Department of Trade

ACCIDENTS INVESTIGATION BRANCH

British Airways Trident 1E G-AVYD Report on the accident at Bilbao Airport, Spain on 15 September 1975

Translation of the report produced by

the Spanish Civil Aviation Accident Commission

Released July 1978

LONDON
HER MAJESTY'S STATIONERY OFFICE

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ISBN 0 11 511812 8

Operator:		British Airways (Northeast Airlines)
Aircraft:	Type:	Trident
	Model:	110
	Nationality:	United Kingdom
	Registration:	G-AVYD
Place of Accident:		Bilbao Airport, Spain 43°18″04″N 02°54″40″W
Date of Accident:		15 September 1975 at 1348 hrs

All times in this report are GMT

Synopsis

The accident was notified to the United Kingdom Department of Trade on 15 September 1975 by the operator. The investigation was carried out by the Spanish Civil Aviation Accident Commission. The United Kingdom Accidents Investigation Branch appointed an Accredited Representative to take part in the investigation.

The accident occurred when the aircraft was taking off on Runway 28 at Bilbao which was very wet and contaminated with standing water. As the aircraft encountered an area of standing water at or close to V_1 the Commander abandoned the take-off when he experienced what he described as a 'marked deceleration'. Subsequently it became apparent that the aircraft would not stop within the runway length available and it was turned off the runway. None of the occupants was injured.

It is considered that the marked deceleration experienced by the Commander was a momentary reduction in acceleration occasioned by the aircraft's encounter with standing water. Contributory factors to the accident were the low effective breaking coefficient of friction achieved by the aircraft during the deceleration phase and the omission of the Commander to ascertain the extent and depth of water present on the runway prior to take-off.

1. Factual Information

1.1 History of the Flight

The aircraft was operating British Airways flight NS552, a scheduled service from Bilbao to London (Heathrow) Airport. Earlier in the day the aircraft and crew had operated scheduled service NS551 from London to Bilbao and after an uneventful flight had landed at Bilbao on Runway 10 at 1231 hrs. At the time of landing light rain was falling and the runway was wet. No standing water was seen on the runway during the landing run by the Commander or the First Officer.

While the aircraft was being prepared for the return flight rain fell intermittently varying in intensity from moderate to heavy, but abating to light as the aircraft taxied out for take-off. Prior to start up the crew requested the airfield information on RTF from Bilbao Tower and were passed the following at 1321½ hrs: Surface Wind – calm; Runway in use – 28; QNH – 1014 mbs. The Commander had given a full take-off briefing before the aircraft left London that morning. As permitted by normal company procedures he curtailed his briefing at Bilbao and called for "Standard emergencies; 510 (normal) take-off power; engine relight switches on; wet V_1". The take-off data was extracted from tables in the Operations Manual (Volume III) and the Check Lists taking into account the airfield information and the Commander's briefing. The take-off data card was made up in part as follows:

Engine Thrust Index No 1 Engine = 118 No 2 Engine = 106
No 3 Engine = 118
Wet V_1 = 117 knots V_R = 131 knots Flap Setting = 23^o

Start-up was normal and at 1337 hrs the aircraft was cleared to taxi and to hold short of the runway because of landing traffic – a Caravelle. The crew watched the Caravelle land on Runway 10 and the Flight Engineer commented to his two colleagues on the considerable amount of water spray being thrown up at the rear of this aircraft during its landing run. The Commander remarked that he would assess the runway conditions while back-tracking to the take-off position from the taxiway entrance to the runway. He noted a number of pools of standing water on the runway surface as the Trident back-tracked along the runway. Although he could not estimate their area or depth, the pools appeared to be well within the limits imposed for take-off using 510 (normal) power. As the greater part of the runway surface he had looked at was damp he did not change his take-off briefing.

The taxi drills were actioned by the First Officer and the Flight Engineer during this time and "runway items" were completed after the Commander turned the aircraft through 180^o close to the threshold of Runway 28, aligned it on the runway centre line, and selected the wheel brakes to park. A power setting of 100 per cent thrust was made, all engine indications were checked as correct, and the engine relight switches were selected 'ON' before the wheel brakes were released and the take-off run commenced at about 1346 hrs with the Commander piloting the aircraft. According to crew statements taken after the accident the aircraft accelerated normally; the First Officer called out the indicated airspeeds at 80 knots and 100 knots and made a call of 'Wet V_1' at 117 knots then removed his hand from the throttles. At the time or just after 'Wet V_1' was called the Flight Engineer and the First Officer heard a noise which the latter crew member attributed to the aircraft's entry into standing water. According to the Flight Engineer the aircraft appeared to decelerate at the same time that he heard the noise.

The Commander has stated that as 'Wet V_1' was called he felt a marked deceleration consistent with a loss of engine power, whereupon he immediately closed the throttles, called "Abandon", deployed the airbrakes and lift dumpers and applied the wheel brakes fully. However according to the Flight Engineer all engine indications had been normal prior to the closing of the throttles. On seeing a hand close the throttles the First Officer selected emergency reverse thrust on the pod engines, checked the engine indications were correct and maintained the application of emergency reverse thrust until the aircraft eventually came to rest. The First Officer and the Commander checked the indicated pressures on the wheel brake gauges which showed the wheel brakes were fully applied. The initial deceleration felt satisfactory to the crew, then quickly deteriorated and the First Officer formed the impression that the aircraft was aquaplaning. According to the First Officer and Flight Engineer the Commander commented on the poor rate of deceleration about this time. The Flight Engineer then noticed that the aircraft had begun to drift gradually to the left of the runway centreline apparently as the result of a deliberate action by the Commander. Subsequently it became evident to the Commander that he could not bring the aircraft to a halt within the runway confines. Some 200 metres to 300 metres before the end of the runway he turned the aircraft to the left using nose-wheel steering and applied full left rudder. As the nosewheels ran off the runway onto the grass, the aircraft slewed to the left then skidded broadside to the right for a short distance before it came to an abrupt stop at the side of the runway in a right wing down attitude with the right wing tip close to the threshold lights of Runway 10.

As soon as the aircraft had come to rest the First Officer shut down the engines and on instructions from the Commander operated the engine fire extinguishers. At the same time the Flight Engineer carried out the emergency electrical shut down drills. Evacuation drills were initiated and the passengers left the aircraft in a reasonably orderly manner, the majority by slide from the main exit doors and foremost right overwing emergency exit. Catering equipment in the galleys came out of stowage during the accident obstructing access to the forward emergency exit door and preventing use of this exit and its slide during the evacuation. The Airport Fire Services were quickly on the scene and as a precautionary measure discharged extinguishant into the engines. They were followed by an ambulance and by airport personnel who arrived in time to assist passengers from the aircraft.

There was no fire and no injuries were sustained by the passengers or crew.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	–	–	–
Non-Fatal	–	–	–
None	7	110	

1.3 Damage to aircraft

The aircraft was substantially damaged during the accident and sustained further damage when it was removed from the accident site in order to render the runway operational.

1.4 Other damage

Three runway lights were broken. The undercarriage wheels scored deep ruts in the ground at the left side of the runway during the final broadside to the right.

1.5 Personnel Information

1.5.1 Commander

Age:	41 years.
Licence:	Airline Transport Pilot's Licence valid to 27 October 1975.
Aircraft Ratings:	Group 1 (in command) Trident 1E, B170, Bristol Britannia, Viscount, Airspeed Ambassador, Auster.
Instrument Rating:	Valid until 5 May 1976.
Last Competency Check:	5 April 1975.
Last Route Check:	15 April 1975.
Last Medical Examination:	20 May 1975 – valid until 30 November 1975. Assessed fit; no restrictions.
Total pilot hours:	10,895 hours 25 minutes.
Flying hours in command on type:	1,685 hours.
Total flying hours in last 28 days:	39 hours 05 minutes (all in command on type)
Previous take-offs from Bilbao, Trident 1E:	45.

1.5.2 First Officer

Age:	39 years.
Licence:	Commercial Pilot's Licence valid to 8 April 1978.
Aircraft Ratings:	Group 1 (in command) Trident 1E, DH82A, Auster Variants, C47.
Instrument Rating:	Valid until 28 March 1976.
Last Competency Check:	28 February 1975.
Last Route Check:	2 April 1975.
Last Medical Examination:	24 April 1975 – valid until 30 April 1976. Assessed fit; no restrictions.

Total pilot hours:	5,359 hours.
Flying hours on type:	782 hours 20 minutes (all as co-pilot).
Total flying hours in last 28 days:	45 hours 50 minutes (all as co-pilot on type).
Previous take-offs from Bilbao, Trident 1E:	10.

1.5.3 *Flight Engineer*

Age:	26 years.
Licence:	Flight Engineer's Licence valid to 25 April 1978.
Aircraft Ratings:	Trident 1E, Comet 4.
Last Competency Check:	21 February 1975.
Last Route Check:	7 May 1975.
Last Medical Examination:	14 April 1975 – valid until 30 April 1976. Assessed fit; no restrictions.
Total hours as Flight Engineer:	1,998 hours 10 minutes.
Total hours on type as Flight Engineer:	1,731 hours 40 minutes.
Total flying hours in last 28 days:	66 hours 25 minutes (all on type).

1.5.4 *Cabin Staff*

Four female cabin attendants were carried, all of whom were properly qualified in emergency procedures.

1.6 Aircraft Information

1.6.1 *Construction*

The Trident series 1E-110, a three engined jet airliner of all-metal construction is a low wing monoplane fitted with a retractable tricycle undercarriage and equipped with hydraulically operated nosewheel steering.

Two of the three Rolls Royce Spey 511-5W turbofan engines are mounted in pods, one on each side of the rear fuselage, the third (centre) engine being mounted inside the rear fuselage. A reverse thrust unit is fitted to each pod engine and controlled by levers on the respective throttles in the flight deck. Reverse thrust cannot be selected until the throttles are closed. A water injection system to increase engine power on take-off is provided. However the system had been rendered in-operative on the accident aircraft. Without water injection the engines are capable of being operated to the following take-off ratings: 510 dry (normal thrust).
511 dry (for use when operationally necessary).

The 511 dry rating gives approximately 4 per cent more thrust than the 510 dry rating.

The nose undercarriage is fitted with two wheels each with a single tyre. Each main undercarriage unit is equipped with two twin-tyred wheels mounted on a common axle. The anti-skid braking system fitted to the aircraft is basically mechanical. Maxaret anti-skid units are fitted to the multi plate disc brakes on each main wheel. Each unit consists of a valve assembly regulated by a spring-loaded fly wheel housed in a shell, which is rotated by direct contact with a track on its wheel, and hence acquires a store of kinetic energy. When the units are 'spun up' and the brakes are continuously applied a higher than normal deceleration of the main wheels such as may occur in an incipient skid results in an inertial movement of the unit fly wheels causing the valve assemblies to operate and release the brake pressures for an interval of time which at 4000 units rpm is 2.8 to 4.0 seconds. As the units are dependent on main wheel speed for their kinetic energy a lower main wheel speed reduces the interval of time during which brake pressures are released. In the 'dynamic aquaplaning' case when it is likely that the main wheels would stop rotating, the anti skid units would lose kinetic energy and if aquaplaning persisted would 'run down'. Brake pressures would then be re-applied locking the mainwheels until such time as the brake pressures were released, by pilot action in the flight deck. A handlever on the centre control pedestal in the flight deck permits selection of either the anti-skid (normal) or emergency braking systems. Differential wheel braking can be applied with either system selected by operation of the toe pedals on the Commander's and/or the Co-pilot's rudder controls.

The aircraft has two doors on each side of the fuselage, front and midships passenger entry/exit doors on the left side, and front and midships emergency exit doors on the right side. An escape slide is stowed in an underfloor compartment adjacent to each door. Two overwing window emergency exits are provided on each side of the fuselage.

There are two galleys in front of the passenger cabin one with athwartships loading facilities opposite the front emergency exit door and the second adjacent to the door itself. Food containers may be stowed in individual compartments in both galleys. The containers are retained within their compartments by a single blade catch at the top of the compartment and the lower forward lip of the compartment. The food container doors are secured in the closed position by their own catches. The door of an oven unit fitted in the galley with athwartships loading facilities is secured by a fixed latching bar and spring loaded catch.

1.6.2 *General Information and Maintenance*

The aircraft was manufactured in the United Kingdom in 1968 and was registered in that country in the name of Northeast Airlines Ltd - a division of British Airways. It had a valid Certificate of Airworthiness in the Transport Category (Passenger). The last Certificate of Maintenance was issued on 4 September 1975 and was valid for 300 hours or a period of three months whichever was the sooner. Since the last maintenance check the aircraft had flown 68 hours 56 minutes. At the time of the accident it had flown a total of 12,892 hours 17 minutes including 3,008 hours 31 minutes since the Certificate of Airworthiness was last renewed.

1.6.3 *Weight and Balance*

The Regulated Take-off Weight shown in the Operations Manual for Runway 28 at Bilbao in zero wind, temperature + 12°C and 23° flap was 54,850 kgs. The aircraft weight at take-off as shown on the loadsheet was 53,132 kgs. Its centre of gravity was calculated to be slightly forward of the mid-range (12.26 per cent SMC).

1.7 Meteorological Information

Meteorological records at Bilbao Airport show that 21.6 mm of rain fell between 2235 hrs on 14 September 1975 and 0605 hrs on 15 September 1975.

From 0627 hrs to 1348 hrs on 15 September 1975 a further rainfall of 7.0 mm was recorded. 3.8 mm fell between 1230 hrs and 1348 hrs, on average a moderate to heavy rainfall for this period of time during which the Trident was on the ground at Bilbao.

The take-off forecast provided to the crew by the Bilbao Meteorological Office was: Surface wind – calm, temperature + 12°C, QNH 1014 mbs.

The weather observation for Bilbao Airport at 1320 hrs included in part the following:

Surface wind – calm
Weather – slight rain shower
Visibility – 7 kms
Temperature – + 12°C
QNH – 1014 mbs

At 1346 hrs the Tower Controller passed the surface wind as 220/04 knots to the aircraft along with take-off clearance. According to the Commander and the First Officer light rain was falling as the take-off run commenced.

The accident occured in daylight in reasonably good visibility.

1.8 Navigation Aids

Not relevant.

1.9 Communications

Satisfactory communications were maintained between the aircraft and Bilbao Tower on RTF 118.5 MHz until the accident occurred. The Tower Controller attempted to contact the aircraft on RTF immediately after the accident but was unsuccessful. The frequency was recorded on tape for the relevant period and was subsequently transcribed. Examination of the transcript revealed that the Commander had not asked for information on the runway state.

1.10 Aerodrome and Ground Facilities

Bilbao Airport is at an elevation of 40.2 metres (132 feet) amsl and has one asphalt surfaced runway 10/28 from which the aircraft was taking off to the west. Runway 28 is 2,000 metres long x 45 metres wide with 5 metres of asphalt covered hard shoulder at each side and with an additional 55.3 metres of asphalt covered stopway 45 metres in width at the end. A further 12 metres beyond the stopway end the ground drops sharply to a road. The ground immediately at the side of the hard shoulders is sparsely covered with grass and consists of heavy clay with limestone chippings just below the surface. A medium sized rock with its upper surface protruding slightly above ground level was evident at the left side of the runway 4 metres from the hard shoulder edge and 50 metres before the end. A taxiway from the parking apron on the south side of the airport provides the sole access to the runway at a position approximately 1,470 metres from Runway 28 threshold. This necessitates back-tracking to the take-off positions followed by a 180° turn before take-off.

The declared distances for Runway 28 were:

Take-off run available	– 2,000 metres (6,562 feet)
Emergency distance available	– 2,055 metres (6,742 feet)
Take-off distance available	– 2,055 metres (6,742 feet)

The overall gradient of the runway is 0.2 per cent down. Evidence from ground witnesses indicates that at the time of the accident the runway surface was wet, but the extent to which it was contaminated by pools of standing water is not known.

At 0845 hrs a HS 125 aircraft sustained flap and aileron damage due to standing water while landing on Runway 10. As a result the runway was examined by an employee of the operator some ten minutes later. He found a pool of standing water on the surface east of the taxiway intersection and south of the runway centre-line which he estimated to be 23 metres long, 2.75 metres wide with an average depth of 20 mm to 30 mm. Beyond this pool towards Runway 28 threshold he observed some other pools of water. Later that morning an airport official inspected the section of runway concerned and found a depression in the surface equidistant from both thresholds south of the centre-line which was approximately 20 metres long, 4 to 5 metres wide and 25 mm deep. An inspection of the runway throughout its length on 11 October 1975, a day of heavy rain, revealed that a pool of standing water had formed in the area between 900 metres and 1,050 metres along Runway 28, between and at an angle to the runway centre-line and the left hand edge. The pool was subsequently measured on 13 October 1975 at a time when its contents were considered to be stable, nine hours after rain had ceased, and was found to be 45 metres long, up to 5 metres wide with depths of 25 mm at several points and 35 mm at others. It was concluded from a survey made of the runway transverse profile covering the area between 930 metres and 1,030 metres along Runway 28 that the runway slope in this area did not comply with Recommendation 1.6.7 of ICAO Annex 14, Part III (see 1.17) and that it was possible for a pool of standing water to form of even greater dimensions than the one measured.

On 22 February 1976 measurements of the co-efficient of friction (μ) were taken on Runway 28 at specific distances each side of the runway centre-line by Mu-meter. The runway surface at the time was wet but the exact runway conditions were not recorded. The measured values were generally well in excess of 0.4 apart from those measured at positions 2.5 metres and 4 metres left of the centre-line and 1,070 metres along the runway when the respective values were below 0.2 and 0.3 approximately over very short distances.

1.11 Flight Recorder

1.11.1 General

The aircraft was equipped with a Plessey Davall PV710 flight data recorder which recorded the following mandatory flight parameters on steel wire: pitch attitude; indicated airspeed; magnetic heading; normal acceleration; pressure altitude; roll attitude. At the time of the accident the United Kingdom regulations specified engine power and flap position as mandatory parameters. However the operator had been granted exemption, valid until 30 September 1975, by the United Kingdom Civil Aviation Authority permitting operation of the aircraft without recording of these additional parameters.

The recorded indicated airspeed and altitude were fed from transducers within the flight data recorder. The remaining four recorded parameters were fed to the recorder from external sources.

The protected recorder cassette mounted in the tail of the aircraft aft of the rear pressure bulkhead was recovered undamaged. In order to assist the Spanish Accident Authorities in their investigation the recorder cassette was returned to the United Kingdom where it was replayed under supervision of the Accidents Investigation Branch and was found to have functioned correctly. The recorder airspeed transducer and both pilots' airspeed indicators were removed from the aircraft and returned to the United Kingdom for calibration. The results of these calibrations showed them to be within the manufacturers tolerances.

1.11.2 *Accuracy of Data*

Since the aircraft did not become airborne in this accident the only parameter used for analysis was recorded airspeed sampled once per second. The subsequent analysis confirmed the validity of this parameter apart from a few random excursions most probably due to pitot/static error or variations in surface wind strength.

1.11.3 *Analysis of Accident Flight Data*

An analysis of the recorded flight data was carried out by the United Kingdom Accidents Investigation Branch. The conclusions drawn from the analysis were as follows:

1. The acceleration to V_1 was in close agreement with the theoretical performance.

2. There is no evidence of marked or sustained reduction in acceleration up to V_1.

3. It is considered that action to abandon the take-off was taken at approximately 120 knots on the Commander's airspeed indicator, the reaction times being such that the decision to abort must have been made very close to V_1 of 117 knots.

4. The subsequent crew actions in braking, selecting reverse thrust, airbrakes and lift dumpers were better than the flight manual times.

5. The deceleration phase of the accelerate/stop performance was below that to be expected due to the low effective braking coefficient of friction, attributable to a very wet runway surface.

6. With this poor braking performance if the Commander had not turned the aircraft off the runway it would not have stopped in the remaining distance but would have gone off the end of the runway at between 40 and 50 knots and off the end of the stopway at between 30 and 40 knots.

1.12 Wreckage

1.12.1 *Runway and Ground Markings*

The aircraft's movement over the ground and its change of heading during the aborted take-off run were determined from measurements taken of tracks made both on and off the runway by the mainwheels and nosewheels (see Appendix 2).

Continuous scald markings produced on the runway by the mainwheel tyres under braking application first became apparent 835 metres before the end of Runway 28 and for the first 585 metres of their length contained intermittent rubber scuff marks corresponding to the mainwheel tyre shoulder positions. Both right and left main undercarriages struck an isolated buried rock during the short sideways slide to the right after the aircraft left the runway.

1.12.2 *Examination of the Aircraft*

The aircraft could not be examined at the accident site as it was obstructing the runway. Photographic evidence showed that it had come to a halt resting on its left main undercarriage, nose undercarriage, fuselage and right wing, with the rear fuselage overhanging the runway, the airbrakes and lift dumpers extended fully, the leading edge slats out and the flaps extended to 23^{o}. During an inspection of the accident site a section of the left undercarriage inboard wheel rim was found adjacent to the rock aforementioned.

As far as could be ascertained from an examination made after its removal from the accident site damage sustained by the aircraft during the accident was as follows:

The impact of the right undercarriage with the buried rock imparted an excessive side loading to its side stay stabilising linkage which fractured. The undercarriage then collapsed inwards pulling the oleo air head from the oleo assembly. During the collapse both tyres on the inboard wheel ruptured (on impact with*) the undercarriage door structure and the inboard wheel fractured the centre fuel tank which at the time contained 300 kgs of aviation kerosene. Both tyres on the left undercarriage inboard wheel ruptured on impact with the buried rock. The right wing tip, right outer wing skin panel and outer wing rib were damaged by ground contact after the right undercarriage collapsed.

Slight rubber reversion was found on the shoulders of all mainwheel tyres. An area of wet scuffing with rubber reversion over the full footprint with heavy diagonal scoring across the scuffed area was found on each mainwheel tyre. Small areas of rubber reversion and heavy transverse score marks were found on both nosewheel tyres. The brake handlever in the flight deck was found selected to anti-skid (normal).

Examination of the engines revealed evidence of ingestion damage on the first stage LP compressor blades of both pod engines.

The reverse thrust unit clam shell doors of these engines were found in the closed (reverse thrust) position. The centre engine appeared to be undamaged.

Catering equipment was removed from the aircraft after the accident and before an examination of the galleys could be made. As far as could be ascertained catering items dislodged from stowage during the accident came from the galley opposite the forward emergency exit door and included food containers, the oven unit liner and their contents. All retaining catches on the food container stowage compartments in the galley operated satisfactorily when examined. Attempts to dislodge a container from its compartment whilst the retaining catch was applied were unsuccessful and it was impossible to force open the container door by hand snatch loads. It is considered therefore that displacement of the food containers from stowage had resulted from their retaining catches not being correctly applied. The oven unit door was found to be ineffective due to a deflection of the fixed latching bar which had occurred over a period of time. The door was found to spring open when the unit was jolted and it is considered that this is what occurred during the accident.

With the approval of the Spanish Accident Investigation Authorities the engines, engine instruments, and the undercarriage complete with wheels, tyre and brake assemblies were removed from the aircraft and sent to the United Kingdom for examination, testing or calibration as applicable. The results were as follows:

*not in original Spanish report.

Engines:

A detailed survey was carried out on all three engines. The centre engine was found to be undamaged. Slight ingestion damage on the pod engines was confined to the first stage LP compressor blades and is considered to have been caused by gravel, an indication that these engines were rotating at high rpm when the aircraft left the runway. Some dressing out of the damaged compressor blades was carried out and subsequently all three engines were subjected to test bed performance checks (see 1.16).

Engine Instruments:

The HP and LP tachometers, thrust indicator gauges and turbine gas temperature gauges were calibrated and found to be within the manufacturer's permitted tolerances.

Tyres:

In the opinion of experts the rubber reversion around the shoulders of all mainwheel tyres was consistent with the anti-skid (normal) braking system operating on a wet surface. The reverted rubber of the foot-print on each of these tyres had been produced when the wheels locked as the aircraft changed direction shortly before it left the runway. The score marks evident on each foot-print were superimposed during a slide across unprepared ground. Damage to both nosewheel tyres was produced by sliding across unprepared ground.

It is considered that the rubber reversion around the shoulders of the mainwheel tyres and the intermittent rubber scuff marks evident within the scald markings on the runway indicate a low co-efficient of friction had existed between the tyres and the runway surface during the period of braking. This had resulted in "Viscous Skidding" between the mainwheel tyres and the runway surface. There was no evidence that "Dynamic Aquaplaning" had occurred.

Brake Assemblies:

All four brake units and heat packs were stripped and examined. Apart from some impact damage to the right brake units the brakes had had little wear and were in satisfactory condition.

The right undercarriage outer wheel "Maxaret" unit was damaged during the collapse and could not be tested. A strip examination of the unit revealed no evidence of malfunction prior to the damage being sustained. The three remaining "Maxaret" units were tested (see 1.16).

1.13 Medical and Pathological Information

Not applicable.

1.14 Fire

There was no fire.

1.15 Survival Aspects

The passengers had been briefed and asked to read the safety instructions before take-off. All passengers and crew were correctly strapped in.

The passengers and cabin attendants lap straps and the flight deck crew full safety harnesses remained intact during the accident.

There was no warning of the emergency so the passengers could not be prepared for the evacuation. Most passengers evacuated the aircraft by slide from the two main doors and the midships emergency exit door but about twelve left through the foremost right overwing emergency exit. Some delays occurred due to language difficulties and attempts by a few passengers to retrieve their hand baggage. The extent to which the evacuation was hampered by the inaccessibility of the forward emergency exit door and slide could not be determined. All passengers had been evacuated without injury some three to three and one half minutes after the aircraft came to rest.

1.16 Tests and Research

1.16.1 Engines

During test bed runs a full set of performance readings was taken from each engine and compared with those obtained at its last previous test bed performance check. Changes in performance were small on all engines and were considered to be commensurate with the installed engine life.

1.16.2 Maxaret (anti-skid) Units

The units from the left undercarriage mainwheels functioned perfectly on test. The 'run on' time of the right undercarriage inboard wheel unit was found to be 2.1 seconds, very close to the permitted limits of 2.8 to 4.0 seconds. Examination of the unit revealed that this was due to compression of the casing sustained during the accident.

1.16.3 Brake Cooling Fan Motors

All four cooling fan motors functioned satisfactorily on test.

1.17 Other Information

1.17.1 Take-off from Contaminated Runways - Puddles

British Airways, Northeast Division Operations Manual, Volume II, Ice and Rain Protection section (e) contains the following information:

"Observe the limitation and procedures described below.

> PUDDLES Less than 12mm deep and 6m (20 ft) long on the intended take-off run:
>
> Treat as normal wet runway
>
> 1 Use wet V_1.
> 2 Select Engine anticing On if OAT below + 10°C.
> 3 Select Relight switches On.
> 4 Use wet runway crosswind component.
> 5 Select Airframe anticing On at 400 ft if OAT below + 10°C.

PUDDLES 12mm to 20mm deep or exceeding 6m (20 ft) long on the intended take-off run:

Take-off at Captain's discretion.

NOTE: Consider particularly the number and position on the runway in relation to the intended take-off run; the consequences of encountering pools of excessive depth can be particularly serious when this occurs during the later stages of the take-off run. If necessary consider accepting a small tailwind component in the opposite take-off direction.

1 Lift dump must be serviceable.
2 Wheelbrake system must be fully serviceable.
3 Both thrust reversers must be serviceable.
4 Use wet V_1.
5 Select Engine anticing On if OAT below + 10°C
6 Select Relight switches On.
7 Do not make a rolling start.
8 Use 511 power rating on all engines.
9 Use the skimming technique. (Max crosswind component 15 kt).
10 Select Airframe anticing On at 400 ft if OAT below + 10°C.
11 Request visual engine compressor check before next flight.

PUDDLES More than 20mm deep of any length on the intended take-off run:

Do not take-off. There is a risk of engine malfunction due to water ingestion."

1.17.2 *Extracts from Operations Manual, Standard Operating Procedures*

"1.5 PRE-START BRIEFING

Before the first take-off and with each change of First Officer/Flight Engineer the Captain will carry out a take-off briefing which must include the following:-

1 P2 and Flight Engineer to monitor instruments and report any malfunction.

2 P2 to call out on take-off run:-

a) Power 100%
b) 80 Kts
c) 100 Kts
d) V_1 and V_R

3 Conditions for which take-off will be abandoned

a) Up to 100 Kts .... at the Captain's discretion and on his command.
b) 100 Kts to V_1 .... only for Engine Fire or Engine Failure.

For either of these two failures any crew member will call "Abandon".

NOTE: In this context Engine Failure means a significant loss of thrust supported by falling HPRPM and falling or rising TGT.

4 Drill to be carried out in event of failure before V_1.

On the call "Abandon" -

Captain will:-

a) Apply brakes
b) Select lift dump
c) Bring the aircraft to a standstill and call for the required drill.

P2 will:-

a) Close all throttles
b) Select reverse idle on both engines
c) Select emergency reverse on the good engine(s).

Flight Engineer will call and check:-

a) Lift dump selected
b) Brake pressure

P2/Flight Engineer will carry out the required drill called for by the Captain.

5 Drill to be carried out in the event of failure after V_1.

a) P2/Flight Engineer will report any malfunction.
b) P2 will advance throttles to full power if an engine fails.
c) When established in the climb with the undercarriage retracted, Captain and crew will confirm the failure and P2/Flight Engineer will carry out the required drill called for by the Captain.

6 Power setting and ice protection to be used.

7 Any special points regarding departure routing and terrain clearances.

8 Any special points (other than item 6) dictated by ambient conditions.

NOTE: It is Company Policy that all the flight deck crew are aware of any malfunction before the relevant drill is carried out.

On each subsequent departure with the same crew, items 1 to 5 inclusive may be cleared by the term "standard briefing", providing that the Captain is satisfied that the crew is fully conversant with the procedures."

"1.27 **ALLOCATION OF DUTIES**

1.27.8 *Abandoned Take-off*

If it becomes necessary to abandon the take-off, the operative call is "Abandon" from any crew member.

Captain, on receipt of the order "Abandon", will:
a) apply full brakes and select LIFT DUMP
b) keep the aircraft straight
c) call for required drill when aircraft has stopped.

P2 will:
a) close the throttles
b) select and apply Emergency Reverse thrust on operative engines.
c) deal with the emergency after the aircraft has stopped.

F/E will check brake pressures and lift dump selected. When stopped he will call out the appropriate emergency drill and operate the systems station as required."

1.17.3 *Extract from Aircraft Flight Manual, Section 5, Page 39.*

"If the decision is made to abandon a take-off, all three throttles should be closed immediately and the two outer reverse thrust levers selected to emergency reverse thrust. Wheel braking should commence immediately and the airbrakes and lift dumpers should be selected out. Reverse idle should normally be selected at 60 knots but power may be maintained at emergency reverse rpm in marginal conditions until the aeroplane comes to rest. In the event of either pod engine being inoperative emergency reverse should be selected on the operative engine and this may be maintained if necessary until the aeroplane comes to rest.

Allowance is made for the use of reverse thrust in the scheduled emergency distances."

1.17.4 *Decision Speed (V_1)*

When calculating an aircraft accelerate/stop performance for a given runway in accordance with British Civil Airworthiness Requirements, a take-off decision speed (V_1) must be selected such that after failure of the critical engine at the power unit failure point associated with the V_1 (slightly earlier than the V_1) the aircraft can be stopped within the Emergency Distance Available (EDA). Values of V_1 are defined appropriate to both a dry runway surface and a reference wet runway surface (sic*). In both cases the gross distances required must not exceed the EDA. The V_1 must lie between the minimum control speed on or near the ground (V_{MCG}) and the rotation speed (V_R). It is at the discretion of the applicant (normally the aircraft manufacturer) whether the V_1 for given conditions is a single speed or whether a choice of speeds is provided.

A choice of V_1 is allowed so that the maximum value may be selected according to the available Take-off Run, Take-off Distance and Emergency Distance. Any V_1 allowed by the scheduled performance will be such that the Take-off Field Length and Emergency Distance requirements are met.

In this accident the maximum value of Wet V_1 that could have been used as determined from the aircraft Flight Manual was 122 knots flight deck Indicated Air-Speed (IAS) uncorrected for instrument error. The corrected Air-Speed Indicated Readings (ASIR) would have been Commander's ASIR - 120 knots, Co-pilot's ASIR 121 knots.

1.17.5 *Runway Physical Characteristics*

The ICAO Annex 14, Part III, Para 1.6.7 relates to transverse slopes on runways and recommends in part the following;

*should read wet hard runway surface

> "To promote the most rapid drainage of water, the transverse slope of a runway shall be as steep as is compatible with the handling characteristics of the aeroplanes the runway is intended to serve and should not exceed:
>
> 1.5 per cent where the runway code letter is A, B or C."

The code letter for Runway 28 Bilbao is B.

2. Analysis

2.1 As the accident followed an aborted take-off and no evidence was found of any pre-crash defect or malfunction of the aircraft as a causal factor, this analysis is concerned with the reasons why the take-off was abandoned and why the aircraft subsequently left the paved area of the runway.

2.1.1 *Weather*

The only significant factor of the weather at Bilbao at the time of the accident was the precipitation which had occurred and its effect on the runway conditions. The amount of rain that had fallen prior to the aircraft's departure will have been noted from Part 1 of the Report. The pilots did not notice any standing water on the runway when landing from the outbound flight. However, unbeknown to them approximately four hours earlier standing water had been present sufficient to cause damage to a HS 125 aircraft and necessitate an inspection of a section of the runway by a representative of the operator and an airfield official. Some weather details were included in the airfield information obtained by the Commander before briefing his crew. If he was in doubt about the runway conditions it would have been prudent to request further information. The fact that he did not indicates that at this stage he considered the conditions satisfactory for the intended take-off.

2.1.2 *Pre-flight Planning*

As far as can be determined the pre-flight planning was carried out correctly. The full take-off briefing given at London, which still applied, was supplemented by the Commander prior to start-up to cover local conditions. The runway length, surface wind and ambient temperature were well within the operating envelope of the aircraft at the actual take-off weight and the take-off data extracted including the decision speed was substantially correct.

2.1.3 *Runway Conditions*

The Commander had little information available on the runway conditions when the aircraft taxied out from the parking apron. However, before entering the runway his attention was drawn to the considerable amount of spray thrown up by the Caravelle aircraft on landing and he had the opportunity of assessing the amount of standing water on the runway when he backtracked over approximately three quarters of its length including the area in which the aircraft would normally have become airborne. While accepting that it is difficult to assess the depth and extent of standing water on a runway from the flight deck of a Trident, had the Commander been uncertain about the runway state he could either have requested the Tower for further information or amended his take-off briefing to the crew. This he did not do.

2.1.4 *Flight Recorder*

Analysis of the flight recorder airspeed data revealed no marked or sustained reduction in acceleration up to V_1. However it is possible because of the airspeed sampling rate that a momentary reduction in acceleration would not be recorded but would be noticed by the crew.

The effective braking co-efficient of friction achieved by the aircraft during the deceleration phase was so low that if the aircraft had continued on the runway it would not have stopped within the confines of the paved area and would have run off the end of the stopway at 30 knots to 40 knots.

2.1.5 *Accelerate/Stop performance*

2.1.5.1 Acceleration

There is no evidence that the performance of the aircraft was substandard up to the time it attained V_1. However at this speed, according to the Commander he experienced what he described as 'a marked deceleration compatible with a loss of engine power' and reacted by immediately closing the throttles. This was imprudent as the evidence indicates no engine malfunction had occurred, and the supposedly 'marked deceleration' he experienced was probably no more than a momentary reduction in the rate of acceleration caused by the aircraft's entry into standing water. Moreover there is no evidence to indicate the aircraft would not have got safely airborne had the take-off been continued.

2.1.5.2 Deceleration

The analysis of the Flight Recorder Data indicates that the decision to abandon the take-off was made at or close to Wet V_1 (117 knots) an airspeed at which theoretically it should have been possible to bring the aircraft to a halt within the Emergency Distance Available and was 5 knots lower than the maximum value of Wet V_1 which could have been used. The evidence indicates that the crew activated all the systems for stopping the aircraft within the flight manual times. However if the Commander had continued along the runway he could not have stopped (the aircraft) within the paved area and it was in the face of this possibility that he applied control inputs to turn it off the runway.

It is necessary therefore to examine the factors which affected the performance of the aircraft after the take-off had been abandoned.

When the wheel brakes were applied the aircraft speed and the probable conditions on the runway were such that dynamic aquaplaning could have occurred, and the satisfactory deceleration first experienced by the crew, which quickly deteriorated, was compatible with its onset. However in the opinion of experts damage sustained by the tyres and the intermittent rubber scuff marks on the runway are not attributable to dynamic aquaplaning. Had this occurred and persisted the mainwheels would have stopped rotating, the anti-skid units would have 'run down' and the wheels would have locked under brake pressure, remaining locked as long as the brakes were applied. It is considered that directional control problems would then have arisen. Moreover it is possible that tyre bursts would have occurred while the aircraft was travelling along the runway with the mainwheels locked exacerbating any control problems. There is no evidence that such problems arose.

The calculated accelerate/stop distance of the aircraft on a wet runway as given in the Flight Manual is based on a conservative estimate of the runway braking co-efficient of friction likely to be experienced in practice. The evidence in 1.11 and 1.12 indicates that the effective braking co-efficient of friction achieved by the aircraft during the deceleration phase was considerably lower than the value used to calculate the accelerate/stop distance. The serviceability of the tyres, brake units and anti-skid system is not in doubt.

The only other factor that could have affected the braking co-efficient of friction was the amount of water on the runway and it is apparent from this that the runway surface must have been at least very wet.

The resultant degradation of the aircraft's stopping performance was such that had the Commander not turned the aircraft off the runway it would not have stopped within the paved area available. However it is considered that once the aircraft had left the runway its subsequent progress was beyond the Commander's control.

Had the aircraft continued off the end of the stopway there can be little doubt that the consequences to the occupants would have been disastrous.

2.1.6 *Other Factors*

At the time the take-off commenced the Commander was unaware of the extent and depth of standing water on the runway. This was due in part to his not seeking further information and in part due to Air Traffic Control not passing any information they had. Although they may not have had precise information on the runway conditions they should have been aware of the circumstances in which the HS 125 aircraft accident occurred.

Nevertheless in the absence of detailed information about the runway conditions it would have been a more prudent decision by the Commander to carry out the take-off using the 511 power rating and nose wheel skimming technique. The use of this power rating would have meant a reduction in the take-off run, the aircraft would have encountered the standing water at a slightly higher speed and the use of the skimming technique might have avoided or reduced the sensation which he experienced. However it is a matter of conjecture whether these measures would have prevented the accident.

2.1.7 *Evacuation*

In this accident the inaccessibility of the forward right emergency exit was by chance not critical. In more extreme circumstances its inaccessibility could have resulted in injury or even a loss of life to the aircraft occupants.

3. Conclusions

(a) *Findings*

(i) The crew were properly licensed and adequately experienced to make the flight.

(ii) The aircraft had been maintained in accordance with an approved maintenance schedule and its Certificates of Airworthiness and Maintenance were valid.

(iii) The weight of the aircraft and its centre of gravity were within the prescribed limits.

(iv) The Commander attempted a take-off on Runway 28 at Bilbao which at the time was wet and contaminated with standing water.

(v) The Commander was unaware of the extent and depth of the water contamination at the time of attempted take-off.

(vi) The aircraft entered an area of standing water on the take-off run at V_1 117 knots.

(vii) The Commander abandoned the take-off at or very close to V_1 when he experienced what he described as a marked deceleration. This was probably a momentary reduction in acceleration caused by the aircraft's entry into standing water.

(viii) The take-off would have been successful had it not been abandoned.

(ix) There was no evidence of any pre-crash failures in the aircraft, its engines or braking systems.

(x) The crew activated all the systems available for stopping the aircraft within the Flight Manual scheduled times.

(xi) The effective braking co-efficient of friction achieved by the aircraft during the deceleration phase of the abandoned take-off was considerably lower than that used in Flight Manual calculations of the aircraft accelerate/stop distance on a wet runway.

(xii) The low effective braking co-efficient of friction achieved by the aircraft was attributable to a very wet runway surface.

(xiii) Because of the low effective co-efficient of braking achieved the aircraft could not have been brought to a stop within the remaining runway and stopway distance available.

(xiv) Had the Commander not turned the aircraft off the runway before it reached the end of the paved surface the consequences to the occupants might have been disastrous.

(xv) The aircraft's progress after it left the runway was beyond the Commander's control.

(b) *Cause*

The accident was caused by the Commander's decision to abandon take-off on a wet runway at or close to V_1. Contributory factors were the low effective braking co-efficient of friction achieved by the aircraft and the failure of the Commander to ascertain the extent and depth of water present on the runway prior to take-off.