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Improper Loading of Cargo Causes Loss of Aircraft Control on Approach

The Fokker F27 pitched nose-up when the flight crew extended full flaps on final approach. The crew did not regain control, and the aircraft stalled and struck the ground. The accident report said that the aircraft's center of gravity was "significantly aft" of the approved limit.

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FSF Editorial Staff

At 1706 local time Jan. 12, 1999, a Fokker F27-600 operated on a cargo flight by Channel Express struck the ground after the flight crew lost control of the aircraft on approach to Guernsey Airport, Channel Islands, United Kingdom. Both pilots were killed, and the aircraft was destroyed.

The U.K. Air Accidents Investigation Branch (AAIB) said, in its final report, that the investigation identified the following causal factors:

- "The aircraft was operated outside the load-and-balance limitations;
- "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; [and,]
- "The crew received insufficient formal training in load management."

The commander, 36, had an airline transport pilot certificate and type ratings in the F27 and several light aircraft. He had 3,930 flight hours, including 750 flight hours in type, of which 315 flight hours were as pilot-in-command.

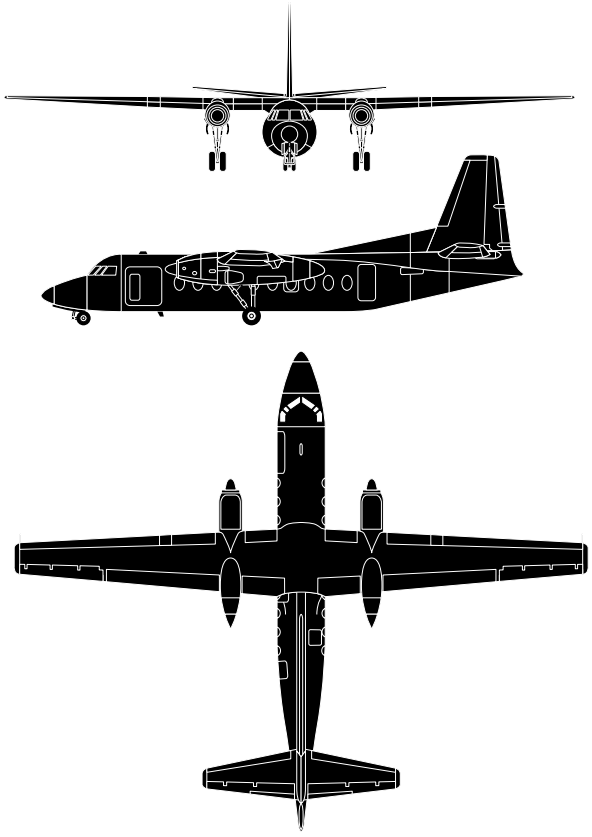
"The commander acquired most of his flying hours through instructing on light aircraft types, predominantly light single-engine aircraft," the report said. "He joined the operator's flying staff in February 1997 as a first officer. He was promoted to captain in April 1998."

The first officer, 41, had a commercial pilot certificate and type ratings in the F27 and several light aircraft. He had 958 flight hours as a pilot, including 317 flight hours in type.

"The first officer joined the operator's flying staff in January 1998," the report said. "He served in the Royal Air Force from 1981 until 1996. During his service, he acquired extensive flying experience as a flight engineer in Vickers VC10 and Lockheed Hercules aircraft. … Most of his pilot's flying hours were acquired in light single-engine aircraft."

Channel Express was the air-freight subsidiary of the Dart Group and operated four aircraft types: Airbus A300, Dart Herald, Fokker F27 and Lockheed Electra.

"The A300 and Electra generally [were] operated with a crew of four: commander, first officer, flight engineer and loadmaster," the report said. "The F27 and Dart Herald could



Fokker F27-600

The first flight of a prototype Fokker F27 was conducted in 1955. Deliveries of the twin-turboprop, medium-range airliner began in 1958. The F27-100 had Rolls-Royce Dart 511 engines and 32 seats. The F27-200 was introduced in 1959 with Dart 536-7R engines.

The first flight of the F27-600 was conducted in 1968. The aircraft is similar to the F27-200 but has a large cargo door on the forward, left side of the fuselage. The cargo door is 5.8 feet (1.8 meters) high and 7.6 feet (2.3 meters) wide. The passenger door is on the aft, left side of the fuselage. The cockpit has two flight crew seats and a folding seat for a third crewmember. The cabin accommodates 44 passengers or 48 passengers, and can be equipped with a quick-change interior with roller tracks and palletized seats and/or cargo pallets.

The Dart 536-7R engines each produce 2,140 shaft horsepower (1,596 kilowatts) for takeoff and turn four-blade Dowty Rotol propellers.

Wing span is 95.2 feet (29 meters). Overall length is 77.3 feet (23.6 meters). Basic operating weight with 44 passenger seats is 26,800 pounds (12,157 kilograms). Maximum payload with 44 passenger seats is 14,200 pounds (6,441 kilograms). Standard maximum fuel load is 9,090 pounds (4,123 kilograms). Maximum takeoff weight is 45,900 pounds (20,820 kilograms). Maximum landing weight is 42,000 pounds (19,051 kilograms).

Rate of climb at sea level and at 40,000 pounds (18,144 kilograms) is 1,480 feet per minute (451 meters per minute). Normal cruising speed at 20,000 feet and at 38,000 pounds (17,237 kilograms) is 259 knots (480 kilometers per hour). Range is 1,020 nautical miles (1,889 kilometers).

Source: *Jane's All the World's Aircraft*

carry a loadmaster, but they generally [were] operated with two pilots."

The report said that loading teams at the operator's F27 bases in Bournemouth, Guernsey and Jersey were experienced in loading and unloading the aircraft.

"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 [cargo] compartment," the report said. "Before issuing this report, the team leader used a mechanical calculator to ensure that the load distribution was within the aircraft's center-of-gravity [CG] envelope.

"Technically, the [aircraft] 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."

On Jan. 11, 1999, the flight crew began duty at 1815. They flew the aircraft from Exeter Airport, where scheduled maintenance had been conducted, to Liverpool, where freight was loaded. The crew departed from Liverpool at 0015 Jan. 12, 1999; their intended destination was London Gatwick Airport.

"However, visibility in the London area was poor that night, and the aircraft diverted to East Midlands Airport, where it landed at 0143 hours," said the report.

The crew obtained weather information that showed that freezing fog was expected at Gatwick until 0500. The crew had been scheduled to fly the aircraft from Gatwick to Guernsey.

"After consultation [by the crew] with company operations [personnel], the aircraft took off at 0247 and flew [from East Midlands Airport] to Luton Airport, where it landed at 0312," the report said. "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 hours, and they arrived at the hotel at 0345 hours."

The first officer telephoned the company at 1100 and was told to expect a 1730 departure from Luton for a flight to Guernsey.

"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, [a cargo of] newspapers had not been loaded at Gatwick," the report said. "The [crew of the other] aircraft was instructed to return to Gatwick to collect the newspapers, but [the aircraft] went unserviceable shortly after takeoff at around midday and had to return to Guernsey for recertification."

The company then asked the accident-aircraft commander to revise the departure time from Luton to 1600.

"He agreed to the request and told the operator's crewing staff that both pilots would report for duty at Luton Airport by 1515 hours," the report said.

The newspapers were transported from Gatwick by road and arrived at Luton at 1500.

"The newspapers had been stacked on five pallets and secured by plastic wrapping," the report said. "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."

The three-person loading team decided not to use a belt loader, because the belt was wet and would have damaged the newspapers.

"To work around this problem, the vehicle was reversed to the aircraft's forward cargo door and the bundles were transferred [by hand] from the vehicle's tailboard into the aircraft," the report said. "The dispatcher assisted the load team."

Neither the loading-team leader nor the dispatcher had experience in loading an F27. The loading-team leader had not been given a loading-instruction form; 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 kilograms [6,753 pounds]," the report said.

The report said that a copy of the "Loading Instructions" section of the company's flight operations manual (FOM) was in a wooden box aboard the aircraft.

"Even if [the dispatcher and loading-team leader] had known of the existence and location of the document, [they] would not have had time to read and digest its contents," said the report.

The dispatcher asked the commander how the cargo should be loaded.

"The dispatcher recalled that the commander said 'from the back,'" the report said. "The load-team leader's recollection of the dispatcher's instructions was to 'put it all in the rear.'"

The loading team stacked the newspapers in rows about 75 centimeters (30 inches) high. The first row extended across the cargo bay near the forward edges of the rear doors; the last row extended across the cargo area near the trailing edge of the wings.

The dispatcher said that both pilots remained in the "vicinity of the cockpit" while the loading was completed. The loading-team leader said that the commander periodically stood near the cargo door and watched the loading.

"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," said the report.

When the loading was completed, the commander told the loading team to fasten a cargo net over the load, and he gave copies of the load sheet and technical log to the dispatcher. Both the commander and the first officer had signed the load sheet.

"The three loaders secured the cargo with a single net while the commander watched," the report said. "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 loading-team leader saw no attachment points on the floor behind the load, so he used draw straps and hooks to pull the net tight.

"The tension at the rear of the net was taken by the attachment points on either side of the fuselage," the report said. "[Another loading-team member] placed three clips into the attachment rails on the floor about six inches [15 centimeters] in front of the load. … 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."

The loading-team leader then asked the commander if the load was secured sufficiently.

"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," the report said. "As they drove off, the commander closed the cargo door from the inside."

The first officer then emerged from the cockpit and borrowed a screwdriver from a source unidentified by the report. The first officer said that 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," the report said. "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."

The flight crew then started the engines and taxied the aircraft to the runway. They departed from Luton at 1614.

"The aerodrome controller saw nothing unusual about the takeoff," the report said. "During the flight, the crew did not mention any handling difficulties to ATC [air traffic control] by radio or to each other on the 30-minute cockpit voice recording … . 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 [the accident aircraft] or by other crews."

The commander was the pilot flying. The report said that he conducted a comprehensive and timely approach briefing.

"The cockpit voice recording portrayed two pilots operating in a relaxed but professional manner," the report said. "Good rapport between them was evident, and, despite taking minimum rest in Luton, neither pilot sounded tired."

The flight crew began descent about 60 nautical miles (111 kilometers) from Guernsey and were vectored by Jersey Radar onto the localizer course for the instrument landing system approach to Runway 27.

Figure 1 shows aircraft parameters correlated from the aircraft's digital flight data recorder (DFDR) and cockpit voice recorder (CVR) for the last 60 seconds of the flight.

The flight crew completed the approach checklist and extended the flaps to 16 degrees before turning the aircraft to intercept the localizer course.

"With less than six miles [11 kilometers] to run to the [runway] threshold, the commander told the first officer that he could see the runway and was content to continue the approach visually," the report said. "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."

The tower controller told the flight crew to continue the approach. He then cleared the crew to land and said that the wind was from 330 degrees at 17 knots (32 kilometers per hour).

The 1650 weather observation at Guernsey Airport was 25 kilometers (16 statute miles) visibility, scattered clouds at 1,900 feet and at 6,000 feet, and surface temperature 8 degrees Celsius (46 degrees Fahrenheit).

The flight crew extended the landing gear and extended the flaps to 26.5 degrees. The commander then asked the first officer to conduct 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 glide path indicated by the precision approach path indicator lights), which the first officer acknowledged," said the report.

The aircraft was at 650 feet (approximately 300 feet above ground level) when the commander said, "OK, the decision is to land. Speed [is] below one four four [knots]. Flaps forty."

The first officer acknowledged the instruction and said "running." About five seconds later, the first officer said, "Flaps forty, 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," the report said.

The commander applied full engine power. Airspeed decreased below 97 knots as the aircraft began to climb.

"Normal acceleration reached a peak of 1.5 G," the report said. "The aircraft continued to climb [and] reduce airspeed, and the normal acceleration readings started to decrease. The aircraft also started to turn to the left.

"As [the aircraft] climbed through 1,000 feet with an airspeed of 70 knots, engine power was reduced. One and a half seconds later, at approximately 55 knots and 1,100 feet, a continuous warning horn was heard in the cockpit."

The report said that the warning horn could have been triggered by any of the following conditions:

- "When either throttle is retarded below 10,500 rpm [revolutions per minute] and any landing gear is not down and locked;
- "When flaps are in any position beyond 25 degrees and any landing gear is not down and locked; [or,]
- "Airspeed is below 55 knots, right-hand power lever is below 14,000 rpm and [propeller] ground-fine pitch is not activated."

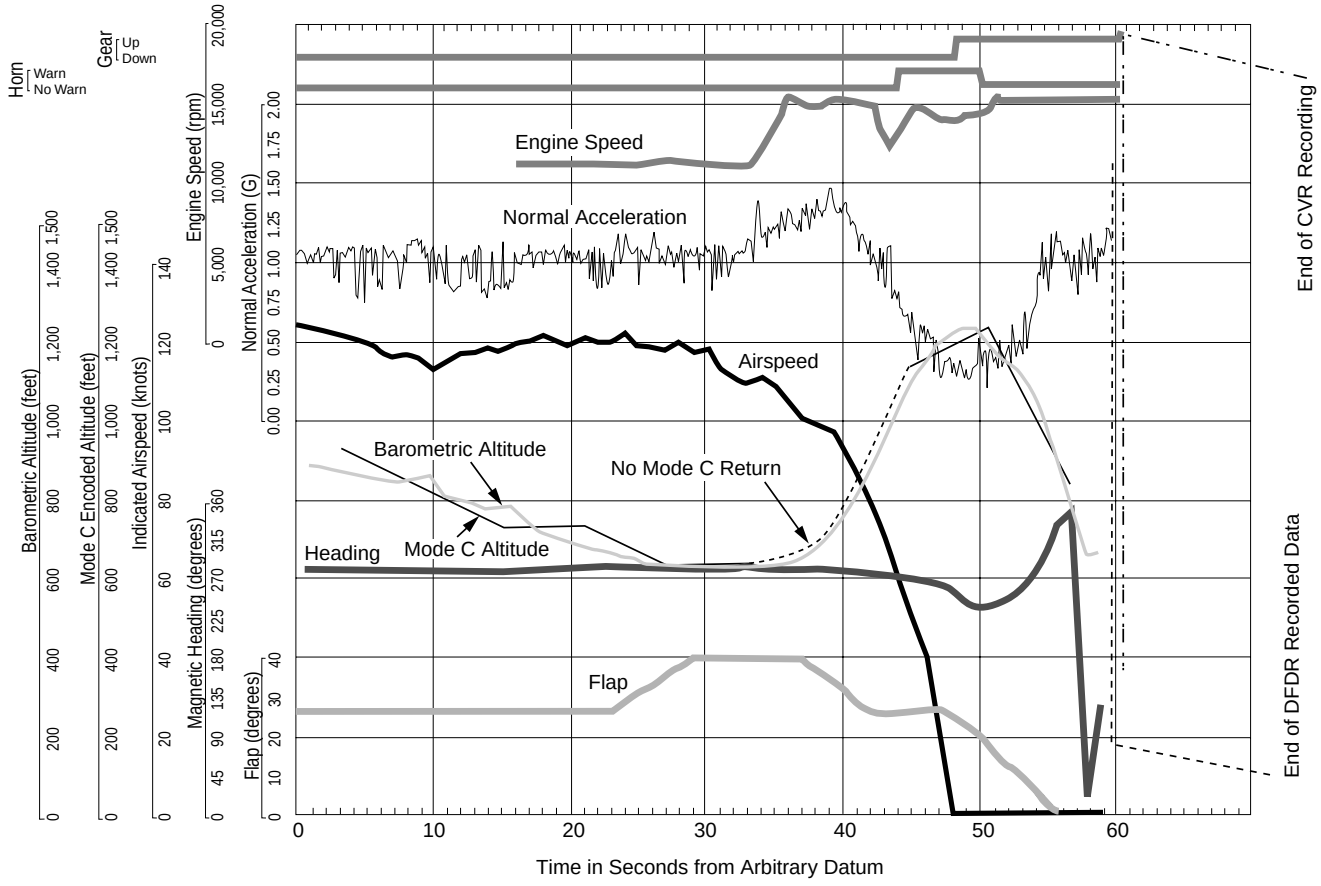
The report said that DFDR data and CVR data show that the warning horn sounded because airspeed was below 55 knots, the right power lever was below 14,000 rpm and propeller ground-fine pitch was not activated.

When the warning horn sounded, the commander increased engine power but did not apply full power.

"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 degrees," said the report.

The crew retracted the landing gear and selected flaps up.

Correlated Flight Data Recorder Data and Cockpit Voice Recorder Data, Fokker F27-600, Near Guernsey Airport, Channel Islands, U.K., Jan. 12, 1999



CVR = Cockpit voice recorder DFDR = Digital flight data recorder

Source: U.K. Air Accidents Investigation Branch

Figure 1

"Full engine power was applied, and the cockpit warning horn stopped," the report said. "As normal acceleration readings started to increase, the aircraft began to turn to the right and descend rapidly."

The report said that the tower controller observed the aircraft "going high" on the glide path and assumed that the crew was conducting a go-around. The controller then looked toward the departure end of the runway, to see if the go-around airspace was clear of traffic. When he looked back at the aircraft, he saw the aircraft bank left and descend.

"Many other witnesses heard and saw the aircraft on what appeared to be a normal final approach," the report said. "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 [witnesses] 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 said that the aircraft completed one rotation around its yaw axis before striking the ground. Other witnesses said that the aircraft rotated slowly about 180 degrees.

"Most [witnesses] agreed that [the aircraft] 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," the report said. "There was only one person in the house; she was unhurt and able to leave through the front door."

The report said, "A postmortem examination was made of both crewmembers. 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."

The accident site was 0.6 nautical mile (one kilometer) from the runway threshold and 900 feet (275 meters) south of the runway extended centerline.

"Examination of the accident site showed that the first impact was between the aircraft's left wing tip and the rear roof of the [single-story] house," the report said. "The effect of this initial impact was to slew the aircraft to the left through approximately 35 degrees 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 degrees magnetic, traveling forward at a speed of about 40 knots, traveling downwards at about 70 knots, banked to the left 10 degrees and pitched nose-down 15 degrees."

The report said that the landing gear and flaps were retracted, and the propellers were producing "high thrust" when the accident occurred.

"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," said the report.

Fires erupted near both engines and were fed by fuel discharged from ruptured fuel tanks. Airport firefighters arrived four minutes after the accident occurred, and Guernsey firefighters arrived soon thereafter.

"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," the report said. "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 firefighter 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."

The cargo was removed from the accident site and allowed to dry for four months before it was weighed.

"The weight of the cargo was found to be 3,164 kilograms [6,975 pounds], whereas the manifest stated that it was 3,063 kilograms," the report said. "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 percent) was considered to be within measurement tolerances. Nevertheless, the measured weight of the cargo was used in the calculation of [CG] position."

The report included the following information on two other F27 accidents that occurred during cargo flights:

"In 1967, a domestic F27 flight from Manila to Mactan in the Philippines was loaded with a mix of freight and passengers," the report said. "On final approach to land, the aircraft suddenly assumed a nose-high attitude, and additional power was applied. A [flight] crewmember 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 [1.7 kilometers] before the runway threshold."

Weight-and-balance computations showed that the CG was outside the aft limit.

"No technical failure or malfunction of the aircraft was found," the report said. "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."

The aircraft did not have a DFDR, and the flap position when the upset occurred was not determined. The flaps were in the retracted position when the aircraft struck the ground.

The report said, "In 1988, an F27 cargo aircraft transporting freight from Billund [Denmark] to Hanover [Germany] pitched up uncontrollably on [short-final approach] 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 meters [3,084 feet] from the runway threshold."

The freight of cast-iron parts had been loaded too far aft, and the aircraft's CG was 11 percent aft of the aft limit.

"Moreover, the heavy cast-iron parts had not been properly secured longitudinally, and it was possible for them to move aft, which some probably did when the aircraft initially pitched up, thereby intensifying the loss of pitch control," said the report. "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 degrees) flap for landing.

"During the attempted go-around, the landing gear was retracted and a flap position of 26.5 degrees was ordered, but these actions were unsuccessful in regaining pitch control."

The report said that the accident in Mactan and the accident in Hanover had "marked similarities" to the accident in Guernsey.

"All three accidents followed apparently normal takeoff, climb and cruise phases, with subsequent loss of control during the approach phase," said the report.

In the Hanover accident and the Guernsey accident, the flight crews lost aircraft control after extending full flaps.

"The accident in [Mactan] could not be directly related to the selection of landing flap, but the accident at Hanover followed the deployment of full flap," the report said. "Moreover, as in [the Guernsey] accident, returning the flaps to the intermediate approach setting of 26.5 degrees and raising the landing gear did not restore controllability."

The CG of all three aircraft was outside the aft CG limit.

"Calculations of the [Guernsey] aircraft's weight and balance, based on the distribution of the cargo as loaded, showed that the weight was within approved limits but the [CG] position was significantly aft of the approved limits before the aircraft taxied," the report said. "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 [load sheet]."

The report said, "The distribution of the load as shown on the load sheet completed by the pilots at Luton bore little resemblance to the actual loading."

The aircraft had three cargo bays, designated as Bay A, Bay B and Bay C. The pilots' load sheet showed 800 kilograms (1,764 pounds) of cargo in Bay A, the aircraft's forward cargo bay.

"Detailed reconstruction of the loading, based on a combination of physical [evidence] and witness evidence, revealed that all the cargo had been placed in Bays B and C," said the report. "Calculations indicated that the loaded aircraft [CG] was significantly aft of the aft limit."

The calculations showed that the CG was at approximately 42.7 percent mean aerodynamic chord (MAC) when the aircraft was on final approach to Guernsey with the landing gear extended and the flaps fully extended. For this aircraft condition, the aft CG limit is 38 percent MAC. (For cruise flight, with landing gear and flaps retracted, the aft CG limit is 40.7 percent MAC.)

Examination of the wreckage showed that about 20 percent of the newspaper bundles were aft of the rear cargo bay. The report said that the bundles most likely shifted ("migrated") after the flight crew lost control of the aircraft and the aircraft pitched up to a near-vertical attitude.

"However, migration could have occurred earlier," the report said. "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, while 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 [CG] during flight would have produced a more extreme aft [CG] position."

The report said that the first officer might have detected the misloading if he had conducted a preflight inspection of the aircraft after the cargo was loaded.

The report said that the first officer might have detected the misloading if he had conducted a preflight inspection of the aircraft after the cargo was loaded.

"The first officer carried out a preflight external inspection before loading was completed," the report said. "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 [CG] position."

The report said that the first officer might have observed abnormal extension of the nose-landing-gear shock absorber when he stood with his head in the nose-gear bay after the cargo was loaded.

"He was formerly a flight engineer," the report said. "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."

The report said, "Exactly what the first officer was attempting to rectify when he entered the nose-gear bay with a screwdriver 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."

The report said that the aircraft's aft CG probably did not cause the flight crew to experience any "strikingly unusual" handling characteristics until they conducted the approach to Guernsey.

"At [airports] where the takeoff distance was not a limiting factor, the operator's standard procedure was to take off with flaps retracted," the report said. "Elevator trim was routinely set to neutral before takeoff, 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 takeoff, and there could have been little, if any, symptoms of abnormal behavior in pitch on takeoff.

"Assuming the cargo did not migrate earlier, in cruising flight, the [CG] position would have been about 2 percent 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."

The report said that the aft-CG loading might have produced the following "subtle but recognizable" effects on aircraft handling during takeoff and cruise:

- "Light elevator forces during rotation on takeoff with a possible tendency to overrotate;
- "Reduced in-flight dynamic stability leading to low control-column forces in pitch and a difficulty in trimming; [and,]
- "Excessive nose-down elevator trim required."

The report said that the aircraft's static stability was reduced during the approach.

"Static stability is the aircraft's [initial] 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 [AOA]," the report said. "If there is an increase in [AOA], there will be an increase in wing lift. If, at the same time, the aircraft tends to pitch nose-up, thereby further increasing the [AOA], it is said to be statically unstable. If, on the other hand, the aircraft pitches nose-down and tends to return toward its original [AOA], it is said to be statically stable."

The report said that, for an aircraft to be statically stable, the CG must be forward of the "aerodynamic neutral point."

"The variation of total lift with [AOA] acts through the neutral point, and the aircraft's weight acts through its [CG]," the report said. "Any change in the lift force will tend to pitch the aircraft about its [CG].

"A small increase in [AOA] caused by an airflow disturbance will create an increase in total lift. If the [CG] 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 [AOA]. This is a stable situation.

"If, however, the [CG] is astern of the neutral point, a momentary increase in lift causes a pitch-up moment, which further increases the [AOA]. This is an unstable situation."

The accident aircraft's neutral point moved forward as airspeed was reduced and flaps were extended during the approach.

"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," the report said. "This is normal F27 behavior."

The neutral point moved forward of the CG when the flaps were extended from 26.5 degrees to 40 degrees.

"The commander would have pushed forward on the control column in an attempt to stop the nose [from] rising, but the elevator would have reached full travel, and he would have been unable to stop [the nose from] rising," said the report.

The commander's instruction to retract the flaps to 26.5 degrees and his application of full power did not correct the situation.

"Unfortunately, increasing power moved the neutral point further forward, which negated the effect of returning the flaps to 26.5 degrees, and the aircraft continued pitching up," the report said. "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 [CG] further aft and aggravated the loss of stability."

Retraction of the landing gear also moved the CG 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 the [CG] and aerodynamic neutral point," said the report.

The report said that, with the aircraft in a nearly vertical nose-up pitch attitude and the CG at almost 49 percent MAC, "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 [CG] and low height."

The report said that the flight crew's performance in the air, preceding the loss of aircraft control, differed from their performance during the loading of the aircraft.

"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," the report said. "However, during their preflight preparations, they overlooked errors in the loading process which could have been revealed by a quick-and-simple comparison of [the] load sheet with load distribution."

U.K. Civil Aviation Publication (CAP) 360, *Air Operators' Certificates*, said, "The person responsible for the trim of the aircraft must give written instructions to the person responsible for loading the aircraft."

The report said, "No such instructions, even in the most rudimentary form, were given to the load team by the [flight] crew. The reason why no written instructions were issued probably stemmed from the loading procedures adopted at some of the operator's bases."

The report said that the loading teams at the bases in Bournemouth, Guernsey and Jersey were trained and experienced in loading F27 aircraft, and that "there was no requirement for detailed load planning or loading instructions."

"The [FOM] 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," the report said. "A quick check of the overall load security as part of the preflight inspection was generally all that was practicable."

The report said that the "most puzzling aspect of this accident" was that the commander did not supervise the loading team.

The report said that some procedures in the FOM "Loading Instructions" section were inappropriate.

"The method described for loading cargo … was only applicable to loading items by hand," the report said. "Had the loading team followed this procedure, a gross loading error would not have occurred. Nevertheless, [the procedure] was not a practical method for loading the palletized cargo presented to [the loading team] when they opened the vehicle. Moreover, there are pitfalls associated with loading palletized cargo onto an F27 (e.g., tipping the aircraft onto its tail) which were not described [in the FOM]."

The FOM included information about load-sheet documentation of aircraft weight and balance. The report said that the load sheet included a section to be signed and dated by the "traffic officer," certifying that the aircraft was loaded in compliance with the "current loading instructions" in the FOM.

The report said, however, that the roles and responsibilities of a traffic officer were not documented by the FOM, and that "it was first officers who habitually prepared the load sheet and signed the 'traffic officer's certificate' at the bottom of the load sheet."

"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 load sheet without inspecting the load was flawed," said the report.

The FOM included a sample "Load Instruction/Report" form, which was designed for use in recording requested load distribution and actual load distribution. The report said that this form is a "suitable format" to provide written loading instructions, but the forms were not carried aboard company aircraft.

The report said that the operator did not provide load-planning tables to its flight crews.

"Crews were expected to devise a load plan by 'trial and error,' using the balance chart on the load sheet," the report said. "This method could be time-consuming, and it was not as error-resistant as preplanned tables."

The first officer's clipboard contained load-planning tables from an unofficial source.

"A situation whereby crews may rely upon unofficial planning tables is unsatisfactory," the report said. "A verbal recommendation that official planning tables be provided was made to the operator's management staff soon after the accident. The operator … swiftly published official tables. The operator's F27 aircraft now have a copy of these tables attached to the smoke barrier [between the cockpit and cargo area], where they are accessible to pilots and loading teams."

The report said that the "most puzzling aspect of this accident" was that the commander did not supervise the loading team.

"He arrived early at the aircraft, so lack of time was not a factor," the report said. "He should have realized 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 among the [cargo] bays."

The report said that, at the time of the accident, CAP 642, *Airside Safety Management*, developed by the Airside Safety Management Group, did not recommend that loading crews unfamiliar with an aircraft type obtain written loading instructions.

"It seems sensible that if a handling agent's 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," said the report.

The report said that the commander of the accident aircraft did not conduct a thorough check of the load team's work.

"This behavior contrasts strongly with the commander's careful manner and thorough attitude while actually flying," the report said. "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."

The report said that the operator's ground-school syllabus for F27 conversion training contained "adequate" instruction in aircraft loading, "but there was no follow-up training that covered the fundamentals of load planning and load restraint."

The training syllabus for prospective F27 commanders did not specify instruction in aircraft loading.

"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," said the report.

The report said that the commander of the accident aircraft received F27 command training in March 1998 and April 1998.

"The contents of his training file were reviewed; there was no mention of loading procedures," the report said. "Every sector [completed with a line-training captain] 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 or supervise a loading operation had been structured into his command line training."

The report said that some line-training captains might have provided guidance on aircraft loading to prospective commanders, but the training syllabus for line-training captains did not require this.

"The company had a high turnover in its F27 pilot work force, 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," said the report.

The report said that the work-force situation at the time of the accident differed from a previous situation in which the majority of the company's F27 commanders were completing, rather than beginning, their airline careers.

"In recent years, through the expansion of commercial aviation in general, the availability of experienced commanders has [been] reduced, and the company promoted the commander [of the accident aircraft] soon after he achieved the minimum requirements for command," the report said. "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 of the loading team. He was a competent pilot who was insufficiently trained in the cargo-transport role, specifically in load management and loading supervision."

The report said that, at the time of the accident, Channel Express was not required to comply with Joint Aviation Requirements (JARs) but was working toward compliance.

"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," said the report.

The report said that the accident aircraft's DFDR did not record pitch attitude, roll attitude or engine power, and that the absence of these data "impeded the investigation of the accident."

"The U.K. 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 report said. "The requirements state that pitch attitude, roll attitude and engine power only have to be recorded 'if the equipment provided in the airplane is of such a nature as to enable [these data] to be recorded.' Although aircraft-attitude and engine-performance information was displayed to the crew of [the accident aircraft], these parameters were not recorded on the DFDR.

"At the time that the [ANO Schedule 4,] 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 capable of recording these parameters."

The report said that the findings of the accident investigation were as follows:

- "The crew were properly licensed and qualified to operate the flight;
- "The aircraft was serviceable throughout the flight;
- "The weight of the cargo submitted for carriage was considered to be within measurement tolerances;

- "Upon completion of the loading, the aircraft's [CG] was significantly aft of the approved limit;
- "The defect in the nose-gear bay was not a 'no-go' item related to the flight controls, landing gear or nosewheel steering;
- "The crew were not rushed by the loading process;
- "The pilots were unlikely to have experienced any strikingly unusual handling qualities until the approach phase;
- "Deployment of full flap initiated the undemanded pitch-up on final approach;
- "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;
- "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 [CG] and low height;
- "Migration of the cargo did not cause the accident, but it moved the [CG] further aft and aggravated the loss of stability;
- "The loading errors were not attributable to the handling agent's staff;
- "Errors in the load distribution could have been revealed by a quick-and-simple comparison of [the] load sheet with load distribution;
- "No written loading instructions were given to the load team by the crew;
- "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 load sheet;
- "The commander did not visit the rear of the aircraft after the loading was completed;
- "If written loading instructions had been given to the loading-team leader by the crew, the accident could have been prevented;
- "There were no official 'load-planning' tables provided by the operator for flight-crew use;
- "There was no supply of blank 'Loading Instruction/ Loading Report' forms carried on the aircraft;
- "A quality audit of the 'Loading Instructions' volume would have revealed that some of the instructions were not being followed;
- "The distribution of 'Loading Instructions' did not include personal copies for flight crew;
- "The operator's type-conversion training syllabus conformed to the latest regulatory requirements;
- "The absence of sufficient role training would not necessarily be discovered during an audit of the operator's conversion-training syllabus;
- "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;
- "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;
- "There was no system which ensured that line-training captains were fully competent to teach loading and load restraint;
- "Pilots were not provided with blank loading-instruction forms and load-planning tables;
- "The operator could have extended its loadmaster-training scheme to teach load management to its pilot work force; [and,]
- "The operator omitted to adapt the F27-command course to meet the needs of an inexperienced commander operating away from a main base."

Based on these findings, the AAIB made several recommendations to Channel Express, the Airside Safety Management Working Group and the U.K. Civil Aviation Authority.

AAIB said that Channel Express should:

- "Modify its operating procedures to ensure that the person who signs the traffic officer's certificate:
  - "Has inspected the load and reconciled the actual load distribution with the loading instructions or load report;
  - "Has ensured that the load is properly restrained throughout the cargo compartments;
  - "Is appropriately trained, qualified and periodically examined on his or her competency to carry out the above; [and,]

– "Has sufficient time to carry out meaningful checks;

- "Review and amend its 'Loading Instructions' to make them practicable and consistent with minimizing risk;
- "Issue personal copies of 'Loading Instructions' to pilots;
- "Amend its induction training to ensure that the topic of load distribution is covered in great detail;
- "Ensure that command-training courses include the opportunity to devise and supervise a loading operation under the supervision of a suitably qualified line-training captain;
- "Provide pilots with substantial initial and recurrent training on the planning, loading, carriage and restraint of cargo;
- "Use only appropriately qualified and experienced training staff;
- "Assess the effectiveness of its training by periodic testing; [and,]
- "Review and amend its quality system to ensure that it fully meets the requirements specified in [the JARs]."

AAIB said that the Airside Safety Management Working Group should "consider an addition to CAP 642 which encourages handling agents to ask for written loading instructions when loading cargo onto unfamiliar aircraft types."

AAIB said that the U.K. Civil Aviation Authority should:

- "Require operators to reassess the relevant equipment and engine fit on all U.K.-registered aircraft subject to the requirements of the [ANO] 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; [and,]
- "In conjunction with the JAA [Joint Aviation Authorities], review the appropriate [JARs] with a view to requiring that pitch attitude, roll attitude and engine thrust [are] recorded on all aircraft which carry a flight data recorder."♦

[FSF editorial note: This article, except where specifically noted, is based entirely on the U.K. Air Accidents Investigation Branch *Report on the accident to Fokker F27-600 Friendship, G-CHNL, near Guernsey Airport, Channel Islands, on 12 January 1999*. The 94-page report includes diagrams and appendixes.]

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