AIRCRAFT ACCIDENT REPORT 1/93

Air Accidents Investigation Branch

Department of Transport

Report on the accident to Piper PA-28-161 Cadet, G-BPJT at Oxford Airport, Kidlington on 12 July 1992

This investigation was carried out in accordance with

The Civil Aviation (Investigation of Air Accidents) Regulations 1989

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Department of Transport
Air Accidents Investigation Branch
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10 March 1993

The Right Honourable John MacGregor
Secretary of State for Transport

Sir,

I have the honour to submit the report by Mr R StJ Whidborne, an Inspector of Air Accidents, on the circumstances of the accident to Piper PA-28-161 Cadet, G-BPJT, that occurred at Oxford Airport, Kidlington on 12 July 1992.

I have the honour to be
Sir
Your obedient servant

K P R Smart
Chief Inspector of Air Accidents

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	-	Air Accidents Investigation Branch
AIC	-	Aeronautical Information Circular
AFIS	-	Aerodrome Flight Information Service
AFISO	-	Aerodrome Flight Information Service Officer
agl	-	above ground level
AIC	-	Aeronautical Information Circular
ATC	-	Air Traffic Control
ATCO	-	Air Traffic Control Officer
ATIS	-	Aerodrome Terminal Information Service
CAA	-	Civil Aviation Authority
CAP	-	Civil Aviation Publication
DOT	-	Department Of Transport
FAA	-	Federal Aviation Administration
°M	-	Magnetic
MATS	-	Manual of Air Traffic Services
MHz	-	Megahertz
MTWA	-	Maximum Take-off Weight Authorised
NASA	-	National Aeronautics and Space Administration
QNH	-	Corrected mean sea level pressure
RPM	-	Revolutions per minute
SEWC	-	Special Events Working Group
UK	-	United Kingdom
US	-	United States
UTC	-	Coordinated Universal Time

Air Accidents Investigation Branch

Aircraft Accident Report No: 1/93 (EW/C92/7/2)

Registered owner:	CSE Aviation Limited	
Operator:	Oxford Air Training School	
Aircraft:	Type:	Piper
	Model:	PA-28-161 Cadet
	Nationality:	British
	Registration:	G-BPJT
Place of accident:	Oxford Airport, Kidlington	
Date and Time:	12 July 1992 at 1627 hrs	
	All times in this report are UTC	

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) at 1715 hrs on 12 July 1992 and an investigation began the same day. The AAIB team comprised Mr R StJ Whidborne (Investigator in Charge), Mr A W Skinner (Operations) and Mr A P Simmons (Engineering).

Sunday 12 July 1992 was the day of the British Grand Prix motor race at Silverstone and Oxford Airport, Kidlington, was in use as a feeder airport for helicopters to transfer passengers to and from the race circuit and also to refuel. There was therefore, unusually for a weekend, a large number of aircraft movements on that day. The weather was fine with a light to moderate westerly surface wind and the grass runway 27 was in use.

The Piper PA-28-161 G-BPJT ('JT') was being flown on a dual instruction flight of circuits and landings. The Sikorsky S-61N helicopter, G-BHOF, radio callsign Pink Echo ('PE') was transferring passengers between Kidlington Airport and a landing site near Silverstone. At 1622 hrs 'JT' reported downwind for a 'touch and go' landing and one minute later 'PE' reported finals for runway 27 and was advised to 'land at the pilot's discretion'. At 1627 hrs 'PE' came to the hover over runway 27 and then turned left to hover-taxi clear of the left side of the runway. Shortly afterwards witnesses observed 'JT' descend on the final approach to a height of about 30 feet above ground level (agl) at which point the engine power was heard to increase as a 'go around' was initiated. As the nose of the aircraft was raised and some right bank smoothly applied, the aircraft was observed to flick suddenly to the right before the nose dropped and it descended steeply to the ground. The instructor was fatally injured at impact and his student died shortly after reaching hospital.

The following causal factors were identified:

(i) At a late stage in the approach for a 'touch and go' landing the aircraft encountered wake vortices or turbulence generated by the Sikorsky S-61N helicopter which, at the time of the accident, was hover-taxiing close to the active runway.

(ii) The decision to continue the approach may have been made without realising that a large helicopter was still in hovering flight close to the runway.

(iii) The dangers caused by rotor downwash generated by large helicopters when hovering close to an active runway have not been sufficiently researched. Although helicopter downwash and wake vortex is recognised as being hazardous it may be that such conditions associated with hovering helicopters are not widely appreciated.

Six safety recommendations have been made.

1 Factual Information

1.1 History of the flight

At 1610 hrs on 12 July 1992 the pilots in the Piper PA-28-161 'JT' requested taxi instructions prior to a dual instruction flight of circuits and landings. The flight had been routinely briefed and was self-authorised by the flying instructor. At 1619 hrs 'JT' was advised by the Kidlington Aerodrome Flight Information Service Officer (AFISO) to take off from runway 27 at 'pilot's discretion', and informed that the surface wind was 300°/13 knots. At 1620 hrs the S-61N helicopter 'PE' reported its position as overhead Bicester to join the Kidlington traffic circuit, and confirmed that the current Automatic Terminal Information Service (ATIS) had been received. The AFISO requested 'PE' to "REPORT LOW LEVEL VIA THE NORTH EASTERN BOUNDARY". This request was acknowledged incorrectly by 'PE' as via the eastern boundary, but the error was not commented on by the AFISO. At 1622.30 hrs 'JT' reported downwind for a 'touch and go' and was requested by the AFISO to "REPORT FINALS". The crew of 'JT' were advised that they were "NUMBER TWO IN TRAFFIC".

At 1624 hrs 'PE' reported on final approach and, having confirmed that this was for runway 27, the AFISO advised 'PE' "LAND YOUR DISCRETION THE SURFACE WIND IS WESTERLY 10 KNOTS." At 1625.50 hrs 'JT' reported "FINALS FOR 'TOUCH AND GO'". It was not possible to establish the aircraft's precise position or distance from the runway threshold when this transmission was made. The AFISO requested 'JT' to standby and, after advising the pilot of a departing Learjet to hold his position on the taxiway immediately to the south of runway 27, requested 'PE' to clear the runway to the left. This request was acknowledged. The pilots of 'PE' have stated that the helicopter crossed the runway threshold at a height of about 100 feet agl and came to the hover about 600 feet in from the threshold. Thereafter it was hover-taxied to a position just west of the crossing grass runway 03/21 (see aerodrome diagram at Appendix A) before commencing a left turn to clear runway 27 to the south, followed by a further left turn to face the terminal buildings. The helicopter commander also stated that throughout these manoeuvres, which took approximately 30 seconds, due to the helicopter's weight of 19,400 lbs (maximum permitted 20,500 lbs) he was using high engine power with torque settings between 75% and 95%.

Eyewitnesses close to the runway 27 threshold observed 'JT' descend on the final approach to a height of approximately 30 feet agl at which point the engine power was heard to increase as a 'go around' was initiated. As the nose of the aircraft was raised and right bank smoothly applied, the aircraft was observed to flick suddenly to the right to approximately 90° of bank, whereupon the nose dropped and it descended steeply to the ground. The initial impact was on the grass undershoot area 84 feet east of the taxiway. Thereafter the aircraft had continued forward, disintegrating until the main fuselage section came to rest on the tarmacadam taxiway at a position just north of the runway centreline. The cabin attendant in 'PE' reported that as the helicopter was hovering towards the passenger disembarkation area she glanced out of a left side window and saw a light aircraft close to the ground. When she looked a second time she saw what she assumed to be the same light aircraft inverted on the ground. From eyewitness evidence and the position of the wreckage it is estimated that, at the time that the accident sequence commenced, 'JT' was about 275 metres from 'PE'.

Immediately following the accident the AFISO initiated the appropriate alerting action and then instructed 'PE' to land. There was a rapid response from the aerodrome emergency service and all three fire and rescue vehicles were at the scene in less than two minutes. Units from the Oxfordshire Fire Service, Oxfordshire Ambulance Service and Thames Valley Police also attended the accident. The danger of fire from spilled fuel required extra care in the extrication of the casualties.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	-	-
Serious	-	-	-
Minor/None	-	-	

1.3 Damage to aircraft

The aircraft was destroyed by ground impact.

1.4 Other damage

Minor impact damage was caused on the grass undershoot area to Kidlington runway 27.

1.5 Personnel information

1.5.1	Commander:	Male, aged 40 years
	Licence:	Airline Transport Pilot's Licence valid until 20 March 2001
	Aircraft ratings:	L 1011 Tristar, PA-28, PA-34, Slingsby T 67
	Medical certificate:	Class I, valid until 3 September 1992
	Instrument rating:	Multi-crew only
	Instructor rating:	Full Flying Instructor rating
	Flying experience:	Total all types: 4818 hours Total on PA-28: 141 hours

The Commander had retired from the Royal Air Force in 1991 having held a Central Flying School A2 flying instructor category. He had extensive experience of instructing pilots undergoing initial flying training.

1.5.2	Student Pilot:	Male, aged 39 years
	Licence:	None required - student pilot under instruction
	Medical certificate:	Valid
	Flying experience:	Total all Types: 19 hours Total on PA-28: 19 hours

The student pilot had commenced a course of instruction for a Private Pilot's Licence on 9 February 1992. His flying records show that he had made slow progress. The accident flight was his second instructional flight in circuits and landings.

1.5.3.	AFISO	Male, aged 24 years
	Licence:	Issued 7 February 1992
	Medical certificate:	Not required
	Currency:	Validated for Kidlington 20 March 1992

1.6 Aircraft information

Type:	Piper PA 28-161 Cadet
Constructor's number:	2841031
Year of manufacture:	1989
Certificate of Registration:	Registered in the name of CSE Aviation Limited
Certificate of Airworthiness:	United Kingdom (UK) Civil Aviation Authority (CAA) Transport Category (Passenger) issued 6 February 1989 and last renewed on 18 February 1992, valid for three years
Total airframe hours:	2004 hours
Engine:	Lycoming 0-320-D3G serial number L-14976-39A
Propeller:	Sensenich 74DM6-0-60 serial A53063
Centre of gravity at time of incident:	Within approved limits

The aircraft had been UK registered in February of 1989, with 41 hours total time. It had previously been US registered for the purpose of the delivery flight.

1.7 Meteorological information

1.7.1 A weather observation taken immediately after the accident recorded the following conditions: Surface wind 260°/08 knots; Visibility more than 10 kilometres; cloud 2 oktas at 2800 feet.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Kidlington Aerodrome Flight Information Service (AFIS) was operating on 118.875 MHz, and the Kidlington departure ATIS was broadcast on 121.950 MHz. Both these frequencies were recorded and transcripts were obtained. The radiotelephone recordings showed that communications between the subject aircraft and the AFISO were normal at the time of the accident. From the time that 'JT' first came on frequency 118.875 MHz (1610 hrs) until the time of the accident (1627 hrs) there were eight other aircraft receiving a flight information service.

On 12 July 1992, at the time of the accident, the Kidlington departure ATIS message was as follows:

> "THIS IS OXFORD DEPARTURE INFORMATION ECHO RUNWAY TWO SEVEN LEFT HAND CIRCUIT QFE NINE NINE NINE MILLIBARS QNH ONE ZERO ZERO NINE. HELICOPTER AREA THREE RIGHT HAND CIRCUIT FIXED WING CIRCUIT HEIGHT ONE TWO ZERO ZERO FEET. GROUND FREQUENCY IS CLOSED CHANGE TO ONE ONE EIGHT DECIMAL EIGHT SEVEN FOR TAXY AND CONFIRM INFORMATION ECHO RECEIVED".

1.10 Aerodrome information

Kidlington Airport is a licensed aerodrome operated by CSE Aviation Limited. The majority of the flying carried out at the aerodrome is concerned with pilot training and large fleets of fixed wing and rotary wing aircraft are permanently based there. Operational procedures are promulgated that are designed to ensure the safe separation of fixed and rotary wing aircraft. Specific areas are set aside for helicopter operations; the area in use being broadcast on the Kidlington departure ATIS. On 12 July 1992 helicopter area 3 was in use. A diagram of the Airport layout is included at Appendix A. Throughout July 1992 Kidlington Airport operated a full aerodrome Air Traffic Control Service during the published operating times on every weekday. At weekends and public holidays an AFIS was provided.

Sunday 12 July 1992 was the day of the British Grand Prix motor race at Silverstone, and Kidlington Airport was being used as a feeder airport for helicopters to transfer passengers to and from the race circuit. On the Sunday 298 movements were logged and this included both the normal pattern of weekend flying and the considerable number of shuttle flights to and from Silverstone. The airport had been used for this purpose in previous years and no great problems had been experienced. The airport operator had decided to limit fixed wing flying at the airport in order to accommodate the large number of helicopter movements expected. Accordingly no flying was to be undertaken by the Commercial School, which normally provides the majority of the airport's traffic, and fixed wing flying was restricted to private pilot's licence training school movements, private operators and visiting aircraft. No changes were made to the normally available weekend Air Traffic Services, accordingly an AFIS was provided.

It had been the operator's intention that fixed wing traffic should use the main runway (02/20) in order to achieve maximum separation from the helicopters. In the event a moderate westerly surface wind required the use of the grass runway 27 for the majority of fixed wing aircraft movements. Thus helicopters in transit to and from Silverstone, which is to the north east of Kidlington, were required to cross runway 27 both on arrival and departure. Runway 20 was also in use for Instrument Flight Rules departures and available for arrivals when requested. At the time of the accident the Control Tower was manned by an AFISO, with an assistant who was logging aircraft movements and providing updates on expected arrivals. The Senior Air Traffic Control Officer was also present but he was not officially on watch and assisted in relieving the work load by manning the telephone and obtaining airways clearances for fixed wing aircraft departing from runway 20.

1.11 Flight recorders

Not applicable.

1.12 Wreckage and impact information

1.12.1 Impact parameters and wreckage plot

The ground impact marks and distribution of the wreckage on the ground showed that the aircraft had impacted on a heading of about 298°M while banked steeply to the right. Following the initial ground contact the aircraft had yawed to the right and the wing had collapsed allowing the nose of the aircraft to strike the ground about 40 feet from the first ground mark. Following this the aircraft had inverted, striking the ground with the left hand wing before coming to rest on the taxiway, with the fuselage on a heading of about 210°M (see Appendices A & B).

1.12.2 Disturbance of the wreckage

The emergency services arrived on the scene very shortly after the accident and recovered the two occupants from the wreckage. In order to do this the left wing control cables were cut and the wings moved from the immediate area, also the fuselage was raised and the top of the cabin was cut away. The cuts and disturbance to the wreckage were noted and recorded and did not, therefore, impede the technical investigation.

1.12.3 Instruments and controls

The following positions of instruments and controls were noted:

Flap lever	25°
Flap	fully down
Rudder pedals	left rudder applied
Rudder trim	near to neutral
Elevator system	no indications of position
Elevator trim	near to neutral
Aileron system	no indication of position
Throttle lever	fully forward
Mixture lever	fully forward
Fuel Selector	right tank selected
Carburettor heat lever	fully up
Airspeed Indicator	zero
Altimeter	200 feet, subscale set to 1001 mb
Direction Indicator	020°
Vertical Speed Indicator	600 feet per minute down
RPM gauge	zero
Clock	1542 hours

1.12.4 Fuel

The PA 28-161 has two wing mounted fuel tanks, which may be selected independently. The usable quantity is 20 Imperial gallons. The right hand tank was broken up in the impact and was completely empty after the accident. The left tank contained considerable quantities of fuel and had to be drained by the Fire Service. The fuel was clean and blue with the appearance and smell of 100LL Avgas. The engine filter drain bowl was released from the aircraft during the impact, it contained no fuel but was clean and bright internally with no evidence of contamination. A fuel sample from the left tank together with bowser and supply tank samples were analysed and all the samples complied with the specification requirements for 100LL Avgas, showing no evidence of contamination either by particulate matter or by water.

1.12.5 Engine and propeller

Examination of the engine and propeller showed that, at impact, the engine was running and producing relatively high or full power.

1.12.6 Flying controls

The aileron control cables had suffered failures at four places in the region of the cabin, one of these was a deliberate cut made by the emergency services to allow a wing to be moved from the wreckage. The three other failures exhibited tensile characteristics combined with evidence of cutting; there was much evidence of cables being pulled through skins and structure; this had resulted in the strands of each cable being pulled and cut as breakup of the aircraft had occurred. The cables terminated adjacent to the instrument panel where they connected to a chain which ran around sprockets on each control wheel, the chain was disengaged from both wheels. The controls and instrument panel had suffered major damage and distortion in the ground impact. No evidence of any disconnection or other malfunction of the aileron system prior to ground impact was found. The position of the ailerons at impact could not be determined.

Damage to the rudder system was confined to the rudder pedals and slackening of the cables due to foreshortening of the fuselage in the impact. There was no evidence of any disconnection or malfunction of the system. The pedals on the instructor's side (right hand) were jammed in a position which would have corresponded to a large input of left rudder at impact. The rudder trim input knob is a screw mechanism, this was found to be near the neutral trim position.

The stabilator trim system consists of a screw jack driven by cables, this was found to be in a position corresponding to slightly nose down trim. The cables to this mechanism were not severed or pulled, indicating that the trim position found is close to that selected in flight.

The flap lever was latched into the correct position for the 25° flap setting. The flap torque tube was in a position corresponding to full flap (40°) or possibly slightly over travelled. The torque tube has levers at its outboard ends which attach to links connected to the flaps themselves, in both cases these links had fractured due to overload at impact. There was no evidence of any asymmetry or other malfunction of the flap system prior to impact.

1.13 Medical and pathological information

Post mortem examination of both occupants revealed that death was the result of multiple injuries sustained in the impact. There was no evidence of any medical condition that could have contributed to the causes of the accident.

1.14 Fire

There was no fire.

1.15 Survival aspects

The force of impact was such that the accident was judged to be non-survivable.

1.16 Tests and research

Nil.

1.17 Additional information

1.17.1 Aircraft vortex wake categories and spacing criteria

Aircraft vortex wake categories and spacing criteria are defined in the Manual of Air Traffic Services (MATS) - Part 1 Chapter 3 & Appendix B. Relevant extracts are included at Appendix C. CAA Aeronautical Information Circular (AIC) 77/1990 draws attention to the dangers associated with wake turbulence caused by aircraft wake vortices. This Circular includes guidance to pilots on wake turbulence avoidance and re-states the aircraft weight categories defined in MATS Part 1. The CAA provided details concerning the methods used to determine these criteria as follows:

> 'The Wake Vortex Classification Scheme recommended by the International Civil Aviation Organisation (ICAO) was introduced on 10 August 1978. (AIC 52/1978). This scheme classifies aircraft by weight (Max. take off weight authorised MTWA). The UK complied with this scheme but with a modification to the medium-light weight threshold to reflect experience in the UK.
>
> AIC 52/1978 (para 2.1) indicated that helicopters such as Sikorsky S-61N or larger, would be counted as medium weight category i.e. a higher category than demanded by MTWA.
>
> Para 5 of the AIC contained information relevant to helicopters. This information was derived from a reported evaluation of Helicopter Wake conducted by NASA Langley Research Centre - NASA TN D-1227 March 1962 and evidence from the UK Wake Turbulence incident data base which had started in 1971. The NASA report, although deemed scientifically inconclusive, together with the evidence, albeit small, from the UK database, led to the Authority's judgement that S-61N and larger helicopters should be placed in the medium weight category. No dedicated evaluations were undertaken in the UK.
>
> Subsequently, in 1981, the UK split the medium weight category into two - a medium and a small category (AIC 81/1981). The lower limit of the original medium category then coincided with the lower limit of the new small category. A further report from NASA Langley - NASA TM-81920

December 1980 supported the earlier report in concluding that a helicopter could produce a wake hazard to following light aircraft that was disproportionately great compared to an equivalent fixed wing aircraft. This report, together with a review of the UK incident database, confirmed that the S-61N and larger helicopters should be retained in the new small category.

It is understood that trials have been conducted more recently in the USA but as yet results have not been published.'

A research programme which began in 1972 addressed the problems of turbulence caused by aircraft wake vortices and included a detailed study of incidents reported by pilots. An analysis of incidents reported under this scheme between 1982 and 1990 was published in 1991 as CAA Paper 91015. During that period about 60 incidents were reported annually, the majority of which occurred on the approach to London Heathrow. None of these incidents involved a helicopter.

On those occasions that arriving aircraft are receiving a full aerodrome control service and are operating visually, the aerodrome controller is required to inform pilots of the recommended spacing. For a light aircraft following an S-61N the minimum distance is 4 miles. However, the recommended spacing criteria as detailed in MATS Part 1, refer to aircraft within the defined 'flight path', ie on take off, crossing tracks and approach and landing. No advice is given concerning the avoidance of turbulence generated by a helicopter that is hovering.

1.17.2 Aerodrome Flight Information Service

Civil Air Publication (CAP) 410 describes the flight information service provided at an aerodrome thus:

'The Aerodrome Flight Information Service (AFIS) is a service provided at an aerodrome to give information useful for the safe and efficient conduct of flights in the Aerodrome Traffic Zone. From the information received, pilots decide the appropriate course of action to be taken to ensure the safety of flight whilst taking off or landing or flying in the aerodrome traffic zone. The service is provided by the holder of an Aerodrome Flight Information Service Officer's Licence which is valid for use at that aerodrome.

The Aerodrome Flight Information Service Officer (AFISO) provides an information service to aircraft that are flying or about to fly within the aerodrome traffic zone and to aircraft moving on the manoeuvring area and apron.

Before landing at an aerodrome, which is notified as prior permission required (PPR), or moving on the apron or manoeuvring area of an aerodrome the commander of the aircraft is required to obtain the permission of the person in charge of that aerodrome. This permission, or refusal of permission, which is passed to aircraft by the AFISO does not imply that a control service is being provided. Any levels passed by aircraft or by the AFISO are for information purposes only.'

1.17.3 Responsibility of AFISO

CAP 410 lists the responsibilities of an AFISO as follows:

'(a) issuing information to aircraft flying in the aerodrome traffic zone to assist the pilots in preventing collisions;

(b) issuing information to aircraft on the manoeuvring area to assist pilots in preventing collisions between aircraft and vehicles and obstructions on the manoeuvring area or between aircraft moving on the apron;

(c) alerting the safety services;

(d) initiating overdue action;

(e) informing aircraft of any items of essential aerodrome information.

Although the AFIS is an information service only, it must be emphasised that the immediate and accurate passing of information could be a vital safety factor when the AFISO becomes aware of a dangerous situation developing within his area of responsibility.'

1.17.4 Special Events

The air traffic operation in connection with the British Grand Prix at Silverstone had been notified to the CAA using the guidance and procedures contained in CAP 403. As in previous years, the CAA Flight Operations Inspectorate required operators of 'Ad Hoc' or green field sites expecting five or more public transport flights in one day to notify such sites before the event. The Flight Operations Inspectorate issued guidance to the effect that that such sites should be licensed and provided with the appropriate level of Air Traffic Service when public transport movements were expected to be in excess of 100 movements. If considered appropriate, the CAA can require that a full Air Traffic Control Service be provided for the event under the conditions of Articles 69A of the Air Navigation Order. These Articles cover the issuing of approval for an air traffic control (ATC) unit, the licensed ATC personnel and the relevant aeronautical equipment therein.

The requirements for flying displays, air shows and any unusual air activities are examined by the CAA Special Events Working Committee (SEWC). The membership of the committee ensures that all aspects of flight safety are represented. The CAA have stated that there are no formal Terms of Reference for the SEWC. It is a twice yearly gathering of interested parties, the aim of which is to discuss the past and forthcoming programme of events, problems which have occurred, to foresee likely problems and to allocate responsibilities and lines of communication for the speedy passing of vital information to prevent the occurrence or recurrence of those problems. The Working Group has no powers.

A full ATC service was provided at Silverstone, and details of the various feeder sites were provided to the CAA, but none of these was expected to generate sufficient traffic to ensure that these sites were treated as Special Events in their own right. Had any of these feeder sites been expected to generate sufficient traffic for Special Event status it would have been incumbent upon the site operator to notify the CAA. As Kidlington is a licensed aerodrome, the use of which requires prior permission, the SEWC were not informed and did not require details of the movements planned for the weekend of 11 to 12 July 1992. In the event Kidlington Airport handled a significant number of helicopters in the 298 movements logged on the day of the accident.

1.17.5 Previous similar accident

On 11 June 1985 at Monmouth County Airport, Belmar, New Jersey, USA, a Cessna 152 on a training flight of 'touch and go' landings collided with a Sikorsky S-76 helicopter that was hover-taxiing alongside the runway. This accident was investigated by the US National Transportation Safety Board and, as the causal factors bear a marked similarity to the circumstances at Kidlington on 12 July 1992, a brief summary is included.

> 'The Monmouth County Airport runway 03 was in use with a light easterly surface wind and good visibility. There is a parallel taxiway to the east of the runway. The Sikorsky S-76 approached the Airport from the south and made an approach to the parallel taxiway and hovered to the upwind end towards a parking area to the east of the taxiway. The flying instructor in the Cessna, who survived the accident, reported that he established visual contact with the helicopter as the aircraft was on the left base leg. The helicopter proceeded to the parallel taxiway in what ground witnesses considered to be a normal approach to land.
>
> The instructor stated that he kept the helicopter continually in sight and that on final approach it was well ahead and to the right. The Cessna made a normal landing and proceeded to take off again. The helicopter was still in sight in the two o'clock position and separation appeared to be

adequate. However as the Cessna lifted off, the instructor realised that the student was having difficulty controlling the aircraft which was banking to the right. He immediately took control and sharply applied full left aileron. The aircraft did not respond and violently pulled further right before eventually colliding with the helicopter's main rotor blades. There was no evidence of any radio message that would have warned the instructor that the helicopter was in the hover. There is no assessment in the report of the distance between the helicopter and the Cessna when the control problems were encountered. However a diagram in the report illustrating the relative tracks of the two aircraft suggests that it was probably in the order of about 800 feet.'

1.17.6 Helicopter rotor downwash and wake turbulence research

Wake vortices are present behind all aircraft including helicopters when in flight and are particularly hazardous to light aircraft with a small wing span during take off, initial climb, final approach and landing. Typical assumed trailing vortex patterns are illustrated in Appendix D Figures 1 & 2. The lack of flight test measurements of helicopter wake turbulence prompted the US Federal Aviation Administration (FAA) to undertake a helicopter wake turbulence programme in the late 1980's. Several different types of helicopter were used during the tests, each equipped with a system that injected oil based smoke into the aircraft wake such that the vortex patterns could be observed. The wake vortices were also probed by light aircraft to obtain a direct assessment of vortex hazard as a function of distance behind the generating aircraft. A typical example of the patterns observed and measured is illustrated in Appendix D Figure 3. An important conclusion from these tests was:

> '...helicopter wake vortices do not descend in the same predictable manner as do those for fixed wing aircraft; the wakes appear to be more buoyant.'

In 1990 the FAA sponsored research into an 'Analysis of Rotorwash Effects in Helicopter Mishaps'. A report, reference DOT/FAA/RD-90/17, was published in May 1991. The stated aim of this analysis was an attempt to determine threshold levels of rotorwash velocity that could result in potential hazards and to determine if critical threshold values of rotorwash velocity could be identified (The illustrations in Appendix E refer). A selected number of accidents was reviewed and analysed but these all involved upsets caused by rotorwash to stationary aircraft or equipment on the ground. There was no data on rotorwash related accidents to fixed wing aircraft in flight although the report does include an analysis of the magnitude of the vortices that will tip over two types of light aircraft parked on the ground (see Appendix F). The report concluded that due to a lack of detailed accident information being available, critical threshold values of velocity could not be identified conclusively. A significant recommendation included in the report was:

> 'Rotorwash flight test data documenting the effects of both wind and manoeuvring near hover should be acquired as soon as possible. The effect of a constant ambient wind significantly increases the potential for rotorwash related accidents (up to some as yet undetermined wind speed). Three common rotorcraft manoeuvres also have the potential to generate higher rotorwash velocities than are measured in a stabilised hover on a calm day. These three manoeuvres are the initial acceleration manoeuvre by a rotorcraft from hover during take off, the final decelerating flare to a hover during landing, and air taxiing. Following the acquisition of these flight test data, rotorwash analysis models should be upgraded to simulate these effects, validated against the flight test data, and documented. Until this recommendation is implemented, questions will continue to exist with respect to the definitions of worst case scenarios in all rotorwash safety analyses.'

1.18 New investigating techniques

Nil.

2 Analysis

2.1 General

The accident occurred in fine weather with no restrictions to in flight visibility. Surface winds were light to moderate westerlies with no previous pilot reports of wind shear or turbulence on the final approach. Post mortem examination of both pilots revealed no medical condition that may have contributed to their loss of control. The engineering examination of the aircraft wreckage revealed no evidence of any pre-impact failure of the aircraft's flight controls. Therefore it may be concluded that, in a late stage in the approach, the aircraft encountered severe turbulence and that this turbulence was generated by the Sikorsky S-61N. It is impossible to establish whether this was residual turbulence which was generated when the helicopter decelerated as it crossed the runway threshold, or active turbulence generated whilst it was hovering and clearing the runway. If, as seems more likely, it was the downwash and turbulance generated during the hovering phase, the surface wind of 270° at approximately 10 knots.would have caused it to drift downwind and directly into the approach path of runway 27 (see Appendix G).

The investigation therefore concentrated on three main aspects. Firstly, the examination of a situation where an experienced flying instructor apparently allowed an approach to continue to such a low level, when presumably he was able to see the helicopter that was clearing the runway ahead. Secondly, an examination of ATC procedures with regard to the safe separation of aircraft in flight. Thirdly, an examination of the current philosophy concerning the dangers of wake turbulence, particularly with reference to that generated by helicopters which may be hovering on or near an active runway.

2.2 Airmanship considerations

Under the circumstances the commander of 'JT' was probably unwise to have allowed the approach to continue to such a low height in view of the close proximity to the runway of such a large helicopter. Following the downwind call from 'JT' stating that it was the intention to carry out a 'touch and go' landing, the AFISO had advised that it was number two in traffic. The AFISO did not advise the type of the aircraft that was ahead, nor was there any reason why he should have done so. The commander, who was an experienced instructor, would most likely have looked out to check the relative positions of aircraft in the circuit . Following the report on final approach for a 'touch and go', the AFISO advised 'JT' to "STAND BY" and advised a departing Learjet to hold its position which was on the taxiway immediately south of the runway threshold. 'JT' did not acknowledge this last transmission but, during the final stages of the approach in the prevailing weather conditions, the pilots should have had no difficulty in seeing both the Learjet, which was at the holding point and the S-61N which either had just cleared or was in the process of clearing the runway to the left. A computer generated simulation of the view that the pilots of 'JT' may have been presented with is included at Appendix G.

Assuming that both pilots in 'JT' could see the S-61N ahead of them, the possible reasons for continuing their approach to such a low level must be considered. It was not possible to determine which pilot was handling the controls during the approach until the initiation of the go around when the accident occurred. Nevertheless, whether it was the instructor demonstrating circuit procedures, or the student being 'talked round' the circuit pattern, it is common instructional technique to allow an approach to continue to as low a height as the instructor considers prudent in the circumstances. In this case the declared intention when downwind was for a 'touch and go' landing. From his experience of flying at Kidlington the instructor would have been well used to seeing and keeping clear of rotary wing traffic that was either hovering or air taxiing at the airport. However, he was probably not so familiar with seeing large helicopters such as the S-61N operating at the airport and he may well have been unaware that it was in hovering flight. The estimated distance of 'JT' from 'PE' at the time control of the aircraft was lost was about 275 metres. The typical wheel height for a S-61N whilst air taxiing is 10 to 15 feet agl. When viewed from a distance and from above by the pilots of any aircraft on an approach to land, it would be virtually impossible for them to distinguish whether the helicopter was on the ground at minimum pitch, when downwash and vortices could be expected to be negligible, or in the hover at high power, when downwash and vortices could be expected to be at the maximum. It is also pertinent that immediately following 'JT's radio message reporting final approach for a 'touch and go', the AFISO advised 'JT' to "STAND BY" and requested 'PE' to "CLEAR THE RUNWAY TO THE LEFT", a request that was acknowledged. It is therefore reasonable to assume that these radio transmissions were received by the pilots in 'JT' and that they expected the S-61N to be well clear by the time that they had completed their approach. At this time the distance of 'JT' from 'PE' would have been considerably more than 500 metres. Given the same conditions, it is considered that many light aircraft pilots would have reached the same judgement and considered it safe to continue an approach to land. The extent of the hazards to light aircraft due to the vortices and downwash generated by a helicopter in the hover do not appear to be widely appreciated.

As a result of the initial investigation into the circumstances of this accident, the AAIB submitted Safety Recommendation No. 92-53 to the CAA on 21 July 1992. It was recommended that: 'The CAA should publish more specific information that will draw the attention of all pilots, ATCOs and aerodrome operators to the potential hazards associated with the atmospheric disturbance generated by heavy helicopters whilst hover-taxiing'. (Recommendation 4.1). The CAA acted upon this recommendation and an entry in the October issue of the General Aviation Safety Information Leaflet highlighted these hazards. In late 1992 The Safety Promotion Section and Public Relations Department of the CAA published a General Aviation Safety Sense Leaflet[1]. This leaflet sets out the hazards associated with wake turbulence and has a complete section on the hazards associated with helicopters; in particular when they are hovering. Nevertheless it is considered that there is still no general awareness of these hazards and it is therefore recommended that an updated version of AIC 77/90 should be published that emphasises the potential hazards of wake vortices and downwash generated by a helicopter whilst in hovering flight. (Recommendation 4.2).

2.3 ATC aspects

The AFIS is a service provided at aerodromes to give information to pilots which is useful for the safe and efficient conduct of flights within the aerodrome traffic zone. From the information received pilots are solely responsible for deciding the best course of action to be taken to ensure the safety of flight whilst taking off, landing or flying in the aerodrome traffic zone. This action includes estimating safe spacing distances that should be maintained from other aircraft operating within the aerodrome traffic zone. Whilst an AFISO is required to transmit information concerning the position of traffic within an aerodrome traffic zone, he/she is not required to advise the recommended minimum safe spacing distances that are advised in MATS Part I for wake turbulence avoidance. In the circumstances of this accident the AFISO, who was busy but not over-loaded, provided all the necessary information required of him. When 'JT' made the final approach call, the AFISO could not respond "LAND AT YOUR DISCRETION" as he was unsure whether or not the S-61N was clear of the runway. He was not aware, nor was he required to be aware, of the guidance and instructions contained in MATS Part I regarding wake turbulence and its avoidance. This would not have been the situation had an aerodrome ATC service been in operation.

When an aerodrome ATC service is provided, the aerodrome controller has the responsibility for issuing information and instructions to aircraft under his control to achieve a safe, orderly and expeditious flow of traffic. Where arriving flights are operating visually, aerodrome controllers are required to advise pilots of the recommended spacing for vortex wake avoidance. Despite this fact, the ultimate responsibility for maintaining safe separation from other aircraft on a visual

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1 Leaflet No 15 [ISSN 0266-1519]

approach for landing rests with the pilot. It would be no more than speculation to consider how an ATCO might have handled the situation, and whether or not this accident might have occurred if an aerodrome ATC service had been in operation. The essential point is whether or not, in the circumstances prevailing, an aerodrome controller might have given 'JT' landing clearance and it is concluded that if, at the time 'JT' called finals, the S-61N was hovering clear of the active runway and outside the defined 'flight path', then an aerodrome controller might well have given landing clearance.

In defining the 'flight path' for vortex wake spacing requirements, MATS Part I includes the definition that:

> 'Hazardous wake vortices begin to be generated when the nosewheel lifts off the runway on take-off and continues until the nosewheel touches down on landing. For vortex wake spacing purposes this phase of flight is known as the 'flight path' of the aircraft.'

This definition clearly relates to the vortices generated by fixed wing aircraft when they are taking off, landing or passing behind each other at similar levels. Whilst MATS Part I includes the requirement that the S-61N and larger helicopters are included in the wake vortex category above that relating to their maximum total weight at take off, the resultant spacing requirements still only refer to flight within the defined 'flight path'. No advice is given on spacing distances that should be applied if a large helicopter is hovering (ie in flight) close to an active runway. In such a situation it would be outside the defined 'flight path'. This is unsatisfactory and the definition of 'flight path' is inadequate. It is therefore recommended that the CAA reconsider the entry in MATS Part I that defines hazardous wake vortices and defines the 'flight path', with a view to amending that paragraph so that the advice is relevant to all types of aircraft, including helicopters that may be hovering close to an active runway. (Recommendation 4.3).

2.4 Special events

The requirement that whenever unusual air activity is planned to take place, the CAA should be notified so that appropriate action can be taken to ensure the safety of the operation is sensible. The air traffic control operation at Silverstone had been notified to the CAA as a Special Event and had been considered by the SEWC. The ATC arrangements at Silverstone for 1992 were, in essence, the same as have been in operation for the past five years, during which no particular problems had arisen. Equally no particular problems had been notified to the CAA by the operators of any of the various feeder sites, either the 'Ad hoc' green field sites or licensed aerodromes. It is important that events of this magnitude are reviewed regularly not only by the CAA SEWC but also by the operators of licensed aerodromes that are in use during such events. It is particularly important that the arrangements for annual events are scrutinised with a view towards safety in the future and not with the intention of determining whether the previous year's arrangements were satisfactory and can therefore remain unaltered. Traffic volume may increase and ATC provisions that were considered satisfactory one year may need to be revised for the following year's event.

High levels of air traffic movements do not present the only problem in achieving a safe, orderly and expeditious flow of traffic. Of equal significance can be the wide variety of aircraft types that may be involved. The unexpected arrival of a large fixed wing aircraft or helicopter at aerodromes that do not have an ATC service and are accustomed to accommodating only small aircraft can cause unexpected problems that may be detrimental to flight safety. In this respect it is considered that the increased level of Sunday flying activity at Kidlington on the day of the accident was not a causal or contributory factor. However, the arrival of the S-61N helicopter, although pre-warned, was an event outside the routine flying training operations that make up a large part of the flying that normally takes place at Kidlington Airport. It is unlikely that either the helicopter's size or the hazards of its wake turbulence and downwash were recognised by the pilots of 'JT' and this is considered to be a causal factor in the circumstances of this accident.

This accident also illustrates the difficulties all aerodrome operators experience of being aware of and prepared for the unanticipated or rare event. In considering ATC factors it would be unrealistic to expect AFISOs to be familiar with aspects which they were never going to use. The management and ATC personnel of aerodromes with an unusual or varied mix of aircraft types are usually aware of the particular factors associated them. This is not the case at aerodromes where such events are rare. The pilots and ATC personnel at Kidlington, for instance are well used to managing a mixture of fixed and rotary wing aircraft. What they rarely see is the presence of a large helicopter, especially in hovering flight. Circulating reminders to aerodromes to draw attention to particular perceived problems is one way of disseminating information. However, if that information is not perceived to be relevant to the unit concerned at the time, the chances of it being absorbed may be reduced. Information on the hazards of wake vortices could, for example form part of the preparation for a special event. It is therefore recommended that the CAA should require the organisers of Special Events, as part of their planning, to draw attention to any unusual features such as a high volume of helicopter traffic that may in general constitute a hazard to flight safety. (Recommendation 4.4).

2.5 Helicopter vortex wake turbulence and downwash

In general terms, wake vortex tends to be associated with large fixed wing aircraft. What may be often overlooked by pilots is the considerable turbulence that is generated by helicopters, particularly when they are hovering. Whereas fixed wing aircraft produce wake vortices only while moving through the air, a helicopter moving slowly or hovering directs downwards a forceful blast of air which rolls outwards in all directions. Whilst the hazards of the wake vortex generated by heavy helicopters in flight have been recognised, and spacing distances adjusted accordingly, the fact that the considerable dangers of turbulence associated with vertical flight do not appear to have been fully addressed by aviation authorities.

Helicopters hovering over an active runway are an obvious hazard to landing aircraft and pilots are unlikely to attempt to land in these circumstances. For the same reasons an ATC landing clearance is unlikely to be issued. However, helicopters hovering upwind of an active runway can also create a hazard but in this case the hazard is somewhat subtle since it is a false assumption to accept that they are unlikely to cause a problem simply because they are hovering at what appears to be a safe distance from the active runway. Whilst some valuable research has been carried out on behalf of the FAA in the US into downwash related accidents to aircraft and equipment on the ground, this research has also identified a lack of data on the effects of surface winds and worst case scenarios. This investigation could find no such data within the UK. The CAA Paper 91015 contains a valuable analysis of wake vortex encounters reported by pilots. The first paragraph in the report's conclusions identifies areas that require further research. It states:

> 'It should be apparent from the preceding sections of this report that, despite all the work that has been done in recent years on the subject of wake vortices, there remains much uncertainty. Aspects of vortex decay such as core bursting are not well understood. Many of the detailed effects of atmospheric or aircraft-related factors on vortex behaviour and lifetime are still uncertain; the data on vortex-related accidents, as opposed to incidents, is (fortunately) rare.'

It is therefore recommended that the CAA, in consultation with interested parties, should develop and implement a research programme into helicopter wake vortex and downwash effects. (Recommendation 4.5). It is further recommended that the CAA should require that for wake turbulence spacing purposes, all large helicopters that are not known to be on the ground, including those hovering, should be treated as in flight and within the 'flight path' as presently defined. (Recommendation 4.6).

3 Conclusions

(a) Findings

(i) The commander was properly licensed, well experienced and qualified to instruct on the PA-28-161 Cadet aircraft.

(ii) The aircraft was correctly loaded, it had been properly maintained and it had a valid Certificate of Airworthiness.

(iii) There was no evidence of any pre-impact malfunction or failure of the aircraft's flight controls.

(iv) At a late stage in the approach for a 'touch and go' landing the aircraft encountered wake vortices or turbulence generated by the Sikorsky S-61N helicopter which, at the time of the accident, was hover-taxiing close to the active runway.

(v) The pilots of 'JT' were probably unaware that the S-61N was carrying out a manoeuvre that required the use of high engine power with consequent strong downwash.

(vi) The AFISO carried out his duties in accordance with the procedures detailed in CAP 410.

(vii) There is no requirement for an AFISO to advise pilots of the recommended spacing distances for wake turbulence avoidance.

(viii) It is doubtful whether the provision of a full aerodrome Air Traffic Control service would have significantly altered the circumstances of this accident to an extent that it was avoidable.

(ix) In all cases, whether advisory spacing distances have been received or not, pilots are responsible for maintaining a safe spacing distance from other aircraft.

(x) There is insufficient knowledge concerning the hazards to flight safety caused by hovering helicopters near active runways.

(b) Causes

The following causal factors were identified:

(i) At a late stage in the approach for a 'touch and go' landing the aircraft encountered wake vortices or turbulence generated by the Sikorsky S-61N helicopter which, at the time of the accident, was hover-taxiing close to the active runway.

(ii) The decision to continue the approach may have been made without realising that a large helicopter was still in hovering flight close to the runway.

(iii) The dangers caused by rotor downwash generated by large helicopters when hovering close to an active runway have not been sufficiently researched. Although helicopter downwash and wake vortex is recognised as being hazardous it may be that such conditions associated with hovering helicopters are not widely appreciated.

4 Safety Recommendations

The following Safety Recommendations were made to the CAA:

4.1 The CAA should publish more specific information that will draw the attention of all pilots, ATCOs and aerodrome operators to the potential hazards associated with the atmospheric disturbance generated by heavy helicopters whilst hover-taxiing.
[Recommendation 92-53]

4.2 An updated version of AIC 77/90 should be published that emphasises the potential hazards of wake vortices and downwash generated by a helicopter whilst in hovering flight.
[Recommendation 93-11]

4.3 The CAA should reconsider the entry in MATS Part I that defines hazardous wake vortices and defines the 'flight path',with a view to amending that paragraph so that the advice is relevant to all types of aircraft, including helicopters that may be hovering close to an active runway.
[Recommendation 93-12]

4.4 The CAA should require the organisers of Special Events, as part of their planning, to draw attention to any unusual features such as a high volume of helicopter traffic that may in general constitute a hazard to flight safety.
[Recommendation 93-13]

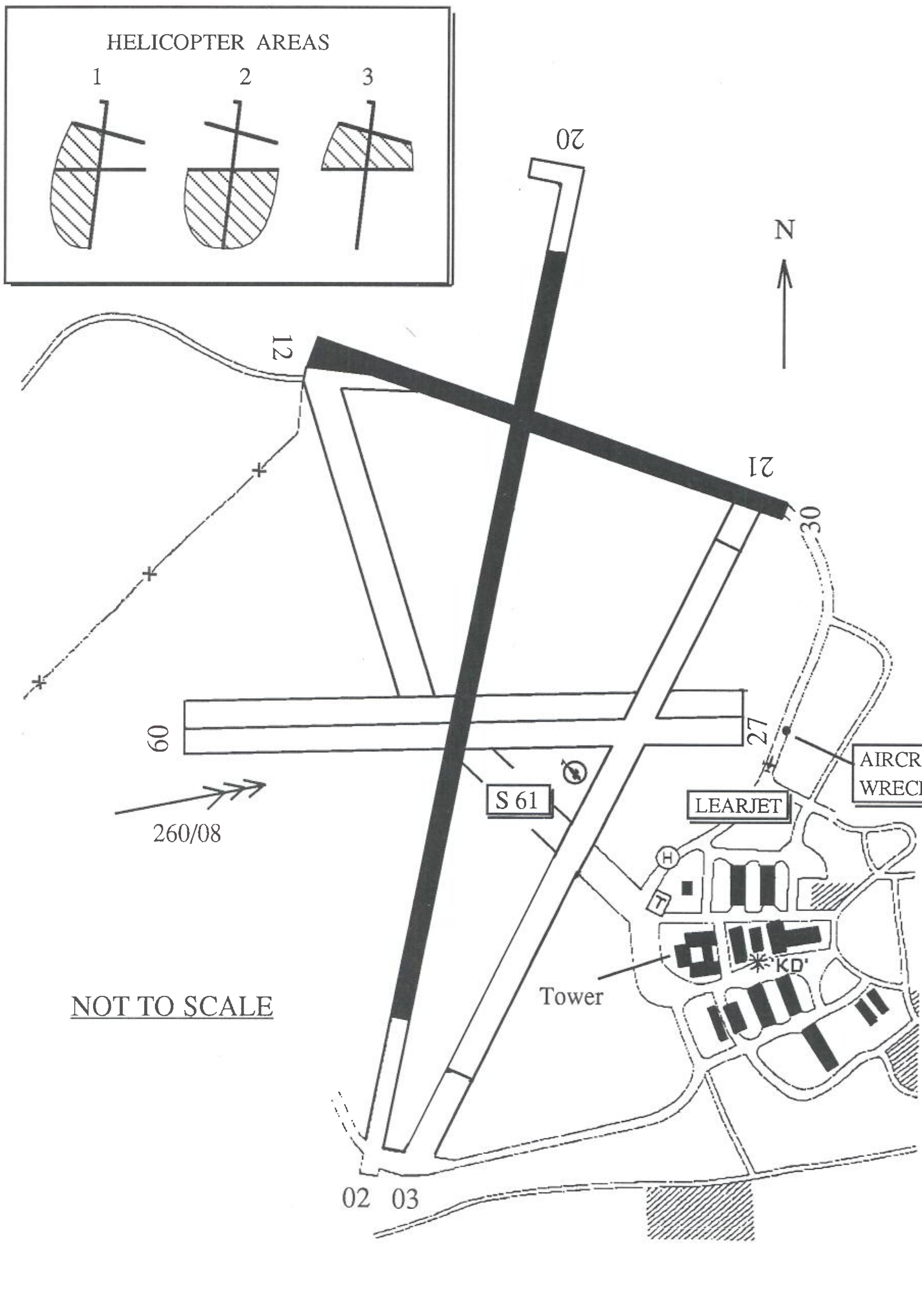
4.5 The CAA, in consultation with interested parties, should develop and implement a research programme into helicopter wake vortex and downwash effects.
[Recommendation 93-14]

4.6 The CAA should require that for wake turbulence spacing purposes, all large helicopters that are not known to be on the ground, including those hovering, should be treated as in flight and within the 'flight path' as presently defined.
[Recommendation 93-15]

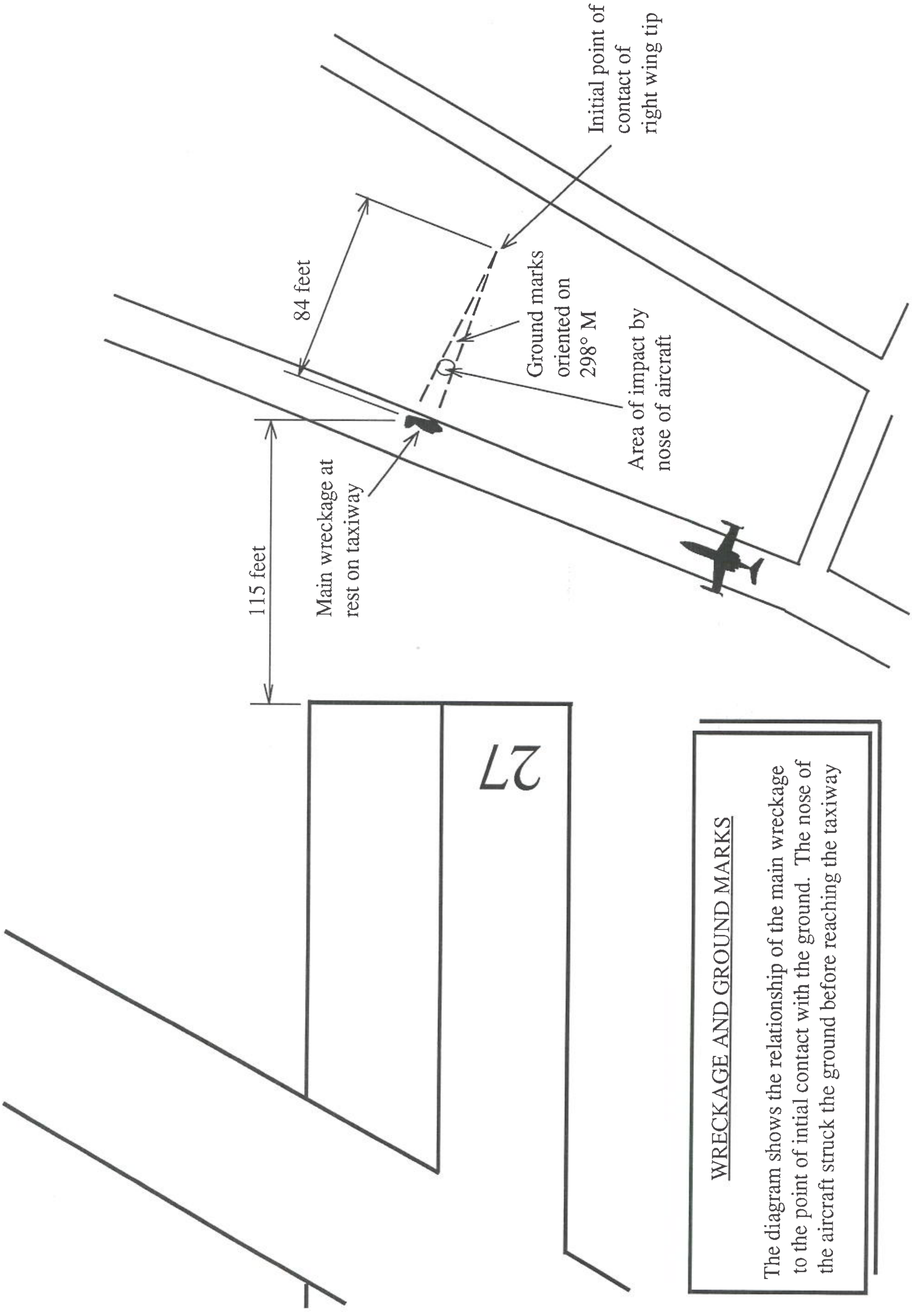
R StJ Whidborne
Inspector of Air Accidents

February 1993

OXFORD KIDLINGTON AIRPORT



APPENDIX B



WRECKAGE AND GROUND MARKS

The diagram shows the relationship of the main wreckage to the point of intial contact with the ground. The nose of the aircraft struck the ground before reaching the taxiway

VORTEX WAKE SPACING

EXTRACTS FROM MANUAL OF AIR TRAFFIC SERVICES PART I

VORTEX WAKE SPACING REQUIREMENTS

The spacing between aircraft, determined either by time or distance, is to be applied so that aircraft of a lower weight category do not fly through the wake of an aircraft of a higher category within the area of maximum vortices. Where minimum separation between IFR flights is greater than the vortex wake spacing requirement then the IFR minima shall be applied. The UK vortex wake categories are listed in Appendix B on page C-3. It should be noted that they differ from the categories used for flight plan purposes.

Flight Path

Hazardous wake vortices begin to be generated when the nosewheel lifts off the runway on take-off and continues until the nosewheel touches down on landing. For vortex wake spacing purposes this phase of flight is known as the 'flight path' of an aircraft.

Arriving Flights

Where flights are operating visually (IFR flights operating under the reduced minima in the vicinity of aerodromes, VFR flights, or a mixture of the two), pilots are to be informed of the recommended spacing.

For other flights the spacing listed below is to be applied between successive aircraft on final approach.

Leading Aircraft	Following Aircraft	Minimum Distance
HEAVY	HEAVY MEDIUM SMALL LIGHT	4 miles 5 miles 6 miles 8 miles
MEDIUM	MEDIUM SMALL LIGHT	3 miles 4 miles 6 miles
SMALL	MEDIUM or SMALL LIGHT	3 miles 4 miles

AIRCRAFT CATEGORIES

SUMMARY OF CONTENTS

This Appendix contains tables of aircraft categories under the following headings:

1 Vortex Wake Categories.

2 Aerodrome Categories for Rescue and Fire Fighting.

1 VORTEX WAKE CATEGORIES

The UK categories differ from the ICAO wake vortex categories used for flight planning purposes. In the UK, aircraft are divided into four categories according to their maximum total weight at take-off as follows:

Heavy:	136 000 kg or greater
Medium:	less than 136 000 kg and more than 40 000 kg
Small:	40 000 kg or less and more than 17 000 kg
Light:	17 000 kg or less

Helicopters generate more intense vortices from their rotors than fixed wing aircraft at the same weight. Therefore Sikorsky S61N and larger helicopters are included in the Small category.

It will be noted that several aircraft types have been grouped in vortex wake categories which do not conform to those listed above. For example, the B707, DC8, VC10 and IL62 have been classified as MEDIUM as experience has shown that the characteristics of these types conform more to that group. Similarly, it has been decided to include the British Aerospace-146 in the SMALL category.

HEAVY

Aircraft Type	*Maximum Take-off Weight (kg)*
Airbus A300B	160 000
Airbus A310 Series	149 000
BAC-SUD Concorde	182 000
Boeing 747 Series	371 000
Boeing 767 Series	151 950
Douglas DC10	251 000
Ilyusin IL-86	206 000
Lockheed C5A Galaxy	350 000
Lockheed L1011 Tristar	222 000

SMALL

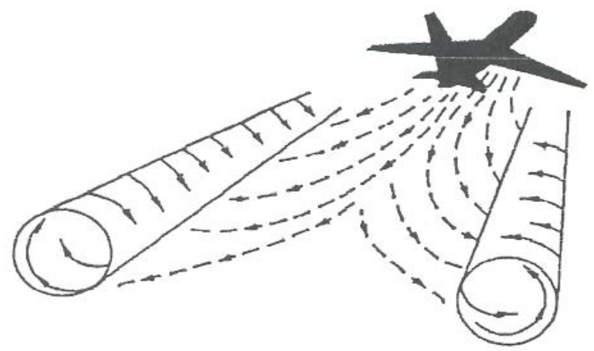
Aircraft Type	*Maximum Take-off Weight (kg)*
BAC Viscount 800	32 600
British Aerospace 146 Series	45 970
Convair CV440	22 200
De Havilland Dash 7	19 500
Fokker F28	29 000
Fokker F27	19 000
Handley Page Herald	19 100
Hawker Siddeley HS748	20 900
Nord Noratlas	23 000
Helicopters	
Boeing Vertol Chinook	
Sikorsky S61N	
Sikorsky CH53E	

MEDIUM

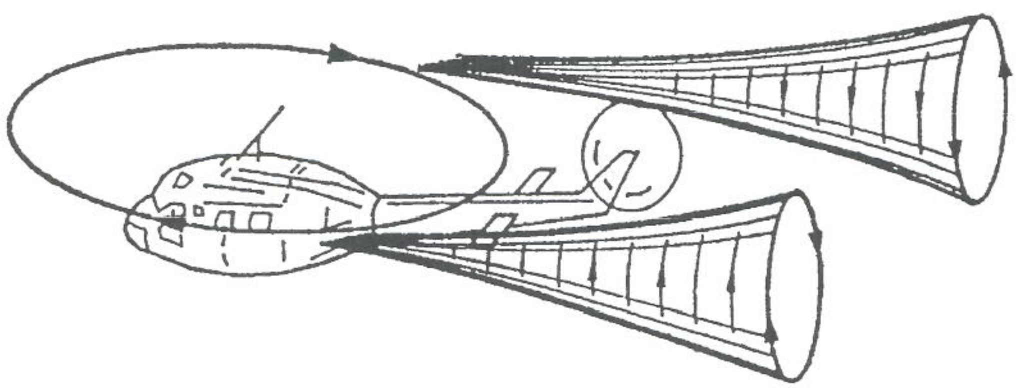
BAC 1-11	45 000
BAC Vanguard VC9	66 500
BAC Britannia	84 900
BAC Super VC10	151 000
BAC VC10	141 000
Boeing 707 Series	161 000
Boeing 720	106 600
Boeing 727	95 000
Boeing 737	52 400
Boeing 757 Series	108 800
Convair CV990 Cornado	114 700
Douglas DC8 Series	161 000
Douglas DC9	54 400
Hawker Siddeley Trident Series	71 670
Hawker Siddeley Argosy	42 100
Ilyushin Il-62	162 000
Ilyushin IL-18	61 400
Lockheed Hercules	70 200
Lockheed Electra L188	51 200
SUD Caravelle	52 000
Tupolev TU134	45 000
Tupolev TU154	

LIGHT

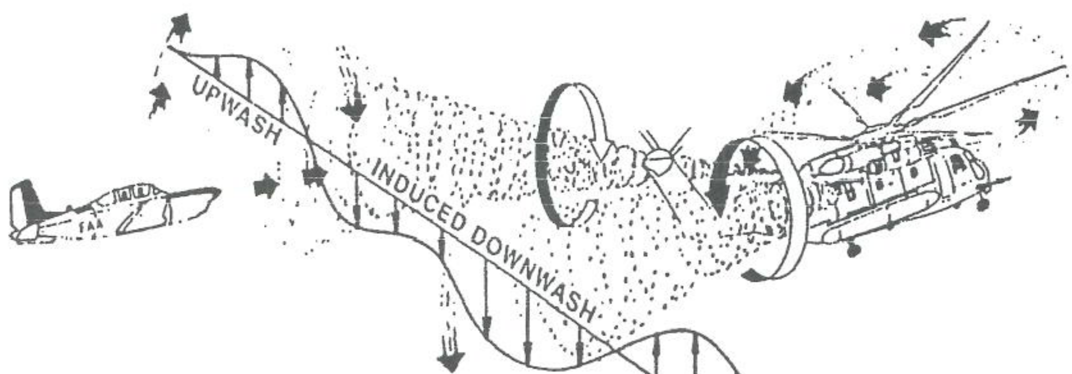
Aero Commander	3 175
Aerospatiale - Aeritalia ATR 42	16 150
Jet Commander	7 257
Beechcraft Kingair	5 667
Britten Norman BN2 Islander	2 993
Britten Norman Trislander	4 500
Cessna 310	2 400
Cessna Citation	5 210
Dassault DA20 Falcon	16 000
De Havilland Dove	3 991
De Havilland Rapide	2 700
De Havilland Heron 2	6 100
Douglas DC3	11 400
Grumman Gulfstream 1	15 921
Handley Page Jetstream	5 700
Hawker Siddeley HS125	11 300
Learjet 25	6 800
Learjet 28	10 600
Nord 262	10 300
Piper Navajo	3 800
Piper Seneca	1 903
Rockwell Sabreliner	10 400
Short SD3-30	10 000
Short Skyvan	4 214
Yakovlev YAK40	16 100
Helicopters	
Aerospatiale Puma	
Bell 212	
MBB BO 105	
Sikorsky S58	
Sikorsky S76	



General view of aircraft trailing vortex system

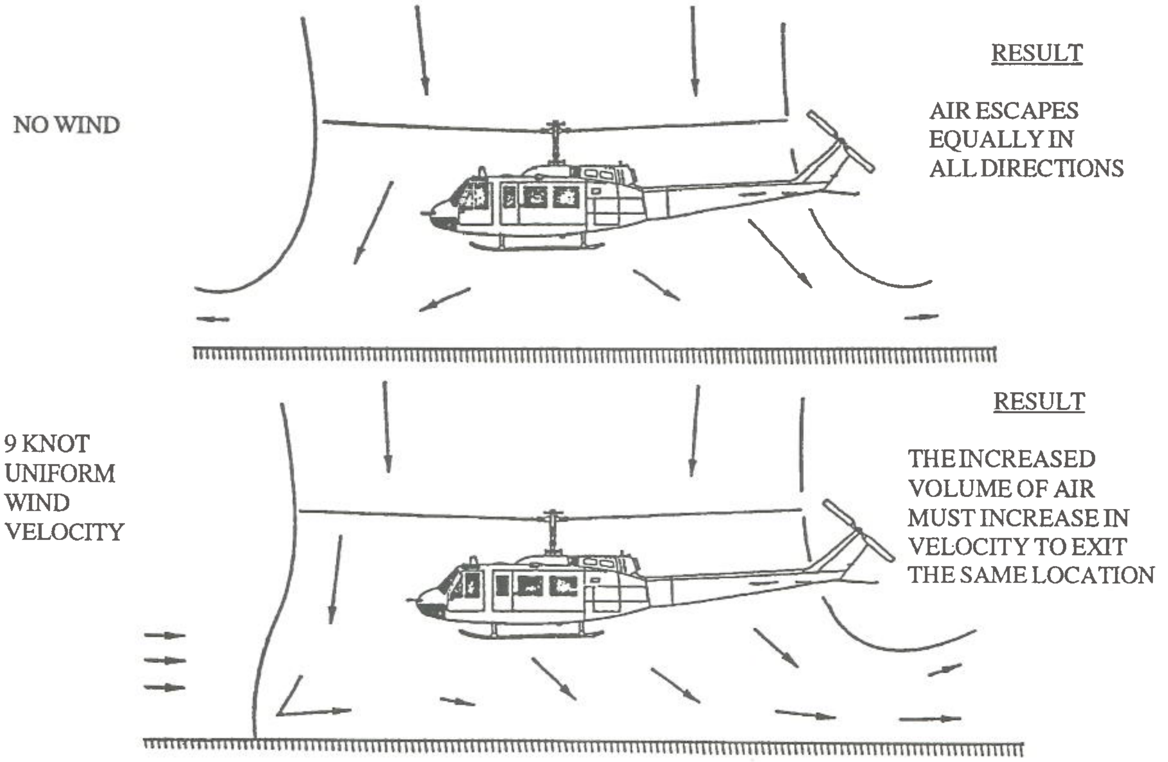


Helicopter Vortices



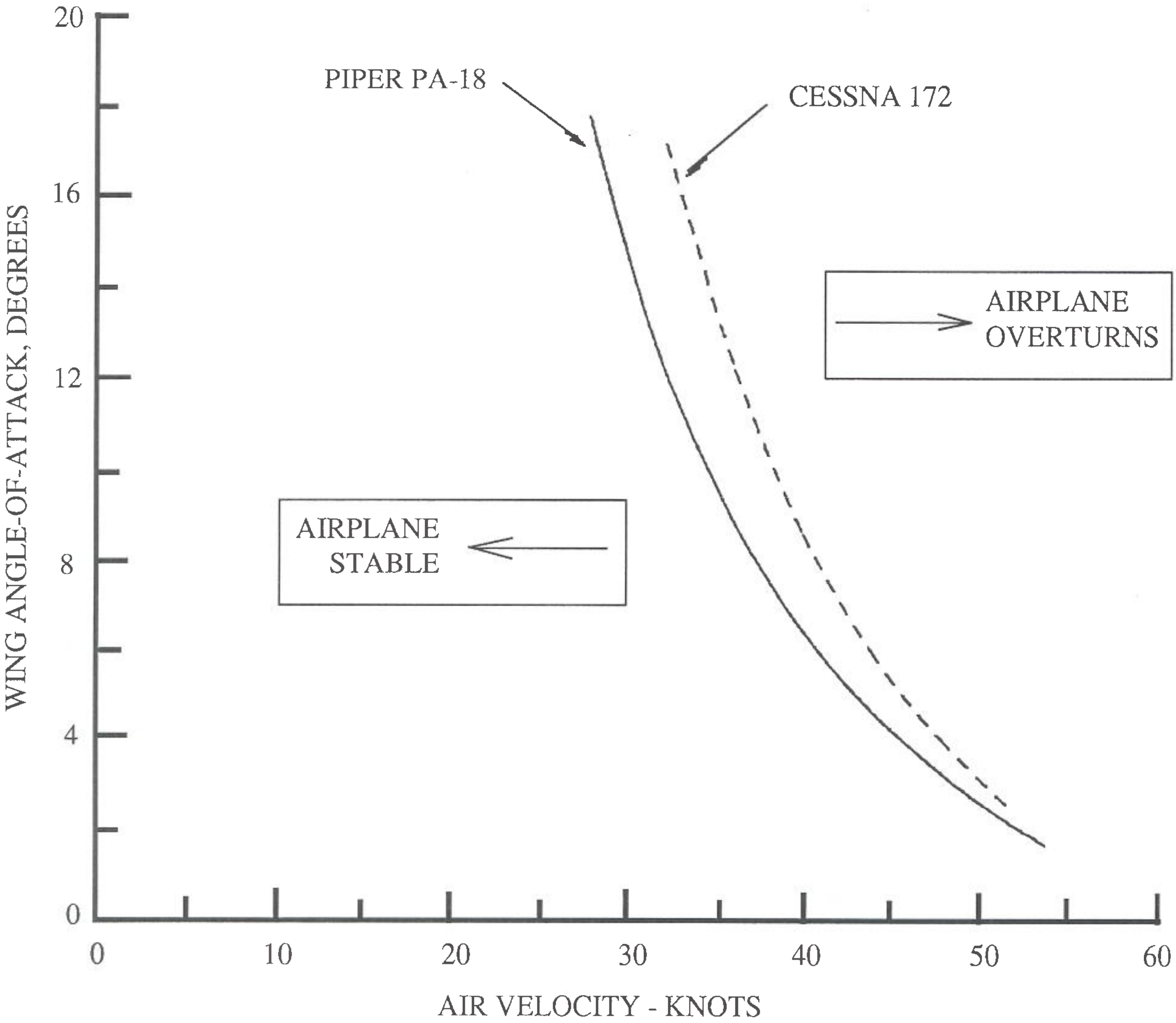
Vortex probing techniques

ROTORWASH AIRFLOW PATTERN DEPICTED OVER WATER

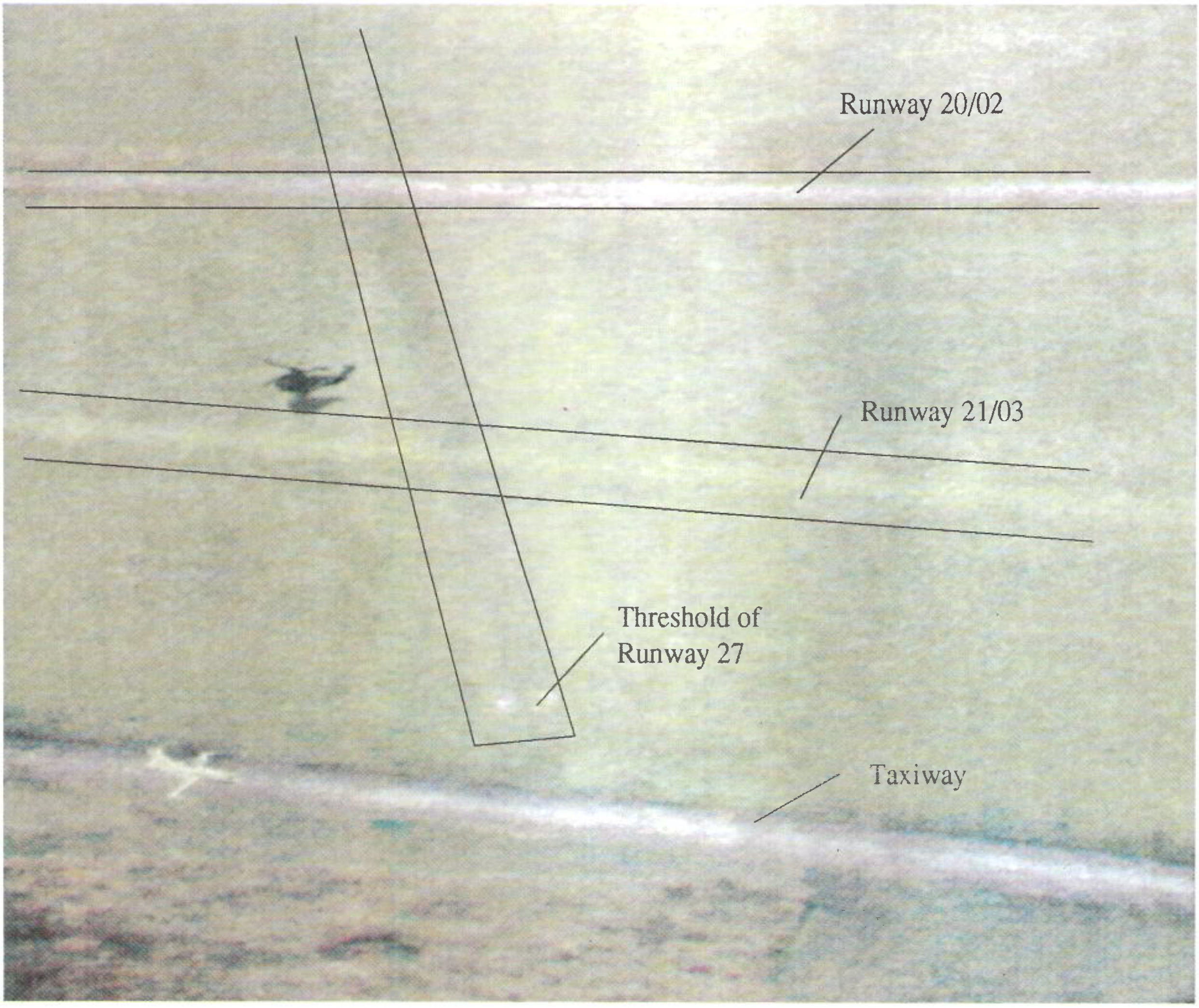


TYPICAL HOVER ROTORWASH FLOW PATTERN CHARACTERISTICS WITH AND WITHOUT WIND

CRITICAL OVERTURNING ANGLES OF ATTACK



MINIMUM AIRSPEED/ANGLE OF ATTACK
REQUIREMENTS FOR THE OVERTURNING
OF LIGHT FIXED WING AIRCRAFT



COMPUTER GENERATED RECONSTRUCTION OF THE VIEW FROM THE APPROACH TO RUNWAY 27 AT KIDLINGTON

This image is reconstructed from an aerial photograph of the accident scene. Using computer techniques the wreckage and rescue vehicles have been removed from the picture and the positions of the S61N and Learjet superimposed, in accordance with witness statements. The aircraft are not necessarily exactly to scale.

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