Uncommanded pitch-up, Fokker F27-600 Friendship, G-CHNL

Micro-summary: **On approach, this Fokker F27-600 Friendship had a pitch excursion which ultimately led to a stall and crash.**

Event Date: **1999-01-12 at 1706 UTC**

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

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

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Fokker F27-600 Friendship, G-CHNL: Main document

Aircraft Accident Report No:. 2/2000. (EW/C99/1/2)

Registered Owner:	The Dart Group plc
Operator:	Channel Express (Air Services) Ltd
Aircraft Type:	Fokker F27-600 Friendship
Nationality:	British
Registration:	G-CHNL
Place of Accident:	Approximately 1 nautical mile east of Guernsey Airport
	Latitude: - 49° 26.0' N
	Longitude: - 002° 34.5' W
Date and Time:	12 January 1999 at 1706 hrs
	All times in this report are UTC

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) at 1723 hrs on 12 January 1999 and an investigation began the same day. The investigation was conducted by Mr M M Charles (Investigator-in-Charge), Mr J J Barnett (Operations), Mr J R James (Flight recorders), Mr R Parkinson (Engineering) and Mr R W Shimmons (Operations).

The accident occurred when control of the cargo aircraft, carrying three tonnes of newspapers, was lost during the final stages of an approach to Guernsey Airport. Moments after the wing flaps were lowered to their fully down position, the nose of the aircraft rose and the crew were unable to prevent it rising further. The nose continued to rise until the aircraft's pitch attitude was near vertical. Although the crew applied nose down pitch trim and high engine power, the aircraft lost flying speed, stalled and entered an incipient spin. It descended in a shallow nose down pitch attitude with little forward speed and crashed at the rear of a private house, striking the house with its port wing. Both the house and the aircraft caught fire. The two pilots were killed but the sole occupant of the house escaped without physical injury. The investigation identified the following causal factors:

(i). The aircraft was operated outside the load and balance limitations.

(ii). Loading distribution errors went undetected because the load sheet signatories did not reconcile the cargo distribution in the aircraft with the load and balance sheet.

(iii). The crew received insufficient formal training in load management.

Seven safety recommendations were made during the course of the investigation.

1. Factual information

1.1. History of the flight

1.1.1. Background

The pilots reported for duty at 1815 hrs on the day before the accident in order to position to Exeter Airport where G-CHNL was parked having undergone minor repairs and scheduled maintenance at a contractor's facility. The cargo compartments were empty apart from the normal complement of netting and lashing equipment plus 300 kg of ballast at the rear of the cabin to bring the aircraft's centre of gravity (CG) within the permitted range.

The aircraft took off from Exeter at 2110 hrs for Liverpool Airport where it landed at 2158 hrs. At Liverpool freight was loaded and the aircraft took off at 0015 hrs on the day of the accident with an intended destination of London Gatwick Airport. At Gatwick freight was to be exchanged before completing the night's work by delivering freight to Guernsey. However, visibility in the London area was poor that night and the aircraft diverted to East Midlands Airport where it landed at 0143 hrs. At East Midlands the crew obtained actual and forecast weather data for Gatwick which at the time was affected by freezing fog and likely to remain so until at least 0500 hrs. After consultation with company operations, the aircraft took off at 0247 hrs and flew to Luton Airport where it landed at 0312 hrs. At Luton the freight was off-loaded. By this time the crew were approaching the limit of their flying duty period and after securing the aircraft, they left the airport to rest at a hotel in Luton. They recorded their off duty time as 0330 hrs and they arrived at the hotel by 0345 hrs.

At about 1100 hrs the first officer telephoned the company to ask what the plan would be for operations later that day. He was informed of a planned 1730 hrs departure for Guernsey and he agreed to relay the details to the commander. Meanwhile another aircraft belonging to the operator left Gatwick that morning with freight for Guernsey but on arrival at the Island's Airport it was discovered that, by mistake, the newspapers had not been loaded at Gatwick. The aircraft was instructed to return to Gatwick to collect the newspapers but it went unserviceable shortly after take off at around midday and had to return to Guernsey for rectification. This left the operator with only G-CHNL at Luton with which to deliver the newspapers. Consequently, a facsimile message was sent to the commander at his hotel asking him to bring forward the planned departure time to 1600 hrs. He agreed to the request and told the operator's crewing staff that both pilots would report for duty at Luton Airport by 1515 hrs. Flight plans and aeronautical information for the sectors to be flown later that day were faxed to the crew at their hotel. The computerised flight plan, annotated for 3,000 kg of cargo, was printed at 1403 hrs. The departure time on the flight plan had been amended in handwriting from 1730 hrs to 1600 hrs. The flight plan used by the first officer was the same plan which had been faxed to the hotel; the transmission time marked on the plan was 1552 hrs on 12 January 1999.

Both pilots ate meals in the hotel and two packed meals (for consumption during the night) were ordered. At about 1430 hrs the collection time for the packed meals was brought forward by one hour and the pilots left the hotel at about 1500 hrs with their food. Meanwhile the newspapers were transported by road from Gatwick Airport to Luton Airport where they also arrived at about 1500 hrs.

1.1.2. Preparations for loading

The operator employed the services of a handling agent at Luton Airport to assist the loading and departure of the aircraft. The agent's dispatcher met the two pilots at about 1500 hrs and drove them to their aircraft. When they arrived, both pilots went on board before the first officer disembarked and appeared to carry out an external inspection of the aircraft whilst the dispatcher talked to the commander. The dispatcher asked the commander if he required fuel or de-icing, which he did not, but the commander did ask for 300 kg of ballast because he thought the return flight was to be flown empty (no cargo). The dispatcher explained that the aircraft would be transporting cargo weighing 3,000 kg (which overcame any requirement for ballast) and at about this time the vehicle carrying the newspapers arrived at the stand with its escort vehicle and a load team of three men.

The newspapers had been stacked on five pallets and secured by plastic wrapping. On opening the vehicle it was immediately obvious that the stack of newspaper bundles on the rearmost pallet had dislodged and the pallet was broken, rendering it unfit for loading by fork lift truck. Moreover, there was no fork lift truck at the stand for handling the pallets. To overcome these problems all the pallets were broken down into their constituent bundles. The loading team had intended to use a belt loader to transfer the bundles to the aircraft but the belt was very wet and would have damaged the unwrapped newsprint. To work around this problem the vehicle was reversed to the aircraft's forward cargo door and the bundles were transferred from the vehicle's tailboard into the aircraft.

The dispatcher assisted the load team. On boarding the aircraft he noticed some loose netting at the rear, netting laid along the right (starboard) side of the fuselage and a set of metal boarding steps beside the front cargo door. There were also one or two small boxes and the pilots' bags at the forward end of the fuselage on the right-hand side. The dispatcher noticed markings on the side walls of the fuselage with labels identifying the various cargo bays but the load team leader did not remember seeing these markings. He did, however, notice a tool kit, a small box and some ropes at the rear of the aircraft but apart from these items the cargo area was empty. The load team leader had not been supplied with a load plan so he asked the dispatcher for instructions. The dispatcher had not been supplied with any written documentation apart from the cargo manifest which showed three consignments of newspapers assembled into 264 bundles weighing a total of 3,063 kg. There was no mention on the manifest of pallets or pallet weights.

1.1.3. Conduct of the loading

Neither the dispatcher nor the load team leader had previously loaded an F27 cargo aircraft so the dispatcher asked the commander how the cargo should be loaded. The dispatcher recalled that the commander said "from the back". The load team leader's recollection of the dispatcher's instructions was to "put it all in the rear". During the next 30 to 45 minutes the bundles were hand carried and stacked spanning the width of the floor. The bundles were of different sizes and to achieve a consistent load density, they were stacked to give a reasonably even height of about two feet six inches (75 cm). The loading team placed the first bundles in a row abeam the forward edges of the rear door apertures and worked their way forwards through what the team leader estimated to be between one quarter and one third of the cabin length. The dispatcher estimated that they finished loading at a position consistent with the trailing edge of the wing. Both agreed that the load was continuous with no gaps and fairly even in height.

Whilst the loading was carried out, according to the dispatcher both pilots remained in the vicinity of the flight deck. However, the load team leader's perception was slightly different; he remembered seeing the commander standing at the front of the fuselage near the cargo door watching the loading, interspersed with shorter periods spent on the flight deck. Both witnesses agreed that the first officer remained in his seat throughout the loading procedure and that at no time was the commander seen at the rear of the cargo cabin.

1.1.4. Load restraint

When the last of the bundles was loaded the dispatcher disembarked to supervise the withdrawal of the vehicle. Whilst he was standing beside the cargo door the commander appeared from the flight deck and stood beside the door. From that position he looked at the load and asked for it to be 'netted'. At the same time he handed to the dispatcher copies of the completed loadsheet and technical log.

The three loaders secured the cargo with a single net whilst the commander watched. The net was already attached to hard points on the starboard side of the cabin floor. A few bundles on that side had to be moved to allow the net to be pulled over the bulk of the cargo. A few more bundles on the port side of the fuselage were moved to permit access to the attachment points on the floor.

The load team leader stated that the net was secured to the seat rails with approximately 12 fastenings. He secured the rear of the load which had a near-vertical face. He could see no obvious attachment points on the floor behind the load and so he pulled the net tightly over the load with draw straps and hooks fitted to left side of the net. The tension at the rear of the net was taken by the attachment points on either side of the fuselage which, longitudinally, were almost abeam the end of the load, leaving no surplus netting at the rear of the load. His colleague at the front of the load placed three clips into the attachment rails on the floor about six inches in front of the load. Surplus netting ahead of the load was folded over and drawn rearwards where it was secured to the outermost rail on the port side. The third loader attached several clips along the port side outer attachment rail and tensioned the net using the clips, hooks and draw straps already attached to the net. When the loading team had finished securing the net, the team leader asked the commander if the load was "ok". The commander moved towards the front of the netted cargo, looked at it and reportedly said, "yes, well done lads" at which point the load team disembarked. As they drove off, the commander closed the cargo door from the inside.

1.1.5. Aircraft push back

After the load team had departed, the first officer disembarked from the aircraft through the crew door and asked to borrow a screwdriver. A screwdriver was obtained and after saying he was "going to do something with a microswitch", the first officer was seen with his head inside the nose gear bay for a few seconds. He then reappeared and asked the commander to make a switch selection. The commander apparently did so and indicated to the first officer that his attempt at rectification had been unsuccessful. The first officer said "ah well it was worth a try" as he handed back the screwdriver. He then returned on board the aircraft and closed the crew door. The dispatcher stayed at the aircraft with the tug driver for the remainder of a normal start-up and push back sequence, which was completed at about 1600 hrs.

1.1.6. The accident flight

The aircraft departed the stand and taxied to the runway. There were no reports of any taxiing difficulties and it took off from Luton at 1614 hrs. The aerodrome controller saw nothing unusual about the take off. During the flight the crew did not mention any handling difficulties to ATC by radio or to each other on the 30-minute cockpit voice recording (which began when the aircraft was just north of Southampton). Moreover, no reports of turbulence at their cruising flight levels of 150 and 160 (approximately 15,000 feet and 16,000 feet above sea level) were made to ATC by the crew of G-CHNL or by other crews.

In flight the first officer made all the radio transmissions. The commander, who was the handling pilot, briefed the first officer comprehensively and in good time for the approach and landing at Guernsey. The descent was begun at about 60 miles from Guernsey Airport and the aircraft was vectored onto final approach by Jersey Radar. The approach checklist was actioned and the flaps were lowered to 16° just before the aircraft was turned to intercept the ILS localiser. With less than six miles to run to the threshold the commander told the first officer that he could see the runway and was content to continue the approach visually. The first officer informed ATC that they wished to continue the approach visually; they were given the appropriate clearance and control of the aircraft was then handed over to Guernsey Tower. Initially the aerodrome controller cleared the aircraft to continue the approach (there was departing traffic on the runway) and the commander called for flaps to 26° followed by the landing checklist.

About one minute later the commander said "three whites" (meaning that he was aware that the aircraft was slightly high on the glidepath indicated by the precision approach path indicator lights) which the first officer acknowledged. The commander then said "ok the decision is to land, speed below one four four, flaps forty". The first officer acknowledged the instruction to select flaps to 40° and announced "running". There followed a pause of about five seconds before the first officer said, "flaps fourty gear and clearance you have - oops". The commander then said, in an anxious tone of voice "ok flaps twenty six" and the engines could be heard accelerating on the cockpit voice recording. There then followed a number of expletives from the commander interspersed with some loud clicks as controls or switches were operated and the sound of a warning horn which stopped before the end of the recording.

1.1.7. Witness evidence

The aerodrome controller saw the aircraft on long finals. He noticed that, unusually, the taxi light attached to the nose landing gear was not illuminated but the landing lights in each wing leading edge were on. He then looked away to watch the departing aircraft clear the runway before looking back at G-CHNL to clear the aircraft to land; at the same time he informed the crew that the surface wind was from 200° at 17 kt. At that moment the aircraft was about three nautical miles from touchdown on a normal flightpath. Some seconds later he noticed it 'going high' on the glidepath, assumed it was going around, and annotated the flight progress strip 'G/A 1705'. Next he looked towards the go-around airspace to ensure that it was clear and upon looking back at the aircraft he saw it drop its left wing and descend.

Many other witnesses heard and saw the aircraft on what appeared to be a normal final approach path. Generally their perception that all was not well was first aroused by the sound of the engines accelerating. They then looked up to see the aircraft adopting an ever-increasing nose-high attitude with the right wing lower than the left. Some thought the aircraft reached the vertical and several thought it might fall backwards. The aircraft reached an apogee before one wing dropped sharply and the whole aircraft descended rapidly. Some witnesses reported that the aircraft rotated in yaw through more than one revolution but some thought it changed direction only slowly and through about 180°. Most agreed that it fell in a fairly flat pitch attitude with little forward speed and caught fire shortly after impact with a house, which was struck principally by the aircraft's left wing. There was only one person in the house; she was unhurt and able to leave through the front door.

1.2. Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	2	-	-
Serious	-	-	-
Minor / None	-	-	1

1.3. Damage to aircraft

The aircraft was destroyed.

1.4. Other damage

A domestic house sustained substantial structural and fire damage and an agricultural field was contaminated with aviation turbine fuel. Two small domestic outbuildings were destroyed.

1.5. Personnel information

1.5.1

Commander:	Male aged 36 years
Licence:	Air Transport Pilot's Licence issued 18 December 1998
Type ratings:	Fokker F27 series 100, 200, 500 & 600 Piper, Cessna & Beech light aircraft
Instrument rating:	Renewed 13 March 1998
Base check:	7 September 1998
Line check:	9 April 1998
Medical certificate:	Class One renewed 23 January 1998 endorsed with requirement for correcting spectacles with second pair available
Flying experience:	Total all types: 3,930 hours Total on type: 750 hours (of which approximately 315 hours were in command) Last 90 days: 89 hours Last 28 days: 19 hours
Flying duty period:	2 hours 6 minutes
Rest period before duty:	11 hours 30 minutes preceded by 65 hours on 9 and 10 January 1999

1.5.2

First officer:	Male aged 41 years
Licence:	Commercial Pilot's Licence issued 29 November 1996
Type ratings:	Fokker F27 series 100, 200, 500 & 600
	Piper and Cessna light aircraft
Instrument rating:	Renewed 30 January 1998
Base check:	14 July 1998
Line check:	7 April 1998
Medical certificate:	Class One renewed 22 May 1998 with no conditions
Flying experience:	Total all types:* - 958 hours
	Total on type: - 317 hours
	Last 90 days: - 83 hours
	Last 28 days: - 28 hours
Flying duty period:	2 hours 6 minutes
Rest period before duty:	11.5 hours on 12 January preceded by 4 days off-duty

1.6. Aircraft Information

1.6.1 General information

Manufacturer:	Fokker VFW NV* (see note below)
Powerplants:	Two Rolls-Royce Dart 532-7 turboprop engines
Manufacturer's serial number:	10508
Year of construction:	1975
Certificate of Airworthiness:	Transport Category (Passenger) issued 19 May 1998
Certificate of Maintenance Review:	Issued 11 January 1999

*The aircraft manufacturer ceased trading in March 1996. Responsibility for continued airworthiness of the Fokker F27 was transferred to Fokker Services BV which assumed the Type Certificate holder's responsibilities specified in JAR 21 regulations.

1.6.2. Aircraft description

The Fokker F27-600 was a high wing all metal monoplane fitted with retractable tricycle landing gear and two turboprop engines driving variable pitch propellers. The fuselage was of parallel section over the greater part of the cabin and was a light alloy semi-monocoque structure. Aft of the flight deck door on the left-hand side was a large cargo door, which incorporated a crew entry door. At the rear of the cabin there was an entry door on the left side and an emergency door on the right side.

1.6.3. Flight controls

The primary flight controls were manually operated via push-pull rods and cable runs; spring and balance tabs were used to reduce the operating forces. The tailplane was fixed and pitch trim was altered using hand wheels on the centre pedestal connected by cable runs to a trim tab mounted on the trailing edge of the left elevator. A mechanical pointer that traversed a scale adjacent to each hand wheel indicated trim tab position. To improve stall warning under certain conditions, a stick shaker was provided on the left control column.

Each wing had an inner flap between the fuselage and the engine nacelle and an outer flap outboard of the nacelle. The flaps were driven by a reversible electric motor that actuated the flaps via torque shafts, gearboxes and jackscrews. The inner flaps could be extended a maximum of 26.6° and the outer flaps 40°. A handle on the right side of the control pedestal controlled the flaps. The handle moved in a notched slot with placarded detent positions of UP (0°), 11.5°, 16.5°, 26.5° and DOWN (40°). A gauge on the left main instrument panel indicated flap position.

1.6.4. Powerplants

The aircraft was powered by two Rolls Royce Dart Mk 532-7 turboprop engines, each developing a minimum of 1,835 shaft horsepower and 485 lbf of thrust at 15,000 rpm at dry power rating. Water methanol injection could be used for short periods to increase the thrust rating to 1,990 shaft horsepower and 520 lbf thrust at 15,000 rpm. Each engine drove a four-bladed, constant speed, hydraulically operated and featherable propeller. The propellers did not have a reverse pitch capability but a ground fine pitch stop setting of approximately 0° was used for maximum drag during the landing roll.

The propellers incorporated a number of other stops and locks. The flight fine pitch stops engaged when the engines exceeded 14,000 rpm and remained engaged until the throttles were lifted and retarded against spring pressure from the idle position, whereupon the ground fine pitch stops were electrically activated. An audio warning horn sounded if the ground fine pitch circuit was not active at indicated airspeeds below 55 kt.

1.6.5. Cargo compartments

The fuselage was divided into five cargo compartments as shown in the diagrams.

Hold 1 and Hold 2 were legacy compartments from the aircraft in its passenger fit and were originally used to accommodate role equipment and passengers' baggage. The area once occupied by passenger seating was divided into three cargo bays labelled A, B and C. There was no physical division between the bays; their forward and rearward limits were identified by markings on the fuselage floor and walls. A smoke barrier was fitted across the fuselage just behind the entrance to the flight deck. Aft of the smoke barrier, Holds 1 and 2 together with Bays A, B and C formed one continuous cargo area.

1.6.6. Cargo restraint equipment

The cabin floor had been converted from that of a passenger cabin to a cargo bearing floor by placing large sections of plywood sheeting between the 'Vickers' attachment rails. The 'Vickers' rails, which had originally been used for attaching the passenger seating to the cabin floor, had been extended fore and aft to include the areas of Holds 1 and 2 to allow moveable lashing rings to be fitted within these Holds. A number of fixed lashing points were mounted in the cabin floor. One side of two large cargo security nets were semi-permanently attached, using moveable lashing rings, to the 'Vickers' rail that ran down the starboard side of the cabin. The forward security net was used to secure the cargo placed in Hold 1 and Bay A and the rear security net for the cargo placed in Bays B and C. After the aircraft had been loaded the security nets would be pulled over the cargo and attach with adjustable load straps to movable lashing rings fitted to the 'Vickers' rail on the port side of the cabin. The forward and rear ends of the cargo loaded in Hold 1 and Bays A, B and C were secured using the ends of the security nets, adjustable load straps attached to fixed lashing points and moveable lashing rings. A loose security net was used to secure the cargo in Hold 2. The Operator carried spare moveable lashing rings and adjustable load straps in a container in Hold 2.

1.6.7. Weight and balance

A specialist company weighed the aircraft on 12 May 1995 shortly before it entered service with Channel Express. The weight and balance report was then adjusted by Channel Express staff to account for variations in minor items that were added or removed after weighing. The basic data was then converted into Index format for use by crews and loading staff. The conversion process is described at Appendix A.

1.6.7.1. Limitations

Details of the basic data and conversion into Index format are given at Appendix A.

Maximum Take-Off Mass:	20,410 kg
Maximum Landing Mass:	18,597 kg
Maximum Zero Fuel Mass:	17,917 kg
Aircraft Prepared for Service (APS) Mass:	11,110 kg
Unladen centre of gravity Station:	353.09 inches aft of datum
Unladen centre of gravity position:	12.9% MAC
Unladen Index:	1.75
Centre of Gravity Limits:	See Appendix B page 6

1.6.7.2. Cargo manifest

The cargo manifest was a single page stating that there were 264 pieces of loose cargo weighing 3063.0 kg. The manifest did not state that the newspapers were assembled onto pallets, the number of pallets or the weight of each pallet. Three waybills identified three separate consignments, all prepared by the same shipper as follows:

No of pieces	Gross Weight kg	Description
16	117.2	Newspapers
52	369.0	Newspapers
196	2542.9	Newspapers

Total 264	Total 3029.1

1.6.7.3. Loadsheets

Copies of the loadsheets prepared by the crew at Exeter, Liverpool, East Midlands and Luton Airports are contained at Appendix C. Names and signatures have been electronically removed from these loadsheets. Where applicable, the fact that a loadsheet was signed is indicated on the sheet by a printed statement to that effect.

1.7. Meteorological information

1.7.1. General situation

An aftercast was obtained from the Meteorological Office at Bracknell. The synoptic situation at 1700 hrs showed a cold front lying from Walton on the Naze through Eastbourne to Caen in France. It was moving steadily south-eastwards with an unstable north-westerly airstream covering the route from Luton to Guernsey. Outside scattered showers along the route the visibility was generally 20 to 25 km. The freezing level was at 3,100 feet and the tops of the highest clouds were at 6,800 feet amsl. Moderate turbulence was probable in cloud and below 5,000 feet amsl.

1.7.2. Guernsey weather

Recordings of the Guernsey Airport weather observations before and after the accident are shown in the table.

1.7.3. Meteorological warnings

The Jersey Met Office issued a warning of significant meteorological conditions (SIGMET) at 1318 hrs on 12 January valid for the period 1300 hrs to 1600 hrs. The warning was:

'Severe turbulence and windshear forecast below 3,000 feet in the Channel Islands (Air Traffic) Zone'.

No further SIGMETS were issued during that afternoon.

1.8. Aids to navigation

All the appropriate aids to navigation at Guernsey Airport were serviceable. Navigation was not a factor in this accident.

1.9. Communications

Tape recordings of all the RTF communications between G-CHNL and the air traffic service units contacted during the flight were obtained from the CAA Safety Regulation Group Transcription Unit, Jersey ATC and Guernsey ATC.

1.10. Aerodrome and approved facilities

Guernsey Airport has a single runway 1,463 metres long and 45 metres wide. The elevation of Runway 27 threshold is 334 feet amsl. There is an ILS approach system with 3° glidepaths for both runway directions augmented by optical Precision Approach Path Indicators set to a 3° slope. The full runway distance is available for landing on Runway 27 and there is extensive approach and runway lighting which meets Category 1 requirements.

1.11. Flight recorders

The aircraft was fitted with a 30-minute Cockpit Voice Recorder (CVR) and a 25-hour Digital Flight Data Recorder (DFDR).

1.11.1. Recorder installation

The DFDR installation on the subject aircraft provided transducers for airspeed, altitude, magnetic heading, normal acceleration and flap position. Transducers were not provided for recording aircraft pitch attitude, roll attitude or any engine parameters, nor were they required to be under the UK regulations.

The CVR system provided a four track recording of aircraft audio; one track being allocated to each crew member and a third for recording sounds made on the flight deck through an area microphone. The fourth track was not used.

Both recorders were fitted to vibration damped racks on avionics shelves and located in the rear of the aircraft, just aft of the rearmost cargo hold. At the accident site, both recorders were found lying on the floor at the rear of the aircraft amidst the cargo of newspapers. The CVR was still attached to its rack and appeared to be essentially undamaged. The DFDR had become separated from its rack, which was still partially attached to the avionics shelf. The DFDR had sustained crushing damage to the front face of the enclosure but was otherwise intact.

1.11.2. Recorder Replay

The recorders were taken to the AAIB at Farnborough, disassembled and the undamaged recording media (0.25 inch magnetic tape) replayed on open reel tape transports.

The DFDR retained aircraft data from the entire accident flight with the exception of the last second of flight. This was due to the manner in which the DFDR held data in a buffer prior to recording on the crash-protected magnetic tape. The data buffer was not crash protected and required electrical power to retain the contents. Upon replay it was also found that the DFDR had a previously undetected fault which resulted in random corruption of all the recorded parameters over the entire recording. Although the DFDR was equipped with built-in test circuitry to alert an operator to most modes of erroneous operation, it would not have been capable of detecting this particular fault. The method of recording data was to regularly sample the output voltage from each of the aircraft transducers in turn and convert the resulting value to a 12 bit binary number. The 12 bits were then, after buffering, sequentially written to the crash-protected tape. The nature of the data corruption caused by the fault in the DFDR was such that, on a frequent but irregular basis, a binary '0' was changed to a binary '1'. Gross errors (in the more significant bits of the 12 bit binary encoded words) were identifiable by large discontinuities once the raw data had been converted to engineering units. These errors were corrected by manual inspection of the recorded 12 bit binary words; whereas much smaller discontinuities caused by errors in the less significant bits could not be identified and hence corrected. Attempts to recreate the fault after the accident by tests on the surviving electronic circuitry were unsuccessful.

The conversion of recorded raw data to engineering units was effected using algorithms derived from the results of the most recent calibration of the DFDR installation, which was completed two days before the accident flight. As far as possible, the data was corroborated with that from other sources, such as SSR mode 'C' radar returns from the Jersey radar head, ATC tapes and meteorological information.

The CVR contained aircraft audio for the last 30 minutes of the accident flight and covered the period from when the aircraft was in the cruise approaching Southampton until the final impact. The quality of the audio recorded on the two crew channels was excellent whereas the recorded signal from the cockpit-mounted area microphone was of such a low level that this source provided very little useful information. As far as was practicable, the area microphone channel was tested and no anomalies found. It was noted however, during post-accident testing, that the overall acoustic sensitivity of the cockpit-mounted microphone and pre-amplifier unit was poor and, in particular, low frequency sounds (less than 250 Hz) generated signal levels that were extremely low and indistinguishable from the electronic noise. It should be noted that, for this generation of equipment, the microphone and the pre-amplifier were specifically designed to have a reduced response at low frequencies to reduce distortion and improve overall intelligibility.

1.11.3. Accident flight

The flaps-up take off, climb to FL160, descent and interception of the ILS for Runway 27 at Guernsey were uneventful. The landing gear was lowered and Flap 26 selected. The crew carried out the landing checks and Guernsey Tower cleared the aircraft to land, giving a final surface wind check of 330°/17 kt.

At 650 feet (approximately 300 feet agl) Flap 40 was selected. Once the flaps had extended, the first officer confirmed the selected flap position, that the landing gear was down and that they had clearance to land. The aircraft stopped descending at 630 feet and airspeed began to reduce as the first officer muttered an exclamation. As the normal accelerometer values began to show increasing g levels, the commander called for Flap 26 and applied full engine power. Over the next three seconds as the flaps travelled towards 26 degrees, airspeed reduced through 97 kt, normal acceleration reached a peak of 1.5 g and the aircraft began to climb, passing through 730 feet at this point. The aircraft continued to climb, reduce airspeed and the normal acceleration readings started to decrease. The aircraft also started to turn to the left. As it climbed through 1,000 feet with an airspeed of 70 kt, engine power was reduced. One and a half seconds later, at approximately 55 kt and 1,100 feet, a continuous warning horn was heard in the cockpit.

Engine power was reapplied (not full power) and over the next four seconds the aircraft climbed to a maximum altitude of 1,230 feet and airspeed decayed to zero; normal acceleration reduced to a minimum of 0.3 g and the aircraft had turned left to 236°M. The landing gear was raised and flaps up selected. Full engine power was applied and the cockpit warning horn stopped. As normal acceleration readings started to increase the aircraft began to turn to the right and descend rapidly. The last recorded parameters on the DFDR were:

1.7 seconds before impact	Heading 124°M Barometric Altitude 930 feet (corrected for 1004 mb)
1.4 seconds before impact	Airspeed 0 kt Flaps up
1.0 seconds before impact	Normal acceleration 1.1 g

Both flight recorders stopped recording at the point of impact due to the removal of electrical power. A plot of the pertinent aircraft parameters and time-correlated CVR events during the final stages of the flight is shown in Figure 1.

1.11.4. CVR spectral analysis

In the absence of any engine related parameters having been recorded on the DFDR, an acoustic assessment of the CVR was conducted. The very poor quality of the area microphone channel precluded analysis of this particular noise source, but spectral analysis of the crew channels yielded some information. Although the ambient noise level was, for periods of time, masked by crew speech, no evidence of engine asymmetry was found during the final minutes of the accident flight.

1.11.5. Cockpit warning horn

The continuous warning horn fitted to this aircraft could be triggered by three different sets of conditions:

1. When either throttle is retarded below 10,500 RPM and any landing gear is not down and locked.
2. When flaps are in any position beyond 25° and any landing gear is not down and locked.
3. Airspeed is below 55kt, right-hand power lever is below 14,000 RPM and ground fine pitch is not activated.

Combining information from the CVR and DFDR, at the time that the landing gear was raised, the flaps were travelling up through the 25° position and engine speed (from CVR spectral analysis) was greater than 10,500 RPM. In the absence of any evidence of engine performance asymmetry, these conditions did not satisfy the requirements of 1) and 2) above and therefore would not have triggered the warning horn. However, it is considered that, as full engine power (15,000 RPM) was not reapplied until the aircraft began to descend rapidly and airspeed had reduced below 55 kt, the requirements of 3) above were satisfied and the warning horn triggered.

1.12. Aircraft examination

1.12.1. Accident site

The accident site was 90 feet to the south of one of the two main roads from the Island's capital to the airport, in an area of domestic housing and agricultural land. The aircraft wreckage came to rest partially in the rear of a single storey domestic house, its garden and an animal grazing field. The area was approximately two thirds of a mile from the end of the airport's runway, 900 feet to the south of the runway's extended centreline and 25 feet below the height of the airport.

1.12.2. Impact sequence and parameters

Examination of the accident site showed that the first impact was between the aircraft's left wingtip and the rear roof of the house. The effect of this initial impact was to slew the aircraft to the left through approximately 35° before it came to rest. Assessment of the impact marks on the aircraft, the house and the ground indicated that at the initial impact the aircraft was on a heading of approximately 146° magnetic, travelling forward at a speed of about 40 kt, travelling downwards at about 70 kt, banked to the left 10 degrees and pitched nose down 15 degrees. When the aircraft came to rest both wings outboard of the engine nacelles had broken away rupturing both integral wing fuel tanks. The fuel that had been contained in these tanks was discharged into the rear of the house and an old brick structure in the grazing field. These structures contained the post impact fires that had initiated in the areas of the engines, until they were extinguished by the fire services. Examination of the aircraft showed that both sets of wing flaps and all three landing gears were retracted and that both propellers were rotating at speed and under power. The elevator trim tab operating mechanism mounted in the tail of the aircraft was found at almost the full nose down position, which was consistent with the position of the elevator trim control in the cockpit.

1.12.2. Examination of the cargo

The aircraft's cabin contained a cargo of bundles of various types of newspapers and magazines spread between Bays A, B, C and Hold 2 (for layout of bays see para 1.6.6). The cargo found in Bay A was contained under the security net for Bays B and C but had slid forward, stretching the security net, during the impact. The cargo found in Hold 2 consisted of loose unsecured bundles of newspapers. The cargo found in Bay C consisted of bundles of newspapers and magazines that were both on top of and under the security net. All the cargo found in Bay B was under the security net. No cargo was found in Hold 1 although some aircraft items and crew baggage were present. A number of aircraft items and a crew bag, that had originally been located in Hold 1, were found on top of the security net in Bays B and C. The security net for Hold 1 and Bay A was found not to have been used to secure the cargo. The security net for Bays B and C had been used and had been correctly fastened to the 'Vickers' rails; the load straps and associated lashing rings had either held or had been torn from their cargo floor fittings as a consequence of the impact forces. The forward edge of the security net for Bays B and C had been secured with adjustable load straps fitted to moveable lashing rings that had been fitted across the cargo area approximately 31 inches to the rear of the forward limit of Bay B. There was no evidence that the rear edge of this security net had been secured to any fixed lashing points or moveable lashing rings. There was no evidence of a security net or load straps having been fitted to the rear of the cargo. A number of adjustable load straps, moveable lashing rings and a small security net were found loose and unused at the rear of Hold 2. The location of the cargo was documented in detail prior to its removal from the aircraft. Following its removal from the accident site the cargo was allowed to dry out for four months before being accurately weighed. When weighed it was found that the total weight was 3,164 kg of which 644 kg, 20%, was found outside the cargo security net. The following cargo distribution, by weight, was found onboard the aircraft at the accident site:

Hold 1	Nil
Bay A	184 kg
Bay B	1980 kg
Bay C	771 kg
Hold 2	229 kg

1.12.3. Pre-impact failures

A detailed examination of the aircraft wreckage did not reveal any pre-impact airborne collision, fire or systems failures. Examination of the propeller mechanisms at the manufacturer's facility showed that they were both in good working condition and that they were each producing similar high thrust at impact. The cargo floor, the fixed lashing points, the moveable lashing rings, the 'Vickers ' rail, the security nets and the adjustable lashing straps were examined for indications of pre-impact failures, but none were found.

1.13. Medical and pathological information

A post-mortem examination was made of both crew members. There was no evidence of any pre-existing disease, alcohol, drugs or toxic substance which might have caused or contributed to the accident. Both pilots suffered multiple and immediately fatal injuries when the aircraft struck the ground.

1.14. Fire

The aerodrome controller saw the aircraft descending in uncontrolled flight. He immediately dispatched the Airport fire appliances to the scene of the accident; he also alerted the Island's fire service. The Airport appliances arrived four minutes after the crash and the Island fire service arrived shortly afterwards to tackle fuel-fed fires centred on both engines. The fire in the aircraft's left engine spread to the rear bedroom and roof of the bungalow which had probably been contaminated by fuel from the disrupted left-wing fuel tank. Two firemen donned breathing apparatus and entered the aircraft through the forward left entrance door to the flight deck. There were no signs of life in either pilot and one fire fighter switched off the aircraft's batteries. The combined fire services extinguished the fires before they spread to the interior of the aircraft but the house was severely damaged by fire and smoke contamination.

1.15. Survival aspects

The accident was not survivable.

1.16. Tests and research

Not applicable.

1.17. Organisational and management information

1.17.1. Operating company structure

The operating company ('the Operator') was one of three companies within the Dart Group plc. The other two companies were principally involved in forwarding freight and freight distribution. The activities of all three companies were closely linked. Channel Express (Air Services) Ltd was the air freight element of the Dart Group and operated four aircraft types in the cargo role. The operator had three F27 bases: Bournemouth; Stansted and Coventry. Handling agents were employed to prepare and document loads for air carriage, and to load and unload the aircraft.

1.17.2. Operator's management structure

The Dart Group occupied the same office complex as the Operator (Channel Express (Air Services) Ltd) and its managing director was formerly the managing director of Channel Express Ltd. The operator's management structure had undergone several changes since October 1997 partly because the company's fleet expanded and partly because key personnel left the company. At the time of the accident the key executives were the managing director, technical director and flight operations director.

1.17.3. Operator's aircraft fleet

The aircraft types operated were: Airbus A300; Lockheed Electra; Fokker F27 and Dart Herald. The A300 and Electra generally operated with a crew of four: commander, first officer, flight engineer and loadmaster. The F27 and Dart Herald could carry a loadmaster but they generally operated with two pilots.

The F27 aircraft were used to transport cargo between the mainland and the Channel Islands. They were also used to service contracts for several other companies forwarding mail, parcels and newspapers. The fleet was heavily committed to scheduled night freight contracts between airports in England, Eire, Guernsey and Jersey.

1.17.4. Authority for operations

The Operating Company's 'Flight Operations Manual' was formulated to comply with CAP (Civil Aviation Publication) 393 'Air Navigation: The Order and The Regulations' and CAP 360 'Air Operators' Certificates'. Relevant extracts from these documents are at Appendix E.

1.17.5 . Company Flight Operations Manual

The Flight Operations Manual was compiled in the JAR-OPS 1 format with the expressed intention of complying with Joint Aviation Requirements and the Company's Air Operator's Certificate. At the time of the accident there was no legal compulsion to comply with JAR-OPS 1 although the Company was working towards so doing.

The Flight Operations Manual was divided into several volumes as follows:

Part A	General/Basic (All aircraft types)	
	Operating Staff Instructions	
Part B	Aeroplane Operating Matters (Type related)	
	Volume 3A	Aircraft Technical - F27
	Volume 5A	Loading Instructions - F27
Part C	Route and aerodrome Instructions and Information (all types)	
Part D	Training (Type related)	
	Volume 4	Training Manual - F27

Extracts relevant to loading procedures and responsibilities are at Appendix F.

1.17.6. Distribution of Operations Manual

Copies of Parts A, and the relevant volumes of Parts B and C were carried on board the aircraft. In addition, each of the operator's flight crew was issued with a personal copy of Part A and the Part B aircraft technical volume relevant to the aircraft type they operated.

There were 17 copies of Volume 5A for the F27: one for each aircraft in the fleet (8 copies); one each for the company operations offices; the CAA, the Director of Flight Operations and the Fleet Chief Pilot. Aircraft copies were stowed in a wooden documents box in Hold 1 (the forward portion of the main cabin). F27 Pilots were not issued with personal copies of loading instructions.

1.17.7. Load planning tables

The operator's loading instructions did not contain load planning tables to assist crews to devise load plans which resulted in an acceptable centre of gravity position, nor were such tables issued to F27 flight crews under cover of any other formal document.

The first officers own clipboard was recovered from the aircraft. The clipboard had a variety of reference material and data tables stuck to both sides. The reverse side had 'unofficial' load planning tables which had been photocopied from an unidentified source document. These tables contained planning guidance for cargo distribution amongst the loading bays of both the F27-500 and the F27-600. The figures for the F27-600 are reproduced on the next page.

<u>First officers load planning table</u>

F27-600	1000 KG	2000 KG	3000 KG	4000 KG	5000 KG
ADD PIL	0	0	0	0	0
HOLD 1	0	0	0	0	0
BAY A	0	0	800	1100	1500
BAY B	0	800+	1000+	1400	2000
BAY C	600	800	800	1100	1500
HOLD 2	400	400	400	400	0

1.17.8. F27 loading process

The physical loading and unloading of aircraft engaged on scheduled freight contracts was carried out either by handling agents or by load teams drawn from airport employees or the customer's staff. At Bournemouth, Guernsey and Jersey the loading teams were experienced and well equipped for loading and unloading the F27. Loads were usually transported between the airport warehouse and the aircraft by forklift truck on wooden pallets. At the aircraft freight was either loaded on the pallet or loose loaded by hand. The load teams at these airports check-weighed all freight for air carriage and prepared a load report for the crew stating the total weight of freight and the weight distribution in each compartment. Before issuing this report, the team leader used a mechanical calculator to ensure that the load distribution was within the aircraft's centre of gravity envelope. Technically the commander was still held responsible for ensuring that loading complied with various regulations and was properly secured, but he was not normally required to be present during the loading process. During loading and unloading of freight at Bournemouth, Jersey and Guernsey, pilots normally left the aircraft to obtain refreshment or meals. At some other airports where 'quick turn rounds' were necessary, the F27 flight crew were expected to remain with the aircraft to supervise refuelling and the unloading and loading processes.

1.17.9. Company training schemes

The Operator's training organisation was contained in Part D Volume 4 of the Operations Manual. The document covered pilot training syllabuses for all the fleets, flight engineer training and loadmaster training. Initial, command course, and recurrent training syllabuses were included. Also included were the crew qualifications required by the company and requirements for persons holding training appointments.

1.17.9.1. F27 pilot ground training

F27 pilot induction training commenced with a 9-day (58.5 hours) groundschool syllabus concentrating on type technical issues. This was followed by a tour of the aircraft and additional classroom tuition on 'Performance and Flight Planning', 'Company Administration' and 'Emergency Procedures'.

The tour of the aircraft was divided into six topics. Only one topic - 'Cargo Compartment Bays and Lashing Equipment' - was directly relevant to the carriage of cargo. 'Performance and Flight Planning' training was allocated one day and was conducted by an F27 pilot. The training was classroom based and delivered using computer generated graphics.

1.17.9.2. F27 pilot line training

Commanders were allocated a minimum of 20 sectors and first officers a minimum of 20 sectors/30 hours with a Line Training Captain. The Line Training Checklist did not include loading procedures as a separate entity; loading was mentioned only under 'Load and Trim Calculations'. The only other reference to cargo related training was 'Dangerous Goods'. On completion of line training, pilots had to attend a 1-hour 'Dangerous Goods Appreciation' Course in accordance with CAA requirements.

1.17.9.3. Loadmaster training

The Operator employed loadmasters to supervise the load planning, loading, restraint and unloading of cargo, predominantly on its Electra and A300 aircraft but infrequently on its F27 aircraft. However, unlike the role of cabin attendant, the role of 'Loadmaster' is not formally recognised by UK aviation legislation as part of a crew complement. Consequently loadmasters may be carried as a de-facto member of a crew but they do not require to be licensed. They have to meet company requirements for proficiency and CAA requirements regarding emergency procedures. Nevertheless, their legal status on the aircraft is technically similar to that of a passenger.

Loadmaster induction training comprised a minimum of 40 hours classroom instruction, a safety and survival course and a minimum of 12 laden sectors under the supervision of a Training Loadmaster. Recurrent training included an annual competency check.

1.17.10. Flight time limitation scheme

The operator's flight time limitation scheme was contained in part A section 7 of the company Operations Manual. The scheme was necessarily complex. According to the Manual the standard reporting time was 60 minutes before scheduled departure but this had been reduced to 45 minutes through an Operating Staff Instruction (OSI G53 of 23 Feb 1998). The remaining relevant details were as follows. For a planned night's flying of 3 sectors (positioning does not count as a sector) and a reporting time of 1815 hrs, the maximum flying duty period was 10.5 hours. Fifteen minutes duty time (30 minutes pre-OSI G53) was allowed for post-flight activities. The minimum rest period between duty periods was normally 12 hours but this could be reduced to 11 hours if suitable accommodation was within 30 minutes travelling time and the rooms were available for occupation for a minimum of 10 hours.

1.18. Additional information

1.18.1. Previous accidents

Two previous accidents involving F27 aircraft carrying cargo were relevant to this accident.

1.18.1.1. PI-C501

In 1967 a domestic F27 flight from Manila to Mactan in the Philippines was loaded with a mix of freight and passengers. On final approach to land the aircraft suddenly assumed a nose-high attitude and additional power was applied. A crew member came out of the cockpit and instructed a number of passengers to move forward from the rear of the aircraft. Moments later a flight attendant instructed all the passengers to move forward but before they could comply, the aircraft started banking alternately left and right. It then descended in a tail low attitude and crashed 0.9 miles before the runway threshold.

The weight and balance computation based on the load manifest showed a centre of gravity within the allowable range. However, staff who participated in preparing the load manifest and loading of the aircraft stated that they were not sure that the load was distributed as reflected in the manifest. In particular they were unable to state exactly what weight of cargo had been loaded in the front cargo compartment, on 28 blocked seats and in the rear cargo compartment.

The investigation determined that the foremost 28 seats were loaded with an estimated 1,200 lb of cargo at an average of 43 lb per seat whereas persons weighing an average of 155 lb each occupied the rearmost 16 seats. Subsequent to the accident, weight and balance computations under four different load configurations all resulted in a centre of gravity position beyond the prescribed aft limit.

No technical failure or malfunction of the aircraft was found. It was considered that as the airspeed was reduced during the final approach, the aircraft progressively assumed a nose up attitude that was checked by the application of nose down trim until the limit of trim was reached and the elevator was at its maximum travel. There was no flight data recording and the position of the flaps during the approach was unknown; however, the flaps were retracted at impact.

Recommendations arising from the investigation were principally concerned with improving the knowledge and competence of everyone within the Philippines likely to participate in the preparation of weight and balance computations.

1.18.1.2. OY-APE

In 1988 an F27 cargo aircraft transporting freight from Billund to Hanover pitched up uncontrollably on short finals to land. The crew attempted to go-around from the approach but the aircraft rapidly lost airspeed, rolled about its longitudinal axis and crashed tail first in a stalled attitude approximately 940 m before the runway threshold.

The freight consisted mainly of 4,200 kg of cast iron parts. There was no qualified aircraft dispatcher and so the aircraft commander supervised the loading and securing of the freight. The investigation determined that the load manifest prepared by the commander did not correspond with the actual distribution of the freight within the cargo compartment. In fact the freight had been loaded too far aft and the centre of gravity position was 11% aft of the aft limit of 38% MAC. Moreover, the heavy cast iron parts had not been properly secured longitudinally and it was possible for them move aft, which some probably did when the aircraft initially pitched up, thereby intensifying the loss of pitch control.

No technical failure or malfunction of the aircraft was found. Flight recordings showed that loss of control was associated with the deployment of full (40°) flap for landing. During the attempted go-around the landing gear was retracted and a flap position of 26.5° was ordered but these actions were unsuccessful in regaining pitch control; the aircraft was by then uncontrollable.

No safety recommendations arising from the investigation were made.

1.18.2. Professional Pilot Licensing Examinations

Professional pilots holding licences issued by the UK CAA have to pass ground examinations before their licence can be issued. These examinations are general and are not specific to a particular aircraft type. The requirements are contained in CAP 54 'Professional Pilots' Licences'. There are two groups of examinations: navigation and technical.

'Weight and Balance (Loading)' and 'Principles of Flight (Aeroplanes)' are two modules of the technical group sat by candidates for the ATPL(A) and CPL(A). These examinations employ the objective testing format whereby candidates select the correct answer from a given selection of three or four alternatives. The weight and balance examination is chiefly concerned with the applicable regulations and the arithmetic calculation of weight and centre of gravity limits. The syllabus also includes the effects of flying an aircraft with the centre of gravity out of limits but excludes loading procedures and load restraint.

1.19. Useful or effective investigation techniques

Not applicable.

2. Analysis

2.1. General

The aircraft taxied and took off from Luton without any apparent problem. There was no evidence of any handling difficulty en route to Guernsey and the cockpit voice recording, which commenced as the aircraft approached Southampton, indicated a normal flight until just before the intended landing. There was no evidence within the wreckage of any significant aircraft defect nor was there any evidence of a meteorological problem such as wind shear or severe turbulence. There were, however, clear indications on the flight recorders that control was lost at about 300 feet above ground level on final approach, shortly after the flaps reached the fully down position of 40°.

The most obvious clues to the root cause of the accident were the absence of any cargo in Bay A, which according to the loadsheet should have contained 800 kg, and the elevator trim position, which was close to fully nose down. The forward half of the cargo was contained within the netting which had distorted under impact loads but was generally still restrained by its lashings. However about 20% of the cargo had been liberated at the rear of the aircraft. No cargo had been loaded into Hold 2 but 229 kg had come to rest there. Some 315 kg of liberated newspapers were distributed on top of the cargo netting in Bay C. The dynamics of the aircraft's impact with the ground would have thrown loose cargo upwards and forwards so liberated newspaper bundles must have migrated rearwards into Hold 2 in flight and then forwards into Bay C at ground impact. It was not possible to determine when migration to Hold 2 took place but it would not have occurred if the cargo had been adequately restrained at the rear of the aircraft.

There were marked similarities between this accident and two previous accidents related to extreme aft centre of gravity. All three accidents followed apparently normal take off, climb and cruise phases, with subsequent loss of control during the approach phase. The accident in the Philippines could not be directly related to the selection of landing flap but the accident at Hanover followed the deployment of full flap. Moreover, as in this accident, returning the flaps to the intermediate approach setting of 26.5° and raising the landing gear did not restore controllability.

Calculations of the aircraft's weight and balance, based on the distribution of the cargo as loaded, showed that the weight was within approved limits but the centre of gravity position was significantly aft of the approved limits before the aircraft taxied. Consequently, there can be no doubt that this accident was provoked by operating the aircraft outside the cleared load and balance limitations. The error went undetected because nobody ensured that the cargo distribution in the aircraft was the same as that shown on the load and balance sheet.

2.2. Scope of the analysis

This analysis begins with an overview of the aerodynamic reasons for loss of control and failure to regain control after the gear and flaps were raised. This is followed by examination of the process by which the aircraft was improperly loaded and why the error was not detected by the pilots. It concludes with a review of the unusual circumstances which allowed latent organisational and training factors to contribute to the sequence of events which led to the accident.

2.3. Aerodynamics and flight control

2.3.1. Cargo weight

The weight of the cargo was found to be 3,164 kg whereas the manifest stated that it was 3,063 kg. One consignment on the manifest had been entered as 182.0 kg whereas the waybill listed the consignment weight as 117.2 kg. It was not clear whether there had been last minute changes to the cargo which increased its weight. However, because the moisture content of the newspapers when weighed at the AAIB could not be confirmed as consistent throughout every bundle, the difference between the manifest weight and the measured weight (3.3%) was considered to be within measurement tolerances. Nevertheless, the measured weight of cargo was used in the calculation of centre of gravity position.

2.3.2 . CG position

The distribution of the load as shown on the loadsheet completed by the pilots at Luton bore little resemblance to the actual loading. Detailed reconstruction of the loading, based on a combination of physical and witness evidence, revealed that all the cargo had been placed in Bays B and C as shown on diagram:

Calculations indicated that the loaded aircraft centre of gravity was significantly aft of the aft limit of 38%. The positions of the centre of gravity during flight are illustrated on the graph.

In flight there is a small movement of the centre of gravity arising from fuel consumption but the main changes occur when the gear is raised and lowered.

The graph assumes that cargo migration did not start until after control was lost and the aircraft pitched-up to a near-vertical attitude. However, migration could have occurred earlier. The rear face of the stack of newspaper bundles was essentially vertical but their rearward motion was restrained solely by tension in the net from one side of the cabin floor to the other. If, whilst the aircraft taxied or flew, vibration dislodged one or more bundles, the overall tension across the rear of the net would have been reduced enabling more bundles to slip out. If migration in this manner took place before control was lost, the change in centre of gravity during flight would have produced a more extreme aft centre of gravity position.

2.3.2. Ground handling at aft centre of gravity

The first officer carried out a pre-flight external inspection before loading was completed. If he had carried it out afterwards, he might have noticed abnormal extension of the nose landing gear shock absorber which can indicate an aft centre of gravity position. On the other hand, the first officer did not react to any abnormal extension of the nose gear when he entered the nose gear bay after loading had finished. He was formerly a flight engineer. It would have been natural for him to have taken a keen interest in the aircraft's mechanical systems and to notice an unusual nose high attitude yet he made no mention of abnormal gear extension to the commander or to the ground crew.

Once the engines were started, even at idle power, propeller thrust would have produced a nose down moment sufficient to add weight to the nose gear which would improve nosewheel steering effectiveness. According to the Type Certificate Holder, at the actual centre of gravity the commander was unlikely to have noticed any reduction in nosewheel steering effectiveness unless the paved surface was distinctly uneven.

2.3.3. Defect rectification

Exactly what the first officer was attempting to rectify when he entered the nose gear bay with a screw driver could not be determined. However, the aircraft departed on time with the fault apparently still present. Two deductions arising from this activity may reasonably be made. Firstly, because the aircraft still taxied and apparently took off normally, the defect was not a 'no go' item related to the flight controls, landing gear or nosewheel steering. It seems most likely that the defect was within a minor, switched electrical circuit. Secondly, since they had time to spare for troubleshooting, the crew were not rushed by the loading process.

The most likely minor defect was a fault related to the taxi light mounted on the nose gear which had a microswitch in its power circuit to isolate the lamp when the landing gear was retracted. This would be consistent with the account given by the air traffic controller at Guernsey who saw the aircraft on final approach. He was used to seeing F27 aircraft approaching with three white lights illuminated but on this occasion he saw only two. The landing lights on the wings were on but the nose gear mounted taxi light was off.

2.3.4. Flying qualities at aft centre of gravity

At aerodromes where the take-off distance was not a limiting factor, the operator's standard procedure was to take off with flaps retracted. Elevator trim was routinely set to neutral before take off and the handling pilot would hold any initial out of trim forces. Consequently, pilots would have grown used to holding out of trim forces on take off and there could have been little if any symptoms of abnormal behaviour in pitch on take-off. Assuming the cargo did not migrate earlier, in cruising flight the centre of gravity position would have been about 2% MAC aft of the aft limit for that phase of flight. The tail surfaces would have been producing a download and there would have been no danger of running out of elevator authority. Therefore, the pilots were unlikely to have experienced any strikingly unusual handling qualities until the approach phase. Nevertheless there could have been some subtle but recognisable symptoms of extreme aft CG position in flight such as:

a.. Light elevator forces during rotation on take off with a possible tendency to over-rotate.

b.. Reduced in-flight dynamic stability leading to low control column forces in pitch and a difficulty in trimming.

c.. Excessive nose down elevator trim required.

2.3.5. Handling during approach

As explained in Appendix B, provided the centre of gravity remained ahead of the aerodynamic neutral point, the aircraft was statically stable. Static stability reduces as the neutral point moves forward towards the centre of gravity but the aircraft does not become unstable until the neutral point moves ahead of the centre of gravity.

During the accident approach, as speed was reduced and flap lowered, the neutral point moved forwards. Each time a stage of flap was deployed, the nose of the aircraft would have tended to rise and more nose down elevator would have been required to maintain the desired flight path. This is normal F27 behaviour. As the flaps extended the commander would have pushed forward on the control column and trimmed nose down to relieve the push force. Experienced pilots adjust elevator trim habitually and without looking at the trim wheel or the trim position indicator. Provided that the trim tab still had sufficient authority to trim the aircraft at flap 26.5°, the commander would not have noticed anything amiss.

As the flaps moved beyond 26.5° to 40°, the neutral point moved forwards and ahead of the centre of gravity. The commander would have pushed forward on the control column in an attempt to stop the nose rising but the elevator would have reached full travel and he would have been unable to stop it rising. Under the circumstances the commander's instruction to re-select flaps 26.5° was instinctive, as was his opening of the throttles to maintain airspeed. Unfortunately, increasing power moved the neutral point further forwards which negated the effect of returning the flaps to 26.5° and the aircraft continued pitching up. If the rear portion of the cargo had not migrated earlier during the flight, it must have done so as the aircraft adopted an ever increasing nose-high attitude. Cargo migration would have moved the centre of gravity further aft and aggravated the loss of stability.

One of the pilots raised the landing gear during the pitch-up. The commander did not ask the first officer to do it so he may have done it himself. Alternatively, the first officer may have acted on his own initiative. At that stage, like the majority of witnesses on the ground, the first officer probably thought that the commander was 'going around' from the approach. The commander's tone of voice would have alerted the first officer to a problem but not to its nature. Thinking, perhaps that his colleague had omitted part of the go-around procedure, he may have raised the landing gear without waiting for the instruction. This would have been a logical action for him to take under the circumstances. He was not to know that raising the gear would also aggravate the pitch-up because it moved the centre of gravity position aft. However, the effect of raising the landing gear was insignificant compared to the effects of migrating cargo and full power on the relationship between centre of gravity and aerodynamic neutral point.

2.3.6. Recovery

Although one pilot subsequently raised the flaps to the fully retracted position, before they were fully retracted the aircraft lost flying speed. Rapidly it reached an almost vertically nose-up attitude at its apogee about 900 feet above the ground. By this time migration of 20% of the cargo into Hold 2 must have occurred. The centre of gravity would have been near 49% MAC or even greater if slackness in the netting allowed the restrained 80% of the cargo to slip slightly rearwards. In this condition there was nothing either pilot could have done to prevent the subsequent stall and incipient spin as the aircraft fell earthwards, and there was no prospect of a successful recovery from the combination of low airspeed, aft centre of gravity and low height.

2.3.7. The effect of cargo migration

Calculations and extrapolation of flight test data by the Type Certificate Holder indicated that the centre of gravity position of the aircraft 'as loaded' was sufficient to explain the aircraft's behaviour. The contribution of cargo movement from Bay C to Hold 2, whenever it happened, was simply to aggravate the pitch-up and reduce the likelihood of recovery from the near-vertical flight path.

2.4. Loading supervision

2.4.1. The handling agent's staff

The handling agency did not hold a copy of the operator's 'Loading Instructions' because there was no standing contract with the operator for aircraft loading. At first this was immaterial because the aircraft was originally scheduled to leave without a payload. The decision to transport newspapers to Guernsey was a late change of plan but the dispatcher and load team leader had never before loaded an F27 cargo variant. The only written guidance available to them was copy of the operator's 'Loading Instructions' carried in a wooden box on board the aircraft. Even if they had known of the existence and location of the document, the agent's staff were busy people and would not have had time to read and digest its contents.

In essence the load team were neither trained in loading an F27 nor expected to accomplish the loading task unsupervised. For this unplanned task they and the handling agent's managerial staff had a right to expect the flight crew to be the 'experts' on the loading procedures appropriate to their aircraft. Simply put, the load team had no option but to rely upon the flight crew for instructions and supervision and they did their best to comply with the instructions they received. Moreover, they did not leave the aircraft until the commander had unmistakably indicated that he was satisfied with their work.

The loadsheet was handed to the dispatcher when all the bundles had been transferred from the vehicle to the aircraft. By that time both pilots had signed the loadsheet, thereby absolving the dispatcher of any responsibility for its accuracy. He was outside the aircraft supervising the withdrawal of the vehicle and the commander's actions signified that the dispatcher was not expected to verify the accuracy of the load distribution.

2.4.2. The pilots

The cockpit voice recording portrayed two pilots operating in a relaxed but professional manner until control was lost with no apparent warning. The commander, who was the handling pilot, gave a good approach briefing and the first officer supported him by tuning and identifying navigation aids, obtaining weather details, performing fuel checks, reading checklists and making all the radio transmissions. Good rapport between them was evident and despite taking minimum rest in Luton, neither pilot sounded tired. Their attention to detail in the air was impressive and this must be, to a large degree, a reflection of the flight training given to them by the operator. However, during their pre-flight preparations they overlooked errors in the loading process which could have been revealed by a quick and simple comparison of loadsheet with load distribution.

The apparent difference between the pilots' performance during the loading process and their performance in the air is so striking that there has to be a more complex explanation than memory lapse for such a fundamental mistake. Consequently, the requirements standards and procedures expected of them by the regulatory authorities and their employer were reviewed.

2.5. UK regulations and guidance

2.5.1. Loading regulations

Article 31 of the Air Navigation Order (see Appendix E) specifies the legal requirements for loading a public transport aircraft. Sub-para (2) states *'The operator of an aircraft registered in the United Kingdom shall not cause or permit it to be loaded.......except under the supervision of a person whom he has caused to be furnished with written instructions as to the distribution and securing of the load.'* Read in isolation this sentence could be interpreted in two ways but sub-para (2) of the Article clarifies the matter and makes it clear that the operator must furnish the required instructions and information to whoever supervises the loading. The operator discharged this responsibility through Volume 5A Loading Instructions - F27 of its Operations Manual.

2.5.2. Guidance to Air Operator Certificate holders

CAP 360 contains guidance to air operators rather than legal requirements. The document states at paragraph 19.1.3 (e) that *'The person responsible for the trim of the aircraft must give written instructions to the person responsible for loading the aircraft'.* This statement is quite clear in its meaning and imposes a responsibility on the person devising or supervising the load plan to give written instructions to the load team supervisor stipulating how the cargo should be distributed within the aircraft. No such instructions, even in the most rudimentary form, were given to the load team by the crew. The reason why no written instructions were issued probably stemmed from the loading procedures adopted at some of the operator's bases.

2.6. The operator's loading procedures

2.6.1. Loading procedures at cargo bases

The operator's Flight Operations Manual stipulated that '*The person supervising the loading must confirm by signature that the load and its distribution are as stated on the mass and balance document'*. At Bournemouth, Jersey and Guernsey the handling agent's supervisor ensured that the weight and distribution of the cargo were accurately known. The supervisor also used a mechanical calculator to ensure that the load plan would result in a centre of gravity position within the approved limits before the aircraft was actually loaded. When loading was complete the supervisor provided a load report to the crew which he or she signed to the effect that the aircraft was properly loaded. The load report data were then used by crews to complete the loadsheet. In this way the compiler of the loadsheet (the mass and balance document) was able to certify that the loadsheet was a true reflection of the load mass and distribution.

The Operations Manual made clear that it was still the captain's responsibility to *'monitor and where necessary supervise aircraft loading, load distribution and load security during loading operations'* but such was the competence and experience of the loading staff, supervision by the commander during the loading process was unnecessary. Crews normally left the aircraft for refreshments during unloading and loading operations. On their return they frequently found the aircraft filled to capacity with no spaces in the cabin to inspect the contents and security of every cargo bay. In these circumstances a quick check of the overall load security as part of the pre-flight inspection was generally all that was practicable.

2.6.2. Loading procedures at other airports

The procedures used at Bournemouth and the Channel Islands airports were not standard practice everywhere. The operator had other contracts which required strict time keeping and expeditious turn round procedures during which the flight crew remained on board. The operator also undertook 'ad hoc' cargo operations throughout Europe and for these the crew were entirely responsible for load planning and supervision of the loading team.

At some airfields and with some types of cargo (eg parcels), the flight crew justifiably had less than complete faith in the accuracy of the information supplied to them regarding the distribution of the load. The total weight of cargo might be known reasonably accurately but not the weight of each item and hence the weight in each cargo bay. Fortunately, on many of these flights the aircraft was filled to volumetric capacity. The weight of the cargo moved the centre of gravity aft to an acceptable position even though the trim sheet calculations might have been an approximation. Also, if the cargo compartment was full, there was little space for the cargo to move.

Some of these cargo operations were conducted on the basis of seeing how much cargo could be fitted into the space available and the issue of written loading instructions by the crew to the loading team would have been impractical. Sometimes all the loading team needed from the crew was the maximum weight the aircraft could carry on the next sector. However, there were occasions when the weight of cargo was known and yet it did not fill the available space. Under these conditions, especially with a part load, there was a greater opportunity for misloading the aircraft. Safety could have been enhanced if crews had issued loading instruction forms to load teams. However, crews did not habitually supply loading teams with written instructions for any of these operations, although some crews may have done so. The format for an acceptable load instruction/load report was contained in the 'Loading Instructions' Volume carried on board the aircraft. An example of this format is at Appendix F page 4 but there were no blank forms carried on the aircraft for crews to use.

2.6.3 . Traffic officer's responsibilities

Aircraft loading responsibilities were described in the operator's 'Loading Instructions' as follows:

'The loadsheet must be completed accurately and the aircraft must be loaded in accordance with the issued written instructions. A certificate to this effect must be signed by the person responsible for the loadsheet. The aircraft commander will also sign a certificate to the effect that he/she is satisfied that all the relevant requirements of the air navigation order and the air navigation regulations have been complied with.'

Similar words were used in the 'Flight Preparation Instructions' (see Appendix F). The relevant sentences were: *'The person supervising the loading must confirm by signature that the load and its distribution are as stated on the mass and balance document which must also contain the name of the person who prepared it. The mass and balance document must be acceptable to, and countersigned by, the aeroplane Commander'.*

There was no mention in either document of the role or responsibilities of the traffic officer yet there was a signature box for this person on the bottom of each loadsheet (see Appendix C).

A reasonable interpretation of these written instructions is that the Traffic Officer had two key functions to perform:

a.. Certify that the aircraft had been loaded in accordance with the issued written instructions (ie in accordance with the load and balance limitations).

b. . Ensure that the load and its distribution were as stated on the mass and balance document.

Only the first of these two functions was quoted in the traffic officer's signature box. Consequently there was no reminder to the person performing the role of traffic officer that he or she must reconcile the load distribution with the loadsheet.

2.6.4. Execution of the Traffic Officer's role

Irrespective of the type of cargo carried, the airport where it was loaded or the composition of the loading team, it was first officers who habitually prepared the loadsheet and signed the 'traffic officers certificate' at the bottom of the loadsheet.

At airfields where the load team leader provided the crew with a load report, the spirit of the operator's loading instructions was met because the load team leader and the first officer shared the traffic officer's role. The team leader certified that the aircraft was correctly loaded on the load report and, using the load distribution shown on the report, the first officer certified on the loadsheet that the load distribution was within applicable limits.

However, at some other airfields this arrangement broke down. During short turn rounds first officers usually remained on the flight deck and took no part in observing the loading process or the end result. Moreover, it was not possible for a first officer to see the cargo compartment from the flight deck because of the smoke barrier. The result was that a first officer's signature on the loadsheet signified that the aircraft loading was within weight and balance limits provided that the load was distributed as shown on the loadsheet. First officers were not expected or empowered to check the final load distribution so they were poorly placed to certify that the aircraft had been loaded in accordance with the *'current Loading Instructions'*.

The caveat in the commander's signature box that commanders must ensure that all the regulations were met did not explain the detail of what was actually expected of them. Specifically, there was no mention in the operator's F27 checklists or pre-flight procedures for commanders to reconcile the load distribution on the loadsheet with the load distribution in the cargo compartment, nor to inspect the load for proper restraint.

The end result was that if a commander countersigned the loadsheet without reconciling the assumed distribution with the actual distribution of the load and without inspecting its security, both pilots would have relied on the loading team to ensure that the aircraft was in trim and the load secure.

2.6.5. Crew appreciation of load planning and restraint

The operator had experienced few problems with its loading practices at Bournemouth, Jersey and Guernsey because the F27 loading teams there were trained and experienced. At some other airfields although the crews nominally supervised the loading and restraint of cargo, the load teams repeatedly did much the same thing with contractually limited quantities of cargo. The loading and unloading operations conformed to a well practised routine and there was no requirement for detailed load planning or loading instructions. Moreover, no company pilot had reported any handling problems arising from loading errors. However, for any flight containing three tonnes or more of bulk cargo of reasonably uniform density, if the cargo was evenly distributed through the cabin from the front of Hold A to the rear of Hold 2, the centre of gravity of any of the operator's F27-600s would always have been within limits. Most of the operator's contracted loads were greater than three tonnes.

2.6.6. Preparations for aircraft loading

Preparations for the accident flight were abnormal in the sense that the aircraft had diverted to Luton and the decision to load newspapers was a late change of plan made at around 1400 hrs. The handling agents at Luton were a large company well used to loading newspapers and so, understandably, the operator's staff saw no need to specify the requirement for pallet handling equipment. The realisation that it was required came too late to the flight crew and the loading team for the equipment to be provided. Since one of the pallets was broken and could not be fork lifted, and the belt loader was soaking wet, they had to improvise a loading system which did not require any machinery. Although the agent's dispatcher and load team leader were generally inexperienced, having been employed in those roles for just over four months, they coped well under the circumstances.

Before leaving the hotel the commander had telephoned the operator and spoken to the rostering staff who informed him of the revised departure time and the schedule for the remainder of the night. However, according to the dispatcher, the crew arrived at the aircraft unaware that they were transporting a payload to Guernsey. This was surprising since the flight plan sent to their hotel was prepared for a three tonne load. However, the commander did not telephone company operations to determine why the departure time had been brought forward and the crew may not have studied the computerised flight plan which, according to the hotel's facsimile machine, was received at 1553 hrs. There must have been an error in the machine's clock for they left the hotel at about 1500 hrs, so it was not possible to determine when the crew first had sight of the plan, or if both pilots had seen it. Nevertheless, the flight plan which was prepared in Bournemouth at 1403 hrs could not have reached them at the hotel much before 1415 hrs and so the commander had little time to consider the implications of a late change in plan.

2.6.7. Loading supervision

Because they had flown a ballasted positioning flight to Liverpool the previous evening, both pilots must have known that an empty aircraft was nose-heavy and required ballast in Hold 2 before it could be flown. Consequently, the commander's instruction to start loading at the rear of the aircraft was logical because, until he arrived at the aircraft, the commander expected to fly the aircraft empty to Guernsey.

The commander was present at the aircraft whilst it was loaded. Had the load team done something wrong or used an improper procedure, they could reasonably have expected the commander to have informed them and asked them to correct any significant mistakes. Perhaps the most puzzling aspect of this accident is why the commander did not supervise the loading team more closely. He arrived early at the aircraft so lack of time was not a factor. He should have realised that the dispatcher and load team were unfamiliar with the F27 cargo variant yet he seems to have given them only rudimentary verbal instructions from his seat on the flight deck. He did not show them where to start loading nor did he ask for the load to be divided amongst the loading bays.

It is possible that sub-consciously, the commander temporarily mistook his aircraft for an F27-500. The fuselage of this variant is longer than the F27-600 and the operator had more of them in its F27 fleet. When empty, the F27-500 cargo aircraft has a more nose-heavy centre of gravity than the F27-600 and requires more weight at the rear to achieve a satisfactory centre of gravity position. Had a typical F27-500 been loaded in the same way as G-CHNL, from the rear doors forward, the centre of gravity would still have been outside the operating envelope but possibly not so far aft as to have induced total loss of control.

The commander's reaction to finding the load insecure after the last bundle had been placed is particularly revealing. The fact that the load team had not netted the bundles should have prompted him to carry out a thorough check of their work but he did not leave the vicinity of the cargo door. If he had supervised or observed closely the load team at work, he would have noticed that they were placing bundles over the Vickers rails where the restraint clips would later have to be attached. Moreover, he did not visit the rear of the aircraft. If he had, he should have seen that the rear of the load was improperly secured.

This behaviour contrasts strongly with the commander's careful manner and thorough attitude whilst actually flying. It would appear as if either he was not aware of the importance of load positioning and restraint, or that he was not sure how to direct and supervise the loading operation.

2.6.8. Loadsheet accuracy

The possibility was considered that this crew were completing loadsheets which would withstand post flight scrutiny, without necessarily being an accurate reflection of the true aircraft weight and load distribution.

There were no load reports to compare with the loadsheets but a detailed examination of all the other flight records and the customer's records of loads submitted for carriage revealed that the first officer had used logical and accurate figures on all the loadsheets. They also revealed that he was in the habit of preparing loadsheets in advance. Provided the first officer entered only details which would not change during turn round such as aircraft weight and structural limits the loadsheet then served as a useful tool for calculating the maximum payload whilst en route to the next airport.

An example of the first officer's technique was the loadsheet found on the flight deck for a flight from Gatwick to Guernsey that was anticipated but did not take place. The loadsheet (See Appendix C page 3) was annotated for Flight 820 on the day of the accident which had a scheduled departure time of 0455 hrs. It had been fully completed - including the load distribution - and signed by both pilots. At first sight this appeared to be an example of a 'bogus' loadsheet prepared only to withstand post flight scrutiny. However, close inspection of the sheet showed that the load and its distribution were identical to the load sheet for the previous flight from Liverpool and the trip fuel had been amended to the exact figure on the flight plan prepared for the sector from East Midlands to Luton. The first officer had in fact used a pre-prepared loadsheet to save time during the unscheduled stopover at East Midlands. Although the crew omitted to change the flight details on the heading, the loadsheet was otherwise correctly completed for the flight from East Midlands to Luton.

This early preparation habit may explain why the first officer assumed 300 kg of cargo would be loaded into Hold 2 for the flight to Guernsey whereas his load planning tables suggested 400 kg was appropriate for a three tonne load. For the ballasted flight from Exeter to Liverpool the previous day he had entered 300 kg into Hold 2. He probably anticipated an empty ballasted flight to Guernsey and prepared the loadsheet whilst still in his hotel room. When at the aircraft he discovered that they had a payload, he may have decided (correctly) that the 100 kg difference was not important and used the same loadsheet.

The first officer's compilation technique was sound and all the loadsheet arithmetic was correct. It was not possible to verify whether the load distribution on loadsheets which preceded the accident flight was accurate but there was no evidence to indicate that it was not. Given the accuracy of the weights entered, it seems very unlikely that the crew were deliberately producing bogus loadsheets.

2.7. Modified loading procedures

At airfields where load teams are not supervised by an appropriately trained team leader, dispatcher or loadmaster, the practice of the first officer signing the traffic officer's certificate on the loadsheet without inspecting the load was flawed.

Therefore, on 29 March 1999 it was recommended to the operator that the company should modify its operating procedures to ensure that the person who signs the traffic officer's certificate:

a.. Has inspected the load and reconciled the actual load distribution with the loading instructions or load report.

b.. Has ensured that the load is properly restrained throughout the cargo compartments.

c.. Is appropriately trained, qualified and periodically examined on his or her competency to carry out the above.

d.. Has sufficient time to carry out meaningful checks.

In a letter dated 1 September 1999 the operator stated that the company accepted these recommendations and had altered its Operations Manual procedures and ground school syllabus. The operator had also reviewed its schedule times with its customers to provide more time for commanders to check load security before departure and, if necessary, to recall the load team and suffer a delay if the load was not adequately restrained.

2.8 . Handling Agents' requirement for written loading instructions

Although the flight crew did not issue loading instructions to the handling agent's staff, there was no reciprocal expectation that they would do so. If loading instructions, however rudimentary, had been given to the load team leader, he would have been prompted to ask how the loading bays were to be identified and how he should estimate the weights to be placed in each Bay. If this simple process had occurred, the accident could have been prevented.

Consequently, it seems sensible that if a handling agents' staff are unfamiliar with the aircraft they are loading and do not hold a copy of the customer airline's 'Loading Instructions', they should insist on being given a written loading plan issued by or on behalf of the commander. This is a measure which could be achieved by treating it as 'good practice' rather than a legal requirement.

An appropriate vehicle for promulgating this practice is CAP 642 entitled Airside Safety Management. This document was devised by the Airside Safety Management Working Group (ASMWG) with representatives from industry and the regulators.

Therefore it is recommended that the ASMWG considers an addition to CAP 642 which encourages handling agents to ask for written loading instructions when loading cargo on to unfamiliar aircraft types.

2.9. Loading documentation and support

2.9.1. Load planning tables

There were no official 'load planning' tables provided by the operator for flight crew use. Crews were expected to devise a load plan by 'trial and error' using the balance chart on the load sheet. This method could be time consuming and it was not as error resistant as pre-planned tables. What crews needed was a simple method of determining how to distribute a given weight of cargo amongst the cargo bays to achieve an acceptable centre of gravity position that was tolerant of small deviations or slightly inaccurate estimations. No load planning tables were found in the commander's personal possessions but the first officer had obtained tables from an unofficial source and fixed them to his clipboard.

A situation whereby crews may rely upon unofficial planning tables is unsatisfactory. A verbal recommendation that official planning tables be provided was made to the operator's management staff soon after the accident.

The operator accepted this recommendation immediately and swiftly published official tables. The operator's F27 aircraft now have a copy of these tables attached to the smoke barrier where they are accessible to pilots and loading teams.

2.9.2. Provision of loading instructions to loading teams

Had written instructions been supplied to the loading team, they would have been prompted to enquire of the commander how they should divide the load (since the pallets were not annotated with their individual weights). However, neither pilot was routinely required to issue loading instructions to load teams.

If the pilots had realised that the Luton loading team would have benefited from written instructions they could have produced something in writing. However, F27 flight crew were not issued with personal copies of Volume 5A and there was no cross-reference in Volume 3A Part III (Crew Duties) specifying any requirements or situations for loading instructions to be provided to loading teams. Consequently, it seems likely that on the day of the accident, nobody read the loading instructions in Volume 5A carried in the cargo cabin.

There was a suitable format for providing written loading instructions in Volume 5A but there was no supply of blank forms on the aircraft. Verbal recommendations that suitable loading instruction forms be carried on the aircraft and be routinely issued to loading teams was made to the operator's management staff soon after the accident.

These recommendations were accepted and acted upon by the operator under cover of an Operating Staff Instruction dated 19 January 1999.

2.9.3. Validity of Operations Manual Loading Instructions

The method described for loading cargo in the operator's Loading Instructions was only applicable to loading items by hand. Had the loading team followed this procedure, a gross loading error would not have occurred. Nevertheless, it was not a practical method for loading the palletised cargo presented to them when they opened the vehicle. Moreover, there are pitfalls associated with loading palletised cargo onto an F27 (eg tipping the aircraft onto its tail) which were not described.

If staff had routinely used or read the Loading Instructions their unsuitability would have been readily apparent and they might have been amended.

2.9.4 . Operator's quality system

A quality audit of the Loading Instructions volume would have revealed that the instructions were not being followed because some were inappropriate.

At the time of the accident the operator was not required to comply with JAR-OPS but the company was working towards compliance. Subpart J of JAR-OPS 1 requires an operator's Operations Manual to specify the principles and methods involved in loading and for the loading system to cover all types of intended operation.

The operator had a quality system which it intended to develop to satisfy the requirements of JAR-OPS 1.035. The company had appointed an Operations Quality Manager on 1 January 1999, 11 days before the accident and he had not had sufficient time to undertake an audit.

Nevertheless, on 29 March 1999 it was recommended to the operator that the company should review and amend its quality system to ensure that it fully meets the requirements specified in JAR-OPS.

In a letter dated 1 September 1999 the operator stated that the company accepted this recommendation. The company had drafted an Operations Quality Manual and was discussing amendments to the draft with the CAA.

2.9.4. Issue of Loading Instructions to Flight Crew

The distribution of Volume 5A of the Operations Manual was restricted to company operations offices, management pilots and individual aircraft. The distribution did not include personal copies for F27 pilots. A preface to the instructions stated:

'When the aircraft has been loaded, the Traffic Officer responsible shall sign the Loadsheet in the space provided to certify that the aircraft has been loaded in accordance with these instructions.'

The operator's schedules did not permit sufficient time for pilots to study the document on board the aircraft so if they were to have a working knowledge, they should have been able to study it before flight. Providing flight crew with individual copies of 'Loading Instructions' could facilitate this working knowledge.

Therefore, on 29 March 1999 it was recommended to the operator that the company should:

a.. Review and amend its Loading Instructions to make them practicable and consistent with minimising risk.

b.. Issue personal copies of Loading Instructions to pilots.

In a letter dated 1 September 1999 the operator stated that the company accepted this recommendation. Part B of the company Operations Manual, which is issued to all pilots, has been revised to include an expanded section on loading and load security in addition to load and balance information.

2.10. Training of F27 crews

2.10.1. Conversion course regulatory requirements

The operator's F27 type conversion course had been assessed and approved by the CAA on several occasions. On 21 October 1998 the course had been awarded TRTO (Type Rating Training Organisation) status in accordance with new flight crew licensing regulations known as JAR-FCL which became effective on 1 July 1999. Therefore, the operator was entitled to the view that its F27 conversion course conformed to the latest regulatory requirements.

CAP 682 entitled 'Guidance For Approval of Training Organisations for Joint Aviation Requirements - Flight Crew Licensing' amplifies the requirements specified in JAR-FCL for the award of type ratings. The document provided a '*guide to the minimum acceptable training requirements'* and stated that a type rating training course '*must, as far as possible, provide for integrated ground and flight training designed to enable the trainee to operate the aircraft type safely*'. Furthermore, in describing the ground training theoretical knowledge requirements for type rating courses, CAP 682 states *'The level of knowledge required for the safe operation of the aircraft type is demonstrated by passing the theoretical knowledge examination as a qualification for starting the flight instruction phase of training.*'

It was not necessary for trainees to be taught loading procedures before commencing flying training. Indeed, inspection of CAP 682 and JAR-FCL made it clear that both were concerned with **flying** training, there being no mention of any differentiation between the passenger and cargo transport roles.

The quality of the operator's flight training was not questioned during this investigation but deficiencies in the operator's **role** training were discovered. Role training is not addressed by JAR-

FCL or by CAP 682. Consequently the absence of sufficient role training would not necessarily be discovered during an assessment of the operator's F27 conversion training syllabus.

2.10.2. Ground school syllabus

The operator's Ground School syllabus for pilots converting to the F27 was contained in Volume 4 - 'Training' - of the Operations Manual. The course was allocated 58.5 hours spread over 9 days.

The *'Performance, Flight Planning and Loading'* course was a separate part of the ground school syllabus and not part of the 58.5 hours. It was not possible to audit the course completed by the crew of G-CHNL because of changes in the delivery method and staff in August 1998. Nevertheless, the training they had received was similar to the course material in use at the time of the accident. This material was reviewed by the AAIB to determine its scope and content. It was of good quality but the scope was broad, having to cover all three topics in a single day. Understandably the content of the training was orientated towards flight deck preparations but the instructor, an F27 pilot, had a good grasp of the topics and included a wide range of examples which tested trainees' comprehension of the knowledge and procedures required on the flight deck.

2.10.3. Cargo loading procedures

Within the ground school syllabus three hours were allocated to a tour of the aircraft which itself covered six topics. Only one topic - *'Cargo Compartment Bays and Lashing Equipment'* - was directly relevant to the carriage of cargo. Cargo loading procedures were not a stand-alone topic but they were mentioned in the *'Company Administration'* paragraph under the sub-heading *'Use of Loadsheets'*. Historically the operator had not needed to train crews in loading procedures and load restraint requirements because aircraft at its Bournemouth and Channel Island bases were loaded by competent teams. However, with the expansion of the company's operations across Britain and Europe, pilots had progressively absorbed more responsibility for loading supervision. As a workforce they would have benefited from formal instruction in loading procedures. The theory of these procedures could have been taught in the classroom but a realistic demonstration of correct loading and load restraint procedures requires an aircraft and cargo. Therefore, it was reasonable to teach some aspects of loading procedures during line training.

2.10.4. Line training

The content of the ground school course was appropriate for the early stages of conversion training but there was no follow-up training that covered the fundamentals of load planning and load restraint. The line training syllabus was biased towards flight operations and there was little mention of role training. The only reference to load and balance was *'Load and Trim Calculations'* under *'Pre-Flight Preparation'*. In practice this seems to have been construed as preparation of the loadsheet.

Therefore, on 29 March 1999 it was recommended to the operator that the company should amend its induction training to ensure that the topic of load distribution is covered in greater detail.

In a letter dated 1 September 1999 the operator stated that the company accepted this recommendation. All conversion courses have been amended to include an extra day of ground school during which commanders and first officers complete practical and theoretical load training delivered by a qualified loadmaster.

2.10.5. Annual Refresher Ground School

The content of the annual Safety and Survival Training course was comprehensively covered in the Training Manual. The syllabus was designed to meet regulatory requirements and specified the topics to be covered. The operator also provided two days of classroom instruction and discussion on a number of subjects, one of which was *'Loading and Dangerous Goods'*.

In a letter dated 1 September 1999 the operator stated that the company had added an extra half day in its annual Refresher Training to provide loading revision training to all aircrew.

2.10.6. Command training syllabus

The operator's 'Flight Deck Management' procedures for the F27 (Volume 3A of the Operations Manual) did not specify who should supervise or inspect the loading of cargo nor did they specify who should devise the load plan or who should complete the loadsheet. However these tasks were ultimately the responsibility of the commander, irrespective of who actually carried out the work. More specific instructions regarding crew responsibilities relating to cargo loading were set out in Operating Staff Instructions (OSIs) which form part of the Operations Manual. One OSI was quite specific that '*Aircraft commanders are required to monitor and when necessary supervise aircraft loading, load distribution and load security during loading operations'*. The task could be delegated to the first officer or loadmaster but not unless the commander was satisfied that *'these staff fully understand what is required during the load distribution and security when delegating this task'*.

Since the operator's procedures placed heavy emphasis on commanders' responsibilities regarding the payload, formal training on all aspects of cargo loading and carriage would have been a logical part of the command course. However, there was no specific course syllabus in the training manual for new commanders. The only reference that related to command training stated that it consisted of 20 sectors with a Line Training Captain followed by an assessment with a Type Rating Examiner.

2.10.7 . The commander's command training

The commander had undergone command training in March and April of 1998. The contents of his training file were reviewed; there was no mention of loading procedures. Every sector had involved flights between the operator's bases at Bournemouth, Jersey and Guernsey where the pilots are not required to remain at the aircraft during turn rounds. Consequently, no opportunity to devise a loading plan and supervise a loading operation had been structured into his command line training. His was unlikely to be an isolated occurrence because loading procedures was not a structured element of the command training syllabus. Undoubtedly some pilots were given the requisite training but there was evidence that some were not.

In general, pilots upgrading to commander status may have received guidance from line training captains on loading procedures and load restraint but there was nothing in the line training captains' own training syllabus that broached these topics. Consequently, there was an element of chance that new commanders might not be properly trained on what to look for when inspecting a load. Even if they were trained, there was no system which ensured that line training Captains were fully competent to teach loading and load restraint.

On 29 March 1999 it was recommended to the operator that command training courses include the opportunity to devise and supervise a loading operation under the supervision of a suitably qualified line training Captain.

In a letter dated 1 September 1999 the operator stated that the company accepted this recommendation and had revised its line training syllabus and line training records.

2.10.8. Loadmaster training

Loadmasters are carried on the operator's Airbus A300 and Lockheed Electra aircraft as a de-facto member of the crew. Their duties are to supervise the load planning, loading, restraint and unloading of cargo. The training syllabus for loadmasters was comprehensive and once qualified, loadmasters undertook further consolidation training that covered the carriage of dangerous goods and aviation security.

Pilots of F27 aircraft in particular sometimes had to fulfil the role of loadmaster. They may not have done so very often but they did need to do it conscientiously and competently within a limited timescale.

The operator employed staff who knew how to train loadmasters and it could have extended this expertise to its pilot workforce.

Therefore, on 29 March 1999 it was recommended to the operator that:

a.. Pilots should be given substantial initial and recurrent training on the planning, loading, carriage, and restraint of cargo.

b.. Such training should be given by appropriately qualified and experienced persons.

c.. The effectiveness of the training should be assessed by periodic testing.

In a letter dated 1 September 1999 the operator stated that the company accepted these recommendations. Pilots are now given appropriate training by qualified Training Loadmasters and Line Training Captains. Tests to assess the effectiveness of the training will be completed at the end of ground school and during recurrent training.

2.11. Flight crew experience

2.11.1. General experience

The first officer had been a well regarded flight engineer in the Royal Air Force. He had also been an enthusiastic private pilot but the F27 was his first exposure to piloting transport aircraft. He joined the operator just 12 months before the accident having come from an environment where all transport aircraft carried a trained loadmaster to devise and supervise loading operations. His F27 type conversion training covered only the mathematics and limitations of loading and so, although he was a mature and experienced aviator, his practical knowledge of load planning, loading procedures and supervision of load teams was limited to that gained during his year with the operator. Moreover, he was not routinely involved in the supervision of load teams.

Until joining the operator, the Captain had commanded only light aircraft used primarily for flight instruction. The F27 was the first aircraft type he had commanded that required the privileges of his ATPL. During his 15 months as a first officer he would have prepared the loadsheet but not participated in loading. His licence examinations and initial F27 type training ensured that he was competent to compile and cross-check loadsheets but there was no structured training to ensure that he was competent to devise and supervise the loading process.

The load planning task would have been simplified by the availability of official load planning tables. The crew also needed load instruction forms and comprehensive training in several aspects of cargo handling and loading procedures, particularly when they encountered abnormal circumstances such as a diversion. That they did not receive sufficient training was not a deliberate policy decision or evasion of management responsibility; it was a situation which came about through historical precedent and a reduction in the availability of trained pilots.

2.11.2. Operator's training history

Historically the operator had crewed his aircraft with experienced commanders the majority of whom were completing rather than beginning their airline flying careers. The first officers were mostly inexperienced and often joined the company soon after acquiring their Commercial Pilot's Licence. The experience of the commanders compensated for the inexperienced first officers who, after gaining experience of airline flying, often left the operator's F27 fleet for employment with another fleet or another airline, and the commanders retired at age 60 years. Consequently, the company had a high turnover in its F27 pilot workforce and this stretched the training department's resources to the extent that they probably had insufficient time and staff to review their training methods and objectives. In essence the operator's management and training staff had come to rely upon the previous employment experience of their commanders.

In recent years, through the expansion of commercial aviation in general, the availability of experienced commanders has reduced and the company promoted the commander soon after he achieved the minimum requirements for command. There were sound reasons for so doing but the operator omitted to adapt the F27 command course to meet the needs of an inexperienced commander operating away from a main base. This latent error probably explains the commander's lack of direct supervision over the loading team. He was a competent pilot who was insufficiently trained in the cargo transport role, specifically in load management and loading supervision.

2.12 . Minimum standards of aircraft data recording

The absence of aircraft pitch attitude, roll attitude and engine power being recorded on the DFDR impeded the investigation of the accident.

The UK requirements for the flight recording system fitted to an aircraft of the age and weight category of the accident aircraft are detailed in the Air Navigation Order (ANO), Schedule 4, Scale P. The requirements state that pitch attitude, roll attitude and engine power only have to be recorded '*if the equipment provided in the aeroplane is of such a nature as to enable this item to be recorded*'. Although aircraft attitude and engine performance information was displayed to the crew of G-CHNL, these parameters were not recorded on the DFDR.

At the time that the Scale P requirements were introduced, the capabilities of available flight data recorders and avionics fitted to aircraft were such that it might not have been practicable or economical to enable the recording of aircraft attitude or engine performance. However, with improvements in flight recorder and avionics technologies together with changes in engine build, it is considered that many of the Scale P aircraft may be now be capable of recording these parameters.

It is therefore recommended that the CAA require operators to reassess the relevant equipment and engine fit on all UK registered aircraft subject to the requirements of the Air Navigation Order, Schedule 4, Scale P and require that, where now practicable, those aircraft are modified to enable the recording of pitch attitude, roll attitude and engine thrust.

Prior to this aircraft accident, the AAIB has encountered the inadequacies of the five-parameter DFDR system for investigation purposes. Of particular note were the following, recent occurrences to Fokker F27 aircraft:

January 1991, G-BHMX icing incident, no engine parameters recorded,

July 1992, G-STAN wake vortex event - no pitch or roll attitude recorded,

August 1995, G-JEAH propeller pitch event - no engine parameters recorded,

May 1997, G-CEXA landing accident - no pitch or roll attitude recorded,

December 1997, G-BNCY landing over run - no engine parameters recorded.

It is considered that, in all of the above instances, the availability of aircraft pitch attitude, roll attitude and engine data would have assisted considerably in the investigation of the circumstances.

The National Transportation Safety Board (NTSB) in the United States has also recognised, through investigation of many aircraft accidents, that a basic five-parameter DFDR system (time, altitude, heading, airspeed and normal acceleration) is inadequate to perform accident investigation. It therefore made recommendations to the FAA to increase the number of parameters recorded. The extra parameters highlighted by the NTSB as a minimum requirement included pitch attitude, roll attitude and thrust of each engine. The FAA accepted the recommendations and changes were made to Federal Aviation Regulations (FARs) to reflect the increased requirements. There was no provision to omit any of these parameters if the aircraft was not currently fitted with a pertinent transducer. The revised FARs required that modifications be carried out on existing large aircraft, regardless of type certification date or manufacture date, to raise the minimum standard. A time limit was imposed by the FAA to complete the update with the result that, from May 1994, an F27 with a DFDR installation such as was fitted to G-CHNL would not have been permitted to fly in the USA.

However, as part of the European harmonisation process, the intention is for the UK to move over to the requirements of the European standards contained within JAR-OPS. Although not yet implemented, the proposed minimum standard of flight recorder installation for this category of aircraft is a basic five-parameter system which does not consider the possibility of recording pitch, roll and engine thrust, even if available. The recently published fourteenth report by the UK Environmental, Transport and Regional Affairs Committee expressed concern that as *'the safety standards of the member states of the JAA are unequal ..... the desire to reach an agreement across the JAA might lead the (Civil Aviation) Authority to accept a lower common denominator than might otherwise apply'.* The Safety Regulation Group of the CAA responded that *'when it thought the standards proposed by the JAA were inadequate, it would apply a higher standard in the United Kingdom'.*

To prevent the possibility of flight recording standards on UK registered, Scale P category aircraft being lowered by the introduction of the currently proposed JAA requirements, it is recommended that the CAA in conjunction with the JAA review the appropriate Joint Aviation Requirements with a view to requiring that pitch attitude, roll attitude and engine thrust is recorded on all aircraft which carry a Flight Data Recorder.

3. Conclusions

(a) Findings

(i) The crew were properly licensed and qualified to operate the flight.

(ii) The aircraft was serviceable throughout the flight.

(iii) The weight of the cargo submitted for carriage was considered to be within measurement tolerances.

(iv) Upon completion of the loading the aircraft's centre of gravity was significantly aft of the approved limit.

(v) The defect in the nose gear bay was not a 'no go' item related to the flight controls, landing gear or nosewheel steering.

(vi) The crew were not rushed by the loading process.

(vii) The pilots were unlikely to have experienced any strikingly unusual handling qualities until the approach phase.

(viii) Deployment of full flap initiated the undemanded pitch-up on final approach.

(ix) The adverse effect on static stability of raising the landing gear was insignificant compared to the adverse effects of migrating cargo and applying full power.

(x) After the aircraft pitched up uncontrollably, it is unlikely that either pilot could have done anything to recover control from the combination of low airspeed, aft centre of gravity and low height.

(xi) Migration of the cargo did not cause the accident but it moved the centre of gravity further aft and aggravated the loss of stability.

(xii) The loading errors were not attributable to the handling agent's staff.

(xiii) Errors in the load distribution could have been revealed by a quick and simple comparison of loadsheet with load distribution.

(xiv) No written loading instructions were given to the load team by the crew.

(xv) There was no mention in the company Operations Manual of the role or responsibilities of a traffic officer yet there was a signature box for this person on the bottom of each loadsheet.

(xvi) The commander did not visit the rear of the aircraft after the loading was completed.

(xvii) If written loading instructions had been given to the loading team leader by the crew, the accident could have been prevented.

(xviii) There were no official 'load planning' tables provided by the operator for flight crew use.

(xix) There was no supply of blank Loading Instruction/Loading Report forms carried on the aircraft.

(xx) A quality audit of the Loading Instructions volume would have revealed that some of the instructions were not being followed.

(xxi) The distribution of Loading Instructions did not include personal copies for flight crew.

(xxii) The operator's type conversion training syllabus conformed to the latest regulatory requirements.

(xxiii) The absence of sufficient role training would not necessarily be discovered during an audit of the operator's conversion training syllabus.

(xxiv) It was reasonable to teach some aspects of loading procedures during line training but no opportunity to devise a loading plan and supervise a loading operation had been structured into the commander's command training.

(xxv) There was an element of chance that commanders might not be properly trained on what to look for when inspecting a load on board their aircraft.

(xxvi) There was no system which ensured that line training Captains were fully competent to teach loading and load restraint.

(xxvii) Pilots were not provided with blank loading instruction forms and load planning tables.

(xxviii) The operator could have extended its Loadmaster training scheme to teach load management to its pilot workforce.

(xxix) The operator omitted to adapt the F27 command course to meet the needs of an inexperienced commander operating away from a main base.

(b) Causal factors

The investigation identified the following causal factors:

(i) The aircraft was operated outside the load and balance limitations.

(ii) Loading distribution errors went undetected because the load sheet signatories did not reconcile t distribution in the aircraft with the load and balance sheet.

(iii) The crew received insufficient formal training in load management.

4. Safety recommendations

4.1 It was recommended to Channel Express that the company should modify its operating pro to ensure that the person who signs the traffic officer's certificate:

a. Has inspected the load and reconciled the actual load distribution with the loading instructi load report.

b. Has ensured that the load is properly restrained throughout the cargo compartments.

c. Is appropriately trained, qualified and periodically examined on his or her competency to c the above.

d. Has sufficient time to carry out meaningful checks.

The operator accepted these recommendations.

[Safety recommendation No 99-13]

4.2 It was recommended to Channel Express that the company should:

a. Review and amend its Loading Instructions to make them practicable and consistent with minimising risk.

b. Issue personal copies of Loading Instructions to pilots.

The operator accepted these recommendations.

[Safety recommendation No 99-14]

4.3 It was recommended to Channel Express that the company should:

a. Amend its induction training to ensure that the topic of load distribution is covered in great detail.

b. Ensure that command training courses include the opportunity to devise and supervise a lo operation under the supervision of a suitably qualified line-training Captain.

c. Provide pilots with substantial initial and recurrent training on the planning, loading, carria restraint of cargo.

d. Use only appropriately qualified and experienced training staff.

e. Assess the effectiveness of its training by periodic testing.

The operator accepted these recommendations.

[Safety recommendation No 99-15]

4.4 It was recommended to Channel Express that the company should review and amend its qu system to ensure that it fully meets the requirements specified in JAR-OPS.

The operator accepted this recommendation.

[Safety recommendation No 99-16]

4.5 It is recommended that the Airside Safety Management Working Group considers an addit CAP 642 which encourages handling agents to ask for written loading instructions when lo cargo on to unfamiliar aircraft types.

[Safety recommendation No 99-64]

4.6 It is recommended that the CAA require operators to reassess the relevant equipment and e

on all UK registered aircraft subject to the requirements of the Air Navigation Order, Sche
Scale P and require that, where now practicable, those aircraft are modified to enable the re
of pitch attitude, roll attitude and engine thrust.

[Safety recommendation No 99-65]

4.7 It is recommended that the CAA in conjunction with the JAA review the appropriate Joint
Requirements with a view to requiring that pitch attitude, roll attitude and engine thrust is r
on all aircraft which carry a Flight Data Recorder.

[Safety recommendation No 99-66]

M M Charles

Principal Inspector of Air Accidents

Air Accidents Investigation Branch

Department of the Environment, Transport and the Regions

Fokker F27-600 Friendship, G-CHNL: Appendix A

APPENDIX A - CENTRE OF GRAVITY CALCULATIONS

Aircraft Accident Report No: 2/2000 (EW/C99/1/2)

1. Definition of centre of gravity

An aircraft's weight is distributed throughout its structure with regions where the weight is concentrated (eg the engines) and regions where there is little weight (eg an empty cargo area). Consequently, the point at which an aircraft would, in theory, balance on a fulcrum is unlikely to be its geometric centre. For aerodynamic purposes, it is necessary to determine the point along the length of the fuselage at which the aircraft would, in theory, balance. This point is called the 'centre of gravity' which is often abbreviated to 'CG'. It's relevance is that for aerodynamic purposes the entire weight of the aircraft may be considered to be centred at this point.

2. Station numbers

The aircraft manufacturer uses a system of station numbers to identify the location of fuselage components. 'Station 0' is essentially the tip of the aircraft's nose and the station number of any fuselage component is simply the horizontal distance between station zero and the fuselage location expressed in inches. For instance, the horizontal distances between the tip of the nose and the aircraft's nosewheel and main landing gear axles are 122·8 and 396·9 inches respectively. For CG calculation purposes, the nosewheel may be considered to be at 'Station 122·8' and the mainwheels at 'Station 396·9'. See diagram.

3. Empty aircraft centre of gravity

The aircraft manufacturer used Station 0 as the datum for calculating the longitudinal position of the centre of gravity, expressed as a distance in inches aft of Station 0. The position of the empty aircraft's CG was determined by weighing the aircraft and determining the weight borne by each landing gear leg. These weights are then multiplied by the 'moment arm' which is the station number of each wheel. The sum of these moments is then divided by the total weight to determine the horizontal distance of the CG from the datum. This process was completed for G-CHNL by a specialist company and their figures are reproduced in the diagram.

4. Loaded aircraft centre of gravity calculations

As role equipment, crew, fuel and payload are added to an aircraft, the longitudinal movement of the centre of gravity can be determined by calculation provided that the weight of each object is known together with its station number. For large objects and fuel in the tanks, the moment arm is measured horizontally from the object's own geometric centre to the datum point. For bulk cargo, the mid-point of the cargo bay is used as the moment arm.

Each component gives rise to a moment and a weight. The same process of dividing the sum of all the moments (including that of the aircraft itself) by the sum of the weights can be used to calculate the position of the centre of gravity. However, in practice this method of determining the CG requires numerous calculations and the manipulation of large numbers. The method is suitable for computer generated loadsheets but it is not user friendly on the flight deck.

5. The index system

When calculating mass and balance the weight units used are unimportant provided they are consistent. The operator chose to use kilograms instead of pounds. The position of the datum point for determining moment arms is also unimportant because the choice of datum position will not affect the location of the aircraft's centre of gravity.

Because the Fokker F27 has straight wings and all the fuel tanks are inside the wings, a good datum point is the centre of gravity of the fuel tanks. This datum has two distinct advantages: firstly, it is inside the wing chord (and close to the allowable range for the centre of gravity); and secondly, although the centre of gravity may move in flight as fuel is consumed, because the centre of gravity of the fuel in the tanks does not change, the laden index does not change. (See diagram).

6. Index units

Despite the choice of datum position and the use of kilograms for weight, numerically large moments still occur. In the index system, to reduce the numbers to manageable size, all the moments are divided by 10,000. By convention, moments produced by weights aft of this index datum will be positive and those forward of it will be negative. If, as in this case, the sum of the moments is negative because the empty aircraft CG is forward of the datum, the index number can be made positive by adding an arbitrary number to the end result. This is explained more fully in the next paragraph.

7. Aircraft Prepared for Service

The operator's F27 aircraft normally flew in the same freight configuration with two pilots and appropriate role equipment such as route documentation, cargo nets and wooden floor boards. To save the crews routinely calculating the weight and CG changes induced by these items, the operator determined an equipped empty weight termed 'Aircraft Prepared for Service' which is usually abbreviated to APS. The index in this configuration was -28·25. To avoid mixing positive and negative numbers on a loaded index scale, the operator chose to add 30 to the aircraft's APS index number thus changing it from -28·25 to + 1·75. There was no special significance to the number 30. The addition of 30 simply converted the aircraft's APS index to a positive number thus ensuring that all the index positions between the forward and aft CG limits were positive.

8. Loaded aircraft index computation

To calculate the index for a loaded aircraft, it is necessary to calculate the change in index position for each item of payload. However, it is important to appreciate that 30 must not be added to the indices of load components because these indices represent CG movement relative to the APS index. Because the distance of the operator's trim datum from Station 0 remains fixed at 378·52 inches, the moment arm of an object relative to the operator's trim datum is determined by subtracting 378·52 from the object's station number. Consequently, the index of any object carried on board G-CHNL may be calculated from the station using the formula:

$$\text{Index} = \frac{[\text{Mass(kgs)} \times (\text{Station number} - 378{\cdot}52)]}{10{,}000}$$

9. Graphical determination of CG position

The aim of the index system is to allow calculation of the CG position by graphical means. Vertical and horizontal lines can be drawn from the aircraft's 'unladen index' to represent movement of the CG caused by loading a given weight in a specific compartment. The index number for a component of the payload can be represented by divisions on a graph. The number of divisions can be minimised by using practical weight units of 100, 500 or 1000 kg for each division. Some index numbers will be positive and some will be negative; these can be graphically represented by movement left or right. If all the load component indices are algebraically added to the index number for the empty aircraft, the total will be the index for the loaded aircraft or 'laden index'. The process is illustrated at paragraph 11 of this appendix

10. Mean aerodynamic chord

The option of using a different trim datum position to that used by the aircraft manufacturer could give rise to a requirement for the operator to translate the manufacturer's CG limits to new figures relative to its chosen trim datum. In practice this is avoided by expressing the CG position in non-dimensional terms. The system adopted is to express CG position in terms of a percentage of mean aerodynamic chord (MAC). (The expression standard mean chord or SMC has the same meaning as MAC).

The mean aerodynamic chord is the average distance between the leading edge and trailing edge of the wings across the full span. It may be calculated by dividing the wing area by the wing span but it is normal practice to use the MAC defined by the aircraft manufacturer. For aerodynamic reasons, in flight the CG is between these two positions and thus it is convenient to relate the CG position to a percentage aft of the leading edge as shown in the diagram.

The station of the leading edge is also provided by the aircraft manufacturer. For the F27-600 the station for 0% MAC is Station 340 and the length of the mean aerodynamic chord is 101·38 inches. Using this system the index can then be related to the CG position on a trim graph. This technique was used on the operator's loadsheets.

11. The trim graph

The trim graph example shown at the end of this paragraph is extracted from the load and balance sheet prepared by the co-pilot for the accident flight. It illustrates the process of determining the CG. To begin, a line is drawn vertically downwards from the aircraft's unladen index of 1·74 (marked 'Start') to the horizontal row of any hold containing cargo; in this example Hold 2 is chosen. From the point where the vertical line crosses the sloping line within the row, a horizontal line is drawn in the direction of the arrow for 3 divisions since the arrow indicates one division for every 100 kg and there is 300 kg in Hold 2. From that end point a vertical line is drawn upwards to the region of the next bay containing payload.

The process is repeated for each area containing cargo, noting that the arrows point in different directions and the weight represented by each division may differ (eg Bay B is 500 kg per division whereas Bays A and C are 100 kg per division). From the end of the last line, a vertical line is drawn downwards to the laden index line (the x axis), which in this case is intersected close to 18. Finally, horizontal lines are drawn from the weight scale (the y axis) to intersect the laden index line at three important weights: take-off, expected landing and zero fuel.

Interpretation of the graph is simple. The shaded area represents an unacceptable total weight or CG position; in this example the CG is approximately in the centre of the range. Fuel consumption during flight does not change the laden index but movement of the CG is represented in SMC (MAC) units by the intersection of the laden index line with the array of lines which slope steeply downwards from left to right. In this example, the CG moves from 30·5% at take-off to 30% at planned landing weight.

It is also apparent from the graph that the aircraft cannot be flown empty (ie with a laden index of 1.75) because the CG would be forward of the forward limit. For this reason, empty positioning flights required ballast to be carried at the rear of the aircraft to move the CG aft into the acceptable range. It was normal practice to load ballast into Hold 2 for empty positioning flights. The ballast was subsequently off-loaded before a cargo flight.

The loadsheet for the flight from Exeter to Liverpool on page 1 of Appendix C shows the effect on centre of gravity of loading 300 kg ballast into Hold 2.

Fokker F27-600 Friendship, G-CHNL: Appendix B

Aircraft Accident Report No: 2/2000 (EW/C99/1/2)

APPENDIX B

AERODYNAMICS

1. Aim

The aim of this appendix is to explain the rudiments of pitch control to persons unfamiliar with aerodynamics. It is neither a detailed nor a comprehensive explanation of all the aerodynamic factors contributing to this accident.

2. Lift forces

For an aircraft in level flight, total lift must be equal and opposite to weight. There are two main components of lift: lift from the wing and lift from the tail surfaces. In very simple terms for aircraft such as the Fokker F27, lift produced by the wing is a function of the speed of the air over the wing and the angle between the airflow and the wing ('the angle of attack'). The same factors apply to the tailplane.

However, in producing lift the wing and fuselage create a rotational force, which normally acts in the nose-down sense. This nose-down force or 'pitching moment' has to be counterbalanced by forces on the tailplane.

Balancing the moments mathematically gives rise to the concept of the 'neutral point'. The neutral point is an imaginary point about which the variation of the nose-up and nose-down pitching moments with angle of attack is zero. Consequently there is only a variation of the resulting lift force, acting at the neutral point.

In the diagram above the neutral point is represented by the letters NP and the aerodynamic centre of pressure of the wing is annotated CP. The nose-down pitching moment is opposed by the wing lift moment acting over the moment arm 'A'. If the wing lift moment is insufficient to counterbalance the nose-down pitching moment, the tail surfaces have to augment it by producing a downward force which, although relatively small, acts over the much longer moment arm 'B'. Because the tail surfaces are producing a downward force, the total lift acting through the imaginary neutral point is less than the wing lift, which must be sufficient to oppose the sum of the aircraft's weight and the tailplane force. This balance of forces is typical for a conventional aircraft at normal cruising speed. Therefore the tailplane design is optimised for a certain amount of download.

3. Variation of tailplane force

Because most aerodynamic forces vary in flight, the tailplane force must be variable, both in magnitude and in direction, to enable the pilot to control the aircraft. On the Fokker F27 this capability is achieved by moving the elevator attached to the trailing edge of the tailplane. The control linkages are arranged such that pulling the control column backwards raises the trailing edge of the elevator increasing its downward force; pushing the control column forwards has the opposite effect.

It would be very tiring for the pilot to have to hold the elevator in the required position for long periods so a section of the elevator called the trim tab can be moved relative to the trailing edge of the elevator. The trim tab is actuated by a wheel on the centre console of the flight deck moving a linkage which keeps the trim tab in the same position relative to the elevator without any requirement for the pilot to hold the wheel. By rotating this wheel, the pilot can reduce to zero the control force required to keep the elevator in the required position. This state is known as being 'in trim'. Two different situations are illustrated.

This is a simplistic explanation. In reality, moving the elevator just varies the force created by the tail surfaces. Other factors such as airspeed, manoeuvres, propeller slipstream and flap position also affect the tailplane force. In some circumstances moving the control column forward may just decrease the downward force created by the tail surfaces instead of creating an upward force.

4. The effect of flap extension on pitch trim

At landing speeds, trailing edge flaps on the wings are lowered to restore the wing's ability to produce sufficient lift. This produces a stronger nose-down pitching moment, requiring a greater downward force on the tailplane. However the local angle of attack at the tailplane will become more negative because of the wing downwash effect (see diagram).

This may produce more download on the tailplane than required to counterbalance the pitching moment, so that a downward elevator deflection (aircraft nose-down sense) may be needed to adjust the tailplane download and restore equilibrium. Some of the effects of extending the trailing edge flaps may be mathematically represented by a forward shift of the neutral point.

Within the approved centre of gravity range, the F27 will need an upward tailplane load only at low airspeeds with flaps retracted and an aft CG position. With movement of the CG rearwards, the wing lift and the aircraft weight forces produce an increasing nose-up pitching moment, needing an upward change of the tailplane load to counterbalance. At extreme aft CG positions (beyond the permitted envelope), the upward tailplane load change needed to obtain static equilibrium may exceed the elevator capacity, particularly in conditions in which the tailplane itself would generate a substantial amount of download due to negative local angle of attack.

5. Pitch stability concepts

There are two types of pitch stability: static and dynamic. Static stability is the aircraft's tendency either to diverge from or to return to a steady pitch state when affected by a disturbance of the airflow, usually conceived in terms of a small change in the angle of attack. If there is an increase in angle of attack there will be an increase in wing lift. If at the same time the aircraft tends to pitch nose-up, thereby further increasing the angle of attack, it is said to be statically unstable. If, on the other hand, the aircraft pitches nose-down and tends to return towards its original angle of attack, it is said to be statically stable. Dynamic stability is concerned with what happens after that. If the aircraft returns to the original angle of attack or oscillates through a series of pitch changes, which get progressively smaller until it returns to the original trimmed angle of attack, it is dynamically stable. Problems with dynamic pitch stability were not a factor in this accident but the transition from a statically stable approach configuration to a statically unstable configuration was responsible for the initial loss of control.

6. Pitch stability and centre of gravity

The relationship between the longitudinal positions of the neutral point (NP) and the centre of gravity (CG) affects static stability. Mathematically the relationship assumes that the variation of total lift with angle of attack acts through the neutral point and the aircraft's weight acts through its centre of gravity. Any change in the lift force will tend to pitch the aircraft about its centre of gravity.

A small increase in angle of attack caused by an airflow disturbance will create an increase in total lift. If the centre of gravity is ahead of the neutral point the increase in lift acting on the aircraft's inertia creates a nose-down pitch moment, which tends to reduce the angle of attack. This is a stable situation. If, however, the centre of gravity is astern of the neutral point, a momentary increase in lift causes a pitch-up moment which further increases the angle of attack. This is an unstable situation. The two states are illustrated.

Consequently, to be statically stable, the aircraft's centre of gravity must be ahead of the neutral point.

7. Variations in stability

The aircraft's stability is also a function of the distance between the neutral point and the centre of gravity. If the CG is too far ahead of the neutral point the aircraft will be so stable that its response to pitch control inputs will be sluggish and the control forces will be high. If the CG is aligned with the neutral point, the control forces will be low but the aircraft will be difficult if not impossible to trim. As the CG moves progressively aft of the neutral point, the aircraft will become more difficult to fly, particularly in turbulent air. It will be impossible to trim and the pilot will frequently have to make considerable control inputs to constrain the flight path. Eventually, if the CG moves too far aft of the neutral point, the elevator will reach full travel as the pilot attempts to stop the aircraft's nose rising. If full travel is insufficient to overcome the pitch-up, control will be lost.

8. Movement of the neutral point

Normally in-flight centres of gravity movements are small. Fuel consumption may slowly move the centre of gravity and other effects such as passenger movement or landing gear operation may alter the CG position relatively rapidly. The neutral point may, however, move much more significantly and more quickly than the centre of gravity. One feature of propeller driven aircraft is that when the engines accelerate from idle power to full power, the neutral point moves forward. On the Fokker F27 it moves approximately 10% MAC further forward (for an explanation of MAC see Appendix A). Lowering flap also moves the neutral point forward. The pilots feel this movement as a tendency for the aircraft to pitch up and they need to push forward on the control column to hold a steady flight path (thus lowering the elevator). Usually the pilot will re-trim by winding the trim wheel forward which moves the trim tab to keep the elevator in the new position without the pilot having to maintain a push force on the control column.

9. Stability control

The manufacturer of a transport aircraft such as the Fokker F27 must ensure that the aircraft is statically stable at all times. Movement of the neutral point in flight can be minimised by careful design but unlike the centre of gravity, its position cannot be directly controlled. Consequently, the primary method of ensuring that the aircraft is always statically stable is to limit the position (and movement) of the centre of gravity. Flight-testing and calculation determine limitations on the position of the CG. Limitations on CG movement in a cargo aircraft are achieved by securing the cargo to the cabin floor.

Once the absolute limits are determined, safety margins are applied to the absolute limits to produce the operating limits, which are published in the manufacturer's aircraft manuals. An aircraft will also have structural weight limits and these may be combined with CG limits and illustrated on a graph. The limits for G-CHNL are shown on the diagram.

The allowable range for the CG is given as a percentage of MAC. In real terms the distance between 20% and 38% MAC equates to 18·25 inches. These are the limits for the aircraft both on the ground and in the air under any conditions apart from cruising flight with gear and flaps retracted.

The F27's landing gear is heavy and its movement between retracted and extended causes an average 0·7% MAC rearward shift in the centre of gravity. In the cruise a margin of 2% is permitted to allow for the movement of passengers. These two factors result in an allowable range **in the cruise** between 18·7% (20-2+0·7) and 40·7% (38+2+0·7). Beyond these limits, control of the aircraft throughout a flight is no longer assured. Under any other conditions, particularly take-off and landing, the allowable range reverts to between 20% and 38%.

10. Elevator capacity

The capability of the elevator to provide sufficient control authority is known as its 'capacity'. As the aircraft's CG position approaches the aft limit, progressively more down elevator is required to trim the aircraft. Eventually, when the CG is well aft of the aft limit, there is insufficient elevator capacity to control the aircraft at any stage of flight. It is not practicable to determine this point by flight testing because of the inherent dangers but the aircraft manufacturer can draw conclusions as to the probable limit by extrapolating flight test data. However, there is a range of CG positions in which the aircraft is controllable depending on flap position and engine power. Using data relevant to the accident flight, the Type Certificate holder prepared the diagram.

The diagram shows that lowering full flap (40°) requires more nose down elevator than approach flap (26·5°). It also shows that as the CG moves further aft towards 50% MAC, the elevator position approaches the end stop of 22°. Moreover, although the diagram indicates that the endstop is not reached until the CG position reaches about 50%, the lines indicate an equilibrium position. In practice, more elevator travel is necessary for adequate control margins and to allow for aerodynamic disturbances such as turbulence.

Finally, the diagram does not show the likely effect of increasing engine power from low power to high power. The increase in power moves the neutral point forward which requires still more nose-down elevator to counteract the aircraft's tendency to pitch up. Consequently, there is a range of CG positions in which the aircraft flies reasonably normally until full flap is lowered and/or power is significantly increased.

Fokker F27-600 Friendship, G-CHNL: Appendix E

Aircraft Accident Report No: **2/2000 (EW/C99/1/2)**

APPENDIX E

EXTRACTS FROM RELEVANT REGULATIONS

Source material

The following texts which relate to loading and loading procedures have been extracted from CAP 393 and CAP 360. The words have been copied verbatim but the formatting varies slightly from the original documents.

Extract from The Air Navigation (No 2) Order 1995

ANO Art. 31

Loading - public transport aircraft and suspended loads

31 (1) The operator of an aircraft registered in the United Kingdom shall not cause or permit it to be loaded for a flight for the purpose of public transport, or any load to be suspended therefrom, except under the supervision of a person whom he has caused to be furnished with written instructions as to the distribution and securing of the load so as to ensure that:

(a) the load may safely be carried on the flight; and

(b) any conditions subject to which the certificate of airworthiness in force in respect of the aircraft was issued or rendered valid, being conditions relating to the loading of the aircraft, are complied with.

(2) (a) Subject to sub-paragraph (b), the instructions shall indicate the weight of the aircraft prepared for service, that is to say the aggregate of the weight of the aircraft (shown in the weight schedule referred to in article 18 of this Order) and the weight of such additional items in or on the aircraft as the operator thinks fit to include; and the instructions shall indicate the additional items included in the weight of the aircraft prepared for service, and show the position of the centre of gravity of the aircraft at that weight.

(b) Sub-paragraph (a) shall not apply in relation to a flight if:

(i) the aircraft's maximum total weight authorised does not exceed 1150 kg;

(ii) the aircraft's maximum total weight authorised does not exceed 2730 kg and the flight is intended not to exceed 60 minutes in duration and is either:

(aa) a flight solely for training persons to perform duties in an aircraft; or

(bb) a flight intended to begin and end at the same aerodrome; or

(iii) the aircraft is a helicopter the maximum total weight authorised of which does not exceed 3000 kg, and the total seating capacity of which does not exceed 5 persons.

(3) The operator of an aircraft shall not cause or permit it to be loaded in contravention of the instructions referred to in paragraph (1).

(4) (a) Subject to sub-paragraph (b), the person supervising the loading of the aircraft shall, before the commencement of any such flight, prepare and sign a load sheet in duplicate conforming to the prescribed requirements, and shall (unless he is himself the commander of the aircraft) submit the load sheet for examination by the commander of the aircraft who shall sign his name thereon.

(b) The requirements of sub-paragraph (a) shall not apply if:

(i) the load and the distributing and securing thereof upon the next intended flight are to be unchanged from the previous flight and the commander of the aircraft makes and signs an endorsement to that effect upon the load sheet for the previous flight, indicating the date of the endorsement, the place of departure upon the next intended flight and the next intended place of destination; or

(ii) paragraph (2)(a) does not apply in relation to the flight.

(5) (a) Subject to sub-paragraph (b), one copy of the load sheet shall be carried in the aircraft when article 66 of this Order so requires until the flights to which it relates have been completed and one copy of that load sheet and of the instructions referred to in this article shall be preserved by the operator until the expiration of a period of six months thereafter and shall not be carried in the aircraft.

(b) In the case of an aeroplane of which the maximum total weight authorised does not exceed 2730 kg, or a helicopter, if it is not reasonably practicable for the copy of the load sheet to be kept on the ground it may be carried in the aeroplane or helicopter, as the case may be, in a container approved by the Authority for that purpose.

(6) The operator of an aircraft registered in the United Kingdom and flying for the purpose of the public transport of passengers shall not cause or permit baggage to be carried in the passenger compartment of the aircraft unless such baggage can be properly secured and, in the case of an aircraft capable of seating more than 30 passengers, such baggage (other than baggage carried in accordance with a permission issued pursuant to article 40(2)(d) of this

Order)shall not exceed the capacity of the spaces in the passenger compartment approved by the Authority for the purpose of stowing baggage.

ANO Sect 1/38

August 1995

Extract from AIR OPERATORS CERTIFICATES

Air Operators' Certificates Operation of Aircraft CAP 360 Part ONE

19 **LOADING**

19.1 Loading Instructions

In order to carry cargo in what would normally be the passenger cabin an Approved modification is usually necessary, taking into account the airworthiness requirements for the particular type of aircraft and the Flight Manual limitations.

NOTE The airworthiness requirements to be satisfied in order to gain CAA Approval for the carriage of cargo in passenger compartments are given in CAP 360 Part 2 Chapter 4.

19.1.1 The Approval reference number of the appropriate Approved modification must be shown in the Operations Manual or, if the Authority has deemed that a modification is not necessary, the basis for the Authority's acceptance.

19.1.2 Where no Approval/acceptance has been granted and shown in the manual, cargo must not be carried other than in designated cargo compartments.

19.1.3 Instructions must provide guidance for traffic staff, handling agents and aircraft crew, as appropriate, on the loading, weight and balance of an aircraft and include instructions on:

(a) Controlling and promulgating the basic or Aircraft Prepared for Service (APS) weights and indices. Where used, all items of equipment that convert basic to APS weight must be listed;

(b) regulating the carriage and stowage of baggage and cargo in passenger compartments, including instructions on the amount of hand baggage allowed and how it is stowed. Emergency exits, gangways and dinghy launching stations must be kept clear during taxying, take-off and landing;

(c) carriage of Dangerous Goods;

(d) limitations on floor loading, the strength and distribution of attachment points, use of weight spreading devices and positioning and securing of ballast;

(e) checking that items of cargo or baggage allocated to particular compartments or holds are distributed and restrained correctly. The person responsible for the trim of the aircraft must give written instructions to the person responsible for loading the aircraft;

(f) advising the aircraft commander and cabin crew of seating restrictions;

(g) the effect of the maximum zero fuel weight, landing weight restrictions at planned destination, take off and climb performance requirements at the departure aerodrome and en route performance requirements on Regulated Take-Off Weight (RTOW);

(h) the care and maintenance of Unit Load Devices (ULD), responsibilities for ensuring their fitness for use prior to loading and the procedure for directing damaged units to an Approved organisation for repair;

(j) fuel loading limitations;

(k) where appropriate, limitations on loading for ferrying aircraft with one engine inoperative, Certificate of Airworthiness (C of A) tests or any other non-standard flight;

(l) where applicable, the use of the standard weights or any notional weights given in exemptions granted by the Authority.

19.2 Cargo Loading Instructions

These instructions must include the following additional details:

(a) diagrams and dimensions of cabin bays and cargo holds and compartments to facilitate the pre-planning of cargo distribution;

(b) the strength and usable directions of all lashing points and/ or rings and details of the spacing between lashing points;

(c) the types and working strengths of lashing provided, and stowage, when not in use;

(d) instructions concerning the loading of stretchers, carriage of livestock or other unusual loads;

(e) where appropriate, the handling, loading and securing of pallets or containers;

(f) a care and maintenance programme for Unit Load Devices (ULDs); these include cargo containers, nets and pallets. Guidance must be given to both loading and maintenance personnel on the division of duties in respect of ULD serviceability;

(g) instructions on the use of passenger aircraft for the carriage of cargo;

(h) guidance on the duties and responsibilities of individuals when making cabin configuration changes. These changes require a

Certificate of Release to Service (CRS). Further information on these procedures can be obtained from the Assigned Inspector;

(j) where appropriate, instructions on the loading and securing of mail bags or similar cargo, including checking for leakage or spillage and consequential aircraft contamination;

(k) a statement that a load/trim sheet cannot serve as a loading instruction and a trim slide rule does not dispense with the requirement to complete a load sheet.

19.3 The position of the laden centre of gravity must be given on the load sheet. For this purpose, a trim sheet may be regarded as part of the load sheet, even though it can be a separate document. The complete document must include particulars of how the load is distributed and special attention paid to the wording of the loading certificate. This may be met by establishing that the Centre of Gravity (C of G) lies within the permitted limits and it is not necessary to determine the precise position, unless it affects aircraft handling or other factors. The load sheet must bear the reference of the APS form used and, if standard weights have been used, an endorsement to that effect.

19.4 Where a 'loading plan' method is used, the basic assumptions upon which the plan is formulated must be given and must specify C of G limits more stringent than those permissible under the C of A. It must also be stated that loading in accordance with the 'plan' ensures that the laden C of G always falls within the restricted limits. If this is done, a simple statement on the load sheet that the laden C of G is between the operator's more stringent limits is acceptable.

19.5 Operators must provide traffic staff and handling agents, including agents at overseas aerodromes, with:

(a) loading instructions, including the principles of effective cargo restraint;

(b) current APS forms for all types, marks and variants of aircraft used;

(c) details of the RTOW and fuel load for each flight.

19.6 Where traffic staff and handling agents are responsible for calculating the RTOW, operators must ensure that they are provided with all relevant information and are competent.

Fokker F27-600 Friendship, G-CHNL: Appendix F

Aircraft Accident Report No: **2/2000 (EW/C99/1/2)**

APPENDIX F

Extracts from company operating procedures

Source material

The following texts which relate to loading and loading procedures have been extracted from the Operator's 'Flight Operations Manual' Part A General/Basic, from Operating Staff Instructions, and from Volume Five A Loading Instructions. The words have been copied verbatim but the formatting varies slightly from the original documents.

Extract from Section 8.1 entitled "Flight Preparation Instructions'.

Paragraph 8.1.8.6

(Part of section 8.1.8 entitled 'Mass and centre of Gravity')

A company mass and balance document is to be raised in duplicate for each flight carried out for the purpose of commercial air transport. One copy is to be carried on the aeroplane whilst another, as accepted by the Commander, must remain available on the ground for at least 3 days. Part B contains detailed loading instructions and a sample mass and balance document for the particular aeroplane type. Irrespective of whether a 'drop-line' mass and balance document, an index system, a trim wheel, or a computer programme is used in establishing the aeroplane's mass and C of G position, the final mass and balance document must contain details of the disposition of all loaded items, including fuel, cargo, mail and any supernumerary crew/couriers. The person supervising the loading must confirm by signature that the load and its distribution are as stated on the mass and balance document which must also contain the name of the person who prepared it. The mass and balance document must be acceptable to, and countersigned by, the aeroplane Commander. Details of any late alterations in the load must be passed to the Commander and entered in the 'last minute changes' spaces on the mass and balance documents.

Extract from Section 8.2 entitled "Ground Handling Instruction".

Paragraph 8.2.2.3 Loading and Securing of Cargo

Cargo is not to be carried on an aircraft unless the aircraft has been specifically cleared and equipped to do so. The equipment required will be detailed in Part B Sections 6 and 7 of this Manual. Procedures for loading cargo will be detailed in Part B section 7 and/or the cargo loading Manual.

During loading a qualified person must check that the cargo is correctly positioned and secured and accessible if required. The Commander must be informed of the mass and arrangement of the load carried.

Hold baggage is to be stowed and secured only in those areas and compartments which are designated for its carriage and subject to the floor loading limitations of the particular area. It may be necessary to restrict the weight carried for balance purposes rather than structural considerations. The Commander is to ensure that all personnel who may be responsible for loading the aeroplane are made aware of any additional restrictions.

For the transport of live animals refer to the IATA "Live Animal Regulations" manual, held in Bournemouth operations.

For the carriage of Dangerous Goods refer to Part A Section 9 of this Manual.

Extract from Volume 5A Part II Section 3 Page 3 paragraph 3

3. LOADSHEET

The company is required by law to, for every flight, calculate the weight and the centre of gravity of an aircraft. These details are to be recorded on a loadsheet, the person completing the loadsheet shall unless he/she is the commander of the aircraft submit the Loadsheet to the commander for approval.

The loadsheet must be completed accurately and the aircraft must be loaded in accordance with the issued written instructions. A certificate to this effect must be signed by the person responsible for the loadsheet. The aircraft commander will also sign a certificate to the effect that he/she is satisfied that all the relevant requirements of the air navigation order and the air navigation regulations have been complied with. All entries on the loadsheet are to be clear and legible with blue or black ink.

Extract from Operating Staff Instruction G11 dated 1 Sep 1991.

Loading of Aircraft for on time departures

Unsatisfactory load distribution and/or load security should never be the cause for a delayed departure in our operations. This applies equally to ....*(five named clients)...* and any other operation.

Aircraft commanders are required to monitor and where necessary supervise aircraft loading, load distribution and load security during loading operations, so that as and when loading is completed last minute delays in this area will be eliminated.

When it is not possible for the aircraft Commander to be in attendance at the aircraft for all or part of the loading procedures the task is to be delegated to the F/O or to the loadmaster; however, an aircraft Commander must satisfy himself that these staff fully understand what is required regarding the load distribution and security when delegating this task.

The monitoring of aircraft loading can usually be combined with other essential pre-flight checks and it is the Commander's responsibility to organise the pre-flight time available to the crew so as to ensure all essential tasks are carried out in an efficient and expeditious manner. This will also ensure that any delay to departure time which may then occur, will not reflect on the performance of the crew, their operating procedures, or the reputation of Channel Express.

Extract from Volume 5A Part II Section 9 Page 7