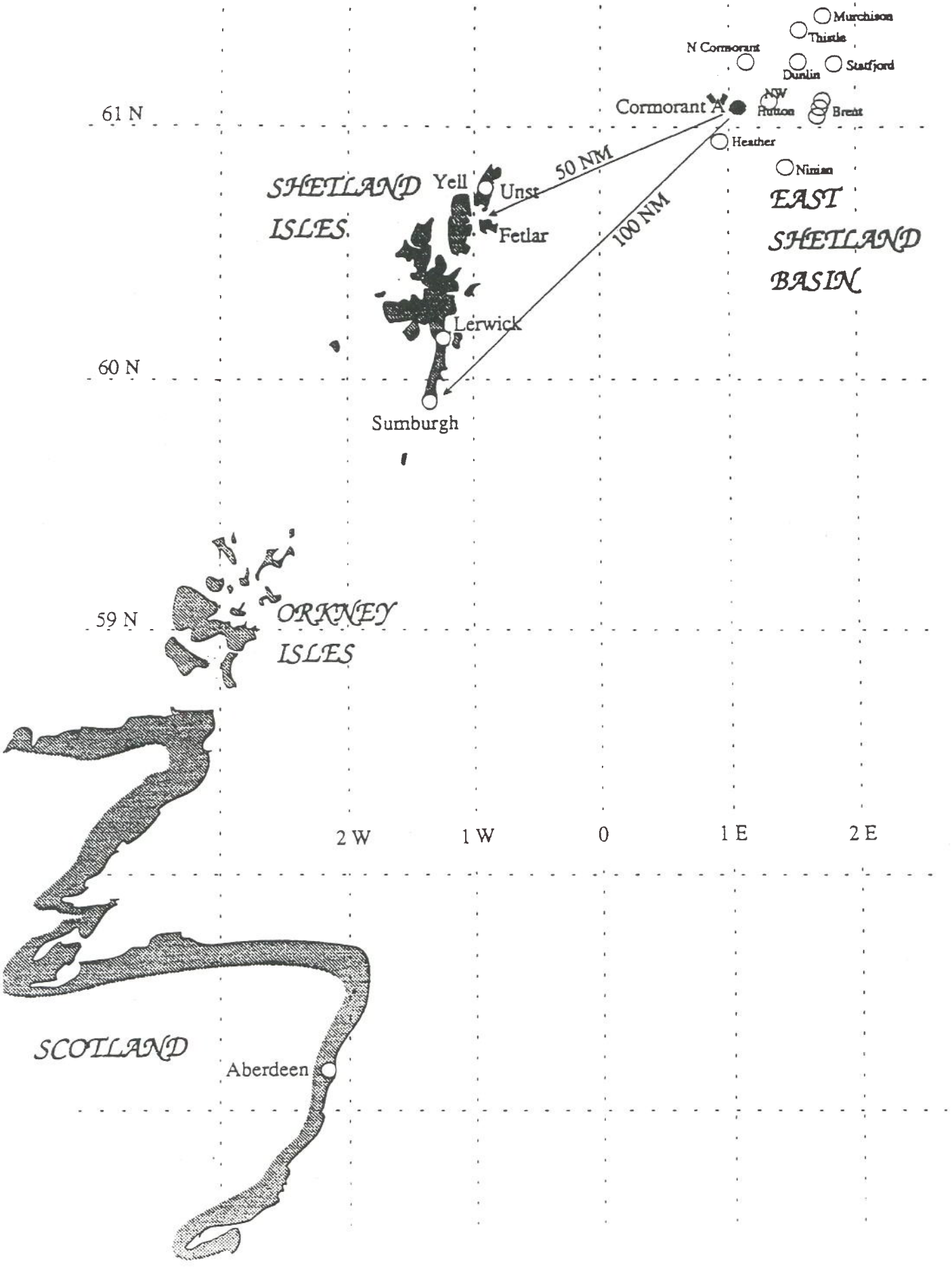
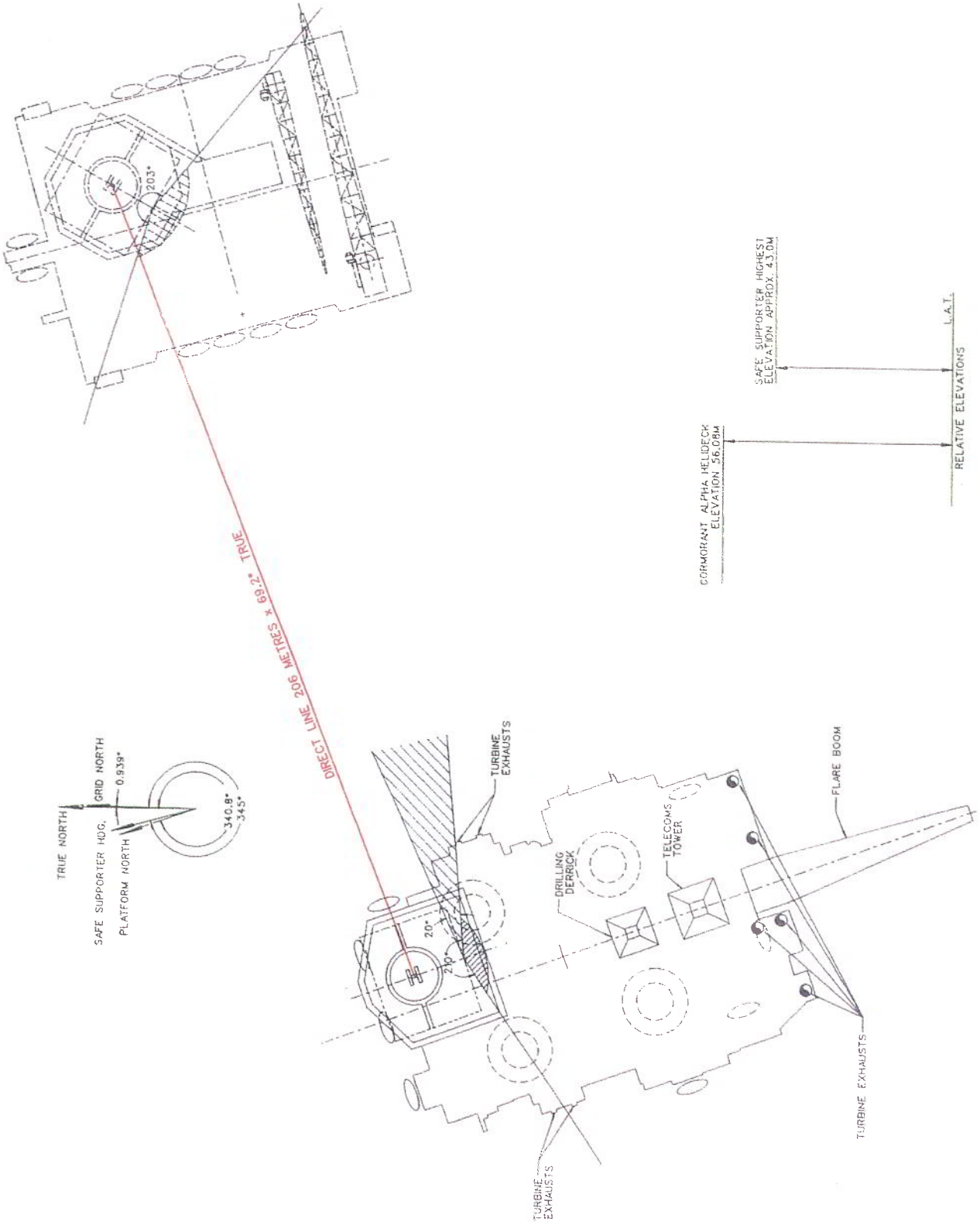
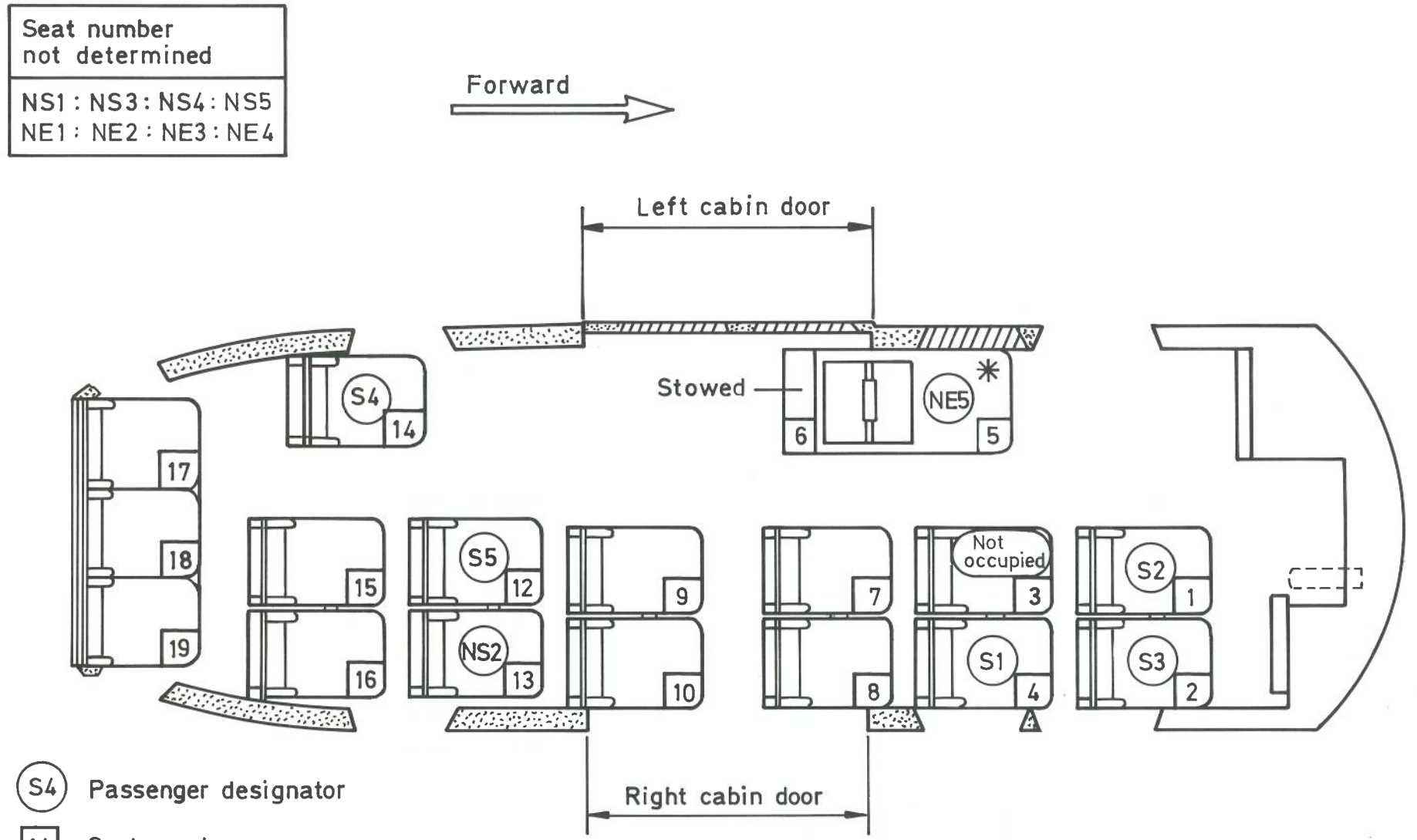
Map of East Shetland Basin





Relative position of Cormorant 'A' and 'Safe Supporter'



Cabin seating arrangement

Figure C1

AS 332L 'escape' window EXIS lighting

Figure C2

Right cabin door G-TIGH

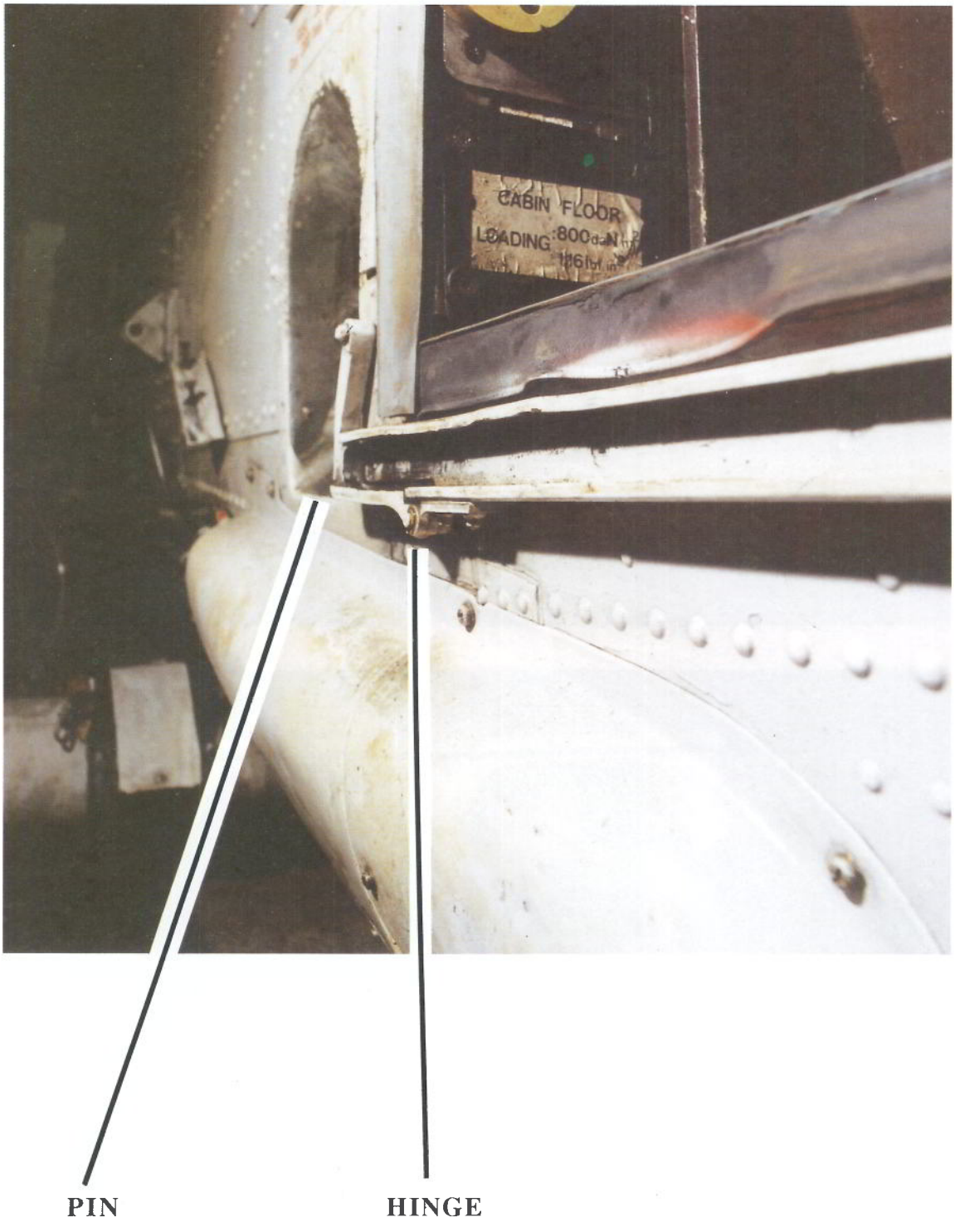


Figure C3

G-TIGH right cabin door, bottom attachment showing emergency jettison mechanism

Meteorological information

1 Data sources

The meteorological information used came from the following sources: Shell UK (Aberdeen); Oceanroutes UK Ltd. (Bracknell); Meteorological Office (Bracknell); Meteorological Office (Aberdeen); Météorologie Nationale (Toulouse).

Meteorological observations are made every hour, every 3 hours or on request (aeronautical and synoptical observations), on a certain number of drilling or production platforms in the various offshore oilfields. For instance, in the Brent oilfield, the platforms form a network operated for Shell by meteorologists working for Oceanroutes UK Ltd on board the Dunlin 'A' platform (61°16'N; 001°07'E). They have complete and modern facilities at their disposal enabling them to observe, to forecast and to radio telecommunicate. Oceanroutes UK Ltd is not an aviation service and their forecasts are not routinely made available to aircraft operations.

2 Pre-flight briefing

When the crew departed from Sumburgh they were given the latest meteorological data for the mainland area and the Dunlin platform, Brent oilfield. Those given below were available to the crew of 'GH' and included this en route wind and temperature forecast chart issued at 1500 hrs and valid for 1200 - 1800 hrs on 14 March 1992:

1000s feet	Direction	Knots	Temp °C
	60° N 000° E		
10	310	35	-29
05	320	35	-17
03	320	35	-12
02	320	35	-09
01	320	35	-06
0.5	320	30	-04
	61° N 001° E		
10	320	25	-29
05	320	35	-17
03	320	35	-11
02	320	35	-08
01	320	35	-06
0.5	320	30	-04

The TAFs[1] and METARs[2] were transmitted, in the following manner:

TAF: Time validity (hrs from - to); Wind (degrees/knots); visibility; cloud (oktas type height in feet).

METARs: add temperature/dew point (°C) and mean sea level regional pressure (mb).

Glossary:

ac	altocumulus	Prob	probability
cb	cumulo-nimbus	Ra	rain
ci	cirrus	Re	recent
cu	cumulus	Sh	showers
Gr	Hail	sc	stratocumulus
Inter	intermittently	Sn	snow
Max	maximum	Tempo	temporarily

Relevant METARs at 1520 hrs were:

Aberdeen: 050/11; 10 km; 1 cu 1800; 3 cu 2400; 7 ac 10,000; +6/-1; 1002

Inverness: 060/20-30; 10 km; RaSh; 2 cu 2500; 5 sc 1100; 6 ci 20,000; +5/-2; 1003.

Kirkwall: 040/16; 10 km; 1 cb 1500; 2 cu 1800; +6/0; 1005.

Sumburgh: 030/21; 10 km; ReSh; 1 cb 1200; +6/-3; 1005; Tempo 4000 m; Gr; 5 cb 1000.

Dunlin platform (Brent oilfield) at 1450 hrs: 300/44-54; 4000 m; SnSh; 6 cb 1500; -3.9/-9.3; 993.3.

Relevant TAFs were:

Aberdeen: 1601; 040/25-40; 10 km; 2 cu 1600; Prob 30 Tempo 1601; 8000 m; Gr; 5 cb 1000.

Inverness: 1622; 050/18-28; 10 km; 3 cu 2000; Prob 20 Tempo 1622; 4000 m; Ra; Sn; Gr; 5 cb 1000.

Kirkwall: 1622; 040/15; 10 km; 3 cu 1500; Prob 20 Inter 1622; 8000 m; 5 cu 1200.

---

1 Terminal Area Forecast issued with a validity of the whole hours shown ie 1601 is from 1600 hrs to 0100 hrs

2 Reports of actual weather present at the time of reporting

Sumburgh: 1621; 030/18; 10 km; 2 cu 1200; Tempo 1621; 030/25-36; 3000 m; Gr; 6 cb 800.

Unst: 1620; 030/18; 10 km; 2 cb 1200; Tempo 1620; 030/25-36; 3000 m; Snsh; 6 cb 800.

Wick: 1621; 040/15; 10 km; 3 cu 1500; Prob 20 Inter 1621; 8000 m. 5 cu 1200.

Dunlin (Brent oilfield): 1322; 340/42-60; 10 km; 3 cb 1000; 5 cu 3000; Inter 1322; 500 m; SnSh; Gr; sky obscured; vertical visibility 300 feet.

Dunlin: 1601; 320/42-60; 10 km; 3 cb 1000; 5cu 3000; Tempo 1601; 500 m; Heavy SnSh; sky obscured; vertical visibility 300 feet; 30% prob Inter 1721; Max 70 kt; 300 m in Heavy Sn; sky obscured; vertical visibility 200 feet.

Dunlin: 1904; 310/45-60; 10 km; 3 cb 1000; 5 cu 3000; Tempo 1904; 800 m Heavy SnSh; sky obscured vertical visibility 300 feet; Inter 1923; Max 75 kt 300 m; Heavy Sn; sky obscured vertical visibility 200 feet; Gradu 2202; 340/40-50 kt.

At 1500 hrs, the Oceanroutes UK Ltd[3] meteorological service also telexed an area forecast for the Shell northern platforms. It was not an aviation broadcast, but was available in the Sumburgh briefing room. It contained the following information:

> 'Warnings: Winds above 40 kt (50 metre level). Heavy snow visibility below 1000 metres at times. Winds (kts):
>
> 10 metre - NW 30-38 with gusts 50, veering NNW.
>
> 50 metre - NW 38-48 with gusts 60, veering NNW.
>
> Waves: Significant ht: 7.0 - 8.0 metres. Maximum ht: 11.0 - 13.0 metres. Period: 9-11 seconds.
>
> Weather: Mainly cloudy with frequent squally snow and hail showers, risk of longer periods of snow at times.
>
> Visibility: 8 - 15 nm lowering 500 metres in snow.
>
> Temp (°C): Around minus 4 falling minus 7 in showers (wind chill) around minus 25.
>
> Cloud: 4-7 oktas cu/cb 800-3000 feet, sky obscured in heavy snow.'

---

[3] Oceanroutes UK Ltd is a privately owned meteorological forecasting organisation for shipping

At 1901 hrs, Oceanroutes UK Ltd issued an urgent update to the forecast for Shell Northern Platforms, valid until 0700 hrs 15 March 1992. Again this was not an aviation broadcast and although its content was announced on the 'Safe Gothia' public address system, it was not passed to the crew of 'GH'. The relevant portions of this broadcast were:

'Polar low (pressure area) is expected to pass close to the area within the next three hours, giving a temporary increase in wind and seas.

Winds (kts):

10 metre: NW 34-40 increasing 48-56 gusts 70, veering NNW and decreasing 30-38 gusts 50 late evening.

50 metre: NW 43-50 increasing 60-70 gusts 80, veering NNW and decreasing 38-45 gusts 60 late evening.'

3 Information gained en route

Whilst inbound to Unst, the crew requested the en route weather from a BIH S-61N which was returning from the Shetland Basin, who informed them that, along their route from the southern end of the Basin, at about 90 nm out on the 090° radial from Unst, "...the (snow) showers were about ten to twelve minutes in duration but otherwise it was quite good.....there's nothing sticking at all, its just snow." When 'GH' departed from Unst, ATC gave the wind as 320°/30 kt.

Upon request, at 1658 hrs, outbound with Sumburgh Radar, they received the Bergen and Stavanger area forecasts:

'*Bergen*: 1800-0300 hrs: Wind: 340°/15 gusting 25 kt; 9 km visibility in snow showers; 3 oktas cumulo-nimbus at 1000 feet; 6 oktas cumulus at 1500 feet; Temporarily 320°/25 gusting 40 kt; 500 metres in heavy snow showers; sky obscured; vertical visibility 400 feet; fog; 2300-0300 hrs: 290°/25 gusting 40 kt; 300 metres in snow; sky obscured; vertical visibility 300 feet.

Stavanger: 1800-0300 hrs: Wind: 330°/22 gusting 35 kt; visibility 10 km; 1 okta cumulo-nimbus at 1200 feet; 5 okta cumulus at 1800 feet. Intermittently; 1000 metres in snow showers; vertical visibility 800 feet. Temporarily; 2000-0300 hrs; 300°/30 gusting 45 kt.'

At 1928 hrs, Viking Approach ATC informed 'GH' that there was a snow shower and a cloud base of about 500 feet at Cormorant 'A'. Then at 1938 hrs, informed them that the wind was 295°/50-53 kt, but that it had generally been 40-45 kt, and that a snow shower was passing through with the wind "gusting a bit". A few seconds later Viking Approach controller said "The direction's steady 295°".

Whilst planning their return flight, at 1920 hrs, the crew were given the Sumburgh weather by Brent Approach ATC:

METAR at 1920 hrs 330°/28 max 38 kt; visibility 6km in snow showers; 5 oktas cumulo-nimbus cloud at 1000 feet; temperature minus 2 °C; dew point minus 5 °C and QNH 1001 mb.

TAF: 1922; 320°/22 max 32 kt; visibility 10 km; blowing snow; 2 oktas cumulo-nimbus at 1200 feet; 3 oktas cumulus at 1800 feet; temporarily 1922; visibility 4000 m in hail; 6 oktas cumulo-nimbus at 1200 feet; intermittently 1922; 330°/28 max 42 kt (although this was passed to the crew, there is no evidence of this wind being included in the TAF); visibility 500 metres in heavy snow; sky obscured.

At 1926 hrs, they were given the Aberdeen weather by Viking Approach ATC:

METAR at 1926 hrs: 310°/21 kt; visibility 10 km; recent snow shower; 1 okta cumulo-nimbus at 800 feet; temperature minus 1°C; dew point minus 4°C; QNH 1005 mb; temporarily; visibility 2000 m with 5 oktas at 1000 feet.

TAF; 1923: 320°/25 max 42 kt; visibility 10 km; 2 oktas cumulus at 1500 feet; temporarily 1923 hrs; 2000 m in snow showers; 5 oktas cumulus at 1000 feet; 20% probability 1921; visibility 800 m in heavy snow showers; 7 oktas cumulo-nimbus at 500 feet; gradually 1922: wind 300°/15 max 25 kt.

4 Expanded general synopsis

4.1 Situation at altitude

Between 14 March 1992 at 1800 hrs and 15 March 1992 at 0600 hrs, the general situation at altitude between 500 and 850 hPa was characterised by a significant low pressure zone over Scandinavia and the ocean up to Spitzbergen. This low pressure zone led an unstable north west rapid flow above the North Sea and the British Islands and a ridge of high pressure over the Atlantic moved towards the British Islands from the west on 15 March 1992 at about 1200 hrs.

Above the East Shetland Basin, the wind and temperature estimation at different levels of pressure and at true altitudes in the evening of 14 March 1992 was the following:

500 hPa (5100 metres): 320°/70-90 kt; - 40°

700 hPa (2700 metres): 320-340°/30 kt; - 22°C

850 hPa (1250 metres): 330°/30-40 kt; - 12°C.

Temperature inversion at high altitude, evaluated from radio soundings at 1200 hrs and midnight was around 500 hPa. The expansion of the strong instability was therefore limited at that level.

4.2 Surface situation

On 14 March 1992 a large low pressure zone extended all over Northern Europe to 85° latitude. The main centre situated West of Cape North at 1800 hrs moved slowly towards the east and filled up slowly. A deep trough over Eastern Europe up to the Black Sea was associated with it.

This deep depression led, on its western side, to a strong unstable northerly flow from the Arctic Ocean to the North Sea. This flow had been established since the afternoon of 13 March 1992, and the sea state had been gradually increasing until the morning of 14 March 1992. The strongest NNW swell arrived in the East Shetland Basin in the afternoon and kept heading towards the accident site.

Over the Norwegian Sea, between 1200 hrs and 1500 hrs, a series of secondary depressions (pressures below 975 hPa) in the form of a deeply unstable trough moved among the general flow. This trough was stopped by the windward Norwegian relief at 1800 hrs. A powerful squall line was associated with this NE - SW trough and passed over the Brent oilfield at 2000 hrs. The cold air at the head of the trough (temperature from -2 to -4°C and dew points from -6 to -10°C) was followed by a strip of warmer air in lower layers which backed from NE around the main low. This did not last past midnight. The trough gradually became out of shape and at midnight a low became separated at 983 hPa south of Bergen. It moved along the western side of the Norwegian Alps. This was caught up by the NW flow south of Stravanger and gradually filled up. It reached the opening of the Skagerrak (990 to 992 hPa) on 15 March 1992 at 0600 hrs.

Another secondary low centered at 997 hPa above Orkney at 1200 hrs passed over the Forties oilfield (995 hPa) at 1800 hrs. It kept moving in the rapid NW flow and at midnight on the 14 March 1992 was located over the Elbe river mouth (995 hPa).

The study of barometric tendencies at 1800 hrs shows a decrease in pressure of -1 to -2 hPa as the secondary low passed over. This situation caused a strengthening of the pressure gradient in the East Shetland Basin which generated an acceleration of the NW flow. Because of the pressure increasing behind the trough (+2 to +4 hPa within 3 hours), this acceleration lasted part of the night until the secondary depressions of the North Sea passed away.

4.3 Conditions during the final flight and the accident

During the short time before the takeoff and during the accident flight, the trough passed over the site. These atmospheric conditions, ruled by the northerly unstable flow established since the previous day, had kept on increasing and, during the day of 14 March 1992, the average conditions at the Brent oilfield were the following:

Wind[4]:	NW/35-45 kt, gusting 50-60 kt
Visibility:	10 km decreased at 1500 to 3000 metres under squalls
Significant weather:	Snow showers or squalls
Clouds:	5 to 7/8 cumulus and stratocumulus at 1000 to 1200 metres (3300 to 4000 feet) temporarily; 6/8 cumulo-nimbus at 150-300 metres (500 to 1000 feet)
Air temperature:	-3 to -4°
Dew point temperature:	-8 to -10°C
QNH:	Decreasing from 993 to 995 hPa to 990 to 993 hPa (average values from east to west)
Sea surface temperature:	+7 to +8°C
Prevailing wave direction:	340° (T)
Significant waves height (H1/3)[5]:	7 to 8 metres
Maximum wave height:	11 to 13 metres
Waves average period:	8 to 10 seconds

From 1700 hrs, these atmospheric conditions were worsening because of the trough drawing near to the site and the strengthening of the pressure gradient.

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4 Wind measurements, direction and force, are made at about the height of 50 to 100 metres; measuring instruments being placed at the top of the derricks or cranes structures

5 The significant height of waves corresponds to the average height of the 33 highest waves out of a sample of 100 waves (H1/3)

According to the observations made on the Brent oilfield platforms and to the general situation, the line squall arrived at:

	NORTH CORMORANT	DUNLIN 'A'	CORMORANT 'A'	BRENT 'B'
Time	1940 hrs	1950 hrs	1955 hrs	2000 hrs
Measured wind	305°/50kt gusting 58 kt	300°/54 kt gusting 64 kt	300°/50 kt evaluated gusting 64 kt	300°/50kt gusting 59 kt
Significant weather		moderate snow fall	snow shower	
Ceiling		1200 feet	500 feet	
Air temperature (T/Td)	-1.1°C	-0.4°C/-2.6°C	-0.1°C	
QNH	994 hPa	989 hPa	(993 hPa)	989 hPa
Sea temperature	+8°C		+7°C	
Sea state: H 1/3	7.90 metres	7.40 metres	9.1 metres	
H max	14.80 metres		12.0 metres	
Period	9.7 seconds	9.2 seconds	10.0 seconds	
Tide			+ 1.40 metres	

The prevailing atmospheric conditions during the flight of the Super Puma, according to the observations of the witnesses present on the Cormorant 'A' helideck (height 55 metres) and by the commander of the G-TIGH, were:

Wind:	NW 50-55 kt, gusting 60-65 kt
Visibility:	Poor in snow storm
Snow:	Violent squall
Icing:	Rime or impacted snow of about 3 mm thickness on the G-TIGH landing gear sponson
Sea state:	Very high

4.4 Rescue conditions

The passage of the trough through the site temporarily increased the gradient until around 2100 hrs, and this was characterized by very frequent gusts 60-65 kt. Then a slow amelioration was noticed, as well as the wind veering north. However, by 0300 hrs on 15 March 1992, when the wind backed to 330°, the speed gradually decreased until it stabilized around 30 kt at about 0900 hrs. At the same time the sea state slowly improved. The squalls lasted until 15 March 1992, with increasing intervals between snow showers and with long bright spells.

The first search and rescue, between 1800 hrs and 2200 hrs, occurred when the atmospheric and marine conditions were at their worst. Later, during the search for and the localisation of the wreckage, the weather conditions improved.

Time (hrs)	1950-2100	2100-0300	0300-0900	0900-1200
Wind	320°/50-55 kt	340-360°/ 40-45 kt	360-330°/ 35-30 kt	320°/30 kt
(Derrick height)	gusting 60-65 kt	gusting 55 kt then 50 kt	gusting 45-40 kt	gusting 40 kt
Ceiling	1500 to 2000 feet	1500 to 2000 feet	2000 to 3000 feet	
	800 feet under Cb	800 feet under Cb	tempo 1200 feet	
Air temperature (T/Td)	-2 to -3°C/ -3 to -1°C	-3° to -4°C/ -2 to -5°C	0 to +3°C/ -2 to -4°C	+3 to -5°C/ -2 to -4°C
QNH	993 hPa	991 to 996 hPa	997 to 1005 hPa	1005 to 1009 hPa
Sea temperature	+7 to +8°C	+8°C	+8°C	+8°C
Sea state H 1/3 H max period	 8 metres 12 to 14 metres 9 to 10 secs	 7 metres 12 metres 9 to 10 secs	 6 to 5 metres 11 to 10 metres 9 to 10 secs	 5 metres 7 metres 8 to 9 secs

5 Summary of wave patterns

The wave heights and the wind force at the 10 metres reference height are closely connected. On the platforms the wind measurements are made between 50 and 100 metres. Correction formulae are frequently used to determine the wind speed at 10 metres, using the measured or estimated values at a different height. The wind and sea parameters at the 10 metres reference height are then reconstructed from the observations and measurements made in the case of storm and strong instability. Violent and frequent gusts as well as the height of waves have to be taken into account.

5.1 14 March 1992

Until the evening, the prevailing average conditions at about 10 metres on the Brent site were:

Wind:	NW/30-35 kt, gusting 40-45 kt
Waves:	Significant height: 5 metres
Period:	8 to 10 seconds

Swell:	Direction: 340° true North
Significant height:	7 to 8 metres
Maximum height:	11 to 13 metres
Period:	10 seconds

At 1940 hrs at North Cormorant, the superimposition of phases of the wind, sea and swell led to the conjunction of depths and crests, where the maximum height of waves reached 14.80 metres, and at 1955 hrs at Cormorant 'A' where the significant height was 9.10 metres.

5.2 Search and rescue

According to the 10 metres height reference, the wind conditions on the site during the night of the 14 March 1992 and the morning of the 15 March 1992 were the following:

Time period (hrs)	1950 - 2100	2100 - 0300	0300 - 0900	0900 - 1200
Wind:	320°/40-44 kt gusts 50-55 kt	340°-360°/ 32-36 kt gusts 45 then 40 kt	360-330°/ 30-25 kt gusts 35 kt	320°/25 kt gusts 30-35 kt
Wind sea: H 1/3	6-7 metres	6 metres	5 then 4 metres	3 metres
H max	10 metres	9 metres	7 metres	4-5 metres
period	9-10 sec	9-10 sec	9 then 8 sec	8 sec
Swell: Direction H 1/3 H max Period	 340° 8 metres 12-14 metres 10 seconds	 340° 8 - 7 metres 12 metres 10 seconds	 340° - 360° 6 metres 11 then 10 metres 9 - 10 seconds	 340° - 360° 5 metres 7 metres 8 - 9 seconds

Extract of cockpit voice recording

TIME TO IMPACT	FROM	TO	INTELLIGENCE	REMARKS
	P1		THERE'LL BE A LITTLE BIT OF TERN STUFF BUT THAT'S ALL - ERM - GO AND HAVE A PIDDLE AND THEN IF I - I'LL FLY IT FROM HERE DOWNWARDS	
	P2		YEH	
	P1		BY DOING A RIGHTHAND CIRCUIT POSITION YOU ON A FINAL	
	P2		FINE	
1:54	P1		TO DO IT - TO SAVE A BIG LONG LOOP ROUND	
	P2		OKAY - YEH	
	P1		THAT WAY - AND THEN GO THROUGH THE TURBULENCE	
	P2		GOOD	
	P1		ERM THAT'LL PROBABLY	
	P2		YES	
	P1		THE QUICKEST WAY	
1:44	P1		SO YOU GOT THAT	
	P2		OKAY	
	P1		I HAVE CONTROL	
	P2		YOU HAVE THE AIRCRAFT	
	P1		(THESE ?) OFF	UNCERTAIN WORD
	P2		AH GOT TO SAY HELLO TO THE GUYS	
1:39	P1		OKAY CAN YOU SEE IF THEY'VE GOT THEIR HATS ON	
1:34	P2		YEP THEY'RE ALL IN	
	P1		HELLO GENTS JUST MAKE SURE YOU HAVE YOUR SEAT BELT FASTENED PLEASE KEEP YOUR HEADSET ON MAKE SURE YOU KNOW WHERE YOUR NEAREST EMERGENCY EXIT IS HOW TO GET TO IT HOW IT WORKS	
1:18			LITTLE BIT BUMPY AND IT WILL BE BUMPY GOING ON TO THE SUPPORTER IT'S MOVING AROUND A BIT I'M GOING TO SWITCH THE CABIN LIGHTS OFF NOW SO WE'VE GOT A BETTER VIEW FORWARD THANKS A LOT	
1:08	P1		RIGHT YOUR CALL I'LL DO THE CHECKS (LEAVE THEM)	
	P2		AH OH YEH WE'RE WITH THE VIKING NOW OF COURSE	
	BHL790		VIKING ER SEVEN ZERO NINE I'M READY TO LIFT THE CORMORANT FOR SAFE SUPPORTER WITH SEVENTEEN SOULS	
	VIKING		REPORT ON THE SUPPORTER	
1:02	BHL 790		WILL DO SEVEN NINE ZERO	
	P1		OKAY	
	P2		YEH	

TIME TO IMPACT	FROM	TO	INTELLIGENCE	REMARKS
55 SECS	P1		LIFTING	
	P2		OKAY	
51 SECS	P2		YEH ITS LOOKING GOOD - (PHAAW) THIRTEEN DEGREES OF PITCH IF THAT - ALL LOOKING GOOD - YOU GOT FIFTY KNOTS OF WIND ALREADY	
	P1		CAN YOU TURN THE FLOODS OFF	
	P2		THE FLOODS ARE GOING OFF NOW	
	P1		THANKS - COMMITTED	
31 SECS	BHL 790	SUPPORT	SAFE SUPPORTER HELIDECK SEVEN NINE ZERO FOR DECK CLEARANCE	AVAD CHIMES ("CHECK HEIGHT")
27 SECS	SUPPORT	BHL 790	SEVEN NINE ZERO SAFE SUPPORTER (GOOD EVENING) DECK IS CLEAR	
	BHL 790	SUPPORT	DECK CLEAR THANKS	
			(AT ?) ONE HUNDRED PLEASE	UNCERTAIN WORD
	SUPPORT	BHL 790	AND SEVEN NINE ZERO SAFE SUPPORTER JUST FOR INFORMATION PITCH IS FOUR DEGREES ROLL IS FIVE DEGREES HEAVE UP TO FOUR METRES	
	P2		I DIDN'T HEAR THAT	
	P1		NO NOR DID I	
	VIKING	SUPPORT	YOU'RE UNREADABLE WAS THAT PITCH AND HEAVE FIVE AND FIVE	
3 SECS	SUPPORT	VIKING	PITCH FOUR DEGREES ROLL FIVE DEGREES HEAVE UP TO FOUR METRES	AVAD CHIMES ("ONE HUNDRED FEET")
	P2		WATCH THE HEIGHT	(TRANSMITTED
	P2		WATCH THE HEIGHT	SIMULTANEOUSLY
	P2		WATCH THE HEIGHT	WITH P2
	P2		WATCH YOUR HEIGHT	INTELLIGENCE)
	P2		WATCH YOUR HEIGHT	
				IMPACT
0				

Extracts from Flight Data Recorder

The following Figures show extracts of the recorded data from the Penny and Giles Model 900/D51506 Combined Voice and Data Recorder and derived information:

Figure F1 and F2	Flight Data Recorder plots from before lifting from the helideck to the end of data, showing some of the recorded parameters.
Figure F3	Track plot derived from recorded accelerometer data, showing magnetic heading of the helicopter along the track and the limit of cockpit visibility of 135°M from the recorded heading.
Figure F4	Three-dimensional trajectory plot of the final flight path showing the time in seconds to end of data, and relevant comments from the audio data.
Figure F5	Plot showing airspeed and ground speed from before lifting to end of data, with recorded IAS, recorded RNAV ground speed, derived ground speed from accelerometer data, derived airspeed from accelerometer data and estimated wind speed and direction, and ground speed derived from recorded IAS and estimated wind speed and direction.
Figure F6	Plot of vertical flight path profile from before lifting to end of data, showing derived flight path from accelerometer data, recorded radio height which was corrected for the height of the helideck, and recorded pressure altitude corrected for the mean sea level pressure.
Figure F7	Plot of vertical speed from before lifting to the end of data, showing vertical speed derived from accelerometer data, vertical speed derived from radio height, and recorded pressure altitude rate.

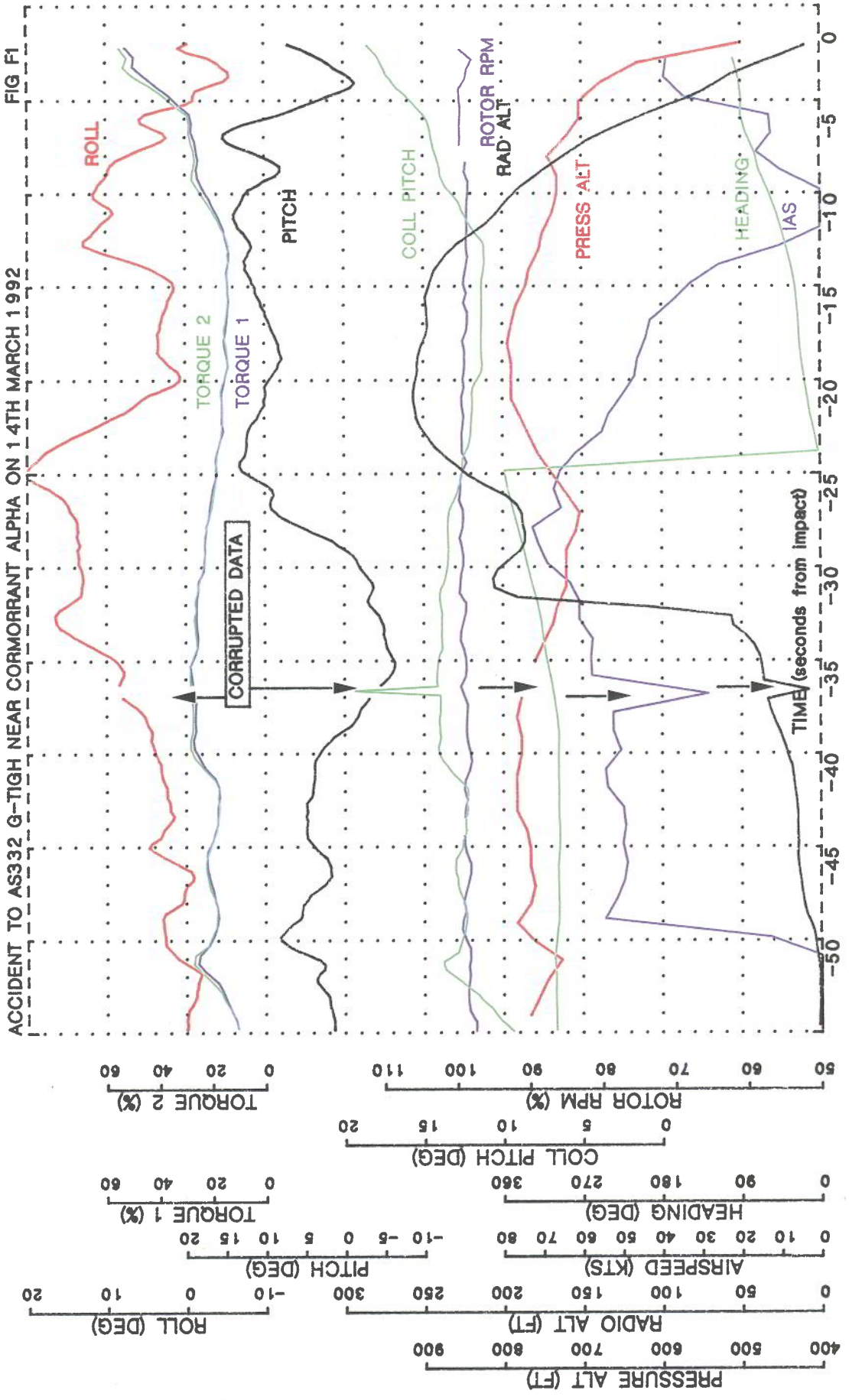


FIG F1
ACCIDENT TO AS332 G-TIGH NEAR CORMORRANT ALPHA ON 14TH MARCH 1992
ROLL
TORQUE 2
TORQUE 1
PITCH
CORRUPTED DATA
COLL PITCH
ROTOR RPM
RAD ALT
PRESS ALT
HEADING
IAS
TIME (seconds from impact)
0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
ROLL (DEG)
PRESSURE ALT (FT)
RADIO ALT (FT)
AIRSPEED (KTS)
HEADING (DEG)
PITCH (DEG)
COLL PITCH (DEG)
ROTOR RPM (%)
TORQUE 1 (%)
TORQUE 2 (%)

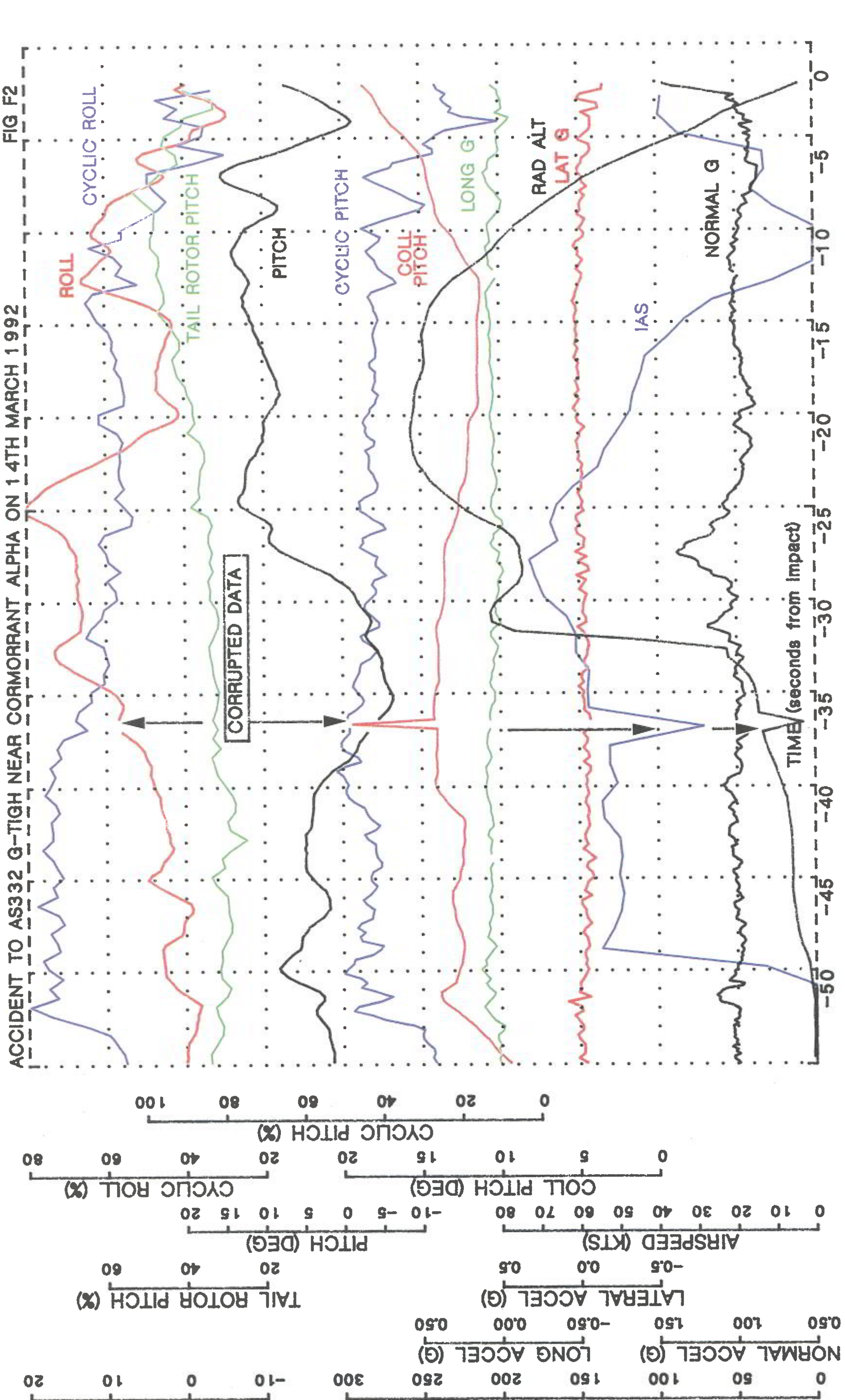

ACCIDENT TO AS332 G-TIGH NEAR CORMORRANT ALPHA ON 14TH MARCH 1992
FIG F2
ROLL
CYCLIC ROLL
TAIL ROTOR PITCH
PITCH
CYCLIC PITCH
COLL PITCH
LONG G
RAD ALT
LAT G
IAS
NORMAL G
CORRUPTED DATA
TIME (seconds from impact)
ROLL (DEG)
RADIO ALT (FT)
NORMAL ACCEL (G)
LONG ACCEL (G)
TAIL ROTOR PITCH (%)
LATERAL ACCEL (G)
AIRSPEED (KTS)
PITCH (DEG)
CYCLIC ROLL (%)
COLL PITCH (DEG)
CYCLIC PITCH (%)

FIG F3 G-TIGH TRACK PLOT SHOWING HEADING AND LIMIT OF VISIBILITY

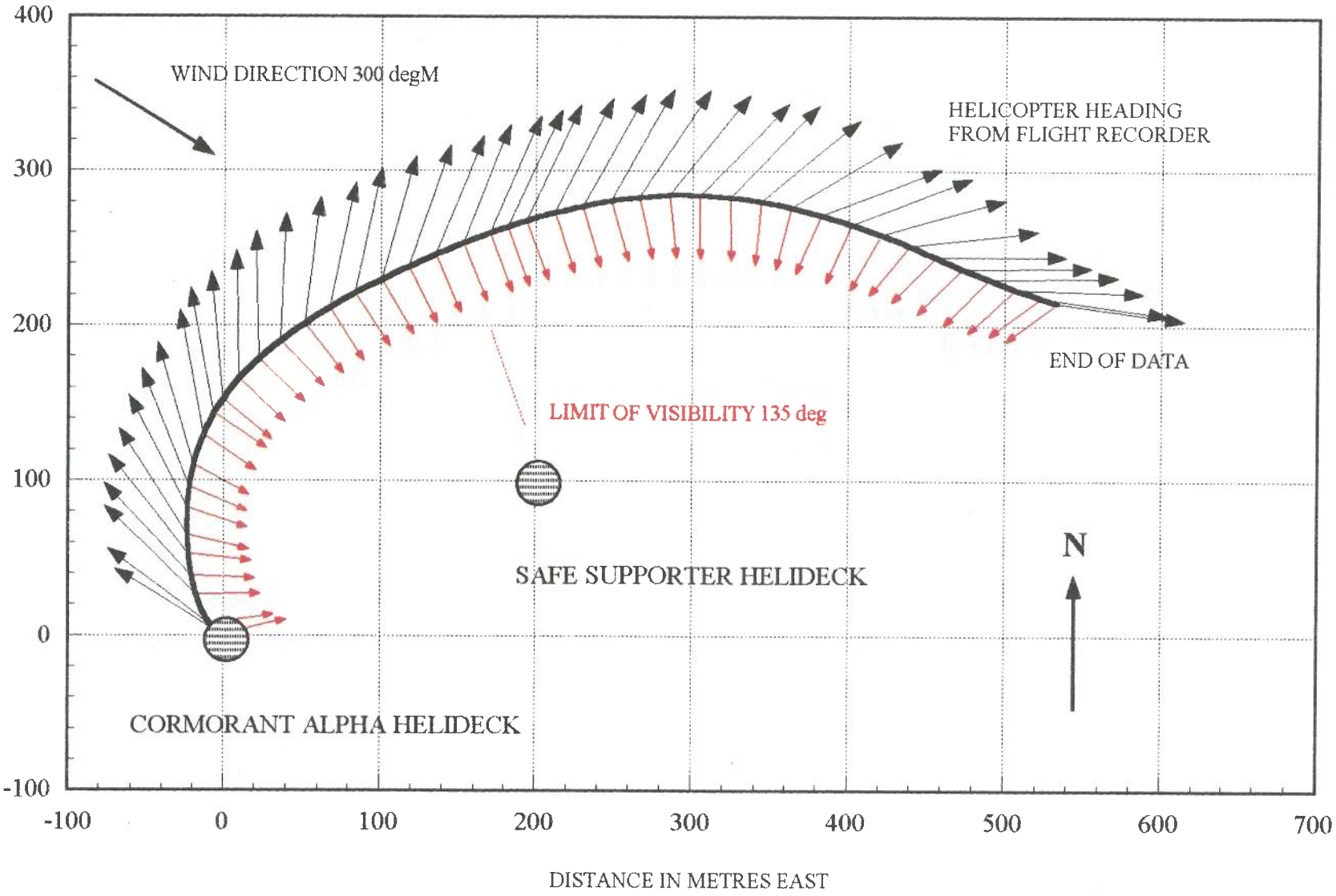
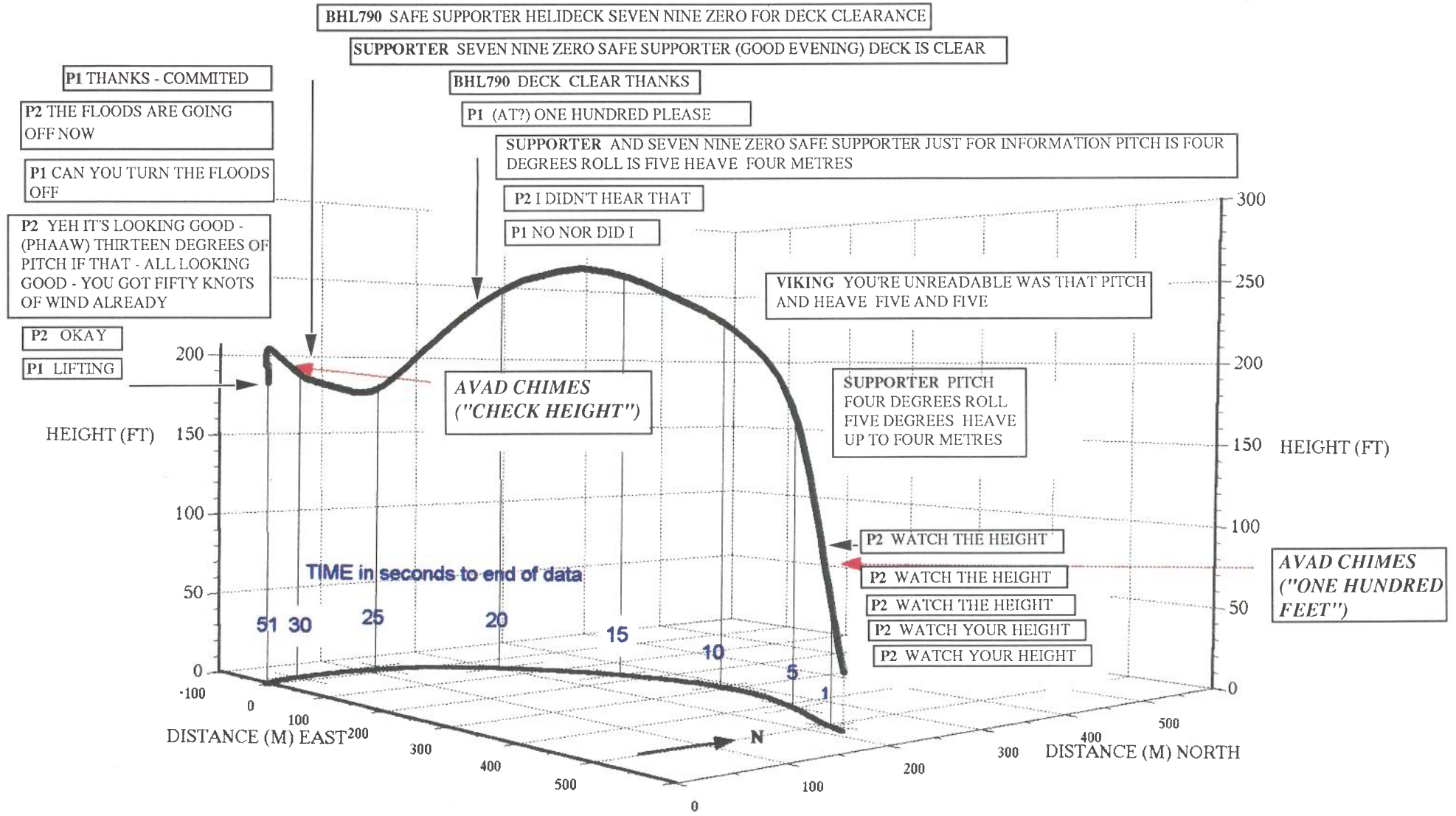


FIG F4 3-D FINAL FLIGHT PATH TRAJECTORY WITH CVR COMMENTS



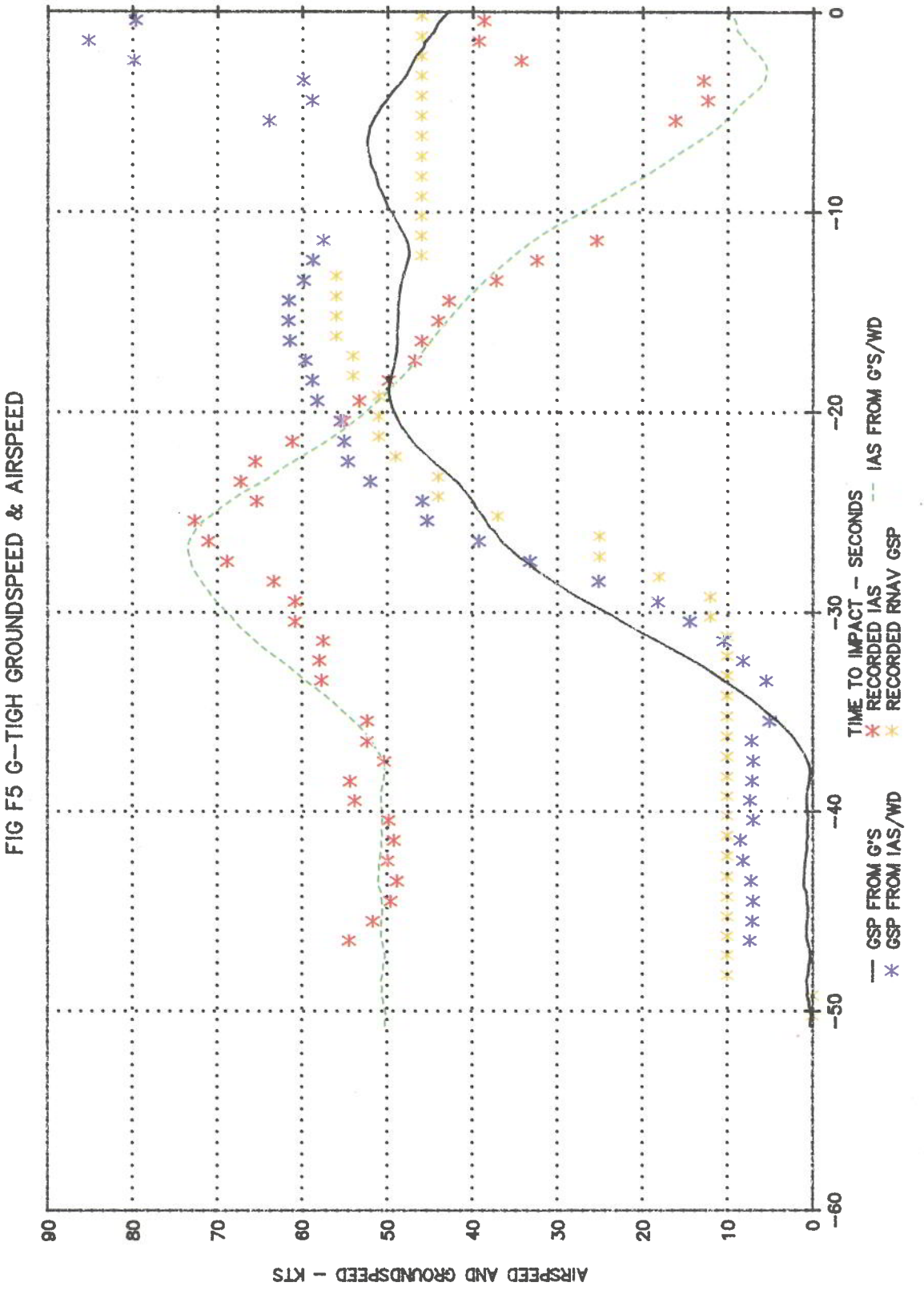


FIG F5 G-TIGH GROUNDSPEED & AIRSPEED
AIRSPEED AND GROUNDSPEED - KTS
90
80
70
60
50
40
30
20
10
0
-60
-50
-40
-30
-20
-10
0
TIME TO IMPACT - SECONDS
GSP FROM G'S
GSP FROM IAS/WD
RECORDED IAS
RECORDED RNAV GSP
IAS FROM G'S/WD

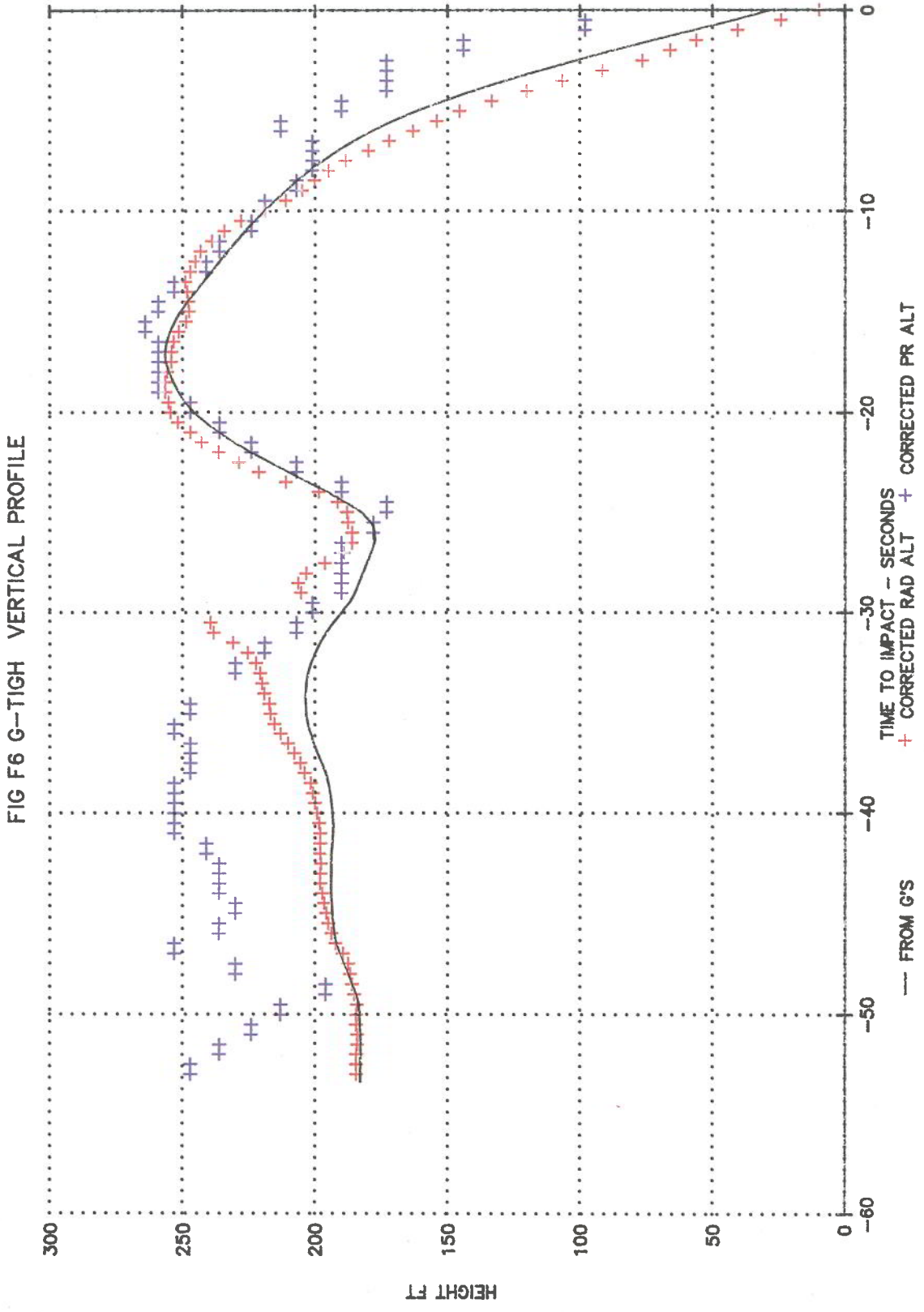


FIG F6 G-TIGH VERTICAL PROFILE
HEIGHT FT
300
250
200
150
100
50
0
0
-10
-20
-30
-40
-50
-60
TIME TO IMPACT - SECONDS
— FROM G'S
+ CORRECTED RAD ALT
+ CORRECTED PR ALT

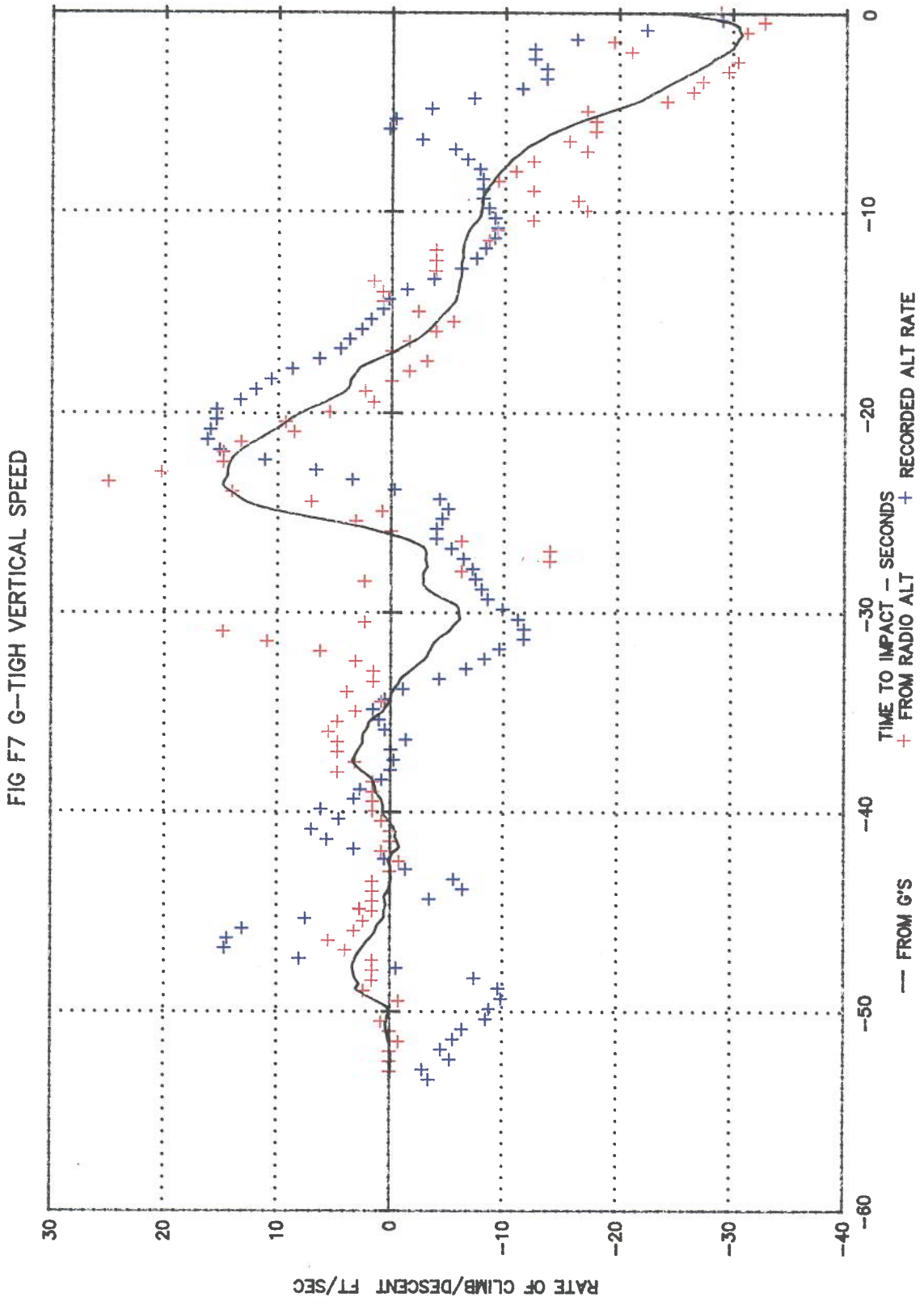


FIG F7 G-TIGH VERTICAL SPEED
RATE OF CLIMB/DESCENT FT/SEC
30
20
10
0
-10
-20
-30
-40
0
-10
-20
-30
-40
-50
-60
TIME TO IMPACT - SECONDS
— FROM G'S
+ FROM RADIO ALT
+ RECORDED ALT RATE

Computer modelling of helicopter flight path

1 Analysis conducted by Eurocopter (France) using S80 flight mechanics model validated from flight test data

Analysis showed: 'The paths (recorded data and S80 model) are very similar with the exception of the height evolution in the very last seconds of the recording. A similar deviation can also be noted on the V_Z (ie vertical) speed. The good agreement between the simulation and the measurement with the exception of this last point is an argument in favour of the good representativeness of the model. However the important deviations obtained at the end of the manoeuvre (10 m/s of deviation on the V_Z speeds) show that at this moment a physical phenomenon existed which is very poorly or not at all represented. In flight the aircraft continues to drop whereas in simulation it cancels downward speed very quickly and even recovers a positive V_Z speed. This behaviour leads to the assumption that the aircraft entered the Vortex Ring condition which is not at all simulated by the S80.'

Eurocopter (France) concluded that: 'The comparison of the flight parameters with the simulation results show a very good agreement, except on the end of the manoeuvre where the aircraft responds immediately to the collective step in simulation, contrary to the flight. These elements give rise to the assumption that the aircraft was in Vortex Ring condition at the moment of the pitch increase.'

In a vertical descent at zero airspeed, initially at low rates of descent the rotor induced downwash dominates the flow around the rotor and there is a decrease in rotor power required from the hover. As the rate of descent increases, the helicopter enters the Vortex Ring state where the upflow through the rotor is approximately the same as the rotor induced downwash, so the tip vortices cannot move away from the rotor disc and the airflow recirculates around the rotor. This causes unsteady flow through the rotor, and so variation in rotor thrust which also flaps in pitch and roll. High power is required to maintain rotor thrust, with the helicopter in some cases continuing to descend with full engine power applied.

2 Computer simulation by the Defence Research Agency, Farnborough

DRA Farnborough reported that 'generally good agreement with test data is achieved'. The simulation was started around 30 seconds into the flight. The analysis showed '...the first calculation, reproducing the aircraft pitch attitude and

collective pitch, showed that impact with the water occurred much earlier than observed...the only possible conclusion was that the aircraft encountered a vertical gust after attaining its maximum altitude.

The calculation was modified therefore to include a vertical gust. The gust had a constant upward velocity of 14 feet/sec between 245 and 220 feet, then decreased linearly to zero at 140 feet. A downward velocity was assumed below 140 feet which increased linearly to 14 feet/sec at 60 feet and below 60 feet the gust velocity was zero'. They showed that the predicted values of altitude and pitch attitude correspond closely to the measured values, and the simulated variation of collective pitch corresponds to the actions of the pilot. 'The calculated engine torque agrees also with the flight recorder data reaching about 50% of the maximum available at the moment of impact.'

Further simulations were made, firstly using different rates of application of collective pitch, from 0.6 deg/sec which was the rate of input in this accident to 1.0 and 1.5 deg/sec. The report concludes: '...the aircraft could fly away with either of the faster applications of collective pitch and the engine power in both cases remained within the limits.

The second set of calculations maintained the same rate of application of collective pitch as the datum case, 0.6 deg/sec, but applied the collective pitch one and two seconds earlier '... a fly away was again possible with an earlier application of collective.'

Injury Severity Scores

The ISS is a method of indicating the severity of injuries and it has been used in recent AAIB investigations of public transport accidents. Injury details for the deceased were coded from autopsy records. Injury details for the survivors were coded from medical records supplied by the Gilbert Bain Hospital, Lerwick, Shetland. These are included here as a matter of record.

1 Survivors	ISS
Commander	1
S1	1
S2	0
S3	0
S4	1
S5	1

2 Non survivors	
Co-pilot	0
NS 1	1
NS2	0
NS3	1
NS4	1
NS5	1

3 Non escapers	
NE1	0
NE2	1
NE3	0
NE4	0
NE5	1

Search and rescue

1 Rescue

The initial alert message was broadcast at 1950 hrs. The SBVs 'Seaboard Support', which was about 1½ nm north west of Cormorant 'A' platform, and 'Grampian Monarch', which was in the vicinity of the North Cormorant platform, responded immediately. The two SBVs were reported to have been at the scene at 2005 hrs and 2110 hrs respectively. Due to the adverse sea conditions, the Captains of both vessels elected not to launch their Fast Rescue Craft (FRC).

A total of thirteen surface vessels ultimately became involved in the surface search. The immediate response was given by the SBVs and the platform supply vessels 'Edda Fram', 'Star Aries' and 'Far Sleipner'; the supply vessels arrived at the scene at 2018 hrs, 2030 hrs and 2110 hrs respectively.

The initial air search was carried out by three helicopters; a Bell 212, call sign 'Rescue 145', departed from the accommodation semi-submersible 'Safe Gothia' at 2010 hrs and arrived on scene at 2028 hrs and a Norwegian operated Bell 214, call sign 'Rescue 146', departed from the Statfjord platform at 2046 hrs and arrived on scene at 2059 hrs. An S-61N of HM Coastguard, call sign 'Rescue 117', departed from Sumburgh at 2008 hrs and arrived on scene at 2107 hrs.

The 'Seaboard Support' sighted three people in the water and manoeuvred into position to attempt a rescue. One survivor, S3, was recovered over the starboard rescue zone at about 2030 hrs. A second person was held alongside by two crew members but the extreme sea conditions caused him to be pulled from their grip; it is possible that his lifejacket was torn in this action. Lines were thrown to the other person in the water but he was unable to help himself and it proved impossible to recover him.

At 2029 hrs, 'Rescue 145' sighted the liferaft and positioned to start the rescue. Conditions were extremely difficult and the damaged liferaft was very unstable; it repeatedly overturned. On the first attempt the winchman was unable to engage the strop on a survivor. He tried again but this time the liferaft overturned and he was struck on the head by the gas bottle; he was recovered, semi-conscious, to the helicopter and a second winchman was lowered. S1 was recovered at about 2046 hrs.

The 'Edda Fram' manoeuvred alongside and threw lines to two men linked together in the sea. While both were probably conscious at the time, they were unable to help themselves and the vessel's crew had great difficulty in reaching them. The two survivors split up and one was eventually brought alongside and recovered via the pilot access area. A member of the crew, with a rope tied round

his waist, jumped into the sea, swam to the second survivor and pulled him towards the pilot access area; other crew members then lifted them on board. The first, later identified as S4, was rescued at 2050 hrs. The second man, identified as NS3, had lost consciousness and, after he had been brought aboard at 2100 hrs was found to be dead.

At 2051 hrs the commander was winched from the liferaft by 'Rescue 145' which then flew to Cormorant 'A' where the commander, S1 and the injured winchman were off loaded. It was then refuelled and departed at 2102 hrs to return to the area of the liferaft where another survivor, S5, was winched aboard at about 2115 hrs. During this period 'Rescue 145' had failed in an attempt to recover another body. His suit was unzipped and had taken in a considerable amount of water; he was not identified but appeared to be dead. 'Rescue 145' landed on Cormorant 'A' at 2118 hrs.

Shortly after 2108 hrs the Norwegian Bell 214, 'Rescue 146', recovered S2 and positioned above another person in the water some 100 metres away. The winchman was lowered but he noted that the man's lifejacket was over his head and his face was under the water; he could find no sign of life and concluded that the person was dead. Attempts were made to recover the body but these were unsuccessful. 'Rescue 145' departed Cormorant 'A' at 2120 and returned to the area. 'Rescue 146' kept its spotlight on the body until 'Rescue 145' made contact; the former then took S2 to Cormorant 'A', where it landed at 2025 hrs; the latter recovered the body of the first officer at 2132 hrs. SBV 'Grampian Monarch' recovered a body, identified as that of NS4 at 2115 hrs.

At 2118 hrs 'Rescue 117' was engaged in winching up one body and had laid a smoke/flame float near a second body. When recovered the body was identified as that of NS2; it was noted that his lifejacket had ridden up over his head and his survival suit was partially unzipped and had taken in a considerable amount of water. At 2137 hrs 'Rescue 117' moved to the body which had been marked. The 'Grampian Monarch' was at the position and, at 2142 hrs recovered the body of NS5 which was reported to have been floating face down in the water with a deflated lifejacket.

The supply vessel 'Far Sleipner' recovered a body at 2145 hrs; it was floating low in the water with the lifejacket up at the front and rear and apparently not secured at the waist; this was later identified as the body of NS1.

The search and rescue team had recovered a total of six survivors and six bodies. The four survivors on Cormorant 'A' were later flown to Lerwick Hospital. The conditions were such that it was considered to be too dangerous to winch the

survivors off the 'Edda Fram' and 'Seaboard Support' so they remained on board and both vessels sailed to Lerwick. The air and sea searches were terminated at 0255 hrs and 0900 hrs respectively on 15 March 1992.

At 1953 hrs the wreckage on the sea bed was examined by divers; it was confirmed that five bodies were in or near the passenger cabin. All five occupants had released their seat belts and appeared to be in the process of escaping. Apart from discarded acoustic headsets and their associated leads, the cabin was generally clear of loose debris such as seat fittings and aircraft panels. NE3 was found face down outside the aircraft; NE2 was lying across the right exit door; NE1 was partially out of the escape window aft of the right door and NE4 was lying across the rear bench seat. NE5 was the only passenger who appeared to have been hampered by aircraft equipment in his attempt to escape. He was found with the acoustic headset cord from seat No 5 around his neck; during recovery the cord had to be cut as it was not possible to remove it from the body or to detach it at the seat fitting.

2 Evacuation

Both the cockpit area and cabin remained relatively intact and neither the crew nor the passengers appear to have been impeded in their escape by the aircraft structure. The commander escaped through the window of the right-hand door and it is probable that the co-pilot escaped through the left.

Ten passengers[1] escaped from the cabin, six of whom are thought to have escaped on the right side of the aircraft; S1, S3 and S5 were known to have escaped on the right side and S5 had seen NS2 pass through the escape window ahead of him. As NS1 had been identified trying to board the liferaft, it is probable that he had also escaped from the right side. NS5 was probably one of the group of three people who the Seaboard Support tried to rescue; it is therefore possible that he escaped from the right side as did S3 who was known to be in the group.

S2 and S4 escaped from the left side of the cabin. Shortly after escaping S4 was very close to two other passengers; one, NS3 with whom he linked himself and the other NS4 who was apparently dead. In the conditions prevailing, it would have been unlikely for passengers who had escaped from different sides of the aircraft to have been so close to each other at this early stage, so it is probable that NS3 and NS4 also escaped from the left side.

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[1] Identified as: S = Survivor; NS = Non Survivor; NE = Non Escaper

The five passengers who did not escape were probably conscious after the impact because they had released their seat belts. The fuselage inverted and then sank about four minutes after impact. However, the predicted breath holding time in the conditions prevailing was less than 20 seconds; this was probably the limiting factor in the case of the four who were not apparently physically impeded in their attempt to escape. Once the fuselage inverted those still in it would have had to overcome the extra buoyancy provided by air in their survival suits making it more difficult for them to reach the escape windows.

The body of NE4 was found lying across the rear bench seat. The escape windows either side of this seat have a relatively small aperture and a restriction is imposed on the size of occupants of the seat. The stature of NE4 was considered to be such that it would have been possible for him to pass through the aperture.

NE5 appeared to have been impeded in his attempt to escape; the cord from his acoustic headset had wrapped around his neck and the jack-plug had not disconnected because it had been carried down into the headrest slot and had become jammed. During the investigation the upper part of the seat was dismantled to extract and examine the jack-plug. If the plug had been loosely tucked into the seat cover when the headrest was extended, subsequent lowering of the headrest could have taken the plug downwards and caused it to jam in the position in which it was found.

An assessment of the immersion suits and lifejackets worn by the passengers and crew of G-TIGH on 14 March 1992

[Report prepared on behalf of AAIB by the Environmental Sciences Division of the RAF Institute of Aviation Medicine - Project 95/07]

INTRODUCTION

1. On the 14 March 1992 at approximately 1950 hrs an Aerospatiale AS 332L helicopter (G-TIGH), carrying 15 passengers and 2 crew, crashed into the North Sea, less than 1 minute after taking off from the Cormorant 'A' oil platform. At the time of the accident the air temperature was 0°C, there were heavy showers of hail and snow and the wind was gusting 50-58 knots. The sea temperature was 7°C and the wave height was estimated to be 8-11 metres. After hitting the water, the helicopter immediately inverted, floated briefly and then sank. Unfortunately only 12 of the occupants, 10 passengers and 2 crew, were able to escape and subsequently six of these were recovered from the water dead. The remainder, 5 passengers and 1 crew, survived to be rescued 40-85 minutes after the accident. Some of these survivors reported later that they had been in the water with their immersion suits partially unzipped, although they had not been aware of any leakage occurring inside. Rescuers also described finding bodies with their suits partially undone and full of water. Similarly the divers who recovered the 5 victims from the wreckage confirmed that they were also wearing their immersion suits partially unzipped. Concern was also expressed about the performance of the lifejackets. Several survivors described feeling that they were slipping out of the harness and indeed some bodies were recovered from the water with the lifejacket up around their heads. As a result the Air Accident Investigation Branch requested assistance from the RAF Institute of Aviation Medicine in assessing the condition and performance of the immersion suits and lifejackets worn at the time.

DESCRIPTION

2. Passenger Immersion Suits. All of the passengers were wearing a Multifabs Passenger Suit. This is a single layer, one piece Goretex coverall, with a front opening through-neck zip, neoprene hood, latex wrist seals and integral socks. Neoprene mittens are stowed in pockets on the forearms for use in emergency.

3. Aircrew Immersion Suits. Both aircrew were wearing a Multifabs Pilot Suit. This is a single layer, one-piece Goretex coverall, with a front opening through-neck zip, latex wrist seals and integral socks. Unlike the Passenger Suit it has neither an insulated neoprene hood nor neoprene mittens.

4. Passenger Lifejackets. The passengers were all wearing a Beaufort Mk 28 Series 4 lifejacket. This is a twin lobed life preserver secured around the waist by an adjustable strap and inflated manually from a CO_2 cylinder. It has a spray hood packed into the stole cover at the back of the neck.

5. Aircrew Lifejackets. Both aircrew were wearing a Beaufort Mk 28 Series 1 Lifejacket. This is very similar to the passenger lifejacket, but has storage pockets on the waist belt containing survival aids including an emergency beacon and emergency flares. It is not fitted with a spray hood[1].

TEST METHODS

6. Immersion Suits. Unfortunately only 5 immersion coveralls, 4 passenger and 1 crew, were returned. These had come from the survivors and only 1 was intact, the remainder having been cut to ease removal. However, they were each subjected to close examination of their external and internal surfaces for signs of damage or wear. It was also decided to measure the quantity of water able to leak into an immersion suit which was left partially unzipped. This test involved a subject wearing an immersion suit over clothing similar to that worn by the survivors of the accident. This was estimated to consist of: Short sleeved vest, Jockey pants, Socks, Cotton shirt, Denim jeans.

The subject then entered the IAM immersion pool by descending a ladder and remaining totally submerged 1 metre below the surface for a period of 15 seconds, to simulate escape from the submerged helicopter. He then returned to the surface, manually inflated his lifejacket and then remained in the water for 20 minutes facing into artificially induced waves. The leak rate was calculated by weighing the clothing worn beneath the immersion suit before and after the exposure. This test was performed twice, once with the zip fully closed and once with it open 100mm.

7. An immersed insulation value was also obtained for the clothing assembly. This was measured using an aluminium thermal manikin, which was dressed in the clothing previously described with the immersion coverall fully closed. The manikin was then immersed to the neck in water at a flotation angle of 45° and left for 90 minutes to reach equilibrium and enable calculation of the insulation value. Once again the leak rate was measured by weighing the clothing worn beneath the immersion suit before and after the test.

8. Lifejackets. Only 7 of the lifejackets were returned, 5 passenger and 2 crew, and of these 3 had been cut during removal. However each lifejacket was checked to confirm that the CO_2 cylinder had fired and the light activated. A visual inspection was also made for any signs

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[1] Spray hoods were not included in the BHL version of the Beaufort Mk 28 lifejacket in an attempt to reduce the bulk behind the neck and thus improve comfort and head mobility. All pilots were issued with a separate spray hood to be carried in the immersion suit leg pocket. BHL intend to equip aircrew lifejackets with spray hoods during an impending modification programme

of damage or wear. Also a flotation assessment was made of the Beaufort Mk 28 lifejacket when worn over the Multifabs Passenger Immersion Suit by one subject who completed 2 tests in the IAM pool to determine the benefits of adding crotch straps to the lifejacket.

9. Wearing the clothing assembly as before and with the lifejacket manually inflated the subject entered the water and swam for 5 minutes in artificially induced waves. At the end of this period the wave machine was stopped and the surface of the pool allowed to settle. The subject's mouth freeboard, the distance between his mouth and the surface of the water, was then measured. This test was repeated with crotch straps attached to the lifejacket.

10. All of the in-water tests were performed using a new Passenger Immersion Suit provided by Multifabs Survival Ltd and a new Mk 28 Series 4 lifejacket provided by Beaufort Air-Sea Equipment Ltd.

RESULTS

11. Immersion Suits. Visual inspection of the immersion coveralls showed them to be in good condition, with one passenger suit (504/3/8282) probably brand new. Of the remaining 4 only 1 (504/3/3877) showed evidence of damage, a small tear in the right-hand buttock area. These 4 suits all had intact repair patches evident on the inside. Also the 3 passenger suits each had a large Velcro patch on top of the neoprene hood which was heavily impregnated with cotton threads and 'fluff'.

12. The 20 minute leak tests resulted in 561ml of water entering the immersion suit when the zip was fully closed. Inspection of the underclothing showed a damp area from the chest down to the crotch, with the back, arms and legs dry. It was the impression of the subject that most of this water had entered through the hood and neck seals when his head was totally immersed. By comparison when the zip was left open 100mm, 17 litres of water entered the suit over the same time period. On this occasion the whole of the underclothing was saturated and there was also a large quantity of free water in the suit. This was more probably the result of a continuous ingress of water throughout the 20 minutes.

13. The immersed thermal insulation value was calculated as 0.21 clo after 90 minutes. During this time the immersion suit leaked 537ml. This further supports the theory that in the earlier leak test, when the zip was fully closed, the majority of the water had entered the immersion suit during the first 15 seconds when the subject was totally immersed.

14. Lifejackets. Visual inspection of the lifejackets confirmed that all 7 had been manually fired and the activating pin to operate the light had deployed. No evidence of any damage or wear was found. The results of the flotation assessment showed that after swimming in waves for 5 minutes, mouth freeboard was increased from 120mm to 140mm by the addition of crotch straps. Perhaps just as important are the comments made by the subject who reported that with the crotch straps attached he felt relaxed and confident in the lifejacket.

By comparison without the crotch straps attached he had felt very insecure, especially in the earlier leak tests when the immersion suit had been full of water. On occasions he had even felt that he was about to slip through the lifejacket, the lobes of which were often up around his ears, and it was only his continual pulling down on the waist strap that had prevented this.

DISCUSSION

15. It is unfortunate that of the 17 immersion coveralls worn by the occupants of the helicopter only 5 were subsequently returned for assessment. However, those 5, which were all worn by survivors, were in good condition. One appeared brand new and the remaining 4 had obviously been serviced as they had repair patches in them. Only one suit had suffered damage, a small tear in the buttock, and this was quite likely to have occurred during the escape from the helicopter.

16. Criticism was levelled by survivors at the neoprene mittens stowed in pockets on the forearms of the Passenger Immersion Suit. Under the conditions prevailing and with already cold hands they proved almost impossible to deploy and subsequently put on. Also criticised was the attachment of the emergency strobe light carried in the leg pocket of the Passenger Immersion Suit. Once deployed from the pocket and switched on it should be attached to the top of the neoprene hood by means of Velcro. Unfortunately the lights were frequently knocked off by waves. Inspection of the suits showed that the Velcro patch was clogged with 'fluff' which would have reduced its gripping capabilities. This is a deficiency of Velcro and an alternative method of attaching the strobe light to the hood should be found. It should be noted that the neoprene mittens and hood which are attached to the Multifabs Passenger Immersion Suit are absent from the Aircrew Immersion Suit. In the cold, large amounts of heat can be lost through the unprotected head and much discomfort caused through unprotected hands. It seems illogical therefore that these items would appear to be a requirement for passenger survival but not for aircrew, especially when they both fly in the same aircraft, over the same stretches of water, wearing very similar clothing assemblies. Similarly, the aircrew lifejackets were not provided with spray hoods.

17. The results of the leak test, during which 17 litres of water entered a partially open immersion suit within 20 minutes, highlight an important area. It is pointless providing a person with a watertight immersion suit, if at the time of immersion it is not properly sealed. In the short term the sudden ingress of cold water may increase the problems of involuntary gasp, hyper-ventilation and disorientation. Subsequently the increased weight of water inside the suit may hinder the ability of a survivor to climb aboard a liferaft or be lifted from the water. In the long term the insulation of the clothing will be destroyed which will increase the possibility of hypothermia and consequently lessen the chance of survival.

18. It has been shown that a 500ml leak reduces immersed insulation by 30% and a leak of 3 litres or more reduces it by 60% (Reference). The tests performed on the Passenger Immersion Assembly gave an immersed insulation value of 0.21 clo but during the period of

the test the suit leaked 537ml. Assuming this represents a 30% decrement of its dry immersed value, this would equate to an immersed insulation of 0.32 clo for the same assembly with no leaks. Similarly a 60% decrement caused by a large leak would therefore reduce the immersed insulation value to 0.11 clo.

19. These insulation values were entered into a mathematical model to determine survival times for immersion in water at 7°C. The model assumes the worst case of a thin individual, having a body composition equivalent to the 10th percentile (mean weighted skinfold thickness) and is a prediction of the time taken for arterial temperature to fall to 34°C. The resultant estimated survival times in water at 7°C for both measured and predicted insulation values are given in Table 1.

LEAK RATE (ml)	INSULATION (clo)	SURVIVAL TIME (mins)
0	0.32	106
537	0.21	66
>3000	0.11	41

TABLE 1. Estimated survival time in water at 7°C

20. Finally, the results of the lifejacket tests confirm the importance of securely attaching this vital piece of lifesaving equipment. It is worn over a one-piece immersion coverall, which by design is an overgarment and consequently loose fitting. The lifejacket is then secured by a single waist strap and has to be tightened by the wearer for a snug and secure fit. Inevitably this may be looser than is required, in order to make the transit in the helicopter more comfortable. As a result if the wearer should find himself in the water it is likely that the inflated lifejacket will slip up in relation to the immersion coverall and similarly the immersion coverall will move in relation to the wearer. Consequently the survivor may float progressively lower in the water. The simple attachment of crotch straps was shown to be effective in preventing this. However during egress from a helicopter it is recognised that crotch straps are a potential snagging hazard. This problem may be overcome by routing the straps through tunnels in the immersion coverall, but this would add to the price and complexity of the garment and increase the time and cost of routine servicing. A simpler solution may be to change the design of the lifejacket and use a waistcoat similar to the Beaufort Mk 25 which is successfully worn by the RAF over immersion clothing.

CONCLUSIONS

21. The 5 immersion suits, worn by survivors of G-TIGH, which were available for inspection were found to be in good condition. One had a small tear in the buttock which most probably occurred during escape from the helicopter or subsequent rescue.

22. The leak rate into a Multifabs Passenger Suit with the closure zip open 100mm was 17 litres in 20 minutes. The immersed thermal insulation of the Multifabs Passenger Suit assembly was estimated to be 0.32 clo when dry and 0.11 clo with a leak in excess of 3 litres. Estimated survival times in water at 7°C are 106 minutes and 41 minutes respectively.

23. When a Beaufort Mk 28 Series 4 lifejacket was worn over the Passenger Immersion Suit assembly, mouth freeboard and subjective security in water was improved by the attachment of crotch straps.

25. Criticisms were made by survivors concerning the difficulty of deployment and donning of the neoprene survival mittens with cold hands and the attachment method for the emergency strobe light on the Multifabs Passenger Suit.

Reference:

Allan, J.R.; Higenbottam C; Redman, P; (1984). The effect of leaking on the insulation provided by immersion protective clothing. RAF IAM AEG Report No 511.

Summary of helicopter accidents involving collision with the sea for no apparent airworthiness cause

Date	A/C Type	Location
29 MAY 78	BELL 206 B	CHANNEL

A/C CRASHED INTO THE SEA
1 CREW 3 PASSENGERS KILLED, LOW LYING FOG OVER THE ENGLISH CHANNEL. NO EVIDENCE FOUND TO INDICATE WHETHER OR NOT THERE HAD BEEN ANY TECHNICAL FAULT.

31 JUL 79	BELL 212	STAVANGER

SLOW LOWERING COLLECTIVE LOST ROTOR RPM PITCHED UP STRUCK WATER AC WAS ON TEST AFTER MAINT AND PILOT WAS NOT FAMILIAR WITH AUTOROTATE MANOEUVRE IN THIS AC. EMERG FLOATS KEPT AC AFLOAT WHEN THEY DEPLOYED AUTOMATICALLY.

14 JUN 80	BELL 212	NR MACAU

WHILE EN ROUTE BETWEEN OIL RIGS THE CREW LOST CONTROL OF THE A/C WHICH STRUCK THE SEA & SANK WITH 7 FATALITIES. CAUSE UNKNOWN.

12 AUG 81	BELL 212	NR DUNLIN A

LOST CONTROL FAST DESCENT IN NORTH SEA
THE ACCIDENT OCCURRED DURING A DAYTIME FLIGHT, PLANNED FOR VMC, BETWEEN THE BRENT FIELD AND THE DUNLIN PLATFORM IN THE NORTH SEA. THE HELICOPTER ENCOUNTERED AN AREA OF REDUCED VISIBILITY AND CONTINUED TOWARDS THE DUNLIN AT A HEIGHT OF 200 FT UNTIL A DECISION WAS MADE TO RETURN TO THE BRENT FIELD. DURING THE TURN, CONTROL OF THE HELICOPTER WAS LOST AFTER THE AIRCRAFT PITCHED 20 DEG NOSE UP AND CLIMBED TO 300 FT WITH ZERO AIRSPEED. IT BEGAN YAWING RAPIDLY TO THE RIGHT AND DESCENDING AND STRUCK THE SEA IN AN ESSENTIALLY LEVEL ATTITUDE. THE SINGLE FATALITY AND 13 SURVIVORS WERE RETRIEVED BY ANOTHER HELICOPTER AND A RIG SUPPORT VESSEL AFTER SOME 44 MINUTES. THE WRECKAGE WAS SALVAGED BY THE RIG SUPPORT VESSEL ON THE SAME DAY. SEE ALSO AAR 10/82. THE REPORT OF THE AIB (DEPARTMENT OF TRADE) CONCLUDES THAT THE ACCIDENT WAS CAUSED BY THE LOSS OF CONTROL OF THE HELICOPTER DUE TO DISORIENTATION OF THE COMMANDER WHILE ATTEMPTING TO FLY IN VISUAL CONTACT WITH THE SEA IN CONDITIONS OF VERY POOR VISIBILITY. CAA CLOSURE: CAA RESPONSES TO AIB RECOMMENDATIONS ARE CONTAINED IN FOLLOW UP ACTION ON ACCIDENT REPORTS (FACTAR) No. 1/87.

9 NOV 81	BELL 212	ALERK ISLAND

AIRCRAFT CRASH LANDED IN POOR VISIBILITY
AFTER WAITING 7 HOURS FOR THE WEATHER TO IMPROVE THE HELICOPTER WAS FINALLY DISPATCHED AT NIGHT IN IFR TO BE POSITIONED AT AN OIL RIG. DURING THE INSTRUMENT APPROACH TO THE OIL RIG THE CREW DESCENDED BELOW COMPANY MINIMUMS IN ICE FOG. THE RADIO ALTIMETER WAS UNSERVICEABLE. TO SIGHT THE OIL RIG LIGHTS THROUGH THE ICE FOG THE PILOT DESCENDED TO 150 FT AGL ON HIS ALTIMETER. THE HELICOPTER STUCK THE SEA ICE AND CRASHED. TEMP CORRECTION NOT APPLIED.

28 MAY 82	SA330 PUMA J	NATUNA ISLE

MISSING ON FLT FROM OIL RIG TO NATUNA ISLAND 9 ON BOARD THE HELICOPTER TOOK OFF FROM AN OCEANIC RIG AT 1149 HRS TO TRANSPORT WORKERS TO NATUNA ISLAND. UP TO 1247 HRS THE PILOT REPORTED OPERATIONS NORMAL & WOULD CALL AGAIN AT 1300 HRS. NATUNA CALLED THE HELICOPTER WHEN IT FAILED TO REPORT AT 1300 HRS. A SAR FAILED TO LOCATE THE HELICOPTER. CAUSE UNDETERMINED. (ICAO SUMMARY 1984-2).

Date	A/C Type	Location
14 SEP 82	BELL 212	MURCHISON

A/C COLLISION WITH WATER FATAL CAUSE NOT ESTABLISHED DEPARTED TREASURE FINDER FOR MV BAFFIN SEAL AT 0212 HRS UTC. ROUTINE RADIO CALL HEARD AT 0242 HRS. CALLS SENT TO HELICOPTER AT 0247 NO REPLIES THE HELICOPTER HAD BEEN SCRAMBLED TO WINCH AN INJURED MAN FROM A SHIP 5 MILES NORTH OF MURCHISON PLATFORM. THE A/C WAS SEEN TO PASS CLOSE TO THIS PLATFORM AT LOW ALTITUDE AND FLY TO THE NORTH-EAST DISAPPEARING INTO RAIN AND POOR VISIBILITY. WRECKAGE WAS LOCATED ON SEA BED AT A DEPTH OF 1120 FT APPROX 14 NM FROM THE MURCHISON. 2 BODIES WERE RECOVERED FROM SEA SURFACE AND 2 BODIES WERE RETRIEVED FROM THE WRECKAGE WHICH WAS LATER SALVAGED. TOTAL ON BOARD SIX-2 PILOTS, 2 CABIN CREW, 2 SUPERNUMARY AIB BULLETIN 12/82 REFERS. SEE AIB REPORT 2/84. CAA CLOSURE-RESPONSE TO AIB RECOMMENDATIONS IS CONTAINED IN FACTAR 8/84. SUBSEQUENT TO PUBLICATION THE ANO HAS BEEN AMENDED TO GIVE LEGISLATIVE EFFECT TO RECOMMENDATION 1-RADIO ALT AUDIO HEIGHT WARNING AND TO RECOMMENDATION 4-AUTOMATICALLY DEPLOYED EMERGENCY LOCATOR BEACON.

17 NOV 82	BELL 212	CHINA SEA

CRASHED INTO CHINA SEA ALL 15 ON BOARD KILLED
SOME DEBRIS AND ONE BODY RECOVERED.

25 AUG 82	BELL 205 A-1	NORWAY

PILOT LOST ALL VISUAL REFERENCE DUE TO ROTORS CAUSING FOG TO RISE FROM LAKE. A/C STRUCK SURFACE OF WATER & SANK. 2 FATALITIES.

16 JUL 83	SIKY S61	NR ST MARYS

AIRCRAFT CRASHED IN SEA 2 NM EAST OF ST MARYS
THE HELICOPTER WAS OPERATING A SCHEDULED PASSENGER FLIGHT FROM PENZANCE TO ST MARY'S IN THE ISLES OF SCILLY WHEN THE ACCIDENT OCCURRED. FLIGHTS FROM PENZANCE HAD BEEN DELAYED BECAUSE OF POOR VISIBILITY DURING THE MORNING BUT THIS WAS THE SECOND FLIGHT OF THE DAY. WHEN THE HELICOPTER WAS 18 NM FROM ST MARY'S, A DESCENT TO 500 FT WAS MADE. SINCE THE SEA SURFACE WAS NOT VISIBLE THE COMMANDER DESCENDED FURTHER TO 250 FT AS INDICATED BY THE RADIO ALTIMETER. THE COMMANDER WAS IN VISUAL CONTACT WITH THE SEA SURFACE BUT WITH NO EXTERNAL HORIZONTAL REFERENCE. THE HELICOPTER'S FINAL CONTACT WITH AIR TRAFFIC CONTROL WAS REPORTING 2 NM FROM ST MARY'S AERODROME. A SHORT WHILE LATER THE HELICOPTER STRUCK THE SEA IN AN APPROXIMATELY LEVEL ATTITUDE AND WHILST ON A STEADY HEADING. AFTER THREE IMPACT WITH A CALM SEA, THE HELICOPTER ROLLED OVER AND SANK ALMOST IMMEDIATELY. THIS ACCIDENT WILL BE THE SUBJECT OF AN AIRCRAFT ACCIDENT REPORT BY THE ACCIDENTS INVESTIGATION BRANCH OF THE DEPARTMENT OF TRANSPORT. (AIB SPECIAL BULLETIN 8/83) CAA CLOSURE: ACCIDENT WAS CAUSED BY AN UNINTENTIONAL DESCENT INTO THE SEA IN POOR VISIBILITY & NO EXTERNAL HORIZONTAL REFERENCES. CONSIDERED TO BE A "HUMAN FACTORS" ACCIDENT.

7 NOV 83	SIKY S76	MACAE, BRAZIL

HELICOPTER CRASHED INTO SEA SHORTLY AFTER LIFT OFF 13 SOB ALL SAFE

20 NOV 84	BELL 212	NORTH SEA

THE AIRCRAFT WAS BEING FLOWN TO A RIG TO PICK UP RIG WORKERS. A LOUD BANG WAS HEARD ON THE GAS RIG PLATFORM AND THE AIRCRAFT WAS SEEN TO FALL INTO THE SEA. BOTH CREW MEMBERS DIED IN THE ACCIDENT. THE REPORT OF THE AAIB CONCLUDES THAT CONTROL OF THE HELICOPTER WAS LOST FOLLOWING A DECAY IN ROTOR RPM WHILE BOTH ENGINES WERE DELIVERING FULL POWER. THERE WAS INSUFFICIENT EVIDENCE TO DETERMINE THE CAUSE OF THE ROTOR RPM DECAY.

Date	A/C Type	Location
13 MAR 85	BELL 214	PLACENTIA BAY

CRASHED IN SEA DISTRESS CALL 6 PERSONS ON BOARD NO SURVIVORS HELICOPTER LOST RADIO CONTACT SHORTLY AFTER T/OFF. WEATHER CONDITIONS POOR WITH ICY CONDITIONS, FOG, LOW CEILING & HIGH WINDS. 2 CREW 4 PAX.

3 APR 86	MI-8	BALTIC SEA

A/C CRASHED INTO SEA AS IT ATTEMPTED TO LAND ON OIL RIG 4 KILLED

28 APR 86	SA332S PUMA L	NOT RECORDED

STRUCK WATER DURING ATTEMPT TO LAND ON OIL RIG IN PATCHY FOG A/C HAD MADE 2 APPROACHES & O/SHOOTS. THE 3RD ATTEMPT WAS AN UNAUTHORISED PROCEDURE. THE A/C FLEW INTO THE SEA. NO APPARENT TECH DEFECTS & NO INJURIES.

5 NOV 86	WESSEX	LIMASSOL BAY

A/C STRUCK WATER & SANK DURING MEDICAL EVAC SORTIE 3 FATALITIES

25 NOV 86	BELL 412	SUMATRA

CRASHED ON APPROACH TO OIL RIG IN DARKNESS 5 FATALITIES.

5 APR 86	SIKY S76	SAFE HARBOR

STRUCK WATER WHILE ON NIGHT TIME SAR MISSION NO INJURIES WHILE HOVERING IN VMC CONDITIONS 200 FT ABOVE A RIVER PILOT HEARD LOUD NOISE & MADE AN EMER LDG IN WATER.

1 JUN 87	SIKY S76	MANILA BAY

STRUCK WATER DURING LOW LEVEL CRUISE & SANK 4 FATALITIES

9 DEC 87	SIKY S76 A	NORTH SEA

TOUCHED WATER DUE HIGH ROD RECOVERED & LANDED ON RIG MINOR DAM TO MRB SPINDLE ON APPROACHING RIG CO-PILOT REALISED A/C WAS LOWER THAN EXPECTED & ALERTED CAPT. CONSIDERABLE COLLECTIVE PITCH APPLIED BUT A/C CONTACTED SURFACE OF SEA BEFORE CLIMBING. UNEVENTFUL LANDING MADE ON RIG WHERE EXAM SHOWED MINOR DAMAGE TO MRB SPINDLE ASSY AS RESULT OF STRESSES FELT DURING RECOVERY. FLT CREW REPORT APPROACH TO THIS PARTICULAR RIG DIFFICULT DUE LACK OF VISUAL REF AS NO OTHER PLATFORMS NEARBY. AAIB REPORT (AAR 5/88) CONCLUDES THAT INCIDENT RESULTED FROM A TEMPORARY (UNEXPLAINED) INCAPACITATION OF CAPT & DELAYED RESPONSE TO SITUATION BY CO-PILOT. FURTHERMORE, OPS MANUAL CONTAINED NO PROCEDURES FOR USE OF AUTOMATIC VOICE ALERTING DEVICE DURING VISUAL APPROACHES.

17 OCT 88	SIKY S61 N	NR HANDA IS

UNCONTROLLED LDG ON SEA ROLLED OVER & SANK 2 MINOR INJURIES WHILE CARRYING OUT A NIGHT TIME SEARCH & RESCUE MISSION IN FOG THE A/C DEVELOPED A SIGNIFICANT REARWARDS DRIFT & RATE OF DESCENT UNDETECTED BY THE COMMANDER. FOLLOWING A CREWMANS WARNING THE COMMANDER ATTEMPTED A RECOVERY TO FORWARD CLIMBING FLIGHT BUT THERE WAS INSUFFICIENT HEIGHT. THE A/C STRUCK THE SEA & ROLLED OVER. 1 CREW MEMBER BECAME TRAPPED IN FLOODING REAR CABIN, BEING UNABLE TO REACH EMERGENCY EXIT HANDLE, NOW AT BOTTOM OF INVERTED HULL, DUE TO EFFECT OF BUOYANCY SUIT. ESCAPED WHEN OTHERS OPENED DOOR FROM OUTSIDE.

Date	A/C Type	Location
5 SEPT 89	BELL 214 B	SEA OF JAPAN

A/C CRASHED INTO SEA IN POOR VISIBILITY 2 FATALITIES

15 DEC 89	SA365 DAUPHIN	NR PATNA

CRASHED INTO RIVER GANGES 7 FATALITIES NO OTHER DETAILS KNOWN

12 MAR 90	SIKY S58T	FREETOWN

CRASHED INTO SHALLOW RIVER ESTUARY CAUSE UNKNOWN
12 FATALITIES

31 MAR 90	BOLKOW 105 CB	INDONESIA

RH SKID STRUCK WATER IN STEEP TURN CRASHED INTO RIVER 2 KILLED

30 APR 90	SA332S PUMA	INDONESIA

RAPID INCREASE IN RATE OF DESCENT A/C CRASHED INTO SEA NO INJURIES.

17 AUG 91	SA332S PUMA M	SINGAPORE

A/C COLLIDED WITH SURFACE OF RESERVOIR DURING FLIGHT JUST AFTER DAWN. 2 PILOTS KILLED, 1 PAX SURVIVED. A/C DESTROYED. NO TECHNICAL PROBLEM IDENTIFIED BUT VISIBILITY MAY HAVE BEEN POOR & WATER SURFACE VERY SMOOTH.

30 JAN 92	BELL 212	NR TERBANG

SHORTLY AFTER LIFT-OFF BEGAN TO LOSE HEIGHT. PILOT ATTEMPTED TO LAND ON RIVER BANK BUT A/C CRASHED INTO WATER. NO INJURIES TO 3 POB.

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