AAIU Report No. 2000/001
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Aircraft Type and Registration:	Lockheed Electra L-188C N-285F
No. and Type of Engines:	Four, Allison 501-D13
Aircraft Serial Number:	1107
Year of Manufacture:	1959
Date and Time (UTC):	1st March 1999 08.46 hours
Location:	Shannon Airport, Ireland
Type of Flight:	Public Transport - Cargo
Persons on Board:	Crew - 3 Pax -3
Injuries:	Crew - None Pax - None
Nature of Damage:	Propellers of Engines Nos 2, 3 and 4 damaged by ground impact. Engine No. 3 separated from the aircraft in flight. Main fuselage perforated.
Commanders Licence:	Airline Transport Pilot (FAA).
Commanders Age:	42 Years
Commanders Flying Experience:	5000 hours (incl 200 hrs as Captain on type) Last 90 days - 90 hours Last 28 days - 30 hours Last 24 hours - 5 hours
Information Source:	ATC Watch Manager, Shannon Airport

SYNOPSIS

Formal notification of the accident was transmitted to the UK Air Accident Investigation Branch (AAIB), the USA National Transport Safety Board (NTSB), ICAO and the Irish Aviation Authority (IAA), by the Irish Air Accident Investigation Unit (AAIU) on 3rd March, 1999. Under the provisions of ICAO, Annex 13 (Aircraft Accident and Incident Investigation), State of Occurrence, the Chief Inspector of Accidents, Mr. K. Humphreys, appointed Mr. F. Russell and Mr. J. Hughes, Inspectors of Accidents, to carry out an investigation into the circumstances of this accident and to prepare a Report for publication.

The aircraft was on a regular night cargo flight between Cologne, Germany, and Shannon Airport, Ireland, with an intermediate stop at Dublin Airport. The flight from Cologne to Dublin was uneventful. After unloading and taking on new freight at Dublin the aircraft was cleared by ATC to Flight Level (FL) 120 for a direct track to Shannon. A standard ILS approach was flown to RWY 24 at Shannon. At the point of touchdown, as some of the propeller blades struck the RWY surface, the crew realised that the aircraft undercarriage was not extended so they initiated an immediate go-around. As the aircraft climbed most of No. 3 engine disintegrated and fell from the aircraft to the ground. Debris from this engine damaged No. 4 engine and also perforated the cabin structure, aft of the cockpit jump seats. With only No. 1 engine fully operative and No. 2 engine on reduced power, the crew managed with great difficulty to sufficiently control the aircraft and carry out a successful landing on RWY 24, with the full Shannon Airport Fire Services in attendance. The crew shut down the remaining engines and they and the passengers evacuated the aircraft safely. There was no fire.

1. FACTUAL INFORMATION

1.1 History of the Flight

The aircraft (Flight 6526) departed Cologne at 0300 hours and routed directly to Dublin, where, after more than one hours delay due to the late arrival of a freight truck, the aircraft departed for Shannon Airport at 0816 hours. The crew consisted of the First Officer who was the handling pilot on both of these sectors, the Captain who was the non-handling pilot and the Flight Engineer.

The take off gross weight was estimated at 83,701 lbs, well below the limiting 116,000 lbs take off weight (MTOW), and the centre of gravity was within limits. The landing weight was estimated at 80,345 lbs, again below the maximum landing weight of 98,102 lbs. The total freight on board was 14,000 lbs, less than half the 33,000 lbs maximum amount permissible.

The aircraft reached it's designated altitude of FL120. The crew were handed over to Shannon Approach and given descent clearance. Shannon Approach instructed the crew to keep the speed up (due to an another aircraft behind them) and the aircraft was vectored on an approach to RWY 24. Due to the weather forecast for Shannon the crew decided to conduct the landing with 78% flaps set, rather than the standard 100% flap normally set for landing. During the approach the Captain called 1000 ft above the touchdown zone (TDZ), then 500 ft and every 100 ft thereafter to the Decision Altitude (DA). At an altitude of 700 ft the Ground Proximity Warning (GPWS) horn sounded. The Flight Engineer proceeded to inhibit the GPWS system. Slowing the aircraft to Vma (Maximum Manoeuvering Airspeed) the crew did not carry out the "before landing" checks. Whilst over the RWY threshold the gear warning horn sounded and five seconds later the crew heard a scraping sound and felt severe aircraft vibrations. Realising that the gear was not down the Captain called for a go-around. The First Officer continued to fly the aircraft and was cleared to 3000 ft by ATC.

However, during the climb out the aircraft flew into cloud (Instrument Meteorological Conditions) at about 500/600 feet, and simultaneously the propeller assembly and part of No. 3 engine fell to the ground. Electrical power was lost and the only serviceable flight instruments available to the crew was the standby artificial horizon and wet compass. The First Officer relinquished control of the aircraft to the Captain who had great difficulty in maintaining directional control and it took the combined efforts of both pilots to control the excessive yaw through the rudder pedals. In addition, there was insufficient power available to climb to 3000 ft. In fact, less than 2000 ft was attained, as the aircraft commenced a slow difficult turn in a North Easterly direction and towards the high ground west of Limerick city. It was only by further manipulation of the throttles and feathering No. 4 engine that sufficient directional control was recovered, enough to respond to the instructions of the ATC Radar operator. The aircraft was now flying with only No.1 engine fully operative and No. 2 engine producing only half power and much vibration. The Radar operator vectored the aircraft to approach RWY 24 which became visible to the crew. They selected "gear down" and while only 2 of the 3 green landing lights illuminated, the Captain elected to proceed with the landing, with the flaps again set at 78%. This landing was successful, with all the landing gear deploying correctly. The aircraft was evacuated while the airport crash crews stood by.

1.2 Injuries to persons

There were no injuries to either passengers or crew.

1.3 Damage to aircraft

There was substantial damage to the aircraft. Initial contact with RWY 24 was made approximately 1050 metres from the displaced threshold of the runway. Propeller marks were evident 9M left of the RWY centreline and continued for a further 30M. A second set of marks were found a further 74M further on, almost on the centreline. A third set of marks were found in the same area 2M right of the centreline and continued for a distance of 14M.

As the propeller of No 3 engine struck the ground the blades disintegrated and pieces of blade tip were ejected and punctured the aircraft cabin. One piece went through the cabin and exited at the top of the fuselage two frames aft of the front cargo door.

The aircraft then continued to gain height in the direction of RWY 24. At a point 600 M from the threshold of RWY 06 the aircraft turned and at this point the forward part of engine No 3 including the propeller assembly separated from the aircraft and fell to the ground.

The four blades and hub assembly of No. 3 engine were located at a point 200M north west of the edge of RWY 06/24. Engine cowlings and some electrical cables were also found in this area.

The aircraft made a go-around with full power from engine No 1 only, low power from engine No 2 and no power from either No 3 or No 4. The undercarriage was extended and the aircraft subsequently landed on RWY 24 coming to rest approximately 600M from the threshold of RWY 06.

The aircraft was inspected by AAIU inspectors who found that the forward part of engine No 3 back to the diffuser casing was missing. The engine starter and oil pump assembly were found hanging by electrical cables from the engine. All propeller blades from engines No 2 & 4 were found damaged. Pieces from No 3 engine assembly had struck No 4 engine and penetrated the cowlings of that engine. There was slight skin abrasion to the rear underneath fuselage section, indicating a tail scrape. There was no evidence of fire.

Further examination on the ground showed that aircraft flaps had been selected at 78%. The spinners from No 2 and No 4 engine were missing. Evidence of initial wheel lock on final landing was indicated by the condition of one main wheel tyre. Rubble was later found strewn all along RWY 24 from the initial propeller marks up to Taxiway Alpha.

1.4 Other Damage

There was slight damage to the surface of RWY 24 where the propeller blade tips struck the surface to a maximum depth of 1 inch.

1.5 Personnel Information

Captain	Valid FAA Airline Transport Pilot Licence Total Time: 5000 hours (including 200 hours as Captain and 3000 hours as First Officer on type).
First Officer	Valid FAA Airline Transport Pilot Licence Total Time: 2000 hours (including 760 hours on type).
Flight Engineer	Valid FAA Flight Engineer Licence Total Time: 6000 hours (including 1100 hours on type).

1.5.1 Duty Schedules

The aircraft Operator is based in California while the flight crew reside in various US cities and normally dead-head to Cologne, Germany, for duties. Here they spend 4/5 weeks on duty, mostly flying the Cologne-Shannon night flight run, before returning to other flying duties and off-time in the USA. The rostering out of Cologne has the crew flying 3 nights one week, followed by two nights the next week. This is followed by off duty or stand-by time.

In the week preceding 1st March 1999, the pilots of Flight 6526 flew Monday, Tuesday and Thursday night, with their next flight departure early on Monday 1st March.

The crew indicated that they averaged 40/50 hours per month on this operation, well below the flight time limitations laid down by either the FAA or the CAA. They often flew together as a team.

1.6 Aircraft Information

1.6.1 Maintenance

At the request of the AAIU the NTSB examined the operators maintenance records on 3rd March 1999.

The last "C" check was performed on September 14, 1998. The last "B" check was performed on January 3 1999, in Cologne, by the Operator's maintenance personnel at 64,769 flight hours. The most recent "A" check was performed in Shannon by the operator's personnel on Friday, February 26, 1999 at 64,959 flight hours. The scope of the "A" check includes a Service Check.

According to the operator, the landing gear was swung and the gear warning systems tested as part of the "C" check and, following the "C" check, a functional check flight was flown during which the gear warning system was tested in flight. At that date the aircraft's total flight time was 64,473 hours.

According to the aircraft records, the aircraft was dispatched on the accident flight with no deferred maintenance items.

1.6.2 Landing Gear and Flap Position Warning System.

The landing gear warning horn system on the L-188 is wired through the engine power levers and the flap handle. There is a button installed on the right side of the pedestal to silence the landing gear warning horn when the power levers are retarded with the flap handle out of the retracted position from zero to 78% flap. The horn cannot be silenced by this button if the flaps are extended beyond 78% when the gear is not down and locked.

Thus, the gear warning horn, with the flaps up at 78%, may be prevented from sounding by pressing and holding the horn cancellation button before the power is reduced at or below the position where the power lever switch would activate the warning.

1.7 Meteorological Information

The forecast for Shannon obtained by the crew from the handling agent at Dublin at 06.30 hours was:

Wind & Direction	260/20G38 kt
Visibility	2000 metres
Significant Weather	RERA + DZ
Cloud	BKN 004 OVC 006
Temp/Dew Point	11ºC/11ºC

The Captain reported to the investigation that the actual conditions at Shannon did not differ significantly from the above.

The actual weather conditions recorded at Shannon at 0900 hours, 1st March, 1999 were:

Wind 250/20 kt (gusts of up to 25-30 kt experienced between 08.30 and 09.30)

Weather - Continuous moderate drizzle

Visibility - 3000 metres

Cloud - 5 octas of stratus at 400 ft, Overcast at 600 ft

Temperature - 11.1 Celsius

Dewpoint - 10.7 Celsius

The weather at Shannon improved thereafter as follows:

TIME	VISIBILITY	WIND
08.51	2000 M	260/20 kt
09.00	3000 M	250/17 kt
09.30	4000 M	250/14 kt

1.8 Aids to Navigation

The ILS to RWY 24 was fully serviceable.

1.9 Communications

Communications were maintained throughout both approaches between the aircraft and Shannon Tower (frequency 118.7) and Shannon Approach Radar (frequency 121.4). The crew later complimented the Air Traffic Control (ATC) on the effectiveness of the vectoring back on to the second approach to RWY 24 following the first wheels-up approach.

1.10 Aerodrome Information

International Standard Aerodrome.

1.11 Flight Recorders

The CVR and FDR were recovered by the AAIU from the rear fuselage stowage area. The CVR tape was found to be very noisy and difficult to interpret in some areas. The FDR was forwarded to the UK AAIB for decoding. They had some difficulty in extracting some of the parameters. These difficulties were reported to the NTSB.

Recordings on the CVR ceased on the initial runway impact, due to the absence of electrical power. Additionally, some parameters of the FDR continued to record following the impact,as these were supplied by an internal battery.

1.12 Wreckage and Impact Information

The No. 3 propeller complete (4 blades and hub assembly) was found at a point in the approximate direction 325 degrees NW of RWY 06/24, 600 metres from the threshold of RWY 06 and 200 metres from the north edge of the runway.

Some wreckage was also strewn on the runway itself, close to where the propellers scraped the runway surface.

1.13 Medical and Pathological Information

Not Applicable.

1.14 Fire

There was no outbreak of fire.

1.15 Survival Aspects

Not Applicable.

1.16 Tests and Research

The following aircraft systems were checked and found serviceable:

(a) Circuit Breaker for undercarriage warning located on the Essential Bus panel.

(b) Warning horn test switch

(c) Mechanical operation of micro switches for undercarriage warning activation underneath the throttle pedestal.

1.17 Organisational and Management Information

The flight was operated as an unscheduled 14 Code of Federal Regulations (CFR) Part 121 Cargo flight by its US owners under a wet lease contract to a UK cargo airline. The aircraft was being operated as a feeder for UPS, an international cargo operator,one of whose hub's is in Cologne, Germany. Servicing of the aircraft is carried out at Cologne and Shannon.

1.18 Additional Information

1.18.1 Ground Proximity Warning System (GPWS)

GPWS equipment is intended as an aid to the flight crew to provide information designed to announce a warning of imminent inadvertent contact with the ground due to :

A. (Mode 1) Excessive Rate of descent. "Whoop Whoop Pull Up"
B (Mode 2) Excessive closure rate to terrain "Whoop Whoop Pull Up"
C (Mode 3) Negative Climb Rate "Whoop Whoop Pull Up"
D (Mode4) Flight into terrain when not in landing configuration "Whoop Whoop Pull Up"
E (Mode 5) Deviation from the glide slope "GLIDESLOPE".

Mode 4 is subdivided into 4A and 4B.

On this aircraft, 4A provides a warning if the aircraft penetrates below a nominal 1000 feet radio altitude with the landing gear handle not down.

4B provides a warning if the aircraft penetrates below 200 feet radio height with gear down but flaps not in landing configuration.

On this aircraft the voice warning for 4A and 4B is similar but the Operator indicated that the crew should be able to differentiate between them by checking the radio altitude.

The GPWS incorporates an INHIBIT switch which, in accordance with the Flight Manual Supplement, may be selected if some known or planned condition necessitates aircraft operation within the boundaries of the GPWS warning envelope.

It is the Operator's stated policy that the GPWS warning should not be disabled unless the crew has the ability to visually check that terrain is not a threat, that the sink rate is under control and the landing gear is in the proper position. Only when it can be clearly verified that the warning is spurious, with the crew concurring in the decision, will the GPWS be disabled.

The Flight Manual Supplement states "If during routine operations the GPWS warnings are activated, immediately apply maximum power, rotate to a positive climb attitude and climb until the warning ceases. If the warning continues, continue the climb until terrain clearance is assured and determination can be made for cause of warning".

The other two L-188 aircraft of the Operator's fleet have a FLAP OVERRIDE switch. This switch allows the GPWS to accept 78% flaps as the landing flap setting, but does not inhibit in any way, the other warnings provided by the GPWS.

On the aircraft involved in this accident, N285F, however, the GPWS system was manufactured by a different manufacturer and did not have this override facility. The use of 78% flaps as the landing flap setting is authorised by the aircraft's flight manual. However, on this aircraft the GPWS has to be inhibited to prevent the GPWS from sounding for a flap warning at 200 feet radio altitude. Not withstanding this, it was the Operator's stated policy that on this aircraft the GPWS should not be disabled at such a distance from the RWY that the sink rate, landing gear and other warnings would be lost for an extended period.

1.18.2 Cancellation of the Gear Horn (As against the normal 100% flap setting for landing)

In a revised notification to crews following this accident (dated 22/3/99) the Operator stated "During the terminal phase of flight (below 3000 AGL) it shall be the policy of the company that the gear horn will not be cancelled unless the flying pilot asks for the horn to be cancelled before it sounds (stating "Horn" as the power is pulled back). Once the horn sounds, the flying pilot should state "HORN" or "GEAR TO GO" to have the horn silenced".

The Operator stated that the purpose of the above is to assure that the flying pilot is aware that the horn is being silenced. This is intended to prevent other crew members from silencing the horn without the concurrence of the flying pilot. If the horn is not cancelled, it will sound when the power is reduced at or below the throttle switch point, to make the crew aware of the position of the gear. In this case, the flying pilot initiates the silencing of the horn, not the person who silences the horn. This assumes that at least two crew members are aware of the fact that the horn has been prevented from sounding.

1.18.3 Landing Check

The landing checklist* is as follows:

1. Gear	- Down/3 Greens	- Captain & First Officer
2. Brakes	- Off	- Captain & Flight Engineer
3. Nosewheel Steering	- Centered	- Captain
4. Wing De-icing	- Off	- Flight Engineer
5. Propeller Sync	- Off	- Flight Engineer
6. TD - Brake Lock	- Controlled	- Flight Engineer
7. Landing Check	- Complete	- Flight Engineer

*The Pilot flying calls for the landing checklist, the Flight Engineer reads out the items 1 to 7, and both he and the non-flying pilot carry out the actions listed above.

2. ANALYSIS

The primary responsibility for the safe conduct of a flight rests with the cockpit crew and, in this regard, they have the Aircraft Flight Manual (AFM), company Standard Operating Procedures (SOP's) and other technical manuals at their disposal in the cockpit. In particular, the company lays down the SOP's to be followed by each and every cockpit crew member in the interests of standardisation and flight safety. The implementation of these measures and procedures is carried out by the cockpit crew and they are aided in this process by artificial mechanical/electrical warning systems and audio alerts. In the L188 in question the two audio alert systems consist of a Ground Proximity Warning System (GPWS) and the landing gear warning horn.

The GPWS system sounded at about 700' AGL and this should have been sufficient to warn the crew that the landing gear handle was not down and consequently that the undercarriage was not in the landing configuration. The Flight Engineer, however, reached up and inhibited the GPWS. He said he did this because he understood the aircraft to have 78% flap set for landing and that this was why the GPWS warning sounded. He obviously confused this warning with a warning which he would have got below 200 feet radio height when the flaps are set at less than 100% for landing. The fact that this particular aircraft had no FLAP OVERRIDE switch, as the other two similar aircraft in the fleet had, would probably have added to this confusion.

Whether the engineer was instructed to inhibit the GPWS by other crew members is not clear from the CVR. In the debrief following the accident the other crew members agreed that the engineer would have been correct in inhibiting the GPWS as they were landing with 78% flaps configuration. They, therefore, also misinterpreted the GPWS warning.

Having failed to carry out the landing checks and with the undercarriage not down, the normal undercarriage warning horn should have sounded when the throttles were retarded for landing. However, it is possible to silence this warning in the 78% flap configuration, which would not have been possible if the flaps were set in the normal (100%) configuration for landing. It appears that as the throttles were being retarded the Flight Engineer pressed the warning horn button to prevent the alarm from sounding. Whether he was so instructed is not clear as parts of the CVR tape were difficult to interpret due to its poor quality.

During the final stage of landing the throttles were advanced again thus negating the warning cancellation. As the aircraft rounded out for landing the warning horn was again free to sound, and it did, as the throttles were retarded. However, at this stage, there was too little time to lower the undercarriage and five seconds later the propellers stuck the runway surface.

3. CONCLUSIONS

3.1 Findings

3.1.1 The aircraft had a valid standard Airworthiness Certificate issued by the United States Department of Transportation, Federal Aviation Administration and had been maintained in accordance with an approved schedule.

3.1.2 No evidence was found of any technical problems on the aircraft, or its systems, that could have had any bearing on the accident. In addition, the aircraft records show that the aircraft was dispatched on the accident flight with no deferred maintenance items.

3.1.3 The crew were properly licensed, in accordance with US Federal Aviation Administration Regulations, to undertake this flight.

3.1.4 The Captain stated that he had slight flu symptoms over the two days prior to the flight but that did not disbar him from undertaking the flight.

3.1.5 The flight crew consisted of the Captain, First Officer and Flight Engineer. The First Officer was the handling pilot on this flight.

3.1.6 No emergency call was made to ATC by the Captain or First Officer. The Shannon Radar controller provided invaluable voice and directional assistance to the crew as they struggled to maintain control of their seriously damaged aircraft and this was subsequently acknowledged by the crew.

3.1.7 The subsequent actions of the crew in landing the aircraft safely from the second approach were commendable.

3.1.8 The ILS for RWY 24 was fully serviceable.

3.1.9 Crew fatigue is not considered a factor in this accident as they had sufficient time off duty in the days immediately prior to the flight and their overall flying duties are of average industry standards.

3.1.10 Debris from the disintegrating No. 3 engine fell to earth on the western side of RWY 24, within the boundaries of Shannon Airport. Fortunately, there was no damage to property or people.

3.1.11 The selection of 78% flap setting for the landing was in accord with the Operators SOP's for the prevailing landing conditions. However in selecting 78% flap setting the crew were of the mistaken opinion that the GPWS warning horn should be silenced even though the aircraft was not in the landing configuration.

3.1.12 The Flight Engineer silenced the landing gear warning horn during the approach phase while the engine power levers were being retarded. It is only when these levers were slightly advanced, just before the round-out stage, that the landing warning horn system was again primed and subsequently sounded.

3.1.13 The normal landing checks were not carried out by the flight crew. Not one crew member realised that the under-carriage gear was not down and locked.

3.1.14 The crew stated that this was an inexplicable oversight on their part.

4. SAFETY RECOMMENDATIONS

The report does not sustain any safety recommendation.

Top – Propeller assembley and part of engine missing from No.3 power plant.
Bottom—Damage to No.4 engine inflicted by parts of No.3 propeller