Fokker F27 Mark 500, G-JEAP, 1 July 2000

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Aircraft Type and Registration:	Fokker F27 Mark 500, G-JEAP
No & Type of Engines:	2 Rolls-Royce Dart 532-7 turboprop engines
Year of Manufacture:	1971
Date & Time (UTC):	1 July 2000 at 0508 hrs
Location:	Coventry Airport
Type of Flight:	Public Transport (Cargo)
Persons on Board:	Crew - 2 - Passengers - None
Injuries:	Crew - None - Passengers - N/A
Nature of Damage:	Nose-gear collapsed, engine nacelles and propellers damaged, tyre damage
Commander's Licence:	Airline Transport Pilots Licence
Commander's Age:	61 years
Commander's Flying Experience:	16,995 hours (of which 392 were on type) Last 90 days -104 hours Last 28 days - 41 hours
Information Source:	AAIB Field Investigation

History of the flight

The aircraft and crew were scheduled for an overnight turnaround flight from Coventry to Belfast carrying parcel freight. The aircraft was serviceable, and the flight proceeded uneventfully to Belfast. There was no freight for the return flight to Coventry, and after 50 minutes on the ground, during which 400 kg of ballast and 1,900 litres of fuel were uplifted, the aircraft departed for Coventry with the commander as handling pilot.

The Coventry weather from the Automatic Terminal Information Service (ATIS) was surface wind 120°/5 kt, visibility 1,800 metres in mist and light rain, cloud broken at 400 feet, temperature 13°C, dewpoint 12°C, QNH 1009 mb and runway wet. A surveillance radar approach (SRA) to Runway 05 was in use with a Minimum Descent Altitude (MDA) of 620 feet (375 agl), and the crew were aware that the prevailing low cloudbase might result in a missed approach. However, during vectoring by Birmingham Radar the approach was changed to an instrument landing system (ILS) on Runway 23 with a Decision Altitude (DA) of 465 feet (200 agl). In view of the low cloudbase the crew were content to accept this change despite a 2 to 3 kt tailwind on Runway 23. It was daylight by the time the flight arrived in the Coventry area.

The aircraft intercepted the ILS localizer at about 6 miles from touchdown, and shortly thereafter the commander deselected the autopilot and flight director and flew the rest of the approach manually. The landing gear was lowered just before interception of the glideslope and the operator's standard landing flap setting of 26.5° was extended as the aircraft established its descent on the glideslope. The target speed for the approach was 105 kt with a Vref for landing of 95 kt. The aircraft settled slightly high on the glidepath with the airspeed at 120 kt, and these conditions remained until DH.

At about 300 feet agl the commander could see the approach lights and declared his intention to land. At 200 feet agl, with the speed remaining at 120 kt, the aircraft was still above the ILS glidepath and the First Officer (FO) sought to bring this to the commander's attention with a call of 'four whites', indicating that the Precision Approach Path Indicators (PAPIs) were showing the aircraft to be high on the 3° approach path. The commander stated afterwards that he realised he was slightly steep and slightly fast and he had reduced power to decrease the speed. He also decided to minimise the landing flare to reduce any float. Data from the Flight Data Recorder (FDR) shows that the aircraft touched down in a flat attitude at 114 kt (Vref plus 19 kt) approximately 600 metres along the runway with 1,000 metres of runway remaining. However, an eyewitness in the control tower reported that the aircraft touchdown considerably further down the runway, and that touchdown was initially on the nosewheel.

After touchdown the commander recalls selecting ground fine pitch (GFP) on both engines and he remembers leaving his hands on the power levers throughout the landing roll. However, neither the FO nor the commander could recall hearing the normal aerodynamic braking noise from the propellers. It is normal at this stage for the pilot-not-flying (PNF) to confirm the status of the propellers by calling '6 lights (indicating that both propellers are in GFP), TGTs (turbine gas temperatures) and RPMs falling'. In this case the FO can recall looking for the lights, but in the prevailing light conditions he could not immediately discern whether or not the lights were illuminated. On the Cockpit Voice Recorder (CVR) recording the FO can be heard beginning his normal statement of propeller status but stopping as he tried to confirm the status of the lights. He then became distracted by the higher than normal groundspeed and the fast approaching end-of-runway lights, and the propeller status call was not completed.

Both pilots recalled a lack of retardation in the first part of the landing roll, but both were aware that the brakes were operating because of the noise of the Maxaret anti-skid units releasing pneumatic brake pressure. When the commander realised that stopping on the remaining runway would be difficult he applied maximum braking, but retardation remained low.

At a groundspeed of approximately 60 kt the aircraft left the paved surface just to the left of the runway centreline on a track toward the ILS localizer aerial. To avoid hitting the aerial, the pilot steered the aircraft to the right, in the course of which the nosewheel impacted a slight ridge formed by the concrete plinth of a small ILS monitor aerial. The force of the impact with the ridge collapsed the nose landing gear backwards. The aircraft then skidded across the grass on its mainwheels and the nose gear doors before impacting the airfield perimeter fence and coming to a halt with the nose section protruding across a minor road.

After the aircraft came to a halt the crew shutdown the engines, operated the engine fire extinguishers and vacated the aircraft through the crew exit on the left of the aircraft. They experienced some difficulty in opening the exit door as the perimeter fence had become wrapped around the aircraft's forward section thereby preventing the door from opening fully.

Aircraft damage

Examination of the aircraft revealed that the nose leg had collapsed, leading to extensive damage in the bay area and skin of the nose cone. Both propellers were damaged, the right one being the most severely affected. All the damage was inflicted by contact with the fence, except for some that may have been created by the left propeller striking the left glide slope monitor aerial. There was evidence that both propellers were turning at final impact.

A structural failure had occurred in the right engine mount together with an internal drive failure in the right engine. Some wrinkling of the right nacelle skins was evident adjacent to the landing gear leg pick-up point. Some evidence was also present of similar but lighter damage on the left engine nacelle.

Signs of oleo collapse were evident on the right landing gear leg consistent with those defined in the Maintenance Manual as part of the list of Hard Landing inspection features. Wrinkling at the wing/fuselage junction fairing suggested the possibility of a loss of alignment of the whole aircraft. Both right landing gear tyres had extensive flat spots, the outer one being worn away sufficiently to create a hole, resulting in its deflation.

Aircraft information

On departure from Belfast the aircraft load included: two crew; 2,840 kg of fuel; 180 kg of water methanol; and 400 kg of ballast. The loadsheet indicated that the centre of gravity for both take off and landing was well within the authorised centre of gravity envelope, but was toward the forward end of the limits.

Braking system

The aircraft is fitted with differential wheelbrakes that are operated pneumatically by means of conventional toe brake controls positioned on each rudder pedal. Pneumatic pressure is provided by two pumps, one mounted on each engine accessory gearbox. 'Maxaret' anti-skid units acting on each individual brake pack sense locking of the associated wheel and vent supply pressure to achieve brake release. The anti-skid system is only operative after the wheel has achieved rotational velocity.

Propeller control system

Each propeller is controlled via its individual Propeller Control Unit (PCU). The total operating blade pitch range of the propeller is from zero degrees to fully feathered at 87°. Pitch is limited in flight to a minimum of 20° by means of a withdrawable Flight Fine Pitch Stop (FFPS). This is provided to prevent excessive drag in flight. Withdrawal of the FFPS on the ground allows the propellers to move into the GFP range (0° to 20°). This provides considerable aerodynamic drag and disrupts the airflow over the inboard section of the wing thereby increasing the weight supported by the wheels and increasing braking effectiveness.

Selection of GFP is by means of the flight deck power levers or by engagement of the gust locks. Each power lever can be lifted and moved back beyond its normal rearward position against spring pressure. Movement of either lever energises the FFPS removal circuit and allows the PCUs to remove the FFPS hydraulically. Four lights, two for each engine located above the centre instrument panel, indicate when the FFPS withdrawal circuit is energised and when the propeller moves into the GFP range. When the aircraft is on the ground, a warning horn sounds if the GFP electrical circuit has not been energised and the airspeed reduces below 55 kt.

As the power lever is moved to the closed position engine RPM will reduce. However, once the FFPS is removed and the propeller moves into the GFP range the drag on the propeller in the rotational plane is reduced and there is a brief increase in engine RPM before it resumes decaying towards ground idle RPM.

Meteorological information

The synoptic situation at 0500 hrs on 1 July 2000 showed a complex frontal system over Southern England with a moist south-southeasterly airstream covering the area. Visibility was reduced to about 1,500 metres in rain and drizzle and with a cloudbase at about 600 feet. The surface wind at Coventry Airport was 110° at 6 kt, veering gradually between 500 feet agl and 2,000 feet agl, to become 150° at 12 kt.

Coventry Airport does not have a meteorological observer and actual rainfall is therefore not recorded. The Meteorological Office rainfall radar images for the five hours prior to the accident indicate a maximum rainfall rate of 1 millimetre per hour with rates as low as 0.5 or 0.125 of a millimetre for some of the period. At the time of the accident the runway had been classified as 'wet' over its full length, but there was no standing water and the ATC controllers felt that the runway was closer to being classified as 'damp' rather than having 'water patches'.

Aids to navigation

Runway 23 is equipped with an ILS with the glideslope set to 3°. The system was last checked prior to the accident on the 24 May 2000 by flight test and was switched ON and serviceable at the time of the accident.

Communications

VHF communications between the crew and Coventry approach (119.25 MHz) and Coventry tower (124.8 MHz) were satisfactory. Conversation was recorded and a copy tape with injected time signal was provided to the investigation.

Airport information

Runway 23 at Coventry is 1,825 metres in length with a displaced threshold for landing giving a landing distance available (LDA) of 1,615 metres. The asphalt surface runway is level. The runway is equipped with both 3° and 5.5° PAPIs. The 5.5° PAPIs are used only for training by prior permission and an interlock in the visual control room prevents both sets of PAPIs being selected on simultaneously. At the time of the incident the 3° PAPIs were switched ON.

A runway friction classification survey had been carried out on Runway 05/23 in accordance with CAA Publication (CAP) 683 on 15 June 2000, just two weeks before the accident. The survey reported that the centre portion of the runway had a slightly lower skidding resistance than the outer edges, but the overall friction level of the runway was given as 0.88. CAP 683 sets a design objective friction level of 0.80, a maintenance level of 0.63 and a minimum level of 0.5.

Flight recorders

The 30-minute duration, four channel, CVR and the 25-hour duration, five parameter, FDR were replayed. A recalibration of the FDR airspeed and altitude transducers was carried out as part of an overall 'pitot static' system functional test.

The recordings showed that the aircraft became established on the localiser at about 6 miles from touchdown. The approach was flown at 120 kt IAS and from the CVR it is clear that the crew were aware that the aircraft was above the glideslope throughout the approach. The FO called 'four whites' as the aircraft passed through the DA.

Using FDR data, reported winds, recorded radar data and ATC information, the aircraft's groundspeed and track were derived. Calculations show that the aircraft was between 1 and 2 dots high on the glideslope between the outer marker and DA (1 dot = half scale deviation; 2 dots = full scale deviation).

The aircraft touched down at about 114 kt IAS (Vref plus 19 kt). It was not possible to determine the pitch attitude of the aircraft at touchdown as no attitude data was recorded on the FDR. It was calculated that the aircraft touched down with about 1,000 metres of runway remaining and came to rest at the perimeter fence after 1,260 metres of ground roll.

Within 2 seconds of touchdown sounds of the anti-skid units operating became audible on the CVR. However, the distinctive 'click' of the power levers being lifted and moved into the GFP position was not heard. Furthermore, no increase in aerodynamic noise from the propellers operating in GFP was recorded. Seventeen seconds after touchdown, at a speed of 67 KIAS, the cockpit warning horn sounded indicating either a landing gear unsafe condition or that the GFP circuits had not been activated. The warning horn continued until the end of the recording. Subsequent calibration of the GFP warning horn speed sensor revealed that the horn sounded at 67 kt rather than the design speed of 55 kt. Comparison of the point of the first warning with the point where the nose landing gear collapsed revealed that the initial activation of the horn was due to lack of GFP.

Two to three seconds after the horn sounded both the CVR and FDR recorded information consistent with the aircraft leaving the paved surface. About 7 seconds later there was a heavy crashing sound heard on the CVR recording followed by a period of bumping and crashing sounds. From the site investigation it was determined that these sounds were coincident with the collapse of the nosewheel and the noise of the front fuselage travelling over the ground. Some 14 seconds after the aircraft left the paved surface further loud crashes and the sound of the propellers abrading metal as the aircraft passed through the airfield perimeter fence were recorded. The CVR continued to record until the crew isolated electrical power prior to leaving the aircraft.

No engine or propeller data was recorded on the FDR. However, propeller speed during the landing roll was obtained from the CVR, and a graph of propeller speed against airspeed was produced. The data showed a linear decrease in RPM until just before the aircraft came to a halt when a slight increase in RPM was indicated. This data was analysed both by the AAIB and the propeller manufacturer. Both analyses revealed that the propellers did not pass through the FFPS until just before engine shutdown.

Accident site information

Ground witness marks

Curved tracks of the main landing gear wheels were visible on the grass between the end of the runway and the aircraft's final position. The tracks had the correct lateral spacing on the beginning of the grass where the aircraft left the paved runway end. The left landing gear wheel had passed through a lamp to the left of the runway centreline as it departed the runway. The tracks indicated that at this point the aircraft was travelling parallel with the centreline but was slightly displaced to the left. The tracks on the grass indicated that all five wheels were rolling normally until the monitor foundation was struck. A 3 to 4 inch upward earth lip was noted where the paved surface finished and the grass overrun began.

A gouge (from collapsed nose leg and damaged bay doors) converged to become nearly co-incident with the right main landing gear wheel track (indicating a turn to the right/slide to the left) during the latter part of the ground roll.

No evidence of wheel tracks could be detected on the paved surface at the overrun end. A comprehensive inspection of a major portion of the remainder of the runway was carried out. No tracks matching the spacing and tread pattern of this aircraft were found between the runway mid-point and the over-run end. From runway mid-point to the threshold of Runway 23 large amounts of rubber were present, and it was not possible pick out the tyre patterns of G-JEAP.

Configuration and settings

The landing gear was down, with both propellers at the ground fine pitch stop angle. The flaps were selected to 26.5°and the flight deck indicator also showed 26.5°. The main system pneumatic pressure was zero although it is believed this was a result of the damage to the nose-wheel steering system. The main brake pressure was still indicating and emergency brake pressure was present, the emergency system having apparently not been used. The gust locks were not engaged. Both tyres on the right landing gear contained large flat areas. The tyre, which remained inflated, was only slightly bulged in the flattened area, suggesting that a low contact force was present at the time the sliding damage was inflicted.

Aircraft performance

Landing distance calculations

The Fokker 27 Mark 500 was certified in the UK in accordance with British Civil Airworthiness Regulations Section D Issue 4. Gross landing distance was based on a 50 feet screen height, a dry runway, target threshold speed (Vat) at $1.3V_S$ (where V_S is the landing configuration stall speed), maximum braking and the flaps to be retracted after touchdown. No account was taken for the retardation provided by the use of GFP. The total landing distance is a combination of airborne distance and ground roll. For the F27 the airborne distance is approximately 40% of the total distance.

The gross distance derived using the above assumptions is a theoretical distance based on a high level of pilot skill and favourable conditions. To provide an operationally realistic level of performance for publication in the Aircraft Flight Manual (AFM), the gross distance was multiplied by a 'field length factor' which, in the case of the F27, was 1.67. The application of the field length factor accounts for normal operational variability in day-to-day service, in particular wet runway conditions, and excess threshold speed up to 15 kt. The use of 1.67 factored landing distance makes the chances of an overrun remote, but the allowances provided by the field length factor cannot protect against an overrun if all variables are at the limit of their tolerance.

The aircraft manufacturer advises that the landing distance required (LDR) for flap 26.5° at the prevailing aircraft weight, runway and weather conditions was 1,018 metres. Of this total distance, 609 metres is the factored ground roll.

Threshold speeds

The manufacturer provides aircraft operating information to the operator in three Manuals: AFM Volume 1 (Operating Information), AFM Volume 2 (Certified Performance Information) and Volume 3 (Additional Performance Information). AFM Volume 2 provides, in graphical form, certified target approach speeds and target threshold speeds (Vat) for flap 40° approaches. AFM Volume 1 provides tabulated landing speeds (termed Vthr) for 'easy pilot reference', and the table includes speeds for 0°, 26° and 40° flap settings. The AFM Volume 1 table is included in Part B of the operator's Operations Manual, but the target threshold speed is termed Vref rather than Vthr. The crew was using the flap 26° Vref speed from the Operations Manual tabulated data as the target threshold speed for the landing.

In converting the threshold speed data from graphical to tabular form, the manufacturer used weight bands rather than specifying a target speed for every weight. Some variance therefore exists between the certified data (Vat) and the easy reference threshold speeds (Vthr) at intermediate weights. The variance at weights of 16,000 kg and above is small, but as the landing weight decreases below 16,000 kg the variance increases. The operator's AFM contains certified data only for flap 40° landings but certified data for flap 26° landings provided by the manufacturer indicate that, at the accident aircraft's landing weight, Vthr/Vref is 8 kt greater than the certified flap 26° Vat.

The AFM Volume 2 states that the maximum threshold should be Vat plus 15 kt. AFM Volume 1 on the other hand states only that speed should be at Vthr when crossing the runway threshold at a height of 50 feet. None of the AFM Volumes contains a definition of Vthr or an explanation of the relationship between Vthr and Vat.

Operating procedures

Flap

The AFM Volume 2 specifies that on landing flap should be raised after the nosewheel has been lowered and GFP selected, but in the past this procedure has been considered a factor in cases of inadvertent gear-up selection. Some years previously the manufacturer removed from AFM Volume 1 the requirement to raise the flaps and the operator decided not to raise the flap after landing; however the procedure remains a part of the certified landing performance procedure in AFM Volume 2.

The primary purpose of selecting GFP after touchdown is to prevent turbine overheat during rollout and subsequent taxy at low forward speed. Certified landing data does not include credit for the use of GFP; however, AFM Volume 2 makes clear that the normal landing procedure is to select GFP as soon as the nosewheel is on the runway and that GFP will provide considerable braking effect.

Tests and research

The aircraft

Both ILS systems, both ASIs and both altimeters were functionally checked and calibrated and were all found to be working within the appropriate limits.

The brakes were successfully tested using the remaining internal pneumatic brake bottle pressure (main brake system). Good system pressure remained after several functions. Brake wear was on or close to the maximum limit on one unit, but was well within limits on the remaining three. All Maxarets were tested in accordance with the pre first flight of day inspection procedure. All brakes vented pressure and released correctly.

The full propeller function programme was carried out. All functions took place correctly. The propeller pitch change was noted to take place at the same speed on both sides. These functions were, however, carried out using the feathering pumps whereas the PCUs would be used during a normal landing. The PCUs were therefore removed and were each subjected to a full functional rig test at an appropriate overhaul facility. The units performed within specification in all areas relevant to ground-fine pitch selection.

Performance calculations

The investigation attempted to determine the actual stopping distance required for the aircraft, but the high landing speed was beyond the tolerances of the manufacturer's landing distance model. Calculations were therefore carried out using mathematical functions for lift, drag and propeller performance. The actual accident parameters for surface wind, flap position, runway characteristics, aircraft speed and weight were used and an assumption was made for the level of friction afforded by the wet runway and it was assumed that maximum braking was applied from touchdown.

The results of these calculations closely matched the deceleration rates recorded on the FDR and were very close to similar calculations carried out by the manufacturer.

The calculations revealed that the speed at touchdown was so high that, for the aircraft to remain in contact with the ground during the first 6 seconds of the landing roll, the lift from the wing had to be reduced. The only way this could be achieved without raising the flaps would be the use of forward control column. The result would have been a pronounced nose down attitude where the nosewheel would have taken most of the weight of the aircraft.

The manufacturer advises that when landing with considerable excess speed the pitch angle (angle of attack) in relation to the landing gear geometry may be such that the nose landing gear will touchdown first. Small angles of bank (in the order of 3°) might allow one main landing gear to be in contact with the ground simultaneously with the nosewheel, but in order for the aircraft to remain in ground contact nose down elevator would be required. Use of nose down elevator at high speed would prevent or delay main landing gear ground contact, and even after the speed had reduced sufficiently to allow three point contact the weight supported by the main landing gear would be insufficient to permit significant braking.

The calculations showed that the aircraft would have needed a distance of approximately 1,160 metres to stop and that if GFP had been used this distance would have been reduced to 639 metres. Further calculations using the certified flap 26° threshold speed of 87 kt, rather than the 95 kt recommended in AFM Volume 1, and a touchdown speed of Vref plus 19 kt, revealed that the stopping distance required in the conditions prevailing, without the use of GFP would have been 862 metres.

Additional information

Landing flap

The F27 has two landing flap positions, flap 26.5° and flap 40°. In January 1999 the operator's Flight Operations management directed that flap 26.5° should be used for all landings. This policy was introduced in response to a previous accident, which involved a loss of pitch control following selection of 40° of flap. The increase in landing distance caused by the use of the lower flap setting was considered acceptable for the operator's entire network. The Operating Staff Instruction (OSI), which introduced the policy, emphasised the importance of a stabilised approach, with landing flap and landing gear down by a minimum of 500 feet agl. The OSI also highlighted the decreased drag that flap 26.5° provided compared to flap 40° and the consequent reduced deceleration rates that might be expected in the later stages of an approach. It went on to state *'It is therefore essential that a stabilised speed be established early, in order to achieve a successful landing at the 1000 feet point of the runway at the correct landing speed*'. Both pilots involved in this accident had joined the operating company since the introduction of flap 26.5° for landing and neither had landed using 40° of flap.

PNF monitoring

In 1993 the operator introduced a Standard Operating Procedure (SOP) aimed at clarifying the monitoring role of the PNF and providing guidance on when a takeover of control might be appropriate. A table of maximum deviations was devised which provided a warning limit and an action limit for a range of flight parameters in different phases of flight. If the deviation reached the first limit the PNF was to give a verbal warning and if deviation continued with no sign of correction the PNF was to take control at the action limit. For excess airspeed the warning limit was set at plus 15 kt and the action limit at plus 20 kt. For ILS deviations the warning limit was set at half scale deflection and the action limit at full-scale deflection. In this accident the airspeed was 19 kt fast and the glideslope deviation more than 1 dot above the slope.

Analysis

General

The commander and FO were both properly qualified and adequately experienced for the flight. The aircraft, which was free from defects, was 4,643 kg below the maximum landing weight. At this weight (14,400 kg) the LDR of 1,018 metres was well within the LDA of 1,615 metres. No aircraft technical failures were discovered after examination of the wreckage. The airport ILS system was serviceable and had been recently calibrated and the runway friction characteristics were well above the minimum CAA requirements. The aircraft suffered damage consistent with a heavy landing having occurred, but there was no evidence of a heavy landing on the FDR, and it is concluded that the damage was caused as the aircraft traversed the lip at the end of the runway.

This analysis therefore concentrates on the contributions that may have been made by the weather, crew procedures and published performance data.

The approach

The approach was flown with flap 26.5° in accordance with operator's policy. Despite the warning of reduced deceleration rates in the OSI, the commander stated that he had not previously encountered difficulty in reducing speed during the latter stages of a normal approach.

The commander stated that he tried to reduce the speed for landing by reducing thrust but the speed remained high. A higher tailwind at altitude compared to that at the surface was considered as a possible factor, but the Meterological Office aftercast reveals that the wind at altitude veered from a slight tailwind at the surface to a slight headwind at 2,000 feet. It has not been possible to identify why the commander was unable to achieve the correct glideslope or landing speed.

The PNF tried to bring the commander's attention to the ILS glideslope deviation by calling ' four whites' in the latter stages of the approach. The PNF was therefore operating within the spirit if not to the letter of the operator's SOP on PNF monitoring. The PNF said he felt relaxed operating with the commander, but given the differences in the pilots' ages and experience the overall 'cockpit gradient' is high and it is understandable why the PNF was not more positive in his warning. However, a more positive comment might have prompted the commander to carry out a go-around. The SOP provides a useful guide to inexperienced crew members, but the warning limit for airspeed is set at 15 kt, which for landing is set at the maximum deviation for LDR calculations. A lower warning limit might be more appropriate.

Ground fine pitch

Analysis of both the CVR and FDR indicate the absence of GFP for the majority of the landing roll. Both crew members were convinced that GFP had been selected, but no fault could be found with the power lever selectors or the propeller controls, and the lack of a characteristic audible click on the CVR recording as the thrust levers move into the GFP range makes it probable that no selection took place at the correct point in the landing sequence.

It has not been possible to determine how GFP eventually came to be engaged; however, the point identified on the CVR recording where the engine RPMs increase slightly before continuing to decay is most likely the point where GFP was selected. This point is very close to the position where the aircraft struck the concrete plinth supporting the ILS monitor aerial, and it is therefore possible that the jolt as a result of hitting the plinth was sufficient to move the commanders right hand and one or both of the levers into GFP.

The Operations Manual requires the PNF to check and call that 'six propeller lights are illuminated and that TGTs and RPMs are falling' to confirm that the propellers have successfully gone into GFP. However, the Operations Manual does not contain a procedure for action to be taken by either crewmember in the event that GFP fails to engage or is mis-selected on a normal landing. In this particular accident it is possible that the overrun could have been prevented if a procedure had been available and followed.

Braking effectiveness

Both pilots remarked on the lack of retardation after landing. This is supported by FDR and CVR evidence and the audible operation of the Maxaret anti-skid units on landing. The possibility of aquaplaning was considered, but the rainfall rates in the hours preceding the accident were insufficient to create the amounts of standing water normally required for aquaplaning. The lack of any other evidence of aquaplaning on either the tyres or the runway makes it unlikely that aquaplaning took place.

The damage to the two right mainwheel tyres indicates that locking of the wheels took place at some stage whilst the aircraft was on the paved surface. The pattern of damage on each tyre indicates that the full weight of the aircraft was not on the wheels when the tyres locked. This, combined with the lack of identifiable tyre marks on the runway beyond the touchdown point, tends to point to the damage occurring in the early part of the landing roll. It has not been possible to determine why the damage was caused, but the left tyre on the right landing gear remained inflated and it is not considered that the damage to the tyres was a significant factor in this accident.

Performance analysis

The aircraft landed 19 kt above target Vref and 300 metres beyond the target touchdown point with about 1,000 metres of runway remaining. Nevertheless if GFP had been engaged at the normal place in the landing sequence the overrun would have been prevented despite the landing parameter excesses.

However, the long landing, excess threshold speed and lack of GFP were not the only factors in this accident. Calculations show that without the extra 8 kt introduced by using the AFM Volume 1 threshold speed the aircraft should have been able to stop without GFP in the distance available after touchdown even at a landing speed of Vref plus 19 kt. The fact that the flaps were not raised after landing was also a minor factor in increasing the landing distance.

The extra 8 kt was not the main cause of the accident but in combination with the excess speed above target Vref (19 kt) the aircraft was a total of 27 kt above the normal $1.3V_S$ speed (Vat). At that speed, with flaps remaining in the landing position and a forward centre of gravity, the calculations show that there could be little or no weight on the mainwheels for the first part of the landing roll. The wheelbrakes would therefore be ineffective and it is likely that the aircraft experienced 'wheelbarrowing' with only the nosewheel in contact with the ground.

In summary, the lack of GFP and the other inaccuracies in the landing parameters, together with the reduction in LDR tolerances as a result of using block threshold speeds and not raising the flap after landing, placed the aircraft in a part of the flight envelope never intended or tested for landing.

Causal factors

The following factors contributed to the accident:

a The landing was continued even though the airspeed was above the calculated threshold speed and touchdown was beyond the normal point.

b Ground fine pitch was not selected at the normal place in the landing roll, although the commander thought that he had done so.

c The AFM Volume 1 target threshold speed (Vthr) exceeded the certified threshold speed (Vat) by 8 kt.

d The flaps were not raised after touchdown which was not in accordance with the instruction contained in the Aircraft Flight Manual Volume 2.

Safety recommendations

The following safety recommendations were made during the course of the investigation:

Recommendation 2000-52

The operator should include in the Fokker F27 Operations Manual an Emergency Procedure to be followed in the event of failure or mis-selection of ground fine pitch during a normal landing.

Recommendation 2000-53

The CAA should require the manufacturer (Fokker Services B.V.) to correct the F27 Aircraft Flight Manual (AFM) Volume 1 speeds in accordance with the certified data in AFM Volume 2.

Recommendation 2000-54

The CAA should require the manufacturer (Fokker Services B.V.) to clarify the procedure for the retraction of flaps after landing, and amend the relevant volume of the F27 AFM accordingly.