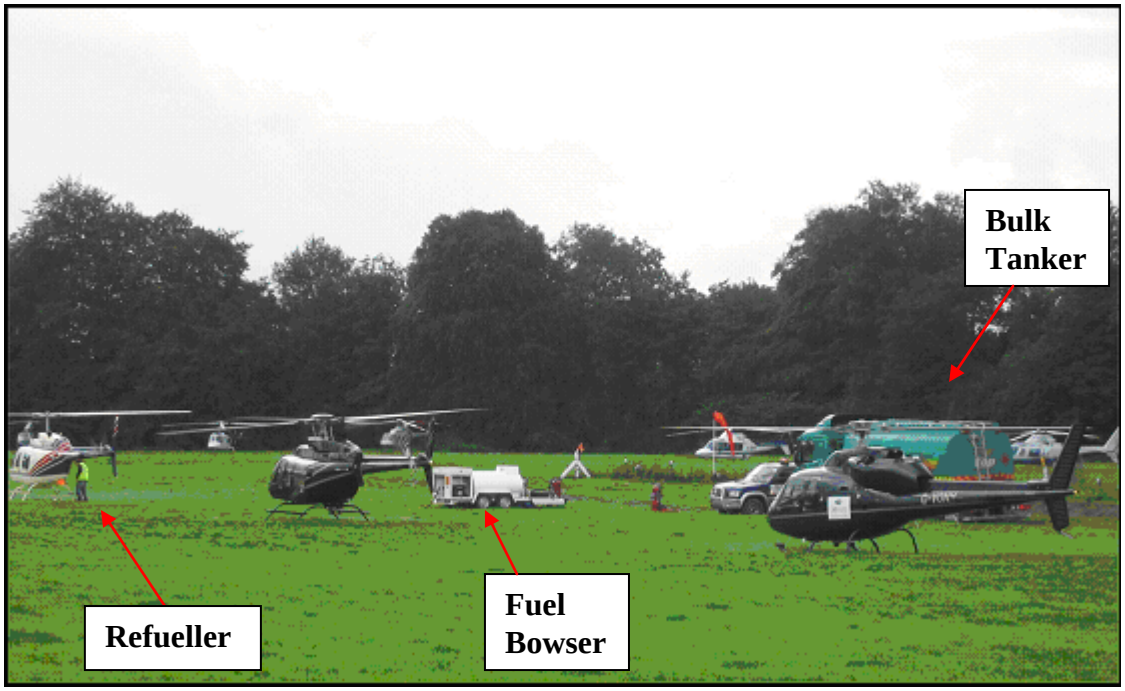

Photo 1: Overview of refuelling with rotors turning

Photo 2: Rear of fuel bowser

Photo 3: Fuel bowser on left, main bulk fuel tanker on right.

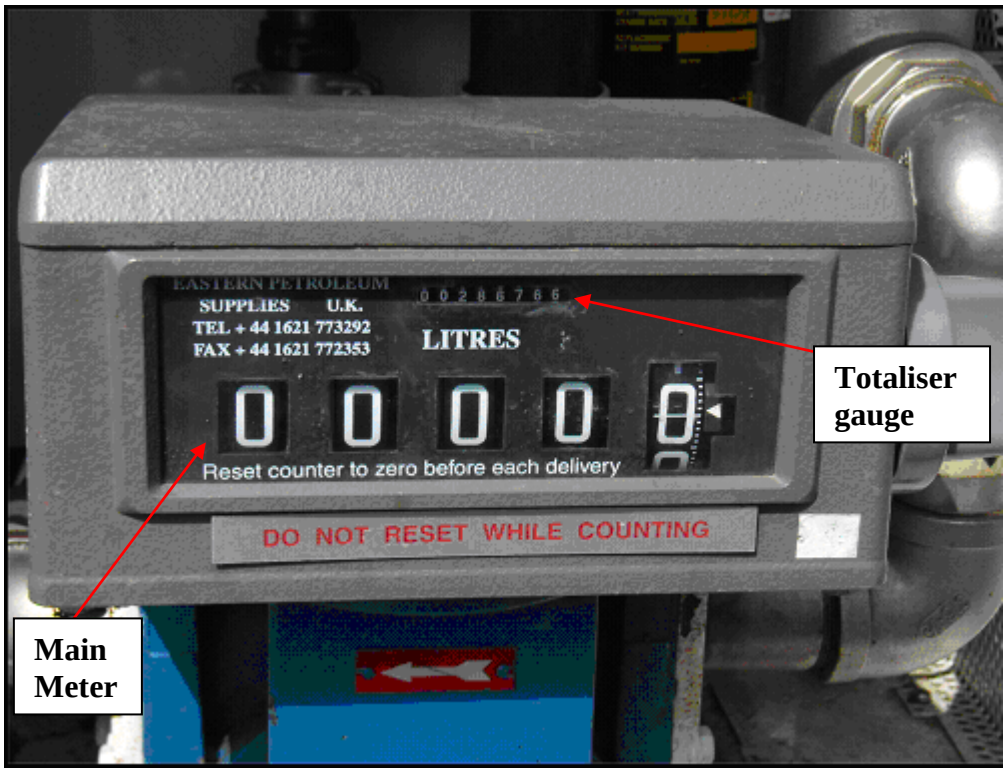

Photo 4: Fuel Bowser Delivery Meter

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