

Department of Trade

ACCIDENTS INVESTIGATION BRANCH

BAC One-Eleven Type 518 G-AXMG
Report on the accident at Stansted Airport,
Essex on 27 February 1978

LONDON

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8/77	British Airways Trident IE G-AVYD Bilbao Airport, Spain September 1975	December 1978
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Department of Trade
Accidents Investigation Branch
Kingsgate House
66-74 Victoria Street
London SW1E 6SJ

30 November 1978

The Rt Honourable John Smith MP
Secretary of State for Trade

Sir

I have the honour to submit the report by Mr P J Bardon, an Inspector of Accidents, on the circumstances of the accident to a BAC One-Eleven G-AXMG which occurred at Stansted Airport, Essex, on 27 February 1978.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch
Aircraft Accident Report No. 7/78
(EW/C615)

Operator: Monarch Airways Ltd

Aircraft: *Type:* BAC 1-11

Model: 518 FG

Nationality: United Kingdom

Registration: G-AXMG

Place of Accident: Stansted Airport, Essex, UK
51° 53' N 00° 14' E

Date and time of Accident: 1407 hrs on 27 February 1978

All times in this report are GMT

Synopsis

The accident was notified to the Accidents Investigation Branch by the Chief Officer of the Civil Aviation Authority at Stansted Airport at 1430 hrs on 27 February 1978.

The aircraft was on a training flight, by day, in good weather, and, as part of his conversion course on to the aircraft, a first officer was carrying out a flapless approach from the right hand seat. The commander was in the left hand seat and another trainee first officer occupied the supernumerary seat. On completion of the approach the aircraft landed with the landing gear retracted.

The report concludes that the commander, in his capacity as pilot not flying the aircraft, carried out the landing checks without lowering the landing gear. Neither of the other crew members noticed the omission, and no-one noted subsequent indications that the gear was not locked down.

The workload imposed on the commander by the training exercise, the lack of a flight deck procedure suited to training flights, and the crew's recent exposure to a number of irrelevant landing gear unsafe warnings during training exercises are considered to have been contributory factors.

1. Factual Information

1.1 History of the flight

The aircraft was engaged on initial conversion training for two first officers who had newly joined the company. The crew had reported for duty at 0830 hrs, and the aircraft left Luton for Stansted at 1016 hrs with only the three members of the crew on board. The commander was in the left hand seat, one first officer was in the right, and the other in the flight deck supernumerary position. The supernumerary first officer was not allocated duties, except in an emergency, and this was in accordance with the company's operations manual. The Stansted weather included some broken cloud at the desired circuit height of 2,000 ft QNH, corresponding to 1,650 ft QFE, but was otherwise good, with a steady wind of about 10 kts down Runway 23, the runway in use. The circuit direction was left-hand. After an uneventful detail that included a total of five landings, the crew stopped to refuel at 1208 hrs. In this interval the crew took light refreshments, and the two first officers changed seats for the second detail.

The aircraft took off again at 1305 hrs and began the second detail with an instrument approach, which ended in a missed approach procedure. A second instrument approach was followed by a full stop landing. At this point a cockpit voice recorder (CVR) record of the events on the flight deck became available and has been used together with the information from the flight data recorder (FDR) and the statements of the crew to compile the remainder of this narrative. During the next take-off the commander simulated an engine failure by closing No.1 throttle shortly after rotation. As the aircraft climbed away the commander raised the landing gear, and the warning horn, correctly indicating an unsafe condition of the landing gear, sounded for about three seconds. The subsequent single-engined circuit was followed by a 'touch and go' landing in which power was restored to both engines during the ground roll. As the aircraft accelerated through Decision Speed (VI) the commander simulated a different engine failure by throttling back No.2 engine. Once again, when the aircraft was airborne and the landing gear was selected up, the warning horn sounded for about five seconds.

The aircraft was then turned downwind, and the commander announced that the next landing would be flapless. It became necessary to adjust circuit height because of cloud, and this was done after ATC clearance had been obtained. The commander then asked the first officer to adjust his downwind heading to prevent the aircraft converging on the runway. After calculating the aircraft weight, the commander ascertained the appropriate speeds for a flapless circuit, and at the first officer's request reminded him of the procedures for a flapless landing. The required speeds were 154 knots at the threshold, 164 knots on finals, and 174 knots downwind. During this exercise, as on previous circuits, the commander wished the trainee to concentrate wholly on his flying, and therefore started the landing checks on his own initiative without waiting for them to be initiated by the pilot handling the aircraft. Also, at about this stage he restored power to No.2 engine.

During the previous circuit the CVR had recorded the sound of movements of the landing gear lever. The voice of the commander could also be heard going correctly through the check-list, and double-checking the position of the landing gear. No sounds of lever movement could be identified during the flapless circuit, but the commander's voice could be heard, starting the landing checks at the third item on the list, the brake anti-skid test; the first two items were the extension of the landing gear and the checking of the brakes. The anti-skid test showed the brake anti-skid test system to be inoperative. A second check of the system, and a re-setting of the circuit breakers by the supernumerary first officer produced a similar result. Considering that this failure was an acceptable one, the commander decided to continue the exercise. Shortly after the second anti-skid system check the IAS fell below 170 knots and the landing gear warning horn sounded for about four seconds. The commander responded to the warning by

pointing out to the first officer that his speed was too low; the first officer then increased power and the horn became silent. The FDR shows that the speed then rose to a mean value of 170 knots for the remainder of the downwind and base legs.

The aircraft was then turned on to its final approach. During the descent towards the threshold the speed again fell below 170 knots and the landing gear warning horn again sounded momentarily. The FDR shows that the rest of the approach was smoothly flown at a mean airspeed of 160 knots, and with very little throttle movement. No warning horn sounded at the flare, and the aircraft touched down with what seemed to the crew to be normal firmness, although the subsequent lowering of the nose was more rapid than usual. Vibration was felt throughout the flight deck accompanied by a considerable noise. The supernumerary crew member saw that the 'gear unsafe' red warning light was flickering. Believing a nose wheel tyre to have failed the commander gave instructions that the landing should be made a full stop, and accordingly extended the spoilers and applied reverse thrust, whilst the first officer applied the brakes. During the ground slide, the twin horns of the stall protection system began to sound and as the aircraft came to rest, smoke could be seen outside the flight deck windows. The time was then 1407 hrs. The supernumerary officer left his seat, opened the forward passenger door, and left the aircraft, taking a fire extinguisher with him. A short while later the commander came to the door, followed by the first officer, and both then realised for the first time that the aircraft had landed with landing gear retracted. The commander then returned to the flight deck to shut down the engines and the Auxiliary Power Unit (APU); the first officer joined him to assist with the shut-down check.

1.2 Injuries to persons

<i>Injuries</i>	<i>Crew</i>	<i>Passengers</i>	<i>Other</i>
Fatal	—	—	—
Non-fatal	—	—	—
None	3	—	—

1.3 Damage to aircraft

The fuselage undersurface was extensively damaged by abrasion, including nose and main landing gear doors. No other parts of the aircraft were affected.

1.4 Other damage

None

1.5 Personnel information

1.5.1 Commander

Age: 39

Male.

Licence:

Airline Transport Pilot's valid until 8 September 1979. Aircraft ratings DHC1, Britannia, BAC 1-11. A Class 1 medical certificate was issued in January 1978. Instrument Ratings, Competency Check, Certificate of Test, Rate Check and Survival Check were all valid.

Flying experience: Total hours on all types: 8,796
Total hours in command: 6,860
Total hours on type: 1040 (all in command)
Total hours in last 28 days 25 (all on BAC 1-11).

Experience as training pilot: Instrument Rating Examiner (IRE) and
Type Rating Examiner (TRE) on Britannia
aircraft.
Appointed IRE and TRE on BAC 1-11 simulator
in April 1977, and on BAC 1-11 aircraft on
13 February 1978.

Duty time: 5 hrs 40 mins to the time of the accident.

1.5.2 Co-pilot

Age: 24 Male

Licence: Commercial Pilot's Licence valid until 5 August
1986. Aircraft ratings Beechcraft 95, Cessna
Citation.
A Class 1 medical category was issued in August
1977 and an Instrument Rating on 26 February
1978.

Flying experience: Total hours on all types: 470
Total hours on type: 4
Total hours in last six months: 116
Total hours in last 28 days: 4
The Co-pilot had completed the BAC 1-11
simulator syllabus prescribed by the company,
and had passed the CAA technical examination
on the aircraft. At the time of the accident he
was engaged on his initial training on the aircraft.

Duty time: 5 hrs 40 mins to the time of the accident.

1.6 Aircraft information

(a) Type: BAC one Eleven 518 FG
Date of Manufacture: 1969
Certificate of Airworthiness: Valid until 29 April 1978
Flying hours: 16,540

(b) Maximum weight authorised: 45,450 kgs
Maximum landing weight: 39,462 kgs
Take off weight: 36,352 kgs
Landing weight: 34,400 kgs

(c) The centre of gravity was approximately in the middle of the permitted range.

1.7 Meteorological information

Routine aerodrome observations were made at 1350 hrs and 1420 hrs. The relevant
features are tabulated overleaf:

	1350 hrs	1420 hrs
Surface wind	210°/9 kts	210°/10 kts
Visibility	20 kms	25 kms
Present weather	nil	nil
Cloud	1/8 at 1,100 ft, 6/8 at 1,300 ft	3/8 at 1,200 ft, 6/8 at 3,500 ft
Temperature	+ 10° C	+ 10° C

The accident occurred in daylight.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Normal RTF communication with Stansted tower was maintained on 118.15 MHz.

1.10 Aerodrome and ground facilities

Stansted Aerodrome (elevation 347 feet) is operated by the British Airports Authority (BAA). Air Traffic Control and radio aids are provided by the Civil Aviation Authority (CAA). Runway 23 has a Landing Distance Available of 2,936 metres. Its surface is asphalt.

1.11 Flight recorders

The aircraft was fitted with a Sperry SADAS digital flight data recorder, and a Fairchild A 100 cockpit voice recorder. Both were installed just aft of the rear pressure bulkhead. Information from both sources was used in the analysis of the accident. The CVR microphone on the flight deck was positioned approximately 4 inches to the right of the landing gear lever, and level with the DOWN end of the slot.

1.12 Examination of the wreckage

The aircraft remained on the runway during the whole ground slide. Marks on the runway and damage to the aircraft indicated that at touch down the aircraft's attitude was normal and its vertical velocity very low. Structural damage was caused by the scraping of the underside of the fuselage, and, although abrasion was limited to a maximum depth of approximately 2-3 ins. a number of pipes associated with No. 2 hydraulic system were ruptured, causing the reservoir contents to spill. The pipes involved were the pressure, suction and case drain pipes associated with No. 2 a.c. pump and which were located in the lower aft region of the main landing gear bay. The aircraft came to rest with all three landing gear units in the retracted position but with the nose gear door and the starboard mainwheel door slightly open. The nose and starboard legs fell when the aircraft was subsequently lifted. The port main wheel door was closed, and remained so when the aircraft was raised. The landing gear selector lever was found to be gated in the down position, and from the unlocked state of the nose and starboard undercarriage legs it can be deduced that this lever was in this position before hydraulic power decayed. The port undercarriage remained locked either because of the pressure of the ground against the door, or because hydraulic pressure was falling at the time of selection. The left hand pilot's seat was found near the aft end of its travel, and the right hand seat near the forward end of its travel. Since the control column occupied much of the space between the seat and the instrument panel it was difficult to climb out of the sight seat in the position found.

When electrical power was switched on the red 'gear unsafe' light illuminated, but there were no "gear locked down" lights. This was consistent with the configuration at the time. When the gear was lowered all three greens were obtained.

Detailed examination of the aircraft could find no fault in the gear operating and indicating systems, in the horn warning system or in the brake anti-skid system. When the aircraft eventually returned to service it encountered some problems with landing gear extension and retraction. These were coincidental and had no bearing on aircraft serviceability at the time of the accident.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

There was no fire, but a BAA fire crew whose vehicle came alongside as the aircraft came to rest, reported smoke from the centre section during the ground slide and after the aircraft had stopped. There was marked frictional heating of the underside of the fuselage, with a glow from the starboard wing root. On entering the aircraft by the port forward door the fire crew found dense acrid smoke within the passenger cabin. It is considered that the most likely cause of this smoke was escaping hydraulic fluid coming into contact with hot fuselage surfaces, the smoke passing from the hold to the cabin via the cabin exhaust air ducts.

1.15 Survival aspects

Deceleration was gentle and the crew had no difficulty in evacuating the aircraft.

1.16 Tests and research

None.

1.17 Additional information

1.17.1 Landing gear indications

The landing gear indications are given by four lights. The upper light is red in colour and will illuminate if any landing gear leg is not locked up or down or is out of agreement with the selector lever, or if either main gear door is not locked up. It will also illuminate if the gear selector lever is not securely gated in either the up or the down position. The three green lights are the usual individual indicators for each leg.

1.17.2 Horn warning system

Provided that the airspeed is below 165 kts, a horn will sound if either throttle is closed below the approximate position for 80% rpm, with the landing gear not locked down. Above 165 kts an airspeed switch will inhibit the system. The horn can in most circumstances be cancelled by the use of the cancel/test switch. Once cancelled the horn will remain silent until the system is reset, either by the power being increased or by the landing gear being lowered and subsequently retracted. Once it is reset the system is able to respond to any new 'wheels up' situation which may occur within the operating parameters. There is one circumstance in which the horn cannot be silenced by means of the cancel/test switch, namely if approach flap is selected whilst the landing gear is not locked down, and either throttle is below the position for 80% RPM. In these circumstances the horn can only be silenced by lowering the gear or selecting flap to a lesser value.

In some circumstances, such as a flapless landing by a heavy aircraft, the approach speed may be above 165 kts, and the system will then remain silent, regardless of gear position or power setting.

1.17.3 Brake anti-skid system

Provided the gear lever is in the down position the anti-skid system can be tested on the flight deck. Operation of the test switch will cause green 'REL' lights to illuminate if the anti-skid system is serviceable. This facility is not available with the landing gear lever in its 'up' position.

1.17.4 Ground Proximity Warning System (GPWS)

A Plessey Ground Proximity Warning System was fitted to the aircraft, but was only partially operational. Although GPWS had been mandatory for this aircraft since January 1978, the operator, in common with others, had obtained a concession from the CAA to operate without GPWS because of a large number of false and nuisance warnings. A fully operational GPWS would have given an 'aircraft not in the landing configuration' warning at 500 feet, providing the flap signal override switch on the flight deck had been operated to cater for the flapless configuration.

2. Analysis

2.1 Position of the landing gear selector

Although the crew expressed their conviction shortly after the accident that the landing gear had been selected down, they have since accepted the evidence of the CVR record that they must have been mistaken. This analysis therefore seeks to determine the reasons for the omission.

The landing gear lever was found in the 'down' position immediately after the accident but the technical evidence is clear that the lever was moved to this position after touch-down but before hydraulic power had dissipated, and that the retracted state of the landing gear was not the result of a malfunction of the system. The crew are adamant that the gear lever was not moved by them after the accident, either as an instinctive though irrational action, or as an attempt to cover up their omission, and this is accepted. It must be presumed therefore that the lever was knocked down accidentally as the crew left their seats, though for this to have happened, it must have been out of its 'up' detent at the time. The illumination of the 'gear unsafe' light during the landing slide suggests that this was in fact so, though why it should have been can only be a matter of conjecture. One hypothesis is that the lever was partially moved from the 'up' position whilst the aircraft was downwind. In his evidence the commander stated that he had briefed the two trainees that an early selection of the landing gear on the downwind leg was advantageous when making a flapless approach. Immediately after the accident, the commander was convinced that this was the procedure that he had followed. So clear was his recollection of extending the gear it is possible that he did in fact start to lower it but discontinued doing so when he remembered that he ought first to restore power on the engine which had been throttled back. However, for this hypothesis to hold good, it has to be accepted that the gear unsafe red light would have been illuminated throughout the downwind leg and final approach, unnoticed by the crew.

2.2 Checks and procedures

The exercise on which the aircraft was engaged at the time of the accident, a flapless approach and landing, is not required by the CAA as part of the initial licensing qualification, but forms part of the company's training requirement on conversion to type. Thereafter it features only as an optional item on base checks, to be performed if extra flying time is available when mandatory training is complete. The company does not believe that the flapless approach can be usefully taught in the simulator, and confines instruction in this exercise to the aircraft. This was therefore the first officer's first attempt at a flapless landing, and it follows that a fair amount of instruction and advice from the commander was necessary.

Since the first officer at the controls needed to concentrate particularly hard on attitude, speed and power during the flapless circuit the commander elected to initiate all checks himself.

The flight deck procedures promulgated by the company do not include a procedure specifically devised for training flights. In the procedures available to the crew a number of items on the check-list are permitted to be performed silently and individually by the pilot not flying the aircraft, but require certain 'starred' items to be cross-checked and confirmed by both pilots. Among the landing checks the only 'starred' item is the setting of altimeters. Since there was no requirement for an itemised sequence of challenge and response, it seems unlikely that the first officer would have been overloaded by following normal company procedures. If the commander had waited for the first officer to initiate the landing checks he would have been unlikely to miss the first two items on the check-list, and the first officer would have been more likely to have noticed the omission of the landing gear check, even though the latter was not a 'starred' item.

For training, the company used the normal operational check-list, and this included checks inappropriate to continuous activity within the circuit. A take-off immediately followed by a circuit, for example, required a number of items to be read, and then to be dismissed as not being relevant. In the course of a series of circuits the status of the check-list as a logical sequence of relevant items inevitably became diminished. Since the accident the company have introduced a flight deck procedure specifically arranged for training flights.

2.3 Commander's work-load

As a result of the circumstances outlined above the commander was responsible for the management of the flight deck and the conduct of the flight as well as for the training of the first officer at the controls. For example, on the downwind leg he had to obtain ATC clearance to adjust his circuit height to avoid cloud, he had to initiate a change of heading because the first officer was allowing the aircraft to converge with the runway, and at the request of the first officer he had to remind him briefly of the necessary procedures for the flapless approach to land. The way he reacted to an apparent malfunction indicated by the brake anti-skid test system suggests that the commander was convinced that he had, among all the other tasks, already lowered the gear, although he knew that this test system would be inoperative whilst the landing gear lever was still in the 'up' position. Had the supernumerary first officer been allocated specific monitoring duties he could have helped to reduce the commander's work load, and exercised a valuable safety function. Since the accident the company has changed its procedures so that this is now done on training flights.

2.4 Landing gear warning horn

Shortly after the check of the anti-skid test system the landing gear warning horn sounded, but its relationship to the retracted state of the landing gear was not appreciated by any of the crew. The horn was in fact a sound the crew was used to hearing in circumstances that called for no response. Under the instruction of the same commander, the two first officers had just completed their simulator training, with its stalling exercises and associated horn warnings. In the aircraft itself, apart from any warnings which may occur during two-engined flight, the horn always sounds as the gear is raised when the aircraft climbs away with one throttle closed after a simulated engine failure. During the nine weeks preceding the accident the commander had spent nearly seventeen hours on base training in the course of qualifying as a Type Rating Examiner, and then in training the two first officers involved in the accident. He was therefore well used to hearing the horn without having to respond to its warning. The crew as a whole had heard at least five landing gear warnings that day, before they entered the downwind leg for the flapless approach.

The commander's reaction to the sound of the horn on the downwind leg was to draw the attention of the first officer to the airspeed. In other words, he appeared to associate the sound of the horn with low airspeed and not with the position of the landing gear. That neither of the other crew members challenged this reaction suggests that they had come to regard the horn as a sound associated with a simulated asymmetric condition or with low airspeed, rather than with an unsafe landing gear position, even on an approach to land. A study of the CVR evidence, in conjunction with FDR readings, shows that on this occasion the horn was most likely stopped by the increase in power applied by the first officer.

Although the CVR recorded the horn sounding once in the downwind leg and later during the final approach, there was no record of the horn sounding during the landing flare as might have been expected. It must therefore have been cancelled by one of the pilots when it last sounded on finals. On finals the warning was of such short duration that the reaction to suppress it must have been instantaneous, and was presumably instinctive. If the approach had been made with flaps at 26° or more, it would not have been possible for the crew to cancel the undercarriage warning horn. This point does not

appear in any of the operator's manuals adduced for the investigation, and the crew of G-AXMG had never had it made clear to them. Thus the system caters adequately for approaches with normal use of flap, but does not provide the same degree of protection during flapless approaches. In this context it is of some significance that this accident is the third occasion since 1970 that a British registered aircraft engaged on training has landed from a flapless approach with its landing gear retracted.

An operational GPWS would probably have alerted the crew to the aircraft's unsafe configuration late on the final approach and it was, therefore, unfortunate that the aircraft was permitted to fly with this equipment inoperative. It is ironic, in the light of what happened, that the GPWS had been made inoperative because of its proneness to false and nuisance warnings. Presumably the consideration behind its withdrawal from use had been that unnecessary exposure to its operation could result in crews learning to disregard it with the attendant risk that they would not respond when the system gave a valid warning. The irony of the situation lies in the fact that the same could be said of the landing gear warning horn, particularly in the training role. It would seem that excessive exposure to the operation of this horn at times when no response was required from the crews has resulted in it becoming largely disregarded. This has been a problem for as long as retractable landing gear has been in existence, and it is still a trap for the unwary. Training staffs in particular need to be reminded of this from time to time and also that they should check to ensure that their procedures do not inadvertently create situations that leave a busy training captain without the support of the aircraft's alerting systems.

2.5 Smoke in the cabin

The ingress of smoke into the main cabin after the aircraft had come to rest was most likely due to the disruption of the hydraulic system in the main landing gear bay where it lay close to the part of the fuselage skin that had been in contact with the runway during the ground slide. It is for consideration whether this smoke and attendant risk of fire is an acceptable consequence of a relatively minor accident or, alternatively, whether it might be advisable to protect the system in that area in some way.

3. Conclusions

(a) Findings

- (i) The crew were properly licenced and competent to carry out the flight.
- (ii) The documents of the aircraft were in order, and it had been maintained in accordance with an approved maintenance schedule.
- (iii) There was no pre-crash failure or malfunction of the aircraft or its systems, in particular the landing gear operating, indicating and warning systems.
- (iv) The Ground Proximity Warning System was by concession, inoperative. An operational system would have provided a positive warning of the aircraft's unsafe configuration during the final approach.
- (v) The commander omitted to ensure that the landing gear was down for landing.
- (vi) The crew's reaction to the subsequent landing gear unsafe warnings was incorrect.
- (vii) The lack of a promulgated flight deck procedure for training flights, the tempo of work during the training task and the crew's abnormally high exposure to irrelevant warnings during the exercises necessary in training contributed to (v) and (vi) above.

(b) Cause

The accident was caused by the crew omitting to lower the landing gear before landing and reacting incorrectly to the 'gear unsafe' warning.

4. Safety Recommendations

It is recommended that:-

- 4.1 Where appropriate, consideration be given to the introduction by operators of flight deck procedures and check lists for use by Training Captains while conducting repetitive circuit and instrument approach training.
- 4.2 The hydraulic system fitted to the BAC One Eleven aircraft be re-examined to assess its vulnerability to damage as the result of a wheels up landing on a runway.

P J BARDON
Inspector of Accidents

Accidents Investigation Branch
Department of Trade
November 1978