FINAL REPORT

AAIU Formal Report No: 2006-019
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Operator:	**Private**
Manufacturer:	**Robinson**
Model:	**R44 Raven**
Nationality:	**Ireland**
Registration:	**EI-DOC**
Location:	**Nr Derrybrien, Co. Galway**
Date/Time (UTC):	**09 July 2005 @ 10.44 hrs**

SYNOPSIS

The helicopter was on a Visual Flight Rules (VFR) flight from New Ross, Co. Wexford, to its base near Galway Airport. En route, it entered an area of rising terrain and low cloud base, near Derrybrien, Co Galway. Radar tracking indicates that the helicopter slowed down, and then made a sharp turn before disappearing off the screen. The helicopter then suffered an in-flight collision with terrain directly after the loss of radar contact. A passenger died at the scene and the pilot died later in hospital. Another passenger survived with serious injuries. The probable cause was the pilot's loss of spatial orientation resulting from inadequate visual reference with the ground due to limited visibility. The Report makes two Safety Recommendations.

NOTIFICATION

Shannon ATC notified the AAIU Duty Inspector of the accident at approximately 12.00 hrs UTC. The Inspector then proceeded to the site. In accordance with the provisions of S.I. 205 of 1997, the Chief Inspector of Accidents, on 10 July 2005, appointed the Duty Inspector, Mr. Graham Liddy, as the Investigator-in-Charge (IIC) to conduct a Formal Investigation of this accident.

1. FACTUAL INFORMATION

1.1 History of the Flight

1.1.1 The pilot, accompanied by two friends, had flown the helicopter from its base near Galway Airport, to New Ross, Co Wexford, on the day prior to the accident. The purpose of the flight was to visit the start of the Tall Ships Race in Waterford on the morning of 9 July 2005. The helicopter landed in the grounds of a hotel at New Ross where it remained overnight. The pilot and his companions then proceeded to Wexford by ground transport. They returned to the helicopter by taxi about 09.30 hrs UTC on the morning of 9 July.

At 09.52 hrs, the pilot phoned Waterford Airport ATC and requested permission to fly from New Ross to the Hook Head area, South Waterford, in order to view the start of the race from the air. Waterford ATC refused to approve the flight plan due to poor visibility and low cloud in the Waterford ATC zone. The pilot then told ATC that he would be taking off shortly and heading west without entering the Waterford zone. A VFR flight plan was subsequently submitted giving a departure time from Waterford of 10.30 hrs and a flight time to Galway of 50 minutes, tracking direct at 2000 ft.

The helicopter took off almost immediately, and the pilot contacted Waterford Tower by radio at 09.59 hrs and stated that he "*was airborne, heading west for Galway at an altitude of not above 2000 ft"*. Waterford ATC passed a transponder code of 0235 which the pilot acknowledged. At 10.03 hrs, the pilot signed off with Waterford ATC and transferred to Shannon ATC on 127.50 kHz. He contacted Shannon ATC at 10.08 hrs, stating that he had departed Waterford about 10 minutes previously and was routing to Galway. Shannon advised him that there was no traffic to affect him. He was also instructed to squawk (use) the transponder code 0235, which the pilot acknowledged.

Shannon ATC called the helicopter again at 10.17 hrs, requesting an estimate for Galway. The pilot replied "50", indicating 10.50 hrs.

The helicopter was subsequently observed a number of times on Shannon Secondary Surveillance Radar (SSR), initially SE of Portumna, Co Galway. The radar did not record the altitude as the transponder was set in Alpha Mode (i.e. transponder was returning its identification code but not altitude when interrogated). Radar returns from the helicopter were intermittent in the Portumna area because of terrain masking.

At 10.40 hrs, the pilot called Shannon and reported abeam Woodford (which would locate the helicopter approximately 7 nm from the accident site) and that he was changing to the Galway frequency. Shannon acknowledged this call and sign-off. The pilot then called Galway ATC. There was no response from Galway, as the duty controller had left the tower for a brief break. The call was heard by another helicopter, EI-EMG, who called back EI-DOC, informing EI-DOC that the tower was "*off-air at the moment*" and passing a QNH of 1026 hPa, which EI-DOC acknowledged. At 10.42 hrs, EI-EMG called EI-DOC informing EI-DOC that it was routing in to the Airport and was over Galway City. EI-DOC acknowledged this call. This was the last communication from EI-DOC.

At approx 10.43 hrs, a witness located at the Derrybrien Wind-Farm site heard a helicopter pass in the near vicinity of the site, coming from the SE and then moving NE. He then heard a loud bang followed by silence. At 11.06 hrs, the Galway 999 service received a call from the pilot via a mobile phone, reporting a helicopter accident in the area of the Derrybrien Wind-Farm. The rescue services were alerted and Galway Airport was informed. This resulted in two helicopters from Galway proceeding to Derrybrien to search the area. One of these helicopters located the wreckage in dense forestry on the northern slopes of the Slieve Aughty Mountains, 1 nm NE of the summit. The pilot of this helicopter directed the emergency services, which had arrived in the area, to the accident site. The Coast Guard helicopter arrived on scene shortly afterwards and evacuated the three casualties to hospital in Galway City.

1.1.2 Witness Information

1.1.2.1 Witness A

The surviving front seat passenger did not initially have any recall of the accident sequence. However with the passage of time he was able to recall some details of the events leading to the accident. He stated that himself, the pilot and the other passenger had gone out for the evening after their arrival in the Waterford area the day before the accident. He and the other passenger had a few drinks but the pilot did not. They all retired to bed between 2 and 3 AM. The following morning, as they left Waterford, the weather was clear and the flight was uneventful. Suddenly the helicopter entered cloud. He stated that he had not noticed any clouds in front of them and he was unsure of how long they were in cloud before the crash. He went on to state: "*We seemed to hit something and I saw XXX* (the pilot) *struggling with the controls, I remember that we went chopping through trees before coming to an abrupt halt"*. At this point he became unconscious. He later regained consciousness but was in a confused state. He recalls asking the pilot what happened and he replied: "*What do you think happened?*". He later stated that he did not know what the pilot meant by this remark.

1.1.2.2 Witness B

A witness at the Wind-Farm heard the helicopter flying over the site. There was nothing unusual about the noise of the helicopter but the witness said he was unable to see it due to poor visibility. As the noise of the helicopter started to fade in an easterly direction, it suddenly stopped and nothing more was heard. This witness was able to fix the time of the event accurately, as he had just received a call on his mobile phone and he was able to fix the time accurately by means of the phone's memory, which recorded the call at 11.40 hrs local (10.40 hrs UTC).

1.2 Injuries

1.2.1

Injuries	Crew	Passengers	Total in aircraft	Others
Fatal	1	1	2	Nil
Serious	0	1	1	
Minor	0	0	0	
None	0	0	0	
TOTAL	1	2	3	

1.2.2 Injuries To Persons

The passenger in the rear seat suffered major injuries in the accident, and did not respond to the revival efforts of the emergency services when they arrived at the accident scene.

The pilot had suffered internal injuries and underwent an operation in hospital the same day, in an effort to stem internal bleeding, but this was not successful and he died at 22.00 hrs that evening.

The front seat passenger suffered serious impact injuries that precluded the Investigation interviewing him after the accident. He had recovered sufficiently to be interviewed 18 days later.

1.2.3 All three persons in the helicopter were Irish Nationals**.**

1.3 Damage To Helicopter

1.3.1 The helicopter suffered significant damage when it initially struck the forest trees. It suffered further damage when it struck the ground and when its forward path was stopped by two trees. The helicopter was totally destroyed as a result of these impacts.

1.4 Other Damage

The helicopter damaged and destroyed approximately 30 trees in the forest. It was necessary to cut down a further area of forest, approximately 500 square metres, in order to recover the helicopter**.**

1.5 Personnel Information

1.5.1 Pilot

Personal Details: Male, aged 33 years
Licence: PPL(H) issued by US FAA
Issued on 12 April 2005
Medical Certificate: Class 2 Issued 11 April 2005

Flying Experience:

Total all types:	123.3	hours
Total all type P1:	57.5	hours
Total on type:	31.2	hours
Total on type P1:	26.1	hours
Last 90 days:	13.3	hours
Last 24 days:	7.2	hours
Last 24 hours:	1.8	hours

1.5.2 The pilot obtained his Joint Airworthiness Authorities (JAA) PPL(H), issued by the Irish Aviation Authority (IAA) on 22 June 2004. The validity of his medical for this licence had expired on 20 May 2005. However, the pilot obtained his US FAA PPL (H) on 12 April 2005, and had successfully undergone a medical examination for this licence on 11 April 2005. Thus his FAA licence was valid at the time of the accident. The IAA has confirmed that this FAA licence was valid for flying EI-DOC in Ireland. The pilot also possessed a fixed-wing Student's Pilots Licence (SPL) and was in the process of obtaining a fixed–wing PPL, having applied to the IAA for a flight test on 4 May 2005.

1.6 Aircraft Information

1.6.1 Leading Particulars

Aircraft type:	R44 Raven
Manufacturer:	Robinson
Constructor's number:	1400
Year of manufacture:	2004
Certificate of registration:	Issued 3 Sept 2004
Certificate of airworthiness:	Valid to 2 Sept 2005, in aerial work category
Total airframe hours:	462
Engines:	1 x Lycoming O-540-F1B5
Maximum, authorised take-off weight:	2,400 lbs

1.6.2 General Information

The Robinson R44 is a single piston-engined light helicopter. In the case of EI-DOC, the engine was a carburetted six-cylinder Lycoming engine. The helicopter has four seats, two forward and two to the rear. The pilot sits in the forward RH seat. There is a provision to equip the forward LH seat with dual controls for instructional flights. The R44 Flight Manual specifies that these LH controls should be removed when the helicopter is engaged in non-instructional flying. The investigation found that the LH controls (cyclic and collective controls) had been removed from EI-DOC and were stored under the pilot's seat.

The Investigation estimates that the gross weight of the helicopter, on take-off from Galway the day before the accident, (at the start of this trip) was just below the maximum authorised take-off weight. It is further estimated that at the time of the accident the gross weight of the helicopter was approximately 2,200 lbs.

1.6.3 ATC Transponder

EI-DOC was equipped with an ATC transponder, with Mode C (altitude encoding) capability. Examination of the transponder selection showed that it was in the ON position but that Mode C was not selected. The selector is a rotating knob. The first position is ON and the next position, in a clockwise direction, is ON with Mode C selected.

1.6.4 Helicopter Maintenance

The helicopter was fitted with a Datcom Meter which records hours flown on the helicopter. The readings of this meter were used to manage the maintenance of the helicopter. The last inspection on the helicopter was a 50-hour inspection, which was carried out on 16 June 2005 at 410.8 airframe hours. The helicopter was due its next inspection, a 100-hour/Annual Inspection, at 460.8 airframe hours, or on 9 July 2005, whichever came first. The Technical Log (Tech Log) was recovered from the wreckage, and shows that the helicopter had departed from Galway with a Datcom reading of 460.8 hours.

The Tech Log also showed that that there were no recent defects on the helicopter and no maintenance items or defects were being carried forward or deferred at the time of the accident. The Tech Log also contained an Engineering Procedures Variation to Maintenance Periods, which extended the maintenance requirement by 5 hours to a total of 465.8 hours, in order to "align the Inspection with Annual Inspection" This variation was authorised and signed off by a licensed aircraft engineer on 8 July 2005. The Tech Log details for the flight to Waterford were filled in, prior to take-off from Galway.

1.6.5 Fuel

The R44 runs on 100 LL Avgas. Both fuel tanks, with a total capacity of 48 US gallons, were ruptured in the accident impact. A strong smell of fuel was detected at the accident site, indicating the presence of a significant amount of fuel. A small fuel sample was recovered from one tank. Assuming that the helicopter was full of fuel when it departed from Galway, the tanks would have been approximately half full, (approx 24 US gallons) at the time of the accident.

1.6.6 GPS

EI-DOC was equipped with a Bendix King Skymap IIIC GPS. The physical configuration of the display unit is that of a high-resolution 5-inch diagonal active matrix thin film transistor (TFT) liquid crystal display (LCD) screen. The unit, which was mounted on top of the instrument panel, is sunlight readable with a wide viewing angle. The map display of this unit does not show the terrain contours. **Appendix A** shows a series of screen images from a Skymap IIIC display for the Derrybrien area, to give the reader an indication of the display provided by this unit. Elevated terrain is only shown as coarse polygons of varying colour. The rising terrain in the Derrybrien area is only indicated by a variation in the shade of green displayed.

This unit suffered some damage in the accident. When subsequent tested, the memory of the unit was found to be blank.

The Manual for the Bendix King Skymap IIIC GPS contains caution regarding the use of this equipment. The Manual particularly cautions against the use of this unit for terrain clearance and stresses: "*it is intended as an aid to VFR navigation only"*. **Appendix B** contains relevant extracts from this Manual.

1.7 Meteorological Information

1.7.1 Met Éireann, the Irish Meteorological Service, provided the following information after the accident.

General Situation: A complex low pressure system in eastern Greenland and a high pressure cell to the southwest of Ireland maintained a general west to northwest airflow over the region. A weak warm front extended down the east coast of Ireland, with a humid airmass over the general area of the accident.

Wind: Surface: 280/320 03 kt.
2000ft: 330/07 kt

Weather:	BR/DZ (mist or drizzle)
Visibility:	5000m or greater
Cloud:	SCT005 BKN010 (AMSL) (scattered cloud cover (3-4 oktas) at 500 ft above sea level, and broken cloud (5-7 oktas) at 1,000 ft)
Temperature/Dew-Point:	17/16degC
MSL Pressure:	1027 hPa

The available information is that the weather was reasonable at New Ross, from where the return flight to Galway commenced, probably with a cloud base of around 1000 ft. The pilot contacted Waterford Airport, with the intention of flying from New Ross to the Waterford Estuary area in order to view the start of the Tall Ships race. Permission for this flight was refused by Waterford ATC, who stated that, because of poor weather conditions, they were operating Special VFR in the Waterford ATC zone, and only permitted one item of traffic into the zone at a time.

As there was already one helicopter operating within the zone, permission to enter the zone was not given to EI-DOC. In the transcript of Waterford ATC, the pilot appeared to be surprised that the weather was so poor in the Waterford zone, which would indicate that the weather was reasonable in New Ross (where the pilot was located at the time). The pilot also phoned another pilot in Galway, who informed him that the weather was reasonable in the Galway Airport area. Another pilot who was flying due east of Galway Airport shortly before the accident, told the investigation the weather was reasonable in that area with a visibility of approximately 5 km, but that visibility did appear to be poorer in the area of the high ground SE of Galway Airport (i.e. the Derrybrien area).

Another pilot, who lives out on the Western slopes of the high ground in the Derrybrien area, had booked a helicopter in Galway, with the intention of flying on the morning of the accident. When he assessed the weather at his home location, especially the low cloud base and poor visibility, on the morning of the flight, he considered it to be unsuitable for flying and he cancelled the booking.

A number of witnesses working on the Wind-Farm project close to the accident site reported poor visibility and low cloud in the area at the time of the accident. While standing at one turbine, it was just possible to see the next turbine tower. These towers are spaced approx 225 metres (740 ft.) apart. The same witnesses reported that the tops of the turbine towers, which are 49 metres (approximately 160 ft) above ground level, were barely visible due to low cloud.

The meteorological definition of fog is where the visibility is less than 1000 metres.
The various classifications of fog are:

- Thin fog is a visibility between 1000 and 1500 metres
- Moderate fog is a visibility between 500 and 1000 metres
- Fog is a visibility between 200 and 500 metres
- Thick fog is a visibility between 50 and 200 metres
- Dense fog is a visibility less than 50 metres

1.8 Aids to Navigation

The only navigation equipment on the helicopter was a magnetic compass, a gyrocompass, an artificial horizon and the GPS unit already noted. Prior to crossing the River Shannon, the helicopter intermittently appeared on Shannon SSR. This intermittent return was caused by the helicopter being obscured by high ground between the helicopter and the radar transmitter. However, consistent returns were recorded after the helicopter crossed the east bank of the Shannon, until contact was finally lost. The radar plot for the final segment of the flight is shown in **Appendix C**. This Appendix also includes an aerial photograph of the Wind Farm area.

1.9 Communications

ATC Communications were not a factor in this accident

1.10 Aerodrome Information

EI-DOC was routing to a small heliport adjacent to Galway Airport. Galway Airport is not radar equipped.

1.11 Flight Recorders

EI-DOC was not carrying any flight recorders. It was not required to carry such equipment.

1.12 Wreckage and Impact Information

The helicopter impacted on the northern slopes of the Slieve Aughty Mountains. The crest line of the high ground runs approximately E - W in this area. The helicopter had passed close to the summit, which is 1,174 ft (358 metres) above sea level. This figure does not include the height of the wind turbines located in this area. The helicopter impacted the trees of a dense plantation. At the impact point the terrain is approximately 1,000 ft (305 metres) above sea level, and the taller trees are approx 33 ft (10 metres) high. An aerial view of the accident site is shown in **Appendix D.** The helicopter made initial contact with the trees on a heading of approx 080° at steep angle descent and possibly a high nose down angle. The main rotor blades made progressively heavier contact with the trees, initially with the light tops, but then with the thicker trunks of the trees as it came closer to the ground at this point of major impact. The undercarriage skids separated at this point and the tail rotor assembly departed. Both main rotor blades suffered major damage during this descent through the trees. One main blade spar remained intact, while suffering major distortion. The other blade spar failed approx 0.5 metres from the tip. The separated segment of this blade was not recovered, notwithstanding an extensive air and ground search. The forward momentum of the helicopter carried the fuselage through a tree. It then struck the ground and was brought to a stop as a result of impact with two more trees.

The tail boom was severed forward of the tail rotor gearbox. This was caused by main rotor blade contact with the boom, as evidenced by witness marks on the boom containing the yellow paint of the main rotor blade tips.

The separated assembly, consisting of the end of the tail boom, the vertical and horizontal stabilisers, the tail rotor gear box and the tail rotor head and blades, landed in the forest very close to the point where the main rotor blades made initial contact with the tree tops.

Examination of the damaged carburettor heat (Carb Heat) valve on the engine showed that full carburettor heat was selected at some point prior to impact.

The engine driven cooling fan, mounted on the rear of the engine showed positive evidence of rotational damage, consistent with the fan and, consequently, the engine, rotating during the impact sequence.

Examination of the engine's air inlet manifold showed considerable quantities of soil/peat, consistent with the soil at the accident site. Normally the ingestion of such debris is prevented by the engine air filter and associated ducting. The presence of such debris indicates that there was normal engine air suction in the manifold when the air intake system was disrupted by ground impact. Pine needles were found on the spark plug electrodes within the engine's cylinders. This evidence indicates that the engine was operating at normal RPM at the time of ground impact.

1.13 Medical and Pathological Information

Post Mortem examinations were conducted on the pilot and fatally injured passenger the day after the accident, at University College Hospital, Galway.

The post mortem of the pilot showed that the cause of death was consistent with the numerous injuries he suffered in the accident. No pre-existing medical conditions, which could have had an adverse effect on the pilot's performance, were found. Toxicology tests did not find any traces of alcohol or drugs in the pilot's system. There was no evidence that physiological factors or incapacitation affected the performance of the pilot.

The Post Mortem of the rear seat passenger showed the cause of death was due to respiratory failure, chest injuries and head injuries. No pre-existing medical conditions, which could have contributed to his death, were found.

1.14 Fire

There was no fire.

1.15 Survival Aspects

1.15.1 General

Given the speed of impact, the high deceleration caused by the final impact with tree trunks, and the light construction of the cabin of the helicopter, survival was unlikely. The compaction of the rear seat area, in particular, made survival in this area improbable. The investigation noted that the seat belts were in use at the time of impact, and remained intact throughout the crash sequence. Emergency service personnel cut them, in order to free the occupants.

The helicopter was not fitted with a crash-activated emergency locator transmitter (ELT). There is no requirement that it be fitted with this equipment.

1.15.2 Search and Rescue

The ground based emergency services responded quickly and arrived in the area in a timely manner. They were hampered in their efforts to locate the accident site by the absence of an accurate position fix, the mountainous terrain and the dense plantation. The latter made it impossible to see the helicopter until one was within a few metres of it. The Galway based helicopters also arrived quickly on the scene. As the first aerial asset to reach the area, one of them was able to locate the wreckage reasonably quickly. This helicopter then landed on the roadway about 100 metres from the accident site and the pilot gave location directions to the ground rescue services. The weather improvement, between the time of the accident and the arrival of this helicopter on scene, was critical in the location of the accident site. At this time, approximately 11.15 hrs, the cloud base was approx 1,500 ft above sea level or about 300 ft above the high ground.

The Coast Guard S61 helicopter arrived shortly after the accident site was located and took over aerial command of the scene. The S61 crew also assisted in the removal of the casualties from the wreckage and their removal to hospital in Galway City.

1.16 Tests and Research

1.16.1 A small sample of fuel was found in one of the ruptured fuel tanks. The sample was analysed and found to be uncontaminated AVGAS.

1.16.2 The Bendix GPS unit was found lying on the ground beside the helicopter. It had been forcibly ejected during the impact sequence and had suffered extensive damage to the screen display and some damage to the casing. Otherwise the unit was intact. However, on examination, the memory was found to be blank.

1.16.3 The fracture surface of the main rotor blade, where the unfound tip had broken off, was examined. The failure was found to be consistent with a single event overload and no evidence was found of pre-impact damage.

1.17 Organizational and Management Information

The helicopter was owned by a private company. The owners of this company made the helicopter available to a helicopter operator located at the heliport near Galway Airport. This operator used the helicopter for instructional and other aerial work activities. He also made the helicopter available to qualified pilots for personal flying purposes, such as the flight that is the subject of this Report.

1.18 Additional Information

1.18.1 Radar Plot

The plot of the Shannon SSR shows that the helicopter maintained a steady track of 308º from the time it first showed on Shannon Radar, until it reached the Derrybrien area.

The speed was steady at just above 100 kts ground speed. This track took the helicopter over varying, and frequently featureless terrain. The track did not follow any ground feature, such as a road, railway, river, etc. The terrain for the final 15 nm of the flight was particularly featureless. During this phase the helicopter crossed only one road of any significance, and this road ran at approx. 45º to the flight track.

The final sections of the radar plot are shown in **Appendix C**. This shows an initial track change to 295° followed by a speed reduction to 30 kts and somewhat erratic track, followed by a northerly track, then another turn back to the track of 307° and an increase of speed up to 95 kts. The track then veered to a northerly heading, followed by a sharp right turn of nearly 180° and a rapid reduction of ground speed to 16 kts. The helicopter then turned left onto a track of 100° and ground speed increased to 62 kts before contact was lost. While viewing **Appendix C**, the reader's attention is drawn to the note in that appendix concerning the lack of accuracy in the geo-referencing of this plot with respect to the position of the wind turbines.

1.18.2 Missing Item

The outer section of one main blade was not found. This piece is approx 0.5 m long, and contains the blade spar and tip balance weights.

1.18.3 The Wind-Farm

The Derrybrien Wind-Farm project consists of 71 wind turbines located around the summit of the Slieve Aughty Mountains. The turbines are located in a grid pattern. The spacing between the turbines is not constant but varies from 200 to 250 metres apart. They are laid out is a roughly rectangular pattern, as shown in **Appendix C**. The area of the Wind-Farm, as measured in the direction of flight of EI-DOC, is 3.2 km wide and 1.4 km deep. Each wind turbine consists of a substantial tower 50 meters high. At the top of this tower, the actual turbine is mounted. The turbine consists of a 3-blade rotor, 52 meters in diameter. Consequently the maximum height reached by the blades is 76 metres above ground level. At the time of the accident virtually all the towers had been erected and half of them were fitted with the blade assemblies.

Inspection of the turbine towers and blades of the Wind-Farm, after the accident, did not show any sign of contact damage, such as would be produced if they were struck by a helicopter.

1.18.4 Rules of the Air

The Irish Aviation Authority (Rules of the Air) Order, 2004 (S.I. No 72 of 2004), in Part III (Visual Flight Rules), Section 34, lays down the general rules for VFR flight. Subsection (2) deals with helicopter operations and states: **"***If the aircraft is a helicopter operating in class F or G airspace* (the accident occurred in class G airspace) *it may, unless otherwise prescribed, be flown below 300 metres (1,000 ft), but not below 150 metres (500 ft), above terrain or water in a flight visibility of not less than 1,000 metres, or such lesser visibility as may be prescribed by the Authority, and in such case shall remain clear of cloud and in sight of the surface and shall be manoeuvred at a speed which would give the pilot-in-command adequate opportunity to observe other traffic or any obstruction in good time to avoid collision."*

1.18.5 Mobile Phone Coverage

The Investigation noted that mobile phone coverage provided by some networks was extremely problematical in the area of the accident.

1.18.6 Use of GPS

The IAA has issued Aeronautical Notice NR O.22 (Issue 2 dated 02.10.03) that gives guidance on the use of GPS. However, this guidance is mostly of a legal nature, and gives little advice on the practical issues, and dangers of using GPS in a low level VFR environment. In particular, there is no reference to the pitfalls of an over-reliance on GPS in deteriorating weather conditions.

1.18.7 NTSB Study

In the United States, the NTSB has conducted a safety study titled "Risk Factors Associated with Weather-Related General Aviation Accidents". This study can be found at http://www.ntsb.gov/publictn/2005/ss0501.pdf The findings on page 47 of this study are noteworthy.

1.18.8 Irish Fatal Accidents in 2005

There were three fatal accidents in Ireland in 2005. In all these accidents, weather was a significant factor, and they occurred in the summer or early autumn (one in July and two in September). It is also noted that all three accidents occurred on the return leg of multi-day trips. It has been confirmed that the aircraft were GPS-equipped in two of these accidents.

1.19 Useful or Effective Investigation Techniques

Nil

2. ANALYSIS

2.1 Examination of the helicopter shows no indications of pre-impact damage or malfunction. The aircraft documentation indicates that the helicopter was serviceable when it departed from Galway

2.2. The evidence of rotation at impact on engine components, and the presence of tree debris inside the engine cylinders, indicates that the engine was run at a normal power setting at the point of impact with the trees. The presence of soil in the intake manifold indicates that the engine was still rotating at ground impact.

2.3 There was no evidence of the helicopter having struck any obstacle prior to the final impact with the trees at the accident site. In particular, any contact of the helicopter's main rotor blades and the wind turbines would have caused the helicopter to crash before it could have reached the actual accident site.

2.4 The failure to locate the missing tip section of one main rotor blade is not seen as significant. This blade had suffered significantly more disruption than the other blade, indicating that it made the initial heavy contact with the trees, and probably with the tail boom, and therefore suffered heavier damage than the other blade. This caused the tip to fail, and to be flung away due to the high centrifugal forces acting on it. Previous experience has shown that the helicopter blade tip elements can be found up to 500 metres from hard impact accident sites. Given the large possible area, the dense forestry and the fact that much of the forest floor was covered with impenetrable peat-stained water up to 0.5 m deep, the probability of finding the tip was low. Calculations showed that if 0.5 metres of tip departed in flight the ensuing imbalance would have been of the order of 6 tonnes. Such imbalance would have caused the main gearbox to immediately depart the airframe in flight. This did not occur, which indicates that the blade tip was present when initial tree contact was made.

2.5 The fact that the helicopter maintained a constant track, even over featureless terrain, particularly in conditions of rising ground, declining visibility and increasing cloud cover, indicates that the pilot was probably following a GPS-derived course.

2.6 Approximately 12 nm before the accident site, the helicopter crossed a significant road, the R352. Had the pilot followed this road north, and then the R351 (the Woodford/Loughrea road), the helicopter would have flown to Loughrea, and hence to Galway by the N6. This route would have avoided high ground and would have increased the flight distance by approx 10 nm.

2.7 The reports of various witnesses indicated that the cloud was sitting on the high ground in the Derrybrien area at the time of the accident and that visibility was poor. Because of the NW airflow, the cloud base on the north facing slopes of the high ground would probably have been lower than that on the south slopes. Thus, if the helicopter maintained constant altitude as it passed over the crest of the high ground, it would have encountered conditions of further reduced visibility, which may have obscured the pilot's view of the ground, as it flew over the descending slope on the north side of the mountain.

2.8 The evidence of the radar plot showed that the helicopter slowed down and started to alter course just as it approached the Wind-Farm. The plotted track goes through the Wind-Farm with significant track and speed changes. This would indicate that the pilot saw the wind turbines and manoeuvred his way through the turbines at reduced speed. Having passed through the turbines and the crest of the high ground, the ground fell away underneath, and the helicopter had now entered the area of the northern slopes and the associated lower cloud level. At this point the pilot probably would have had little or no visible contact with the ground. In such circumstances, the loss of spatial awareness can be expected. The final right turn to the east that the helicopter performed prior to impact, which has no obvious explanation, may well be indicative of spatial disorientation, which quickly led to an unintentional loss of height and consequent contact with the trees at the accident site. In this regard it is noted that this turn was immediately after a sharp right turn of 180°. Sharp turns in conditions of poor/no horizon reference are a frequent cause of spatial disorientation.

It should be noted that the radar plot speed is only the horizontal ground speed component of the helicopter's total speed vector. If the final descent rate was large, which was probably the case, then the airspeed in the final moments of the flight would have been significantly more than the 62 kts plotted ground-speed. This is consistent with the damage suffered by the helicopter.

2.9 The fact that carburettor heat was selected to full ON at some stage prior to the accident indicates that the pilot was concerned that the ambient conditions were conducive to the formation of carburettor icing. The ambient temperature of 17° C would not normally warrant the use of carburettor heat, while operating at cruise power in dry, clear air. Furthermore, because the selection of full carburettor heat has an adverse effect on fuel consumption and available power, and can lead to "coking" of the spark plugs and cylinders, a pilot would not select full carburettor heating for long periods as a matter of precautionary routine. The forgoing indicates that prior to the accident, the pilot was concerned with the humidity/moisture levels in the area. Poor visibility, precipitation or proximity to fog or cloud would cause such concern.

2.10 The Rules of the Air show that the helicopter, while flying VFR in the area of the accident site, was required to fly at least 500 ft above ground, clear of cloud and in a minimum flight visibility of 1000 metres. The evidence of witnesses on the Wind-Farm at the time of the accident indicated cloud was approximately 160 ft above ground level and that the horizontal visibility was of the order of approximately 225 metres. Therefore the helicopter was operating well below the required minimum visibility conditions at the time of the accident.

2.11 The enroute weather conditions for this trip were sufficient to maintain VFR, except in the Derrybrien area where local conditions were demonstrably poor. In order to maintain VFR, the pilot had the option, as noted in para 2.6 above, to avoid the high ground on his direct track in the Derrybrien area and to route more northerly and follow relatively lower ground and well-defined geographic features. This is a judgement call which frequently has to be made by pilots and is based, to a large extent, on previous flying experience.

2.12 The pilot had a total of 123 hrs flying experience of which 26 hrs were as PIC on type. In aviation terms the pilot was not experienced. Generally the en-route weather was within VFR limits. However the weather, in terms of visibility and the height of cloud base above ground, deteriorated significantly and progressively as the helicopter approached the high ground in the Derrybrien area. This high ground resulted in the helicopter flying at an increased elevation, where visibility reduced significantly. With the comfort of GPS-derived heading information for Galway, the pilot elected to continue in weather that was below VFR limits. The likelihood is that the pilot, while manoeuvring in poor visibility, inadvertently entered Instrument Meteorological Conditions (IMC), where control was lost and the helicopter impacted the ground.

2.13 The Investigation notes that a reduction of speed by a helicopter in misty, damp or raining conditions has the consequential effect of reducing the clearance of water droplets or rain off the windscreen. This is caused by the reduced speed of the airflow over the windscreen. Furthermore the speed reduction can cause a build-up of mist on the inside of the windscreen, due to a reduction of the ram air effect through the windscreen demisting vents.

Thus, when declining external visibility dictates a speed reduction, the pilot's visibility through the windscreen is further reduced by these effects. This is particularly a problem on helicopters that are not fitted with windscreen wipers, such as the R44.

2.14 The helicopter was due its next maintenance check on the day of the accident, or, (including the authorised extension) at 465.8 hrs, whichever came first. Given the Hobbs meter reading of 462.7 hrs at impact, and because the helicopter would have been expected to land in Galway within 15 minutes additional flying, the flight would, in normal circumstances, have been completed before the 100 hr/Annual Inspection was due.

2.15 Given the absence of an ELT on the helicopter, the poor mobile phone coverage of some networks in the accident area, and the remoteness of the accident area, it was fortunate that the pilot was able to contact the emergency services. It is an unfortunate fact that terrain collision accidents are more likely to occur in remote mountainous countryside where mobile phone coverage is more likely to be poor. While there is no legal requirement to fit an ELT, the potential benefits of such equipment is demonstrated by this accident.

2.16 If the pilot had not been able to raise the alarm, the alarm would have been raised when the helicopter was ½ hr. overdue at Galway, i.e. at approx 11.20 hours UTC.

2.17 The inability to contact Galway ATC was not a factor in this accident. The pilot's call to the emergency services initiated the rescue response before the overdue limit was reached.

2.18 A prompt reaction to the pilot's phone call resulted in a timely response by the Galway based helicopters, and the emergency services, including the Coast Guard helicopter.

2.19 The absence of retained memory data in the GPS unit deprived the Investigation of a valuable source of information with regard to the operation of this flight. A possible cause of the absence of such data was that the memory unit was never initialised.

2.20 There were two fatal air accidents within Ireland in 2005, and another flight, which took off from Ireland, crashed into the Irish Sea, in UK airspace. A total of six people were fatally injured in these accidents. The Investigation notes that continued flight into bad weather was a common and significant factor in all three accidents. Furthermore, at least two of the aircraft were carrying GPS at the time of the accident.

2.21 This accident, and the other two fatal accidents that occurred/originated in Ireland in 2005, indicate factors which show significant correlation with the findings of the NTSB study, noted in para 1.18.7 above, particularly with regard to pilots' age at qualification.

2.22 In this accident, and other fatal accidents that occurred/originated in Ireland in 2005, adverse weather was a factor. It is also noteworthy that all three accidents occurred on the return leg of a multi-day trip.

3. CONCLUSIONS

3.1 Findings

3.1.1 The helicopter was fully operational prior to impact with the trees in the plantation.

3.1.2 The pilot continued the flight into an area of featureless rising terrain, probably navigating by GPS, where there was a significant deterioration of visibility.

3.1.3 Approaching the site of the accident, the pilot continued to fly into conditions of visibility significantly below the minima laid down in the Rules of the Air for VFR flight.

3.1.4 The pilot probably lost ground reference in the final stages of the flight and became spatially disorientated. This resulted in unintentional loss of height and ultimately to in-flight collision with terrain.

3.1.5 The probability of surviving the accident was low.

3.1.6 The pilot elected to follow a direct course, probably using GPS, to his destination, over higher ground, in reducing visibility. An alternative low-level route, to the north, was available.

3.1.7 Some significant factors in this accident, and other recent fatal accidents, are consistent with the findings of an NTSB study into the causes of General Aviation weather related accidents.

3.2 Causes

3.2.1 The pilot entered conditions of poor visibility/cloud that probably led to spatial disorientation. This resulted in loss of control and, ultimately, in-flight collision with terrain.

3.3 Contributory Factors

3.3.1 The pilot's decision to continue the flight along a GPS derived track, over rising terrain, in conditions of reducing visibility, which were significantly below VFR minima.

4. SAFETY RECOMMENDATIONS

The IAA should revise Aeronautical Notice NR O.22 to give guidance on the practical use of GPS in low-level VFR operations, with particular emphasis on the pitfalls arising from an over-reliance on this equipment in conditions of declining visibility. This guidance material should also stress that pilots of General Aviation aircraft, equipped with GPS systems, should ensure that the tracking facility memory function is initialised. **(SR 7 of 2006)**

4.2 The IAA should review the NTSB study into General Aviation Weather Related Accidents to determine if a programme of possible action can be initiated to reduce such accidents**. (SR 8 of 2006)**

Appendix A

The following images are digital pictures taken of a Skymap III display. The images were taken in a Bell 206 inside an aircraft hangar and hence a "NO FIX POSSIBLE" message was displayed in the centre screen. The two images were taken at varying range settings and show the Derrybrien area. It was not possible to determine what range setting was selected in EI-DOC at the time of the accident due to the damage suffered by the unit. The images are shown here at approximately full size and the display in EI-DOC was located approximately 60 cm (arm's length) from the pilot's eyes.

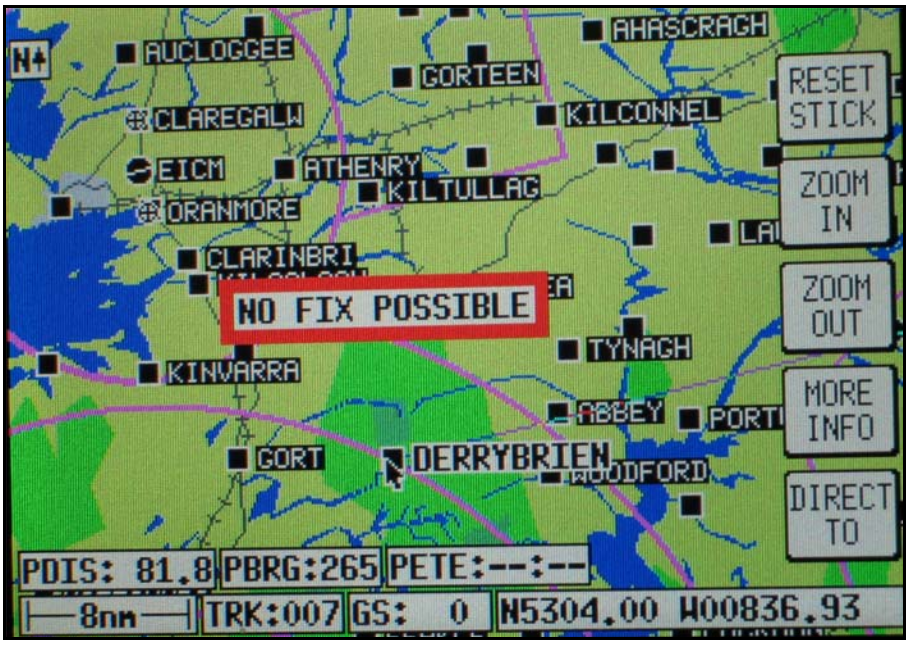


Image 1

This image was taken at an 8nm setting (ref lower left of display). This setting is probably the maximum range setting that the pilot would have used. The high ground in the general Derrybrien area is shown by the light green area surrounding Derrybrien. The summit area is shown by the darker green rectangle immediately north of Derrybrien. The accident site is approximately in the centre of this darker green rectangle. It may be noted that none of the local roads in the area are displayed. The two "rivers" shown (blue) starting near the summit area are, in fact, just mountain streams and are virtually invisible from the air in this area. The pink lines are the boundaries of Air Traffic Control areas.

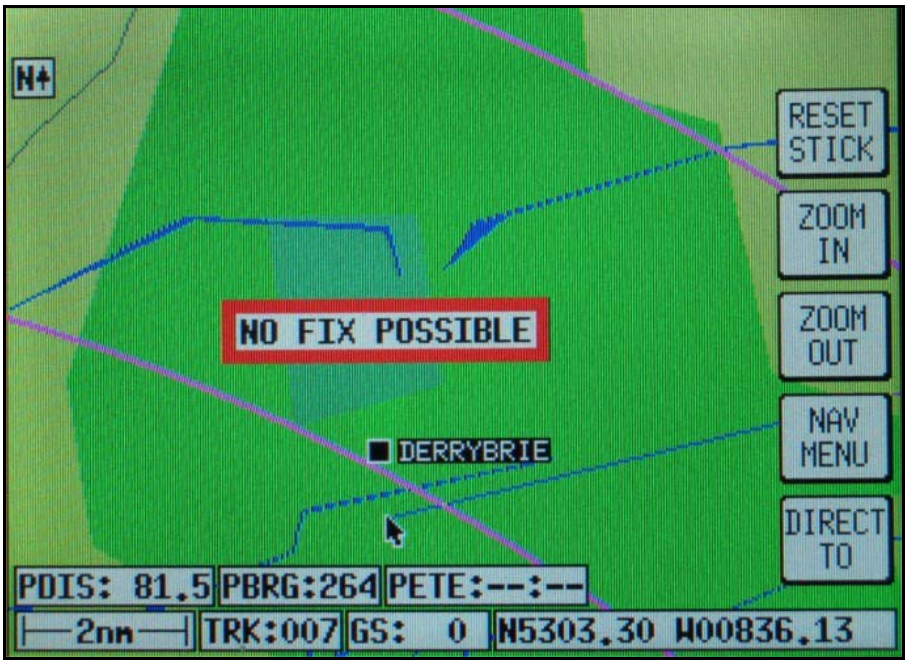


Image 2

This image again shows the Derrybrien area, but at a range setting of 2nm. This setting is probably the minimum range setting that the pilot would have used. The accident site is just above the centre of "NO FIX POSSIBLE" message. Again the lack of local terrain features in the display is noticeable.

Appendix B

Extract from Manual for Bendix King Sky Map III Global Positioning System

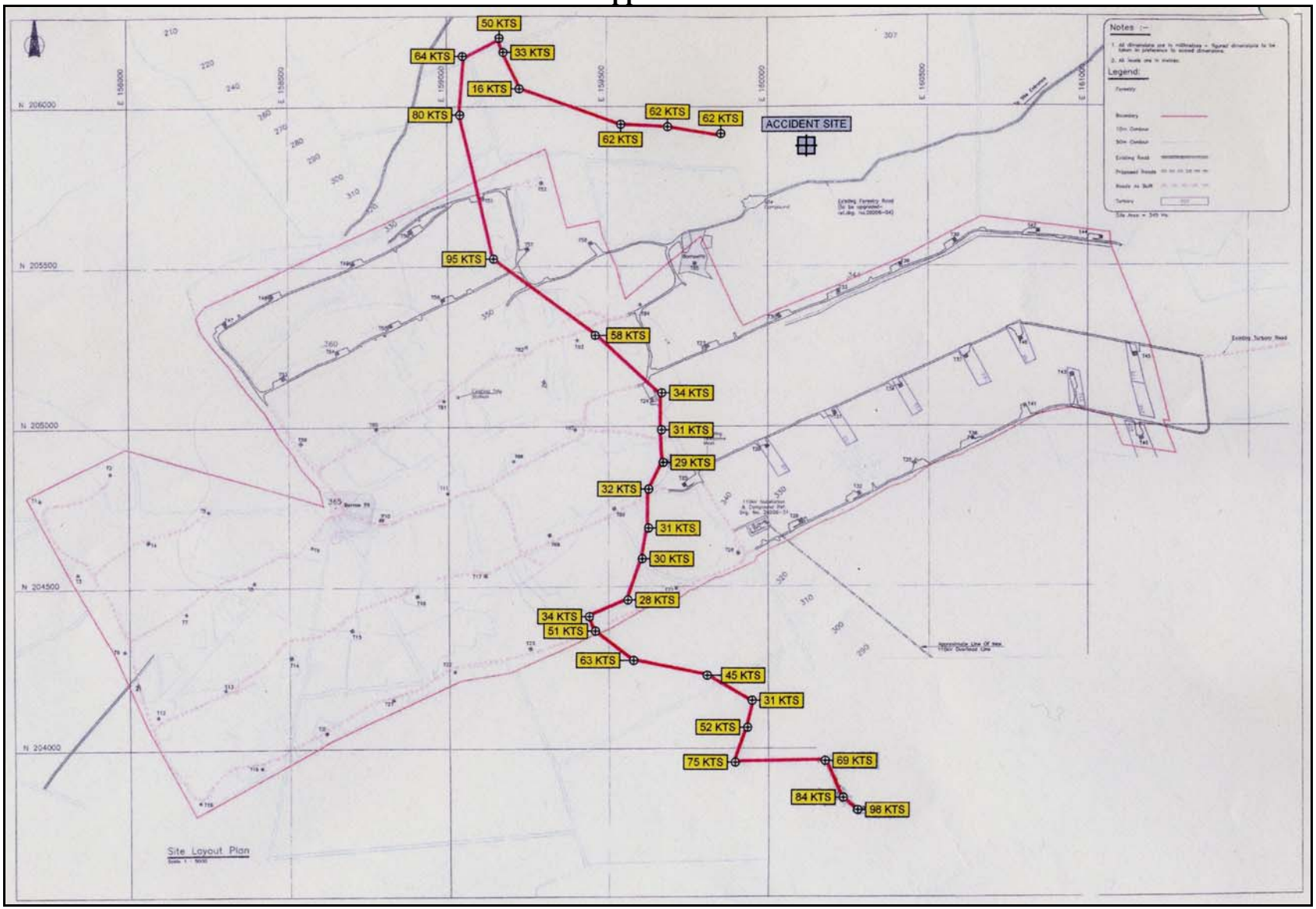
Warnings

The Global Positioning System (GPS) satellite constellation is operated by the Department of Defence (DoD) of the United States, which is solely responsible for its accuracy and maintenance. Although declared fully operational on July 17th 1995, the system is still under development and subject to changes, which could affect the accuracy and performance of all GPS equipment.

Use this equipment at your own risk. Your new Bendix/King equipment is a precision navigation aid but like any navigation aid it can be misused or misinterpreted and so become unsafe. You are strongly advised to read and fully understand this Manual before using it. Your unit has a DEMO MODE or simulation facility that allows you to practice with it before you begin using it for actual navigation.

Whenever you are using the unit for navigation in the air you should treat it as a **supplemental navigation system.** You should always carefully compare indications from your Bendix/King equipment with the information available from all other navigation sources including NDB's, VOR's, DME's, visual sightings, charts, etc. For safety, any discrepancies observed should be resolved immediately.
The altitude calculated by GPS equipment is geometric height above a theoretical mean sea level of a mathematically calculated ellipsoid that approximates to the shape of the earth. This altitude can differ significantly from that displayed by your pressure altimeter. You must therefore **NEVER USE GPS ALTITUDE FOR VERTICAL NAVIGATION OR TERRAIN CLEARANCE.**

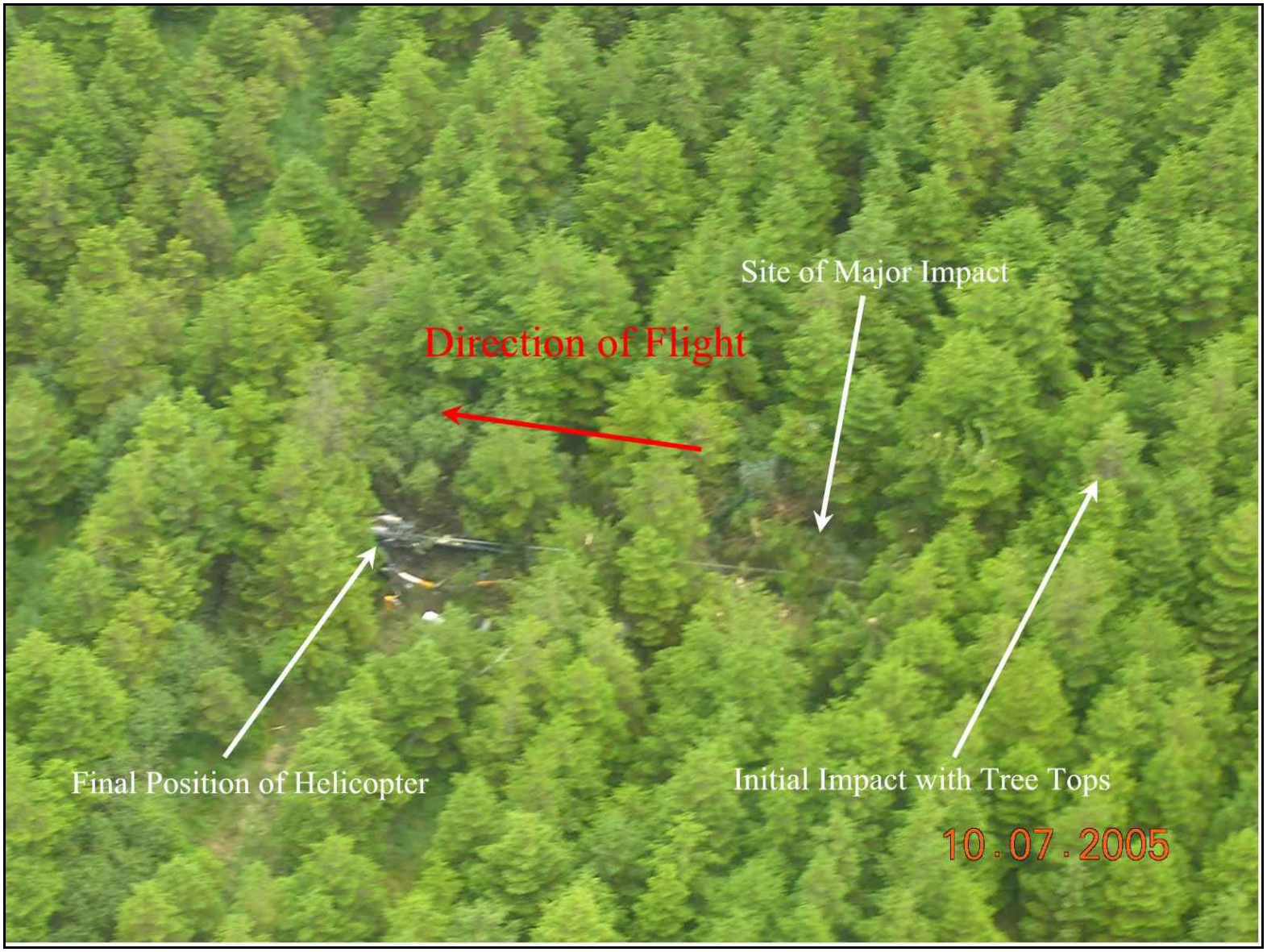
This equipment is not a replacement for your chart. It is intended as an **aid to VFR navigation only.** The database within the equipment has been compiled from the latest official information available, and although every care has been taken in the compilation, the manufacturers will not be held responsible for any inaccuracy or omissions therein.



This map shows an overlay of the Shannon radar record onto a site-map of the Derrybrien Wind-Farm project, which includes the accident site. The speeds shown are the instantaneous speeds calculated by the radar at the points in question. While the shape of the plot is reasonably accurate, the plot can't be accurately geo-referenced onto the map, due to the (relatively) poor resolution of the radar. The placement of the plot was achieved by estimating the probable vertical flight path from the last recorder point (at 62 kts ground-speed) to the accident site. Between these two points the radar was unable to detect the helicopter, because it had descended below the crest of the high ground between itself and the radar transmitter. Because of the foregoing, no inference should be drawn as to the proximity of the flight path to any of the turbine towers of the Wind-Farm.

This aerial photo of the Derrybrien Wind Farm was taken some time after the accident, when construction of the farm was complete. The flight path of EI-DOC was from left to right.

Appendix D



Aerial Photo of Accident Site

Note: the white line streaming back from the helicopter is a survey tape being used by the Investigation.