AIRCRAFT ACCIDENT REPORT 2/99

Air Accidents Investigation Branch

Department of the Environment, Transport and the Regions

Report on the accident to Piper PA-31-350, CN-TFP 3 nm north-west of Jersey, Channel Islands on 12 June 1998

IN CONFIDENCE UNTIL DATE OF PUBLICATION

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Department of the Environment, Transport and the Regions
Air Accidents Investigation Branch
DERA Farnborough
Hampshire GU14 6TD

21 January 1999

Sir Philip Bailhache
The Bailiff of Jersey

Sir,

I have the honour to submit the report by Mr J J Barnett, an Inspector of Air Accidents, on the circumstances of the accident to Piper PA-31-350, CN-TFP 3 nautical miles north-west of Jersey on 12 June 1998.

I have the honour to be
Sir
Your obedient servant

K P R Smart
Chief Inspector of Air Accidents

Department of the Environment, Transport and the Regions
Air Accidents Investigation Branch
DERA Farnborough
Hampshire GU14 6TD

21 January 1999

The Right Honourable John Prescott MP
Secretary of State
for the Environment, Transport and the Regions

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AD(s)	-	Airworthiness Directive(s)
amsl	-	above mean sea level
ATC	-	Air Traffic Control
BHP	-	brake horsepower
CAA	-	Civil Aviation Authority
°C	-	Celsius
EGT	-	exhaust-gas temperature
FAA	-	Federal Aviation Administration (USA)
FL	-	flight level
gall imp/US	-	gallons, imperial or United States
hp	-	horsepower
hrs	-	hours
IFR	-	Instrument Flight Rules
kg	-	kilogram(s)
km	-	kilometre(s)
kt	-	knot(s)
lb	-	pound(s)
mb	-	millibar(s)
MHz	-	Megahertz
nm	-	nautical mile(s)
RPM	-	revolutions per minute
TAS	-	true airspeed
UTC	-	Universal Time Co-ordinated
VFR	-	Visual Flight Rules

Air Accidents Investigation Branch

Aircraft Accident Report No: 2/99 (EW/C98/6/4)

Registered Owner:	RIF AIR S.A.R.L.
Operator:	Ferry pilot
Aircraft Type:	Piper PA-31-350 Navajo Chieftain
Nationality:	Moroccan
Registration:	CN-TFP
Place of Accident:	3 nautical miles north-west of Jersey, Channel Islands Latitude: 49° 14' N Longitude: 002° 18' W
Date and Time:	12 June 1998 at 1842 hrs All times in this report are UTC

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) at 2115 hrs on 12 June and an investigation began the next day at the request of the Deputy Bailiff of Jersey. The investigation was conducted by Mr J J Barnett (Operations) and Mr R D G Carter (Engineering).

The accident occurred when both engines lost power during a ferry flight from Tangiers to Guernsey. The commander ditched the aircraft into the sea near the island of Jersey but he did not survive.

The investigation identified the following causal factors:

(i) The commander had not made an appropriate allowance for adverse headwind components before or during the flight.

(ii) The aircraft was not carrying sufficient fuel for the intended flight.

(iii) The commander apparently ignored pre-flight and in-flight indications that he should land and refuel in France.

(iv) The commander's chances of survival were adversely affected by not adopting the optimum configuration and heading for ditching.

No safety recommendations were made during the course of the investigation.

1 Factual information

1.1 History of the flight

1.1.1 Background

The aircraft was owned by a Moroccan company but had not flown since December 1997. It was offered for sale through a UK based aircraft sales company which had negotiated the sale of the aircraft to an Icelandic company. The aircraft was to be ferried from Tangiers to Iceland where the sale would be completed after delivery to the purchaser. A ferry pilot known to both the broker and the purchaser was contracted to fly the aircraft to Iceland. The pilot (the commander) arrived in Morocco on or about 2 June with the intention of surveying the aircraft and carrying out an acceptance test flight. The need to complete formalities in Morocco created delays and the aircraft did not fly or leave Tangiers until 12 June.

In one of his progress reports to the broker, the commander told him that the aircraft was equipped with nacelle fuel tanks and that these extended the aircraft's capabilities to 8 hours endurance. In the event, no acceptance test flight was carried out and the commander told the vendor that if he discovered any serious technical problems after departing for Guernsey, he would return to Tangiers.

1.1.2 Preparation for flight

Between 0941 and 1000 hrs on the morning of 12 June the aircraft was refuelled. The fuel supplier did not accept credit card payments and the commander was obliged to pay with cash. The supplier stated that the commander had asked for fuel to the value of about 4,000 Moroccan Dirhams to be loaded. The delivered quantity was 725 litres which cost 4,242 Dirhams and it was loaded into the aircraft's various tanks under the commander's supervision. The refuelling company stated that the quantity loaded was insufficient to completely fill all the aircraft's tanks; the wing tanks were filled but there was space in both nacelle tanks. The aircraft vendor stated that there was about 50 litres of fuel remaining in the aircraft's tanks before it was refuelled and so the total fuel quantity on board was in the region of 775 litres. (The capacity of aircraft's tanks was 931 litres - see paragraph 1.6.3). The aircraft vendor also stated that he believed that the commander did not have enough cash to pay for the extra fuel required to fill the tanks; that he told the commander that the left fuel gauge was inoperative; and that he advised him to refuel in France because he had insufficient fuel on board to reach Guernsey. According to the vendor, the commander replied that he would review the need to refuel in France depending on the winds in flight.

1.1.3 The accident flight

The aircraft left Tangiers at 1310 hrs. The commander's IFR (Instrument Flight Rules) flight plan was not accepted by Tangiers ATC (Air Traffic Control) and the commander subsequently departed under VFR (Visual Flight Rules) (For details see Appendix A). Because the flight was eventually conducted under VFR the aircraft's route across Spain and France was not constrained by airway routes and the track flown during the early stages of the flight was not determined during the investigation.

The aircraft was first detected by Jersey's radar at 1751 hrs when it was on a bearing of 188° at 144 nm from the radar head. That position placed the aircraft over the Bay of Biscay a few miles to the north-west of the Ile de Yeu (46° 53'N 002° 37'W) and directly south of Guernsey. From that position until 1824 hrs it maintained a northerly track at an indicated flight level of 108 (approximately 11,000 feet altitude). At 1824 hrs the aircraft began to descend and about two minutes later the commander made contact with Jersey ATC reporting his altitude as 10,000 feet. He was cleared to continue at FL 100 and to route direct to Guernsey. There followed a brief exchange between the commander and ATC regarding the IFR/VFR status of the flight and the commander stated that he would need a long approach into Guernsey. ATC acknowledged this request and issued a Special VFR clearance to the commander and instructed him to descend to FL 50 (approximately 5,200 feet altitude).

At 1830 hrs the commander was cleared to descend to 3,000 feet altitude and at 1833 hrs he was given a radar vector of 010° for positioning towards a long approach at Guernsey. In his reply to ATC's vector instruction the commander stated that he was at 3,000 feet.

Ar 1838 hrs, with some 20 track miles to go to Guernsey Airport, the commander was instructed to turn left onto heading 360°. Having stated that he could see Guernsey, the commander was invited to resume his own navigation but he implied that he would prefer to receive radar vectors. The controller responded with a radar vector of 360° and instructions to descend to 2,000 feet altitude. A few seconds later the commander uttered an expletive followed by the explanation "I THINK I HAVE A FUEL STARVATION ON BOTH ENGINES BUT I HAD ENOUGH FUEL LEAVING, CAN I TURN RIGHT TOWARDS JERSEY TO BE CLOSER TO THE COAST". The aircraft was immediately cleared and given a radar vector of 130° but the commander stated that his engines were spluttering and that he did not know why. He was advised that the surface wind was 290° at 8 kt and he appreciated that should he be able to reach Runway 09, that he would be landing downwind. The aircraft was unable to maintain height and at 1841 hrs the commander stated that he was at 300 feet altitude and would have to ditch in the sea. His final transmission, which included a statement that the aircraft was lost but there had been enough fuel on board, ceased at 1841:34 hrs.

An aircraft which had just departed Jersey Airport was vectored to the position where the aircraft had last been seen on radar and it arrived on the scene within five minutes but there was no sign of either the commander or the aircraft. More aircraft and vessels joined in the search that evening and resumed it the next morning but apart from a few items of floating wreckage and some oil, there was nothing to indicate the location of the aircraft. The wreckage was eventually located on the sea bed; the commander's body was still strapped into the pilot's seat.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	-	-
Serious	-	-	-
Minor / None	-	-	-

1.3 Damage to aircraft

The aircraft was destroyed in its impact with the sea. The fuselage and wings were so disrupted that there was little residual flotation and the aircraft quickly sank. The wreckage was further damaged during the salvage operation.

1.4 Other damage

None

1.5 Personnel information

Commander:	Male aged 49 years
Nationality:	Austrian
Licence:	FAA Air Transport Pilot's Licence issued June 1992
Type Ratings:	Airplane Single and Multiengine Land
Instrument rating:	An instrument rating is a requirement for the issue of an FAA ATP

Medical	First Class dated 18 March 1997 endorsed "holder shall possess corrective glasses for near vision"

Flying experience:	Total all types	≥9100 hours
(see below)	Total on type	unknown
	Last 90 days	unknown
	Last 28 days	unknown

Flying Duty Period	6 hrs 30 mins
Rest period before duty	Unknown

The commander's flying records were probably on board the aircraft but were not recovered; they may have been swept away by the strong currents. The Austrian, Swiss and German Aviation authorities held no licence records for the commander and so his flying and duty hours had to be estimated.

The commander, as a student pilot, attended a flying training course at a military flying school in Austria between 23 May and 18 September 1972. He did not complete the course. The Austrian Air Accident Investigation Bureau made enquiries about the commander's subsequent flying career but nothing substantial was revealed.

On 9 April 1997 the commander updated his licence records with the FAA (probably because he had changed his address) and at that time he stated that his total civil flying experience was 9,100 hours. His FAA licence had no type rating endorsements which indicates that he was not qualified to fly aircraft with a maximum all up weight greater than 12,500 lb. It is understood that much of his flying experience was acquired on small twin-jet and turbo-prop aircraft. He had, however, previously ferried a PA-31 to Iceland for the same broker and customer. He was also working towards a Boeing 747-400 type rating endorsement.

1.6 Aircraft information

1.6.1 General Description

The Piper PA-31-350 Navajo Chieftain is a stretched version of the Piper Navajo, powered by two Textron Lycoming TIO-540 piston engines each rated at 350 hp. Although the engines are turbocharged, the aircraft is unpressurised. There are two seats for pilots and the cabin can contain up to 8 passenger seats. The airframe has retractable landing gear and electrically-driven trailing edge flaps. The flight controls are conventional and manually operated.

CN-TFP was a PA-31-350 which had been built by the Piper Aircraft Corporation in 1975 as serial number 31-7552086. The aircraft was initially delivered to an operator in France and registered as F-BXLD. The aircraft was subsequently registered as TL-AAB (Central African Republic) and F-GNMC.

1.6.2 Restraint harnesses

The manufacturer confirmed from the delivery records that the aircraft was originally delivered, in 1975, with diagonal shoulder harnesses at both flight deck seats. The aircraft vendor in Morocco stated that the aircraft did not have shoulder harnesses, only lap belts, indicating that the shoulder harnesses had been removed at some point.

Because of the aircraft's diverse history, it could not be determined when the diagonal shoulder harnesses had been removed, nor by whom. However, the DGAC in France states that, for aircraft receiving their first Certificate of Airworthiness before 1981, the provision of a diagonal shoulder harness would not be compulsory.

1.6.3 Fuel system

A diagram of the fuel system is shown at Appendix B. In the PA-31-350, fuel is stored in four flexible fuel cells (tanks), two in each wing panel. The outboard tanks hold 40 US gallons (151 litres) each and the inboard tanks each hold 56 US gallons (212 litres), giving a total of 192 gallons (727 litres), of which 182 US gallons (689 litres) are usable.

At some point after delivery, this particular aircraft (s/n 31-7552086) was also fitted with auxiliary fuel tanks in the engine nacelles, using an installation designed by the Nayak Aviation Corporation and approved by the FAA as STC (Supplementary Type Certificate) 13053W. In this installation, each nacelle tank had a capacity of 27 US gallons (102 litres) giving a potential total fuel capacity of 246 US gallons (931 litres). The tanks are of simple welded aluminium construction with, for each tank, a single 28V DC pump transferring fuel into the inboard tank.

1.6.4 Fuel gauging

Two fuel gauges are mounted on the overhead panel, one for the left wing cells and one for the right wing cells. Each gauge has markings of: E (empty), 1/4, 1/2, 3/4 and F (full) to indicate cell contents. The gauges indicate the contents of the respective inboard or outboard cell, depending on which is in use. The contents of the additional nacelle tanks are not gauged.

With the Nayak nacelle tank installation, procedure for transferring nacelle fuel is to wait until the inboard wing cells are less than half full and then to select the nacelle fuel tank pumps to ON. Electrical power to the pumps is indicated by a pair of amber warning lights and transfer is indicated by a slow increase in the contents of the respective inboard cell.

1.6.5 Fuel management and controls

The fuel management controls are located on the fuel control panel at the base of the control pedestal. Located on the panel are the controls for the fuel tank selectors, the firewall shutoff valves and the crossfeed valve. During normal operation each engine should be supplied with fuel from its own respective fuel system but fuel can be crossfed when necessary. The crossfeed valve, firewall shutoff valves, selector valves and electric fuel pumps are all located in the wing roots.

The outboard fuel tanks should only be used in level flight. Take-off, climb, descent and landing should be carried out using fuel from the inboard tanks.

1.6.6 Fuel flow warning lights

Right and left 'fuel flow warning' lights are mounted at the base of the windshield divider post, intended to warn the pilot of an impending fuel flow interruption. These lights are activated by a pair of 'fuel sender' sensing probes mounted near each inboard fuel tank outlet, warning the pilot that the fuel level in that tank is low and fuel flow interruption and power loss could occur.

1.6.7 Aircraft maintenance history

Most of the aircraft's maintenance documents were lost at sea in the accident. However, limited documentation was recovered on the surface and this included portions of the most current aircraft logbook and the logbook for the left engine. These records showed that, up to its final flight, the aircraft had been recorded as operating for 5,253 flying hours and that the left and right engines had, respectively, 1,005 hours and 372 hours since overhaul.

Almost all of the aircraft's 5,253 hours had been accumulated between 1975 and 1986. The left engine logbook showed no operation between May 1986 and September 1994. In October 1994 the aircraft was ferried back to France from the Central African Republic. It then underwent a major (2000 hrs/4 years) overhaul at Marignane in France, including new propellers and a large number of Airworthiness Directives (ADs). Following this work the aircraft was operated for some 58 hours up to its last recorded flight in January 1997, after its move to Morocco. There is no evidence of the aircraft having flown between January 1997 and its last flight, in June 1998. The aircraft had been the subject of a 100 hour/Annual inspection in

June 1997, including engine compression checks, and a 'Visite Semestrelle' by Bureau Veritas, also in June 1997.

A further, and independent, view of the state of the aircraft was provided by a visit from a UK-based engineer in December, representing a potential buyer of the aircraft. The majority of the points raised concerned the exterior and interior finish of the aircraft but the survey also noted the lack of any documentation on the engines over the period May 1986 to September 1994.

1.6.8 Flight Documentation

The aircraft check list was recovered. It was printed in French but the commander was not a fluent French speaker. However, a manufacturer's Flight Manual in English was apparently available on board the aircraft although, like much of the flight documentation, it was not recovered.

1.6.9 Airplane Flight Manual

Page 1-1 of the standard manufacturer's Flight Manual for the aircraft type states within the first paragraph:

> *'Performance for a specific airplane may vary from published figures depending on the equipment installed, the condition of the engines, airplane and equipment, atmospheric conditions and piloting technique.'*

The Manual contains 'Performance' data in Section 8. The data, in the form of charts and tables, were used to calculate a time to climb at 6000 lb weight of 6 minutes to FL 110 using full power. Power tables gave the Manifold Pressures and RPM combinations required to achieve the 195, 230 and 260 BHP ratings for cruising. Chart 8-9 was used to determine the true airspeed (TAS) obtainable for three specified power ratings against density altitude. It indicated a cruising speed of 210 mph TAS (true air speed) at FL110 using 230 BHP power rating with the mixture leaned to best economy. This speed equates to 182 kt. Chart 8-11 was used to determine fuel flow and maximum range at the 230 BHP power setting. Copies of these charts are at Appendix C.

Figures taken from the charts indicated that at 230 BHP the fuel consumption was 30.8 USG/hr (117 litres/hr) and the maximum range available by cruising at FL 110 (without nacelle fuel) was 1,010 statute miles (877 nm) in still air with 45 minute reserve and 1,170 statute miles (1,016 nm) to dry tanks.

The technique for leaning the mixture to best economy at cruise power was covered in Section 6 of the Flight Manual. In essence the technique was to adjust the mixture to achieve peak EGT (Exhaust Gas Temperature).

1.6.10 Airplane Operating Data

The New Piper Aircraft Company were asked to provide performance data for the specific aircraft and weather conditions applicable to the flight. The reply was that the time required to climb to 11,000 feet density altitude would be 6.64 minutes burning 9.2 US gallons of fuel. The Company also stated that, in their opinion, a 3% performance degradation relative to the Performance Chart figures could apply to a well maintained aircraft of the same age as CN-TFP whereas a 7% degradation could be applicable to a poorly maintained aircraft. Using an intermediate figure of 5% degradation, the aircraft's fuel consumption in the cruise was likely to have been 34 US gallons per hour (129.3 litres per hour). The Company calculated the aircraft's endurance to be 5.3 hours.

1.6.11 Aircraft weight and balance

The aircraft's weight at take-off was estimated to be 6000 lb. The centre of gravity was not calculated because it was irrelevant in this accident.

1.7 Meteorological information

There was little significant difference between the Jersey Airport meteorological observations timed at 1820 hrs and 1850 hrs. The 1850 hrs observation was visibility 40 kilometres; a few clouds with bases at 1,500 feet and 1,600 feet above airport level (277 feet amsl) and broken cloud at 10,000 feet. The surface wind was 270°/9 kt and the surface air temperature was 12°C. The QNH (effectively the sea level air pressure) was 1021 mb.

Weather satellite imagery showed no problematic weather over Spain or the Bay of Biscay. The forecast winds and air temperatures at FL 100 for Europe issued by the London World Area Forecast Centre valid for 1200 hrs on 12 June forecast winds from the north-north-west at 15 kt over southern Spain which increased to 20 kt over central Spain. Near the northern coast of Spain the wind direction backed to north-west at 25 kt. The forecast for 1800 hrs showed winds from 290° to 280° at 35 kt between the Spanish coast and the Brittany peninsula, becoming 270°/20 kt over the Channel Islands.

At sea in the search area there was a westerly wind of Beaufort Force 3 (between 7 and 10 kt) with a height difference of 3 to 9 feet between troughs and swells.

1.8 Aids to navigation

The flight plan stated that the aircraft was equipped with standard airways navigation equipment. For the last few minutes of the flight the aircraft was vectored by Jersey ATC using surveillance radar equipment. A listing of the radar data recorded at the Airport was made available to the investigation team. Graphical plots of the data are presented at Appendix D.

1.9 Communications

The commander conversed with Jersey Approach Control on frequency 125.2 MHz. The conversation was recorded and a copy tape with injected time signal was provided to the investigation team. A transcript of the conversation prepared by Jersey ATC is at Appendix E.

1.10 Aerodrome and approved facilities

Not applicable.

1.11 Flight recorders

There was no requirement to carry a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR) on board the aircraft and neither was fitted.

1.12 Aircraft examination

1.12.1 Recovery of the pilot and aircraft

Following the accident, a number of items of aircraft debris and documentation were found close to the last radar position of the aircraft, but with no sign of any occupant. The rapid sinking of the aircraft thus indicated that the pilot was probably still with the aircraft. It was also considered likely that the aircraft would be found close to the final radar position.

Following discussion with AAIB and the Police, the States of Jersey Harbour Office initiated an operation to locate the aircraft, recover the pilot's body and then, if possible, recover the wreckage of the aircraft. The operation commenced on 19 June, using 'side scan' sonar equipment and divers from both Jersey and Guernsey. The sonar equipment was useful in the area to the north-east of the final radar position, with a flat sea bed, but of limited use in the rocky area of the final radar fix.

The first portions of the aircraft were found on 19 June and on 20 June the main section of fuselage was located, at a depth of 25 metres, with the pilot still strapped into his seat. The pilot's body was recovered later on that day, after extensive videotaping of the wreckage in its undisturbed state. On 22 June the States of Jersey tug returned to the spot and recovered the wreckage from the sea bed. The wreckage was put ashore at St. Helier that evening and delivered to the airport where it was examined in detail by the AAIB.

1.12.2 Videotape examination

The videotape recordings of the wreckage made before either the pilot or wreckage were disturbed were helpful in confirming the configuration of the aircraft at impact and the damage caused to the airframe. In particular, the images showed that, at impact, the pilot was restrained by a lap belt only, with no evidence of a shoulder harness or other upper torso restraint. The videotape also showed that the nose of the aircraft had been demolished in the initial impact with the sea, leaving the flight deck seats exposed.

1.12.3 Airframe

The divers' videotape and subsequent examination of the wreckage showed that, at the impact with the sea, all three landing gear legs were in the UP position, with the landing gear doors closed. The wing flaps, which are driven by flexible shafts from an electric motor in the fuselage centre section, were also found in the fully retracted position. This position was confirmed by inspecting the 'Dukes' screwjack mechanisms, which showed no movement from the fully retracted position.

The pattern of the structural damage to the two wings was similar, with almost identical damage to the inboard sections of leading edge and similar failures of the outboard sections of wing. This pattern of damage indicated that the aircraft had struck the sea in a wings-level attitude, with no appreciable bank. As well as the massive damage to the nose section, the tail section of the fuselage was almost detached.

1.12.4 Engines and propellers

The divers were only able to recover the left-hand propeller and engine, which had become detached from the wing. The propeller and engine were intact, with the crankshaft moving smoothly. The lack of damage to the propeller blades and their pitch at impact indicated rotation but very little, or no, power, consistent with fuel starvation of the engine.

1.12.5 Fuel controls and instruments

The position of the handles on the fuel control panel were recorded by the divers and confirmed during later examination. This panel is mounted at the base of the centre pedestal in the flight deck and the disruption to the linkages gave very high confidence that they represented the positions at impact with the sea.

The crossfeed valve was in the ON (open) position and both engine supplies were selected to Inboard (main) tanks. These selections agreed with the positions of the actual valves. The controls for the left and right 'firewall shut-off' valves, also on the central fuel control panel, appeared slightly out of their detents but the front of the fuel control panel had been bent downwards and the linkages and shut-off valves themselves showed that the valves had been open at impact.

Both of the low fuel level electrical sender units from the inboard tanks were tested. Although both had suffered from the corrosive effects of the sea, both produced reasonable resistances in relation to the Maintenance Manual, indicating that the problem with the left-hand fuel contents gauge was in the instrument or wiring.

1.12.6 Fuel tanks

The four wing tanks had been disrupted in the impact and there was no evidence as to the amount of fuel remaining. In contrast, the auxiliary nacelle tanks were better protected and had remained intact. Both the left-hand and right-hand tanks had collapsed under hydrostatic pressure as the aircraft sank, indicating that both tanks contained little or no fuel at that stage. In addition, neither tank showed any of the characteristic 'bulging' on the forward walls, such as occurs when there is a substantial amount of fuel in the tank at impact.

Electrical power was applied to the nacelle tank transfer pumps after they had been removed from the wreckage. Both pumps were affected by salt water immersion but both operated.

1.13 Medical and pathological information

Following the recovery of the pilot's body, an autopsy was performed. The Pathologist's report indicated that the pilot had died of multiple injuries, the pattern of which were consistent with those seen in accidents involving rapid deceleration.

1.14 Fire

There was no fire.

1.15 Survival aspects

The autopsy report indicated death from multiple injuries and it is probable that, had the pilot's harness included some form of 'upper torso' restraint (such as a diagonal belt) that he would have been less injured in the initial impact with the sea. However, with the massive disruption of the forward fuselage and flight deck, it is unlikely that the pilot, who was not wearing a flotation device, would have survived.

1.16 Tests and research

None.

1.17 Organisational and management information

Not applicable.

1.18 Additional information

1.18.1 Practical fuel planning

The aircraft vendor stated that the safe endurance of the aircraft was 4 hours 50 minutes with full wing tanks and 6 hours 15 minutes with full nacelle tanks.

Advice regarding practical fuel planning figures for the PA31-350 was sought from UK based commercial operators of the type. The advice received was for cruising at FL 100 at 180 kt TAS the engines should be set to 2300 RPM and 30 inches Manifold Pressure giving a block fuel consumption of approximately 130 litres per hour.

1.18.2 Ditching advice

Factors to be considered when ditching were taken from the UK CAA Safety Sense Leaflet number 21. This leaflet was probably not available to the commander but similar advice is sometimes published in aviation magazines and books.

1.18.3 Human factors

The commander was unexpectedly delayed in Morocco for several days by the need to complete formalities before he could export the aircraft. During that time he probably incurred unexpected living expenses which may have depleted his local currency to the level at which he could no longer pay cash for sufficient fuel to completely fill the nacelle tanks. Furthermore, on 10 June, two days before he left Tangiers, his daughter was born in Innsbruck.

1.19 Useful or effective investigation techniques

Not applicable.

2 Analysis

2.1 Fuel starvation

Given his calm and unconcerned tone of voice on the radio, it is reasonable to assume that when the commander said "OH S**T" in an anxious tone of voice, it was in reaction to both engines starting to misfire. In his next transmission, a few seconds later, the commander said that he had "FUEL STARVATION ON BOTH ENGINES BUT I HAD ENOUGH FUEL ON LEAVING...." which indicates that he recognised the symptoms of fuel starvation but not the cause. He reinforced this diagnosis in a subsequent transmission when he mentioned that the boost (probably meaning booster pump warning) lights had illuminated.

There is no reason to doubt the commander's own analysis of why both engines had suddenly lost all effective power. The simultaneous onset of misfiring by both engines is symptomatic of a problem common to both. Simultaneous technical failure in the fuel injection or ignition systems of both engines after more than five hours of flight is so remote a possibility that it can be discounted. It is also reasonable to discount induction icing in the ambient atmospheric conditions with fuel injected engines. Consequently there seems no doubt that the engines were being starved of fuel.

The wreckage revealed that the crossfeed cock was open and the inboard fuel tanks were selected when the aircraft ditched (but not necessarily at the time misfiring started). These are reasonable selections under the circumstances and the commander had stated that he had "ALL THE NACELLE FUELS ON EVERYTHING". Therefore, only three explanations for fuel starvation seem likely. They are:

a. There was insufficient fuel on board the aircraft when it took off.

b. Fuel was lost in flight through leakage.

c. There was fuel in one or more tanks which was not available to the engines, either through a technical problem or because the commander had mismanaged the fuel.

2.2 Fuel on board at Tangiers

The aircraft vendor stated that the tanks contained about 50 litres before refuelling. The commander was probably unable to confirm how much residual fuel was in the aircraft, if only because the left fuel gauge was inoperative. However, the fuel quantity he purchased was more than sufficient to fill all four wing tanks and so, at that stage when the fourth wing tank reached full, the refueller asked for instructions from the commander who was present. Since fuel was loaded into both nacelle tanks, the commander would have wanted an equal quantity in each tank. He is likely to have specified to the refueller how much to load into each tank. If he did, then he would have been able to calculate exactly the quantity of fuel on board by adding the quantity loaded into the nacelle tanks to the known capacity of the wing tanks.

The capacity of the wing tanks was 727 litres so, if the vendor's estimate of 50 litres residual fuel was accurate, the total fuel on board was in the order of 775 litres (205 US gallons). Therefore, approximately 50 litres must have been carried in the nacelle tanks. With only 25 litres in each nacelle tank, they would have been just one quarter full.

2.3 Flight planned endurance

Since refuelling was completed at 1000 hrs and the flight plan sent to Jersey by Tangiers ATC was transmitted at 1044 hrs for an 1130 hrs departure, it seems highly probable that the commander knew the aircraft's true fuel state when he submitted the plan. He had earlier told the broker that the aircraft had an endurance of 8 hours with the nacelle tanks but he should have calculated the aircraft's endurance relative to the 775 litres carried and not the potential maximum of 931 litres. Consequently, even if the commander was mistaken about the aircraft's ability to fly for 8 hours with full nacelle tanks, with these tanks a quarter full there was no logical basis for declaring the endurance to be 8 hours in the flight plan.

2.4 Potential for calculation errors

It is difficult to understand why the commander thought the aircraft could fly for 8 hours unless he miscalculated the endurance. In aviation, the variety of units used (eg fuel quantities can be given in litres, Imperial gallons, US gallons, pounds or kilograms) are a potential trap for the unwary when the need to convert from one to another is overlooked or miscalculated. Nevertheless, these units are easily converted using a simple flight navigation computer which every commercial pilot must know how to use before obtaining his licence. The commander may have miscalculated but the vendor's advice to refuel in France should have triggered the commander to re-check his figures.

2.5 Flight planned airspeed

The IFR flight plan submitted by the commander covered a total distance of 884 nm. Flying this distance in exactly five hours as stated in the plan would have required an average ground speed of 177 kt. The flight plan also stated the intention to cruise at 180 kt TAS. The difference between the two is immaterial in practical terms but the similarity between the two figures infers that the commander had made no allowance for wind when he submitted the plan.

Radar data for the cruise portion of the flight north of the Ile de Yeu showed the aircraft's ground speed to be 177 kt on a track of true north. This groundspeed would be consistent with cruising at 180 kt TAS with a wind from 290°/25 kt as per the forecast. Consequently, the commander appears to have adhered to the planned TAS of 180 kt.

2.6 Flight time calculation

The commander's intention to consider the need for a refuelling stop in France in the light of any adverse or favourable wind components en-route indicates that he thought that there may have been sufficient fuel for the flight, but not ample fuel. A study of the forecast weather charts would have shown him that there would be no favourable tailwind components en-route. At best, the forecast winds over the Bay of Biscay would have had a neutral effect on groundspeed but for slightly more than half the flight, between Tangiers and the northern coast of Spain, the average headwind component was forecast to be about 20 kt.

If, for the first 500 nm of the flight there was to be a 20 knot headwind component, the aircraft would be cruising at about 160 kt ground speed. The effect would be to increase the flight time by about 20 minutes. Consequently, the commander should have expected the duration of the flight to be nearer 5 hrs 20 minutes than 5 hours.

2.7 The impact of flying VFR

The more realistic estimate of flight time compares quite closely to the actual flight time. The aircraft took-off at 1310 hrs and had it reached Guernsey Airport, it would have done so at about 1846 hrs giving a total flight time of 5 hours 36 minutes. Although the IFR flight plan was not accepted, the VFR plan was very similar to the IFR plan as far as the Campo Real navigation beacon (CPL) in Spain. Assuming the aircraft followed the VFR planned route to Campo Real and flew from there direct to the position where it was acquired on radar at 1750 hrs, the total flight distance would have been reduced by just 18 nm relative to the IFR plan. Moreover, the average ground speed to the radar acquisition point was 153 knots which reinforces the deduction that the commander was cruising at or about 180 kt TAS with a headwind component of at least 20 kt (possibly slightly more). Assuming also that the commander achieved an altitude close to FL 100 over Spain (it could not be much less because there was terrain above 6,000 feet amsl close to his route), these figures are close enough to the IFR flight plan figures to conclude that refusal by Tangiers ATC to accept the commander's IFR flight plan had no significant effect on the planned fuel consumption or endurance.

2.8 Fuel consumption

2.8.1 Flight Manual performance data

The chart on page 8-9 of the Flight Manual (see Appendix C) illustrates the relationship between TAS and altitude for three cruise power settings. The equivalent of 180 kt is 207 mph and by inspection, the 230 BHP best economy curve results in about 180 kt TAS at 10,000 feet. The chart is valid for 7,000 lb gross weight which is some 1,500lb more than the average gross weight on the accident flight. Consequently, planning figures of 180 kt TAS at 230 BHP would have been reasonable assumptions.

The chart on page 8-11 of the Flight Manual illustrates the aircraft's range in still air conditions, both with and without a 45 minute reserve, based on full wing tanks and 7,000 lb gross weight. It states that with full wing tanks only 182 US gallons is usable and assumes that 5 US gallons is used for taxi and take-off leaving 177 US gals (670 litres) usable fuel for the remainder of the flight. Thereafter, the cruise fuel consumption at 230 BHP is 30.8 US gallons/hr (117 litres/hr). No figures are given for climb or descent fuel consumption.

At 230 BHP chart 8-11 gave a maximum still air range of 1,180 statute miles (1,050 nm) and a fuel consumption rate of 30.8 US gallons per hour which equates to a flight time of 5 hours 45 minutes. The distance of 1,050 nm in that time equates to a TAS of 182 kt which correlates with chart 8-9. If the commander had assumed he would have the use of 50 litres in the nacelle tanks, this would have extended his range and endurance by about 77 nm and 25 minutes respectively. Consequently, based on the performance charts in the Flight Manual, the aircraft's still air range was about 1,127 nm and its endurance was approximately 6 hours 5 minutes to dry tanks. The flight planned distance was 884 nm but an appropriate allowance for headwind components would have increased the equivalent still-air distance to at least 950 nm.

2.8.2 Data validity

The Flight Manual performance chart states the requirement to 'lean to best economy' (mixture). If this leaning is not done properly, or if the engine is badly worn, then fuel consumption for a given power setting will be greater than the stated figures. Moreover, the cruise speeds used in the calculations will have been achieved in a new and aerodynamically 'clean' aircraft, devoid perhaps of the multitude of minor dents, blemishes and radio antennae of an ageing aircraft. Therefore, the aircraft manufacturer's performance data is not, necessarily, applicable to an ageing aircraft.

2.8.3 Performance degradation

Owners and operators of ageing light aircraft are well aware of the need to factor manufacturer's performance data for their particular aircraft. A warning to that effect was placed on page 1-1 of the manufacturer's Flight Manual (see para 1.6.9). In the case of this 23 year old aeroplane which appears to have received minimal maintenance in recent years, significant degradation relative to the Manual figures should have been expected.

According to the aircraft vendor, full nacelle fuel (204 litres) extended the aircraft's safe endurance by 1 hour 25 minutes, which equates to a burn rate of 144 litres per hour. If the vendor's advice was accurate, with the nacelle tanks only one quarter full the safe endurance of the aircraft was no more than 5 hours 10 minutes. On the other hand, the estimate of 5% degradation by the aircraft manufacturer seems more reasonable and results in a cruise fuel consumption figure which is almost identical to the practical figure of 130 litres/hour provided by a UK operator of the same aircraft type.

Had the commander calculated his endurance on the basis of 130 litres per hour, he would have arrived at a practical endurance of 5 hours 24 minutes to dry tanks. When the engines started misfiring, he had been airborne for 5 hours 28 minutes.

2.8.4 Aircraft vendor's advice

Both the aircraft vendor and the commander were English speakers and the vendor's practical knowledge of the aircraft was available to the commander. The vendor stated that the safe endurance of the aircraft was 4 hours 50 minutes with full wing tanks which increased to 6 hours 15 minutes if the nacelle tanks were also filled to capacity. The vendor stated that he advised the commander (verbally) that there was insufficient fuel to reach Guernsey and that he should land in France.

Evidently the commander rejected the vendor's advice; he thought he could reach Guernsey depending on whether or not the winds aloft were favourable. Either he doubted the value of the vendor's advice or he had calculated more favourable figures. He may have obtained fuel consumption figures from another source, perhaps by telephone from another pilot familiar with the aircraft type, but the only official figures available to him were those in the airplane Flight Manual. Having spent 10 days in Morocco, the commander would have had ample time to read the Manual, plan the flight and calculate the aircraft's performance. Nevertheless, the inability of a 23 year old aircraft to match the manufacturer's performance data should have been expected and an appropriate allowance made. In the circumstances, the best advice available was the vendor's.

2.9 Fuel management

2.9.1 Dependable Fuel

Whilst inspecting the aircraft the commander should have discovered that the left fuel gauge was inoperative. Even if he had not noticed this, the aircraft vendor stated that he had informed the commander that it was inoperative. Consequently, the commander had no way of gauging (in flight) the contents of the left wing tanks and the left nacelle tank. He would know if either of the wing tanks was not feeding because he could connect the individual tanks to the left engine but without a fuel gauge, he had no way of knowing whether or not the left nacelle tank contents had transferred to the left inboard tank. Moreover, he had no way of knowing, apart from a roll trim imbalance, that fuel was being consumed by both engines at the same rate. Consequently, the failed fuel gauge for the left side would also have prevented the commander from managing the fuel balance in flight to ensure that each engine had the same quantity of usable fuel available to it. Therefore, it would have been sensible for the commander to operate the flight on the assumption that fuel carried in one or both the nacelle tanks would not transfer.

2.9.2 Nacelle fuel transfer

A full nacelle tank takes 55 minutes to transfer to the associated inboard tank. If there is insufficient space in the inboard tank, when it is full further transfer of nacelle fuel results in it being vented and lost overboard. Consequently, the Flight Manual states that nacelle fuel transfer should not be started before the inboard tank is half empty.

With only about 25 litres in each tank, there would have been no need to wait until the inboard tank was half-empty. The aircraft would have consumed about 50 litres of fuel by the time it reached the top of climb, so provided the commander waited until he was comfortably established in the cruise, there would have been little chance of venting fuel overboard during nacelle tank transfer.

Evidence from the wreckage recovered off the sea bed indicated that the nacelle fuel tanks were empty at impact and both transfer pumps were operable. Consequently, the fuel loaded into the nacelle tanks was probably used by the engines.

2.9.3 Simultaneous fuel starvation

The inability to gauge the contents of the left engine tank group meant that the commander would have had no logical reason to open the crossfeed cock in flight if both engines kept running. There was no evidence of one engine failing before the descent began and if one failed during descent, it seems unlikely that the commander would have continued in such a relaxed manner beyond Jersey Airport. However, if he had appreciated that his fuel state was low, he could have opened the crossfeed cock to feed both engines from both inboard tanks, in order to keep both engines running in case there was a disparity between the remaining contents of each tank. Had he done so, and one inboard tank had run dry, the length of the 'filled' fuel pipework to each engine would have been different when the second inboard tank ran dry. In that situation one engine would have run for slightly longer than the other. However, both engines appear to have started malfunctioning at the same time.

A logical explanation for both engines misfiring simultaneously is that equal quantities of fuel were loaded into the nacelle tanks, that fuel had been transferred from both nacelle tanks and that both engines had consumed the fuel at the same rate. It is possible that in the cruise at 3,000 feet both engines were close to running dry but a small pool of fuel covered the outlet pipes of both inboard tanks. These outlet pipes are located towards the rear of each tank which is the lowest point in level flight. If, when the commander was cleared to descend to 2,000 feet, he lowered the aircraft's nose and these two pools of fuel moved forward, then both tank outlet pipes could have been uncovered simultaneously. Once air was introduced into the fuel injection systems of both engines, they were bound to misfire and without a reasonable head of fuel in each tank, there was little chance of them recovering when the commander attempted to maintain level flight.

2.9.4 Crossfeed cock position

The crossfeed cock was in the open position when the wreckage was recovered from the sea bed. Given the simultaneous fuel starvation of both engines, it is likely that the crossfeed cock was closed until both engines started to misfire and the commander opened the cock in an attempt to restore the fuel supply. This was a sensible action.

2.10 Fuel exhaustion

The flight time achieved was consistent with the flight time expected if the aircraft's endurance was calculated using either the aircraft vendor's advice, the aircraft manufacturer's expectations or another operator's practical data (see paragraph 1.18.1). There was no evidence in the wreckage of fuel trapped in any tank and so it seems beyond doubt that the aircraft's fuel supply was exhausted because the usable fuel had been consumed by the engines.

2.11 Intermediate fuel stop

The attractions of Guernsey to a ferry pilot were cheap fuel, no requirement to employ a handling agent, convenient parking and plentiful nearby accommodation. However, the fuel and airport charges en-route were going to be met by the aircraft purchaser and so the additional cost of refuelling elsewhere was not likely to have persuaded the commander to reach Guernsey at the risk of running out of fuel over the sea.

The commander appreciated before take-off that his ability to reach Guernsey depended on the winds aloft but he pressed on despite adverse headwinds. Time and the navigation equipment on board the aircraft were sufficient for him to determine that his progress was being impeded by headwinds and yet he seems to have bypassed suitable refuelling stops adjacent to his route (eg Nantes). If lack of cash was a potential problem, he could have used his radios to find out whether he could pay for fuel and landing fees by credit card. Nantes Airport accepts credit card payments for fuel and other charges and so he could have landed there to refuel even if he had no local currency. Furthermore, if, as stated on the refuelling invoice, the commander's intended final destination that day was Glasgow, he could have refuelled and reached Glasgow (550 nm from Nantes) without another intermediate fuel stop.

2.12 Fuel quantity indications

Although the fuel gauges commonly fitted to light aircraft are often inaccurate, unless a pilot knows the idiosyncrasies of a specific aircraft, he would be unwise to assume that a fuel tank contains more fuel than is indicated by the gauge.

By the time the aircraft reached the north coast of France, if the right fuel gauge was still working properly it must have been showing empty or almost empty. If it had failed in flight, then the commander would have had no fuel contents gauging. In either case, the commander should have erred on the side of caution and landed at the nearest suitable airport in France.

2.13 Causal factors

Precisely why the commander pressed on towards Guernsey must remain conjecture, but is seems most odd that he did given the vendor's advice about the need to refuel, the inoperative left fuel gauge and his unfamiliarity with the fuel consumption and gauging characteristics of this particular aircraft.

There was simply not enough fuel on board the aircraft when it left Tangiers for a non-stop flight to Guernsey unless the winds aloft significantly augmented the aircraft's ground speed, which they did not.

Evidently the commander ignored all the pre-flight and in-flight indications that he should land and refuel in France. Consequently, the fundamental reason for the fuel exhaustion appears to be that the commander had a misplaced faith in his assumptions or calculations of the aircraft's range and endurance capabilities.

2.14 Survivability

The reasons why the commander did not survive the ditching deserve consideration.

2.14.1 Ditching technique

Conventional wisdom when ditching is that swell direction is more important than wind direction, the imperative being not to ram into the face of a rising swell (effectively a wall of water). Consequently, a landing on water should be carried out along the general line of the swell. However, the second priority is to touch down as slowly as possible. Flaps should be fully extended, landing gear should remain retracted, and if possible, a headwind component will always be preferable to a tailwind component. Ideally, the aircraft should be held off the water, in ground effect, so as to achieve the lowest practicable impact speed.

2.14.2 Ditching direction

The recordings of radio transmissions and radar returns used the same timebase so when the commander announced "I DO HAVE TO DITCH I'M THREE HUNDRED FEET" it was possible to determine that the corresponding Mode C transponder altitude was minus 200 feet. The difference of 500 feet between the altimeter reading and the encoded altitude is illogical, even after allowing for a 200 foot difference between the sea level air pressure at the time (1021 mb) and the encoder's fixed air pressure datum of 1013 mb.

The transcript shows that the commander had earlier acknowledged the appropriate altimeter pressure of 1021 mb before descending to 3,000 feet. Provided that he had set that pressure on his altimeter subscale, the reading of 300 feet above sea level should have been reasonably accurate and so there must have been a calibration error of about 200 feet within the altitude encoding system. This deduction is reinforced by the data recorded when the aircraft was cruising over the Bay of Biscay. There the aircraft should have been flying at a flight level (11,000 feet with the altimeter set to 1013 mb) but the encoded altitude generally read 10,800 feet.

The relevance of the encoded altitude data is that they show that the aircraft descended for another 300 feet after the commander reported his altitude as being 300 feet. Subsequently the radio transmissions and radar returns ceased at much the same time. Consequently, it seems likely that the last radar return was acquired when the aircraft was skimming the wave tops and whilst the commander was transmitting or had just finished transmitting. At this time the radar range and bearing data show the aircraft was still tracking towards Jersey Airport at a groundspeed of about 100 kt.

2.14.3 Ditching configuration

The stalling speed of the aircraft with flaps up was about 80 kt at maximum gross weight which equates to about 66 kt at zero fuel weight. With a tail wind of 8 kt the minimum ground speed would have been 74 kt whereas with a similar head wind it would have been 58 kt. The difference between the two is considerable in terms of kinetic energy to be dissipated on impact.

From a height of 300 feet the commander would have had little time remaining in which to turn onto an appropriate heading. Nevertheless, he could have lowered flap which would have reduced the aircraft's stalling speed by about 7 kt. However, he continued to talk as the aircraft neared the waves, the electrically operated flaps remained up and the last radio transmission was made at wave top height.

The sudden onset of fuel starvation, the three to nine foot swell in the area, the 'flaps up' configuration and the tailwind component were all factors which adversely affected the commander's chances of surviving the ditching.

2.14.4 Previous ditchings

The aircraft manufacturer was aware of only one previous ditching of a Navajo Chieftain. There were two pilots on board, one engine was producing power and the crew had 18 minutes to prepare themselves and their six passengers for the ditching. They all survived but the aircraft sank within one minute of impact.

2.15 Commander's injuries

Although the aircraft had been delivered in 1975 with diagonal shoulder harnesses on the flight deck, at some point in the aircraft's history the diagonal harness had been removed, leaving only the lap belts. This situation was allowable within the French airworthiness regulations as the aircraft had received its first Certificate of Airworthiness before 1983.

However, it is unlikely that the provision of a shoulder harness would have saved the pilot's life. The disruption of the forward fuselage and flight deck was massive from the aircraft's impact with the sea with flaps up and the aircraft travelling downwind. In these circumstances it is unlikely that the pilot, who was not wearing a flotation device, would have remained conscious and the witness and physical evidence is that the aircraft sank rapidly.

2.16 Human factors

The potential for a pilot to suffer from mild hypoxia varies with many factors but medical opinion suggests that the first effects occur between 8,000 and 15,000 feet altitude. Any effect should have worn off by the time the aircraft reached 3,000 feet but the commander's judgement may have been affected during the cruise, particularly at the stage when he decided he had sufficient fuel remaining to reach Guernsey. However, when cleared to descend from flight level 50 (approximately 5,000 feet) to 3,000 feet altitude, the aircraft descended to 2,700 feet (corrected) before climbing back to the assigned altitude. This was probably a lapse in concentration after a long and tiring day. The commander had also suffered a frustrating delay of several days before he was able to leave Tangiers. His departure had been further delayed on the day of the accident by rejection of his IFR flight plan and he had foregone the intended acceptance test flight. Under the circumstances, it would have been natural for him to wish to complete the ferry flight as soon as he could so that he could return home and see his new-born daughter. Tiredness, mild hypoxia, frustration and anxiety may have adversely affected the commander's judgement in the air.

3 Conclusions

(a) Findings

(i) The commander was properly qualified for the flight but he probably had little recent experience of the aircraft type.

(ii) The total fuel on board the aircraft was in the order of 775 litres (205 US gallons)

(iii) There was no logical basis for declaring the aircraft's flight-planned endurance to be 8 hours.

(iv) The commander may have miscalculated his endurance but the vendor's advice to refuel in France should have triggered the commander to re-check his figures.

(v) The commander appears to have adhered to the planned cruising speed of 180 kt True Air Speed.

(vi) Because of forecast headwind components, the commander should have expected the duration of the flight to be nearer 5 hours 20 minutes than 5 hours.

(vii) Refusal by Tangiers ATC to accept the IFR flight plan had no significant effect on the planned fuel consumption or endurance.

(viii) The commander would have had ample time to read the Airplane Flight Manual, plan the flight and calculate the aircraft's performance.

(ix) According to the Flight Manual, the aircraft's still air range was about 1,127 nm and its endurance was approximately 6 hours 5 minutes to dry tanks.

(x) The difference between the vendor's advice and the Flight Manual figures should have alerted the commander to the need to allow for the aircraft's age and condition, and to factor any calculations based on Flight Manual performance data.

(xi) A realistic estimate of the aircraft's endurance was 5 hours 24 minutes to dry tanks. When the engines started misfiring, it had been airborne for 5 hours 28 minutes.

(xii) It would have been sensible for the commander to operate the flight on the assumption that fuel carried in one or both nacelle tanks would not transfer.

(xiii) The fuel loaded into the nacelle tanks was probably used by the engines.

(xiv) The crossfeed cock was probably closed until both engines started to misfire.

(xv) There was no evidence in the wreckage of fuel trapped in any tank.

(xvi) The commander could have reached Glasgow without another intermediate fuel stop if he had refuelled in northern France.

(xvii) If the right fuel gauge was working properly it must have been showing almost empty as the aircraft approached the north coast of Brittany. If it had failed, the commander would have had no fuel contents indications.

(xviii) The sudden onset of fuel starvation at low altitude, the three to nine foot swell in the area, the 'flaps up' configuration and the tailwind component adversely affected the commander's chances of surviving the ditching.

(xix) The shoulder harness had been removed from the commander's seat at some point but it is unlikely that the provision of upper body restraint would have saved his life.

(xx) Tiredness, mild hypoxia, frustration and anxiety may have adversely affected the commander's judgement in the air.

(b) Causal factors

The investigation identified the following causal factors:

(i) The commander had not made an appropriate allowance for adverse headwind components before or during the flight.

(ii) The aircraft was not carrying sufficient fuel for the intended flight.

(iii) The commander apparently ignored pre-flight and in-flight indications that he should land and refuel in France.

(iv) The commander's chances of survival were adversely affected by not adopting the optimum configuration and heading for ditching.

4 Safety recommendations

No safety recommendations were made.

J J Barnett
Inspector of Air Accidents
Air Accidents Investigation Branch
Department of the Environment, Transport and the Regions

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