Pitch-up moment, Fokker F28 Mark 0100, G-BYDN, 3 November 2000 at 1945 hrs

Micro-summary: **This Fokker F28 Mark 0100 experienced a pronounced pitch-up moment.**

Event Date: **2000-11-03 at 1945 UTC**

Investigative Body: **Aircraft Accident Investigation Board (AAIB), United Kingdom**

Investigative Body's Web Site: **http://www.aaib.dft.gov/uk/**

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Fokker F28 Mark 0100, G-BYDN, 3 November 2000 at 1945 hrs

AAIB Bulletin No: 8/2001 Ref: EW/C2000/11/02 Category: 1.1

INCIDENT

Aircraft Type and Registration:	Fokker F28 Mark 0100, G-BYDN
No & Type of Engines:	2 Rolls-Royce Tay 650-15 turbofan engine
Year of Manufacture:	1991
Date & Time (UTC):	3 November 2000 at 1945 hours
Location:	Approaching Paris Charles de Gaulle Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 5 - Passengers - 71
Injuries:	Crew - None - Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	6,900 hours of which 1,000 hours were on type.
	Last 90 days - 120 hours
	Last 28 days - 40 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft was on the fifth rotation of the day flying between Newcastle (NCL) and Paris, Charles de Gaulle (CDG). The flight crew had flown the previous two sectors from NCL to CDG, returning to NCL and these had been uneventful. The First Officer (FO) was undergoing line training and was the handling pilot for the sector from NCL to CDG. The weather on departure was surface wind calm, visibility 40 km cloud few at 2,000 feet, few CB 3,000 feet, temperature +5°C, dew point +3°C and QNH 991 mb. The aircraft flew only briefly through the lower layer of cloud and did not enter the areas of CB. There were no visible signs of icing and no ice warning was activated.

The transit to Paris was made in cloudless conditions with clear skies during the descent and on arrival in CDG. The arrival was via the reporting point Merue and the aircraft was cleared to descend to FL 110 maintaining 280 kt. Autopilot 2 (AP2) was engaged and the aircraft was being navigated by the Flight Management System (FMS). The FO was using the vertical speed mode to adjust the flight path of the aircraft to arrive at the assigned level at Merue. The aircraft levelled at FL110 and turned onto the 100° radial for the VOR 'CRL'. At this point the aircraft began to gently oscillate in pitch and this increased with the aircraft gradually descending. The nose down pitch increased and the commander instructed the FO to de-select the autopilot, which he did and heard the 'cavalry charge' audio warning, which he cancelled. Taking manual control the FO found he had only approximately 2 cm of fore and aft control column movement, which rapidly reduced to having no movement at all in pitch control. The commander took control and confirmed the column had jammed and only by exerting a large aft force was he able to free the column to a limited extent and raise the nose of the aircraft, which was climbed back through FL 110. ATC called the aircraft to question the level excursions and were advised of the control difficulties. Both pilots had to maintain an increasing forward pressure on the control column and, given the deteriorating situation, the commander transmitted a Mayday distress call. At about this time autopilot 1 (AP1) was selected although subsequently neither pilot could recall making the selection or noticing the information on their display screen. ATC acknowledged the distress call and instructed the crew to 'turn right heading 120° and descend 3,000 feet 1002'

The aircraft now began to gently pitch up and the crew, in an effort to prevent this pitch up, pushed the control column forward. It is possible that a further speed selection reducing to 230 kt was made and the forward pressure needed on the control column took both pilots to hold it in the almost fully forward position. The commander instructed the cabin crew to move all the passengers to fill up the seats from the front to assist in pitching the aircraft down, and to prepare for an emergency landing. This was accomplished promptly and in an orderly manner. With the control column still nearly fully forward and the air speed at 232 kt the commander lowered the first stage of flap (8°). It now became possible to reduce the forward pressure on the control column and the commander, having at various points throughout the incident tried to operate the electric trim with what appeared to be little effect, moved the manual trim wheel to try and trim the aircraft more nose down. The commander decided to land on Runway 27 Right, which was the nearest runway. He carried out a radar vectored ILS approach and made a normal landing at 1948 hrs with Flap 42. Reverse thrust was used to slow the aircraft. After landing the control column electric trim switch was operated it functioned normally

Flight Recorders

Recorded information was available only from the tape-based DFDR fitted to the aircraft. The CVR did not contain a recording of any part of the incident. It was later determined, from the decoding of the time signal recorded on one of the tracks, that the CVR had been allowed to operate during one of the days subsequent to the flight when maintenance activity was in progress on the aircraft

Analysis of the recorded data, in conjunction with the aircraft manufacturer, has indicated that there were two distinct periods of pitch instability during the incident flight. The first period occurred at the end of the descent to level at FL110 and the second during the final descent from that flight level. In the following description of events, extracts from the recordings of communications with ATC have been included where relevant.

Descent towards FL110

Following an uneventful departure and cruise, the aircraft was in the descent towards FL110 under the control of autopilot 2. Lateral navigation was being controlled by the Flight Management System (FMS). The recorded values of total air temperature (TAT) had been progressively increasing during the descent and reached 0°C at 11,200 feet. At 1935 hrs, as the aircraft descended through 11,160 feet, a target altitude of 11,000 feet was captured and the autopilot active path mode changed from 'vertical speed' to 'altitude hold'. Following this change the autopilot applied a small amount of nose up elevator and the aircraft pitch attitude increased smoothly from 0.85° nose down to 0.6° nose up. The auto-throttle, which was in IAS thrust mode, increased engine thrust to maintain 280 kt. The parameters 'selected speed' and 'selected altitude' were not required to be recorded on the DFDR however, where it has been possible to determine the values selected by the crew from other sources, these selections have been stated.

As the altitude approached 11,001 feet, a small amount of nose down elevator was applied to arrest the pitch-up and level the aircraft at the selected altitude; TAT values of +1°C were recorded. For the next 24 seconds there was very little movement in the recorded values of elevator surface position except a very small, gradual change (0.24°) in the nose up sense. During this period the aircraft gently descended below the required altitude, reaching a minimum of 10,973 feet sixteen seconds after the onset of the elevator ceasing to move. The autopilot should have responded to this deviation by applying nose up elevator but none was observed. However, the stabilizer, which was designed to trim out a constant elevator deflection by responding to the presence of an electrical current in the elevator servo, did begin to trim in the nose up sense. This action increased pitch attitude to 1.25° nose up and the aircraft began to climb back towards FL110. In an attempt to level at that altitude, the autopilot should have responded with a nose down elevator deflection but again none was observed. However, the position of the stabilizer, the control loop of which had a much slower response time than that of the elevator servo, began to respond in a nose down sense, decreasing the pitch attitude of the aircraft in an attempt to level at 11,000 feet.

Under the influence of stabilizer trim, the pitch of the aircraft continued to reduce through a level pitch attitude as the aircraft reached a maximum of 11,002 feet and began to descend again. With the slow response time of the stabilizer servo, the peak nose down trim was achieved two seconds later as the aircraft descended through 10,988 feet with pitch attitude reducing through 1.25°° nose down. During the following two and a half seconds, pitch attitude reduced to a minimum of 2.5°° nose down, the aircraft had descended to 10,923 feet and the stabilizer had begun to trim in the nose up sense. At that point the elevator position changed rapidly from a previously static reading of 0.8° nose down to 1.8° nose up, a value which remained constant for 1.25 seconds as the aircraft pitched up to 0.7° nose down. Subsequent to the events above, there were no other instances of anomalous elevator behaviour observed during the remainder of the flight.

The crew manually disconnected the autopilot, made a brief application of nose down elevator and then maintained an average of 1° nose up elevator as the aircraft pitched up. As pitch attitude increased through 2° nose up and the elevator position remained relatively constant, the stabilizer trimmed nose down, changing from 0.4° to 1.4° over six seconds. Pitch attitude reduced and the aircraft began to descend. A further input of nose up elevator was applied which arrested the pitch down at an attitude of 2° nose down. During the subsequent 30 seconds, a reducing amount of nose up elevator and progressively more nose up trim was applied as pitch attitude slowly increased and the aircraft climbed back towards 11,000 feet. It was apparent from the recorded values of airspeed and engine performance that the auto-throttle system had been attempting to maintain a selected airspeed of 280 kt. As the aircraft became more stable in pitch, the same recorded parameters indicated that a reduced airspeed had been selected, in the order of 260 kt. The crew reported that considerable force was required to move the control column in pitch throughout this period.

During the period of pitch instability the aircraft had descended to a minimum altitude of 10,500 feet and pitch attitude excursions of between 2.5° nose down and 4.4°° nose up were recorded; airspeed had remained relatively constant at between 276 kt and 281 kt. Graphs of pertinent parameters recorded during this initial event are shown in Figures 1 and Figure 2.

Once the aircraft became stable at FL110, with a pitch attitude of between 1° and 1.5° nose up, a pitch trim setting of 0.1° and an airspeed of 260 kt, the crew informed ATC that they had a control problem and would like to declare an emergency. Shortly after this, autopilot 1 was engaged. The pitch attitude was maintained as further changes in trim and elevator were recorded resulting in a pitch trim setting of -0.4° and an elevator position of 1.7° nose down. No other significant variations were observed in the recorded data during the phase of level flight at this altitude, a period of approximately one minute.

Final descent from FL110

The crew transmitted a MAYDAY distress call whereupon ATC instructed them to make a right turn onto 120°M and descend to 3,000 feet. Coincident with the start of the heading change from 100°M, engine pressure ratio (EPR) on both engines reduced from 1.3 to 1.18; airspeed started to reduce from 260 kt.

Nine seconds later, still in right turn and with airspeed reducing through 255 kt, the autopilot operational mode altered to 'level change' and speed mode changed to 'elevator controlled airspeed'. These mode changes were consistent with a crew selection to descend to a lower level under autopilot control, although, believing the auto-pilot to be deselected and the aircraft under manual control, these selections were made using the flight director. A small amount of nose down elevator and pitch trim was recorded as EPR on both engines started to reduce towards idle; pitch attitude reduced and the aircraft began to descend. The crew again advised ATC that they had control difficulties and requested a priority landing.

Nine seconds after the autopilot mode change the lateral navigation mode changed from FMS control to 'heading select'. Over the ensuing half a minute, progressively more nose *up* elevator and more nose *down* pitch trim values were recorded. In addition, progressively more fly left rudder (up to a maximum of 6.4°) was applied as the aircraft attempted to complete the right turn onto 120°M. Aileron deflection increased in the roll right sense to compensate for the applied rudder. The crew again emphasized that they had a major control problem and requested radar vectors for a visual approach to any runway. ATC responded with a clearance to runway 27 right. At the end of the half minute period, elevator position was recorded as being 8.7° nose up, the stabilizer had stopped moving at a position 2.65° nose down, airspeed had reduced to 250 kt and the aircraft had descended by 1,000 feet to FL100. The response of the pitch trim system during this phase was consistent with an attempt by the autopilot to reduce altitude and achieve a target selected airspeed of 250 kt whilst being opposed by a force on the control column in the aft direction. The response of the aircraft in roll was consistent with an attempt by the autopilot to turn the aircraft to the right under aileron control whilst being opposed by a rudder deflection in the opposite direction.

As pitch trim stabilized at the high, nose down position (maximum travel was 3° nose down) there was a considerable period (12 seconds) of corrupted data. Immediately afterwards it was observed that airspeed was reducing towards 245 kt, the stabilizer had started to trim nose up and, as pitch attitude began to increase, less nose-up elevator was being applied. Once airspeed had reduced to 245 kt stabilizer trimming ceased at +0.85° for a period of 8 seconds and elevator position remained relatively constant at 3° nose up. There then followed a period of continuous nose-up stabilizer trimming which lasted for half a minute, during which the stabilizer moved to -4.9° and the elevator moved in the opposite direction to 14° nose down. Airspeed during this period was observed to start to reduce towards 235 kt as pitch attitude increased from 4° nose down to 1.6° nose up and the aircraft descended through 8,700 feet. As the aircraft's heading approached 120°M, less left rudder began to be applied and a reduction in roll-right aileron deflection was observed. The pitch trim response during this phase was consistent with an attempt to target a selected airspeed of 230 kt whilst being opposed by a force on the control column in the forward direction.

Over the next minute, airspeed varied between 231 kt and 236 kt as stabilizer positions of between -3.9° and -5.9° (more nose up), elevator positions of between 10° and 16° (nose-down) and pitch attitudes of 0.8° nose up to 2.7°° nose down were recorded. During the latter half of the minute the predominant trend was more nose down elevator against more nose up trim.

By this time the aircraft had descended to 6,850 feet and, as a further nose down input was made bringing the elevator position to 17° nose down (close to maximum deflection), the first stage of flap was selected. During flap extension the stabilizer trimmed in the nose down direction to -4.9° and pitch attitude reduced to 4.4° nose down. Less nose down elevator was applied and pitch attitude increased. Airspeed, which had been fluctuating between 231 kt and 233 kt, began to reduce towards 220 kt. Over the next thirty seconds, progressively less nose down elevator was applied and the stabilizer moved in an increasingly more nose down direction, resulting in positions of 11° nose down and -4.1° respectively.

At that time, as the aircraft descended through 5,600 feet, the stabilizer position moved in the nose down sense by 1.5° to -2.3°. The movement was much quicker than that which had previously been recorded due to stabilizer servo control and it is considered that this was in response to a crew trim input. Pitch attitude reduced by 2.5° to 4.5° nose down before less nose down elevator was applied, raising pitch attitude to an average of 3° nose down.

Whilst maintaining this pitch attitude, two further movements of the stabilizer in the nose down direction were recorded. The second of these was coincident with the disengagement of the trim 1 and 2 systems and an automatic autopilot disconnect.

Over the subsequent half a minute pitch attitude remained relatively constant as the stabilizer was manually trimmed progressively more nose down to a position of +3°; the elevator position was recorded as moving progressively more nose up, through the neutral point, to -10°. Airspeed increased to 230 kt during that period. After a further 10 seconds, during which the control surfaces had remained relatively constant, the stabilizer was manually trimmed in one step to 0° (more nose up), pitch attitude increased to level and less nose up elevator was applied. The trim 1 and 2 systems were re-engaged and further movements of the stabilizer and elevator surfaces were recorded, bringing both to a mid-range position. These events were coincident with the receipt of further radar vectors from ATC instructing a right turn and then intercepting the ILS for 27R. A graph of pertinent parameters recorded during the descent from FL110 is shown in Figure 3.

The remaining five minutes of the flight were uneventful. Touchdown occurred at 1948 hrs with Flap 42 selected at an airspeed of 130 kt; reverse thrust was used to slow the aircraft.

Description of the elevator and stabiliser

The aircraft was equipped with an Automatic Flight Control and Augmentation System (AFCAS) which controls the aircraft in pitch, roll, yaw, speed and thrust. The AFCAS consists of three subsystems: the Automatic Flight Control System (AFCS) which provides the autopilot, flight director and altitude alert functions, the Auto-throttle System (ATS) and the Flight Augmentation System (FAS) which provides yaw damper and stabiliser trim functions.

The pilots' control columns are connected via cables to a pulley wheel and cable tension regulator assembly located in the bullet fairing atop the stabiliser. An output rod from the pulley provides an input to a dual hydraulic actuator; the left actuator is powered by hydraulic system No 1, the right actuator by system No 2. Either system is capable of operating the elevator. Two autopilot servomotors (one for each autopilot) are located aft of the cable tension regulator, and drive cable capstans connected to the same pulley assembly as the pilots' control columns. The relevant components are shown at Figure 4.

The stabiliser is also operated by two hydraulic actuators. Trim is usually controlled by the FAS whilst an autopilot is engaged. In manual flight, trim is controlled by means of switches on the control column yokes; the FAS disable these when an autopilot is engaged. In the event of a failure of the FAS, a manual trim wheel on the pedestal can achieve trim. The stabiliser actuator has a gearbox for the alternate electric trim motor. The motor is coupled to the spindle via a hydraulically operated clutch. If either one of the stabiliser actuators is pressurised this clutch is disengaged. When no hydraulic pressure is available in the stabiliser actuator then the clutch will engage and the stabiliser can be deflected by operating the alternate trim switch on the pedestal.

Examination of the aircraft

Following the incident the aircraft was examined by the operator's usual maintenance organisation. The elevator servo cables, which run between the servo motor cable drums and the elevator cable tension regulators, were found to be slack. Other, minor defects were also found; these included slightly reduced elevator up travel, lack of lubrication on the right hand tension regulator cross-head shaft and excessive friction on the manual trim wheel. No circuit breakers had tripped during the incident.

Both elevator servo assemblies, No 1 flight control computer and the flight mode selector panel were removed for testing at the aircraft manufacturer's facility. All were found to be satisfactory with the exception of the No 2 elevator servomotor, which failed both an insulation test and a torque test. The unit was subsequently returned to the autopilot manufacturer's overhaul facility in the UK, where it was examined under the supervision of an AAIB Inspector.

Examination of No 2 elevator servo motor

The servomotor was placed on a test rig and subjected to a torque test in accordance with the manufacturer's Inspection Manual. Despite the indications from the tests conducted by the aircraft manufacturer, the results were satisfactory. However the insulation problem was confirmed when it failed the 'dielectric' test. This manifested itself as a voltage drop when a test voltage was applied to the electrical connector. The engineers conducting the test noted that this was a common feature on units tested 'as received' from the field and in fact the inspection procedures only required this test to be performed at the end of the overhaul process. The servomotor was then disassembled and it was found that wear had occurred on the motor brushes, and as a consequence, carbon dust was distributed around the interior of the unit. Again, this was considered to be typical for a motor returned from service. After cleaning and re-assembly the test was repeated, with improved results. It was considered that the internal current leakage stemmed from the carbon dust.

The autopilot manufacturer was asked if such current leakage could interfere with the control loop functions of the autopilot, thus causing anomalies in autopilot operation. The response was to the effect that it was possible that the carbon dust could cause current leakage, or shorts, between the various signals in the unit. In severe cases these could momentarily destabilise the servo loop. However, monitors are incorporated in the system which would detect this condition and disconnect the autopilot if it persisted for more than one second. This would thus limit the period of anomalous operation to a period of one second.

Elevator servicing history

The aircraft manufacturer had received reports of a number of events that occurred in the early 1990's which involved high elevator forces following a manual disconnection of the autopilot. Investigation revealed that under certain conditions of temperature and humidity, ice could accumulate in the elevator servo cable groove such that it impeded the movement of the cable in the groove. Deflection of the elevator caused the ice to break away, thus restoring normal control forces. A temporary solution was the issue of Service Letter No 134. This advised operators to apply silicon grease to the servo cable capstan at intervals of 250 flying hours.

In 1994 a Service Bulletin, SBF100-22-039, was issued which introduced a modified servo mount capstan. The cable grooves were of a different profile, wider and with lower flanges, as shown in Figure 5. Whilst ice could still form, the breakout forces were reduced. The SB was eventually incorporated on the aircraft production line, but remained optional for existing operators. G-BYDN did not have the SB embodied although one of the two other aircraft in the operator's fleet did. Following the incident the operator stated its intention to modify its aircraft with a superseding Service Bulletin, SBF100-22-047, (see below) as soon as parts became available. Pending parts availability the instructions contained in Service Letter No 134 would be carried out.

Note: All Fokker F70 aircraft had SBF100-22-039 embodied at build. The earlier F28 model aircraft were equipped with autopilots from a different vendor and are therefore unaffected.

Two other Service Bulletins initially were thought to be potentially relevant. The first was SBF100-51-008, which introduced improved drainage in the bullet fairing following complaints about accumulations of water when the aircraft was on the ground. There was no reason to believe that water could accumulate in this area during flight however, and although the subject aircraft was not modified, it was considered it was not relevant in this case. The second Service Bulletin was SBF100-22-047: this was issued after the autopilot manufacturer noted that the internal friction of the servo motor was higher than previously thought, leading to higher than normal elevator forces after autopilot disconnection. A revised servomotor was introduced which had lower internal friction. The servo mount and associated cable capstan that came with the new motor were the same as those introduced by SBF100-22-039.

Automatic Flight Control System (AFCS) and Electronic Flight Instrument System (EFIS)

The incident aircraft was fitted with a Rockwell Collins duplex AFCS, a four screen EFIS and a two screen Multi Function Display Units (MFDU). In front of each pilot were a Primary Flight Display (PFD) and a Navigation Display (ND) screen mounted on the instrument panel one above the other. On the upper screen was displayed attitude, airspeed, altitude and flight mode information. The lower screen gave horizontal situation information including heading and navigation data. The two Multi Function Display Unit (MFDU) screens were mounted on the lower part of the instrument panel between the two pilots. The left screen displayed systems information and the right hand MFDU showed checklists both normal and emergency.

Of special relevance to the incident was the Flight Mode Annunciator (FMA) displayed at the top of the upper PFDU screen. This comprises five columns of information, which read from left to right with an upper and lower line of abbreviations. The five modes shown are thrust (THR), speed (SPD), flight path (PATH), lateral navigation (LAT) and autopilot, autothrust and flight director engaged status (STATUS).

AFCS selection is made by pressing switches located on the glareshield above the instrument panel. The switches select autopilot one or two and are marked AP1 and AP2. The switches have a glass insert which when an AP is selected a green light, the intensity of which can be adjusted, illuminates to show which AP is active. This is confirmed on the FMA on the upper PFD with an AP1 or AP2 shown in white in the STATUS column. The AFCS is disconnected either by using a push button on either control column or an AP disconnect bar below the two AP selector switches. Using the column disconnect button activates an undulating warning tone and causes the AP symbol on the FMA to flash amber. The warning automatically cancels but a second press of the button is required to stop the amber flashing AP symbol which changes to flight director (FD) on the FMA in white. During the incident flight autothrust was engaged which was indicted by the letters AT in white below the AP information on the FMA STATUS column.

Following the engagement of AP1, the aircraft was in the navigation mode using the Flight Management System (FMS). As described in the Flight Recorder's section of the report the operational mode altered to 'level change' and shortly after the lateral navigation FMS control changed to 'heading select'. Level change can be activated either by selecting a new level or altitude in the altitude window on the AFCS control panel and pressing the level change switch (LVLCH) or having selected the new altitude pulling the rotary selector knob will activate the level change mode. When this occurs, the FMA will show thrust having reduced in the left column with the letters LL in green, speed in the second column will show IAS controlled by elevator (IASE) in green. PATH in the third column will show ALT in cyan having moved from the top line to the second line down to show the altitude selected is armed. Heading (HDG) selected in the fourth column would appear in green. With AP1 selected the AFCS would control the aircraft to follow the level and heading change commands. AP1 in white would be shown in the right hand column with AT in white below it.

Any attempt by the crew to try and fly the aircraft with the AFCS engaged would result ultimately in the selected altitude and heading being achieved by the AFCS. The FD bars would show any deviation from the commanded flight path caused by the crew trying to counter the AFCS, on the PFDU. The large control forces required in attempting to counter the AFCS inputs would only cause the AP to disconnect when in the 'land' mode below 1,500 feet with ILS coupled. In the 'land' mode with ILS coupled both AP1 and AP2 are automatically engaged.

The manufacturer's Technical and Operation Notice'Fokker70/100 [TON 100.028 dated 2 July 1999], issued in regard to auto-pilot overpowering exercises conducted in the simulator, summaries the theory of the auto-pilot operation thus:

'If the auto-pilot is 'told' to maintain a pre selected altitude it will go to any length to do just that. If the pilot overpowers the system using his elevator then the autopilot will 'correct' this input by using the stabiliser. Movement of the stab Indicator in the opposite direction followed by an 'Out of Trim' alert will be the logical result and the first sign that something is wrong..............As the stabiliser has more authority than the elevator the auto-pilot eventually able to climb to the pre-selected altitude again while the pilot is still pushing in order to descend.'

Analysis

For a period of 24 seconds, during which the elevator movement was severely restricted, AP2 was controlling the pitch attitude of the aircraft by means of the stabiliser alone. The elevator restriction was most probably due to ice accretion on the servo capstans and cables but, due to the transitory nature of ice build up this could not be positively established. Nevertheless, the aircraft had climbed through a layer of cloud on its departure from Newcastle. These symptoms were consistent with other reported cases.

In attempting to correct the observed perturbations in pitch the pilots found that the control forces were extremely heavy, giving them the impression that the elevator could not be moved following their de-selection on AP2. The commander was aware of other traffic 1,000 feet below his aircraft and put on his landing lights to increase his conspicuity. Combined with those actions both pilots had to use extreme force on the controls in order to try and overcome the control restriction.

AP1 was inadvertently selected some 78 seconds after AP2 was disengaged; during which time the pilots were occupied in arresting the aircraft's descent from FL 110. In this situation the trim switches on the control columns would have been isolated. During this time the commander had decided to reduce speed to 250 kt. Neither pilot could recall selecting AP1, but from that selection until the movement of the manual trim wheel, which automatically disconnected AP1, the autopilot controlled the flight path of the aircraft. The AFCS commanded increased control surface positions to overcome the control inputs of the crew attempting to counter the aircraft flight path which they had not selected using the flying controls. When the AFCS is engaged it will always overcome any control inputs due to the greater control power of the stabiliser. The electric trim only works with the AFCS deselected and, consequently, the commander's attempts to use the electric trim was probably when AP1 was connected.

The mode and status of the AFCS was presented on each pilot's PFD. Whilst each crew member recalled seeing information displayed on their respective PFD, relating that information precisely to the exact sequence of events was not possible. The comment by the FO that he could not see a green light in the AP1 select switch might have been due to its brightness having been turned down.

The Abnormal Procedures Checklist includes actions relating to de-selecting hydraulic systems where servo valves have become disconnected. The checklist calls for both affected (hydraulic) flight control push buttons to be selected off simultaneously. This action has a secondary effect of de-selecting the AFCS. This checklist is not displayed on the MFDU as the failure is not monitored and pilots must refer to Flight Reference Cards (FRC).

Conclusions

Following the initial restriction of elevator movement, probably due to ice accretion on the servo capstan, which was overcome by the use of extreme force on the control column, the crew de-selected AP2. Both crewmembers remained unaware of the subsequent inadvertent selection of AP1. When the AFCS components, were removed from the aircraft and tested no defect was found that would have caused the AP1 to engage without normal selection by a crewmember. Whilst the crew had initially experienced a genuine control restriction, at a critical time of flight in a busy terminal area, the selection of AP1 with the apparent continuation of control difficulties increased their concerns and workload. The information on the status of AP1 was available on the PFD, but the pilots' preoccupation with trying to maintain control of the aircraft meant that this was not noted. This is not altogether surprising since human factor studies have shown that, at times of heavy workload and in emergency situations, it is possible for pilots to be unaware of both visual and aural alerting devices.

Safety Recommendations

The following Safety Recommendations were made on 11 January 2001:

Recommendation 2001-02

Fokker Services BV should issue an All Operators Letter or similar, drawing attention to the possibility of ice accretion on the elevator servo capstan in cold humid conditions. Operators should be advised to comply with Fokker SB 100-22-039 (or relevant superseding Service Bulletin) at the earliest practicable opportunity. This introduces a revised capstan groove with less possibility of jamming. Pending the availability of parts, operators should additionally be urged to implement the intent of Service Letter No 134, which calls for greasing of the elevator servo cables at intervals of 250 flying hours.

Manufacturer's response

The issue of an Airworthiness recommendation catalogue article to all Fokker 70/100 operators to recommend accomplishment of the service bulletin has addressed this recommendation.

Recommendation 2001-03

In order to reduce the potential for elevator control restriction due to ice accretion on the elevator servo capstans of Fokker F100 aircraft, the Dutch Civil Aviation Authority confer mandatory status on Fokker Service Bulletin SB F100-22-039 (or relevant superseding Service Bulletin), that introduces a revised capstan groove.

Regulatory authority response

The Dutch CAA have indicated that they see no merit is making the SB mandatory since the accretion of ice on the servo capstan could not be positively established and they could see no direct link between the two events in this incident. However, the potential safety implications of overpowering an autopilot had led them to conduct an investigation of autopilot design of aircraft types for which the Netherlands is the primary certification authority.

BULLETIN ADDENDUM

AAIB File	EW/C2000/11/02
Aircraft Type and Registration:	Fokker F28 Mark 0100, G-BYDN
Date & Time (UTC):	3 November 2000 at 1945 hours
Location:	Approaching Paris Charles de Gaulle Airport
Information Source:	AAIB Field Investigation

Please add Figure 5 (shown overleaf) which was unfortunately omitted from the report published in AAIB Bulletin 8/2001.

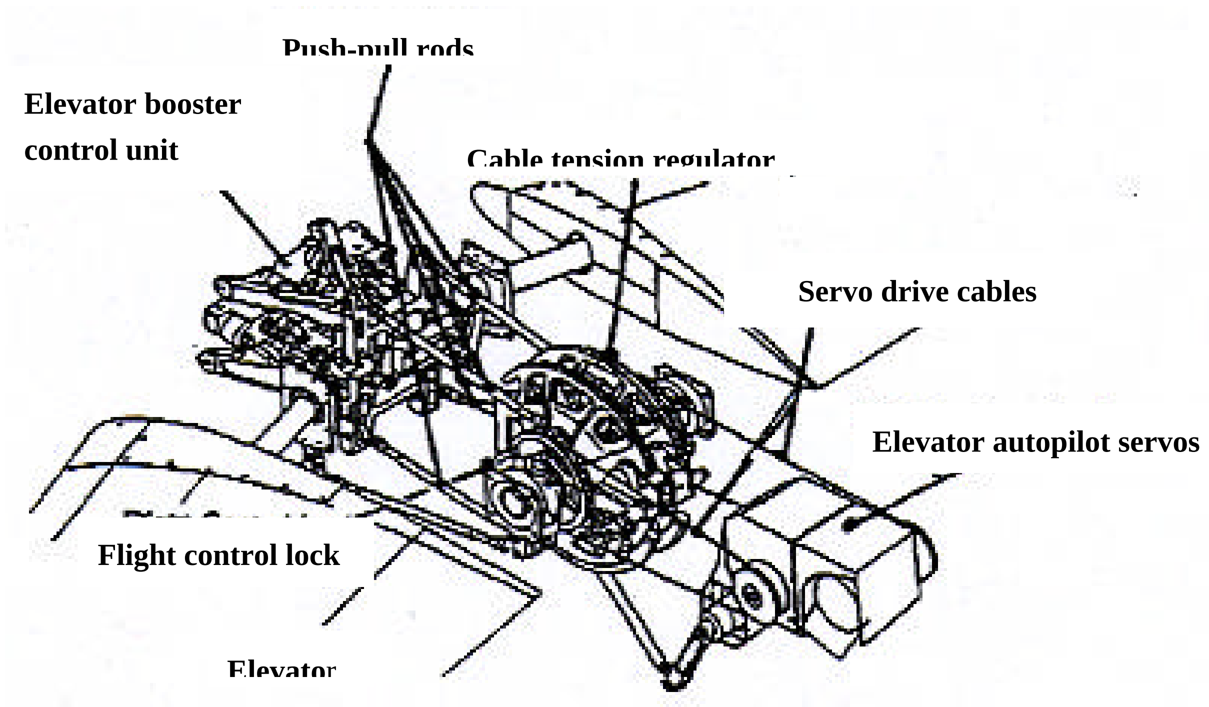

Figure 4. Elevator controls in bullet fairing

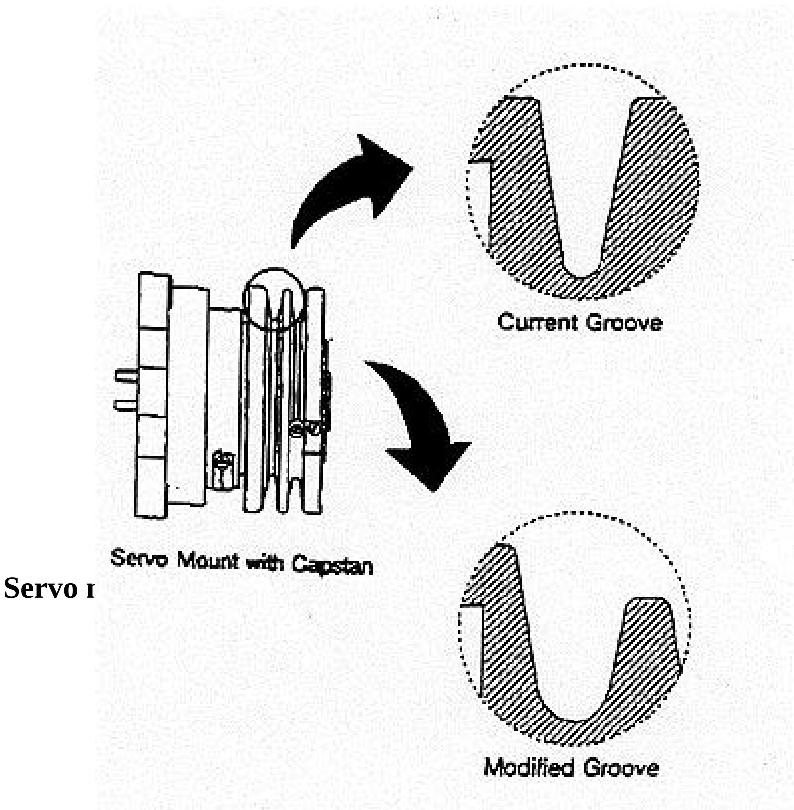

Figure 5. Modification to servo motor capstan cable grooves as per Service Bulletins SBF100-22-039 and SBF100-22-047