Fokker 100, G-UKFN

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INCIDENT

Aircraft Type and Registration:	Fokker 100, G-UKFN
No & Type of Engines:	2 Rolls-Royce Tay 620-15 turbofan engines
Year of Manufacture:	1989
Date & Time (UTC):	24 October 1998 at 1537 hrs
Location:	Southampton Airport
Type of Flight:	Public Transport
Persons on Board:	Crew 5 - Passengers - 96
Injuries:	Crew None - Passengers - None
Nature of Damage:	No significant damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	6,523 hours (of which 1,516 were on type) Last 90 days - 128 hours Last 28 days - 33 hours
Information Source:	AAIB Field Investigation

History of flight

The aircraft was scheduled to leave Stansted Airport at 0750 hrs forthe first sector to Jersey Airport, however, the weather at the destination wasunsuitable and the flight was delayed. The crew that eventually operated the service came on duty at 1035 hrsto relieve the original crew. Theflight departed at 1319 hrs and arrived at Jersey about 1 hour later; itdeparted for Southampton at 1505 hrs.

Solent Radar positioned the aircraft downwind left for an ILS approachto Runway 20 at Southampton. Thecommander was the handling pilot and the autopilot and autothrottle wereengaged. At 2,000 feet amsl, the flightconditions were relatively smooth and visual contact with the ground was intermittent. Abeam the airfield the selected airspeed wasreduced to 220 kt. On the base leg, itwas further reduced to 180 kt when the first stage of flap was lowered. This was followed by a further reduction to160 kt when the landing gear was extended as the localiser was intercepted.

The second stage of flap was lowered when theglideslope was intercepted at 1,800 feet amsl, and the speed was selected to140 kt. The runway was visual fromabout 1,200 feet amsl and the windscreen wipers were selected on because thecrew assessed that they were in moderate rain. At about 800 feet amsl, land flap was lowered and the speed was selectedto 136 kt; the minimum allowable speed (Vma) + 10 kt.

The commander recalled that, at about 500 feetamsl, he noticed the Vma information disappear from the speed tape on thePrimary Flight Display (PFD). He sawthe indicated airspeed decay rapidly to about 120 kt, with the magenta trendvector down to about 115 kt. There wasalso a SPD LIM caption on the primary flying display (PFD) but neither pilotrecalled hearing the audio warning chime.

Withthe autothrottle still engaged, the commander moved both power levers fullyforward and disconnected the autopilot. At the same time he told the first officer to select the airspeed to 150kt. The aircraft accelerated rapidlyand he subsequently called for 136 kt to be reselected. Although the aircraft now appeared to beslightly high on the glideslope, the commander recalled seeing 3 whites and ared on the PAPIs, and he decided to land.

The touchdown was, the commander estimated,between 150 and 300 metres beyond the ideal touchdown marker and was lighterthan he would have liked on a wet runway. The spoilers deployed normally, reverse idle was selected and theautobrake, which was set to medium, initially appeared to provide sufficientretardation. It soon became apparentthat more retardation was required and so the commander over-rode the autobrakeand applied full pressure to his footbrakes. This did not appear to significantly increase retardation and so, at hisrequest, the first officer also stood on the pedals again with little or noeffect. The aircraft was rapidlyapproaching the runway end and the first officer suggested emergency reverse,which the commander selected. Theaircraft left the runway and came to rest between the runway end and thearrester bed.

The air traffic controller estimated that theaircraft had touched down about 300 metres past the ideal touchdown marker, adistance that was subsequently confirmed by several other witnesses. He was concerned enough to activate thecrash alarm as the aircraft passed taxiway Bravo. He declared a Full Emergency, which he upgraded to AircraftAccident when he saw that the aircraft had left the paved surface at the end ofthe runway.

There was little damage to the aircraft and thepassengers were evacuated in slow time using the normal exits.

Aircraft and componentexamination

The aircraft was examined by the operator after its recovery from theoverrun area. The wheels and brakeswere replaced and, after a series of preliminary checks, the aircraft wasferried empty to its maintenance base at Norwich. A more comprehensive programme of systems checks was then carriedout. These included operational checksof the flap and Attitude/Heading Reference Systems, visual inspection of theleft and right angle of attack (AOA) vanes for damage and freedom of movementand operational checks of those vanes. An operational check of the auto throttle system was also carriedout. No faults were found in any of theabove. The Flight Mode Panel (FMP) was removed from the aircraft andreplaced. The aircraft was returned toservice and performed satisfactorily thereafter.

The tyres and brakes, removed at Southampton, were examined. All tyres were within acceptable wear limitsand showed no evidence of aquaplaning or wheel locking. The brakes removed from the aircraft werealso within normal operating wear limits when pressurised in the workshop; noevidence of hydraulic leakage was noted and the rotors were free to turn afterpressure release.

The removed FMP was subjected to preliminary testing by the aircraftmanufacturer. A number of minor displayand selection deficiencies were noted, but when functionally tested by thecomponent manufacturer at their UK base, in the presence of an AAIBrepresentative, no significant operating problems were found. The latter tests were carried out usingAutomatic Test Equipment with the mode panel mounted on a vibrating table to ensurethat, as far as possible, any intermittent problems were identified. No evidence of any relevant defect could befound in the unit.

Meteorology

An aftercast obtained from the Meteorological office indicated that,at 1500 hrs there was a cold front approaching the Southampton area from thewest giving continuous rain which was moderate at times. No rainfall rate information was availablehowever the following amounts were recorded over the period shown:

1100to 1220 hrs	6.8 mm
1200to 1300 hrs	3.6 mm
1300to 1400 hrs	1.8 mm
1400to 1500 hrs	2.6 mm
1500to 1600 hrs	0.4 mm

Southampton info 'Echo' was current:

Runway 20 surface	Wet
Wind	230/11kt
Visibility	6,000metres
Weather	Rain
Cloud	FEW1,200 feet
	SCT2,000 feet

Temp/Dew point	+13°/+13°C
QNH	987mb

The post incident observation, made at 1550 hrs, was:

Runway surface	Wet
Wind	270°/14kt
Varying	210°to 320°
Visibility	6,000metres
Weather	Rain
Cloud	FEW700 feet
	SCT900 feet
Temp/Dew point	12°/12°C
QNH	987mb

The upper wind structure around Southampton wascomplicated by the passage of a trough across the area at the time of theincident. There was medium levelinstability just north of the airfield and reported heavy rain shortly beforethe aircraft touched down would also indicate embedded instability on thetrough.

The following estimate of the wind profile was basedon archived data:

Surface	270°/15 kt with gustto 30 to 40 kt
1,000feet	240°/40 kt
1,600feet	260°/50 kt
2,000feet	260°/50 kt

Note: Southamptonmay enjoy a sheltered position but surface wind gusts of 30 to 40 kt werereported at neighbouring locations.

When the aircraft made its final approach, thesurface wind had veered, or was in the process of veering, from 240° to 270°and there was a 25 kt shear between 1,000 feet and the surface.

The commander recalled that, when ATC gave a surfacewind check of 270/12 kt, the FMS wind at about 1,000 feet amsl was 240/40 kt.

The previous arrival was an HS125 aircraft that hadlanded at 1524 hrs. The commanderreported that, although there was some turbulence during the approach, he hadexperienced no significant windshear. The aircrafts anti-skid system had functioned during the landing roll,however there was no retardation problem. He concurred with the assessment of the runway condition as Wet. Once parked he had remained in the aircraftto complete the paperwork. He was aboutto leave the aircraft when there was what he described as a torrentialdownpour. He estimated that this hadstarted about 30 seconds before FN touched down. The air traffic control assistant who had carried out the lastairfield inspection before the incident was able to confirm that there had beena heavy rain shower shortly before 'FN' landed.

Aids tonavigation

The ILS DME on Runway 20 has a 3.1° glideslope, a localiser on204°(M). A VOR and NDB are situatedclose to the runway threshold. All aidswere serviceable. A complete routineFlight Inspection of the ILS was carried out on 3 November 1998 when itconformed to the required standards.

Airfieldlighting

The only airfield lighting relevant to this incidentare the PAPIs, which consist of four lights, situated to the left of therunway. They are set for a 3.0° visualglideslope and are checked regularly for accuracy.

Normally, if the aircraft is on the visualglideslope the pilot will see the inner pair of lights red and the outer pairwhite. When the aircraft is on the ILSglideslope the aircraft is slightly above the visual glideslope and theinnermost light is red and the remainder are white. This was confirmed by the Lighting Inspection Report associatedwith the ILS Flight Check on 3 November 1998.

Runwaycharacteristics

Runway20 is 1,723 metres long and 37 metres wide. The touchdown threshold is displaced 45 metres and its elevation is43 feet. The runway has a slight downslope of about 0.23%. The declareddistance available beyond the threshold for landing is 1,605 metres. There is a 60 metre long paved area beyondthe runway end and a 90 metre Runway End Safety Area. There is a soft ground arrester bed 19.5 metres beyond the pavedarea. The M27 motorway runs along theairport boundary fence that is just beyond the arrester bed.

The runway was constructed in the mid 1960s andhas a brush finished concrete surface. Whilst it remains in good condition the surface characteristics,particularly the tendency to slow draining of standing water in heavyrain, have imposed significant operating penalties on modern jet aircraft. The Airport Authority carried out a thoroughreview of their options as regards the runway surface.

An immediate decision was taken to improverainfall run-off by transverse grooving of the surface with grooves 3 mm wide,3 mm deep and 6 mm apart. This workstarted soon after the incident and runway refurbishment was completed in April1999.

Runway stateassessment and reporting

When water is present on the surface frequent inspections aremade to determine the runway state. Thenormal frequency is at 30 minute intervals, however, this can be increased ifrainfall intensity increases. Theassessments are recorded in the ATC Watch Log. Runway state is reported in accordance with the table reproduced belowwhich is found in MATS Part 1, Section 9, Chapter 2:

Description	Runway Appearance
Damp	When the surface shows a change of colour due to moisture.
Wet	When the surface is soaked, but no significant patches of standing water are visible.
Water patches	When significant patches of standing water are visible.
Flooded	When extensive standing water is visible.

Water patches will be reported when between 25% and50% of the runway is covered with patches of water of any depth or 25% or lessof the runway surface is covered by water patches exceeding 3 mm in depth. Depth measurements are taken about 3 metreseach side of the runway centreline in each third of the total runway length. The runway is considered to be Flooded ifmore than 50% of the runway is covered by water patches of any depth.

Following review by SRG Working Group, a revised reportingscheme for wet runways was incorporated in the AIP amendment AIRAC 7/99(effective date 15 July 1999), which was distributed in early June. The AIC addressing the Risks and FactorsAssociated with Operations on Runways affected by Snow, Slush or Water,incorporating the revised reporting scheme, was reissued on 3 June 1999(AIC 61/1999 Pink 195).

The following runway assessments were recorded in the ATCWatch Log:

1255hrs Water patches80%, > 3 mm depth

1330hrs Water patches< 25%, < 3 mm depth

1356hrs Wet

1436hrs Wet

1522hrs Wet

A post incident runway inspection was carried out between 1540 and1610 hrs. Depth of water measurementswere taken every 20 to 30 metres and it was assessed that more than 25% of therunway was covered by water patches which were less than 3 mm deep.

Flight recorders

The Cockpit Voice Recorder(CVR), a 30 minute recycling model A100, and the Flight Data Recorder (FDR), aSundstrand UFDR, were replayed by the AAIB.

The aircraft was descending on the glidepath at around 700 feet amsl,with the autopilot engaged and the lift spoilers armed. The airspeed was around 148 kt CAS withvariations of ±7 kt in the turbulent conditions. With the autothrottle engaged, the power began to decrease toidle N1 (35%) on both engines. From theCVR, the crew at this stage commented that they had noticed the loss of the Vmaindication. Figure 1 shows a plot ofheight AAL, airspeed and groundspeed together with the derived headwindcomponent and the autothrottle response. At about 600 feet agl the airspeed decreased to about 130 to 135 kt CASfollowing which the power, controlled by the autothrottle, began to increaseagain. The groundspeed showed a derivedheadwind which increased from 4 kt to 14 kt over 4 seconds. There was then a decrease in the derivedheadwind to 1 kt over the next two seconds. The airspeed continued to decrease, reaching a minimum of 119 ktCAS. The autothrottle clutch engageddiscretes, recorded by the FDR then showed an intermittent indication. This was due to the crew overriding thepower levers thereby declutching the autothrottle. The autopilot was disengaged 5 seconds later. The airspeed increased to about 140 kt IAS.

The aircraft continued the approach and touched down at an airspeed of136 kt CAS, the lift spoilers were deployed and reverse idle was selected. The corrected initial deceleration level was-0.18g, which agreed with the medium autobrake deceleration target of $-1.8\ m/s^2$. Twelve seconds after touchdown there was an indication from the crew, onthe CVR, that they had taken over with manual braking and there was a call offull reverse ten seconds later. Fromthe FDR, at 102 kt CAS, there was an increase from reverse idle power 13seconds after touchdown, to a maximum power level of 89% N1 20 seconds after touchdown. There was then an increase in thedeceleration level to around 0.4g and the aircraft came to rest 28seconds after touchdown on a heading of 187°M. No braking parameters were recorded on the FDR.

Autothrottle behaviour

The autothrottle control law generates a throttle command for both thespeed error (the airspeed target selected on the FMP minus actual airspeed) andthe alpha floor protection. The greaterof the two commands is then used to adjust the throttles. The alpha floor protection uses average AOAfor the minimum allowable speed (Vma) calculation. If the difference between the two AOA vanes is more than 2.6° formore than 0.5 seconds the Vma calculation becomes invalid and only the speederror throttle command is used. Theloss of Vma results in the loss of under speed protection and the Vma relatedlimit on speed selection no longer applies.

Flight simulation

In order to understand the behaviour of the autothrottle during theapproach below 700 feet the aircraft manufacturer performed simulations of theautothrottle control law. The initialassumption was that the crew had inadvertently misselected a the targetspeed and the autothrottle had responded to this value when minimum speedprotection was lost. Aircraft pitchattitude, CAS and longitudinal acceleration were used from the FDR and theoutput of the simulation was the autothrottle command. The initial simulations looked at threescenarios, from an initial target speed of 155 kt CAS, the target speed waschanged to 135, 125 and 115 kt CAS. Thescenario that most closely followed the autothrottle response of the FDR waswhen a speed target of 115 kt was selected.

The wind profile and the sudden torrential downpourindicated that there was a significant storm cell probably centred over orslightly to the west of the airfield. Under these conditions it is possible that a windshear profile existedwhich was more complex than a simple reduction of headwind component. During the incident flight the derivedheadwind component was noted to increase by 10 kt over 4 seconds followedby a 13 kt decrease over the next 2 seconds. Although there is a limit to the confidence which can be placed on thederivation of a wind component in such circumstances, the Type CertificateHolder was asked to consider the possibility that the aircraft had initiallyencountered a sudden increase of headwind component which would have caused atransient increase of CAS, followed by a decrease of CAS caused by a reductionof headwind components.

A fixed-base engineering simulator was then used to investigate variouswindshear profiles. To provide a datumfor comparison, a target speed misselection of 116 kt was used, and anairspeed reduction to 119 kt again was demonstrated. For the windshear profile an initial wind of240°/30 kt, increasing to 240°/40 kt at 750 feet (co-incident with the AOAmismatch) and changing to 270°/30 kt at 650 feet was used. The target speed selected was 136 kt. This simulation also showed an airspeed dropto 119 kt, or below. This scenario wasalso demonstrated without the AOA mismatch and the airspeed still reduced to119 kt. These simulations demonstrated that a combination of windshears,firstly increasing the headwind component and then reducing it, could alsoproduce the loss of airspeed seen in the incident.

The Type Certificate Holder then carried out a moredetailed performance estimation using the FDR data and the ATS control laws, inorder to model the speed selection profile. The required inputs are not recorded and therefore this necessitatedtheir derivation from the FDR accelerations. These were corrected by comparison of the integrated accelerations andvelocities with the recorded FMS ground speed and Drift Angle. These latter parameters, however, havesubstantial filtering applied. Usingthe corrected acceleration and velocity components the response of the ATS wassimulated, using the full set of control laws, for a number of selected targetspeeds. This more detailed analysisshowed that the selected target speed profile could be established, but onlywithin a tolerance band due to the limitations of the recordedinformation. However it did show thatthe selected speed was 160 kt until the selection of land flap. The crew stated that the 140 kt selectionwas made with the second stage of flap. The analysis showed a further anomaly in the prediction of the selectedspeed, which reduced to 140 kt for a period of 2 seconds before returning to160 kt. This brief reduction couldrepresent an intentional selection which was immediately undone, or aninadvertent speed hold mode entry which could result from pushing in the speedselect knob while making a selection. It remains a possibility than the anomaly was caused by switchingbetween speed select and speed hold mode and the Type Certificate Holdercontinues to look at the possibility of a system-generated step.

Following the land flap selection the analysis furthershowed that the target speed became 140 kt, and then reduced further to 116kt. The timing of this reduction couldnot be accurately determined. Thetarget speed reduction occurred at least one second, but possible four secondsbefore the autopilot 2 became engaged, and at least 10 seconds beforeLAND2 was annunciated.

Aircraft landingperformance

A double integration was performed from the FDR recording oflongitudinal acceleration in order to calculate the stopping distance, andtherefore the touchdown point. Thetotal ground run was calculated as 1,085 metres from touchdown to the aircraftcoming to a complete stop. Thetouchdown point was therefore estimated to be 600 metres from thethreshold. This figure is consistentwith the eye witness accounts of the touchdown being about 300 metres past theideal touchdown marker.

Assuming medium autobraking with constant deceleration of0.18g and a brake application speed of 132 kt CAS, the aircraft manufacturercalculated that the aircraft would have required 1,280 m to come to a fullstop.

The aircraft manufacturer also provided landing ground rolldistances assuming the following conditions:

Flap 42°;   lift dump deployed;   aircraft wt: 37,500 kg;   pressure altitude 700 feet;

OAT 14°C;   no wind;   no slope.

No time delays were used for lift dump deployment, brake applicationand reverse selection. The brakeapplication speed was 132 kt CAS. Reverse was assumed to reduce to idle reverse at60 kt CAS. The wet runwaycoefficient was 0.5 x the dry runway.

It was not possible to define the precise condition of therunway during the landing roll but it is evident that it was somewhere between'Wet' and 'Flooded'. The aircraftmanufacturer calculated the following stopping distances for full braking andreverse idle:

Wet runway	854metres
Flooded runway	1,764 metres

Ifnormal maximum reverse thrust had been selected immediately after touchdown thedistances would have been:

Wet runway	827metres
Flooded runway	1,667 metres

Summary

The initial set of simulations made the assumption that the crew hadinadvertently selected a target speed below that required and that theautothrottle had responded to this value when minimum speed protection waslost. The scenario that most closelyfollowed the autothrottle response of recorded on the FDR was when a targetspeed of 115 kt was selected. It wouldhave been surprising if such a gross mis-selection had been made by the crew ata stage when they were visual with the runway and all was apparentlynormal. When interviewed after theincident, both flight crew members reported that the target speed had beenselected to 136 kt when the flap had been selected to the land position,however, there was no evidence from any other source either to support orrefute this.

The second set of simulations suggested that there was a combinationof windshears that could result in the loss of airspeed seen in theincident. In this scenario the loss ofminimum speed protection would not have been a factor as the autothrottlereference would have been the selected speed.

The third set of simulations led to a predicted sequence of targetspeed selection within the limitations of the data available. It was not possible to reconcile thissequence with the selections reported by the crew. Neither was it possible to exclude an anomalous target speedgenerated by the system, or errors produced by intermittent switching betweenspeed select and speed hold modes. TheType Certificate Holder is continuing to look at the possibility of a systemgenerated step.

The loss of minimum speed protection appears to have been the firstthing the commander noticed and it was this that drew his attention to thereducing airspeed. The atmosphere onthe flight deck had been relaxed up to this point, however, the distraction andapparent loss of confidence in the autoflight system led him to disconnect theautopilot and attempt to override the autothrottle. These events led to a destabilised approach and, although theaircraft had recovered the normal approach path prior to the landing flare, thespeed was still high and the aircraft eventually touched down at Vma + 10 kt.

The evidence suggests that the runway assessment prior the incidentwas correct but a heavy rain shower, shortly before the aircraft touched down,had caused a rapid deterioration in its condition to somewhere between Wetand Flooded.

The aircraft had landed lightly and fast, about 300 metres beyond theideal touchdown marker, leaving some 1,000 metres of landing runavailable. The landing ground rolldistances calculated by the Type Certificate Holder indicate that, had fullbraking been applied immediately, the aircraft would have stopped in 854 metreson a Wet runway. On a runway betweenWet and Flooded, with the retardation technique used on this landing, anoverrun was inevitable.

The commander had experienced no retardation problem during thelanding in similar conditions at Jersey and had accepted the Southampton runwaycondition as Wet. He did not appearto have any doubts about stopping the aircraft in the runway remaining after touchdownand consequently showed no sense of urgency in applying maximumretardation. Nor had he consideredcarrying out a missed approach, probably for similar reasons, although thiswould have been an available option.

Despite the fact that it may have had limited effect, oncethe decision to continue the landing had been made, it would have been prudentto have over ridden the auto-brake system, applied full braking and selectedmaximum reverse thrust immediately after touchdown.