ISS 0803-3633

THE AIRCRAFT ACCIDENT INVESTIGATION BOARD/NORWAY (AAIB/N)

REP.: 05/96

REPORT ON THE AIR ACCIDENT AT ÅLESUND AIRPORT VIGRA, NORWAY 5 JANUARY 1995 WITH FOKKER F-27 MK 50, REGISTRATION LN-BBA

SUBMITTED MAY 1996

REPORT ON THE AIR ACCIDENT AT ÅLESUND AIRPORT VIGRA 5 JANUARY 1995 WITH FOKKER F-27 MK 50, REGISTRATION LN-BBA

Aircraft type:	Fokker F-27 MK 50
Registration:	LN-BBA
Owner:	Prime Aviation A/S c/o Chemical Bank, Norge A/S
User:	Norwegian Air Shuttle A/S P.o.Box. 115, N-1330 OSLO LUFTHAVN, NORWAY
Crew:	2/1
Passengers:	35
Accident site:	100 m south of runway 25, near taxiway D at Ålesund Airport Vigra, 62° 33'N 006° 06'E
Time of accident:	5 January 1995 at 1858.

All times given in this report are local times, if not otherwise stated.

NOTIFICATION

Aircraft Accident Investigation Board, Norway (AAIB/N) duty Inspector was informed by the Operations Center of Oslo Policeoffice at 2200 hours on Thursday 5 January 1995 that a scheduled flight with 35 passengers into Ålesund Airport Vigra had veered off the runway after touch-down. There were no injuries to passengers or crew. AAIB/N started preparations to go to the accident site, and contact with Airport Authorities and Civil Aviation Authorities Norway (CAA/N) was established. AAIB/N personnel arrived at Vigra at 0800 hours on Friday 6 January.

The Netherlands Aviation Safety Board appointed an Accredited Representative who with assistance from experts from the aircraft manufacturer has supported AAIB/N in the investigation.

SUMMARY

SUMMARY

LN-BBA was landed in a crosswind on runway 25 at Ålesund Airport Vigra. Shortly after touching down the crew lost directional control. The aircraft turned off the runway and onto uneven ground. In spite of extensive damage to fuselage, landing gear, right propeller and nacelle, there were no injuries to persons on board. The investigation has not disclosed any technical problems that could have any bearing on the accident. The accident was caused by utilization of erroneous procedures for landing in a crosswind.

1 FACTUAL INFORMATION

1.1 History of the flight

1.1.1 The airline Norwegian Air Shuttle (NAS) is leased by Braathens SAFE A/S on a three year contract to operate some segments of the latter company's schedule.

1.1.2 LN-BBA started operations on 5 January 1995 with flight designation BRA 247 on an IFR flightplan covering Bergen, Molde, Kristiansund to Trondheim Airport Værnes. From Værnes the schedule was turning south again, now as Flight BRA 314. First landing after taking off from Værnes was Ålesund Airport Vigra. From there on the flight was scheduled to go to Bergen and Haugesund.

1.1.3 The crew, 2 pilots and 1 cabin crew, started their duty at Bergen Airport Flesland at 1520. Before checking in, the first officer collected weather information and checked NOTAM. This information was then brought to the pilot in command.

1.1.4 The flight northwards from Bergen to Trondheim was normal with moderate turbulence and light surface winds for all landings until the landing at Værnes. At Værnes the wind was registered to be from 160° at 29 kt, gusting 41 kt. The first officer was the pilot flying (PF) on this segment and carried out the landing in severe turbulence and a strong crosswind. The landing runway at Værnes was 09. The landing was uneventful.

1.1.5 LN-BBA departed Værnes at 1813 carrying 35 passengers. The pilot in command was now the pilot flying (PF). The take off was performed in a strong crosswind and the climb-out was made in moderate to severe turbulence. Reaching higher altitude the turbulence was decaying.

1.1.6 During the first part of the approach to Vigra the crew updated their weather information. They received ATIS confirming information already obtained at Flesland and Værnes. Vigra Tower (TWR) complemented the information with actual weather at first radio contact. Cloud base was at approximately 6 000 ft, no precipitation and unlimited visibility, the wind from 190° at 25 kt. The forecast from Weather Service at Flesland about severe turbulence at 5 000 ft was repeated.

1.1.7 The descent from cruising level FL 170 was normal. Descent- and Approach-Check-Lists were completed. The pilot in command briefed on approach procedures and how he wanted navigation equipment configured. At approximately 6 000 ft the crew had the field in sight. This was reported to Vigra TWR, and LN-BBA was cleared for a visual approach and landing on RWY 25. The autopilot was disconnected at 1 500 ft and the continued flight was handled manually. Landing gear was extended and locked in normal position. Flap was initially set to 10°, later extended to the normal landing configuration of 25°.

1.1.8 The flight between Værnes and Vigra was direct to the loalizer for RWY 25. The inbound tracking of the localizer for RWY 25 is 237° M (magnetic). The significance of this is that the course is off-set 11,5° from the runway direction which is 248,5 °M. The reason for this is high terrain NE of Vigra. The pilot in command initially tracked the localizer inbound. Reaching Final Approach at 1 300 ft, he changed the course to track the extended runway centerline. To follow this track in the crosswind, a crab angle of approximately 15° into the wind was required.

1.1.9 Due to the wind the crew decided to increase threshold speed (Vref) of 100 kt with an additional 5 kt to 105 kt. The Vref was taken from the instrument "Fuel Flow/ Aircraft Weight Indicator", where Fuel Flow and Vref for actual weight and 25° flap is indicated. The difference between indicated airspeed and the corrected Vref was called out by the first officer during Final Approach. This is a procedure which differs from the company's Aircraft Operating Manual (AOM), Standard Operating Procedures (SOP), item 7.01.01.

1.1.10 Maximum demonstrated crosswind-component for this aircraft type is 33 kt. During the final part of the approach the crew received repeated wind information. During the last 2 minutes before landing, Vigra TWR announced actual wind 8 times: 190°/36, 190°/30, 190°/27, 180°/26, 180°/26, 190°/28, 190°/28, 180°/25. The last announcement came 2 seconds before the aircraft touched down. The aircraft passed runway threshold at normal height.

1.1.11 During the time span of 2 minutes and 40 seconds before the aircraft came to a full stop, the heading was initially 235°M. At an altitude of 1 300 ft the A/C heading was gradually changing to 215°M. During the continued approach the heading again changed to reach a maximum of 240°M. This is indicative of a crab angle into the wind varying between 12° and 22° for the time period the aircraft was tracking the localizer (course 237°M). After stabilizing on the centerline to runway 25, the crab angle was varying between 18,5° and 10,5°. The touch-down was at a heading of 238°M (runway direction 248,5°M), with a crab angle of 10,5°. Thus the aircraft was landed with approximately 10° skid.

1.1.12 Descending through 2 200 ft the airspeed (IAS) was 190 kt and decreasing. Flaps 10° was selected when the IAS had reached 175 kt, and flap to 25° was set at an IAS of 157 kt. This flap position was maintained for the remainder of the approach. For the last 6 seconds before touch-down the IAS was varying from 114 kt down to 98 kt, back up to 111 kt and down to 95 kt which was the speed at touch-down.

1.1.13 Shortly after touch-down the nose-wheel was lowered to the runway. The throttles were moved from Flight Idle to Ground Idle. The pilot in command then transferred his left hand from the control wheel to the nosewheel steering tiller and initiated directional control by nose wheel steering. The first officer took over the control wheel with a full left (into the wind) aileron deflection. According to his recollection it is possible that the control wheel for a moment came to neutral position during the transfer of controls, before he again established full deflection.

1.1.14 The pilot in command felt that the aircraft was affected by a "force" starting a left turn he could not control, either using flight controls or using brakes and nose wheel steering. A pronounced vibration was felt which by the crew was perceived to come from the nosewheel.

1.1.15 The aircraft touched down twice. Following the first touch-down on the runway centerline, (the aircraft was airborne again for approximately 2 seconds before making the final landing.) For about 3,5 seconds following the first touch-down the aircraft heading remained near constant before a turn to the left started. From then on the aircraft continued turning left until it came to rest, where the aircraft longitudinal axis was recorded at 203°M.

1.1.16 When the pilot in command realized that he had a serious problem with directional control, he stated he applied full wheel brake pedal pressure. The aircraft brakes are equipped with an anti-skid mechanism. The pilot in command stated that differential braking was not used, neither was asymmetric use of engine/propeller thrust attempted. Reverse thrust is indicated (on the FDR printout) approximately 4 seconds after the first touch-down.

1.1.17 After traversing 300 m along runway 25 the aircraft crossed the runway shoulder, traveled across even ground covered with short grass for about 70 m before crossing taxiway D. From the edge of the taxiway the ground was rough with shrub and rocks. The aircraft came to rest about 20 m from the taxiway after suffering failure of the right main landing gear which had been bent backwards, and right hand propeller had contacted the ground (See Appendix 2). When the pilot in command realized that the aircraft was going onto rough ground, he cut fuel supply to both engines. From the initial touch-down until the aircraft stopped it took 17 seconds, ground speed decreasing evenly most of the time.

1.1.18 When the aircraft stopped, On Ground Emergency Check List was carried out and the passengers and crew evacuated through two exits in an orderly manner with no indication of panic. The two exits used were the main forward left hand passenger door, and a smaller door at the rear right hand side of the cabin. Opening the doors and assisting the passengers was taken care of by the first officer in the forward part of the cabin, and by the hostess in the rear part of the cabin. One disabled passenger was given assistance by the two crew members to evacuate the aircraft. The first officer tried to open the forward right hand door, but this exit was blocked by the branches of a tree.

1.1.19 The pilot in command reported via radio to Vigra TWR that assistance was required. He then inspected the cabin before leaving the aircraft.

1.1.20 Airport emergency personnel arrived on the scene shortly.

1.2 Injuries to persons

INJURIES	CREW	PASSENGERS	OTHERS
FATAL			
SERIOUS			
MINOR/NONE	3	35	

1.3 Damage to aircraft

The aircraft was extensively damaged in the accident.

1.4 Other damage

Airport or airport facilities were not damaged to any degree.

1.5 Personnel information

1.5.1 <u>The pilot in command</u>

1.5.1.1 The pilot in command, male, 48 years, was hired by NAS 1 February 1993. Before that time he was employed by the airline Busy Bee of Norway A/S. The pilot in command had a total of 11 789 flying hours, of which 3 245 hours were on this type of aircraft. He possessed an ATP license with one personal limitation: "Must have reading glasses available".

1.5.1.2 The pilot in command had received his initial training at American Aviation, USA. His most recent PFT was carried out on 26 September 1994.

1.5.1.3 His working day had started with a transfer as passenger from Oslo Airport Fornebu to Bergen Airport Flesland on the day of the accident. His flying duty started out of Flesland 1520 with BRA 247. The pilot in command had been awake for about 10 hours, after a night of normal sleep, when the accident took place at Vigra.

1.5.1.4 Flying experience

FLYING EXPERIENCE	TOTAL	ON TYPE
LAST 24 HOURS	2:25	2:25
LAST 3 DAYS	10:17	10:17
LAST 30 DAYS	31:33	31:33
LAST 90 DAYS	163:00	163:00

1.5.2 The first officer

1.5.2.1 The first officer, male, 35 years, was hired by NAS 1 February 1993. Before that time he had been employed by the companies Partnair A/S and Busy Bee of Norway A/S. His total flying experience was 6 429 hours, of which 1 468 were on the actual aircraft type. He possessed ATP-license.

1.5.2.2 The first officer had received his initial training at South West Institute of Aviation, USA. His most recent PFT was held 17 September 1994.

1.5.2.3 His working day on 5 January 1995 started 1245 with a transfer as passenger from Oslo Airport Fornebu to Bergen Airport Flesland. His flying duty started out of Flesland 1520 on flight BRA 247. He had been awake for approximately 11 hours, after a night of normal sleep, when the accident took place at Vigra.

1.5.2.4 Flying experience

FLYING EXPERIENCE	TOTAL	ON TYPE
LAST 24 HOURS	2:25	2:25
LAST 3 DAYS	10:17	10:17
LAST 30 DAYS	31:33	31:33
LAST 90 DAYS	163:00	163:00

1.5.3 Cabin crew

The cabin attendant, female, 23 years, had been employed by NAS since 1 March 1994. She was a holder of cabin attendant license issued 17 March 1994, valid until 7 March 1999. She resides in Bergen, and her working day started when she checked in for duty with flight BRA 247 departing 1520.

1.6 Aircraft information

1.6.1

Registration:	LN-BBA
Manufacturer:	Fokker Aircraft B. V. The Netherlands
Model:	Fokker 27 MK 50
Serial Number:	20 130
Year of manufacture:	1988
Engines:	2 Pratt and Whitney PW 125B
Propellers:	2 Dowty Rotol six-bladed, reversible-pitch, constant speed
Certficat of registration:	No. 2372, issued 26 January 1993
Certificate of Airworthiness:	No. 2372, valid until 30 September 1995.

1.6.2 According to aircraft records all maintenance had been carried out in conformance with regulations and the authorized company maintenance program.

1.6.3 The Maximum Take-Off Weight (MTOW) for the aircraft is 20 820 kg. Actual weight at departure from Værnes was 18 417 kg, and landing weight at Vigra was 17 917 kg. The center of gravity was within limitations.

1.6.4 Before departure 2 351 kg of Jet A-1 was uplifted. At landing 1 850 kg of fuel was remaining on board.

1.7 Meteorological information

1.7.1 AAIB/N received the following report from the Meteorology Service Office at Flesland:

> "Wind condition at Vigra at the time of the accident, 5 January 1995 1758 UTC.

It was a strong south-southwesterly wind in the area around Vigra. Wind at 2 000 ft was S/25-40 kt, locally 45-60 kt (see IGA). Wind at 7 000 ft was 230/45 kt, increasing to 70-80 kt.

Surface wind was 180/20 G 33 kt at 17:50 UTC and 180/28 G 38 at 18:50 UTC.

The wind recorder indicated gusts approaching 40 kt around the time of the accident.

A SIGMET had been issued forecasting severe turbulence locally below FL 070.

There was no precipitation, a high cloud base, and the runway was dry."

1.7.2 The crew obtained weather information covering Vigra from the Meteorology Service Offices at Flesland and Værnes.

1.7.3 Actual weather at Vigra at landing time, 1858, was: Wind 190°/26 kt, visibility more than 10 km, scattered clouds at 4 500 ft, partly clouded at 6 000 ft, temperature +6 °C, dewpoint -7 °C, QNH 1 001 hPa.

1.7.4 The printout from the wind recording (see Amendment 5) is indicating velocities approaching 40 kt 8 minutes before and 7 minutes after the landing, wind direction remaining relatively constant. At the time of the landing of LN-BBA, the maximum wind velocity recorded is about 30 kt.

1.7.5 The crew experienced decreasing turbulence from 1 500 ft downward.

1.7.6 It has been reported to AAIB/N that at times of strong surface winds from south, air eddies have been observed moving across the field without any related recordings on the wind meter. No such activity was observed at the time of the actual landing.

1.7.7 Reported weather- and wind information has been subject to analysis by a meteorologist consulted by AAIB/N. His report:

"The wind meter at Vigra has been manufactured by Vaisela in Finland. This type is in use at a majority of airports in Norway. It is considered very reliable. The meter records at intervals of two seconds, meaning that a gust of three seconds duration, or longer, would be evident in the recording.

The radio-sonde ascension at Stavanger Airport Sola 5th January 1995 at 1200 hours UTC is indicating an overadiabatic vertical temperature gradient for the lower 200 to 300 m, (-1,1 °C/100 m), see Appendix 7. The importance of this is that the air closest to the ground was unstable. At Sola the surface temperature was +2 °C, at Vigra it was +7 °C. Dewpoint at Vigra was -9 °C, giving a spread of 16 °C. This again means that the air mass near the surface at Vigra has been subject to strong downward currents causing instability to a higher degree than found over Sola. The strong southerly wind, about 50 kt below 8 000 ft, must have given the air mass above Vigra the same qualities as the air above Sola. This should give the air mass near the ground at Vigra a strong overadiabatic stratification. This condition is favorable for creation of eddies near the surface, so-called "dust devils". They develop rapidly, and also die away quickly. The buildings at Vigra are located relatively near the eastern end of the runway, a distance of 200 to 250 m. In situations with strong southerly winds and landings on RWY 25, the buildings have potential for changing airflow around themselves. This may influence the landing conditions when RWY 25 is in use with strong southerly winds. With the unstable air stratification near the ground at Vigra this day, it is a relatively high risk that the buildings may have initiated wind eddies. This applies in particular to the west side of the tower. The tower is 24 m high, while the rest of the buildings are of varying height, see Appendix 8. There also is an open area of about 20 m between the firestation and the airport service building.
A possibility exists that a venturi effect may develop in this area. What is in contradiction with this possibility is the fact that no gust was recorded at the time of the landing. However, the wind meter is located about 125 m. north of the runway, and an eddy of small extension could very well escape the meter or disappear before reaching that far."

1.8 Aids to navigation

1.8.1 No anomalities have been reported.

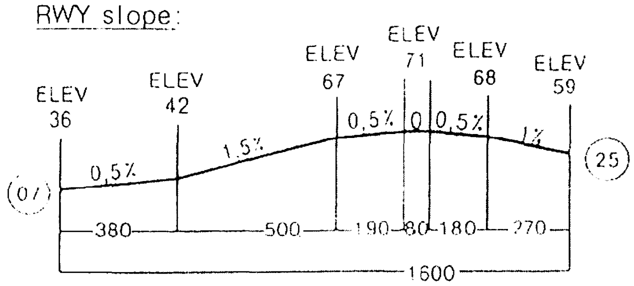
1.9 Communications

1.9.1 No anomalities have been reported.

1.10 Aerodrome information

1.10.1 Runway 25 at Vigra was 1 600 m long and 45 m wide. The surface is grooved asphalt. When LN-BBA landed the runway was bare and dry.

1.10.2 The runway at Vigra has a curved profile. In particular, when approaching RWY 25 one may get an impression of landing "uphill" and that the runway was short.



1.10.3 Operations at the airport were normal at the time of the accident.

1.10.4 Immediately after the accident the runway was inspected, no irregularities were found. It was confirmed that the surface was dry.

1.10.5 The aircraft went outside the runway shoulder designed to support the weight of the aircraft. Only the last part of the roll-out, on rough ground about 100 m from the runway centerline, did inflicted structural damage to the landing gear and fuselage.

1.10.6 The wind meter is situated on the north side of the runway opposite of the TWR at a distance of appr. 100 m from the runway centerline.

1.11 Flight recorders

Flight Data Recorder (FDR)

The aircraft was equipped with a Sunstrand part number 980-4100 FWUS FDR. It was installed in the empennage.

Following parameters were recorded:

- time
- torque left hand engine
- torque right hand engine
- propeller RPM left
- propeller RPM right
- total air temperature

- flap position
- heading, magnetic
- pitch angle (longitudinal axis)
- roll angle
- vertical acceleration
- pressure altitude, coarse
- pressure altitude, fine
- air speed
- yaw damper engaged/disengaged
- transponder code
- autopilot engaged/disengaged
- blade angle, left propeller (high/low)
- blade angle, right propeller (high/low)
- weight-on-wheel, left main gear

This model FDR has capacity to store a higher number of parameters. However, according to the applicable regulations, only the above listed are mandatory for aircraft with a MTOW of 27 000 kg. For aircraft types with a MTOW of more than 27 000 kg, the FDR is required to also record, among other data, the position of the control wheel or the aileron, and the rudder or rudder pedals position.

The specifications of parameters to be recorded by the FDR are not included in airworthiness requirements applicable to (type) design (e.g. JAR 25), but in operations regulations (e.g. JAR-OPS 1 and ICAO Annex 6) imposed on the aircraft operator. These international requirements may be augmented by national requirements, also imposed on the aircraft operator. The role of the aircraft manufacturer in this is to provide certificated recording equipment that the aircraft operator needs or wants. Notwithstanding a trend to install expanded recording systems primarily for flight operations evaluation, still many operators decline to spend money on acquisition and maintenance of recording equipment that is not required by their operating regulations.

AAIB/N sought assistance from Air Accident Investigation Branch (AAIB) i U.K. to read and print FDR-data. All recordings were found satisfactory and in corformance with regulatory requirements.

1.11.1 Cockpit Voice Recorder (CVR):

The aircraft was equipped with a Fairchild (Western Systems) part number 93A 100-80 CVR, also installed in the empennage. Four sound channels are recorded, voice via the captain's microphone, voice from the first officer's microphone, voice from the public address (PA) system, and sound from an area microphone catching environmental sounds in the cockpit. The CVR was brought to AAIB in the U.K.

for processing. It was found to have worked as expected, and communications and other sounds had been registered satisfactory.

1.12 Wreckage and impact information

1.12.1 The accident site

The aircraft came to rest 20 m from taxiway D (see Appendix 2). It was brought to a stop at this position mainly as a consequence of the rough ground. The aircraft had lost most of its speed before entering this area. It came to rest on the edge of a grass covered landfill next to the taxiway. The right hand landing gear hit large rocks which are part of the landfill. The nose section of the fuselage ran into lower, marshy ground, outside the elevated area. This transferred the weight of the aircraft, normally carried by the landing gear, to the belly section of the fuselage, which suffered extensive structural damage.

1.12.2 The aircraft

In their damage assessment report, the manufacturer used the expression "substantial damage". The damage to skin and stringers in the belly region of the fuselage was extensive. Also skin on the fuselage sides had been loaded to a point where it had developed wrinkles. The right hand wing, engine and propeller were damaged. Right hand main gear had folded backwards. The right wing was in contact with the ground and had suffered damage to the leading edge and the skin on the under-side. Right engine nacelle had been damaged, the engine had no visible signs of damage. The right hand propeller had lost the outer third of all six blades when hitting the ground. Left hand wing, engine and landing gear had no visible damage. Due to the uneven ground the left hand landing gear was suspended in the air.

The aircraft was salvaged from the accident site and brought to a stand on the airport apron. Damage assessment was made for the purpose of two levels of repair:

- damage needing repair before a ferry flight to Fokker repair station could be carried out

- damage requiring permanent repair before return to service.

Total repair cost has been estimated at NOK 25 millions.

1.13 Medical and pathological information

No medical condition by any of the crew members has relevance to the accident.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 In this accident the forces of retardation were spread out over some time. It took about 17 seconds from the first touch down until the aircraft came to a full stop. This creates a good opportunity for the passengers to escape without injuries.

This aircraft type has four emergency exits. The passengers were evacuated through two doors, the forward on the left (the normal passenger door) and the rear right (aft cargo door). Rescue service personnel were on the scene about 45 seconds after the aircraft stopped. Also company personnel came quickly to the site. The passengers were gathered and counted on the taxiway D. From there they were escorted to the terminal building where also a doctor was summoned. Three of the passengers were brought to a hospital for a closer examination. All were released after the examination. One passenger was requested to return for a recheck one week later.

1.15.2 According to the AOM page 3.06.02, Emergency Procedures, the first officer is tasked with the duty of assisting passengers during evacuation. When the aircraft had come to a full stop he left the cockpit and proceeded into the cabin where he opened both forward doors. He found the door on the right hand side blocked by a tree. He closed the door again, and only the left door was used. When all the passengers able to walk quickly had left the aircraft, the first officer gave support to the stewardess in her effort to evacuate a disabled elderly lady through the same exit.

1.15.3 The hostess had been sitting on her seat in the rear part of the cabin when the aircraft ran off the runway. Her routines in an emergency on the ground is to check the rear doors for signs of fire or smoke on the outside. When she finds everything satisfactory, she is to open the doors. When the aircraft had stopped, she opened the rear right hand door and led the passengers through this exit. When the passengers had abandoned the cabin, she inspected the area, and assisted together with the first officer an elderly lady out the front left hand passenger door. On taxiway D she tried several times to count the passengers, but had problems in doing so because some of the passengers started moving towards the terminal building.

1.16 Test and research

A salvage company was hired to move the aircraft from where it stopped to a stand on the airport tarmac. There the work to establish the airworthiness status of the aircraft was started at two levels:

a) An assessment of the total damage with the purpose of obtaining an overview of repairs required to prepare the aircraft for a ferry flight to a repair station (Fokker Aircraft Services (FAS) in The Netherlands).

b) An assessment of potential failures of aircraft systems which could have attributed to the accident.

The work under item A was carried out by an assessment team from Fokker Aircraft and was outside the scope of the accident investigation performed by AAIB/N.

In the work under item B AAIB/N co-operated with specialists from Fokker and NAS. The working group established, agreed on following program to be followed, in situ or at the repair station:

In situ:

1. Take a sample of hydraulic oil for analysis
2. Perform a check of the hydraulic filters
3. Check for excessive amount of oil in the overflow drain tank of the hydraulic system
4. Check all hydraulic accumulators for precharge
5. Perform a functional test of the LH brake system
6. Perform a functional test of the Anti Skid System
7. Inspect the brake system for integrity and proper function including the alternate system
8. Perform a functional check of all flight controls, paying special attention to full and free range of movement
9. Perform a functional check of the nosewheel steering system before changing the nose landing gear
10. After compliance with all the above mentioned inspections/checks, perform another check of the hydraulic filters for popout
11. After repair of the aircraft for ferryflight to repair station (Fokker) perform a taxiing of the brake system and the nosewheel steering system.

The following inspection/examination items were carried out at Fokker Aircraft and Dowty Aerospace Hydraulics (Nosewheel Steering Control Valve):

12. Testing of landing gear Selector valve

13. Testing of Nose Wheel Steering Control Valve

14. Check of Brake Units

15. Investigation of fluid sample from Hydraulic System.

The examination and testing performed in accordance with inspection items 1 - 15 above did not reveal any discrepancies which could explain the aircraft control problems.

1.17 Organizational and management information

NAS was formed in 1993 as a consequence of the termination of the airline Busy Bee of Norway A/S. All the aircraft and most of the workforce in NAS came from Busy Bee. Their main activity is to offer transportation service as a subcontractor to established airlines on a long term basis or to accept ad hoc tasks. Presently NAS is flying on a contract with Braathens SAFE. The company has license No. 28 covering IFR/VFR flights with aeroplanes. The aircraft inventory consist of 4 leased Fokker F 27 MK 50 which is annually flown some 6 000 hours.

Total workforce is 65 persons.

Operational and maintenance main base is Oslo Airport Fornebu. Satelite bases are established at Bergen and Trondheim.

The company has been approved as a JAR 145 maintenance repair station, license No. CAA-N016. The main part of their maintenance is contracted to Braathens SAFE A/S.

1.18 Additional information

1.18.1 Crew reports

The day after the accident the crew was interviewed by AAIB/N. Separately the two pilots reported that they had performed a normal approach followed by a cross-wind landing with crossed controls where the left main wheel hit the runway first, then the right main wheel. The pilot in command believes he had close to full de-flexion on both rudder and aileron. The crew did not experience the landing as hard, may be a little bit "firm". The passengers had varied perceptions of the landing.

1.18.2 When the first printout of data from the FDR had been made, the crew was invited to study it with AAIB/N. Both pilots were surprised by the fact that the data indicated a landing with a relatively high crab angle. There was a certain disagreement between the way the crew had experienced the landing, and the presentation of the data from the FDR. In particular this was the case with the heading data. AAIB/N then decided to perform a correlation of data recorded on the FDR. This was done by an extraction of data from all take-offs and landings this crew had performed with the aircraft on the day of the accident. By comparing runway directions with recorded heading data, AAIB/N concluded that the data had a high degree of accuracy.

1.18.3 Compareable event

On 2 September 1991, 0945 UTC, a Fokker F-27 MK 50 from a different operator landed on runway 18 at Evenes Airport. Actual weather: Cloudbase 3 000 ft, visibility good, wind from 210° 14 kt, gusting 27 kt. Runway dry and uncontaminated.

A routine approach was followed by a normal crosswind landing on the centerline. Initially the roll-out was normal. After only a few seconds the aircraft started veering to the right. According to the pilot in command, only immediate full deflexion of flight controls and asymmetrical application of wheel brakes and engine thrust saved the aircraft from going off the runway. The aircraft came to a full stop on the edge of the runway. Left main wheel tire had ruptured due to the excessive braking.

The pilot in command regarded the incident as peculiar and hard to explain, the moderate cross wind component taken into consideration, and asked that the FDR-data should be extracted and printed out. Unfortunately this printout is no longer available. AAIB/N is of the opinion that it would have been interesting to compare data from this incident with the FDR-data from Vigra because the environmental conditions were similar.

The pilot in command filed an "Flight Occurence Report", and the company evaluated the incident in an "Incident Investigation Report" 11 November 1991 where only the cause of the tire failure was discussed. Asides from that, the incident was classified as an operational risk.

1.18.4 Calculating stopping distance

AAIB/N asked the aircraft manufacturer, Fokker Aircraft, to calculate stopping distance for a Fokker 50. Following message was received.

> "Based on the certified landing performance data (AFM) and using assumptions as mentioned below, the stopping distance would be 359 m for no-wind and 271 m for 13 kt headwind. Using the certified performance data as a basis implies a one-engine-out situation, i.e. one engine inoperative/

feathered and the operative engine at Ground Idle. This is conservative in comparison with the situation of both engines/propellers at Ground Idle.

The following assumptions were used:

- landing weight 17 917 kg, flap 25 deg
- touchdown speed 95 kt
- headwind zero and 13 kt
- 1 sec delay between touchdown and start of using brakes
- maximum use of brakes and anti-skid
- selection of Ground Idle (no certified performance data available for Reverse thrust)"

1.19 Useful or effective investigation techniques

1.19.1 Simulations

Data available from the FDR did not include all parameters of interest to explain the sequence of events in the accident. It was decided to try to calculate the force components affecting the aircraft during the actual landing. In these calculations the unknown parameters could be introduced and varied in an attempt to establish a simulation of the events as to compare with the actual sequence of events as they were recorded.

The Norwegian Defence Research Establishment (NDRE) was contacted. It was assumed that NDRE would have the required resources, both expertise and equipment. At a preliminary meeting it was decided to create a mathematical model including the known parameters, where the missing parameters could be added and varied. For practical reasons the model would have to be in the form of a program that could be processed in a computer.

The results from this project are presented in a report from NDRE, "FFI/RAPPORT-95-02194", dated 4 October 1995.

1.19.1.1 Of the parameters not readily available from the FDR, the following were thought to be most important:

- rudder position

- application of wheel brakes

- application of nose wheel steering

- aileron position

- weight distribution on main wheels
- nosewheel in contact with runway
- nosewheel steering activation
- selection of Ground Idle (GI)
- selection of Reverse Thrust (RT).

1.19.1.2 The four last parameters listed above were established by comparing data from the CVR with data from the FDR. Time reference is identical with FDR-data printout (See Appendix 5) where the landing is initiated when left main wheel touches down TD1 at second 1886, and the final landing, TD2, is at 1888. The second numbers are based on a starting point for the printout selected at random about 30 minutes before the landing. Following values were established for the four parameters in question:

- nosewheel "on ground" between 1888 and 1889
- nosewheel steering activated by 1890
- GI has been selected before 1890
- RT is at a measurable level at 1892.

Data established above have been used in the simulations.

1.19.1.3 To keep the model from becoming too extensive and complicated some simplifications and assumptions were made. The main consideration was that this should not influence the results to any degree. The first, and most important, simplification was:

- only force vectors in the horizontal plane were considered.

The simulations were limited to the first seconds of the roll-out. This makes it a reasonable simplification to take into account only forces affecting torsional moment around the vertical axis of the aircraft. One exception was made: Weight distribution on main wheels was variable in the simulations.

- the model was "inflexible".

Elasticity in landing gear and wheels was not included.

The vectors diagram forming the basis for the model is shown in Figure 1.

It was assumed that the aircraft's velocity vector was parallel with runway centerline before and during the initial part of the landing. This assumption is based on crew reports, the measured crab angle in relation to known wind data, and the tire marks from the initial part of the roll-out.

1.19.1.4 To illustrate the results from the simulations, a graphic presentation in three different forms, was selected. The three forms were called "Picture 1, 2 and 3" respectively.

Picture 1 is showing the wheel tracks and the track of Center of Gravity projected on the runway from second 1888 to second 1896, as shown in Figure 2. The squares are indicating the track from left main wheel as it was found on the runway after the accident. It should be noted that the scale is not the same for length and width of the runway. This gives a turning radius out of proportion with other measurements. The runway is 45 m wide, with a 7,5 m shoulder area on each side, giving a total width of 60 m covered with asphalt.

Picture 2 is showing the relations between simulated directions and recorded/calculated directions. The aircraft heading, i.e. the direction of the aircraft longitudinal axis, is taken from FDR-data. Actual direction of aircraft velocity vector has been calculated. A sample is shown in Figure 3.

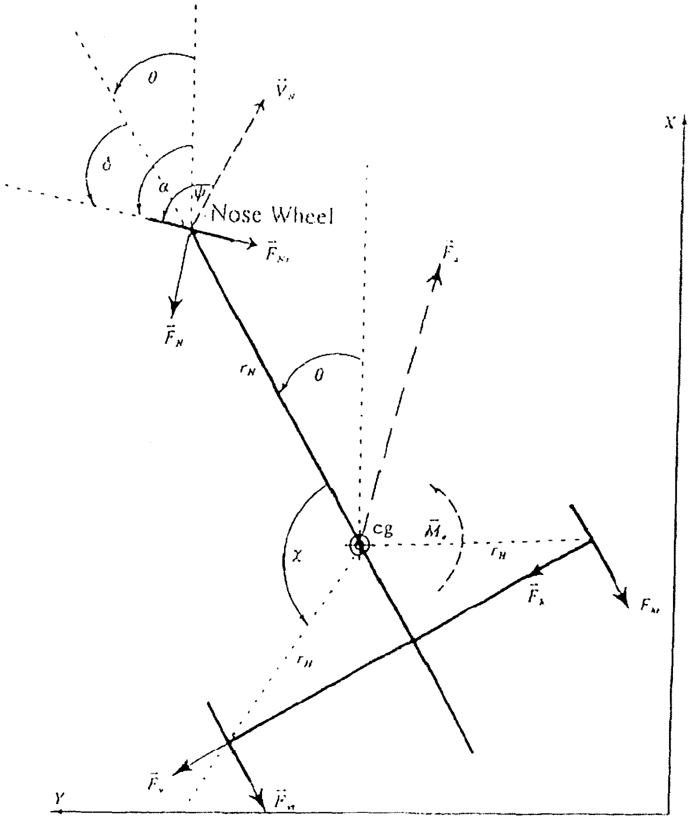
Picture 3 is showing the relations between simulated air speed development and recorded air speed from the FDR. A sample is shown in Figure 4.

The conditions forming the basis for the samples in Figures 2, 3 and 4, are given in Figure 5.

Picture 2 and 3 serve a special purpose as a control/corroboration in relation to Picture1, where a perfect "fit" may be obtained with a number of combinations.

MATHEMATICAL MODEL

The mathematical model is describing the aircraft movements in the horizontal plane. The principle is that all forces acting in this plane (friction from the wheels and aerodynamic forces) are added up and result in CG velocity. Vertical moments around the CG are also added up and result in changes in aircraft rotation. Figure 1 is showing all forces and turning moments acting in this plane.



Forces acting upon main wheels. nose wheel and Center of Gravity (CG).

Symbols:

F_N	Force of friction 90° to direction of nose wheel
F_v, F_h	Force of friction 90° to direction of main wheels, left and right
F_{vt}, F_{ht}	Force of friction tangential to the wheel, left and right
$\bar{F}_a, \bar{M}_a$	Aerodynamic forces and moments
r_N, r_H	Distances, nose wheel - CG, main wheels - CG.

FIGURE 1

1.19.1.5 First part of a validity check of the model was to simulate a landing with no cross-wind component and flight controls neutralized. If the model was working as it was supposed to, it should give a landing straight ahead along the runway centerline. The test was successful.

The model also was tested for stopping distance with maximum use of wheel brakes. The results were compared with flight test data received from Fokker. The results from the simulations coincided quite well with the test data.

1.19.2 Applicable simulations

A large number of simulations were made, all included in the NDRE-report. In the following a few of the simulations leading to the conclusions drawn from this work, will be dealt with.

1.19.2.1 It was considered of importance to try to find out what the significance of landing with 10,5° crab would be. One simulation therefore was made where the aircraft was landed with 10,5° crab, flight controls at neutral, no wheel brakes, and wind as recorded at the accident. The simulated aircraft followed the recorded accident track very closely off the runway. However, the simulated directions did not fit the recorded data around seconds 1889 and 1890. At the accident there was an indication of an initiation of a right turn at this time, before the pronounced turn to the left started at second 1890.

1.19.2.2 By simulating a castoring nosewheel and a 50% symmetrical wheel braking, the result is a good fit in track and air speed, but not a satisfactory fit in directions around seconds 1889 and 1890.

1.19.2.3 By simulating nose wheel controlled in the direction of the runway at all times, a run-off with a smaller radius turn than the actual, resulted. In other words, this mode of nosewheel steering had a negative effect on direction control.

1.19.2.4 The above simulations had all one thing in common: They could not explain the change of directions shortly after TD2, where there first was a slight tendency to turn right, and then, about second 1890 it suddenly changed to a relatively constant left turn of approximately 5°/s. This was an indication that an extra turning force had been added at this time. One way of introducing this extra force, was to simulate a wind gust at this time. The simulation indicated that a wind gust at 35 kt from 178° at second 1889,7 would give the required turning moment around the aircraft vertical axis.

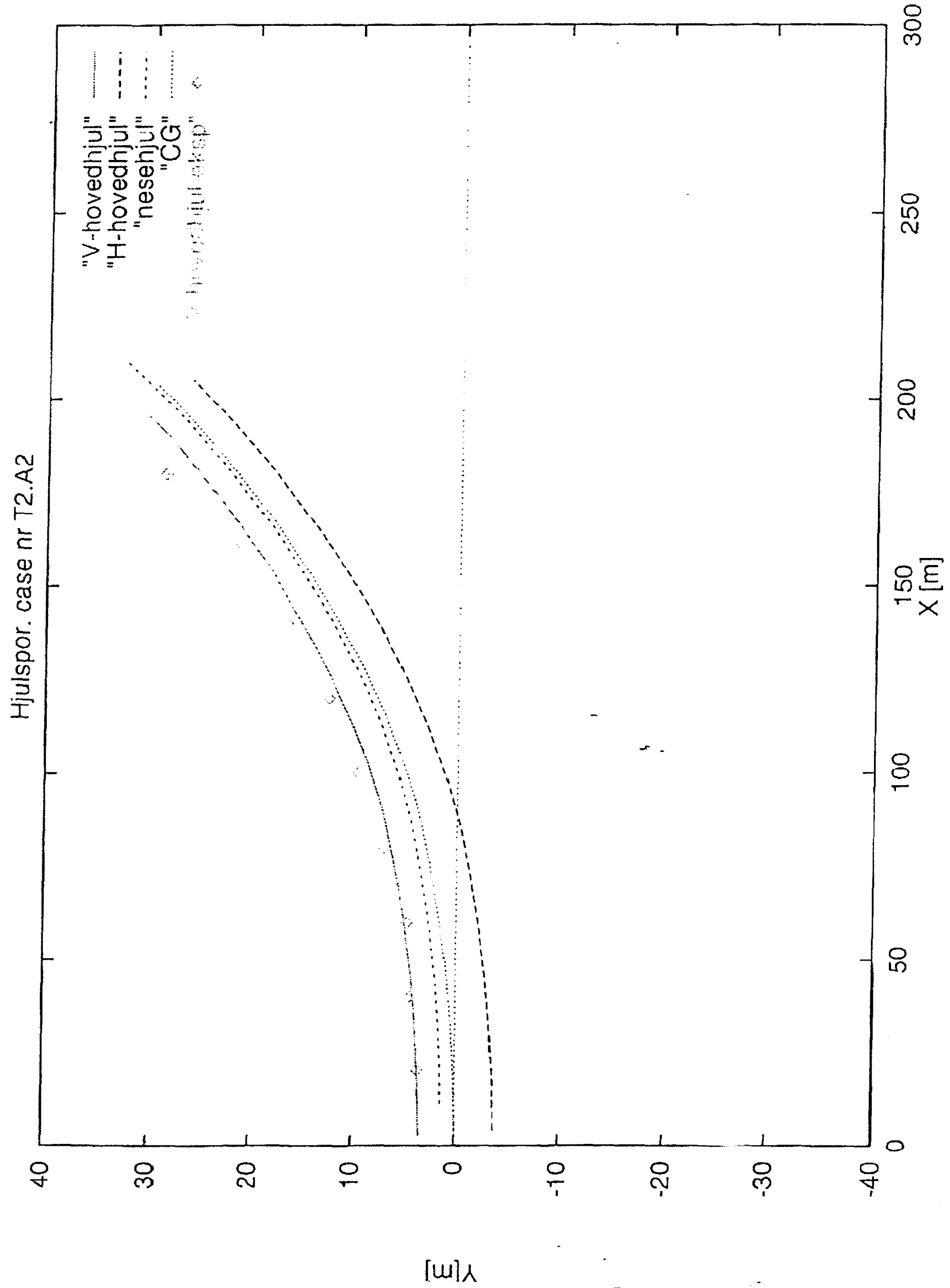
The other option for explaining the increase in turning moment at second 1890, was to simulate nosewheel steering in a certain mode. Simulations indicated a close fit, in all parameters, with the actual case if nosewheel steering was activated at second 1890,5, and the nosewheel at this time was turned in the runway direction.

1.19.2.5 Another question had come up during the investigation: At what time, at the latest, could the landing still be "saved", and the run-off prevented, and what control inputs would have been required to do that? The simulations indicated that if the run-off should have been prevented the following conditions must have been fulfilled:

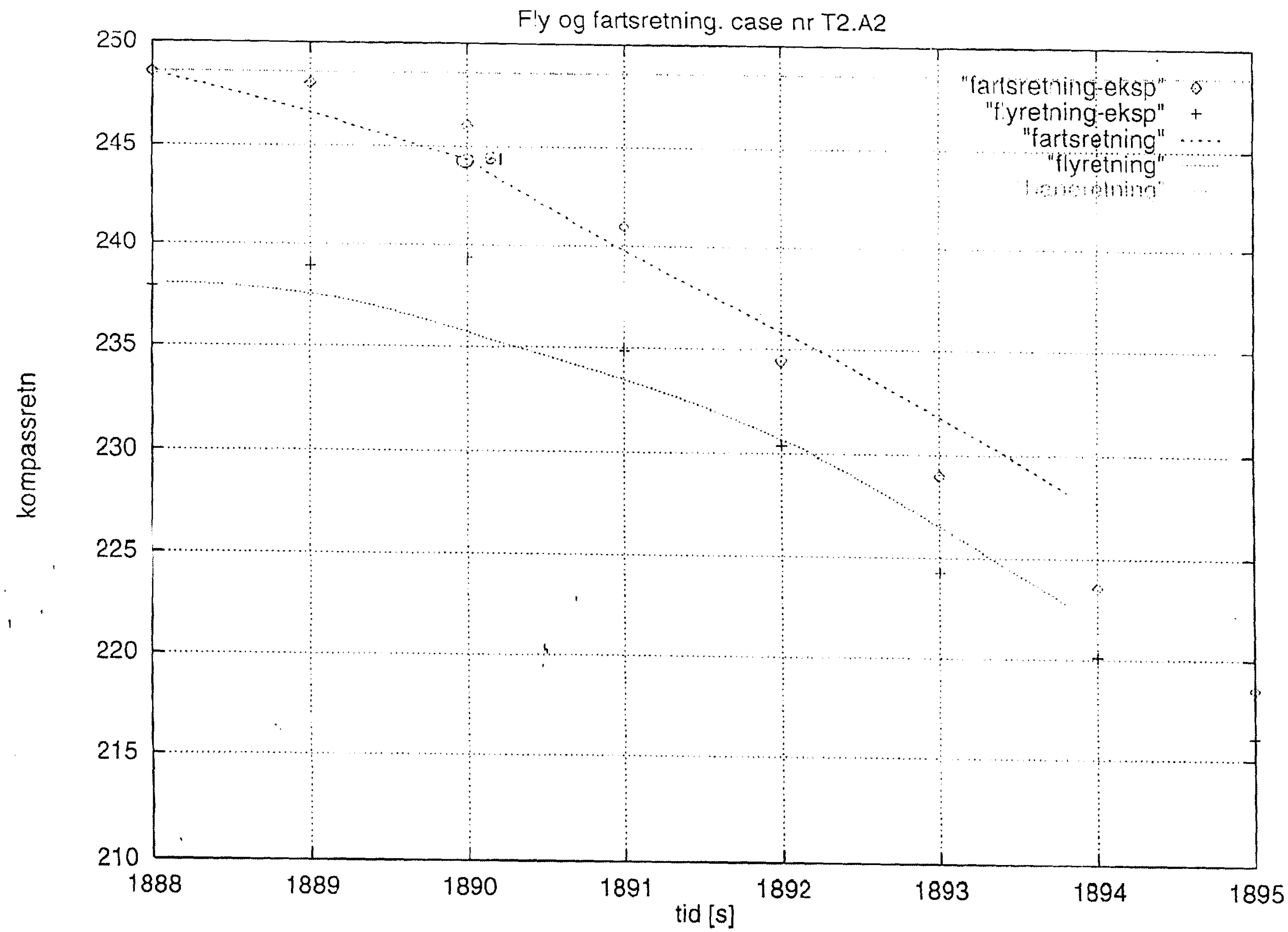
1. The nosewheel could castor or not touch the runway until second 1891

2. From that time the nosewheel steering should be activated and used to its maximum, this is believed to be at approximately 6° angle in relation to the aircraft direction and

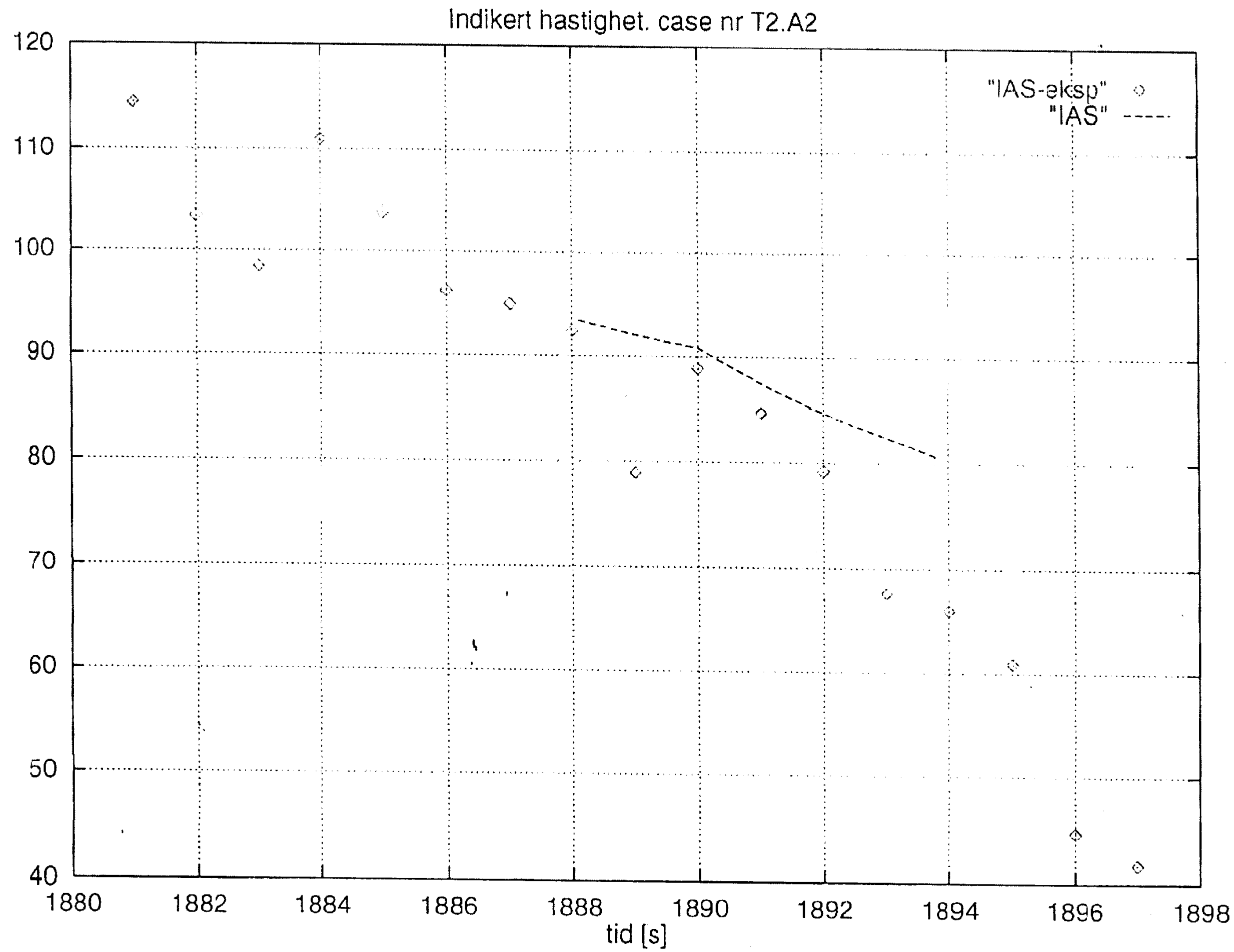
3. at the same second, full rudder deflection must have been obtained and used to its maximum.


Hjulspor. case nr T2.A2
"V-hovedhjul"
"H-hovedhjul"
"nesehjul"
"CG"
X [m]
Y[m]
0
50
100
150
200
250
300
40
30
20
10
0
-10
-20
-30
-40

FIGUR 2


Fly og fartsretning. case nr T2.A2
"fartsretning-eksp"
"flyretning-eksp"
"fartsretning"
"flyretning"
kompassretn
tid [s]
250
245
240
235
230
225
220
215
210
1888
1889
1890
1891
1892
1893
1894
1895

FIGUR 3


Indikert hastighet. case nr T2.A2
"IAS-eksp"
"IAS"
IAS [ms]
120
110
100
90
80
70
60
50
40
1880
1882
1884
1886
1888
1890
1892
1894
1896
1898
tid [s]

FIGUR 4

```
SENR  T2.A2

yets crabvinkel = 10.5
yets hastighet  = 40.1 m/s  (78.0 kn)
s               = 48.2 m/s  (93.7 kn)

ND:  Morvind : 13.0 knop
     Sidevind: 23.0 knop
ft:      t=1888.0: CL=1.40
         t=1890.0. CL-0.84
         t=1896.0: CL=0.56

torskyvkraft [N] : t=1888.0: Fv=     0,  Fh=     0
                   t=1890.0: Fv=     0,  Fh=     0
                   t=1896.0: Fv=-6600,  Fh=-6600

                   t=1896.0: Fv=     0,  Fh=     0

emsing: t=1888.0: VH:  0,   HH:  0
        t=1889.0: VH:  0,   HH:  0
        t=1890.0: VH:  0,   HH:  0
        t=1891.0: VH:  0,   HH:  0
emseffektivitets-faktor: 0.70

sehjul-styring 3: (nesehjul svinger fritt)

derorsbruk:     fra t=   0.0 :  0%
                fra t=   0.0 :  0%
                fra t=   0.0 :  0%
                fra t=   0.0 :  0%
ktor redusert vindhastighet på sideror ved bruk av revers: 0.50

lanserorskompensasjon: Ja

_gli     = 0.40
_max: 0.81 (n) og 0.79 (H)
ltrykk N og H: p=47.86 psi . p=84.99 psi
```

FIGUR 5

2 ANALYSIS

2.1 The scope of the investigation

The crew has reported to AAI/B that the flight from Bergen, with intermediate landings at Molde, Kristiansund and Trondheim Airports was uneventful. Nothing distinguishes this flight from an ordinary winter day flight on the west coast of Norway. This applies to the aircraft, weather conditions, airports and communications. The flight from Trondheim Airport Værnes to Ålesund Airport Vigra also, according to the crew, was routine until the landing on runway 25. Based on this, AAIB/N has centered the investigation around the last 23 seconds preceding the time when the aircraft came to rest off the runway. This includes the last 6 seconds the aircraft was airborne before the first touchdown (TD 1), the roll-out on the runway, and the run-off. AAIB/N has utilized detailed printouts from the FDR both in graphic and alphanumeric presentations. This information has been plotted and analyzed in detail. Furthermore AAIB/N has used the CVR-data and the tape from communication between VIGRA TWR and LN-BBA. This information has been of great importance to understand the short and somewhat complicated sequence of events. AAIB/N is thankful for the assistance rendered by Air Accident Investigation Branch, Department of Transport, Farnborough, UK, Fokker Aircraft, Amsterdam, The Netherlands, Netherlands Aviation Safety Board, The Netherlands, and Norwegian Defence Research Establishment, Kjeller, Norway.

2.2 Airspeed on short final

2.2.1 At the initiation of the approach, about 2:40 min. before the landing at Vigra, indicated air speed was 190 kt. This was reduced when flap 10° and flap 25° was selected. By use of "The aircraft weight indicator", the crew determined that the threshold speed should be 100 kt. The aircraft weight indicator is a calculator installed in the aircraft. It takes into account the entered take-off weight, fuel consumption and a set flap position of 25°. From these data it calculates the threshold speed. This speed is called Vref and is supposed to be at least 30% above stall speed. As an approach speed, the AOM SOP recommends Vref + 10 kt.

The crew added 5 kt to the threshold speed due to the surface winds at Vigra Airport. During the last part of the approach, the first officer in accordance with established routines called out the difference between the actual and agreed speed. Wind was variable on the approach. Probably due to the turbulence giving a changing head wind component, the indicated air speed varied between +10 kt, +5 kt and down to the established value. Passing the threshold the speed was +5 kt, shortly thereafter it dropped to "on speed".

2.2.2 According to AOM, SOP 7.01.01, the callout is supposed to be "Speed" from NFP when approach speed has increased 10 kt or fallen 5 kt below the selected value.

AAIB/N has found that the pilots of this airline usually call out the difference between actual and reference speed also inside these limits. This seems to be a sound procedure for cockpit co-operation which tends to simplify the cross-checking the PF has to do, and is a contribution to flight safety. AAIB/N will recommend the airline to consider introducing this procedure in the AOM.

2.2.3 When the aircraft was cleared to land, wind was reported as 190° at 20 kt, gusting 38 kt. During the last part of the approach the wind was reported from the tower as 190° at 36 kt, 190° at 30 kt, and decreasing, varying between 180° and 190° and speed between 25 and 28 kt. At the time of the landing the wind was recorded as 190° at 26 kt. AAIB/N considers the approach speed to have been stabilized, conditions taken into account, but that the addition to Vref was insufficient. According to the company AOM, SOP 7.05.01, the wind correction for the approach speed is supposed to be half the wind velocity plus the gust factor. It is the opinion of AAIB/N that the conditions, which were known to the crew, warranted an addition of 15 kt to the calculated Vref (half the wind speed, 10 kt, and the gust factor from 20 to 38 kt is 18 kt, for a total of 28 kt, limited to a maximum of 15 kt). This leads to conclusions that approach speed, Vref + 10 kt, should have been 125 kt, and threshold speed should have been 115 kt. The aircraft was landed on the runway centerline at a normal distance from threshold, about 360 m, at an indicated air speed of 95 kt. Increased/correct approach speed would have given increased directional stability.

2.3 Crosswind landings

2.3.1 <u>Procedure</u>

To highlight the sequence of events AAIB/N has compared the procedure utilized by the crew during the landing and the established landing procedure for this type of aircraft.

According to company AOM SOP:

> "When the threshold is passed at about 50 ft height, flare the descent to a slightly nose-high attitude simultaneously as reducing engine power to idle. The normal speed at touch-down will be between Vref and Vref - 10. Following the touchdown on the main wheels the nose is to be lowered carefully. Initial directional control is maintained using rudder. The propellers are set to Ground Idle and reverse used as necessary. Two items are of particular interest: Do not select Ground Idle before the nosewheel is on the ground, and the rudder is not useful for directional control when reverse is selected. At 60 kt speed: Discontinue use of reverse. Landings in crosswind are performed by crabbing the airplane into the wind on final approach to track the runway extended centerline. On passing the threshold, use rudder to align the aircraft with the runway centerline and bank into wind to counteract the wind drift.

(Maximum bank is 3° to 5°). Do not delay the touch-down on the runway after use of crossed controls has been started. After the landing continue straight ahead initially by the use of rudder and counteract the tendency for the upwind wing to lift with determined use of aileron. Be careful using reverse."

The procedure for the continued roll-out when LP (left pilot) is handling the controls:

"LP: Move left hand to the nosewheel steering tiller when the RP(right pilot) is taking over the control wheel and is holding ailerons into the wind. At 60 kt: RP calls out the speed "60 kt" and LP orders "Select T/O". When speed has been reduced to taxi speed, LP orders "Flaps up". This applies when LP is handling the controls (FP). When RP is handling the controls, LP calls out 60 kt, and following this call, LP moves his hand to the nosewheel tiller."

AAIB/N believes there is a need for clarification of the company's routines regarding the correct procedure for initiating nosewheel steering. The procedure in t he SOP should be the same regardless of which pilot is at the controls during the landing roll out.

2.3.2 Landing with a skid (crab angle)

At the landing at Vigra the aircraft was crabbed into the wind to compensate for the crosswind component. The aircraft commander stabilized first on the inbound track to the localizer. This track is off-set 11,5° from the runway direction. Later, at about 1 300 ft, he intercepted and stabilized on the runway extended centerline. To compensate for the crosswind, an average crab angle of about 15° was needed. This crab into the wind was maintained crossing the threshold, and at the actual touch-down the aircraft was brought onto the runway centerline with a crab angle of about 10° out of runway alignment. Crossing the threshold, correct procedures with crossed controls for aligning the aircraft, were not utilized. AAIB/N is of the opinion that landing the aircraft without aligning it with the runway, had a significant bearing on the following events.

AAIB/N checked heading data extracted from the FDR by comparing with actual runway directions for previous landings and take-offs the same day. It was concluded that the data were correct, and the landing at Vigra was made with a 10,5° skid (crab).

2.3.3 Disparity between runway direction and aircraft heading

One possible explanation for the fact that neither the captain nor the first officer were aware of the situation where the aircraft heading did not coincide with the runway direction at the landing, may be the somewhat special conditions experienced landing on runway 25 at Vigra (See Figure at 1.10.2). The first 270 m of the runway has an upslope of 1%. The following 180 m upslope at 0,5%. This may have given the crew only the first part of the runway as reference for directional orientation during the flare.

2.3.4 Directional control and braking distance

AAIB/N has established that the aircraft continued along the runway centerline due to the momentum formed by the mass and the velocity vector, regardless of the aircraft heading. Shortly after TD2 the nosewheel was allowed to contact the ground and the propellers were set to GI, and almost immediately thereafter (according to FDR-data) into reverse thrust. When GI was selected, a considerable amount of the wing lift was dumped and the friction forces from the wheels tried to move the aircraft along its longitudinal axis. This means a turn to the left off the runway at an initial rate of approximately 4°/sec.

As could be expected from an aircraft of this configuration, use of engine reverse power results in significant reduction of rudder authority at lower airspeed. This means that full rudder deflection had little effect after this point of time. All wheels were skidding during the roll-out. Skidmarks were clearly evident on the runway surface.

It is not clear what effect the wheel brakes have had in this landing. According to Fokker Aircraft test data (See calculations at 1.18.4), the aircraft can be stopped under the existing weather conditions on a distance of 271 m. When the exact touch- down point on the runway has not been established with a high enough accuracy, and also there is a lack of friction data for he part of the roll-out across the grass area (70 m) it can not be determined exactly what the distance from the touch-down to full stop actually should be.

Tests and simulations of maximum braking effect are indicating that optimum use of wheel brakes under the existing conditions, should have given a more rapid reduction of speed than was recorded on the FDR. Since no failures of wheels or brakes could be found, it must be assumed that use of wheel brakes has not been optimum. AAIB/N also considers it unlikely that maximum use of brakes can be expected when the crosswind component is as high as 23 kt.

2.3.5 Crosswind component

The airline operates a route network with varying weather conditions. Frequently crews are landing and taking off without problems in wind velocities approaching maximum demonstrated crosswind component for this aircraft type, 33 kt. This is leading the crews to have great trust in the aircraft performance and their own capacity and experience. They are building a high level of personal confidence. AAIB/N has asked the question of the possibility that a crew may not be alert or prepare themselves mentally well enough for a landing where the crosswind component is "only" 23 kt. The crosswind component affected the aircraft during the landing. The main effect was the weather-cocking tendency due to large vertical surfaces, trying to turn it into the wind. This force should normally be counteracted by rudder and aileron, the so-called "crossed controls" technique. The crew are reporting that they used right rudder, and the ailerons were at full left deflection. AAIB/N considers that crosswind component has been a contributing factor in this case, but the primary cause for lack of directional control was insufficient use of rudder.

The effect of the crosswind component could also have been reduced by the brakes on both main wheels being used to their maximum extent. The effect of the wind was decreasing as the aircraft turned into the wind. When the aircraft came to rest it was almost aligned with the wind.

2.3.6 Transfer of control wheel to NFP

In the AOM SOP there was no directions as to when the pilot in command (LP) shall initiate nosewheel steering, other then this transfer shall occur when GI has been selected. To perform this the captain lets go of the control wheel with his left hand and put it on the nosewheel tiller. Simultaneously the RP is taking over the control wheel. At crosswind landings this requires a firm grip to reduce the lift from the upwind wing and increase the lift on the downwind wing. This procedure is to be performed with no orders given. AAIB/N is of the opinion that the company should consider the use of an order or call-out from LP at the transfer. This would preclude the opportunity for the wheel to temporarily go to neutral during the transfer.

2.4 Summary based on the simulations

2.4.1 The recorded sequence of events may be simulated by a number of combinations of factors. It seems realistic to start with the fact that there was a marked increase in turning force to the left at second 1890. This turning moment may hypothetically be introduced in four different ways:

- rudder deflection to the left
- differential braking to the left
- a strong gust from the left
- by a force component to the left from the nosewheel.

Inadvertent use of rudder in the wrong direction is so unlikely it must be dismissed.

The left main wheel started leaving skid marks on the runway before the right wheel did. Still, it must be considered as very unlikely that the left brake was used more efficiently than right brake.

A potential gust would have to be of an unlikely combination of change in direction and speed, and of very short duration to escape being recorded on, either the wind meter at the airport, or on the aircraft airspeed indicator as an increase in headwind component.

What remains is the effect of the nosewheel. The simulations show that if the nosewheel steering is used as the crew reports, and the way the skid-marks on the runway indicate, an unintended severe left turn will be initiated at the critical moment, second 1890.

2.4.2 The main conclusion from the simulations project was that when the aircraft had been landed in a 10,5° skid compared with runway direction and the velocity vector of the aircraft, the crew had available about 3 seconds to select the optimum landing technique. Many variables could be introduced, but the main elements would be full utilization of rudder, and no activation of nose wheel steering at the initial phase of the landing. The simulations show that this would be sufficient, but the situation could be improved by keeping the nosewheel off the runway as long as possible, differential braking to the right, and waiting a few seconds before selecting GI.

2.5 Differential braking and/or engine thrust

At this landing the options of using differential braking or engine thrust were not used. It is not considered normal procedures to use either one at normal landings. The short period from the time the pilot in command considered it a normal landing with a rollout along the centerline, until he lost directional control, may be indicating that there is a need to train crews to quickly regain control where a problem develops during the rollout.

Training landings with one landing gear not down and locked and single engine landings, the crews go through use of asymmetric control. The company does not train in landings in a strong crosswind where directional control is lost and regained. AAIB/N is recommending that the company evaluates the need for such training.

2.6 Parameters on the FDR

According to Norwegian Air Regulatins BSL D 1-12 2.1.2, aircraft with a MTOW of more than 27 000 kg, certified after 30 September 1969 shall include in the FDR-parameters recordings of flight control positions. This aircraft type has a lower MTOW, and thus has not the requirement for such recordings.

The printouts from FDR, the CVR and tape recordings have been of great assistance to gain an understanding of this accident. From the FDR 12 parameters were available. For a detailed understanding of what happened in the seconds after touch-down, data from rudder and aileron deflection would have been of great help. Additional information could have been gained, had the use of wheel brakes been recorded. A modern FDR has a large storing capacity. It is possible to record more parameters, but sensors have not been installed in the aircraft for registrating positions of flight controls and trim.

2.7 The landing at Evenes

AAIB/N was informed that a landing with some similarity to the accident at Vigra had taken place at Evenes some years ago. FDR-data had been extracted. AAIB/N tried to obtain the FDR-data from the incident at Evenes as a comparison to the actual data from Vigra. Unfortunately this effort was without success. AAIB/N must conclude that at both landings, carried out with a crosswind component of about 20 kt on a dry runway, it was possible to loose directional control after a few seconds of the roll-out. It is not known whether the landing at Evenes was made with skid or not.

2.8 Trend analysis

AAIB/N is aware of the fact that within the scheduled airlines community is considered beneficial to the company management to perform systematic extraction's of FDR-data for the purpose of evaluation of operational trends. The aircraft type in question has a modern FDR with a capacity to record a high number of parameters, and AAIB/N will recommend that the company assesses the possibility to start analyzing these data.

In the USA the Flight Safety Foundation has recommended that an independent and neutral organization (a clearing house) collects and analyses the data from different airlines.

2.9 Wind eddies

From persons working at the airport AAIB/N has been informed that in situations with strong southerly winds, occasionally wind eddies may be observed. High wind velocities have been observed in these eddies. The eddies have been passing the airport area without being recorded on the wind meter. Since the location of the wind meter is close to the area where the aircraft rolled out, it is very unlikely that an eddy passed Vigra at the time of the landing of LN-BBA. Due to the strong southerly wind and the buildings near the end of the runway, it can not be totally excluded that an eddy of small size may have passed the area where LN-BBA landed, without being seen or registered.

2.10 Note

The state of manufactures representative participating in this investigation has pointed out that his interpretation of the nose wheel skid marks on the runway leads to the conclusion that the nosewheel was steered to the left of track during the critical face of the landing following the touch down. The AAIB/N does not agree with this interpretation.

3 CONCLUSIONS

3.1 Findings

a. The crew members were properly licensed.

b. The crew had been given all mandatory training.

c. The aircraft was airworthy in accordance with all regulations and registered in the Norwegian Air Registry.

d. No irregularities have been found with the aircraft, its engines, propellers, brakes or other aircraft systems which could have contributed to the accident.

e. The crew action to increase threshold speed with 5 kt was, under the existing wind conditions, not correct. The addition should have been 15 kt.

f. The aircraft was landed on the runway centerline about 360 m from the threshold.

g. The wind was 190° at 26 kt at the landing. This amounted to a crosswind component of 23 kt and a headwind component of 13 kt. No significant changes in wind were registered the minutes preceding and following the landing.

h. Since no failures of wheels or brakes could be found, it must be assumed that use of wheel brakes has not been optimum.

i. Differential braking was not used.

j. Asymmetrical engine power was not used intentionally.

k. Runway 25 at Vigra was dry and uncontaminated at the time of the accident.

l. Evacuation of passengers and crew was performed through two exits.

Factors considered to have had relevance to the sequence of events and cause

m. When touching down the pilot in command had not eliminated the crab angle of about 10°, and the aircraft was landed with a corresponding skid.

n. The pilot in command's method of attempting directional control by the use of nosewheel steering immediately following the touch-down, was not correct, and not in accordance with company operational procedures.

o. The pilot in command did not use rudder to its maximum efficiency during the landing.

4 SAFETY RECOMMENDATIONS

1. It is recommended that the company evaluates the requirement to increase training of crews to maintain, and possibly regain directional control during landings with strong crosswind. Training should first of all be aiming at prevention of loss of control by amplifying the proper crosswind landing technique.

2. It is recommended that the company considers changes in SOP-procedures in AOM 7.05.01 to standardize routines to be independent of which pilot is handling the controls during the landing.

3. The company is recommended to consider introduction of a call-out or command for RP to take over the control wheel when LP wants to initiate nosewheel steering.

4. The company should consider changing SOP procedures to include procedures already in use by the pilots, to call out the difference between actual and selected approach speed.

5 APPENDICES

1. Instrument approach chart - ICAO, Ålesund Vigra.

2. Map with details from the aircraft track after landing.

3. Abbreviations

4A. Graphic projections FDR: 20 min. before landing.

4B. Graphic projections FDR: 3 min. before landing.

5. FDR printout

6. Printout from wind meter.

7. Radio-sonde ascension diagram from Sola.

8. Building outlines from Ålesund Airport Vigra.

AIRCRAFT ACCIDENT INVESTIGATION BOARD
Fornebu
20 May 1996