AIG/ 65 / 1983

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AIRCRAFT ACCIDENT REPORT

(In accordance with Civil Aviation Act Article 145)

ICELAND COAST GUARD

TF-RAN, SIKORSKY S-76A

JÖKULFIRDIR 66°17´N, 22°41´W

8 NOVEMBER 1983

This accident was investigated solely in order
to provide guidance towards prevention
Civil Aviation Act Article 145

CONTENTS

Page:

A special acknowledgement is made to the NTSB, National Transportation Safety Board, Washington D.C., for invaluable assistance in the investigation and the compiling of the report.

The Board especially wants to thank [redacted] of the NTSB for his contributions.

DIRECTORATE OF CIVIL AVIATION (IDCA)
and
NATIONAL AIR SAFETY BOARD (NASB)
Reykjavik Airport
ICELAND

A I R C R A F T A C C I D E N T R E P O R T

REF/AIG/65/1983

AIRCRAFT...........TF-RAN, Sikorsky S-76A.

REGISTERED OWNER...Icelandic Coast Guard (ICG).
Seljavegur 32, Reykjavík, Iceland.

OPERATOR/USER......Registered owner.

CREW...............Four, all killed.

PASSENGERS.........None.

PLACE OF ACCIDENT..Approximately 66°17'N, 22°41'W in the Jökulfirðir fjords, between mount Kvíarfjall and Höfðaströnd coast.

DATE AND TIME......8 November 1983, at appr. 2254 hrs.

NOTIFICATION.......The Flight Safety Department was notified at 0020 hrs. 9 November 1983, that TF-RAN was missing. The IDCA investigator arrived at the scene in the afternoon the same day and the investigation commenced immediately.

NOTE: All times in this report are GMT.

SYNOPSIS:

The Icelandic Coast Guard Helicopter TF-RAN took-off for a short training flight from the ICG vessel OÐINN, where it was anchored in the Jökulfirðir fjords, N.W. Iceland.

The helicopter disappeared shortly after take-off. The wreck was located on the bottom of the fjord on 10 Nov.1983.

It was subsequently recovered and brought to Reykjavik for examination.

The crew of four was killed.

1. FACTUAL INFORMATION:

1.1 History of the flight:

On 7 November 1983 the ICG Operations Control Center decided, that the helicopter TF-RAN should, the following day, fly from Reykjavik to Jökulfirðir and meet the ICG vessel OÐINN, which had also been ordered to be there in the afternoon the same day. The plan was to land on the vessel and exercise night hoist operations over the ship that same evening.

The opportunity was also to be used, weather permitting, for a coast guard patrol mission and to assist in a lighthouse service operation on the next day and return to Reykjavik in the afternoon.

The helicopter was prepared in Reykjavik 8 Nov. for the flight. The crew consisted of a captain, a copilot, a hoist operator, who also was a licenced aircraft mechanic and a mate from the ICG, but he was to be given an additional training as a hoist operator on TF-RAN.

The fuel tanks were full and take-off was at 1504 hrs.

Enroute to Ísafjörður the helicopter searched for a while for missing seamen around a shipwreck near Engey, north of Reykjavik, then it proceeded to Ísafjörður where it landed at 1640 hrs. There the fuel tanks were filled with 535 liters of Jet A-1 fuel and the helicopter took off again at 1724 hrs. and flew direct to Jökulfirðir, where it landed on the OÐINN's helideck at 1742 hrs.

After landing, the two pilots and the mate went to the ship's bridge, to discuss the evening's activities with the Commanding Officer (C/O) of OÐINN.

The hoist operator/aircraft mechanic remained with the helicopter, doing some inspection work, until he went to the mess hall at about 1815 hrs. One of the ship's crew members assisted him. This crew member states, that he did not notice "anything abnormal". There is no entry of any malfunction in the aircraft's Technical log, which was found in the aircraft.

According to the ship's C/O, he discussed the evening's schedule with the helicopter pilots in the bridge. There it was decided, in accordance with the pilots' request, to begin the training flight at about 2300 hrs. and exercise night hovering and hoist operations over the ship's helideck. It was decided to call the ship's crew on deck at 2230 hrs. in order to prepare for the take-off and the training.

The C/O asked the pilots if they could undertake the planned patrol flight in the area called "Gildran", north of Hornbjarg, after the training flight and the helicopter captain agreed. Under the discussions, it was also decided to proceed directly for the patrol flight, without landing on the ship, after the training flight was completed.

There were no comments made concerning weather conditions, but the C/O states, that the pilots brought along weather information from Reykjavik.

The training flight was estimated to last about thirty minutes and then the patrol flight was expected to take from about one hour and thirty minutes to two hours, so the entire operation would take from about two hours to two hours and thirty minutes.

Shortly after 1800 hrs. the helicopter crew, except the mechanic, went together with the C/O to the mess hall for dinner. The aircraft mechanic came to the mess hall at about 1815 hrs.

After dinner there was a brief discussion about the intended flight and two deckmen from the vessel asked for permission to go along with the helicopter but both the helicopter captain and the vessel C/O refused.

Then the pilots listened to the weather report and the forecast broadcast at 1845 hrs.

There was a movie shown on the ship's video, which the helicopter crew watched, except for the captain, who retired to his quarters. The movie was finished at about 2210 hrs. Then the preparations for the training flight started and a signal for "Helicopter Departure" was given at 2230 hrs.

There was no flight plan submitted to the Air Traffic Control in Reykjavik.

The ICG Operation Control Center was as usually closed at 1800 hrs. and the only means to reach the outside world from the ship, was through coastal radio stations.

In accordance with the pilots' request, it was decided to lift anchors while the take-off was prepared and manoeuvre the ship so, that it's starboard (right) side was up-wind when the helicopter was taking off. Then the ship would be turned to the right so that it's port (left) side was up-wind when the helicopter returned. The helicopter captain intended to make the approach and manipulate the controls during the hovering exercise, as he wanted to have a clear view of the ship.

The anchors were lifted before take-off and the ship was kept on course by the bow propeller, until the helicopter had departed. Then the ship began the turn. At that moment the bridge was manned by the C/O, the First Mate at the steering wheel and the Radio Operator in his compartment behind. There was no radar watch.

The ICG regulations stipulate, that there shall be a constant radar monitoring of the helicopter, if it is not on a VFR flight.

There were light snow showers in the vicinity and the only visible light ashore was from the light-house at Sléttaeyri, some 7 NM from the ship to the west, (see Appendix 5.2.). According to the C/O, the shoreline was clearly visible in the darkness. There was no moonlight.

On the ship's deck, the assigned crew members were standing by, functioning as tie down personnel and fire fighters, if necessary.

The helicopter was soon ready for take-off. The hoist operator/mechanic was the last of the crew members to board the helicopter and he closed the right-hand sliding door behind him. The crew was wearing helmets, except the captain, who was wearing a headset. According to witnesses, he was not wearing glasses.

The preparation for the flight was normal and the helicopter took-off into the wind, from the ship's starboard side, at 2253 hrs. It hovered about 7-8 meters vertically over the deck and then flew away in a right curve. The ship began to turn and the deckmen started to prepare themselves for the return of the helicopter. As they were more or less occupied with their task, they did not watch the helicopter closely, except for two deckmen, who were looking in the direction of the helicopter during the last seconds of it's flight.

The following report was taken from the two deckmen, as the investigators arrived on board ÕÐINN:

"I saw the helicopter leave and I saw it's left side. It flew to the west and it was very low. The nose was high and the tail was low. Then the nose lowered. I cannot determine the speed, but the red beacon was flashing and reflecting unusually bright off the ocean surface. Then I think the helicopter climbed a little, the search light came on, pointing down and swinging upwards. Then the Deck Control Officer said:"Hush ! - he is saying something" and I looked at him and then back to the helicopter. Then the helicopter disappeared suddenly, as if it had flown around a corner. There was a snow mist around the helicopter".

The other deckman reported:

"I watched the helicopter when it left, then I looked at something else, but when I looked back, I saw the flashing red light reflecting off the ocean surface. I saw the helicopter from behind. The gear was down and the helicopter was flying low and the tail seemed to be lower. Then the search light came on and the light beam went from the vertical upwards and lit up the mountainside and disappeared".

According to the C/O, the whole flight only lasted approximately one minute.

Just about when the searchlight came on and went off, the Deck Control Officer and the three persons in the ship's bridge heard a garbled radio call from the helicopter. When questioned by the investigators, they maintain the call was "MAYDAY-MAYDAY". The helicopter did not respond to repeated calls and it had disappeared. The dark shoreline was clearly visible against the white coast. There was a high tide.

The vessel was immediately directed towards the anticipated accident site. The life boat crews were therefore not able to launch the life boats at once, but launching took place as soon as the vessel had been slowed down sufficiently. Then the search was initiated. Contact was made with the fishing fleet and soon many fishing boats participated in the search.

The Icelandic Coast Guard Control Center was notified at 2317 hrs., that TF-RAN was missing and this was reported to the Reykjavik Air Traffic Control Center at 0010 hrs.

At about 0105 hrs. the searching boats found debris from TF-RAN floating on the sea.

1.2. Injuries to Persons:

Injuries	Crew	Passengers	Others
Fatal	4	-	-
Serious	-	-	-
Minor/None	-	-	

1.3. Damage to Aircraft:

The helicopter was damaged beyond economical repair, mainly due to immersion in sea water.

1.4. Other Damage:

None.

1.5. Personnel Information:

1.5.1. The Captain:

Male, 52 years of age, born [redacted] 1931. Commercial Pilot's Licence [redacted] with instrument rating, issued [redacted] 1959, after completing a pilot training course in the U.K.

He was holding a British Commercial Pilot's Licence [redacted] issued [redacted] 1958. Icelandic Commercial Pilot's Licence/Rotorcraft, [redacted] issued [redacted] 1960, after completing a helicopter training course with the U.S. Navy. Licence [redacted], issued by the U.S. Navy, [redacted] 1960.

He was employed as a pilot with the ICG in early 1959. He was trained on PBY-5A and on DC-4 as a copilot and later checked out as a captain on the DC-4. He was mainly flying helicopters for the ICG from 1965 when helicopter operations started and he was a current captain on the ICG H-369 and S-76A helicopters.

He obtained his Airline Transport Pilot's Licence Aeroplane/Rotorcraft [redacted] 1970 and the Flight Instructor rating/Helicopter, [redacted] 1972. He was appointed as a check/training captain by the ICG for the helicopter operation and this was approved by the IDCA on [redacted] 1976.

He completed the ground- and flight training on S-76A with American Airlines, in late 1980 and the S-76 type rating was entered to his Licence by the IDCA [redacted] 1980.

He renewed his licence 23 June 1983 and it was valid until 30 June 1985. His last physical was 1st Class, 21 Oct. 1983, with the limitation, that he had to wear correcting glasses for near vision while exercising the privileges of his licence. His last proficiency check was completed in a S-76 flight simulator with Flight Safety, Vero Beach, Florida, 4 Nov. 1983.

His total flying time was approximately 7058 hrs. His total time in helicopters was appr. 4725 hrs. thereof 552 hrs. were on the S-76A.

Total number of hoists on the S-76A were 89, thereof 22 in the last 90 days prior to the accident. Fifteen of the hoists were from ships and 7 from land. All the 22 hoists were done by day.

His total flying time during the last 90 days was 32:15 hrs., thereof 19:20 hrs. were on the S-76. In the last 30 days he flew a total of 13:15 hrs., thereof 10:40 hrs. were on the S-76A. The simulator training during the last week prior to the accident, is not included in these figures.

During his career as a helicopter pilot, he flew Bell-47, Piaggio PD-18, Hughes 269, Hughes 369, Sikorsky HH-52A, S-55 and S-76A helicopters.

He was off duty 7 Nov., but he reported on duty at 0900 hrs. the day of the accident, then soon went home again and returned at about 1500 hrs. in the afternoon.

1.5.2. The Copilot:

Male 40 years of age, born [redacted] 1943. Airline Transport Pilot's Licence [redacted]

He was issued a Student Pilot's Licence [redacted] 1963, Private Pilot's Licence [redacted] 1963, Commercial Pilot's Licence/Aeroplane, [redacted] 1964. Instrument rating [redacted] 1967. Flight Instructor rating, [redacted] 1966, Flight Navigator's Ground School, completed [redacted] 1966.

He was employed by an Air Taxi Operator in Reykjavík from early 1967 until early 1971, when he was employed by the Icelandic Coast Guard. He was trained as a helicopter pilot by Helicopter Service A/S in Oslo, Norway and he received his Commercial Pilot's Licence/Helicopter, [redacted] 1971 and his Airline Transport Pilot's Licence/Aeroplane the same day. The Airline Transport Pilot's Licence/Helicopter was issued [redacted] 1978.

He was checked out as copilot on F-27, by the ICG [redacted] 1972 and as captain [redacted] 1976. He was current captain on F-27 and on S-76 with the Coast Guard. His two ALTP licences were valid until 2 Febr. 1985. He was, by the approval of the IDCA, appointed assistant training and check pilot on the ICG helicopters [redacted] 1976. He had also been checked out as captain, on PA-31, PA-23 and on DC-3.

He was checked out on Hughes H-369 [redacted] 1976 and after being trained by American Airlines, the S-76A Type rating as captain was endorsed on his licence [redacted] 1980.

He renewed his licence 17 March 1983, and it was valid until 28 Feb. 1985.

His last physical was Ist.-Class, no limitations, issued 17 August 1983.

His total flying time was 9344:50 hrs. His total helicopter flying time was 1396:45 hrs. whereof 478:05 hrs. were on the S-76A.

During the last 90 days he had flown a total of 70:10 hrs., thereof 27:45 hrs. were on the S-76A and during the last 30 days he had flown a total of 2:15 hrs., all on the S-76. The simulator training during the last week prior to the accident is not included in these figures.

He had performed a total of 279 hoists on the S-76A, thereof 26 hoists were carried out during the last 90 days, all from ships and 15 of them were by night.

During his career as a helicopter pilot he flew Bell 47, Hughes 269, Hughes-369 and S-76 helicopters.

He was off duty 7 Nov. but he reported on duty at 0900 hrs. on the day of the accident. He went on a 30 minute flight around noon that day in a Cessna aircraft, that was being demonstrated to the ICG and after that, he was occupied with the preparation of the S-76A flight.

1.5.3. The Hoist operator/Aircraft Mechanic:

Male, 36 years of age, born [redacted] 1947. Employed by the ICG, 1 June 1976. He obtained an Aircraft Mechanic's Licence [redacted] 1979, with F-27 endorsement.

The S-76A rating was endorsed on his licence, after training with American Airlines, [redacted] 1980. He renewed his licence 28 Oct. 1982 and it was valid until 31 Oct. 1984.

His last physical was issued 28 Oct. 1982, no limitations. He was trained as a hoist operator and checked out as such on the S-76A on 20 Oct. 1980. He had performed a total of 93 hoists on the S-76A.

1.5.4. The Mate:

Male, 44 years of age, born [redacted] 1939. He was employed by the ICG in [redacted] 1966 and was working on ICG vessels.

He received the initial training, 6 hoists, on the S-76A in 1981 and in 1982. The training was not completed, and the ICG was now planning to continue and complete his training.

1.6. Aircraft Information:

1.6.1. General description:

The helicopter TF-RAN was manufactured in 1980, by United Aircraft Technologies, Sikorsky Aircraft, Bridgeport, Connecticut, U.S.A. It was a Sikorsky S-76A, serial no.760081, a twin engined utility helicopter, powered by Detroit Diesel Allison 250-C30 turbine engines. The engine serial numbers were: Left: CAE 890273 and Right: CAE 890078. The helicopter was configured for two pilots and seven passengers, six seated on benches and one in a swivel chair aft of the captain in front of the right hand sliding door.

The helicopter had four doors, one on each side of the pilots' compartment, a hinged door on the left side and a sliding door on the right side of the passenger compartment.

The helicopter was registered in Iceland 22 Aug. 1980 as TF-RAN, in the name of Icelandic Coast Guard, Seljavegur 32, Reykjavik. The Certificate of Airworthiness was issued in Iceland by the IDCA, 8 Oct. 1980 and it was valid until 30 Nov. 1983.

The helicopter was operated and maintained by the Icelandic Coast Guard and it was used for CG patrol and rescue operations. The total time of the helicopter since manufacture was 894 hrs. Same hours apply to the engines.

1.6.2. Engines and engine controls:

The two 250-C30 gas turbine engines, each rated at 650 shaft horsepower, are mounted aft of the main gearbox. Each engine is connected to the main gearbox with a separate input shaft.

The main gearbox input shafts contain free-wheel units, which permit one engine to drive the transmission or permit auto-rotation of the main rotor, without drag from the inoperative engine.

1.6.2.1. Engine Levers:

The No.1 and No.2 engine levers on the engine control quadrant are connected to the fuel control by mechanical linkage. The quadrant has three marked positions:"OFF", "IDLE", and "FLY". Detents at each position indicate proper positioning of the levers.

The engine lever schedules fuel flow and gas producer speed in the "OFF" to "GRD IDLE" range, and establishes the N1 speed limit for maximum engine power in the "FLY" position.

In addition to manual positioning the lever will also be moved to "OFF" when the respective fire extinguisher T-handle is pulled.

1.6.2.2. <u>N2 Speed Trim Switches:</u>

The No.1 and No.2 engine N2 speed trim switches on the grip of the collective pitch lever, are used to establish the desired power turbine speed and to match engine torque.

N2 is automatically maintained by the power turbine governor's action to meter fuel to the gas producer.

The switches are marked ENG TRIM-1 and 2. To increase N2, the switch is moved to + (forward) and to decrease N2, the switch is moved to - (aft). Trim range is about 96% N2 to 107% N2.

The Captain's switch will override any input from the copilot's switch.

A collective BIAS actuator and a collective pitch signal responds to collective stick movement and resets N2 governor to maintain a constant rotor rpm as established by the N2 speed trim when collective pitch is increased or decreased.

The output from the collective BIAS actuator to the speed trim actuator, is adjustable with a serrated link, which increases compensation with increasing lenght. The No.1 and No.2 engine N2 speed trim system is connected to the DC essential bus by circuit breakers marked SPD TRIM, and the collective BIAS system is connected to the DC essential bus by a circuit breaker marked CLTV BIAS.

1.6.2.3. <u>Torquemeter:</u>

A dual torquemeter marked PERCENT TORQUE has pointers marked 1 and 2, which indicate No.1 and No.2 engine torque output.

The torquemeter sensing system within the engine accessory gear box, provides a hydraulic signal which is directly proportional to torque output. This signal is transmitted electrically to the torquemeter on the instrument panel.

The electrical circuits for the No.1 and No.2 engine torquemeters are connected to the No.1 and No.2 DC primary buses respectively.

1.6.3. <u>Rotor system:</u>

The rotor configuration is a single main rotor and anti-torque tail rotor. Both systems are driven through the transmission and blade angles are controlled through the flight control system.

1.6.3.1. <u>Main rotor system:</u>

The main rotor consists of a main rotor hub bolted to the main rotor drive shaft, four main rotor blades, blade dampers, a swashplate assembly, and a bifilar vibration absorber.

The blades are attached to the main rotor hub by elastomeric bearings which permit the blades to flap vertically, hunt horizontally, and rotate about their spanwise axis.

The four main rotor blades consist of a titanium spar and a Nomex honeycomb core covered by a fiber glass skin. The leading edge of each blade is protected by titanium and nickel abrasion strips.

1.6.3.2. Tail rotor system:

A cross-beam tail rotor blade system provides anti-torque action and directional control. The blades are of graphite- and glass-fiber construction.

Blade flap and pitch change motion is provided by deflection of the flexible graphite composite spar eliminating all bearings and lubrication. The spar is a continuous member running from the attachment joint of one blade, through the center hub, to the joint of the opposite blade.

Like the main rotor blades, the four tail rotor blades have a fiber glass skin that is internally supported by Nomex honeycomb.

Flight control input is transmitted to the blades through control horns that twist the spar.

1.6.4. The fuel system:

The fuel is stored in two 143.2 USG integral tanks, below the cargo compartment floor.

The fuel tanks were filled when the helicopter landed at Reykjavik after a flight on 4 Nov. Then fuel samples were taken, according to regulations, and they were clear. A total of 401 liters Jet A-1 fuel had been added to the tanks and the helicopter was in the hangar until this flight.

At Ísafjörður the tanks were filled again with 535 liters Jet A-1. A test for water gave negative results. At the time of the accident, there were about 719 kg. (1585 lbs.) of fuel in the fuel tanks.

Each engine has its own complete fuel system which can be connected to the opposite engine by a crossfeed valve. The system is a suction type supply system.

The tank on the left hand side normally supplies engine No.1 and the tank on the right hand side supplies engine No.2 and then the fuel is drawn from the tank through the "DIR" position of each fuel selector valve.

The No.1 eng. and No.2 eng. fuel levers are on the engine control quadrant. The levers are connected by a mechanical linkage to the fuel selector valve in each main fuel line.

The quadrant has four marked positions, "OFF", "DIR", "PRIME" and "XFEED". Detents on the valve at all positions except "PRIME", indicate proper positioning of the lever.

"OFF" closes the fuel line between a fuel tank and it's respective engine, but does not close the crossfeed line to the opposite fuel system. "DIR" opens a fuel line between a fuel tank and its respective engine. "XFEED" opens the fuel lines between this engine and the opposite tank. "PRIME", although not a true valve position, is used if the fuel leading to one engine has lost its prime.

Fuel under pressure from the opposite engine or from the ground primer connection is used to fill the evacuated line. The fuel line must be full for the suction-type engine fuel pump to draw fuel from the fuel tank.

1.6.5. Automatic Flight Control System (AFCS):

A dual channel AFCS provides stability around pitch, roll and yaw axis. The channels are redundant, each with a separate electrical power source, vertical gyro, yaw rate gyro, linear actuators and control panel.

Control authority of each channel is limited to 5% with a continued limited authority of 10%. The pilots can easily override the AFCS inputs through normal use of the flight controls, if AFCS system malfunctions.

1.6.6. Weight and Balance:

The maximum permissible take-off weight was 4672 kg. (10300 lbs.) A load sheet was not prepared for this flight, but detailed information is available of the weight carried at the time of the accident.

In the cargo compartment were approximately 101 kg (222 lbs.) of baggage and equipment. The maximum load permitted is 272 kg (600 lbs.). In the cabin were about 45 kg. besides the crew. It is estimated that the take-off weight was about 4327 kg, or 345 kg. below the maximum weight permitted.

The longitudinal center of gravity was 203,5 inches aft of Datum. The allowable CG range was 195,8 - 207 inches aft of Datum. Lateral center of gravity was negative 139,4 lbs/inches. The permissible range was from positive 335 to negative 335.

1.6.7. Intercom:

The helicopter was equipped with an intercommunication system via helmets and headsets, for all crew members.

1.6.8. Airworthiness Documentation:

The helicopter was maintained by the ICG Maintenance Department, according to a Maintenance Schedule recommended by the Sikorsky Aircraft and approved by the Icelandic Directorate of Civil Aviation.

All recommended alterations and repairs had been accomplished and all Airworthiness Directives had been complied with. The documentation was in order and there is no indication that the helicopter had not been in an airworthy condition, when it took-off on it's last flight.

1.6.9. Radio altimeter:

The helicopter was equipped with a Collins ALT-50 Radio Altimeter. This instrument was installed at manufacture. It was calibrated from 0 to 2500 feet, with an accuracy of 0.5 feet plus/minus 2% of the true height.

There was a special decision height cursor that could be set to any chosen height and when the helicopter reached that height, a light illuminated on the instrument face and remained illuminated as long as the height was the same or less than the one selected.

According to ICG flight crews' verbal information the R/A should be adjusted to 120 feet in cruise and when engaged in hoist operations, the captain was to set his cursor to correspond with the hoist height and the co-pilot to set his at 50 feet.

1.6.10. Underwater acoustic beacon (Pinger):

An underwater acoustic beacon was installed in the cabin roof. This beacon is activated by water immersion and it transmits sound on 37,5 kcs. This beacon is intended to aid in the location of submerged aircraft.

In this case it played a key role, when the helicopter wreck was located.

1.6.11. Electrical system:

The primary source of electrical power is a 28v DC system. A 115v AC system is supplied by one AC generator and by one standby inverter.

1.6.11.1 DC Power supply system:

The primary power source for the DC system are two starter-generators. The secondary power source is the battery.

1.6.11.1.1. No. 1 and No. 2 Starter-generators:

A 200 Amp. starter-generator is mounted on the accessory gear box section of each engine. They function as engine starters when provided with DC power from the battery, or an external power source.

After an engine start when the engine is operating at idle, they function as DC generators. Generator control panels regulate generator output and protect against overvoltage, undervoltage, reverse current, and ground fault conditions.

Generator switches on the master switch panel marked GENERATORS "1 DC" and "2 DC", have positions marked ON, OFF and RESET. One connects each generator to its power distribution system when the generator control panel senses, that generator output is within certain limits.

If the generator has dropped off the line due to a momentary overvoltage or other fault, placing the switch to the "RESET" and then "ON" will restore generator operation.

1.6.11.1.2. Battery:

A nickel-cadmium 34 Ah. battery is installed in the electrical compartment. The battery is used for limited ground operation and as a secondary source of power in flight.

The battery provides power only to the most essential equipment.

1.6.11.2. AC Power Supply System:

The primary power source for the AC electrical system is an AC generator, and the secondary power source is an inverter.

1.6.11.2.1. AC Generator:

A three-phase 7.5 KVA AC generator is mounted on and driven by the main gear box. A generator control unit regulates generator output and protects against overvoltage, undervoltage, under frequency and feeder fault.

The generator control circuits are powered by a DC permanent magnet generator.

1.6.11.2.2. Inverter:

The secondary power source for the AC electrical system is a 600 VA inverter. The inverter is powered from the No.2 DC primary bus through a circuit breaker marked "INV PWR" on the DC junction box.

1.6.12. Emergency flotation system:

The helicopter is equipped with an emergency water landing flotation system.

It consists of four separate floats, one on each main landing gear wheel door and two in compartments next to the nose wheel well. Each bag is divided into two compartments.

The system is electrically activated and the bags inflate in approx. 10 seconds from activation. Special bottles contain compressed Nitrogen for this purpose.

The inflation requires two actions:

Firstly, the arming switch, located on the center aft pedestal must be put to "ON" and then a warning light illuminates on the caution panel. Secondly, a switch on the cyclic handle is activated in order to inflate the floats.

The maximum airspeed during inflation is 75 kts. The S-76 Operation Manual states "The arming switch is normally kept in the "OFF" position, to prevent accidental inflation of the floats".

The ICG pilots kept the arming switch normally in the "OFF" position, in order to prevent confusion, because on the other ICG helicopter, the Hughes H-369 the operating switch for the cargo hook is in a similar location as the float arming switch on TF-RAN.

It is known, that certain helicopter operators require similar systems to be armed during flights conducted below 200 feet above water and restricting the airspeed accordingly.

1.6.13. Sliding door:

A sliding door was installed on the right hand side of the helicopter during manufacture. Two primary and two secondary latch pins prevent the sliding door from being accidentally opened in flight.

Operating controls are inside/outside handles and inside/outside locks. To open the door from the inside or outside requires that the lock be turned to the UNLOCK position after which the handle is turned down.

The secondary latches on the top and bottom of the door are backups for the primary latches at the side of the door and prevent the door from being opened accidentally from the inside.

The position of the lock in the locked position and the handle in the closed position provide a visual means for determining proper latching of the door.

A micro switch on the lower secondary latch also indicates to the crew via the caution-advisory panel, whether the door is closed and locked or not. The door slides on an upper and lower track and a swivel assembly.

When the door is pushed open, the door and tracks move out from the fuselage about 4 inches. As the door slides aft, the track and swivel assemblies extend. When they reach full extension, a stop within each assembly halts further extension and a spring-loaded hold-open stop on the door engages a catch, to prevent the door moving forward.

The maximum permitted airspeed for door opening in flight is 50 kts. IAS and the maximum airspeed with the door open is 74 kts. IAS.

1.7. Meteorological Information:

The Iceland State Meteorological Office made the following survey of the weather situation at the time of the accident:

"At midnight there was a 1027 MB high pressure area over the southern part of Iceland, extending to the east and southwest.

There was a 1007 MB low pressure area between Iceland and Jan Mayen moving east and a low pressure trough extending to the south-west between Iceland and Greenland. Because of this, there was a south-easterly wind blowing in the north-west part of the country. Strong in places on the ocean fishing grounds, but somewhat calmer inland.

At 2100 hrs. the weather was as follows:

Galtarviti:
Wind south-west 25 kts., visibility 20 km, precipitation in the near vicinity, 8/8 clouds, 5/8 stratus at 600-1000 meters and altostratus above. Temperature +2°C, pressure 1020,2 MB, falling 0,5 MB in the last last 3 hours.

Hornbjargsviti:
Wind south-west 20 kts, visibility 13 km, snowshowers, 8/8 cumulonimbus at 600-1000 meters, temp. -1°C, pressure 1020,0 MB, falling 1,1 MB in the last 3 hours.

At 2400 hrs. the weather was as follows:

Galtarviti:
Wind south-west 25 kts, visibility 20 km, rain and drizzle, 8/8 stratus at 600-1000 meters, temperature +4°C, pressure 1019,9 MB, falling 0,1 MB in the last 3 hours.

Hornbjargsviti:
Wind south 20 kts, visibility 3 km., snowshowers, 8/8 cumulonimbus at 300-600 meters, temperature +1°C, pressure 1019,9 MB, falling 0,1 MB in the last 3 hours.

In general, the weather in the accident area was not bad, when the accident occurred.

The wind was from the south-west at about 25 to 30 kts, possibly some snow showers and no low clouds. The temperature was rising at the time."

The weather observation made at the ICG vessel OÐINN was as follows:

When TF-RAN landed on the ship at 1741 hrs. the wind was from the south at 30-35 kts, temperature -1°C, pressure 1022,5 MB, 8/8 clouds, no precipitation.

At 2100 hrs. the weather was the same, except the temperature was 0°C.

At 2200 hrs. the weather was still the same and had not changed, when the helicopter took-off from the ship.

Prior to departure from Reykjavík at 1504 hrs. the pilots had discussed the weather with the Met officers on duty at the Meteorological Office. They also had the 1200 hrs. weather observation and the forecast for the next 24 hours. This was as follows for the Jökulfirðir area:

"Wind SW force 3 to 5 and snow showers, becoming SW force 5 to 7 and sleet during the night."

The pilots had the possibility of listening to the broadcasted weather forecast in the ship at 1845 hrs. and at 2215 hrs. This was valid for the next 24 hours:

1845 hrs: "Winds from the SW force 6 to 7, with some snow-showers at first and later drizzle."

2215 hrs: "Winds from the SW force 7, sleet to-night, becoming W force 6 and drizzle, in the morning".

The 1200 hrs. observation was:

Hornbjargsviti:
Wind south 5 kts, 6/8 at 3600 feet, good visibility.

Galtarviti:
Wind SSE 20 kts, 6/8 at 3600 feet, temerature -2°C, good visibility.

Æðey:
Calm, almost clear, good visibility temperature -7°C.

Gjögur:
NE 5 kts, clear, good visibility.

The 1800 hrs. observation was:

Hornbjargsviti:
SW 15 kts., 7/8 at 2500 feet, temperature -1°C, visib. 7 km.

Galtarviti:
SSW 15 kts, 8/8 at 2500 feet, temperature +1°C, visib. 30km.

Æðey:
SW 15 kts, 8/8 at 2500 feet, good visibility.

Ship 10 NM north of Kögur:
SW 35 kts, 8/8 at 1600 feet, visibility 10 km.

Ship 55 NM north of Kögur:
SW 35 kts, 8/8 at 2500 feet, visibility 25 km."

The Icelandic Meteorological Office made a special study of a possible formation of mountain waves in the accident area and their possible effects on the flight. The following is a summary from that study:

"On the morning of 8 November 1983, the winds were calm and the sky almost clear, but in the evening it became overcast with increasing south-west wind in the West-fjords.

Surface weather charts indicate that by midnight the geostrophic wind had gained the strength of 45-50 knots, from the south-west. Higher level charts show strong west winds over the northern part of the country while winds remain almost calm over the southern part.

A vertical wind and temperature profile was constructed for the Jökulfirðir area, based on the midnight radiosonde observation at Keflavik and the corresponding weather charts.

A satellite picture shows mountain waves over the northern part of Iceland. They are clearly formed in the west wind, above the inversion. These waves are not likely to have influenced flight conditions in the Jökulfirðir area where the main mountain ranges lie east-west.

The wind component perpendicular to Snæfjallaheiði indicates a possibility of rotor streaming, and that possibility is further substantiated by calculation of the Froude number and the depth of streaming layer.

From the Brunt-Väisala frequency it may thus be concluded that a rotor was approximately 9.4 km downwind from the mountain, perhaps associated with severe turbulence.

It is very likely, that on the evening of 8 November 1983, there was heavy turbulence above the fjord, because of the downward flow of air at the northern side of Snæfjallaheiði and the associated rotor over the fjord.

It is neither possible to measure in numbers the severity of the turbulence, nor at what altitude it was strongest, for instance if it existed all the way down to the sea level.

It should also be kept in mind, that the "upper air observation" which this study is based on is in major aspects based on theories rather than actual measurements and therefore the conclusion might not be as accurate as desired."

1.8. Aids to Navigation:

None.

1.9. Communication:

The helicopter was in radio contact with the ship. The Deck Control Officer had a portable VHF-transceiver and the ship's Commander and Radio Operator were in the bridge. Frequency used was 122.5 MHz. and the communication was loud and clear.

According to the ship's crew, the helicopter captain was operating the radio and everything appeared to be normal.

After take-off the C/O called TF-RAN and said he was starting to turn the ship. The captain then answered "Roger". A few seconds later, a call was transmitted from the helicopter. This was unclear but without radio interference.

The C/O, the Deck Control Officer and the Radio Operator all maintain, that this was the TF-RAN captain calling "MAYDAY-MAYDAY".

There is no tape recording equipment aboard the ship and this transmission could not be heard elsewhere, so it is impossible to verify or to investigate this further.

1.10. Aerodrome Information:

Not applicable.

1.11. Flight Recorders:

Icelandic Aircraft Operating regulations do not require flight or voice recorders in aircraft of this size.

However, there was a cockpit voice recorder installed in TF-RAN at manufacture, but it was removed for repair in early 1983. It had not been returned to service after being certified as airworthy, at the time of the accident, because of lack of funds to the ICG Aircraft Maintenance Department.

1.12. The Wreckage and Impact Information:

1.12.1. The salvage and the on-site examination:

Immediately after TF-RAN was missing, an extensive search was initiated. At 0105 hrs. fragments of all four main rotor blades were found approximately 1 NM downwind from the point, where the wreck was later located, also some other loose objects from the cabin were found floating. Despite of an intensive search, nothing more was found on the surface of the sea.

On the request of the NASB, the United States embassy in Reykjavik assisted in securing a five man team from the US-Navy and the US-Air Force, who arrived in the evening of 9 Nov. and managed to locate the "Pinger" the following morning.

The wreck was located on the sea bed at a depth of 84 meters, approximately in the middle of the fjord, at about 0.8 NM from the spot where the ship was, when the helicopter took-off. Geographical location of the accident site was approximately 66°17'N,22°41'W.

At about 1500 hrs. on 10 Nov., an attempt was made to locate and if possible to inspect the wreck, by using an underwater TV-camera, lowered from a small fishing boat.

Despite shifting currents and very limited visibility a fairly good view of the wreck was obtained.

The helicopter was resting upside down. The main rotor and the engines were buried in sand and clay on the bottom and the landing gear was extended.

The two right hand chin windows were broken and the sliding door was missing, the door tracks were fully extended and the upper track was bent sharply upwards. The left hand aft door was wide open and the tail rotor assembly was broken off, hanging on its control cables.

During this observation, the camera cage accidentally hooked onto the extended left gear, thus giving the investigators the idea to try to use the camera cables to direct a rope onto the helicopter main gears.

This was successful and when firm attachments to both main gears had been achieved in the morning of 15 November the wreck was hoisted up to a depth of approximately 40 feet, where divers removed the 2 bodies found inside the helicopter. Then an assisting cargo vessel arrived which hoisted the helicopter aboard and subsequently placed it on OÐINN's helideck, where the investigation commenced.

In general, the fuselage structure was in a good condition. The pattern of the damage sustained as a whole, was consistent with the aircraft landing with little forward speed and a low rate of descent. There was however some right yaw rotational damage. The windshield wipers were distorted and pushed over to the left. The right hand side chin windows and the cockpit door window were broken inwards. The tailcone skin was buckled and some frames and stringers on the left hand side of the tailcone were deformed.

There was a small smooth impression on the right hand side of the fuselage above the windshield, adjacent to the cockpit air inlet.

The sliding door had evidently seperated upwards from it's tracks. The search light was almost stowed. The floats had not been inflated and the arming switch was not activated. The landing gear was extended and locked.

The bodies of the copilot and the hoist operator were recovered, the other two are still missing. The search for the missing crew members and parts from the wreckage, especially the sliding door and rotor blade parts, continued by use of the TV-camera and dragnets, but only the swivel chair and a part of the skin from a main rotor blade tip were recovered.

1.12.2. <u>Detailed exmination of the wreckage:</u>

A detailed investigation of the wreck, it's various components and systems was commenced in Reykjavik by the Icelandic Directorate of Civil Aviation, the Icelandic National Air Safety Board, and the National Transportation Safety Board of the United States, with the assistance of Sikorsky Aircraft and Allison, the manufacturer of the engines.

The following components were shipped to the U.S.A., where a thorough investigation was conducted by and under the supervision of the NTSB and a representative of the NASB:

- -Cockpit instruments, such as captain's and copilot's collective heads, triple tachs, vertical speed indicators, airspeed indicators,
- -The tail rotor and gearbox remains,
- -A fiber glass cone from the tail fin,
- -Upper and lower sliding door tracks and stops,
- -Engine fuel system parts,
- -Main rotor hub and all four blade roots,
- -Selected engine parts,
- -Main transmission,
- -The six AFCS actuators,
- -The flight control servos.

This investigation was mainly concentrated in those areas of the aircraft, which affect the aircraft's control characteristics and the aircraft systems.

1.12.2.1. <u>The Main Rotor Assembly:</u>

All four main rotor blades had separated 20-30 inches from the root end.

Smeared and crushed deposit of a white enamel paint which was found on the lower surface of the "black" main rotor stub, was tested in a laboratory and found to be of the same type as used on the aircraft.

1.12.2.1.1. <u>Hydraulics:</u>

The three primary servo actuators (forward longitudinal, aft longitudinal and lateral) were removed from the main transmission and delivered to a hydraulics test laboratory for visual examination and functional testing.

There was no damage evident externally on the three servos. There was no deformation of the power piston rods, follow-up arms, or pilot valve input linkages. All safeties were in place and secure with the exception of the forward longitudinal servo 1st and 2nd stage input linkages.

During the visual examination it was noted that the two lock bolts, which safety the adjustment links, once pilot valve timing has been accomplished, had fractured through the bolt shank area.

Metallurgical examination of the fractures indicated that salt water immersion and the bolt torque had resulted in the initiation of stress corrosion. The servos were then functionally tested.

The servos were installed on the test bench and operated on individual stages and then two stages as they would be when installed in the helicopter. The forward longitudinal servo was functionally tested as received without disturbing the pilot valve linkages. The servo functioned normally in all respects.

Both single stage and two stage operation were satisfactory as to timing, pilot valve centering, internal leakage, stroke, and actuator forces. The aft longitudinal and lateral servos also operated satisfactorily.

A slight misadjustment of the lateral servo second stage pilot valve resulted in a slight power piston rod jump when cycling pressure off and on. This condition would go unnoticed when installed on the helicopter.

In summary, there was no evidence of a pre-impact failure or malfunction noted during the visual examination or functional testing of the three primary servos.

1.12.2.1.2. Rotor head and blades:

The main rotor hub, dampers, main blade fractures, and main rotor spindle assemblies were examined in a metallurgical laboratory.

All blade fractures were the result of an overstress condition and had deformed upward prior to failure. The table below documents the type of damage noted to the spindle assemblies, the spindle retaining ring, damper to blade attachment fitting, and the inner diameter of the individual main rotor hub arms.

The main rotor blade excursions were typical of a rotor system which has been exposed to sudden stoppage:

Blade I.D.	Spindle deformation	Evidence of excess lag.
Red...........	40 degree lag	heavy
Black.........	15 degree lag	heavy
Yellow........	5 degree lag	heavy
Blue..........	minimal lag	heavy

	Evidence of Excess Lead	Flapping Excursions	Damper Attach Failure Direction
Red...........	heavy	up-no down-no	upward & lead
Black.........	moderate	up-no down-moderate	downward & lag
Yellow........	heavy	down-moderate up-heavy	downward & lag
Blue..........	moderate	up-moderate down-moderate	downward & lag

Examination of the "black" blade stub, revealed damage to the lower leading edge, scratches and smears on the underside of the blade, which was very probably caused by the sliding door. (See pictures Appendix 5.3.).

1.12.2.2. Flying controls and hydraulics:

Continuity existed in the main rotor system flight controls in all channels, from the cockpit controls aft to the inputs of the stationary swashplate. The three primary servos were in good condition with no damage evident to the pilot valve inputs or follow up arms. The AFCS servos were also in good condition.

The tail rotor control system was continuous from the cockpit rudder pedals aft to the area where the tail rotor gear box seperated.

There were no marks of overheating on the drive train, and the fracture of the tail rotor box housing was a static fracture. The tail rotor shaft was complete with no damage to the bearings or couplings.

The two hydraulic pumps, which were installed at the time of the accident, were functionally tested and they produced rated flow at varying pressures and compensated properly to flow demand.

1.12.2.3. Tail rotor assembly:

The tail rotor gear box housing had seperated and three of four blades had seperated through the spar at the root area. (See Appendix 5.3.). The fourth blade was complete with only light leading edge damage along its span. The pitch link for the blade was complete. The other three had seperated through the rod end bearing.

The tail rotor gear box housing seperation and center housing crack were examined in detail in a metallurgical laboratory.

All fractures were typical of an overstress condition with no evidence of fatigue.

The tail rotor servo power piston rod output fitting, which attaches to the inboard end of the pitch actuating shaft, had failed in tension due to an overload condition.

The directional control bracket and servo input linkages had also failed as a result of an overload condition.

There was nothing noted during the examination of the tail rotor gear box to indicate that a pre-impact failure or malfunction had occurred.

The tail rotor servo was removed from the tail rotor gear box and functionally tested.

Due to the impact damage that occurred at the tail rotor servo power piston output rod end and input linkages, it was necessary to functionally check the servo at lower than normal operating pressure. The servo, however, operated satisfactorily despite the damage mentioned.

The damage to the tail rotor assembly was examined in a metallurgical laboratory. The three paddle seperations were the result of an overstress condition due to sudden stoppage. The three pitch link rod ends had bent opposite the direction of rotation prior to seperating.

The spacer, located inboard of the tail rotor hub retaining nut, seperated as a result of sudden stoppage.

Witness marks indicated, that the spacer had been forced opposite the direction of rotation prior to seperation. The tail rotor pitch beam was in good condition, with no deformation of the control arms noted.

1.12.2.4. Engines and main transmission:

Disassembly revealed no abnormalities and the engines appeared to be running at impact.

Both impellers had several bent blades, but there were no mechanical indications. The bending was most likely caused by ingestion of water, when the engines entered the water. The AC generator drive shaft had sheared by torsion overload. Both input shafts were in good condition, with no evidence of torsional loading.

The main transmission was disassembled. The rear cover was removed with some difficulty. The accessory drive gear train was continuous with no chipped or missing teeth evident.

The No.1 and No.2 input reduction gears and vertical pinions were intact with no signs of distress. The tail take-off gear train was also in good condition with no evidence of spline damage. The lower cover was then removed. The quill shaft/bull gear was in good condition with no evidence of damage.

In summary, there was nothing noted during the partial disassembly to indicate that a pre-accident failure or malfunction had occurred within the main transmission.

1.12.2.5. SAS actuators:

The SAS actuators were operational at the time of the accident and were as follows:

Roll No.1, slightly retracted, Roll No.2, slightly extended, Pitch 1 and 2 extended and Yaw 1 and 2 fully retracted.

This indicates, that the SAS system was either correcting for nose-up movement and left-yaw rate, or opposing corrective control commands for nose-down and right-yaw attitude.

1.12.2.6. Engine controls:

The collective BIAS engine controls were in a position consistent with normal flight. The no.1 beeper motor was found to be driven to the high stop and the no.2 was centered. The overhead quadrant controls were as follows:

Engine No.1: Engine speed selector in "FLY" position, fuel selector in "Cross feed" and the emergency shut-off lever was in "FLY" position.

Engine No.2: Engine speed selector in "Ground idle", fuel selector in "Direct" position and the emergency shut-off lever was in the aft position.

1.12.2.7. Sliding door:

The inner tracks were missing from both the upper and lower assemblies and both intermediate tracks were fully extended. The aft end of the intermediate track in the upper assembly was bent significantly upwards.

Examination of the lower track assembly revealed only four ball marks or impressions instead of the expected twelve. This could indicate either misassembly or prior ball loss condition before the accident. Also three out of four expected intermediate end cap ball marks were missing. Further examination also revealed, that the end cap cage fasteners were installed improperly, when compared to the upper door track and a new assembly, which leads to the conclusion that such misassembly may have taken place prior to delivery to the ICG.

It is evident, that the sliding door first seperated from the intermediate tracks, pulling out of the lower door track assembly. Then it rotated upwards, pulling out of the upper intermediate assembly which was bent up and forward.

There was a mark on the main rotor pylon and the hoist neck, indicating that the door had been deflected up into the main rotor and deflected forward by the main rotor blades. This is substantiated by the damage and smears on one (black) rotor blade.

The investigation did not reveal the reason for the missing ball marks from the lower track assembly. The maintenance documentation does not include any work performed in the area pertaining to the problem discussed above.

The ICG Technical Manager and the ICG aircraft mechanics, state that neither the door nor the tracks had ever been removed during the helicopter's service life with the ICG.

The position of the upper and lower tracks as received was compared to another S-76A located in the Sikorsky hangar (see 1.17.2.).

Examination of the forward and aft-door latches indicated no damage to the serrated adjustment locking plates. This lack of damage verified that the door was not closed and locked at the time it seperated from the door tracks.

This is also substantiated by the fact, that both tracks were in the fully extended position, when the door seperated.

1.12.2.8. Radio altimeters:

Both radio altimeters were examined. Both had been operating normally.

Captain's showed: 175 feet, bug set at 0 feet, out of view.

Co-pilot's showed: 190 feet, bug set at 50 feet.

1.12.2.9. Collective controls:

The collective controls were in good condition with no noticeable deformation in the sticks themselves.

The outboard side of the primary hydraulic servo switch guard on the co-pilot's collective was bent about 90 degrees outboard. Both controls exhibited evidence of being immersed in salt water. The cannon plug connectors were in good condition with no evidence of broken or bent pins.

A continuity test was performed on the wiring and switches of both collective controls.

Electrical continuity was tested. The pilot's wiring and speed trim switches tested normally. On the co-pilot's control, the No.1 engine speed trim wiring and switches indicated an "open" condition. The No.2 system was satisfactory.

The collective controls were then delivered to an operational S-76A on the Sikorsky Flight Field. External electrical power was supplied, the controls were connected electrically into the helicopter system, and the following observations were made during the functional testing:

The No.1 and No.2 engine trim switches on the pilot's collective operated normally. The No.1 switch on the co-pilot's control was inoperative. The following times were recorded when operating the actuators.

	Captain's:	Co-pilot's:
Events:	No.1/No.2-secs:	No.1/No.2-secs:
Full Decrease to Full Increase	4.7/4.7	INOP/4.5
Full Increase to Full Decrease	5.2/4.7	INOP/4.7

The override capability of the pilot's collective speed trim switches was tested for the No.2 engine and found to operate normally. The No.1 system could not be tested due to the co-pilots No.1 trim switch being inoperative.

The co-pilot's control was examined in an electrical laboratory, in order to determine whether the No.1 switch or wiring was at fault.

The wires were disconnected at the switch terminals and wiring continuity was tested. The wiring within the bundle was satisfactory. This indicated an internal malfunction of the switch due to corrosion damage caused by salt water immersion.

1.13. Medical and Pathological Information:

A post mortem examination of the two bodies recovered revealed, that the cause of death was drowning.

The co-pilot had some minor scratches on the back of his right hand.

There was no sign or trace of alcohol or toxic material in the blood samples taken.

1.14. Fire:

There was no fire.

1.15. Survival Aspects:

The accident is classified as survivable.

1.15.1. Survival suits:

Survival suits were in the process of being obtained for the ICG helicopter crews and some crew members had already received theirs. These suits are water resistant, but they have no flotation material. Both pilots were wearing their survival suits.

The hoist operator/aircraft mechanic was wearing a special flotation suit, but for some reason he had removed the flotation material from it and he was wearing a heavy parka over it.

The captain was not wearing a helmet and there is a reason to believe, that none of the crew was wearing a life vest.

1.15.2. Escape from the helicopter:

The emergency floats had not been deployed and the arming switch was in the "OFF" position. Both pilot doors had been unlocked and the captain's (R/H) door window was broken inwards. The co-pilot was not buckled in his seat and he was without a helmet, when recovered.

The hoist operator had apparently started the preparation for the hoist exercise, as he had released his seat belt, and put the gunner's belt around his waist and attached himself to a special hook in the roof. He had also put on a special glove used during the hoist work and the pendant hoist control cable was wrapped around his leg.

The tethering line (gunner's belt) buckle was locked with a specially installed safety pin and it had not been released.

Aft of the Captain's seat, forward of the sliding door, there is a swivel chair, which locks on each 90 degrees and is loose in other positions (rotational and up). The chair was missing, but it was picked up by a dragnet and recovered 2 days after the helicopter was salvaged. The seat belt had been released.

At take-off the mate was occupying the revolving chair and facing forward.

1.16. Tests and Research:

A detailed examination of selected components, was carried out by the National Transportation Safety Board of the United States and by various manufacturers of the S-76 components, under the supervision of the NTSB.

The results of this investigation are included in this report.

1.17. Additional Information:

1.17.1. The Flight Operation of the Icelandic Coast Guard:

1.17.1.1. General:

The Icelandic Goast Guard has been operating aircraft for almost 30 years and helicopters since 1965.

The Flight Operations Department is located at Reykjavik Airport, in a special building, belonging to the ICG.

The ICG Flight Operation is controlled by a Control Center, located at the ICG headquarters, downtown Reykjavik.

The regular operating hours are from 0800 hrs. to 1800 hrs. each day and a specially assigned officer is on standby duty at other times.

On 8 November 1983, the ICG was operating one F-27 aeroplane, one H-369 and one S-76A helicopter.

The ICG did not have an official Flight Operations Manual and such a manual had at that time not been made mandatory for the ICG by the Directorate of Civil Aviation.

1.17.1.2. The Organization and the Structure of Responsibilities:

According to an Organization Manual issued by the ICG in March 1983, the ICG is organized in a such a way, that the Flight Operation Department and the Naval Operations Department are both controlled by the Operation Control Center.

The commanding officer on duty in the OCC is, according to the Manual, responsible for the training of flight crews other than pilots and for the planning and organization of aircraft activities.

The Manual also states, that a ship's C/O is responsible for the entire operation aboard the ship. It is also his responsibility to see to, that the ship's crewmembers are properly trained and capable of performing their duties.

According to this manual, the ICG Chief Pilot also acts as Flight Operations Manager and is as such responsible for the preparation of flights and flight activities. He is also responsible for helicopter activities.

The captain of TF-RAN was an IDCA approved ICG check and training captain for the helicopters.

According to the Manual the Technical Director is responsible for the maintenance, inspection and for quality control within the ICG maintenance department.

He however reports directly to the ICG Director of Finance, who reports to the ICG Director General.

1.17.1.3. Icelandic Coast Guard "Manual for Helicopter Operation aboard ICG vessels"(HB-1):

This Manual "HB-1", was issued by the ICG 14 June 1973. It was distributed to all personnel involved in the ICG helicopter operation and according to the manual, there were to be 8 copies aboard each ICG vessel.

This Manual spells out the regulations for the heli-copter operation. It explains how this operation is to be performed, how procedures used by the ICG airmen and seamen on board the ICG vessels must be coordinated, in order to achieve and ensure minimum safety levels.

This Manual was issued when the ICG was operating small helicopters, such as Bell-47, limited to VFR flights only.

It has never been revised and therefore it does not include procedures or instructions regarding night operation, flight in accordance with Instrument Flight Rules (IFR) or operation of helicopters such as the S-76A.

Following is an extract of some of the requirements, as laid down in this Manual ("HB-1").

1.17.1.3.1. Helicopters operating from an ICG Vessel:

A C/O can deviate from the laid down procedures, provided all parties are informed, also if it becomes necessary to deviate from the laid down procedures, the C/O must approve that and everybody concerned must be informed properly.

The Manual states that when a flight is planned from a vessel to a landbase, the ship must obtain weather information for the helicopter's planned route and at it's destination.

It states, that when a helicopter is operating from a vessel, there must be three men in the bridge during that operation:

1. One is Manoeuvering the ship.
2. One is acting as Flight Operation Officer and monitoring the flight.
3. One is the Radio Operator and he is in a supervising capacity and maintains the communications.

In the event of a loss of communication between the ship and the helicopter, visual signals are to be used aboard the ship, in order to guide the helicopter.

The 1973 Manual does not specify requirements neither does it take into consideration the possibility of extended helicopter patrol flights from and back to the ICG vessels nor night operation.

The duties of the Deck Commander are defined. However it does not mention the readiness of the life boat crews, when the helicopter is operating and it seems to assume, that the same persons are functioning on the deck as tie-down personnel, fire fighters and lifeboat crews.

A helicopter captain is responsible for training flights and for the combined training of the helicopter crew and the ship's crew.

The C/O is responsible to see to that the ship's crew is well trained and proficient, as helicopter operation is concerned and he shall notify the ICG when a recurrent training is necessary.

An ICG vessel is considered unfit for helicopter operation, if it's crew has not participated in helicopter operation on 5 occasions during the preceeding 6 months period in which case a complete retraining is required.

According to the information given by the ICG, the total helicopter operations involving the ICG vessel OÐINN in the preceeding year, was that 2 landings and 2 take-offs were made on it's deck, on 18 Oct. 1982 and 2 landings and 2 take-offs were made on 20 Sept. 1983, in both instances by TF-RAN.

The ICG vessel radar monitoring of helicopters in flight, is described as follows:

"When a helicopter is operating from an ICG vessel, the ICG vessel must constantly monitor the helicopter by radar, if the helicopter is not on a visual flight".

1.17.2. Sliding door tests:

1.17.2.1. Test performed by the Investigating Authority:

During the investigation, a sliding door mechanism identical to the one on TF-RAN, was examined on a S-76A North Scottish helicopter, which was at the Sikorsky Factory for maintenance/overhaul.

In the hangar, electrical power was applied to the helicopter and the right sliding door was manipulated in an attempt to discover, if door handle positions (primary and secondary) would extinguish the door warning light in the cockpit.

During these manipulations, it was found that the door could be placed in a closed position and the primary locking handle left open. If the secondary lock was in the "locked" position the door warning light would extinguish in the cockpit.

In this "locked" configuration the warning light flickered, when the bottom surface of the door was pulled outboard. This condition, namely the main locking feature not actuated and the secondary lock actuated, seems not to fulfill the intent of the door design and does not give the cockpit crew an indication of the unsafe condition.

1.17.2.2. Sikorsky Aircraft's evaluation:

The Sikorsky Aircraft engineers, provided information of their analysis and testing of the sliding door, as follows:

"Door track has been designed and proof tested to 170 pounds in the lateral direction.

Door load at 65 kts. is 150 pounds limit in a lateral direction.
Door proof test:

- Tracks extended, aft bayonets engaged:
  v=30, d=82, s=+/- 200 (limit loads, forward speed 75 kts. at max. cl.)
- Tracks extended, aft bayonets not engaged:
  v=30, d=82, s=+/- 150 (limit loads, forward speed 65 kts. at max cl.)
- Tracks compressed, swivel arms jammed:
  v=30, d=82, s=+/- 150 (limit loads, forward speed 65 kts. at max. cl.)

(v = vertical load, d = drag load, s = side load)

New door track was statically loaded to 530 pounds laterally and 300 pounds vertically, prior to failure. (This equates to 750 pounds laterally per track of 1500 pounds total on door.)

Sliding door handling qualities flight test, Nov. - Dec. 1979.

- Opened intentionally at speed of 60 kias. and approximate sideslips of 18° left and right.
- Opened intentionally at speeds of 88 kias. level flight.

During a test flight, the sliding door was unintentionally not fully latched and opened in flight at a speed of 135 kts.

Door remained on aircraft with minor damage only to open stop links.

Hydrodynamic loads are 800 pounds, assuming forward speed of 30 kts. with lower 12 inches of door immersed".

1.17.3. Door opening accidentally:

On one occasion, the TF-RAN sliding door opened accidentally shortly after take-off. This was on an ambulance flight and the helicopter had departed in a hurry. Soon after take-off, at an airspeed below 70 kts. the door warning light came on.

The pilots asked the hoist operator to check the door and he noticed that the locking handle was not in it's proper position. When he touched it, the door flew open with a "loud bang". No damage occurred to the door mechanism.

In the U.S.A., Sikorsky test pilots once reported an inadvertent opening of the sliding door, during a Sikorsky test flight at 135 kts. This did not damage the door tracks.

One of these Sikorsky test pilots stated to the investigation board, that he believed the helicopter had suffered a serious engine malfunction since the "bang" sounded like an explosion.

1.17.4. The inflight "BANG":

On the 31 Sept. 1983, when cruising at 4000 - 5000 feet, the crew of TF-RAN suddenly experienced a very distinct "BANG", which resulted in a "kick/yaw" to one side and back. A power-off descent was immediately initiated and the helicopter landed.

A detailed inspection and investigation was conducted at the landing site and continued after the helicopter had been transported to Reykjavik.

The investigation did not reveal the reason for the "BANG".

1.17.5. Crew fatigue:

Both pilots had returned from a recurrent training course in the United States two days prior to the accident.

Both had been off duty on 7 Nov., but they reported to duty 8 Nov., at 0900 hrs.

1.17.6. ICG hoist procedures:

ICG pilots described the hoist procedure as follows:

" The take-off is made off the upwind side of the ship and the pilot closer to the ship is at the controls when taking off.

Maximum take-off power is selected, then climb out airspeed is increased to 52 kts with a climb to 5-700 feet. The pilot not flying is handling the radio and monitoring the operation.

Then a standard traffic pattern is flown and if the captain has not been flying, he takes over the controls on final. He decreases the speed below 50 kts, gives orders to go on the "hot mike" and opens the sliding door. Flare is at 120 feet.

The captain sets his Radio Altimeter bug on the hoist altitude, that already has been decided and the copilot sets his R/A bug on 50 feet. Usually the hoist altitude is 80 feet in darkness and lower in daylight.

When a new hoist operator is being trained, a longer traffic pattern is flown, in order to discuss the procedures with the trainee".

The Hoist Operator's Manual states, that the aircraft should be discharged of static electricity, by dipping the hoist hook onto the ground, before lowering it on to the ship. This was normally done close to the hoist site.

The ICG pilots and hoist operators maintain, that this would not have been carried out under these circumstances.

1.17.7. Adjusting of the controllable searchlight:

The S-76A Flight Manual, Section II, page 2-14Q stipulates:

"For night take-off with controllable searchlight, adjust light in hover so the spot appears in front, just above the glare shield. Leave light in this position throughout the take-off"

1.18. Useful or effective investigation techniques:

Included in this report.

2. **ANALYSIS:**

On the basis of the factual information presented in Chapter 1 of this report, the following can be summarized:

The aircraft was properly certificated and it was equipped and maintained in accordance with existing regulations and approved procedures.

The flight crew was certificated properly and was current, in accordance with IDCA regulations.

The helicopter fuselage was recovered in a relatively good shape as a whole. Among several parts still missing, at the date of this report, is the sliding door, three of the four tail rotor blades and major parts of the main rotor blades.

The onsite observation and examination, the detailed examination in Reykjavik and the thorough examination of selected components and systems undertaken in the United States, under supervision of the NTSB, did not reveal anything, that could with absolute certainty be considered as the initiating factor in the accident sequence.

However the investigation has focused on certain areas, which are thought to have significance in relationship to this accident and the events leading up to it.

The flight was conducted at the end of a long working day for the helicopter crew in a relatively hostile environment, which includes possible rotor/windshear. This left a minimal margin for human errors. The take-off appeared to be normal, after which the helicopter was flown downwind into the darkness, towards the steep snow covered mountainside.

Two of the deckmen observed the helicopter during it's flight. The lift-off was normal, but subsequently the altitude was observed to be unusually low.

This flight path is considered to be unusual in view of the fact, that the standard operating procedures call for a immediate initial climb to 500-700 feet. It must however be kept in mind, that the planned duration of the flight was very short.

It is unlikely, that the low altitude was caused by any malfunction of the helicopter, at least not during the initial stage of the flight, since a radio communication took place where no abnormalities were reported and the fact, that the helicopter was flown away from the ship.

Just before the helicopter disappeared, the searchlight came on and the beam rotated upwards, indicating a nose high attitude, as would be the case during a hoverstop. Then the search light went off.

Towards the end of the accident sequence, an apparent distress call was heard from the helicopter.

It is considered likely, that the reason for the search light being lit, was when the pilot, searching for the float arming switch, unintentionally activated the search light.

The position of the fuel selectors the beeper positions and possibly the position of the engine levers as found could indicate that the pilots had suspected an engine failure. However the position of the engine levers may have been altered during body recovery.

The condition of the lower door track, i.e. the missing ball marks and the misassembly of the end cap cage fasteners can not be explained, since according to the aircraft records and statements by the ICG maintenance personnel, no such maintenance work had ever been performed on these tracks by the ICG Maintenance Department.

Analysis undertaken by Sikorsky Aircraft indicate, that the aerodynamic loads in the most likely airspeed regime, are not sufficient to separate the door from it's tracks, assuming that the strenght of the door track is at it's proper level discounting wear.

However with 8 out of 12 balls missing, as is indicated by the absence of ball marks, it is quite possible that such a separation could have taken place in flight, as the strenght of the door tracks is roughly proportional to the number of balls present.

At some stage of the flight the sliding door was either intentionally opened for reasons unknown, or it opened accidentally and seperated from the lower door track and was deflected upwards into the main rotor system.

The rotational velocity of the main rotor blades, at the assumed point of contact with the door, (35-40 inches from the root end) at 300 rotor RPM, is 110 - 150 MPH.

It is considered very unlikely, that the door was carried upwards into the rotor, after having made contact with the water. The impact force was relatively low and was concentrated on the forward right hand side. Furthermore the relatively large main landing gear doors were not detached from it's hinges by hydrodynamic forces.

It is considered likely, that the helicopter landed on the water, in a tail-down attitude, causing the tail rotor assembly to break off, when the blades contacted the water.

This would inflict a sharp right hand yaw to the helicopter, which then pitches nose-down and to the right.

This is substantiated by the facts, that the lower left hand tail section was buckled, right hand chin windows and the captain's door window were broken.

The flight only lasted approximately one minute, but despite of that, the helicopter's actual track and the location of the accident site, was not established by the ship's crew, as the flight was not radar monitored.

The investigation revealed in many aspects a lack of discipline and non-adherance to the existing ICG regulations.

In the course of the investigation, a number of likely or hypothetical sequences of events has been proposed by various members of the investigating team. A selected number of these are presented below. Some of them can be eliminated, but some can not be excluded as potential scenarios for this accident.

These sequences include rationale based on the tasks accomplished during the investigation:

Event 1 -

An engine power loss occurs shortly after take-off and, for some reason the other engine is unable to supply the power required, resulting in a night landing on the water.

Rationale -

Rotational damage to both engines was minimal, suggesting that they were operating at a low power setting, when water ingestion occurred. The lack of torsional damage to the main transmission input shafts is also supportive evidence. Disassembly of the engines and subsequent disassembly of the fuel pumps, fuel controls, and governors did not reveal evidence of any pre-accident failure or malfunction.

The positions of the engine levers and fuel selector levers as found are difficult to explain. The No.2 engine lever was found in the ground idle detent and the No.1 fuel selector lever was found in the crossfeed position. This would suggest that the No.2 engine was not driving the rotor system and the No.1 engine fuel supply was coming from the No.2 engine fuel tank.

The situation is further complicated by the fact that the control positions after landing may have been altered during the underwater body recovery efforts in the cockpit.

An engine power loss is unlikely, since the installed engine performance data indicate, that either engine was capable of providing the power required, given the existing ambient conditions and the actual weight of the helicopter.

Event 2 -

A massive internal failure occurs in the main transmission, intermediate gear box, or tail rotor gear box resulting in a loss of continuity in the drive train.

Rationale -

The drive train could not be rotated during the first phase of the investigation. Subsequent partial disassembly of the main transmission revealed no discrepancies in the internal gear train.

The intermediate gear box train did not exhibit any signs of internal distress when disassembled. The tail rotor gear box had fractured through it's center housing at water impact. The exposed gears did not exhibit any distress.

Based on the physical evidence, event 2 can be discounted.

Event 3 -

A malfunction occurs in the mechanical or hydraulic flight control system resulting in an unusual attitude from which the flight crew could not recover prior to impact with the water.

Rationale -

Post-crash examination of the mechanical flight control system revealed no discrepancies. There was no loss of continuity between the cockpit controls and the inputs to the main rotor servo actuator inputs.

The tail rotor control system was intact from the cockpit aft to the seperated section of the tail rotor gear box. Subsequent functional testing of the three primary servo actuators and the damaged tail rotor servo actuator revealed no discrepancies.

Physical evidence indicates that Event 3 can be discounted.However it must be remembered, that anunexplained "kick/yaw" had been experienced shortly before this accident (see paragraph 1.17.4.)

The evidence of a controlled landing, discounts this event.

Event 4 -

A malfunction occurs in the helicopter's fuel system, which affects the fuel supply to both engines and subsequent loss of power to the rotor system.

Rationale -

The S-76A fuel system design provides a completely independent fuel supply to each engine during normal operation.

If the flight crew suspected a fuel supply problem with the No.1 engine, then selecting the crossfeed position on the fuel selector lever, would result in fuel being supplied to both engines from No.2 fuel tank.

It is possible that a problem with the fuel supply to No.1 engine made the pilots select the crossfeed position and that for some reason (air in the crossfeed line) the system did not work as designed. Pressure check of the fuel system did reveal a minor leakage.

It should be noted, that the start procedure calls for the fuel selectors to be in the crossfeed position, but before take-off they should be returned to the direct mode.

This event cannot be discounted, but it is considered to be a very remote possibility.

Event 5 -

The helicopter suffers a total loss of electrical power, shortly after take-off, resulting in a loss of primary flight instruments and cockpit lightning.

This emergency causes flight distraction and subsequently inadvertent descent into the water.

Rationale -

The AC generator quill shaft was found separated when the generator was removed from the transmission mounting pad. Subsequent metallurgical examination of the fracture indicated that the shaft had failed due to torsion overload.

This condition is normally caused by sudden stoppage of the transmission gear train.

Several conditions noted which can discount this event, are the reported sighting by the ship's observers of the search light during the last sequence of the flight. The indicator position of the two radio altimeters are suggesting that they were cycling due to loss of a reliable signal.

The battery gives power to the glare shield light, (which was "OFF"), the rotating beacon and to the captain's VHF transceiver.

It is believed, that this event can be discounted.

Event 6 -

Spatial disorientation.

Rationale -

The pilots proficiency may have been below desired levels due to the prolonged duty time and the time of the day. The pilots had returned from their semi-annual S-76A proficiency training in the United States, on the morning of 6 November. Both commenced their duties at 0900 hrs. 8 November, thus having been on duty for 14 hours when the accident occurred.

This might have made the flight crew more susceptible to spatial disorientation or human error.

It must also be taken into consideration, that the helicopter had just left the well lit helideck and entered a relatively dark environment within a minute before the accident.

This event cannot be discounted, but it is very unlikely that it had any connection with the primary cause of the accident.

Event 7 -

The sliding door inadvertently opens in flight with a loud bang, sounding like an explosion.

The distraction caused by this might have lead to inadvertent loss of altitude in the critical environment.

Rationale -

It was reported, that the door of TF-RAN had opened in flight several months prior to this accident, but then the pilots were alerted by the flickering amber warning light and the door was closed and locked successfully after the helicopter was slowed down.

Sikorsky aircraft also experienced a sudden violent opening of the sliding door during a test flight. In neither case did the door seperate or damage the tracks. In the TF-RAN case the hoist operator was slightly hurt, when some of the force was absorbed by his hand.

This event cannot be discounted, but is very unlikely, considering the minimal damage to the helicopter.

Event 8 -

An section of a main or tail rotor blade is damaged during flight, resulting in severe airframe vibration, causing the flight crew to carry out an emergency night water landing.

Rationale -

About 90 percent of the four main rotor blade spars and three out of four tail rotor blades were not recovered.

If a section of a blade or blades had been damaged in flight by bird strike or for other reasons, then the evidence was lost except for the marks found on the underside of the "black" main rotor blade and the smooth dent above the captain's windshield, which could have been caused by a bird strike.

This occurrence would result in the crew deciding to enter the water due to severe vibration.

The damage observed to the main and the tail rotor assemblies are detailed in this report. If an outboard blade section had seperated, then that part had to be small enough, so that the unbalance forces would not affect the structural integrity of the main or tail rotor transmission mounts. Transmission mount damage was not observed during the wreckage examination, but such a damage could have severely affected the operation of the helicopter.

This event cannot be discounted, since all of the main and tail rotor blade sections were not recovered.

Event 9 -

The sliding door inadvertently opens or was opened for some unknown reason in fligh. The door then seperates from the lower track and is carried upwards into the main rotor system. The flight crew then initiates a rapid hover stop, followed by a controlled night water landing.

Rationale -

The sliding door, which weighed approximately 60 pounds has not been recovered. Damage noted to the lower surface and to the leading edge of a main rotorblade near the root, damage to the main transmission cowlings and the rescue hoist neck matched with the door size and was caused by the door.

The door striking the main rotor blades, which even on the advancing side have a considerable angle of attack, very likely caused extensive structural damage and further disintegration of the blade trailing sections, resulting in an aerodynamic and a mechanical imbalance. This required the pilot to initiate a rapid hover stop for a controlled night water landing.

This theory is substantiated by witnesses observing the helicopter to suddenly pitch nose up and disappear.

The white smear on the lower surface of the main blade was identified as the same type of paint used on the aircraft.

This event must be considered as the most likely cause of the accident.

3. **CONCLUSIONS:**

3.1. Findings:

a. The Certificate of Airworthiness was valid and the aircraft documents were in order.

b. The helicopter had been correctly maintained in accordance with an IDCA approved Maintenance Schedule and it was loaded within authorized limits.

c. The flight crew was properly licenced and held valid medical certificates.

d. The helicopter emergency flotation equipment was not armed. The S-76A Flight Manual does not require arming the float system. The arming switch is located among other similar switches.

e. The ICG did not have a Flight Operations Manual and it was not required by the IDCA.

f. The requirements spelled out by the "HB-1", the ICG Manual for Helicopter Operations aboard ICG vessels were not adhered to.

g. The minimum training requirements as set forth by the ICG for helicopter crews versus ship crews, were not met.

h. There was no flight plan filed with the ATC, which is an IDCA requirement for all IFR and VFR night flights.

i. Flights in accordance with the Visual Flight Rules (VFR), are not authorized in Iceland during the period between sunset and sunrise, without a special ATC authorization.

j. None of the helicopter occupants were wearing suits with flotation material or life vests and the Hoist Operator's tethering line (Gunners-belt) buckle was not of an approved type.

k. The flight of the helicopter was not radar monitored by the vessel. "HB-1" spells out, that "radar monitoring of helicopters is not required on VFR flights". (The "HB-1" was written at a time when the ICG was operating helicopters certified for VFR day only).

l. When the helicopter disappeared about 0.8 NM from the ship, approximately one minute after take-off, its location was uncertain to the ICG vessel and the debris was not found until one hour and eleven minutes later.

m. The cause of death of the two crewmembers recovered was drowning. The copilot's injuries were insignificant.

n. The OÐINN's deck personnel was not able to immediately launch the life boats, after the disappearance of TF-RAN, since the vessel was moving too fast.

o. A Voice Recorder was not required by IDCA regulations. It had however been installed at the factory. It was removed for repair several months before the accident and a serviceable unit had not been reinstalled.

p. The Captain's Radio Altimeter height cursor had not been set and the captain was not wearing his glasses prescribed for near vision.

q. The outboard section of each main rotor blade and three of four tail rotor blades were not recovered.

r. There is no explanation for the eight missing ball-marks or the improper installation of the end cap fasteners of the sliding door lower track assembly.

s. The training flight was conducted in a hostile environment. It was a dark night with very limited visual references. The crew had to transit from visual flying to instrument flying and back to visual flying in a short period of time. The crew had to adjust to the sudden change-over from the flood lit helideck immediately after take-off, to almost total darkness. A change-over of controls between the two pilots had also been planned sometime during this short flight. The possibility of turbulence and wind-shear in the actual flight path can not be excluded.

t. The pilots had been on duty for 14 hours and the flight took place at a time of day, when human performance is approaching low ebb and more likely to be affected by distraction and disorientation.

u. The witness reports indicate, that the pilots were attemting a rapid hoverstop and an emergency landing on the water, for reasons unknown. This can also be substantiated by the low impact forces as indicated by the absence of significant damage to the helicopter sustained during the landing and the absence of injuries to the unrestrained hoist operator.

v. A sudden unexpected inflight opening of the sliding door has been described by a Sikorsky test pilot to sound like an explosion and his first impression was, that a serious failure had occurred.

w. The sliding door seperated from the helicopter and at some stage it was deflected upwards into the main rotor.

x. Damage on the lower surface of the "black"blade stub, damage on the main transmission cowlings and on the rescue hoist neck were caused by the door during the deflection and seperation of the sliding door in the air.

3.2. Cause or probable cause:

There is insufficient evidence to enable the cause of the accident to be fully determined.

However there is a reason to believe, that the pilots experienced a problem in the operation and/or performance of the helicopter, such as an (violent) opening and a subsequent seperation of the sliding door. This event could have caused rotor blade damage to a degree, which impaired the handling qualities of the helicopter, causing the pilots to effect an immediate hover stop and an emergency landing.

The hostile environmental, operational factors and the prolonged duty time of the flightcrew, can be considered contributory to the accident.

4. **SAFETY RECOMMENDATIONS:**

It is recommended that:

a. The IDCA consider making Cockpit Voice Recorders mandatory in helicopters carrying more than two passengers.

b. The Iceland Coast Guard Manual for helicopter operation from ICG vessels be updated and become available to all personnel involved and be strictly adhered to. This manual shall be approved by the IDCA.

c. The IDCA make mandatory, that all occupants of helicopters operating on extended overwater flights, be required to wear anti-exposure clothing and life vest.

d. The ICG immediately take measures to issue a detailed Flight Operations Manual. This manual shall be approved by the IDCA.

e. Consideration be given to provide ICG Commanding Officers and other personnel, responsible for obtaining weather observations pertaining to aircraft operations, with regular meteorological training.

f. The ICG Operations Control either be operational at all times, when ICG aircraft are operating or other means taken, to ensure a continuous monitoring of their flights.

g. The ICG vessels should have flares readily available for emergency use.

h. The ICG hold joint ground training courses for seamen and airmen, in order to achieve the required co-ordination and high level of proficiency, discipline and safety in helicopter operation from ICG vessels. Regular proficiency training and tests be conducted.

i. Training flights be performed in accordance with laid down and approved procedures and hostile environment be avoided, in order to minimize the risk of endangering human lives.

j. The ICG Technical Manager and the Flight Operations Manager be responsible directly to the ICG Director General.

k. The hangar used by the ICG for aircraft maintenance at Reykjavik Airport be improved, in order to meet the minimum acceptable standard for an Aircraft Maintenance Facility.

l. The S-76A manufacturer re-design the Float Arming System or revise the Approved Flight Manual, making it mandatory to arm the system when flying over water.

m. The S-76A manufacturer re-consider the design of the safety locking mechanism of the sliding door.

n. The safety locking mechanism of the hoist operators gunner's belt be be re-designed. The use of later models should also be considered.

Reykjavik, 28 February 1985,

[redacted] [redacted]

chief, AIG Section, Flight Safety Departm.

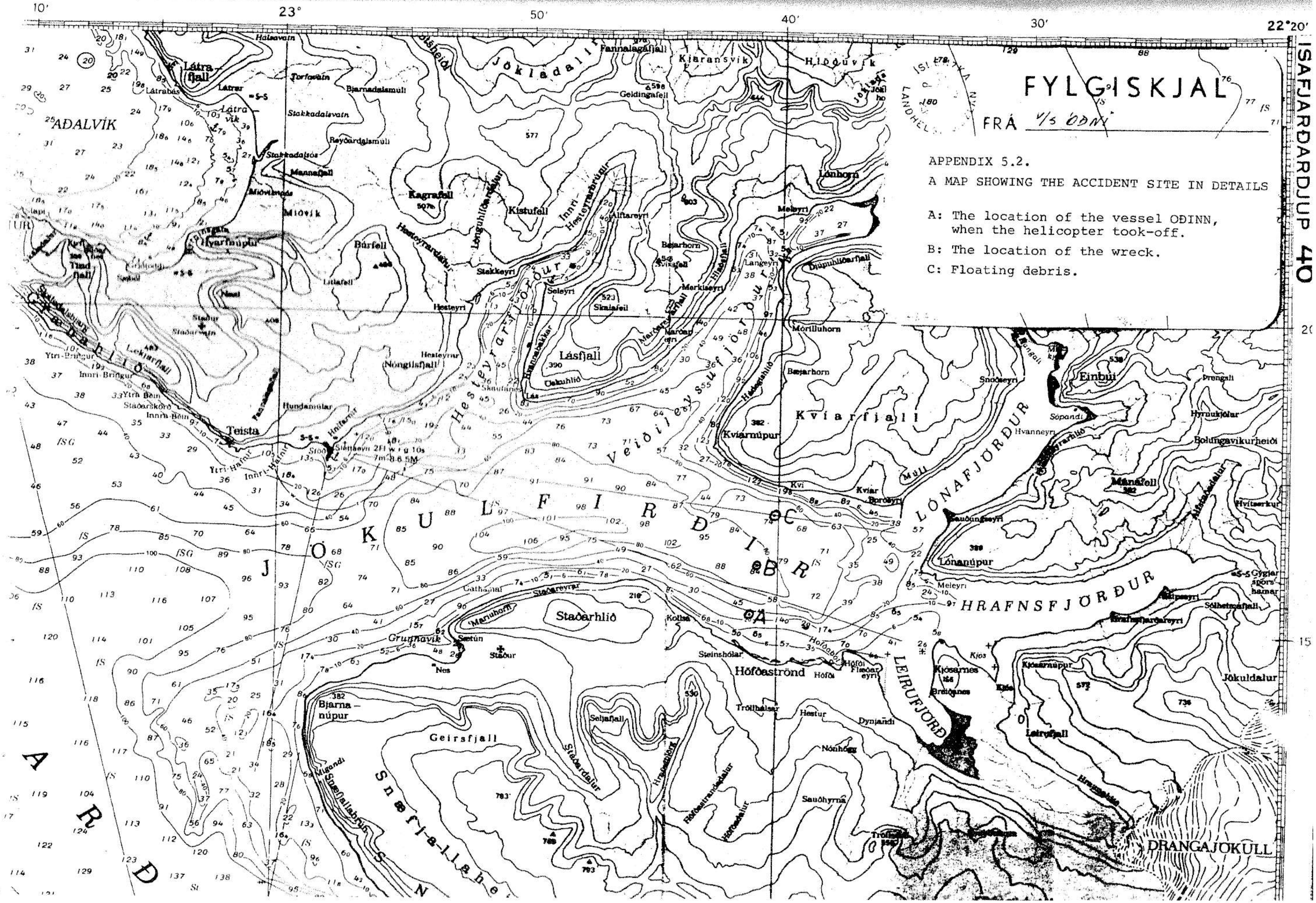
chairman, National National Air Safety Board

5. **APPENDICES:**

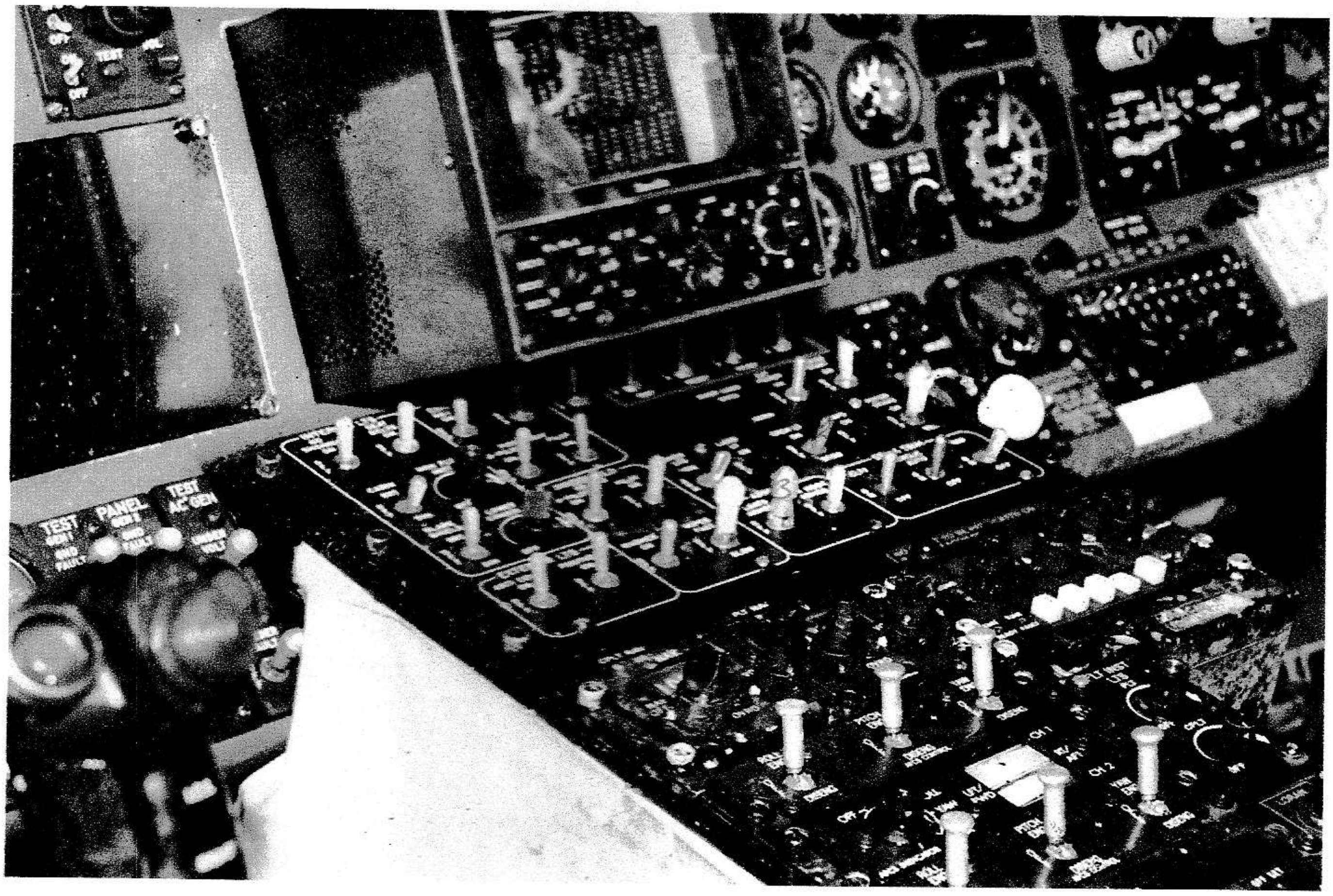
1. A map of western and north-western Iceland.
2. A detailed map showing the accident site.
3. Photographs.
4. A drawing showing the likely movement of the departing sliding door.

APPENDIX 5.1.

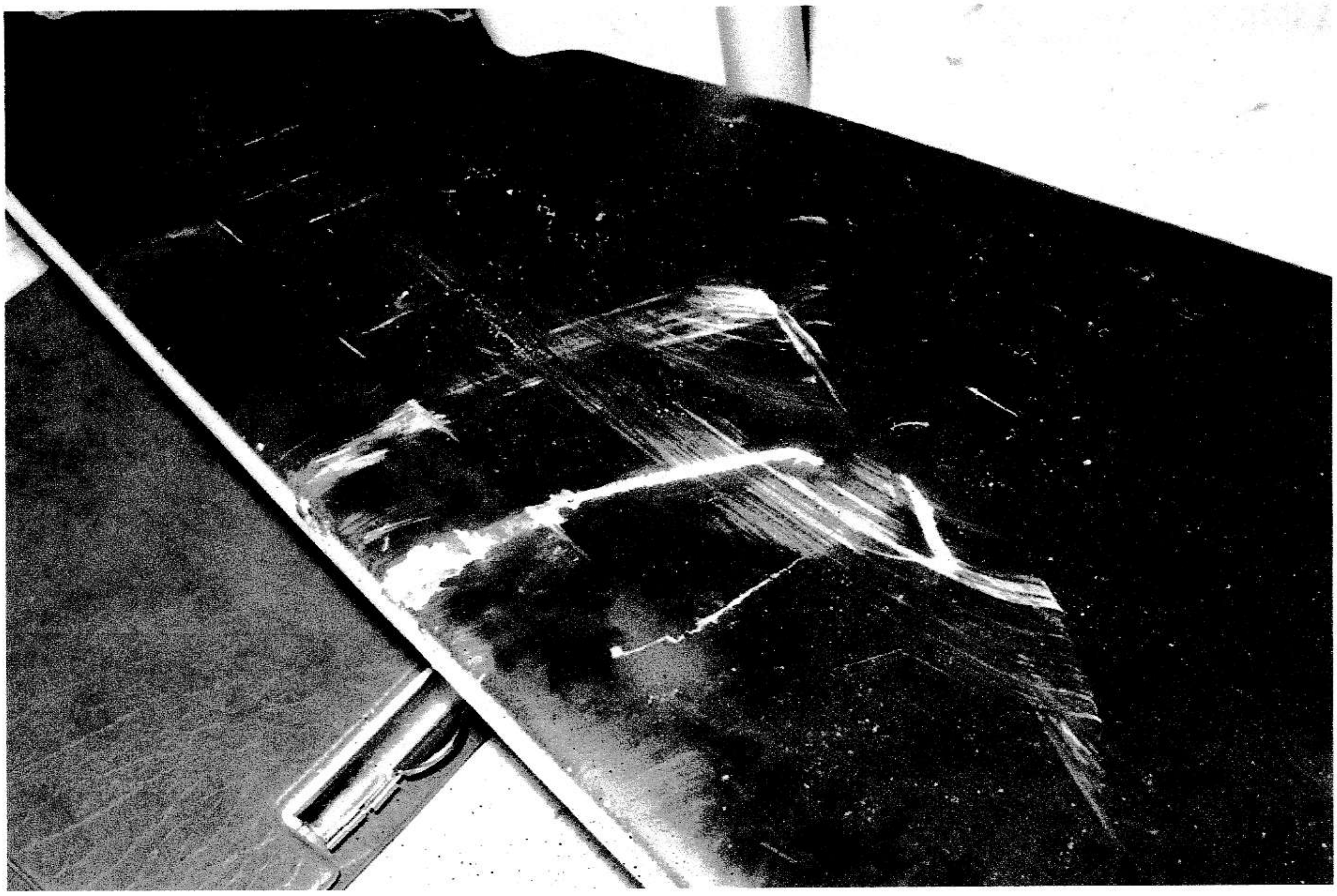
A MAP OF WESTERN ICELAND


FYLGISKJAL
FRÁ v/s ÓÐNI
APPENDIX 5.2.
A MAP SHOWING THE ACCIDENT SITE IN DETAILS
A: The location of the vessel OÐINN, when the helicopter took-off.
B: The location of the wreck.
C: Floating debris.
ISAFJARÐARDJÚP 40
10'
23°
50'
40'
30'
22°20'
JÖKULFIRÐIR
HRAFNSFJÖRÐUR
LÓNAFJÖRÐUR
LEIRUFJÖRÐ
Hesteyrarfjörður
Veiðileysufjörður
AÐALVÍK
DRANGAJÖKULL
Staðarhlíð
Höfðaströnd
Grunnavík
Bjarna-núpur
Geirsfjall
Kvíarfjall
Lásfjall
Einbúi
Lónanúpur
Teista
Hesteyri
Látra-fjall
Jökladalir
Kjaransvík
Hlöðuvík
Mánafell
Bolungavíkurheiði
Jökuldalur

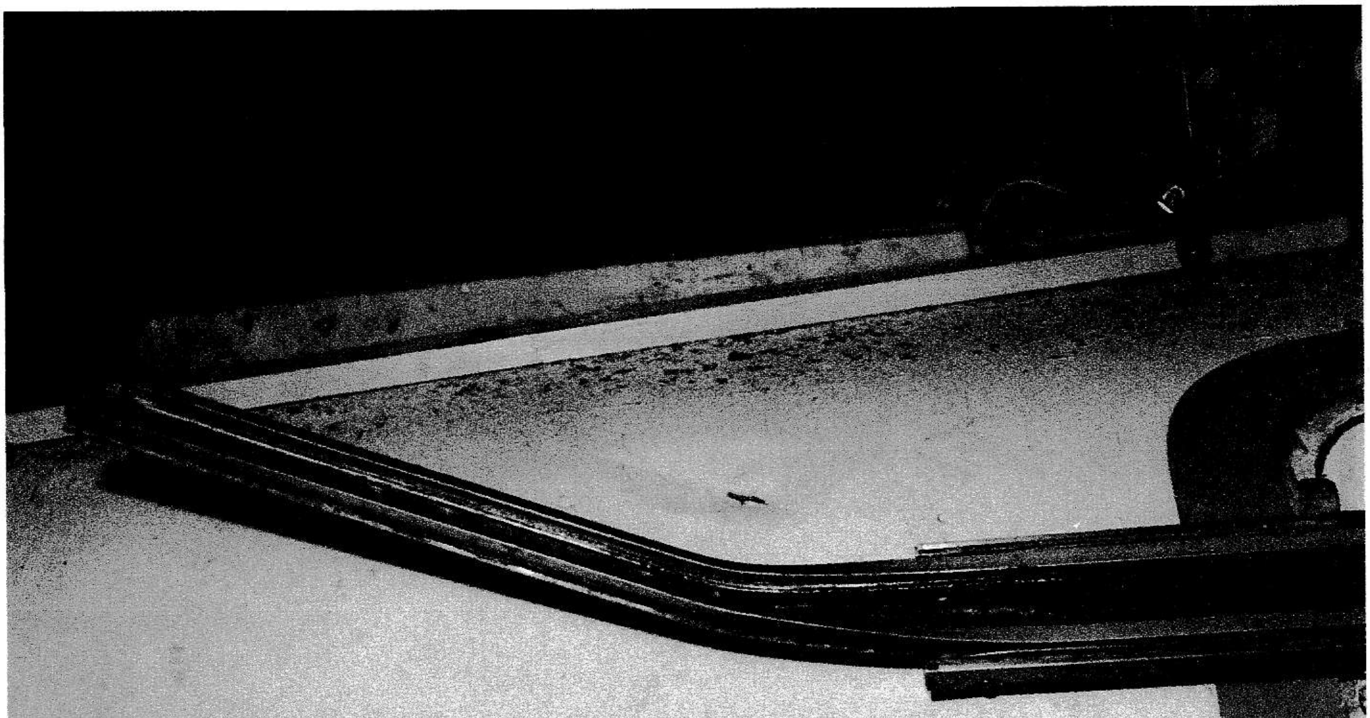
Wreck as recovered on the helideck of Óðinn. Chin and door windows broken and sliding door missing.



View of the pedestal switches. 1. Emergency light switch. 2. Search light switch. 3. Float arm switch.

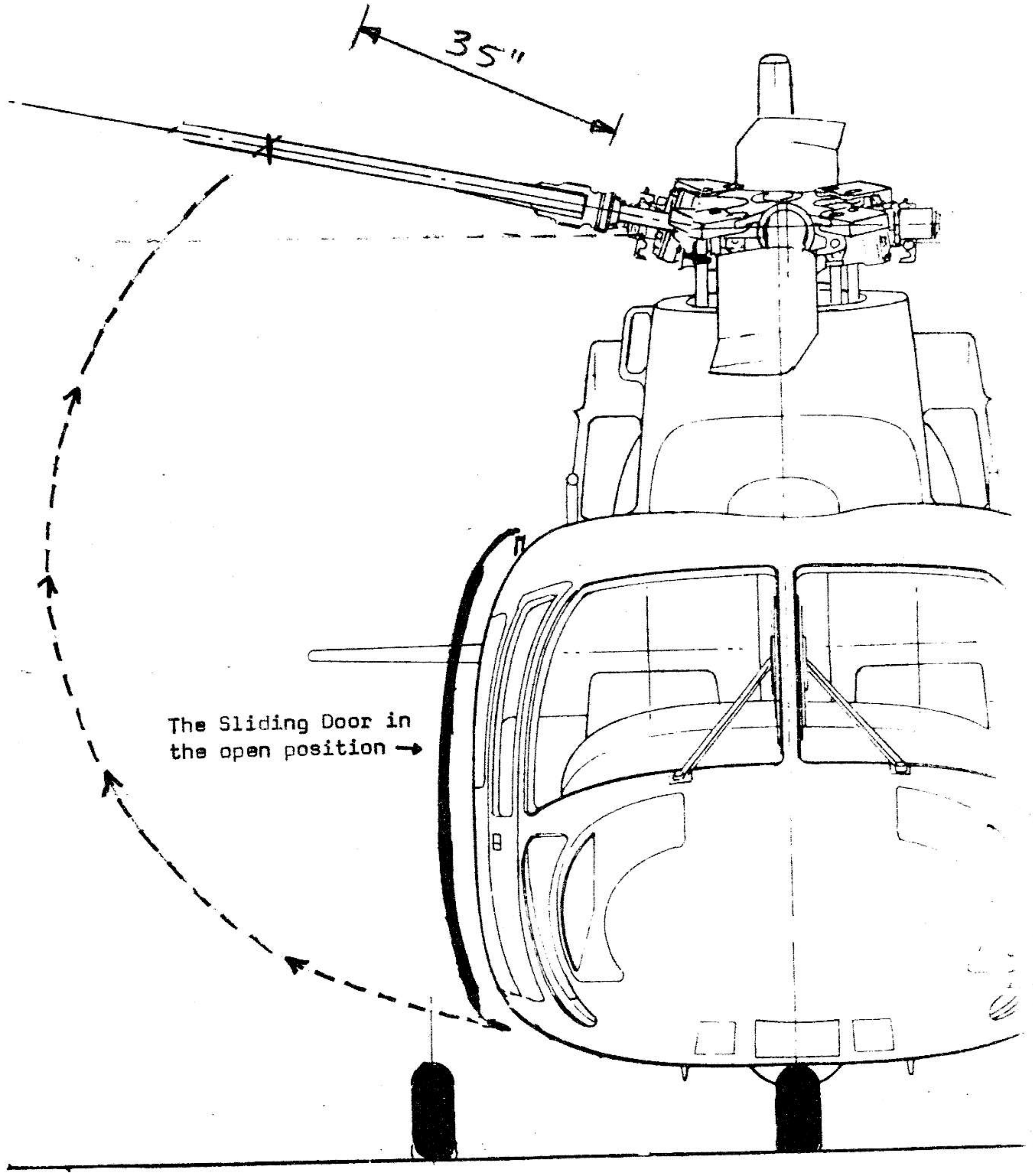


The black main rotor blad stub. Wiew of the marks on the underside caused by the sliding door strike.



The forward and intermediate sliding door track. Showing the up and forward bending and the dent on the fuselage caused by the door.

A drawing showing the
likely movement of the
departing sliding door.



AIG/ 65 / 1983
40 / 1985

DIRECTORATE OF CIVIL AVIATION

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RANNSÓKNARNEFND FLUGSLYSA

AIRCRAFT ACCIDENT REPORT

(In accordance with Civil Aviation Act Article 145)

A D D E N D U M

ICELAND COAST GUARD

TF-RAN, SIKORSKY S-76A

JÖKULFIRDIR 66°17´N, 22°41W

8 NOVEMBER 1983

This accident was investigated solely in order to provide guidance towards prevention Civil Aviation Act Article 145

D 1383 Gutenberg

C O N T E N T S

DIRECTORATE OF CIVIL AVIATION (IDCA)
and
NATIONAL AIR SAFETY BOARD (NASB)
Reykjavik Airport
ICELAND

A I R C R A F T   A C C I D E N T   R E P O R T
A D D E N D U M

REF/AIG/65/1983
/AIG/40/1985

AIRCRAFT..........TF-RAN, Sikorsky S-76A.
Icelandic Coast Guard (ICG).
Seljavegur 32, Reykjavík, Iceland.
PLACE OF ACCIDENT..Approximately 66°17'N, 22°41'W in the Jökulfirðir fjords, between mount Kvíarfjall and Höfðaströnd coast.
8 November 1983, at appr. 2254 hrs.

- -

THE ACCIDENT REPORT:

The recovery of the door and the subsequent investigation by the Accidents Investigation Branch (**AIB**), of the U.K. Department of Transport, Royal Aircraft Establishment, Farnborough, makes it necessary to amend the Accident Report, AIG/65/83, dated 28. February 1985.

These amendments concern both the facts and the analysis.

The paragraphs from the original TF-RAN Accident Report which need to be amended or deleted are published here, as well as new paragraphs describing the sliding door.

Additions, remarks or rewording of these paragraphs are printed in bold letters and material incorrect or not applicable, to be deleted from the original report, is stricken through.

SUMMARY:

The missing right hand sliding door was recovered on 19 April 1985, by the shrimp boat [redacted] which was fishing in the Jökulfirðir fjords.

The boat had been trawling for about 2 hours, making two runs past the TF-RAN accident area.

The fishermen stated, that they did not notice anything abnormal and they did not see the door until they hauled the trawl to the surface.

According to their description, the door was then in the mouth of the trawl. The trawl wires did not damage the door and it was carefully recovered and sent to the IDCA.

After consulting with the U.S. National Transportation Safety Board (NTSB), it was decided to send the door and the attached inner track assemblies to the AIB.

At the same time, the NTSB was requested to contact the Sikorsky factories, who had been examining the various parts of the wreckage, including the sliding door track assemblies and request them to ship the black rotor blade stub and the door track assemblies to the AIB.

The blade was received by the AIB, but unfortunately Sikorsky has at this date not been able to locate the door tracks, for reasons unknown.

The information regarding the alledged missing ball marks, published in the TF-RAN original accident report, was solely based on the Sikorsky investigation.

Therefore it is concluded, based on the investigation of the Board and the AIB report, that all balls were present in the track assemblies when or just before the accident sequence started.

The reason for the track failure has not been established. In order to be able to determine the cause of the failure, the AIB considers it necessary to examine the missing track assembly. See attached AIB report, page 7.:

Quote:"Without the mating rail components to examine, no positive conclusions as to why this ball should have been loaded excessively could been drawn" Unquote.

The mating rail or slide component, was sent to Sikorsky for examination. See above.

1.12.1. The salvage and the on-site examination:

The following sentence should be added to the last paragraph:

The sliding door was recovered by a shrimp boat on 19 April 1985.

1.12.2.7. Sliding door:

1.12.2.7.1. Description of the sliding door:

The condition of the door, when received by the Investigation Board, was as follows:

- The door was complete and no parts were missing,
- Both inner tracks from the upper and lower track assemblies were attached to the door,
- The door latches were in the "open" position,
- The door had evidently been resting on the sea bed, inner side up. It showed clear stains caused by the sea bed clay,
- The general condition of the door was consistent with having been immersed in sea water, with corrosion present on metallic parts,
- Considerable impact damage in the latch area on the rear vertical side, was caused by the black main rotor blade,
- The front vertical side of the door had suffered a heavy blow, possibly by the Hoist Neck,
- Some scuffing damage was found at the lower forward door radius,
- Aft door latch mechanism was severely damaged. Other latches were in a good condition.

1.12.2.7.2. <u>Sliding door tracks:</u>

The inner tracks were missing from both the upper and lower assemblies and both intermediate tracks were fully extended. The aft end of the intermediate track in the upper assembly was bent significantly upwards.

~~Examination of the lower track assembly revealed only four ball marks or impressions instead of the expected twelve. This could indicate either misassembly or prior ball loss condition before the accident. Also three out of four expected intermediate end cap ball marks were missing. Further examination also revealed, that the end cap cage fasteners were installed improperly, when compared to the upper door track and a new assembly, which leads to the conclusion that such misassembly may have taken place prior to delivery to the ICG.~~

Examination of the lower inner track assembly revealed, that all balls were accounted for and that it had seperated while in transit, shortly before reaching the end stop. See attached AIB report.

It is evident, that the sliding door first seperated from the intermediate tracks, pulling out of the lower door track assembly. Then it rotated upwards, pulling out of the upper intermediate assembly which was bent up and forward.

There was a mark on the main rotor pylon and the hoist neck, indicating that the door had been deflected up into the main rotor and deflected forward when struck by the black main rotor blade. ~~by the main rotor blades.~~

This is substantiated by the damage and smears on one (black) rotor blade.

~~The investigation did not reveal the reason for the missing ball marks from the lower track assembly. The maintenance documentation does not include any work performed in the area pertaining to the problem discussed above.~~

The ICG Technical Manager and the ICG aircraft mechanics, state that neither the door nor the tracks had ever been removed during the helicopter's service life with the ICG.

The position of the upper and lower tracks as received was compared to another S-76A located in the Sikorsky hangar (see 1.17.2.).

Examination of the forward and aft-door latches indicated no damage to the serrated adjustment locking plates. This lack of damage verified that the door was not closed and locked at the time it seperated from the door tracks.

~~This is also substantiated by the fact, that both tracks were in the fully extended position, when the door seperated.~~

The airspeed of the helicopter at the time, when the door was opened, is not known. Neither is the reason why it was opened at this phase of the flight.

1.16. Tests and Research:

A detailed examination of selected components, was carried out by the National Transportation Safety Board of the United States, **NTSB** and by various manufacturers of the S-76 components, under the supervision of the NTSB.

The results of this investigation are included in this report.

Upon the recovery of the sliding door, the NTSB was contacted, regarding the examination of the door and the attached inner track assemblies. It was agreed, due to heavy work load of the NTSB staff, to seek assistance of the AIB, in the examination.

1.17.2.2.Sikorsky Aircraft's evaluation:

The Sikorsky Aircraft engineers, provided information of their analysis and testing of the sliding door, as follows:

"Door track has been designed and proof tested to 170 pounds in the lateral direction.

Door load at 65 kts. is 150 pounds limit in a lateral direction.

Door proof test:

- Tracks extended, aft bayonets engaged:
  v=30, d=82, s=+/- 200 (limit loads, forward speed 75 kts. at max. cl.)
- Tracks extended, aft bayonets not engaged:
  v=30, d=82, s=+/- 150 (limit loads, forward speed 65 kts. at max cl.)
- Tracks compressed, swivel arms jammed:
  v=30, d=82, s=+/- 150 (limit loads, forward speed 65 kts. at max. cl.)

(v = vertical load, d = drag load, s = side load)

New door track was statically loaded to 530 pounds laterally and 300 pounds vertically, prior to failure. (This equates to 750 pounds laterally per track of 1500 pounds total on door.)

Sliding door handling qualities flight test, Nov. - Dec. 1979.

- Opened intentionally at speed of 60 kias. and approximate sideslips of 18° left and right.
- Opened intentionally at speeds of 88 kias. level flight.

During a test flight, the sliding door was unintentionally not fully latched and opened in flight at a speed of 135 kts.

Door remained on aircraft with minor damage only to open stop links.

~~Hydrodynamic--loads-are--800-pounds,-assuming-forward speed-of-30-kts.-with-lower-12-inches-of-door-immersed".~~

The Investigation Board considers, that the above information pertaining to the hydrodynamic loads is irrelevant, since it has been determined in the Accident report and by the AIB, that the door seperated while the helicopter was in flight.

2. ANALYSIS:

On the basis of the factual information presented in Chapter 1 of this report, the following can be summarized:

The aircraft was properly certificated and it was equipped and maintained in accordance with existing regulations and approved procedures.

The flight crew was certificated properly and was current,in accordance with approved procedures.

The helicopter fuselage was recovered in a relatively good shape as a whole. Among several parts still missing at the date of this report ~~is-the-sliding-door~~, **are the** three of the four tail rotor blades and major parts of the main rotor blades.

The investigation of the sliding door and the inner tracks by the AIB concludes however, that the sliding door became detached in flight from the lower track, for reasons unknown and pivoted about the upper track into the main rotor system. See attached AIB report.

However the investigation has focused on certain areas,which are thought to have significance in relationship to this accident and the events leading up to it.

The flight was conducted at the end of a long working day by the helicopter crew, in a relatively hostile environment, which includes possible rotor/windshear. This left a minimal margin for human errors. The take-off appeared to be normal, after which the helicopter was flown downwind into the darkness, towards the steep snow covered mountainside.

Two of the deckmen observed the helicopter during it's flight. The lift-off was normal, but subsequently the altitude was observed to be unusually low.

The flight path is considered to be unusual in view of the fact, that the standard operating procedures call for a immediate initial climb to 500-700 feet. It must however be kept in mind, that the planned duration of the flight was very short.

It is unlikely, that the low altitude was caused by any malfunction of the helicopter, at least not during the initial stage of the flight, since a radio communication took place where no abnormalities were reported and the fact, that the helicopter was flown away from the ship.

Just before the helicopter disappeared, the searchlight came on and the beam rotated upwards, indicating a nose high attitude, as would be the case during a hoverstop. Then the searchlight went off.

Towards the end of the accident sequence, an apparent distress call was heard from the helicopter.

It is considered likely, that the reason for the search light being lit, was when the pilot, searching for the float arming switch, unintentionally activated the search light.

The position of the fuel selectors the beeper positions and possibly the position of the engine levers as found, could indicate that the pilots had suspected an engine failure. However the position of the engine levers may have been altered during body recovery.

~~The condition of the lower door track, i.e. the missing ball marks and the misassembly of the end cap cage fasteners can not be explained, since according to the aircraft records and statements by the ICG maintenance personnel, no such maintenance work had ever been performed on these tracks by the ICG Maintenance Department.~~

~~Analysis undertaken by Sikorsky Aircraft indicate, that the aerodynamic loads in the most likely airspeed regime, are not sufficient to separate the door from it's tracks, assuming that the strenght of the door track is at it's proper level discounting wear.~~

~~However with 8 out of 12 balls missing, as is indicated by the absence of ball marks, it is quite possible that such a separation could have taken place in flight, as the strenght of the door tracks is roughly proportional to the number of balls present.~~

At some stage of the flight the sliding door was either intentionally opened for reasons unknown, or it opened accidentally and seperated from the lower door track and was deflected upwards into the main rotor system. **See Attached AIB report.**

~~The rotational velocity of the main rotor blades, at the assumed point of contact with the door, (35-40 inches from the root end) at 300 rotor RPM, is 110 - 150 MPH.~~

~~It is considered very unlikely, that the door was carried upwards into the rotor, after having made contact with the water.~~

The impact force **on the water** was relatively low and was concentrated on the forward right hand side. Furthermore the relatively large main landing gear doors were not detached from it's hinges by hydrodynamic forces.

It is considered likely, that the helicopter landed on the water, in a tail-down attitude, causing the tail rotor assembly to break off, when the blades contacted the water.

This would inflict a sharp right hand yaw to the helicopter, which then pitches nose-down and to the right.

This is substantiated by the fact, that the lower left hand tail section was buckled, right hand chin windows and the captain's door window were broken.

The flight only lasted approximately one minute, but despite of that, the helicopter's actual track and the location of the accident site, was not established by the ship's crew, as the flight was not radar monitored.

The investigation revealed in many aspects a lack of discipline and non-adherance to the existing ICG regulations.

In the course of the investigation, a number of likely or hypothetical sequences of events has been proposed by various members of the investigation team. A selected number of these are presented below. Some of them can be eliminated, but some can not be excluded as potential scenarios for this accident.

These sequences include rationale based on the tasks accomplished during the investigation.

NOTE: There are no changes to Event 1 to Event 8 iclusive.

Event 9 -

The sliding door inadvertently opens or was opened for some unknown reason in fligh. The door then seperates from the lower track and is carried upwards into the main rotor system. The flight crew then initiates a rapid hover stop, followed by a controlled night water landing, **or**

A main rotor blade tip becomes detached, causing severe vibration. The crew then decides to land on the water, opens the sliding door, which as a result of the heavy vibration seperates from the lower track and deflects into the rotor system.

Rationale -

The sliding door, which weighes approximately 60 pounds has ~~not~~ been recovered. Damage noted to the lower sur-face and to the leading edge of a main rotorblade near the root, damage to the main transmission cowlings and the rescue hoist neck matched with the door size and was caused by the door.

~~The door striking the main rotor blades, which even on the advancing side have a considerable angle of attack, very likely caused extensive structural damage and further disintegration of the blade trailing sections, resulting in an aerodynamic and a mechanical imbalance. This required the pilot to initiate a rapid hover stop for a controlled night water landing.~~

There is no doubt, that the door entered the rotor system and was struck by the black blade. This impact would very likely cause such upset to the aerodynamics and the mechanics of the rotor system, so as to result in severe vibration.

The cause of the lower door track failure has not yet been established, as the rest of the door track assembly is not available.

Therefore it cannot be determined, whether the track failure was a result, direct or indirect, of an unrelated problem in the operation and/or performance of the heli-copter, such as the loss of a main rotor blade tip or if it was the cause, when the door entered the rotor system, causing severe and unexpected vibration, leading to the pilot's decision to make an emergency landing on the water.

By "direct" result is meant - problems related to crew opening the sliding door, possibly at a high airspeed and under severe vibration conditions, after descision was made to land on the water.

By "indirect" result is meant - same as "direct", except the door being forced out of it's track by an unknown object, when the crew opened it.

This theory is substantiated by witnesses observing the helicopter to suddenly pitch nose up and disappear.

~~The-white--smear-on-the-lower-surface-of-the-main-blade was-identified--as-the--same--type--of--paint--used--on--the aircraft.~~
The damage to the black rotor blade stub, has been identified beyond doubt to have been caused by the blade striking the door frame in the latch area.
This event must be considered as the most likely ~~cause-of-the-accident~~ **reason for the emergency landing.**

3. CONCLUSIONS:

3.1. Findings:

NOTE: All but the following paragraphs remain unchanged.

~~r.----There-is-no-explanation-for-the-eight-missing-ball-marks-or--the-improper-installation-of-the-end-cap-fasteners of-the-sliding-door-lower-track-assembly.~~

w. The sliding door seperated from the helicopter **in flight, due to unexplained failure of the lower track assembly** and ~~at-some-stage-it~~ was deflected upwards into the main rotor.

3.2. Cause or probable cause:

There is insufficient evidence to enable the cause of the accident to be fully determined.
However there is reason to believe, that the pilots experienced a problem in the operation and/or performance of the helicopter, such as an **intentional or accidental** (violent) opening and a subsequent seperation of the sliding door**, which then entered into the main rotor system.** This event could have caused ~~rotor-blade--damage-to--a--degree, which-impaired--~~ **such upsets to the aerodynamics and the mechanics of the rotor system, so as to result in severe vibration, impairing** the handling qualities of the helicopter**, thereby** causing the pilots to effect an immediate hover stop and an emergency landing.
It is evident, that the vertical contact with the water was relatively gentle, but since the pilots had not been able to activate the emergency flotation system, for reasons undetermined, the helicopter overturned and sank.
The hostile environmental, operational factors and the prolonged duty time of the flightcrew, can be considered contributory to the accident.

4. SAFETY RECOMMENDATIONS:

NOTE: All but the following paragraph remain unchanged:

It is recommended that:

m. The S-76A manufacturer reconsider the design of the **door tracks and the** safety locking mechanism of the sliding door.

Reykjavik, 28 Feb[redacted]986,

[redacted]

Chief, AIG Section,
Flight Safety Departm.

Chairman,
National Air Safety Board

5. APPENDIX:

5.1. **The report submitted by the Accident Investigation Branch of the U.K. Department of Transport.**

ACCIDENT TO SIKORSKY S76A TF-RAN

1.1 Introduction

This helicopter, operated by the Icelandic Coastguard, suffered an accident on 8 November 1983 when operating at night from the ship Odinn in the Jokulfirdir fjords, NW Iceland. It was established that the helicopter had descended slowly into the water, following which it sunk, without deployment of the emergency flotation gear. All four crew men lost their lives. The helicopter fuselage was recovered intact and relatively undamaged, but without the major parts of the main and tail rotor blades (MRB and TRB) and with the right side cabin sliding door missing.

A report on the accident was issued by the Iceland National Air Safety Board (NASB) but, in late 1985, the missing sliding door was recovered by a fishing boat. At the request of the NASB, the AIB were asked to examine the door and its telescopic rails with a view to determining the events surrounding its detachment.

2.2 Door Description, ref Figure 1

The recovered door, as presented to AIB, was structurally intact but without its sliding rail attachments. These had been removed by the NASB for initial examination. The general condition of the door was consistent with having been immersed in sea water for a period of time with corrosion present on its metallic components, most of the door being constructed from a Kevlar composite material.

As illustrated in Figure 1, two main areas of damage were present. The most severe was in the region of the catch on the door's aft edge, this taking the form of localised crushing and failure of the door edge structure. This damage was consistent with the door being struck by a long slender object, from the aft direction, sufficiently hard to break through the door edge and distort part of the latch mechanism.

The second area of damage was on the forward edge of the door, but this was less severe in nature than that described above. The door edge had been locally distorted by a relatively soft object, contacting it from an outboard to inboard direction. The door material had flexed sufficiently to crack the surface finish, weaken the surrounding composite structure and split the unsupported land.

In addition, light surface scuffing had taken place over the outside surface of the door and on the door's edges around the corners.

3.0 Black MRB Damage

It was suggested in the NASB report that the sliding door may have come off the helicopter in flight and flown up into the main rotor. An area of the underside of the Black MRB, approximately 18" out from the blade root, exhibited damage in the form of dents and scratches as shown in Figure 2. The essential details of this blade damage were transposed onto white paper and affixed to the underside of a section of an S76 MRB, with arrows to indicate the directions of smears and dents, as indicated in Figure 5. The following details how door and rotor damage were matched in order to establish if there were any correlation between the two.

4.0 Impact Sequence

Two separate tests were carried out, using the door, "damaged" blade and a serviceable S76 helicopter.

4.1 The door from TF-RAN was offered up to a serviceable S76 in a variety of positions and photographed. It readily became apparent that the major area of damage across the door's aft edge was consistent with a MRB strike, with the door in a similar position to that shown in Figure 3. As seen, the point of contact, with the advancing blade at approximately 45° to the fuselage axis, of door and blade was some 35" out from the blade root. However, if the coning angle of the blades in flight and disc tilt is taken into account and the door rotated further upwards about its upper edge, then this point of contact moves inboard towards the 18" position. Also, the angle of cut across the door was very close to that of the blade leading edge in this position.

As may be seen, to achieve this attitude the door has effectively been pivoted clockwise about its upper forward edge by some 30/40° whilst in the open position, and rotated upwards about its upper edge by some 135°.

An estimate may be made of the door's slowest rate of rotation, as follows. As the MRB preceeding Black blade appears not to have struck the door, then the door has rotated upwards by some 30° in the time taken for 90° of main rotor rotation. This equates to approximately 600°/sec.

A copy of a photograph showing the door upper intermediate telescopic rail and localised fuselage damage on TF-RAN is included as Figure 4, for reference.

4.2 The section of MRB, with highlighted damage details was offered to the door from TF-RAN and photographed in several different sequential positions, each consistent with matching door and blade damage. Figure 5 represents the best initial fit of blade to door and, as may be seen, there is a close correlation between damage and blade witness marking in this position. From this, it was possible to construct the diagram, Figure 6. This shows, relative to a fixed blade end view (looking inboard), the way in which the door moved after being initially struck by the blade.

4.2 The sequence described in paragraphs 4.1 and 4.2 does not explain the lesser damage present on the door leading edge. The S76 used in these tests was not fitted with the winch installation, as was TF-RAN. If the likely position of this winch is considered, then it would seem possible for the door L/E to have struck the aft portion of the winch fairing, possibly in the manner shown in Figure 7.

As far as may be seen from photographs of TF-RAN supplied by the NASB, the aft portion of the winch fairing had been removed by an object moving from outboard to inboard, with an upwards component to its direction.

5.0 Telescopic Rails Examination

The upper and lower telescopic rail assemblies supporting the sliding door are each comprised of three main sections, ref figure 8.

An outer rail, which is supported by a swivel mechanism attached to the fuselage, contains an intermediate rail which similarly contains an inner rail. This inner rail is fixed to the inside of the sliding door. These rails are mutually supported by rows of ball bearings, contained within linear cages, which run along profiled steel inserts in the edge of each track.

Only the inner rails, those attached to the door, were available for direct examination and these are shown in figure 9.

Figure 4 shows the door upper intermediate rail after the accident. The distortion of the rail, its position and localised fuselage damage both indicate the rail to have been fully extended as the door pivoted upwards. In addition, damage caused to the upper inner rail by the balls exiting the tracks was located at the door fully open end of the rail. The nature of the damage also suggested that at rail separation the telescopic rail assembly had reached its end stops with some force and had ceased to extend. As may be seen on both the top and bottom tracks of this upper rail the balls exit marks are essentially opposite one another, revealing the balls in each track to be in two groups of five separated by 3 ball pitches. The ball pitch measured at .625". The more marked damage/corrosion present was on the bottom track.

The nature and position of damage on the lower rail, however, was significantly different. As may be seen from figure 10, the regions over which the balls have exited each track are staggered, the lower set of balls being displaced by some 3 ball pitches towards the door open position by comparison with the upper set. This set was positioned approximately 4.2" from its end stop.

An area of overlap exists between the locations of these top and bottom sets of balls at failure and their normal position with the door fully open. There was no positive evidence of pre-existing damage to the tracks, for example, that might be occasioned should the rail assembly be extended with some force, but it was noted that most mechanical/corrosion damage was present on the rail edges in the area of overlap.

Detailed examination of damage to the upper track of this rail has revealed that deformation of the steel track insert is present in the region where the leading ball (foremost) exited the track. This is the only position on both rails where this type of damage is present. Evidence of track edge deformation made by several other balls indicate that a high side load was applied to the track member whilst the door was in motion toward the open position. In addition, the outer edge of the track in this area shows signs of deformation consistent with most of the balls rolling along the edge after exiting the track, ref figure 11.

The lower track does not exhibit such clear evidence of the balls being subject to a high sideload whilst rolling but more that the door was stationary or moving very slowly as the sideload was applied.

6.0 <u>Additional information</u>

The design of the sliding door mechanism is such that when unlatched it must be pushed outboard before it is able to slide back on the telescopic rails attached along the inboard faces of its upper and lower lands. As the door approaches its fully open position the intention is that two spigots, mounted from the fuselage, engage with two nylon eyes, mounted from the door, in order to provide lateral and vertical support for the door aft end, figure 12.

Examination of several UK registered helicopters has shown that, prior to engagement, the door is weakly supported and easily deflected as the telescopic rails approach full extension. Obvious damage was present on the aft face of the lower nylon eye on the door from TF-RAN, and on several other S76's examined. This damage, ref. figures 13 and 14, is consistent with a mis-alignment of spigot and eye as the door opens. In fact, it has proved relatively easy to deflect the door by hand such that the spigot and eye mis-align sufficiently for the spigot to slide along the outer edge of the eye. It was possible to lock the door back in this situation. Should this happen in flight then inertial and air-loading on the door would partly be reacted through the lower rail in addition to the steady load caused by eye/spigot mis-alignment. It was also noticed during this examination that slight damage to the door latches and surrounding trim was present on one helicopter, this being consistent with the door being slightly low when presented to its aperture as the locks engage. This effect appeared to be due to the combined effect of telescopic rail mounting stiffness and a small degree of backlash across the tracks as the door could be lifted relatively easily into its correct position.

Entries in the S76 Flight Manual of one UK operator state that operation of the sliding door in flight is prohibited unless Customer Service Notice No 76-78 is incorporated. Part of this kit is the installation of the spigot and eyes. With this modification operation of the door in flight is limited to speeds below 50 kts and flight with the door open to 75 kts.

Operator experience in the UK is that if the door is opened at any significant forward speed then it cannot easily be restrained by hand and it is likely to move rapidly rearwards. Also operators have experienced several unintentional door openings in flight at high speed which, on one occasion, led to damage of the door frame. These events were related to the incorrect sequential operation of the door primary and secondary locks prior to flight.

Such an event is understood to have occurred to TF-RAN, which caused injury to a crew members' hand. Although on the occasion no outward sign of damage to the helicopter was seen, it is believed by the NASB that the door was brought to an abrupt halt by the telescopic rails reaching the limit of their travel.

7.0 Discussion

From the examination of photographs, the sliding door, damaged Black MRB and parts of the telescopic rails, there seems to be little doubt that the sliding door detached from its lower telescopic rail assembly, to pivot upwards and aftwards into the main rotor. The evidence suggests that the door was in the open position and moving backwards when a failure occurred within the lower telescopic rail. The door pivoted aftwards about its upper forward edge whilst still attached to the upper rail, whilst rotating about its upper edge until a failure occurred in the upper rail. All rail failures appear to have been by the ball bearings breaking through the edge of the inner and immediate rails.

The nature of the damage exhibited by the upper track of the lower door mounted rail suggests that this is the area in which the failure began, in particular around the leading ball. The localised deformation of the track insert at this point suggests that this ball initially was the only one to see a high side and compressive load. Several possibilities exist as to why the ball may have been the first to break through the track edge but, having done so, then the wedging action of this ball might be expected to apply a side load to the remainder of the balls of the track precipitating further failures. Examination of the mating intermediate track would be necessary to substantiate or dismiss the possibilities.

The speed of door movement of approximately 600°/sec. into the main rotor seems consistent with the door detachment occurring whilst in flight, rather than on entry into the water, particularly when set against the NASB assessment of helicopter water entry speed. In addition, failure of this track due to pure aerodynamic or hydrodynamic loading might have been expected to produce a more uniform deformation of the balls against the track edge on both the top and bottom tracks of the lower rail.

8.0 Conclusions

It was concluded from this limited examination that the right sliding door from TF-RAN detached from the lower telescopic rail assembly whilst the helicopter was in flight. Initial failure of the inner rail of this assembly appears to have occurred on its upper track in the region of the leading (foremost) ball. Without the mating rail components to examine no positive conclusions as to why this ball should have been loaded excessively could be drawn. No direct evidence was observed of pre-existing damage, of the type expected from a previous "hard" door opening, on the undamaged section of the rails.

[redacted]
Senior Inspector of Accidents (Engineering)
Accidents Investigation Branch
United Kingdom

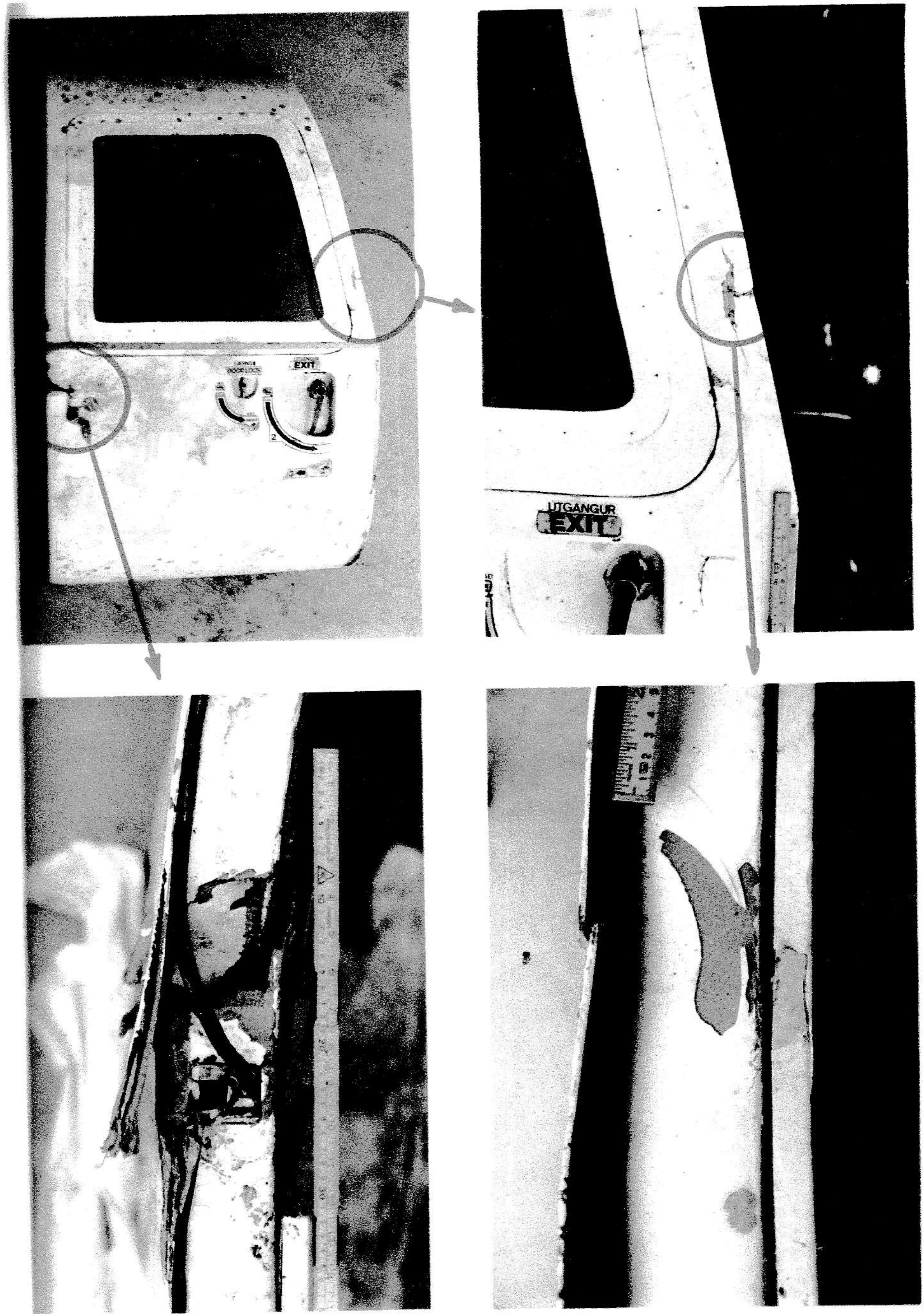


FIGURE 1

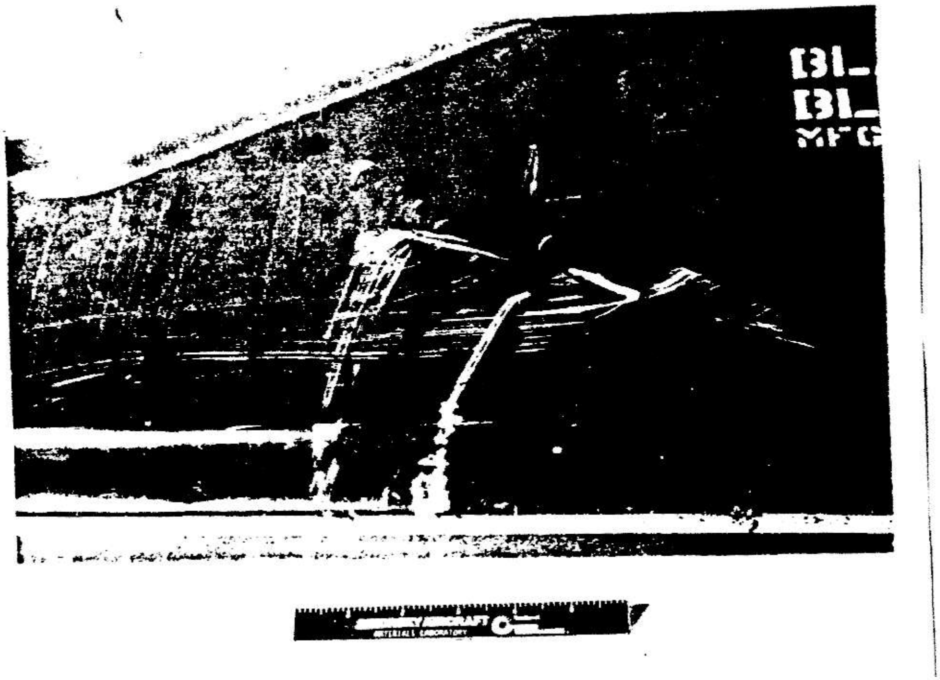
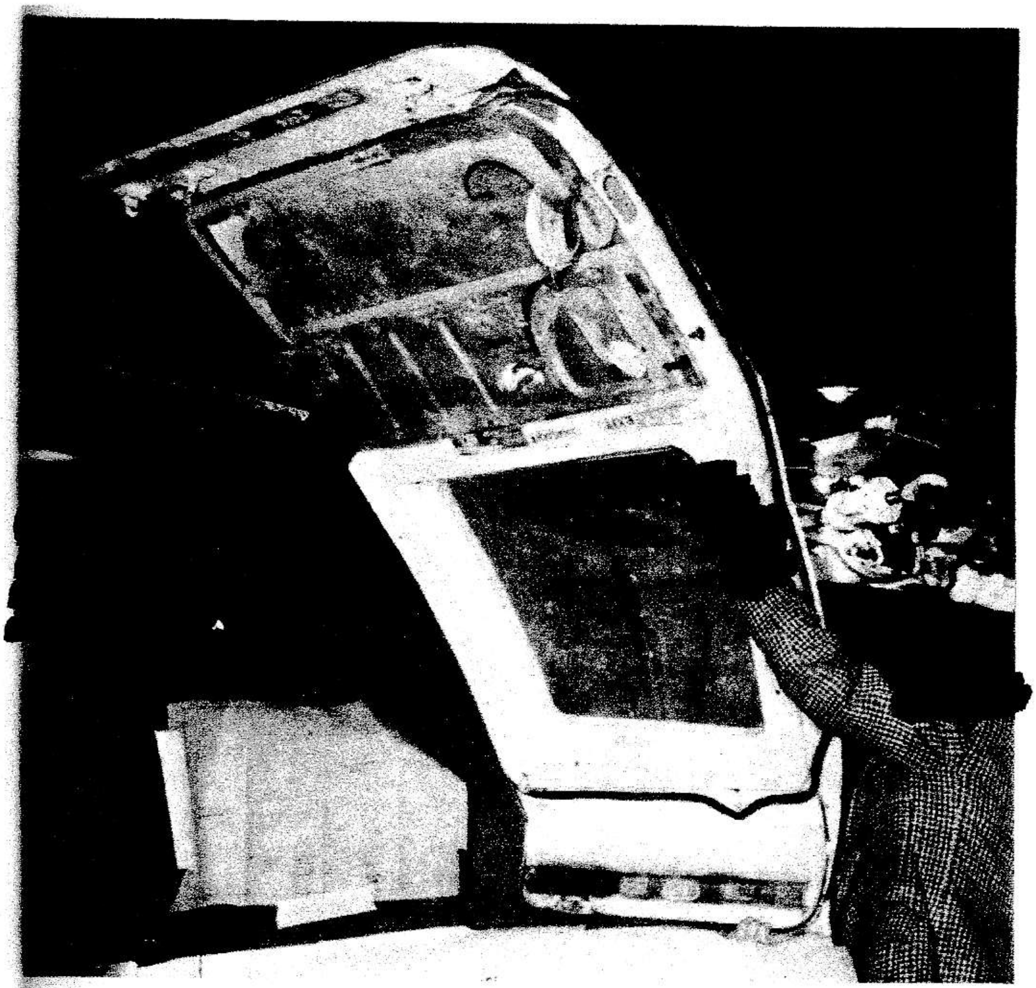


FIGURE 2



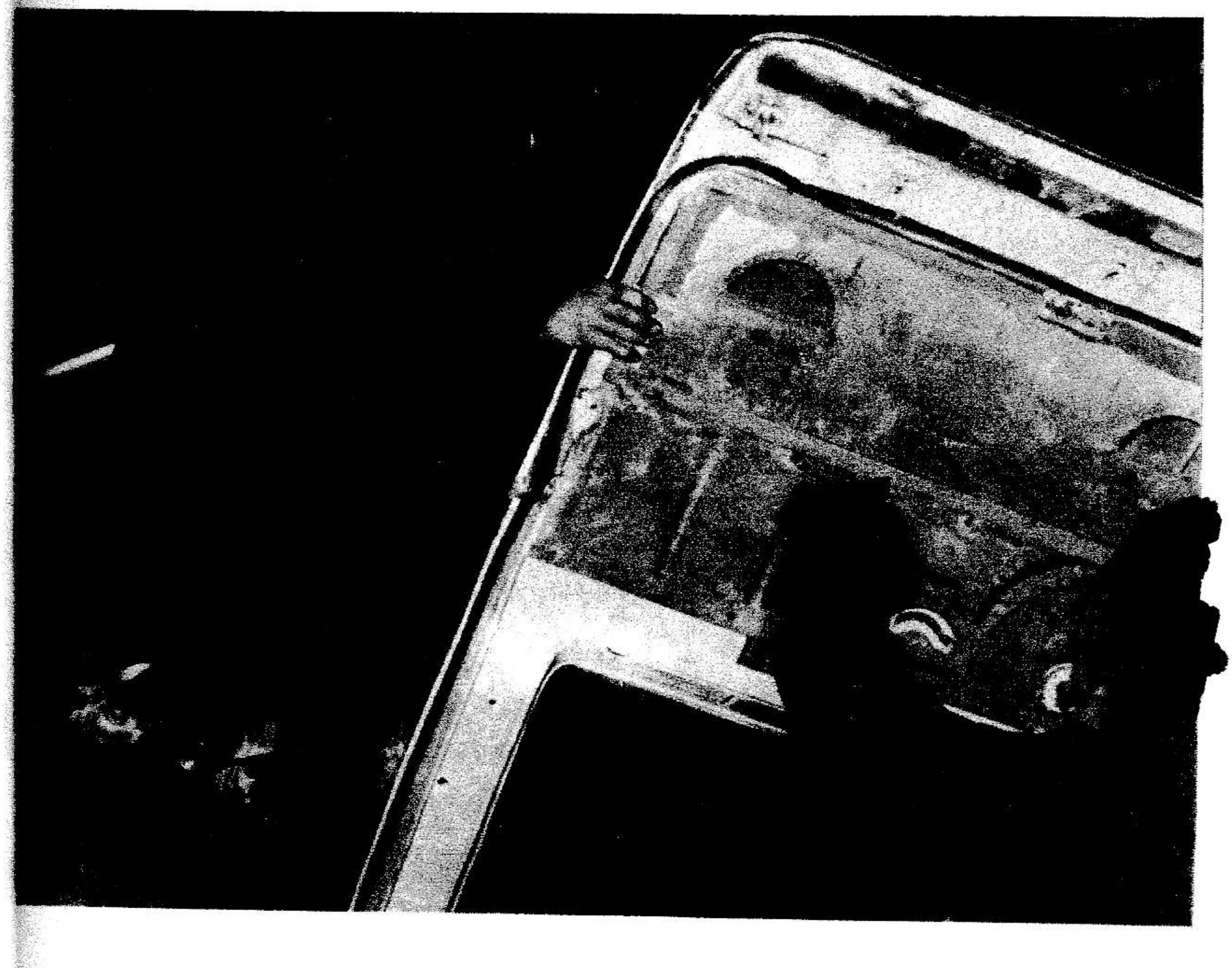


FIGURE 3

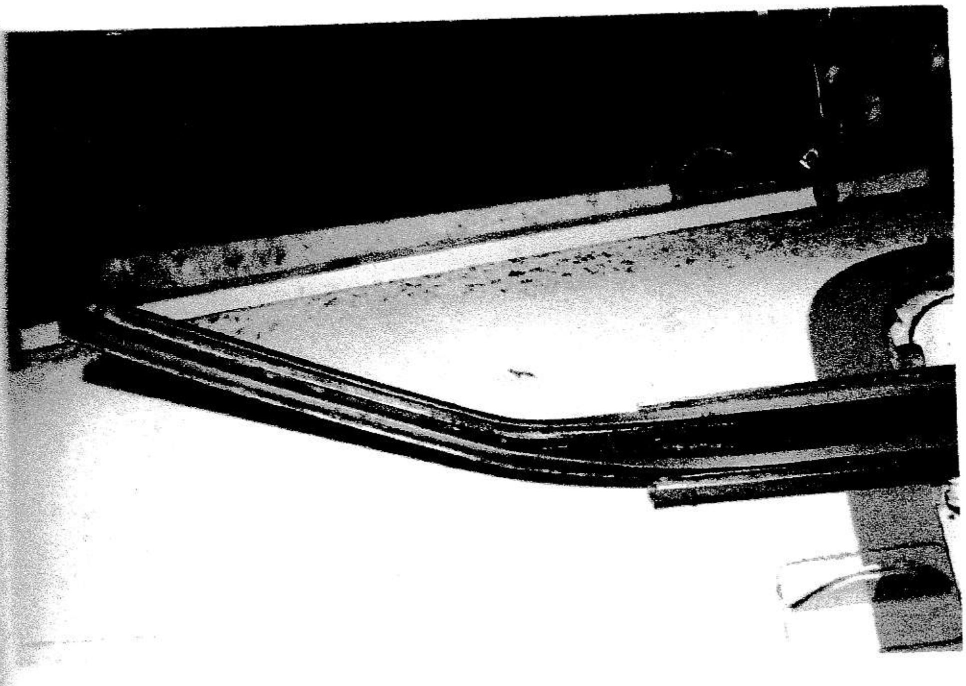


FIGURE 4

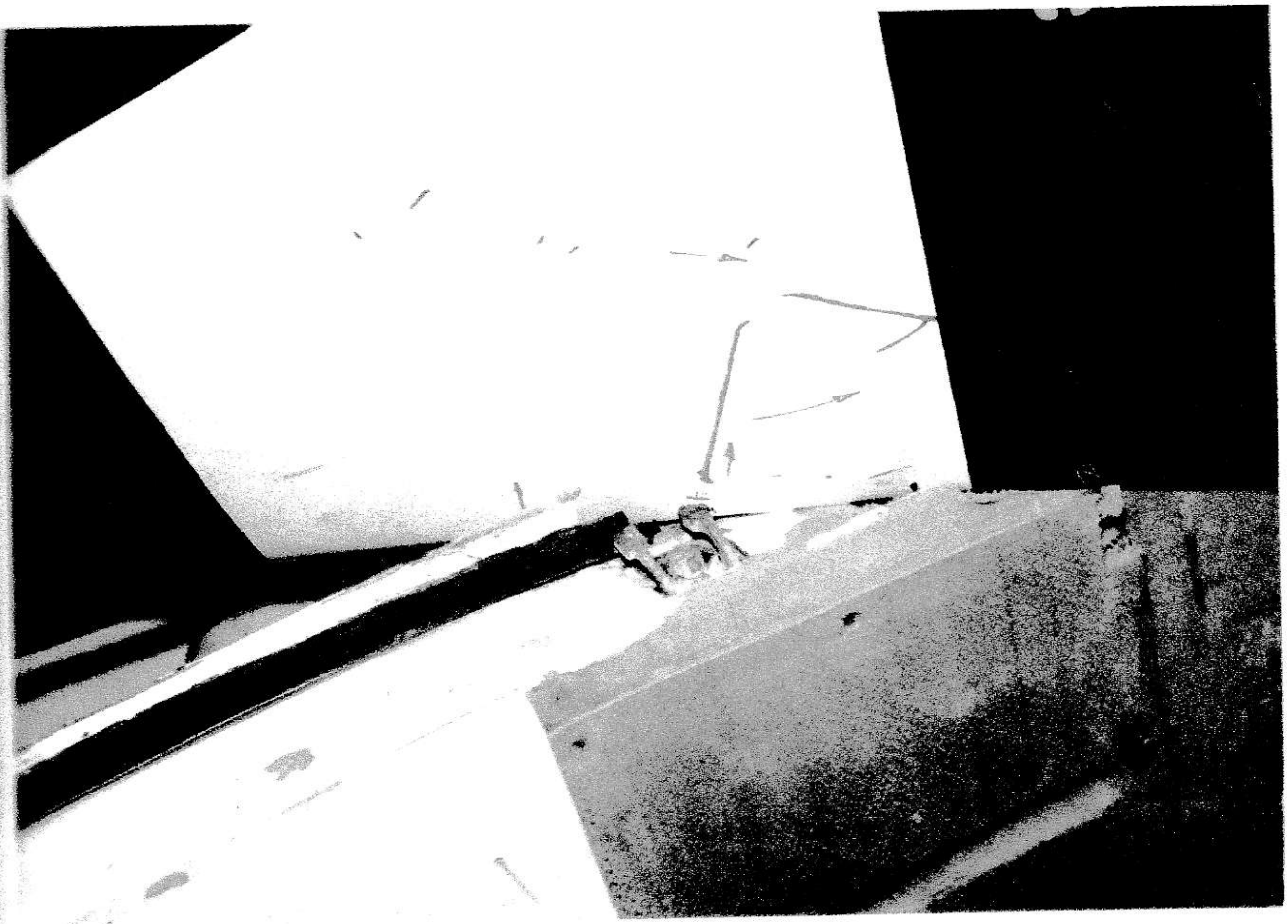
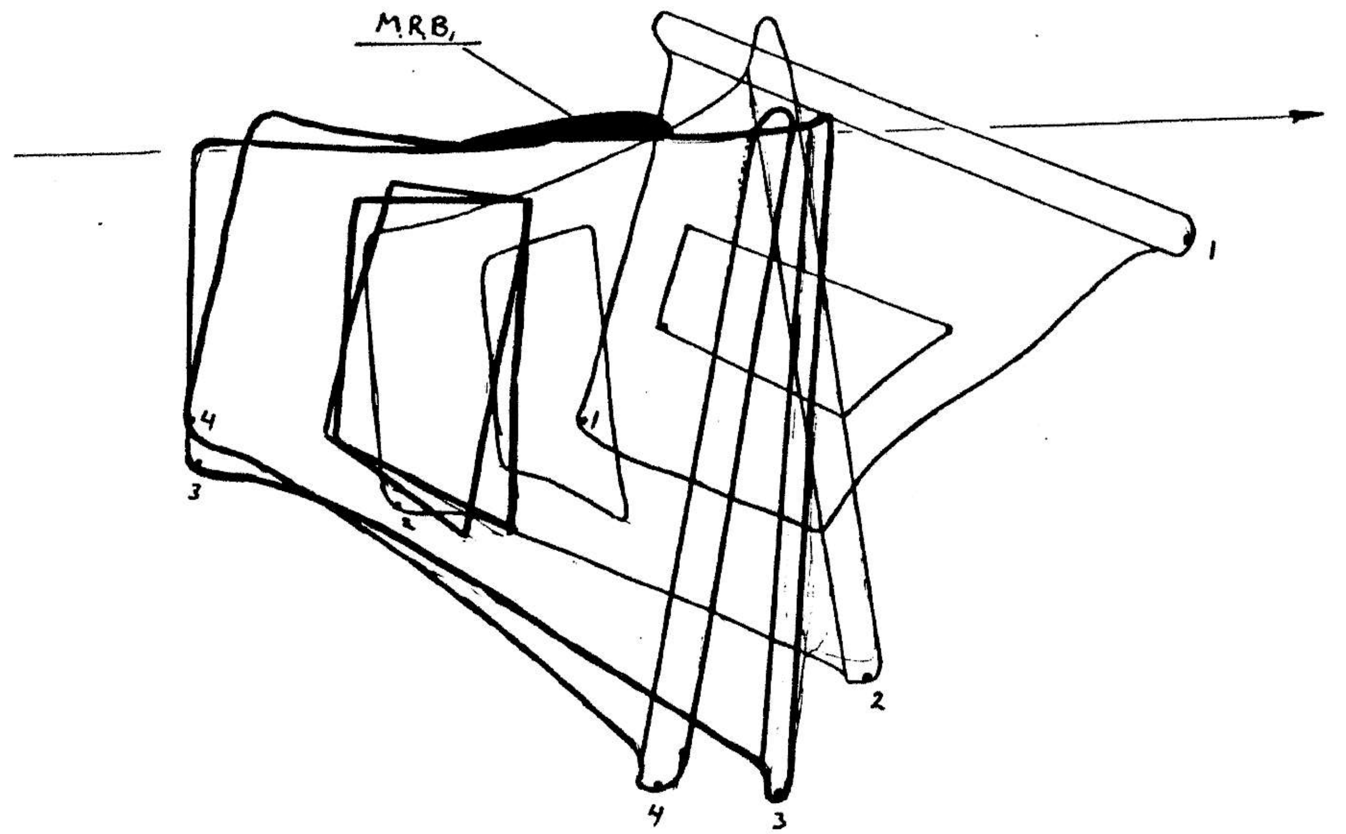


FIGURE 5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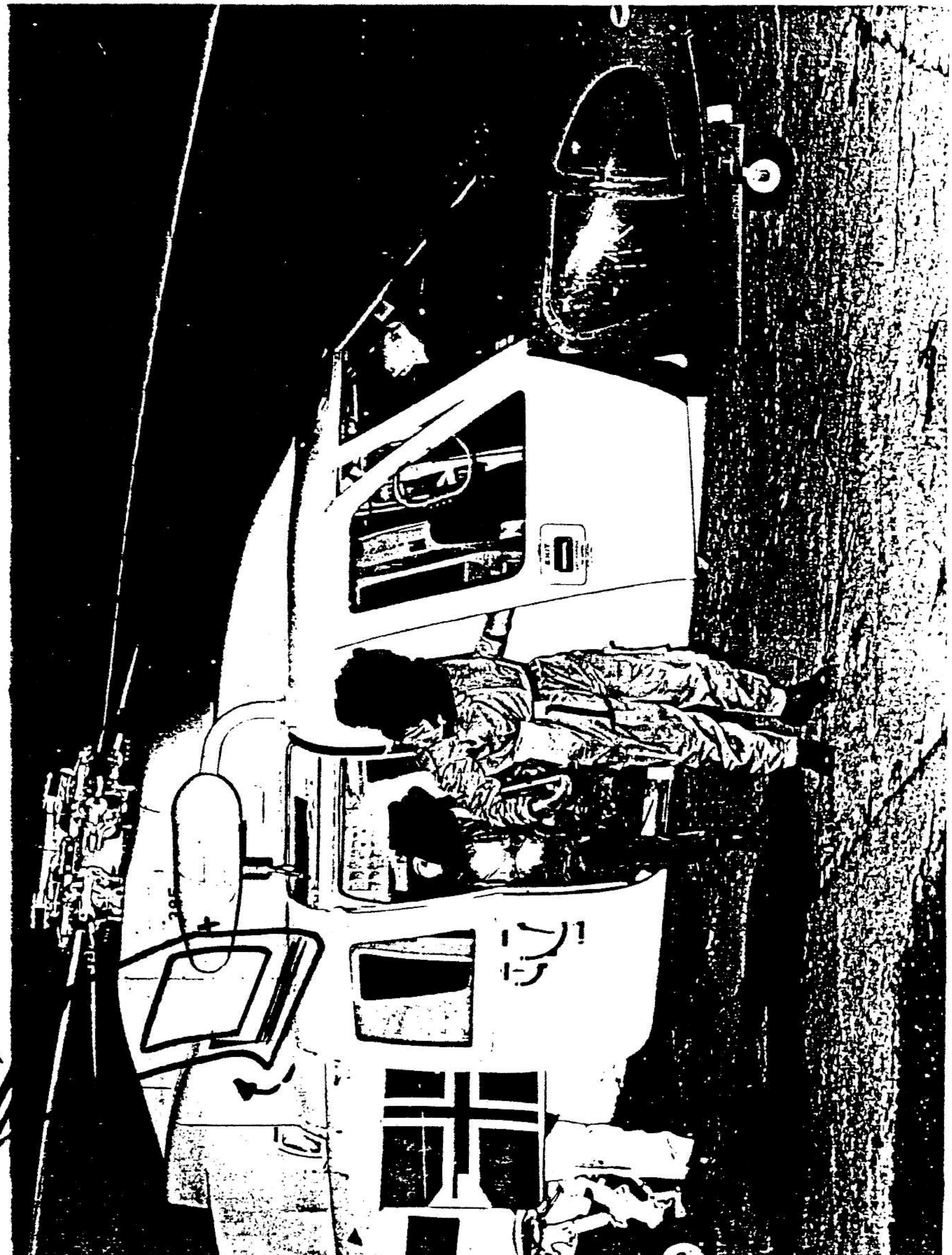
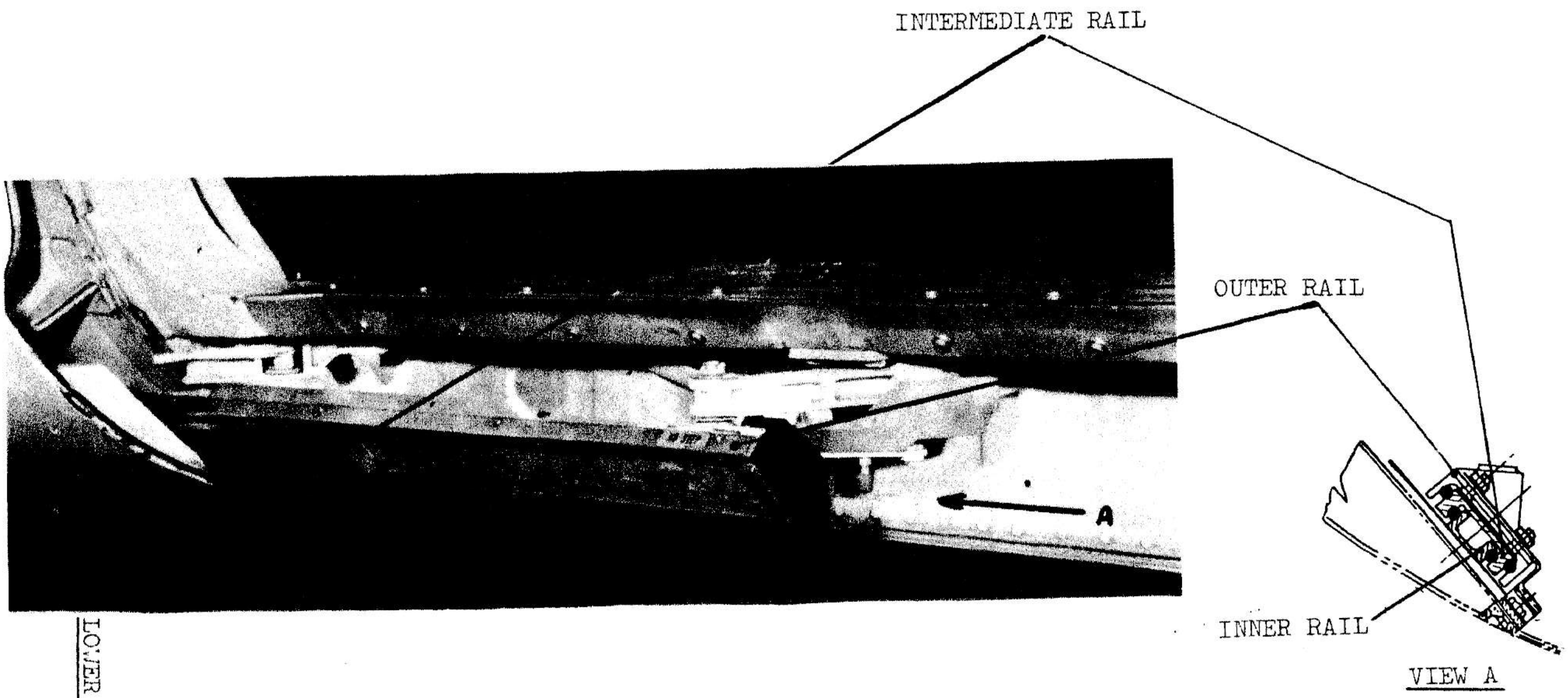


FIGURE 7



LOWER TELESCOPIC RAIL ASSEMBLY

FIGURE 8

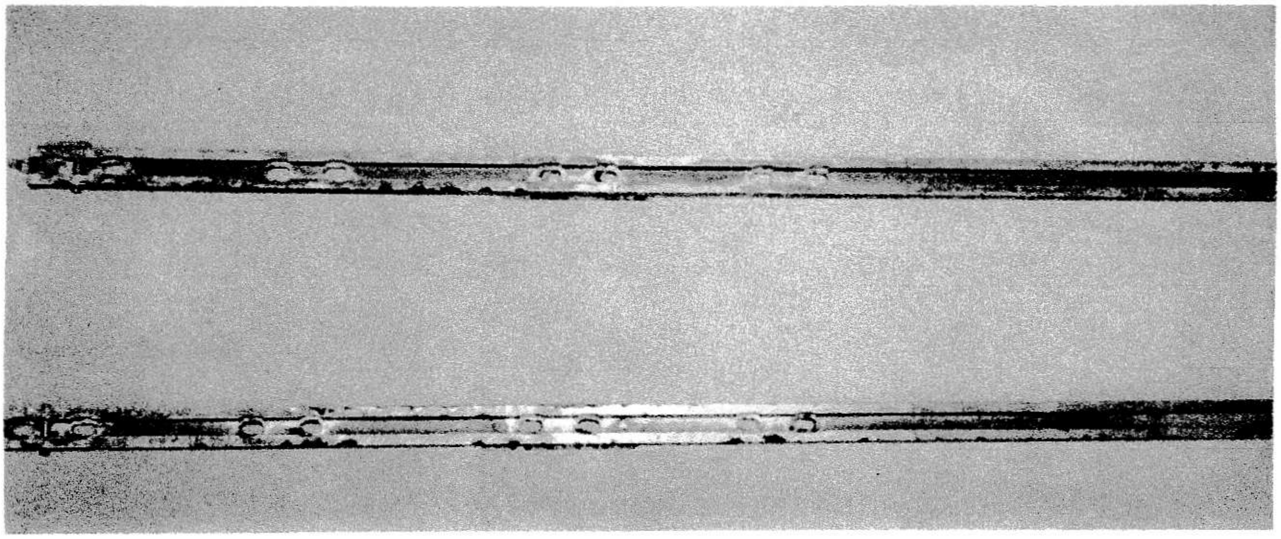
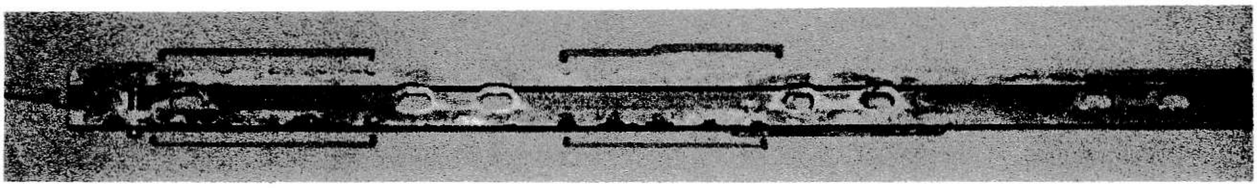
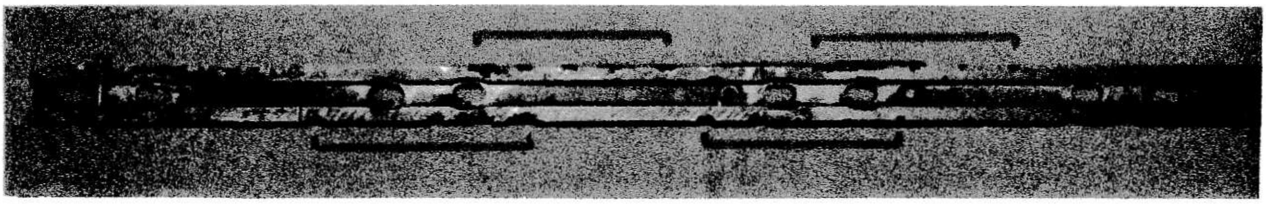


FIGURE 9



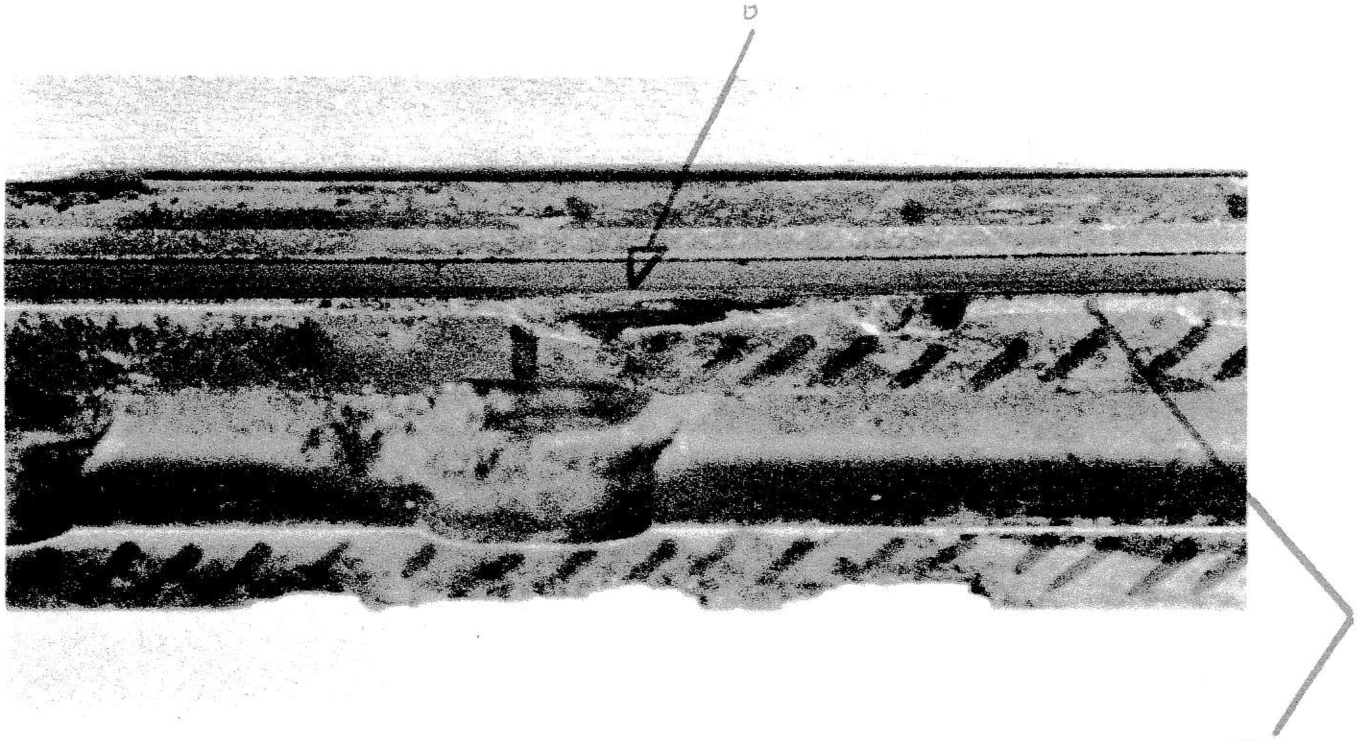
UPPER RAIL

BALL EXIT REGIONS FOR EACH TRACK

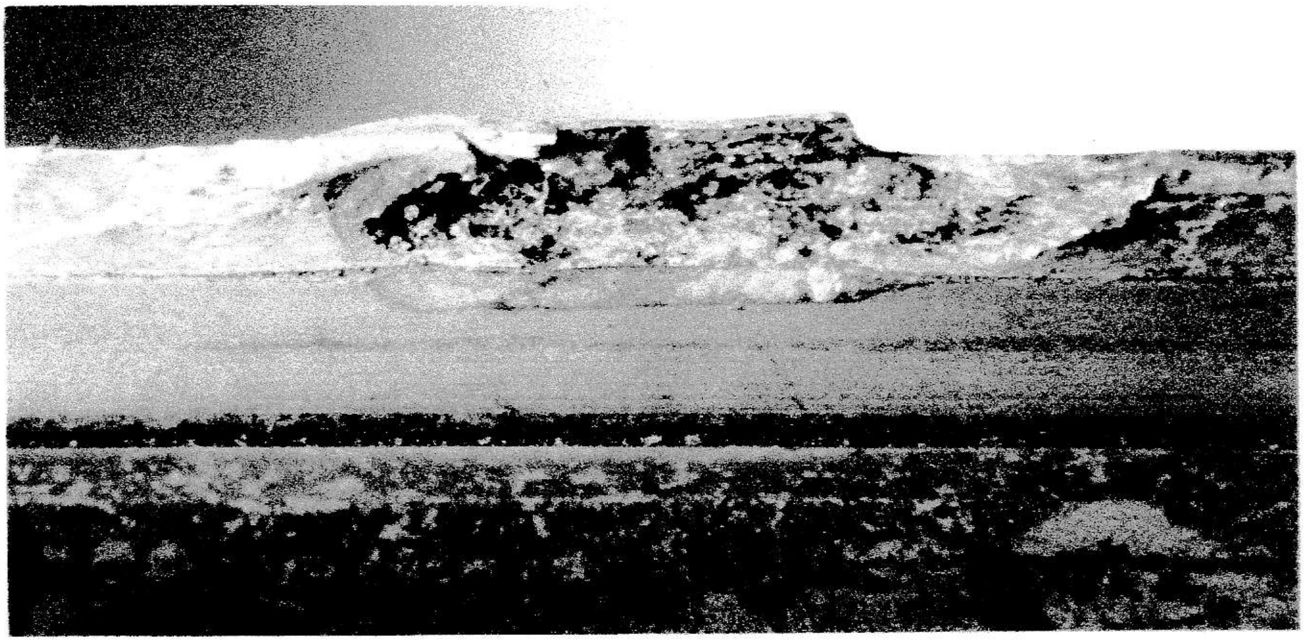


LOWER RAIL

FIGURE 10



TRACK EDGE DEFORMATION ON OUTER EDGE



VIEW B
LEADING BALL EXIT POSITION

FIGURE 11

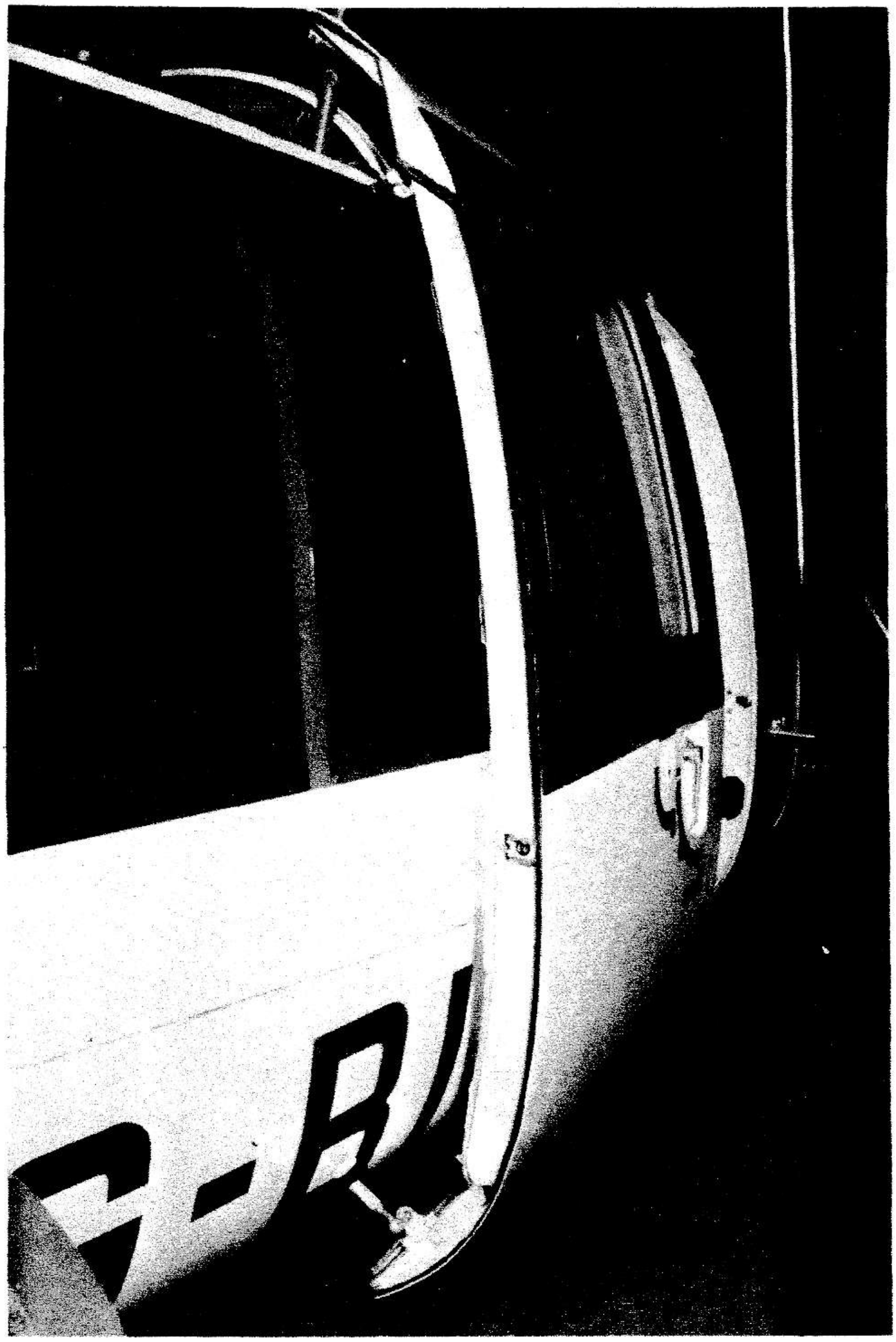


FIGURE 12

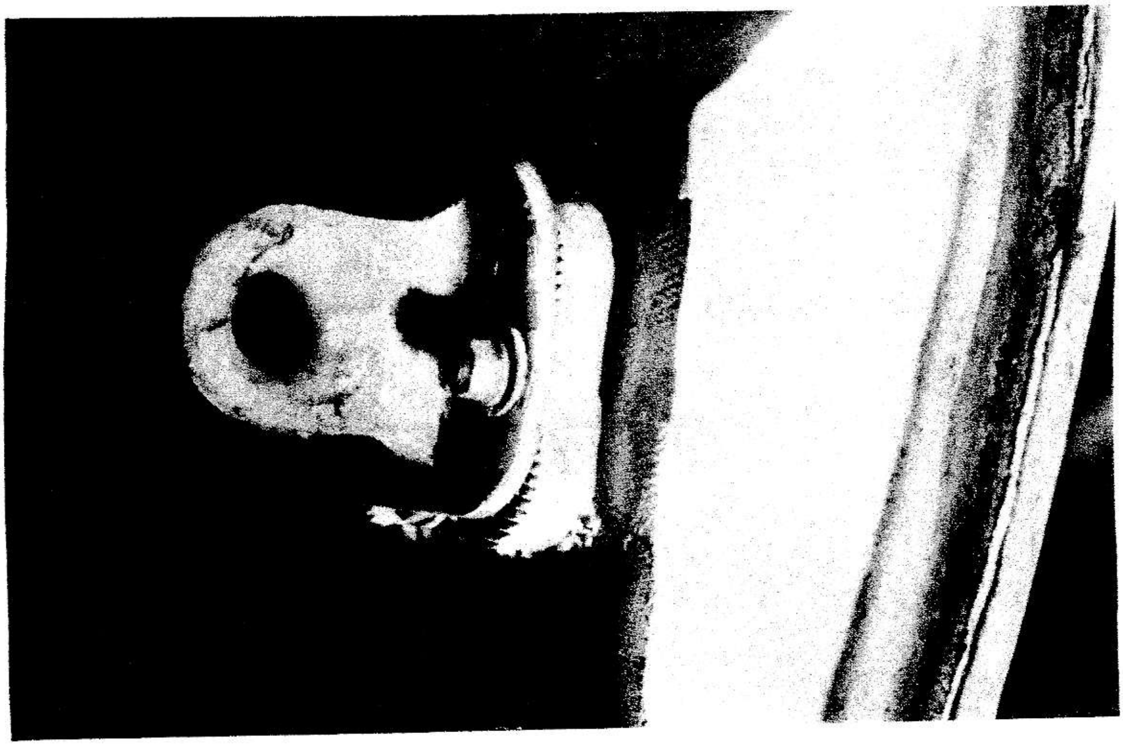


FIGURE 13

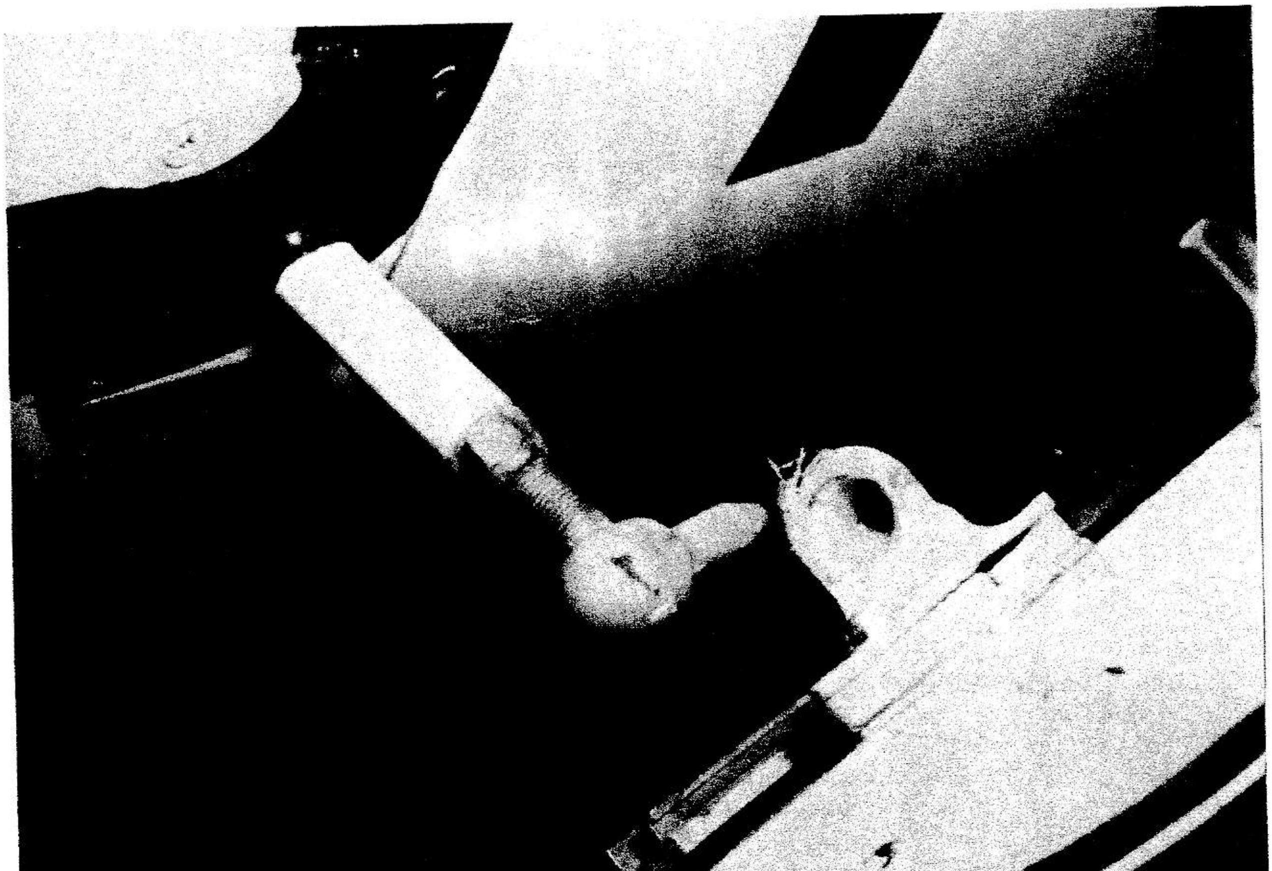


FIGURE 14

SIKORSKY 76

CUSTOMER SERVICE NOTICE

No. 76-78

Subject: DOORS - Right Sliding Door - Incorporation of Door Open Supports and Provisions for Improved Operation

Purpose: This modification is required to permit opening of the right sliding door while in flight.

This modification will incorporate: door open supports to firmly secure the door when open, new track assemblies on certain helicopters to eliminate possible interference with aircraft structure, springs in the door crank mechanism to assist in moving the cranks past overcenter as the door is opened, detent springs to hold the door in position on the tracks, a separate RH DOOR warning light that operates independently of the existing door open warning system, and a handhold for use during door-open flight operations.

Effectivity: SS Nos 760004 thru 760009, 760011
760016 thru 760018
760020 thru 760026, 760033
760036 thru 760040
760042 thru 760044, 760046
760049, 760051, 760052
760056, 760057, 760059, 760064

Description: The right sliding door is removed from the helicopter.

On certain helicopters, the track assemblies are replaced with new tracks. Before removal, the exact location of the tracks on the door is marked to eliminate need for adjustment. The tracks are removed and new tracks are installed in the marked location after inserts are installed.

DOORS - Right Sliding Door - Incorporation of Door Open Supports and Provisions for Improved Operation

Description (Continued):

Next to the forward bulkhead for the sliding door opening in the cabin, a handhold is installed. The interior treatment is modified to accept the handhold.

On the upper and lower forward cranks, an eyebolt is installed and a spring is attached. Clips are attached to the other end of springs and riveted to the fuselage.

On the forward inside part of the door, fasteners are installed and a serrated plate is secured to the latch mechanism cover with rivets. A nylon wedge is secured to the plate

On the door, cutouts are made on the upper and lower aft section. At the upper cutout, a honeycomb threaded insert assembly is secured to the inside of the door with straps and rivets. At the lower cutout, a honeycomb insert assembly is bonded inside the cutout. After curing, baseplates and slotted Nylatron lugs are secured to the inserts with serrated plate assemblies.

On the door, fillers and spring detents are installed to hold the door in position on the track.

The door is installed and an operational check is done to make sure it is adjusted properly.

On the fuselage, two standoffs are located to mate with the lugs on the door when in full open position. A wedge is located on the fuselage to contact the wedge installed on the door. Holes are cut in the honeycomb skin panels for installation of steel threaded inserts for mounting standoffs and a wedge.

In the cockpit, the master switch panel on the console and certain instruments are removed for access. Components are covered for protection in the rework area and a cutout is made in the instrument panel. A light assembly is installed in the cutout and secured. Wires are soldered to a relay bracket assembly and the assembly is installed on the tail rotor pedal support. New wires are spliced into existing

DOORS - Right Sliding Door - Incorporation of Door Open Supports and Provisions for Improved Operation

Description (Continued):

warning system at the caution/advisory panel and interior non-flight instruments light switch on the master switch panel.

The door and interior treatment is modified to accommodate the lugs, wedge, and handhold. Instruction plates are installed on the door and surround. A new EXIT information plate is installed on the door interior if necessary. NO-STEP decals are installed on the track and upper support pin mounting. The decal for not opening the door in flight is removed.

Instructions:

WARNING PREPARE HELICOPTER FOR GROUND MAINTENANCE.

NOTE: For helicopters prior to and including SS No. 760033, use Modification Kit 76070-20015-012.

For helicopters, SS No. 760036 and subsequent, use Modification Kit 76070-20015-011.

A. Remove right slidiing door as follows (Figure 1):

(1) Open right sliding door (76207-03011-042).

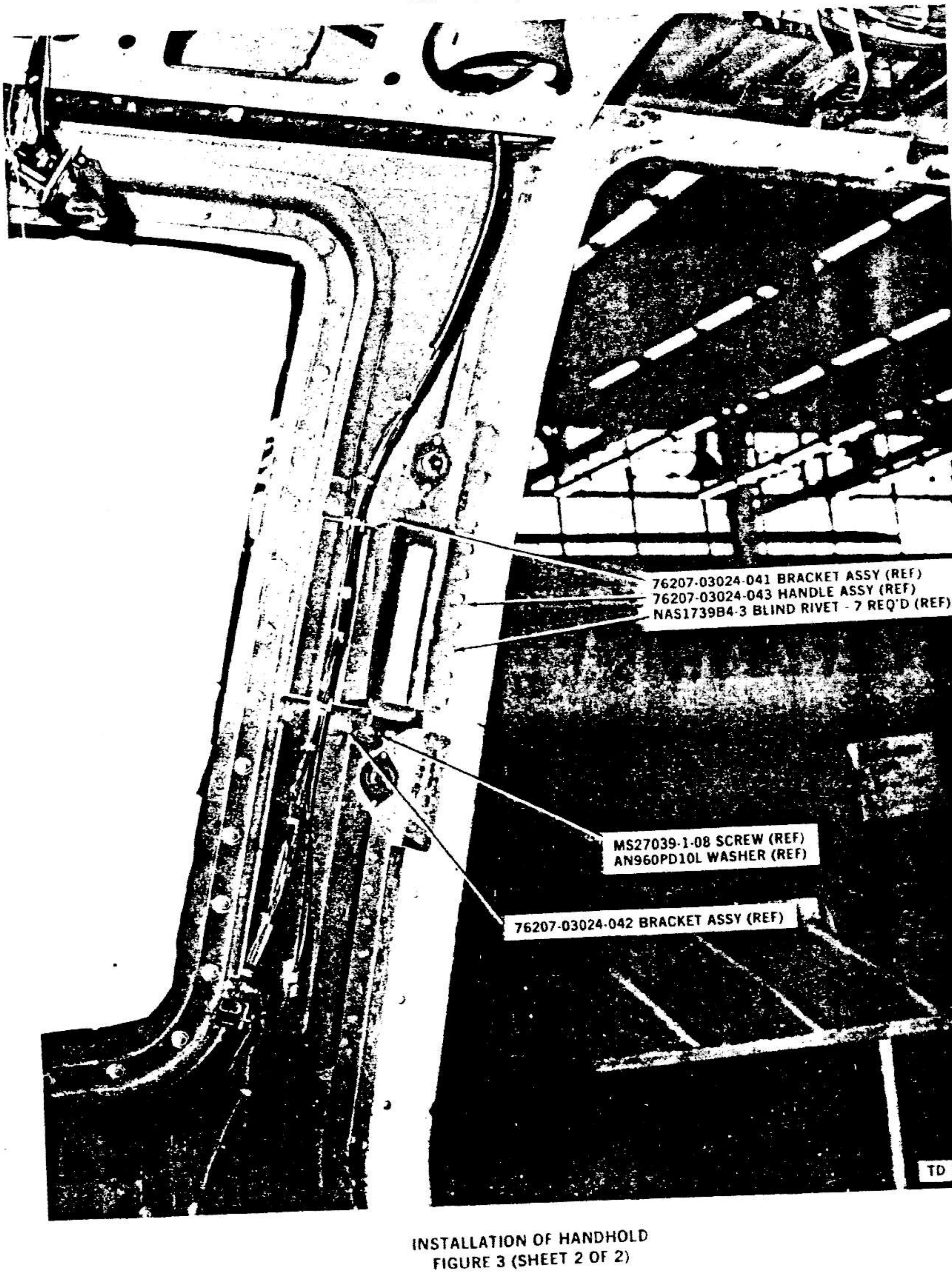
(2) Remove four nuts and washers at each of four swivel fitting attachments to tracks.

NOTE: On lower track and swivel, if hoist cable guard is installed, keep it for reuse (Figure 2).

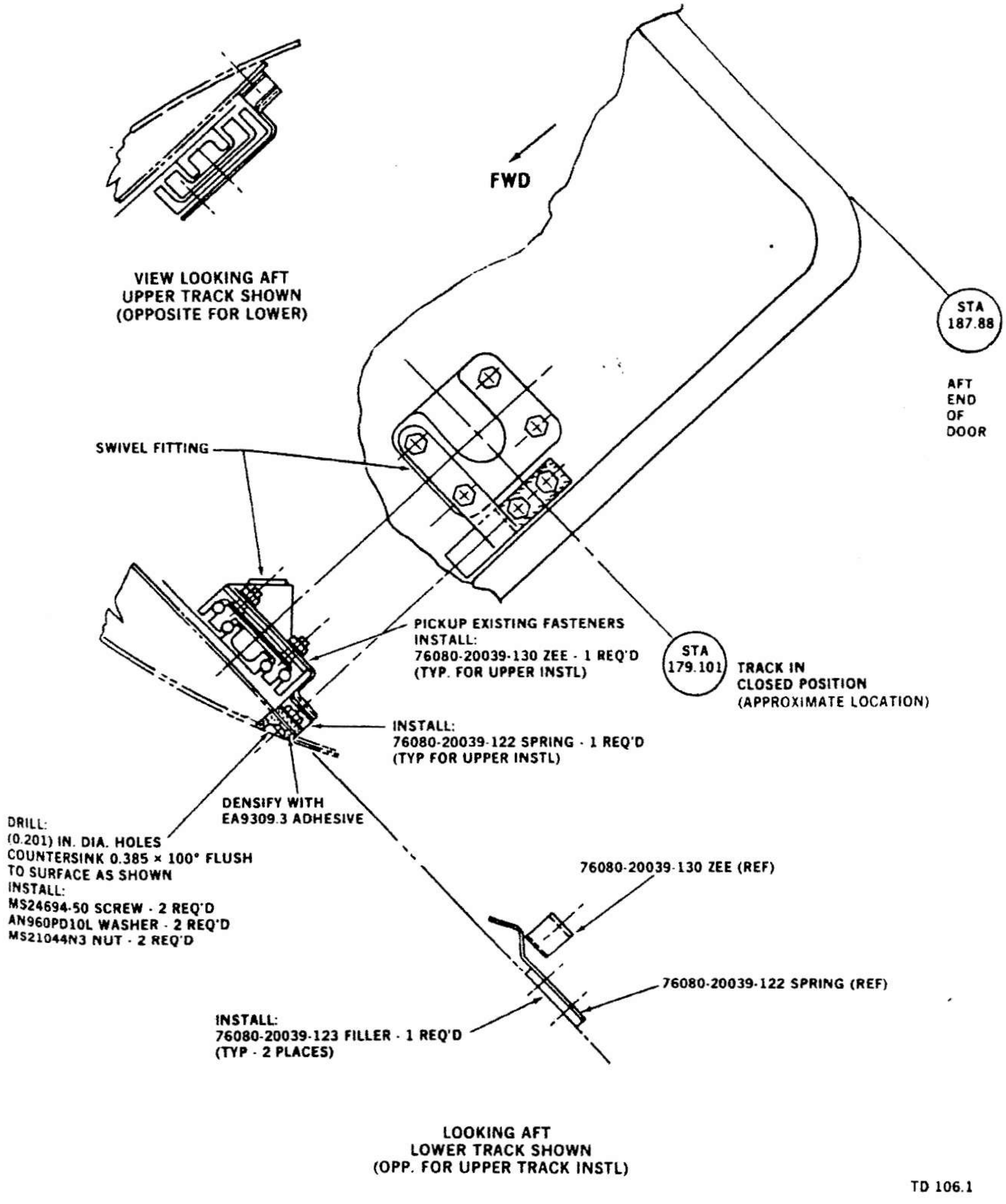
(3) Remove door and place on safe area, using care to protect paint finish.

(4) Remove window per Maintenance Manual.

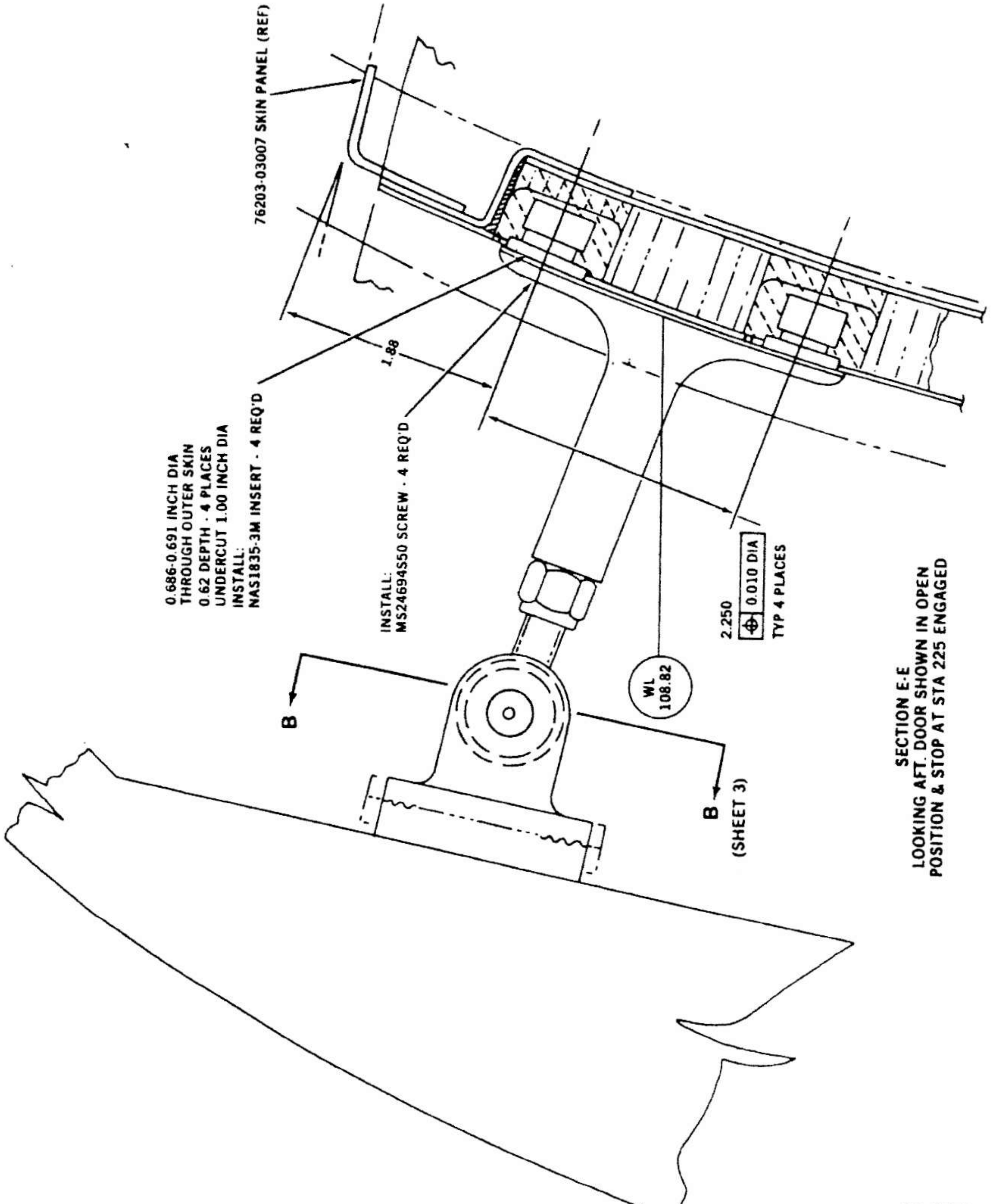
(5) On helicopters SS Nos 760036 and subsequent, track assemblies (76209-03011-103) are installed. Do not remove serrated plates and door catches. Go to step (7).



INSTALLATION OF HANDHOLD
FIGURE 3 (SHEET 2 OF 2)



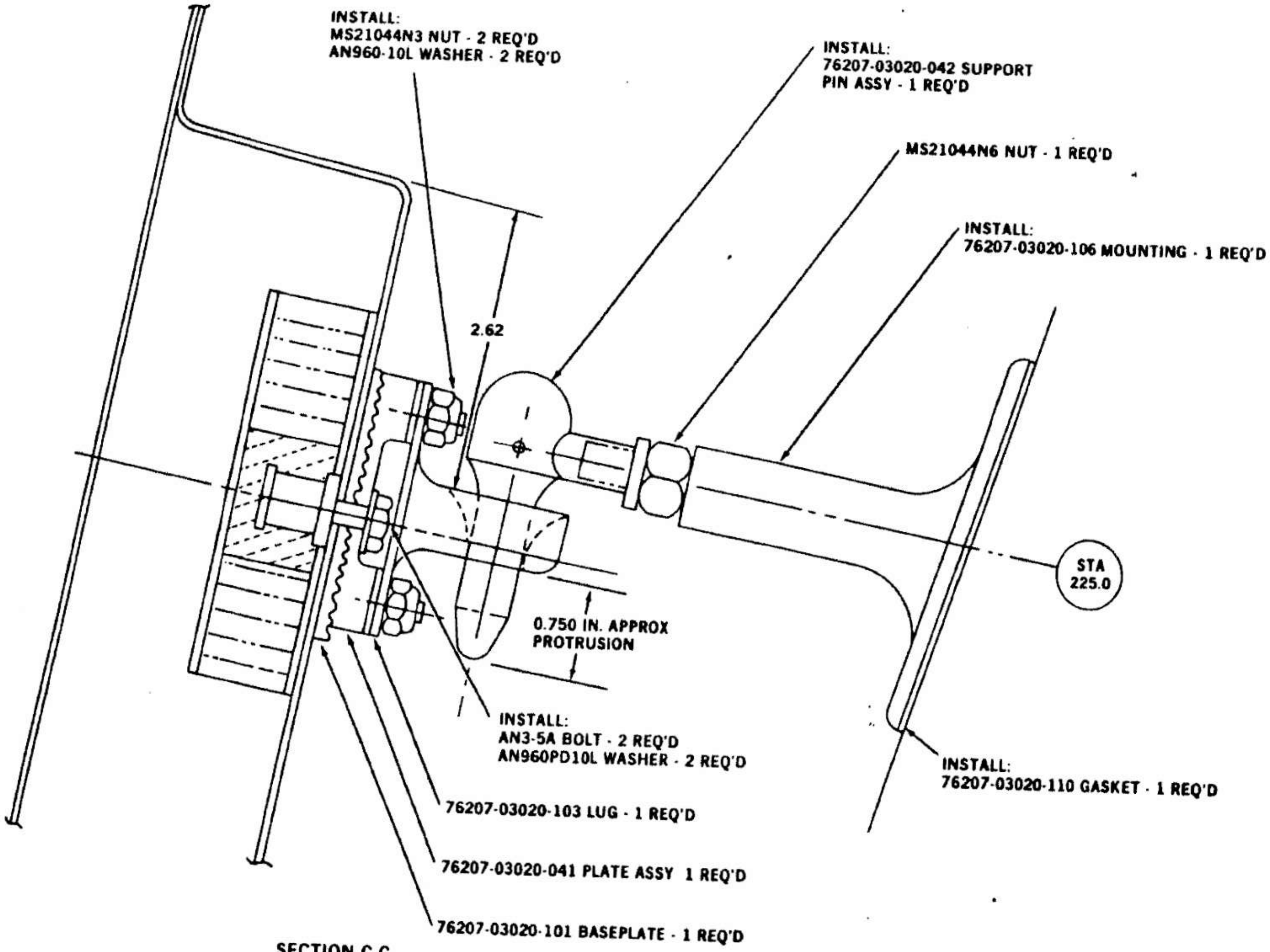
INSTALLATION OF DOOR CLOSED DETENT SPRINGS
FIGURE 7 (SHEET 1 OF 2)



SECTION E-E
LOOKING AFT. DOOR SHOWN IN OPEN
POSITION & STOP AT STA 225 ENGAGED

TD 108.2

INSTALLATION OF DOOR OPEN SUPPORTS (UPPER)
FIGURE 9 (SHEET 2 OF 5)



SECTION C-C
DOOR SHOWN IN OPEN POSITION
AND SUPPORT PIN AT STA 225 ENGAGED

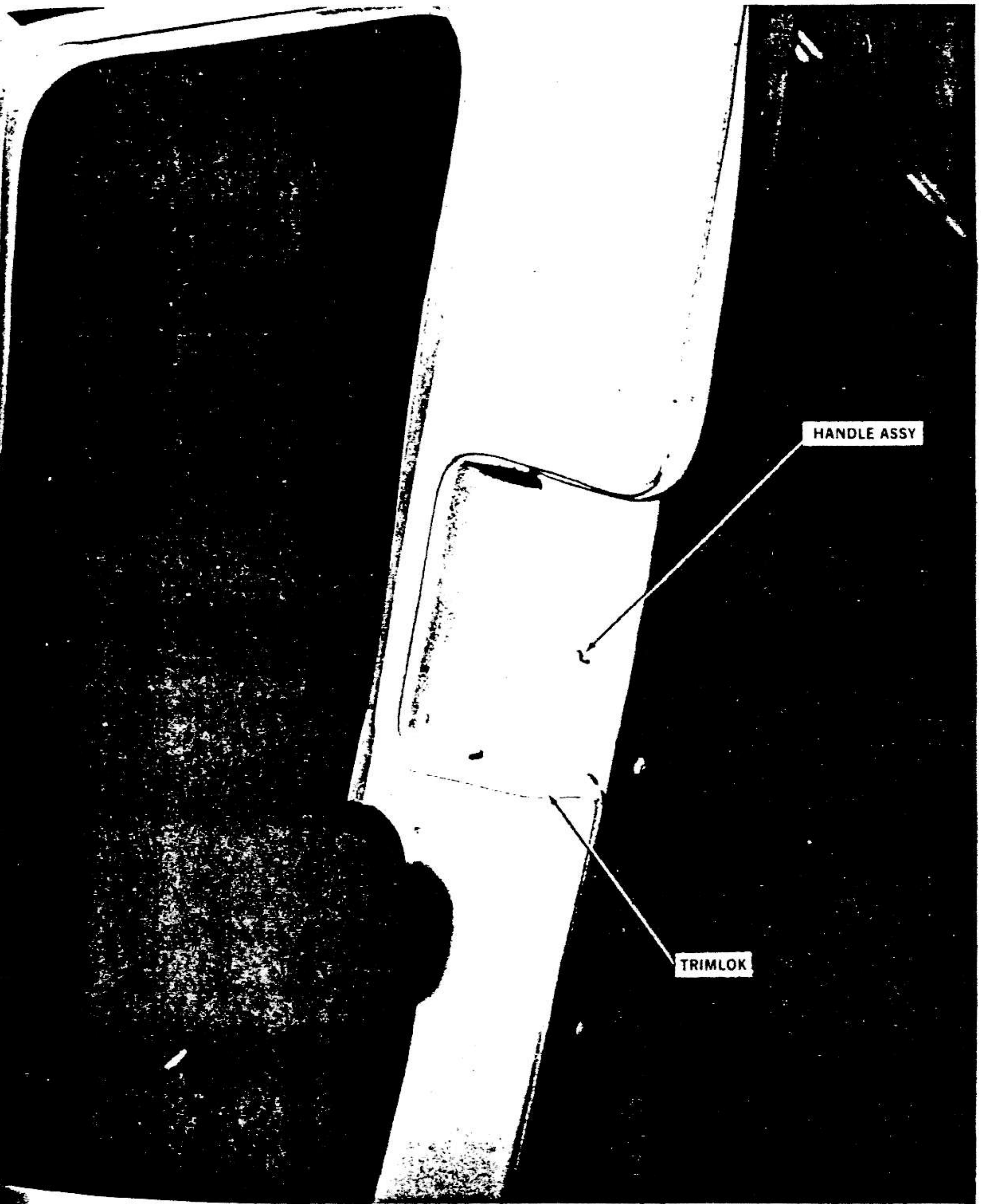
INSTALLATION OF DOOR OPEN SUPPORTS (UPPER)
FIGURE 9 (SHEET 4 OF 5)

TD 108.4

SIKORSKY 76

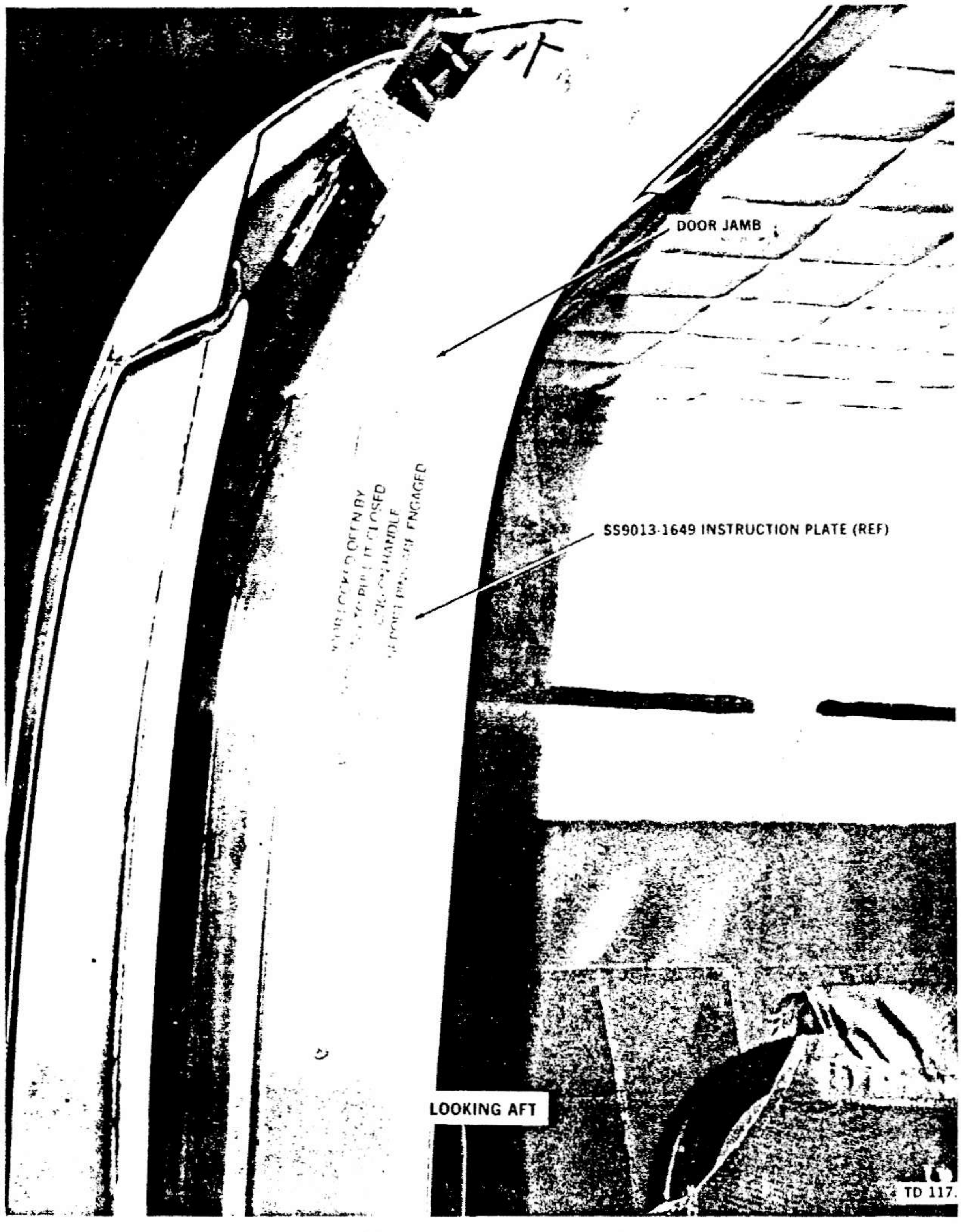
CUSTOMER SERVICE NOTICE

No. 76-78



TD 115.2

REWORK OF INTERIOR TREATMENT FOR HANDHOLD
FIGURE 16 (SHEET 2 OF 2)



INSTALLATION OF INFORMATION AND INSTRUCTION PLATES
FIGURE 18 (SHEET 2 OF 2)