ACCIDENTS INVESTIGATION BRANCH
Department of Trade and Industry

HS 125 Series 3B G–AXPS
Report on the accident at Turnhouse Airport Edinburgh on 20 July 1970

LONDON: HER MAJESTY'S STATIONERY OFFICE
1972

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SBN 11 510814 1

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Accidents Investigation Branch
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18 February 1972

The Rt Honourable John Davies MBE MP
Secretary of State for Trade and Industry

Sir

I have the honour to submit the report by Mr N S Head, an Inspector of Accidents, on the circumstances of the accident to HS 125 Series 3B, G–AXPS which occurred at Turnhouse Airport, Edinburgh, on 20 July 1970.

I have the honour to be
Sir
Your obedient Servant

V A M Hunt
Chief Inspector of Accidents

Accidents Investigation Branch
Civil Accident Report No EW/C 352

Aircraft:	HS 125 Series 3B G–AXPS
Engines:	Two Rolls Royce Viper 522
Owner and Operator:	Imperial Tobacco Co Ltd
Crew:	Captain P Nethercot – Injured Captain B A I'Anson – Killed
Passengers:	None
Place of Accident:	Turnhouse Airport, Edinburgh
Date and Time:	20 July 1970 at 1729 hrs
	All times in this report are GMT.

Summary

During take-off from Turnhouse Airport on a training exercise an engine failure was simulated with the rudder bias system switched 'OFF'. The aircraft yawed and developed a high rate of roll to port; the port wing collided with the ground and the aircraft slithered across the aerodrome and caught fire.

Captain B A I'Anson, who was the pilot under training, was killed and the commander, Captain P Nethercot, was injured. The aircraft was destroyed.

The accident resulted from the application of incorrect rudder following a simulated engine failure on take-off. The reason for this application of incorrect rudder has not been determined.

1. Investigation

1.1 History of the flight

On the day of the accident the aircraft, which was owned by the Imperial Tobacco Company and operated by them for the conveyance of company personnel, left Bristol under the command of the company's chief pilot for a flight to Edinburgh via East Midlands Airport. After conveying passengers to Edinburgh it was scheduled to position empty at Newcastle Airport to collect passengers for Bristol. Weather briefing had been obtained and a through flight plan covering the outward and return flights had been filed before the aircraft left Bristol in the morning. As there were no passengers on the flight from Edinburgh to Newcastle, Captain Nethercot decided to make use of this sector to continue Captain I'Anson's training for command of the HS 125. Accordingly, Captain I'Anson was flying the aircraft from the left hand seat. Prior to take-off he was briefed by Captain Nethercot that a failure of one of the engines (he was not told which one), would be simulated on take-off and for the purpose of the exercise the rudder bias system would be switched 'OFF'. Captain I'Anson indicated that he had heard and understood the briefing.

Prior to take-off all the aircraft's flying and auxiliary controls had been checked and found serviceable. The pilots decided that no flap would be used for the take-off which was started from the end of Runway 13. The point where the aircraft became airborne was approximately 2,700 feet from the start of the roll, which was normal for the aircraft's weight and configuration, with both engines operating. According to Captain Nethercot he called 'rotate' at approximately 120 knots, which was slightly faster than the calculated figure and when the aircraft had reached a height of approximately 12 feet and had accelerated to about 130 knots, he pulled back the thrust lever of the port engine to simulate a failure. He considered that Captain I'Anson's reaction to the emergency was slow and was just about to apply right rudder to counteract the yaw when Captain I'Anson applied considerable force to the left rudder and locked his leg in position. According to his statement, Captain Nethercot immediately applied full right aileron and opened the port thrust lever but he was unable to prevent a high rate of roll developing to the left. Approximately 700 feet after the point where the aircraft became airborne the port wing tip struck the runway, fracturing the port fuel tank and spilling out fuel. The aircraft left the runway at an angle of approximately 30° to the left and travelled across the grass, becoming partially inverted before settling back sideways on the ground on its undercarriage.

The sideways movement of the aircraft pulled off the nose gear and the aircraft then gyrated across the airfield sustaining further structural damage before coming to rest on its main wheels and tail facing approximately in the opposite direction to the direction of take-off. During the aircraft's gyrations on the ground, fuel, which was centrifuged out of the fractured port tank, ignited and a flash fire occurred. When the aircraft finally came to rest there was a small residual fire in the port wing which was very quickly extinguished by the airport fire service.

Both the pilots were trapped in the wreckage. Captain Nethercot was released approximately 20 minutes after the accident but Captain I'Anson was not released for approximately 2½ hours and on arrival at hospital he was found to have died.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*
Fatal	1	–	–
Non-fatal	1	–	–
None	–	–	–

1.3 Damage to aircraft

The aircraft was destroyed except for the engines and certain system components which were salvaged.

1.4 Other damage

None.

1.5 Crew information

Captain Peter Nethercot, aged 37, held a current commercial pilot's licence endorsed for command of HS 125 aircraft. His last certificate of test in the HS 125 was dated 31 October 1969 and his last medical examination was on 9 June 1970. At the time of the accident his total flying experience was 5,192 hours, of which 429 hours were in command of the HS 125. He had flown 52 hours during the 26 days preceding the accident and had 2 days off prior to this flight. He did not hold a flying instructor's rating but had successfully completed a Type Rating Examiner's flight test on the HS 125 in July 1970.

Captain Brian Alan I'Anson, was 40 years of age. He had a current commercial pilot's licence but this was not endorsed for HS 125 aircraft. His last medical examination was on 20 April 1970. At the time of the accident his total flying was 4,594 hours. This included 390 hours on multi jet-engined aircraft in the RAF, mainly prior to 1954, and 144 hours as co-pilot on the HS 125. In addition, he had completed 12 hours training for command on that aircraft. During the 28 days preceding the accident he had flown for 49 hours and had had 2 days off duty prior to the subject flight.

According to Captain I'Anson's flying records he had completed checks on Aztec and Dove aircraft in October 1969 and on the Beagle 206 in May 1970. These checks included engine failures after take-off and single engined landings and overshoots. All were completed satisfactorily. Approximately one month before the subject flight Captain I'Anson had carried out a practice engine failure during take-off on the HS 125 with the rudder bias switched 'OFF'. This also was at Edinburgh with the same commander, who considered that Captain I'Anson's reaction to the emergency was slow and therefore the exercise was to be repeated.

1.6 Aircraft information

1.6.1 *General*

The aircraft was constructed in 1961 and exported to Switzerland. In 1969 it returned to the United Kingdom and was then inspected by the manufacturer and issued with a transport category (passenger) certificate of airworthiness valid until November 1970. It had been maintained in accordance with an approved maintenance schedule. All mandatory modifications had been carried out and no significant defects were noted in the technical records. The aircraft had flown for a total of 1,782 hours including 105 hours since the last routine inspection.

The port engine, Viper 522, was constructed in 1966. It was installed in the aircraft on 25 April 1970. Its total running time amounted to 1,874 hours.

The starboard engine, Viper 522, was constructed in 1964. It was installed in the subject aircraft in November 1969. Its total running time amounted to 858 hours.

Prior to take-off at Edinburgh on the day of the accident the aircraft had been re-fuelled to capacity. It is estimated that its weight at take-off was 19,700 lb and that its centre of gravity was within prescribed limits.

1.6.2 *Rudder bias system*

In order to reduce the foot loads and assist the pilot in controlling the aircraft during flight on one engine an automatic rudder bias system is installed in the HS 125. Air is taken from the compressor stage of each engine and fed on to the respective sides of a free moving piston which is connected to the rudder. The system is so arranged that when it is in operation, loss of engine power and consequent loss of compressor air pressure on one side, causes the rudder to move against the engine providing the greater thrust to counteract the resulting yaw. As it is directly connected thereto, the rudder bar will also move whenever the rudder moves.

Although the flight manual specifies that the rudder bias must be switched 'ON' and checked prior to take-off, dispensation had been given to private operators to consider the rudder bias as an 'allowable deficiency'. Subject to certain conditions they were authorised to fly the aircraft with it switched off.

It was a requirement that any defect that made it necessary to switch the system off should be rectified at the first opportunity and in any case not later than the first return to a maintenance base or on the next 7 day Supplementary Check, whichever was the earlier.

In order to familiarise pilots with the handling characteristics of an engine failure and of flight on one engine with the rudder bias out of action, exercises were considered necessary. Since the accident the rudder bias system is no longer regarded as an allowable deficiency.

1.7 Meteorological information

The weather at the time of the accident was as follows:

Surface Wind:	320° less than 3 knots (Anemograph reading)
Visibility:	11 kilometres
Temperature:	11°C
QNH:	1001.5
Weather:	Intermittent light rain (fine at the time of accident)

Weather is not considered a factor in this accident.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Satisfactory radio communication had been established between the aircraft and Turnhouse tower.

1.10 Aerodrome and general facilities

(a) *Aerodrome*

The aircraft was taking-off from Runway 13 at Turnhouse which is asphalt surfaced, 1,955 metres in length and 50 metres wide. The elevation at the threshold is approximately 30 metres and there is negligible slope. Because of rain earlier in the day of the accident the runway surface was wet but there was no standing water.

(b) *Ground facilities (Fire and Rescue Services)*

The accident was witnessed by firemen on duty and before the aircraft came to a stop the crash alarm had been sounded. Airport fire service appliances and personnel arrived at the scene within 50 seconds and their prompt action, using dry powder extinguishant, brought the fire under control within approximately 5 seconds. The Scottish South-Eastern Fire Brigade, who had also been alerted, arrived at the scene about 15 minutes after the accident occurred. Both pilots were trapped in the wreckage and considerable difficulty was experienced in extricating them. This aspect is dealt with in detail in Appendix 2 to the report.

1.11 Flight recorder

There was no statutory requirement for a flight recorder and none was fitted.

1.12 Examination of the wreckage

Inspection of Runway 13 showed that the aircraft's port wing tip had first come into contact with the runway surface 48 feet to the left of the centre line and about 3,400 feet from the start of the take-off. The marks indicate that the aircraft then continued on to the grass, travelling on a heading of about 100°MAG, with the port wing firmly scraping along the ground. During this, progressive damage occurred to the wing, eventually rupturing the port fuel tank. Escaping fuel ignited causing a ground flash fire of moderate intensity. The aircraft came to rest 600 feet to the left of the runway centre line and marks on the ground showed that it had gyrated in a tail-down attitude through about one and a half revolutions during which the forward fuselage had become almost completely separated from the rest of the aircraft. The fire, which had further damaged the port outer wing had also scorched the port side of the fuselage. Inspection of the wreckage showed that the landing gear was locked 'DOWN', all the trim tabs were neutral, the airbrakes were closed and the flaps were near to the 'TAKE-OFF' setting. (The take-off was actually made with 'ZERO FLAP' and the partial movement DOWN must have occurred when the fuselage became damaged during the accident.) Markings on the port aileron mass balance horn found among the wreckage indicated that the port wing tip had struck the ground at a bank angle of approximately 50° and a sideslip angle of not more than 30° to port.

Both crew seat attachments were damaged and the stowed position of the shoulder harness straps suggested that they had not been used by the occupants. The left hand side of the cockpit had been pushed in forcing the port rudder pedals hard on to the centre console. This had locked both sets of pedals at a position consistent with about one quarter left rudder travel from neutral. On the centre console the guard over the rudder bias master switch was found to be lifted and the switch was in the 'OFF' position. Inspection of the rudder bias strut showed that the piston could move freely in its cyclinder and that its solenoid valve was electrically operable. No fractures or disconnections were found in the air supply lines to this unit. Neither engine revealed any evidence of pre-crash mechanical failure nor was there any evidence of any pre-crash mechanical failure or defect of the airframe or the flying controls.

1.13 Fire

Kerosene fuel, which was released from the port tank when the port wing struck the ground, was ignited most probably from the hot engine by contact or ingestion. A flash fire occurred which was fed by fuel ejected from the fractured tank while the aircraft was gyrating across the grass. When the aircraft came to rest a residual fuel fire in the outer section of the port wing was quickly put out by the airport fire service; hence the major fire damage to the aircraft was confined to this one area. (See Appendix 2.)

1.14 Survival aspects

The pilots were using lap straps only instead of the full shoulder harness which was fitted to the aircraft. Some of the shock loading at the first collision with the ground was absorbed by the progressive collapse of the port wing. The first major deceleration to which the pilots were subjected occurred as the aircraft swung around and travelled backwards along the ground and they therefore had the advantage of being bodily supported by their seat backs during the decelerative 'g' loading. However a certain amoung of bumping occurred as the aircraft changed direction and both pilots sustained head injuries. They became trapped in the wreckage when the lower nose section collapsed about their lower bodies and legs following loss of the nose gear. The forward part of the fuselage came to rest lying slightly on its port side. Captain Nethercot, who was in the right hand seat, was released within approximately 20 minutes but it was not possible to extricate Captain I'Anson until 2½ hours after the accident. Although he received medical attention throughout the whole of the rescue operation he was found to be dead on arrival at hospital.

1.15 Tests and research

The distance between lift-off and the point at which the port wing of the aircraft struck the runway is approximately 700 feet. Therefore, if the thrust lever of the port engine was pulled back exactly at lift-off, ie at about 120 knots, the time between the simulated engine failure and the wing making contact with the runway would have been 3.3 seconds. However, the evidence of the commander is that the failure was simulated when the aircraft had reached a height of about 10 feet and a speed of about 130 knots. On that evidence the time interval between engine failure and port wing tip ground contact reduces to 2.6 seconds. At a height of ten feet the angle of bank necessary to bring the wing tip in contact with the runway is 50°. This angle is also confirmed by the examination of the marks on the port aileron mass balance horn.

From data supplied by the manufacturer it has been possible to analyse, broadly, the behaviour of the aircraft following a simulated engine failure for various combinations of rudder and aileron applications with any assumed time delay. The data (Appendix 1) are estimates and should be regarded as the best possible approximation but are in agreement with flight experience.

Appendix 1 gives angles of bank that would be achieved in a given time, in seconds, resulting from the following separate actions. For a combination of two or more actions these effects are additive.

(i) Assume port engine has failed but no control movements are made. (Allowance has been made for engine thrust die-away characteristics).

(ii) Assume symmetrical engine power but application of 16° of aileron to lift the port wing. (According to flight test records, this aileron angle can be easily achieved.)

(iii) Assume symmetrical engine power but application of half rudder (11°) to port or to starboard.

(iv) Assume symmetrical engine power but application of full port rudder.

Using the graph, the aircraft's movements can be examined during the critical period following the simulated failure of the port engine.

It can be seen that if no action is taken and the controls are kept in a neutral position, in 2.6 seconds the aircraft will have rolled 18° to port. To increase the roll to 50° within this period of time, ie by 32°, it is necessary to apply the effect of full port rudder for 2.25 seconds. With the time scale applicable, this means the rudder would need to have been applied 0.35 seconds after the thrust lever was pulled back.

Whilst the graph shows that within the above time scale the application of even half port rudder produces a situation beyond control, it also shows that there is more than adequate control available if aileron or rudder are used promptly and in the correct sense.

1.16 Flight tests

During the investigation a flight was carried out in an HS 125 aircraft to see if any misleading cues could be detected during engine failure exercises with the rudder bias system switched off. The exercises were carried out at a height of approximately 6,000 feet. With the undercarriage down and flaps retracted the aircraft was climbed at full power at a speed of 125 knots. A pronounced yaw followed immediately a thrust lever was pulled back and if the yaw was not corrected a roll developed. No misleading cues or rudder trail were noticed whilst the aircraft was yawing.

2. Analysis and Conclusions

2.1 Analysis

From the evidence of the commander, which was available early in the investigation, it was known that the accident probably resulted from an application of rudder in the incorrect sense during an engine failure exercise with the rudder bias switched 'OFF'. Nevertheless, as a matter of routine the wreckage of the aircraft was subjected to a detailed examination; no evidence was found of any pre-crash failure or malfunction which could have been a factor in the accident. In addition whilst the calculations referred to in para 1.15 are based on rather imprecise data, ie the distance travelled to lift off and the height and speed the aircraft had attained when the failure was simulated, it is considered that they are accurate enough to show that the aircraft could not have rolled to the extent it did within the relevant period unless incorrect rudder had been applied. The calculations also show that the application of rudder was made almost at the same instant as the failure was simulated and consequently the commander was mistaken in his impression that Captain I'Anson was slow to respond; in the circumstances of the accident and bearing in mind the very short time that elapsed between the take-off and the crash, this mistaken impression is understandable.

When considering possible reasons for the incorrect rudder application attention was directed to the possibility that Captain I'Anson had been conditioned by his previous experience of the rudder bias system so that at least part of his identification of which engine had failed might have come from the automatic corrective movement of the rudder pedals. During the flight tests referred to in para 1.16 it was shown that whilst the aircraft is yawing during an engine failure exercise with the rudder bias switched 'OFF' any momentary trailing of the rudder towards the 'dead' engine which may occur is not detectable at the rudder bar. Consequently there does not appear to be any misleading cue from this source which could have led him into a mistaken identification.

In the HS 125 aircraft with the rudder bias inoperative the immediate effect of an engine failure at about V_2 is a pronounced yaw towards the failed engine and if this is not corrected a roll will develop. In this respect the aircraft's behaviour is similar to that of other twin engined types previously flown by Captain I'Anson and his check records show that he was competent in dealing with engine failure exercises on these types. From his briefing he knew the exercise would require very prompt firm action and, because there is evidence that he had been slow during previous practice in this exercise with the same commander, it is possible that at least part of his attention during the take-off was directed to making the identification as early as possible during the anticipated emergency.

Such a situation is by no means unusual and it is expert opinion that in such circumstances a pilot's ability may be appreciably reduced and, as is known to have happened on a number of occasions, it may lead to an attempt to anticipate the action which will be required. This has resulted in a pilot unconsciously programming himself for the 'failure' of one specific engine so that when in fact it is the other engine which has been 'failed' he has taken action based on his original programme and not on what has actually occurred. It is stressed that this can only be considered a possible reason in this accident to G–AXPS and whilst there is little doubt that incorrect rudder was applied the reason for that mistake cannot be established with certainty.

The possibility that the accident could have been prevented by more prompt action on the part of the aircraft commander has also been considered. Having carried out a considerable amount of flying with Captain I'Anson it is understandable that he did not anticipate that incorrect rudder would be applied. Although he was not a qualified flying instructor, he was qualified as a type rating examiner and bearing in mind the serious effect of incorrect or unduly delayed action at this stage of flight a greater degree of fault anticipation was required. On the other hand, the difficulty in dealing with sudden precipitate action by a pilot under training can be appreciated.

At the time of the accident the rudder bias system was regarded as an allowable deficiency. Consequently, for this reason, and also to cater for an occasion when the system might fail in flight, training was given in the handling of the aircraft with it switched off. With some degree of hindsight it appears that the need for this exercise, which led to the accident, can be questioned. The standard of reliability of both the rudder bias system and the engines is high and the likelihood of an engine failure occurring during the critical few seconds of take-off on an occasion when the bias system is inoperative is extremely remote. Training could well have been confined to cover failures en route; the behaviour of the aircraft during take-off could have been demonstrated at a safe height. It is understood that this is the practice followed by the manufacturer on their training programme for this aircraft.

The rescue and survival aspects of this investigation are dealt with in detail in Appendix 2, but the circumstances of the accident indicate that a supply of plasma available as part of an airport's first aid equipment might have been an advantage. Therefore, it is suggested that consideration should be given to this point. Reference is made in Appendix 2 to the efficient turn out of the airport fire service. Their prompt action and the effective use of dry powder extinguishant was instrumental in the rapid control of the fire and the rescue of Captain Nethercot.

2.2 Conclusions

(a) *Findings*

(i) The documentation of the aircraft was in order and its loading and centre of gravity were within prescribed limits.

(ii) The pilots were properly licensed.

(iii) There was no malfunction of the aircraft or its controls.

(iv) The rudder bias was switched 'OFF' for take-off.

(v) The flight was a training exercise during which the port engine was throttled back immediately after becoming airborne to simulate an engine failure.

(vi) After take-off the aircraft yawed and rolled to port and the port wing struck the ground approximately 3,400 feet from the point at which the take-off was started.

(vii) The wing tip struck the ground under the combined effects of asymmetric thrust and port rudder.

(b) *Cause*

The accident resulted from the application of incorrect rudder following a simulated engine failure on take-off. The reason for this has not been determined.

N S Head
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Accidents Investigation Branch
Department of Trade and Industry
February 1972