AIRCRAFT ACCIDENT REPORT 3/97

Air Accidents Investigation Branch

Department of the Environment, Transport and the Regions

Report on the accident to Gates Learjet 25B, EC-CKR at RAF Northolt, Middlesex on 13 August 1996

This investigation was carried out in accordance with
The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996

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Department of the Environment, Transport and the Regions
Air Accidents Investigation Branch
DRA Farnborough
Hampshire GU14 6TD

3 July 1997

The Right Honourable John Prescott MP
Deputy Prime Minister and Secretary of State
for the Environment, Transport and the Regions

Sir,

I have the honour to submit the report by Mr R StJ Whidborne, an Inspector of Air Accidents, on the circumstances of the accident to Gates Learjet 25B, EC-CKR at RAF Northolt, Middlesex on 13 August 1996.

I have the honour to be
Sir
Your obedient servant

K P R Smart
Chief Inspector of Air Accidents

Contents

GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	Air Accident Investigation Branch
AAIT	Aircraft Accident Investigation Tool
AC	Alternating Current
AIC	Aeronautical Information Circular
AOC	Air Operator's Certificate
APS	Aircraft prepared for service
ASI	Airspeed Indicator
ATC	Air Traffic Control
C of A	Certificate of Airworthiness
C of M	Certificate of Maintenance
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
CIC(L)	Cranfield Impact Centre (Limited)
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
CWS	Caution and Warning System
DART	Data Analysis Reduction Tool
DC	Direct Current
DGAC	Dirección General de Aviación Civil
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FDR	Flight Data Recorder
FIR	Flight Information Region
FSD	Full Scale Deflection
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IRE	Instrument Rating Examiner
JAA	Joint Aviation Authorities
JAR	Joint Airworthiness Requirements
LATCC	London Area and Terminal Control Centre
LOFT	Line Oriented Flying Training
MAC	Mean Aerodynamic Chord
NATS	National Air Traffic Services
OM	Operations Manual
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
QNH	Altimeter setting for height above mean sea level
RESA	Runway End Safety Area
RMI	Radio Magnetic Indicator
RT	Radio Telephony
RVR	Runway Visual Range
SARPs	Standards and Recommended Practices
SSR	Secondary Surveillance Radar
SVFR	Special Visual Flight Rules
UTC	Universal Time Co-ordinated
VHF	Very High Frequency
VMC	Visual Meteorological Conditions

LEARJET ON THE A40 DURING RESCUE

Air Accidents Investigation Branch

Aircraft Accident Report No: 3/97 (EW/C96/8/6)

Operator:	MAC Aviation Sociedad Anonima [Registered on the Registro Mercantil of Zaragoza and based at Zaragoza Airport, Zaragoza, Spain.]
Aircraft Type and Model:	Gates Learjet 25B
Nationality:	Spanish
Registration:	EC-CKR
Registered owner:	PIKOLIN SA
Place of accident:	Royal Air Force Station Northolt Latitude: 51° 33' 09" North Longitude: 000° 25' 00" West Elevation: 124 feet amsl
Date and Time:	13 August 1996 at 0857 hrs All times in this report are UTC

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) shortly after it had occurred and an investigation team travelled at once to the site. The investigation was conducted by Mr R StJ Whidborne (Investigator in Charge), Mr A F Rhodes (Operations) Mr A P Simmons (Engineering) and Ms A Evans (Aircraft performance).

After a flight from Palma de Mallorca Airport, on the island of Mallorca in the Balearic Islands, to RAF Northolt, the aircraft, with two crew members and one passenger on board overran Runway 25 on landing. The aircraft came to rest on the eastbound carriageway of the A40 trunk road and was immediately in collision with a Ford Transit van. The two flight crew and their passenger all received minor injuries; the co-pilot required hospitalisation for two days as a result of concussion. The van driver received minor cuts and bruises. The aircraft was destroyed.

The investigation identified the following causal factors:

(i) The commander landed the aircraft at a speed of 158 (±10 kt) and at a point on the runway such that there was approximately 3,125 feet (952 metres) of landing run remaining.

(ii) The commander did not deploy the spoilers after touchdown.

(iii) The first officer did not observe that the spoilers had not been deployed after touchdown.

(iv) At a speed of 158 (±10 kt) with spoilers retracted and given the aircraft weight and atmospheric conditions prevailing, there was insufficient landing distance remaining from the point of touchdown within which to bring the aircraft to a standstill.

(v) The commander allowed himself to become overloaded during the approach and landing. The safeguards derived from a two crew operation were diminished by the first officer's lack of involvement with the final approach.

Four safety recommendations have been made during the course of the investigation.

1 Factual Information

1.1 History of the flight

1.1.1 Departure and transit

The crew took-off from their home base at Zaragoza in north-east Spain at approximately 0420 hrs on the morning of the accident but, due to a fault in the directional gyro (DG) system and the possible requirement to fly a Precision Approach Radar approach (PAR) on arrival at RAF Northolt, the crew decided to return to Zaragoza and change aircraft. Learjet 25, EC-CKR, finally departed Zaragoza at 0525 hrs and flew to Palma de Mallorca Airport on the island of Mallorca in the Balearic Islands.

At Palma de Mallorca the crew refuelled the aircraft and, after their sole passenger had boarded, they departed at approximately 0645 hrs on an Instrument Flight Rules (IFR) flight plan for their destination airfield, RAF Northolt. The flight to the UK was flown at FL 390 and was uneventful. The aircraft RT callsign for the flight was MIKE ALFA QUEBEC ONE TWO THREE (MAQ 123).

Approaching the UK Flight Information Region (FIR) boundary, the crew contacted the London Area and Terminal Control Centre (LATCC) at 0825 hrs and were given routine clearances to position the aircraft for its approach to Northolt. The aircraft's descent continued normally and control was passed to the Biggin sector of LATCC and then via Heathrow Director South and Heathrow Director North to the RAF Northolt Director.

Northolt Director positioned the aircraft on a right-hand downwind leg at 3,000 feet for Runway 25 and passed the latest weather report. MAQ123 then confirmed that they wished to carry out a QNH based PAR and were advised that the decision altitude was 330 feet, the field elevation was 124 feet and the procedure involved a mandatory $3\frac{1}{2}°$ glidepath. At a position five miles downwind, the pilots were advised to carry out the cockpit checks and report their completion which they did.

Owing to the presence of priority traffic, which was due to depart Northolt at that time, the aircraft was extended downwind to a distance of 10 nm before being turned onto a heading of 160°M. This instruction was followed shortly afterwards by an instruction to continue the turn onto 230°M and report level at 1,800 feet. After a further heading change onto 260° the crew was told to listen out for Northolt Talkdown on the same frequency.

1.1.2 The Approach

On handover, the talkdown controller asked "MIKE ALFA QUEBEC ONE TWO THREE, NORTHOLT TALKDOWN, IDENTIFIED NINE MILES READBACK QNH". MAQ123 asked the controller to repeat the request and he said "ONE TWO THREE YOU'RE IDENTIFIED BY NORTHOLT TALKDOWN, YOUR DISTANCE EIGHT AND A HALF MILES, READBACK QNH SET". The QNH was then correctly read back as 1015 mb.

During the next minute MAQ123 was given a series of headings to establish the aircraft on the runway centre line. Throughout these the aircraft was observed left of the centre line and correcting slowly. At 0855 hrs and at a distance from the runway of 4·5 miles the aircraft was instructed to begin its descent for a $3^1/_2$° glidepath. The first officer subsequently confirmed that the pilots had visual contact with the runway from this time onwards. However, the commander decided that he would fly the approach solely on instruments until the decision height in order to obtain maximum training value.

Initially the aircraft was observed to be slightly high on the glidepath but this was corrected and at 3·5 nm it was on the glidepath. At this point the pilot was asked to confirm that his landing gear was down and locked which is normal procedure at Northolt. This request was repeated three times using the following words, "THREE AND A HALF MILES, CHECK GEAR ACKNOWLEDGE" followed by "ONE TWO THREE CONFIRM GEAR DOWN" and then "ONE TWO THREE CONFIRM UNDERCARRIAGE IS DOWN". MAQ123 then replied "AFFIRMATIVE SIR, GEAR IS DOWN AND LOCKED ONE TWO THREE". During this exchange the aircraft was seen on radar to deviate above the glidepath.

At 2·5 nm, landing clearance was confirmed and the aircraft was advised that the surface wind was "ZERO ONE ZERO FIFTEEN DEGREES" (sic). The next call from the controller was that MAQ123 was "ABOVE GLIDEPATH, ONE AND A HALF MILES, TURN RIGHT FIVE DEGREES HEADING TWO SIX FIVE, SLIGHTLY LEFT OF CENTRELINE, ABOVE GLIDE PATH, CORRECTING NICELY". "TAILWIND OF FOUR KNOTS, SLIGHTLY LEFT OF CENTRE LINE, SLIGHTLY ABOVE GLIDEPATH CORRECTING NICELY, ONE MILE". At the decision altitude, which was at half a mile from the runway, the aircraft was still above the glidepath although seen to be correcting to it.

The aircraft was observed by eyewitnesses to be higher than normal at the runway threshold and to land beyond the normal touchdown point. The length of runway remaining at the actual point of touchdown was estimated at 3,125 feet (952 metres). Towards the end of the landing roll the aircraft veered initially to the right and then swerved to the left and overran the end of the runway. It collided with three approach light units and continued in a south-westerly direction towards the airfield boundary which is marked by a high chain-link fence supported by concrete posts. After bursting through the boundary fence the aircraft ran onto the A40 trunk road and was almost immediately in collision with a Ford Transit van on the eastbound carriageway. The aircraft came to rest in the left-hand lane of the road with the van, which had no possibility of avoiding the collision, embedded in the right side of the fuselage immediately forward of the right wing.

The accident was observed by the crew of an Air Ambulance helicopter which was holding in the hover, 2 nm south of Northolt awaiting clearance to cross the airfield en route. After receiving clearance from ATC to attend the accident, the helicopter was landed on the airfield some 50 metres from the Learjet and the co-pilot, together with a doctor and a paramedic who were also on board, attended the accident victims.

1.2 Injuries to persons

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

RAF Northolt Fire Service were rapidly in attendance and applied foam to the wreckage from which aviation fuel was leaking. There was no fire and all the accident victims were taken by ambulance to nearby hospitals.

As a result of the accident the first officer sustained concussion and bruising and was detained in hospital for two days. The commander suffered bruising and cuts to the scalp and the passenger suffered some bruising but neither of them required hospital treatment. The driver of the van was treated for cuts and shock and was later discharged from hospital.

1.3 Damage to aircraft

The aircraft was destroyed by impact with the airfield fence and its supporting concrete stanchions and by the collision with a Ford Transit van on the A40 road.

1.4 Other Damage

On leaving the runway the aircraft first collided with and demolished three approach light stanchions; its overrun then took it to the airfield boundary fence which it ran through demolishing three concrete supporting stanchions and two plastic light pillars. As it ran onto the eastbound carriageway of the A40 it was in collision with a Ford Transit van which came into contact with the aircraft just forward of the right wing causing the fuselage to break. The van was destroyed in the collision.

1.5 Personnel information

1.5.1	Commander:	Male, aged 39 years
	Last 28 days:	13 hours
	Last 24 hours:	2 hours
	Previous rest period:	18 hours
	Licence:	Airline Transport Pilot's Licence (ATPL) valid to 28 August 1996
	Instrument Rating:	valid to 19 June 1997
	Base Check:	valid to 19 June 1997
	Line Check:	valid to 28 August 1996
	Medical Certificate:	Class One issued valid to 28 August 1996
	Flying experience:	
	Total flying:	5,200 hours
	On type:	1,900 hours
	Last 90 days:	39 hours

1.5.1.1 Operational experience

The commander learned to fly while serving with the Spanish Air Force. The majority of his flying experience was obtained on the Lockheed C130 Hercules aircraft on which he had flown 2,700 hours, of which 2,000 hours were in command. On leaving the air force he joined MAC Aviation on 1 June 1990 and was trained on the Learjet by CAviation of Madrid in Zaragoza. He had operated as a commander since joining MAC Aviation and had flown exclusively within Europe. This was his first flight into RAF Northolt.

1.5.2	First officer:	Male, aged 53 years
	Licence:	Commercial Pilot's Licence First Class valid to 19 December 1996
	Instrument Rating:	Valid to 10 June 1997
	Base Check:	Valid to 10 June 1997
	Line Check:	Valid to 22 November 1996
	Medical Certificate:	Class One issued valid to 22 November 1996
	Flying experience:	
	Total flying:	5,340 hours
	On type:	1,700 hours
	Last 90 days:	45 hours
	Last 28 days:	15 hours
	Last 24 hours:	3 hours
	Previous rest period:	18 hours

1.5.2.1 Operational experience

The first officer was trained to fly by the Spanish Air Force and flew a variety of single-seat military fast-jet types. On leaving the air force he took up a post with the civil aviation authority, specialising in civil aircraft dispatch, where he remained for fifteen years. He joined MAC Aviation in May 1989 and was converted onto the Learjet aircraft. He had operated exclusively as a first officer since joining and had declined an offer of a command on the grounds that he was not prepared to take on the extra responsibility that the position required. It was confirmed during interview with both the first officer and the Operations Manager that he only acted as handling pilot when there were no passengers on board

1.5.3 Training and testing

All recurrent training, including instrument ratings and base checks in MAC Aviation for the Learjet, had been carried out in the aircraft. Training and ratings had been conducted by the Operations Manager. Crew Resource Management (CRM) training had not at any time been undertaken by any of the pilots in MAC Aviation and it was not a regulatory requirement of the Spanish Dirección General de Aviación Civil.

1.5.4 Post accident interviews

Both pilots were interviewed after the accident. Since a PAR is not commonly available at civilian airfields the commander had decided to obtain as much training value from the approach as possible and to fly it to the published minima. He therefore remained on instruments until the decision height when he requested landing flap from the first officer.

The commander stated that he did not appreciate at first that his point of touchdown was considerably further down the runway than was desirable. Once this was appreciated he considered the possibility of carrying out a missed approach but decided that there was insufficient runway length remaining in which to carry out the manoeuvre safely. The first officer described how he was concentrating his attention on the taxi chart with the object of guiding the commander during the taxiing of the aircraft after landing and he did not notice that the spoilers had not been selected.

In her statement, the passenger on the aircraft stated that there was some disagreement between the pilots at a late stage in the approach and that the commander forcibly removed the first officer's hand from the power levers. It was not possible to substantiate this statement in interviews with the crew, both of whom were adamant that no such disagreement took place. The first officer attributed his own lack of intervention to a complete confidence in the commander's flying ability.

1.6 Aircraft information

1.6.1 Leading particulars

Manufacturer:	Gates Learjet Corporation
Aircraft type:	25-B
Constructor's serial number:	184
Year of manufacture:	1974
Engines:	2 General Electric CI-6106-6 turbojet engines.
Certificate of Registration:	Certificate No. 1.076 was issued on 5 March 1975 by the Ministero del Aire Subsecretaria de Aviación Civil of Spain. On 10 July 1985 the aircraft was re-registered to MAC Aviation, S.L.
Certificate of Airworthiness:	The current Certificate, No 1518, was first issued in Madrid on 5 July 1994 by the Dirección General de

	Aviación Civil of Spain. It was last renewed on 21 November 1995 and was valid for one year.
Certificate of Release to Service:	issued 29 February 1996 at 4532.26 hours, valid until 4832.26 hours
Total airframe hours at accident:	4,596 hours

1.6.2 Weight and balance

The aircraft was last officially weighed on the 22 August 1995 by the TRANSAIRCO company in Geneva. At that time the aircraft had an Aircraft Prepared For Service (APS) weight of 7,958·3 lb. The following table lists the weights calculated by the crew for the flight:

Maximum permitted Take off Weight:	15,000 lb (6,804 kg)
APS weight:	7,958 lb (3,609 kg)
Weight of crew and passengers:	531 lb (240 kg)
Zero Fuel Weight:	8,489 lb (3,855 kg)
Fuel load:	5,700 lb (2,585 kg)
Actual Take-off Weight:	14,189 lb (6,436 kg)
En-route fuel burn:	4,085 lb (1,853 kg)
Estimated landing weight:	10,104 lb (4,583 kg)
Maximum certificated landing weight:	13,300 lb (6,032 kg)

The fuel used, up to the time of landing at Northolt, is calculated to have been 4,000 lb, based on fuel flow figures from the Learjet Flight Manual and with allowances for taxi, takeoff, procedural departure and the extended approach pattern. By calculation the landing weight was 10,189 lb and this accords with the crew's assessed landing weight of 10,100 lb. Thus the landing weight of the aircraft was within its maximum certified landing limit, subject to performance considerations.

The Centre of Gravity was calculated as 15·6% of the mean aerodynamic chord (MAC). The aircraft was correctly loaded within its centre of gravity limits.

1.6.3 Aircraft history and maintenance records

The aircraft had been on the Spanish Civil Register from new. It had been re-registered to MAC Aviation, S.L. on 10 July 1985. It was maintained under a DGAC approved Maintenance Programme; this had been revised in 1995 to require all maintenance to be carried out by a JAR-145 approved Maintenance Organisation. In recent times 'A' checks had been carried out at Zaragoza by MAC Aviation, with all other checks carried out by Transairco SA in Geneva.

The last Certificate of Release to Service (CRS) was raised by Transairco on completion of a 300/600 hour check (BI1 and BI2 checks) and other work. There is no Spanish requirement for a Certificate of Maintenance Review, this being implicit in the CRS.

An examination of the Technical Log defect reports showed that no relevant defects had arisen in the previous 30 days of operation, and that there were no carried forward defects.

1.7 Meteorological information

1.7.1 General situation

The Meteorological Office area forecast for Northolt within a 30 km radius for 13 August 1996 for the period 0700 hrs to 1300 hrs stated that a low pressure area over Holland and Germany was due to persist to give a moderate Northerly airflow across Eastern England. Surface wind was forecast at 340°/12 kt gusting to 20 kt. Cloud was estimated to be $^3/_8$ cumulus developing around 0800 hrs with base 2,000 feet and tops 5,000 feet; $^7/_8$ becoming $^4/_8$ stratocumulus with base 2,500 feet and tops at 4,000 feet and $^5/_8$ cirrus base 25,000 feet with tops 30,000 feet. Surface visibility was predicted at 5,000 metres to 10 km in widespread haze at first, slowly increasing to 20 to 30 km by 1000 hrs.

1.7.2 Actual weather conditions

At the time of the accident, Northolt meteorological office reported a surface wind of 360°/13 kt with no gusts; 20 km visibility; $^2/_8$ cloud at 1,800 feet, $^6/_8$ at 2,500 feet; temperature 17°C and QNH 1015 mb.

At 0848 hrs the weather passed to the aircraft by the Northolt radar director was surface wind of 340°/9 kt, 12 km visibility, nil weather, cloud $^1/_8$ at 1,500 feet, $^5/_8$ at 2,200 feet, temperature 16°C, and QFE 1010 mb.

When the aircraft was less than two miles from the runway the surface wind was given as 010°/15 kt and shortly afterwards this information included the information that there was a tailwind of 4 kt.

1.8 Aids to navigation

There were no navigation beacons at RAF Northolt and the aircraft was not fitted with any navigation facility apart from VOR and ADF receivers. Navigation during the let down and approach for landing was conducted exclusively using the ground based radar.

Some 10 years previously the Ministry of Defence had considered the installation of an ILS at Northolt. The surrounding terrain precluded the installation of a standard 3° glidepath with markers and progress on the provision was halted.

1.9 Communications

All communication between the aircraft and the ground stations was conducted using VHF radio which operated satisfactorily throughout. Recordings of RT and radar were obtained for analysis.

Approaching the UK Flight Information Region (FIR) boundary, the crew contacted the London Area and Terminal Control Centre (LATCC) at 0825 hrs and was instructed to "ROUTE DIRECT TO BIGGIN FOR NORTHOLT". At 0827 hrs MAQ123 advised ATC that they were ready for descent and were given a clearance to descend to "FLIGHT LEVEL ONE FIVE ZERO BE LEVEL BY TIGER" which was acknowledged as "ROGER DOWN TO ONE FIVE ZERO MIKE ALFA QUEBEC ONE TWO THREE". The controller immediately asked the crew to confirm that their clearance was to be level by TIGER. Appreciating that the position TIGER was on the direct routing from Abbeville to Biggin and that by routing from a position prior to Abbeville direct to Biggin they would no longer pass directly over TIGER, the crew replied "RIGHT, BE LEVEL BY TIGER, MAYBE I MISUNDERSTOOD, ARE WE PROCEEDING NOW DIRECT TO BIGGIN HILL, IS CORRECT OR SHOULD WE GO VIA ABBEVILLE?" (sic). The controller, understanding the contradiction replied, "MIKE ALFA QUEBEC ONE TWO THREE, ROUTE DIRECT TO BIGGIN AND DESCEND FLIGHT LEVEL ONE FIVE ZERO TO BE LEVEL ABEAM TIGER".

1.10 Aerodrome information

1.10.1 Administration

RAF Northolt is a Government Aerodrome operated by the Royal Air Force and situated 5 nm north of London Heathrow Airport within the London Control Zone. Intermediate Approach Control is conducted by Heathrow Approach Control.

The airfield is open for arrivals and departures between 0800 hrs and 2000 hrs daily. However, between 1800 hrs and 2000 hrs on Monday to Friday and 0800 hrs to 2000 hrs on Saturday and Sunday, civil aircraft are only accepted when the airfield is planned to be open for military movements. Prior permission is required for all flights intending to use the airfield. Other than when operating under a Special Visual Flight Rules (SVFR) clearance pilots must hold a valid Instrument Rating.

For a period of six months commencing 1 October 1996, a trial was to be in effect whereby airfield operating hours were extended by one hour with the airfield opening at 0700 hrs. Civilian airfield movements have been subject to a limit of 7,000 per year (including during the proposed trial period).

1.10.2 Runways and approaches

The airfield operates a single Runway 07/25 which is 5,525 feet long (1,684 metres). The touchdown point for Runway 25, when using a PAR approach, is 700 feet (213 metres) from the runway end and therefore the landing distance available is 4,825 feet (1,468 metres). The ground beyond the threshold of both ends of the runway is grassed and at the 07 end it slopes gently, descending 3 feet over a distance of 315 feet (96 metres) until reaching the boundary fence which separates the airfield from the A40 road at the point where the Learjet broke through.

The centre line of the western end of the runway is, at its nearest point, 229 feet (70 metres) from the A40 and at its eastern end is 520 feet (159 metres) from West End Road. Due to high ground to the east of the airfield, approaches to Runway 25 use a 3·5° glidepath and the Precision Approach Path Indicator (PAPI) lighting system for this runway is also set at 3·5°.

ICAO Annex 14 contains International Standards and Recommended Practices for civilian Aerodromes. Chapter 3 deals with the physical characteristics of runways and paragraph 3.3 recommends:

> *'General*
>
> 3.3.1 A runway and any associated stopways shall be included in a strip
>
> *Length of runway strips*
>
> 3.3.2 Recommendation.— *A strip should extend before the threshold and beyond the end of the runway or stopway for a distance of at least:*
>
> — *60 m where the code number[1] is 2, 3 or 4;'.*

Paragraph 3.4 refers to Runway End Safety Areas (RESAs) and states:

> *'General*
>
> 3.4.1 Recommendation.— *A runway end safety area should be provided at each end of a runway strip where:*
>
> — *the code number 3 or 4; and*
>
> — *the code number is 1 or 2 and the runway is an instrument one.*
>
> *Note: — Guidance on runway end safety areas is given in Attachment A, Section 9.'*

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[1] Code numbers 2, 3 and 4 refer to aeroplane reference field lengths of up to 800 m but not exceeding 1,200 m; 1,200 m but not exceeding 1,800 m and 1800 m and over respectively .

1.11 Flight recorders

Under Spanish airworthiness requirements existing at the time of the accident, the aircraft, by virtue of its weight category, was not required to be equipped with flight recorders (CVR or FDR).

1.12 Wreckage and impact information

1.12.1 General

The aircraft had come to rest on the eastbound carriageway of the A40 road to London. It had passed through the airfield boundary fence and across a shallow kerb before stopping across two of the three lanes of the eastbound carriageway. It was in collision with a Ford Transit van which was travelling at 60 or 70 miles per hour in the middle of the three lanes. The van had traversed the leading edge of the right wing without striking the tip tank but had impacted the fuselage immediately in front of the wing leading edge, causing the aircraft to yaw left and severing the nose of the aircraft. The damage caused by the van was severe but was mainly to an area forward of the rearmost passenger seats and aft of the flight deck and it was fortunate that none of the seats in that area were occupied. Although the van driver was not seriously injured it was some time before he could be freed from the wreckage, due to extensive deformation of the front of the van which was partly underneath the fuselage. There were no skid marks from the van but a following vehicle had left skid marks which showed that it had swerved into the unoccupied right-hand lane to avoid impact.

After the impact sequence the aircraft came to rest on a heading of about 165°M (the A40 is oriented on about 095°M at that point), but ground marks showed that its track had been about 220°M before impact with the van. In traversing on to the road the aircraft had demolished three steel reinforced concrete posts in the boundary fence and two low-level lamp standards. The power supply to the lamp standards remained live until power was disconnected by the local authority. The aircraft batteries were disconnected by the emergency services but it was not possible to disconnect the van's battery or to assess fully the risk of fire from the van until the aircraft had been lifted.

1.12.2 Ground marks

Ground marks from the aircraft tyres began on the runway towards the end of the landing roll where the main gear tracks became apparent. After some distance the nosewheel track became apparent where it deposited rubber on the runway, and the nosewheel diverged to the left of the aircraft track until it was outside the track of the main gear. These tracks showed that, while on the runway, the aircraft deviated right of the centreline but then swung back to leave the end of the runway on the centreline but yawing to the left. The rubber deposits were a result of the lateral slipping of the tyres. After leaving the paved area the aircraft left tracks through the grass showing that throughout it was turning to the left, towards the road. About 20 metres after departing the paved surface the aircraft struck three of the nine frangible approach lights. It then ran across a mixed grass and concrete strip which partly broke up and caused the right outer mainwheel tyre to deflate. At this point the distance between the tracks of the outer edges of the outer mainwheels was measured as 9 feet 5 inches, and the extreme opposite mainwheel to outer edge of the nosewheel was 13 feet. Calculations from the aircraft geometry showed that this equated to just over 25° of slip angle which remained constant, or increasing only slightly, for the rest of the ground roll. The aircraft then continued towards the boundary fence where a paved path just inside the fence caused the right main landing gear to collapse. The gear collapsed inboard by failing at the top end of the retraction jack and its attachment. The damaged attachment also severed a fitting in the hydraulic line which extends the spoilers. There was no evidence that the right wingtip had been in contact with the grass at any time.

1.12.3 Configuration

When examined by the AAIB just over an hour after the accident, the aircraft was configured with the gear down and locked, except the right main gear which had collapsed in the direction of retraction. The flaps, although resting on the ground, appeared to be fully extended. The spoilers were found to be retracted and fully faired. Photographs of the aircraft taken within a few minutes of the accident showed both spoilers fully retracted. Video taken by the Air Ambulance, which had been waiting for the Learjet to clear the runway shows the spoilers both retracted at time 1034:30 BST, by which time the aircraft had been sprayed with extinguishing foam. This was 37 minutes after the time of the accident. The video record shows no activity around the spoilers which might have mechanically retracted them and examination of the patterns left on the wing by the dried foam showed that the spoilers were not extended at the time the aircraft was foamed. The brake parachute had not been deployed.

1.12.4 Recovery

The aircraft was recovered by severing the remaining structure and electrical, pneumatic and hydraulic systems connecting the nose, and lifting the nose clear, followed by the rest of the aircraft. To accomplish the lifting operation with as little risk as possible, the aircraft's fuel was pumped out beforehand. Although there was no fire either at the time of the impact or subsequently, the fire services in attendance had foamed the aircraft and surrounding area as a precaution. For transportation, the wing was removed from the fuselage causing further disruption of hydraulic and electrical systems in particular. The van was removed by the police accident investigation unit.

1.12.5 Cockpit observations

These are shown in detail in Appendix 1. Items of note are as follows:

P1 (left seat) Airspeed Indicator (ASI)	zero, bugged at 127 kt
P2 (right seat) ASI	zero, bugged at 125 kt
Emergency Battery	OFF
Engine Instruments	all zero
Flap indicator	Approach
Gear selector	DOWN
Battery Master	OFF
Anti skid	ON
Circuit breakers	all 'made' except TOILET and ENG SYNCH
Throttles	retarded
Flaps	OFF
Spoiler switch	see following text

Frangible wire on emergency brake broken.

1/2 scale gauge deflection on the emergency air (brakes and landing gear).

1.12.6 Airspeed indicating systems

After the aircraft had been recovered to the AAIB facility at Farnborough, pitot-static checks were carried out and the two airspeed indicators were calibrated. A standard test set was used for this. In order to carry out the test it was necessary to blank off a pitot line which ran to the rear of the aircraft and which had been severed in the impact. Following this the pitot and static lines were leak checked and found satisfactory. The two ASIs were found to be within two knots throughout the range 80 to 300 kt.

1.12.7 Wheels and tyres

The wheels and tyres were examined and found to be free of flat spots or other pre-impact defects, but a helical wear pattern was evident. The tyres had been in generally good condition before the accident. During the overrun the nose landing gear had become slightly bent, also the right outer mainwheel had deflated, causing the tyre to run off the rims with consequent damage to both the tyre and wheel rims. The left inner tyre was also deflated.

Individual tyre observations were as follows:

Nosewheel	tread visible, helical wear pattern of angle approximately 5.4 degrees visible, tyre pressure 50 psi (nominal pressure is 105 psi).
Left outer mainwheel	tread visible, no obvious helical wear pattern, tyre pressure 102 psi (mainwheels are nominally inflated to 115 psi).
Left inner mainwheel	tread visible, similar helical wear pattern to nosewheel, deflated but intact on rims.
Right inner mainwheel	no tread remaining except at the edges. Helical wear patterns evident at varying angles. 101 psi.
Right outer mainwheel	tread visible, helical wear pattern evident, this tyre had come off the rim.

1.12.8 Braking systems

The aircraft is provided with a conventional hydraulically operated braking system and an emergency braking system which is pneumatically operated. The anti-skid facility is not available while the emergency system is being operated. The braking system is shown in diagrammatic form in Appendix 2. All the hydraulic lines, and the pneumatic emergency line, had been fractured at the break in the fuselage and all the lines were disconnected or cut where the wing had been separated from the fuselage.

1.12.9 Emergency pneumatic system

The emergency pneumatic braking system directs high pressure air stored in a bottle in the nose through a pilot operated modulating valve to two shuttle valves in each main landing gear bay. When sufficient air pressure is applied to the shuttle valves they operate to isolate the hydraulic supply and the pressurised air is directed to the brake packs. If the normal brakes are operated subsequently, the shuttle valves return to their normal position, and normal anti-skid braking is restored. By connecting 100 psi air pressure (workshop supply) to the pneumatic line on the wing it was possible to check function the shuttle valves and brake packs, but the left outer brake pack did not operate at this pressure.

Strip examination of all the brake packs showed that they had been affected by corrosion which had occurred after the aircraft was foamed, the left outer pack was most affected and light corrosion had occurred between the pistons and bores of that unit. It was considered that under normal brake pressures from the emergency air bottle (300 psi, below which the bottle must be re-charged) the brake packs would have functioned normally on test, even with the corrosion. The remaining portions of the pneumatic emergency brake line were tested and found satisfactory. The emergency air bottle indicating gauge was reading about 1/2 of full scale deflection (FSD); the gauge has an FSD of 500 psi. This pressure is regulated to a maximum of 600 psi and this is supplied to a modulating valve controlled by a braking lever on the right-hand side of the pedestal. The lever is normally locked with frangible locking wire. On inspection the locking wire was found to be broken, and the lever operated correctly, eventually discharging the remaining air. No defect was found in the pneumatic emergency braking system, and it was sufficiently charged, even after the accident, to operate the brakes.

1.12.10 Brake system hydraulic components

The hydraulic supply pressure for the brakes is taken from the nose landing gear extend line. This system, and all the hydraulic components in the nose, the foot motors, parking brake and shuttle valves between the pilot's and co-pilot's pedals were functionally tested as a complete subsystem. It was found that with the nose landing gear extend line pressurised, system hydraulic pressure could be directed to the left and right brake lines as required by operating the brake pedals. The two dual anti-skid control valves are mounted one in each main landing gear bay. These were flow checked in the unpowered condition to establish that braking was not lost in the event of anti-skid system or electrical system failure. The shuttle valves and hydraulic fuses were flow checked and visually examined, it was evident that no failure had occurred in any part of the braking system which would have prevented brake pressure being applied to any of the brake packs.

1.12.11 Anti-skid system components

It was evident from the runway marks and the tyres that none of the wheels had locked up during the landing roll. The anti-skid system components were examined and it was found that the right-hand outboard wheel speed transducer had been damaged when that wheel and tyre had been impacted during the overrun.

1.12.12 Flap and spoiler systems

The flap system is controlled from an electrical selector on the flight deck. This operates a control valve on the wing, which directs hydraulic pressure to the extend or retract side of the flap actuators. The hydraulic system operating the flaps was found to be undamaged, however the flaps were displaced upwards during the recovery; a pressure relief valve allows this to occur. When the wing was separated from the fuselage, hydraulic fluid was lost from the flap system. There was no evidence of any malfunction in the flap system and after the impact both flaps were found in an almost fully extended position, touching the road surface.

In photographs taken a few minutes after the accident, the spoilers were retracted. The spoilers, like the flaps, are controlled from an electrical switch on the flight deck. The system is shown in diagram form in Appendix 3. This operates a control valve on the wing, which directs hydraulic pressure to the extend or retract side of the spoiler actuators. The spoiler actuators contain mechanical locks which prevent the spoilers extending unless hydraulic pressure is available. The spoilers can run back without hydraulic pressure and the last part of the retraction movement will cause the mechanical locks to re-engage as the spoilers fair with the wing but this requires additional forces to be applied to the spoilers to overcome the forces in the lock mechanisms. Although these forces are minor, the spoilers will not enter the locks under inertial forces unless they are caused to fall back rapidly. It was found that they fell back freely when there was little fluid in the system, but quite slowly when the system contained fluid. Initial attempts to extend the spoilers by pressurising the extend line were unsuccessful as a fitting in the extend line had been broken adjacent to the top attachment of the right main landing gear retraction jack. This had occurred during the gear collapse, as the aircraft entered the road. The bay in which the extend line was broken, which is at the centre line of the aircraft and behind the right gear, is normally completely enclosed, access being via a cover plate. Although testing spilled fluid in the bottom of the bay, elsewhere it was clean and the cover plate and retraction jack fitting, which had been removed earlier, were not contaminated by fluid, thus indicating that the extend line had not been pressurised when it was fractured by the collapse of the landing gear. With the extend line repaired, the spoilers functioned normally.

On the flight deck, the spoiler switch guard had been distorted sideways and forward. This damage appeared to be due to the force exerted by a hand or foot while the crew were being helped out of the damaged nose section. As a result of this distortion the switch would not latch in the EXT (extend) position, to the rear. After removal of the switch from the pedestal it was found to latch correctly, but the toggle mechanism had a rough feel. Continuity and insulation checks on the switch were satisfactory. A strip examination of the switch mechanism showed that the switch was satisfactory internally except for drying out of the silicon grease on the internal mechanism, causing the rough feel.

The spoiler switch obtains its electrical power from the 28V DC buss bar via a 2 ampere circuit breaker CB162. This was not tripped and electrical continuity was established from the 28V buss bar to the switch. The switch supplies 28V DC to either the extend or retract solenoids in the spoiler control valve. The valve was tested both electrically and with hydraulic pressure and functioned normally. Although the electrical wiring between the spoiler switch and the spoiler control valve was cut or broken in several places, it was possible to establish that the spoiler control system had been serviceable during the landing roll.

1.12.13 Hydraulic power

Following the accident the hydraulic system lost a considerable quantity of hydraulic fluid, so that no fluid was visible through the viewing window in the hydraulic reservoir. Considerable quantities of fluid remained in the reserve portion of the reservoir. The hydraulic accumulator is fitted with a pressure gauge; this indicated 1,000 psi after the accident.

1.12.14 Electrical subsystems

Certain other electrical subsystems were of particular interest as follows:

Emergency battery switch: This was found in the OFF position. When selected on it provides electrical power to the spoiler, flap and landing gear systems. In standby it provides a visual indication if 28V DC is lost.

Fuel contents gauge: This is a balanced bridge device, utilising an amplifier, electric motor and gear train to drive the indicator mechanism. Although it does not return to zero if power is lost, the manufacturer advises that its indications will change more or less randomly when it is powered down. It indicated 1,500 pounds approximately remaining.

Flap position indicator: Like the fuel contents gauge, the flap position indicator does not give a reliable indication after electrical power is removed. It indicated a setting slightly less than the Approach setting.

1.13 Medical and pathological information

At the time of the accident both pilots were in good health and there was no evidence of any incapacitating illness or condition brought on by the use of either drugs or alcohol.

1.14 Fire

There was no pre or post-impact fire.

1.15 Survival aspects

1.15.1 The impact

The accident, which involved a low-speed impact with the airfield boundary fence, was survivable. However, the Transit van collided with the aircraft at a speed of approximately 60 mph with a consequent risk of serious injury or death to both its occupant and those of the aircraft. This was averted by the wearing of seat harnesses by the occupants of both vehicles and the rapid arrival on the scene of fire vehicles from RAF Northolt which reduced the risk of fire. This was especially the case for the first officer and the van driver, both of whom were trapped in their seats and required the assistance of the fire service to release them.

1.16 Tests and research

1.16.1 Radar tracking

Three radar outputs were examined in detail covering the period 0845 hrs to 0915 hrs, these were Heathrow 23 cm, Heathrow 10 cm and Debden. Visual examination of the track data showed Heathrow 23 SSR to give the best detection and smoothest track. Towards the very end of the aircraft's approach, Heathrow 10 cm radar lost cover, whilst the Debden data exhibited track jitter, due to range/height limitations. The assigned Mode A code of 5530 confirmed the identity of the track detected at Northolt as that of MAQ123.

To find the approximate touchdown point, the Mode C data from two other aircraft at ground level at Northolt was examined. It appeared that ground level approximated to a Mode C reported height of 100 feet. Also included was the track of a helicopter which landed at the scene of the accident very shortly afterwards (within one minute), this was the air ambulance which diverted to the scene to give assistance.

Using the tabulated radar data it was possible to derive both vertical, horizontal and three dimensional plots of the aircraft's final approach. In addition a plot was made of the aircraft's track from a position in northern France to its point of touchdown at Northolt. The aircraft's speed was derived from a position 8 nm on the approach until 12 seconds after the estimated touchdown.

For speed computations, particular attention was given to the accuracy of the speed model used to determine error magnitudes. It was determined that for aircraft at constant speed and heading, and with no radar errors in time, range or azimuth, the model gave good results. The averaging of simulated radar induced errors over a 5 scan period proved to be effective for aircraft at constant speed and heading. Accuracy to within ±10 kt was estimated. For aircraft in simulated deceleration (ie from touchdown onwards), a positive speed bias of +20 kt was observed which was not effectively removed by the averaging process. Here, manual interpretation of the data was required. Speed accuracy was likely to be degraded from the ±10 kt figure due to the limited data available and the accuracy of positional curve-fitting. Typically speed accuracy of ±20 kt might be achieved in this mode.

The results from the model used were compared with the National Air Traffic Services Ltd. (NATS) Multi Radar Trajectory Reconstruction (Muratrec) analysis tool and the speed profiles agreed favourably. Based on these results, NATS were confident that the method used was sound and with regard to this accident, they were reasonably sure that the aircraft speed deduced up to the point of touchdown was accurate to ±10 kt. After that point interpretation was less certain. Final speed at touchdown was calculated as 158 kt.

1.16.2 Aircraft performance

The Airworthiness Department of Learjet Incorporated was consulted to provide an analysis of the runway performance of the aircraft on landing. This information is not normally available to operators. The landing data which can be derived from an aircraft performance manual would be the landing distance required. This is defined as the distance from the point at which the aircraft is 50 feet above the runway threshold until the aircraft comes to a full-stop on the runway. This distance is factored to make an allowance for variations in pilots' performance and varying coefficients of friction on the runway.

The following assumptions were made in the determination of the stopping performance of the aircraft:

Learjet Model 25B/C unmodified

Flaps set to 40°

Weight: 9,951 lb

Runway altitude 124 feet

Temperature 63°F

4·4 kt Tailwind

0% runway gradient (negligible slope at Northolt ignored)

Full Braking Speeds of 158 kt and 148 kt ground speed (where 148 kt is the estimated speed of 158 kt with the tolerance of -10 kt applied) derived from radar data

V_{ref} bug set to 127 kt

Normal speed for performance landing 117 kt.

The table below shows the calculated distance in feet required to bring the aircraft to a full stop assuming full application of brakes at different speeds with spoilers either deployed or stowed:

V full brake	158 kt	148 kt	127 kt	117 kt
Spoilers deployed	2,630 feet	2,380 feet	2,010 feet	1,775 feet
Spoilers stowed	5,630 feet	4,630 feet	3,380 feet	2,750 feet

1.16.3 Flight Manual derived aircraft performance

Using the same data as in 1.16.2 with the exception of the aircraft weight, which the pilots knew to be 10,100 lb, the actual landing distance required was 3,300 feet. This is the distance which was calculable by the operator. To achieve this landing distance, the Flight Manual specified that the following procedure must be applied;

'(a) Approach through the 50-foot point over the end of the runway at 1·3 times the stall speed with flaps and gear DOWN.

(b) Approach using a glideslope of 2·5°.

(c) Spoilers - EXT immediately after touchdown (ie, the spoilers are to be extended immediately after touchdown).

(d) Wheel Brakes - Apply as soon as practical and continue braking action until the airplane stops'.

1.16.4 Spoilers

Checks were conducted on the spoiler system to discover how likely it was that the spoilers could have retracted during or soon after the overrun. Prior to these tests the extend line had been repaired by installing a new fitting to replace the one broken by the collapse of the landing gear. The spoiler control valve was electrically checked and refitted to the aircraft. Because the wing and fuselage were separated, a hydraulic reservoir was constructed and fitted directly to the servo valve return port. A hydraulic hand pump and pressure gauge were fitted directly to the servo valve pressure port. The system was filled with hydraulic fluid to specification OM15, an acceptable substitute meeting the requirements of MIL-5606. The system was electrically energised, bled, and function tested satisfactorily. The spoilers were then extended fully using the hand pump, and the system shut down electrically and the pressure released at the pump. The spoilers remained fully extended 24 hours later. This test was to confirm that the repaired system performed in the same manner as an undamaged aircraft.

Several tests were then conducted to simulate the sequence of events occurring during the overrun. In each test the system was electrically energised and the spoilers were hand pumped to the fully extended position. The pressure was built up to about 1,000 psi and the extend line then broken by disconnecting at the servo valve and trailing edge 'tee' union (although not the same location as the fitting broken in the accident, it is physically close and sufficiently representative). The various tests simulated electrical shutdown of the aircraft shortly after the impact and also simulated failure to shutdown the electrical power. This was because the spoiler servo control valve is electrically energised at all times unless power is removed from the system, in which case its spool takes up a null position. Also, attempts were made to simulate vertical loads on the spoilers due to inertia or physical interference.

The tests showed that, even with the spoiler extend line broken, the spoilers could retract only quite slowly and that this was insufficient to allow them to re-enter the internal locks and to fair fully with the wing profile. Further, once the spoilers had partly retracted, internal stiffness prevented further retraction due to gravity, even after many hours. The electrical status of the servo control valve made some difference to the rate of retraction but only in that, with the valve in the null de-energised position, the retraction tended to be slower. Following each test significant and sustained pressure was required to fully retract each spoiler.

1.17 Organisational and management information

1.17.1 History of the operator

MAC Aviation was founded in 1984 with one aircraft, EC-CKR, the aircraft involved in this accident. Since that time it had grown to operate a maximum of five aircraft. With a downturn in available business it had reduced in size until at the time of the accident it operated two Learjet aircraft with five pilots, carrying out a mixture of flights for either its parent company or 'ad hoc' charters.

1.17.2 Crew Resource Management

For UK Aircraft Operators Certificate (AOC) holders engaged in public transport flights, UK Aeronautical Information Circular (AIC) 143/1993 (Pink 90) sets out the requirements for AOC holders to train their crews in the practical awareness and application of CRM. It also requires Type Rating Examiners (TRE) and Instrument Rating Examiners (IRE) to complete a CRM course as a pre-requisite to initial validation and revalidation (AIC 37/1995 - Pink 110). All crew employed in the industry were required to have completed a CRM course by 1 January 1995. The requirement for CRM training and validation is to be set out in JAR OPS sub-part N, 1.945(a)(10) and 1.955(b)(6) and 1.965(e) with a proposed implementation date for all signatory states during 1998.

UK AIC guidance and the eventual JAR OPS policy are based on the 1986 ICAO Assembly Resolution A26-9. The particular aspects of CRM training as applicable to flight deck crews are outlined in ICAO Human Factors Digest Number 2 published in 1989. The following attributes of CRM training are listed in this Digest and are mirrored in the UK AIC 143/1993, they are:

(i) CRM is a comprehensive system for improving crew performance;

(ii) CRM addresses the entire crew population;

(iii) CRM is a system that can be extended to all forms of crew training;

(iv) CRM concentrates on crew members' attitudes and behaviour, and their impact on safety;

(v) CRM is an opportunity for individuals to examine their behaviour, and make individual decisions on how to improve cockpit teamwork;

(vi) CRM uses the crew as a unit of training.

1.18 Additional information

1.18.1 Airfield air traffic analysis

RAF Northolt is used by both military and civil traffic. Air traffic movements data for the period 16 October 1995 until 13 August 1996 were examined. The following categories were identified: Royal Air Force fixed wing; non-UK military fixed wing; Ministry of Defence fixed wing; civilian fixed wing and rotary wing traffic.

Analysis of these data showed that, during this period, civilian fixed wing traffic as a percentage of all fixed wing traffic averaged 42%. The next major user of the airfield was the RAF which as a percentage of all fixed wing traffic averaged 34%. Civilian fixed wing traffic as a percentage of all air traffic at Northolt, both fixed wing and rotary wing averaged 36%.

1.18.2 Brake fade

The possibility of brake fade was considered. The brake linings were intact and in good condition and were not glazed. The discs were also in good condition. The fuse plugs were intact. The manufacturer advised that approximately 3.45×10^6 ft lb were required to bring the aircraft to a halt from 158 kt, at the actual landing weight of 10,104 pounds. For the rejected take-off certification case 13.22×10^6 ft lb of brake energy was calculated and demonstrated.

1.18.3 Overrun simulation study

The AAIB and UK Ministry of Defence have jointly sponsored the development, by Cranfield Impact Centre Ltd. (CICL), of a computer based simulation of crash dynamics effects. The programme is able to model quite accurately the dynamic behaviour of structures, taking into account the lumped masses, beam strengths and deflections, and ultimate loads. It is not able to model the complex behaviour of a rolling wheel or to calculate the side forces generated by a wheel travelling at an angle to its rolling axis. Since the side forces so generated cause a vehicle, or aircraft, to turn, the simulation could not be used to model the curved path which the aircraft took after leaving the runway. It was used successfully to model the linear deceleration and other behaviour. The programme was provided with initial conditions at the point where the aircraft left the paved surface, including weight (mass), yaw inertia, ground speed, track, heading, braking and friction coefficients and the aircraft geometry. The model then predicted the deceleration, ground marks, yaw angle and final location of the aircraft as it traversed the overrun area. The results are shown in Appendix 4.

The closest conformance with the actual overrun was achieved with an initial velocity of 70 kt, causing the aircraft to come to rest in about 100 yards. The study results suggested that braking effects became secondary to sliding resistance over the grass due to the yaw angle of the aircraft. This generated decelerative forces of about 0.7g (mean), similar to that which could be expected from braking alone. The simulation showed similar behaviour in yaw to that which occurred during the overrun, with the aircraft reaching a more or less constant angle of yaw sustained against the effects of the nosewheel angle by the large drag force which was well to the left of the centreline of the aircraft. The study did not model the final deceleration due to the aircraft passing through the concrete posts, so it may be assumed that the speed upon leaving the runway was higher, not lower than 70 kt.

1.18.4 Arrester bed research

A review of the available data on arrester beds and their performance was conducted. The main experimental work was carried out in the UK using as test aircraft a Lightning (weight 26,000 lb) and a Canberrra (weight 27,400 lb), but this was supplemented with trials using a Comet 3. In the United States work was carried out by the University of Dayton Research Institute for the FAA using a Boeing 727. That work, and the Comet trials, involved the use of phenolic or urea formaldehyde foam, which was very effective but presented several practical problems, in particular quality control and fire hazards. The American work reviewed overrun accidents for a twelve year period, 1975 to 1987. That data is summarised in a table shown in Appendix 5. It shows that the majority of the overruns occurred at 50 to 60 kt, and that none exceeded 80 kt.

The bulk of the work was on gravel or shingle beds and this showed that the effectiveness of a gravel arrester bed is mainly dependent upon the depth of penetration of the undercarriage into the bed. This in turn depends upon the landing gear footprint and loading. The weight and size of the aircraft have only second order effects. Because of the number of variables it is difficult to make comparisons but in general a gravel arrester bed can be expected to provide a deceleration of up to 0.7g. This assumes that the aircraft has entered the arrester bed without significant yaw. The use of brakes within the arrester bed can also yield a significant improvement in theory, but testing has not always confirmed this.

As a result of an overrun accident on 26 May 1993 in which a Cessna Citation II overran the runway at Southampton Airport, the airport operator installed an arrester bed. Its dimensions are 247 feet (76 metres) in length and 242 feet (74 metres) wide, to cater for those cases where the aircraft depart to the side of the runway. It is 0.7 metres deep and filled with a 6 mm spherical commercial light aggregate (Lytag). The undersurface of the first 35 metres slopes 1:50 into the bed and the first 10 metres are sprayed with bitumen which is designed to minimise dispersion due to jet/prop wash. This has the added advantage of delineating the start of the bed.

1.18.5 Flight recorder requirements

Under proposed JAA requirements, for aircraft in the weight category up to 27,000 kg, the following flight recorders will be required:

Individual aircraft C of A date	*Less than 5,700 kg and more than 9 passengers (multi-turbine)*	*Aircraft weight between 5,700 kg and 27,000 kg*
1 January 1987	None	30 minute CVR 25 hour Digital FDR with 5 parameters
1 January 1989	None	30 minute CVR 25 hour Digital FDR with 5 parameters
1 January 1990	30 minute CVR	30 minute CVR 25 hour Digital FDR with 15 parameters
Adoption date of JAR[2] Note: up to two years may be allowed for implementation	30 minute CVR and 25 hour Digital FDR with 17 parameters	2 hour CVR 25 hour Digital FDR with 17 parameters

[2] Current planned adoption date for small aeroplanes [<10 tonnes] is 1 April 1999.

2 Analysis

2.1 General

2.1.1 Communications

Radar tracking from the UK FIR boundary showed the aircraft adhering strictly to ATC instructions. All radio transmissions, recorded by National Air Traffic Services Ltd.(NATS), were clear and concise. The crew was quick to recognise an anomaly in ATC instructions when advised to be "level by TIGER". Having been given a clearance to route directly to Biggin, the direct track no longer crossed the position TIGER and this was queried.

Immediately after the transfer of control to Northolt Talkdown, the non-handling pilot had difficulty in understanding some of the ATC phraseology. The initial transmission by the controller was "MIKE ALFA QUEBEC ONE TWO THREE, NORTHOLT TALKDOWN, IDENTIFIED NINE MILES READBACK QNH". Although there was no error in this transmission, it did not follow the standard civilian format in that it would not be normal practice for a controller at this stage to ask a pilot to readback the QNH. This, coupled with a somewhat staccato delivery, was not readily understood.

The first officer was conducting the radio communications in what to him was a second language. During the course of interviews subsequent to the accident it was observed that the first officer had considerable difficulty in conducting a conversation in English. However, he was an experienced pilot and therefore he was able to cope with all the routine and familiar radio transmissions which had been made up to this point in the flight. The Talkdown Controller appears to have instinctively understood the difficulty experienced by the Spanish pilot in understanding his first transmission. His rephrasing in both style and speed is more consistent with common civilian practice; "ONE TWO THREE YOU'RE IDENTIFIED BY NORTHOLT TALKDOWN, YOUR DISTANCE EIGHT AND A HALF MILES, READBACK QNH SET".

2.1.2 The approach

No further difficulty in radio communication was observed until MAQ123 was 3·5 nm from touchdown, at which point the Talkdown Controller said "THREE AND A HALF MILES, CHECK GEAR, ACKNOWLEDGE". Once again the speed and style of this transmission is common practice with military controllers, however, the request itself to "CHECK GEAR, ACKNOWLEDGE" is subtly different from standard civilian practice where the pilots are simply reminded to check their undercarriage at this stage but not to "acknowledge".

The first officer did not understand this transmission but before he was able to communicate this, the controller made a second transmission, "ONE TWO THREE CONFIRM GEAR DOWN". Once again, the first officer's knowledge of English was not able to match the speed of this transmission and he was unable to reply within a reasonable time. The controller then made a third transmission "ONE TWO THREE CONFIRM UNDERCARRIAGE IS DOWN". At this point the radio communication was taken over by the commander who had been attempting to explain to the first officer what had been requested. However, the necessity for the commander to both interpret and then to make the radio calls himself served to distract him from his primary task of flying the approach and during this exchange the aircraft was seen to deviate above the glidepath.

2.2 Crew co-ordination

Inter-crew communication was effectively broken when the commander took over radio communications prior to landing. The first officer then began to focus his attention on what he considered would be his next contribution to the conduct of the flight, which was the guidance of the commander during the taxiing of the aircraft after the completion of the landing.

Although the first officer appreciated that the aircraft was high on the approach, he did not ensure that the commander took corrective action. The passenger believed that there had been some disagreement between the pilots at a late stage in the approach and she thought that the commander had forcibly removed the first officer's hand from the power levers. It was not possible to substantiate this statement in interviews with the crew, both of whom were adamant that no such disagreement took place. The first officer attributed his own lack of intervention to a complete confidence in the commander's flying ability. These matters could have been more precisely analysed if the aircraft had been fitted with a Cockpit Voice Recorder (CVR) but Spanish airworthiness requirements did not require the fitting of any flight recorder to this class of aeroplane. When JAR OPS are implemented (see paragraph 1.11) an aeroplane of this weight category and vintage will require both a 30 minute CVR and a 25 hour, 5 parameter Digital FDR. In view of the proposed time scale for the introduction of the relevant JAR a suitable safety recommendation is superfluous and has not been made.

As a direct result of the aircraft becoming high on the glidepath at a late stage in the approach there was little opportunity to reduce the excess speed. Consequently the aircraft touched down fast at a point on the runway such that the landing distance remaining was approximately 3,125 feet. Despite the short distance remaining and the speed of the aircraft, it has been calculated that it would still have been possible to stop the aircraft on the runway had the spoilers been deployed on touchdown. It has been established that they were not deployed and therefore it would not have been possible to stop in the distance available with this configuration (see paragraph 2.3).

Learjet Incorporated do not make any recommendation for the ideal time for the selection of full landing flap in the Flight Manual. It was standard practice with this operator to select full landing flaps at a late stage in the approach at the point at which a transition to visual flight had been achieved and the handling pilot had confirmed that the landing was assured. Such a practice has several drawbacks; these are that the aircraft is flown on the approach in a relatively low drag configuration such that on a steeper glidepath than normal, speed control is more difficult to achieve on a high performance, low drag aeroplane. A consequence of this can be that, should the aircraft become high on the approach, any tendency to correct the situation by making the approach path steeper will result in a consequent increase in speed unless corrective action is taken immediately.

The requirement for the first officer to select the full flap position at a late stage might distract his attention from the details of the flight path, reducing his ability to advise the handling pilot on the best course of action to take should corrective action be required. In addition, by selecting flap at a late stage there is always the possibility that the two pilots will both have their hands on the centre console at the same time. Apart from the possibility of either pilot inadvertently interfering with the actions of the other as a result, to an uninformed observer this may well be interpreted as a conflict between the two pilots which was the impression formed by the passenger. This impression was not substantiated during interviews and therefore the actions described above may well have been misinterpreted. Furthermore, this perception is even more understandable considering that the passenger did not understand Spanish.

The commander of the aircraft remained convinced after the accident that he had selected spoilers after touchdown. However, the physical evidence confirmed that this was not the case and he later confirmed that he could not actually remember making the selection. The first officer had no recollection whatsoever of the selection or otherwise and declared himself content that his concentration at this stage in the flight was with the direction in which the aircraft would have to taxi at the completion of the landing run.

2.3 Aircraft performance

The touchdown point of the aircraft was calculated at between 2,708 and 3,125 feet (825 and 952 metres) from the end of the runway by correlation of the eyewitnesses evidence and allowing a margin for error due to parallax in these observations (see paragraph 1.12). From the manufacturer's performance data (paragraph 1.16.2), it can be seen that, provided the spoilers had been deployed, it would have been possible to bring the aircraft to a stop within the minimum estimated runway distance remaining even at the highest estimated touchdown speed of 158 kt. However, without the use of spoilers, even at the lowest estimated touchdown speed of 148 kt (158 kt minus 10 kt tolerance error), the landing roll required would be 4,630 feet (1,411 metres) which is greater than the longest estimated distance remaining at the point of touchdown.

2.4 Human factors

2.4.1 Workload

Crew Resource Management (CRM) training had not been carried out by either of the pilots involved in this accident. The deviation from the ideal approach path occurred at the same time that the first officer was unable to understand the terminology used by ATC thereby necessitating a handover of the communications to the commander. The effect of this increase in the duties of the commander at a late stage in the approach combined with the operator's standard procedure of late selection of landing flap combined to result in a higher than desired speed as the aircraft reached the runway.

2.4.2 Decision making

By the time the aircraft reached the runway, the crew had ceased to operate as a team and the aircraft handling by the commander was no longer being monitored by the first officer, who was concentrating on the route to the parking area. In normal operations the first officer would have little to do apart from monitoring the performance of the handling pilot, the commander. Due to the combination of high speed and late touchdown the commander's workload increased to the extent that he neglected to deploy the spoilers on touchdown and this, unnoticed by the first officer, resulted in the overrun. Once the commander had appreciated that the landing was well into the runway and at excessive speed, he decided that a go-around was not feasible.

Although the first officer had turned down the opportunity of a command, in an apparent effort to avoid the responsibility that such a position incurs, the operator appears to have accepted this situation without regard to the wider implications of his performance as a crew member. The lack of involvement by the first officer in the operation of the aircraft during the last stage of the flight demonstrated a fundamental ignorance of the principles of CRM. This might be partly explained by his flying experience prior to joining MAC which had been gained almost exclusively in single-seat military aircraft. This fundamental lack of experience could have been addressed, at least in part, by implementation of CRM training by all the pilots in the company. The principal requirement, as a result of the employment of this pilot, was that he be fully integrated into the techniques of multi-crew flying. Therefore it is recommended that the Spanish Dirección General de Aviación Civil should begin to implement the planned requirements for CRM training, in accordance with the ICAO guidance, as soon as possible and in advance of the adoption of the CRM training requirements of JAR OPS. [Recommendation 97-10]

2.5 Air Traffic Control procedures

Air Traffic Control procedures in use at Northolt at the time of the accident were standard procedures for RAF airfields. However, the data in paragraph 1.18.1 show that the principal user in terms of numbers of aircraft movements was civilian fixed wing traffic. Under these circumstances it is highly desirable for standard ICAO air traffic control procedures to be introduced.

As the majority of the military traffic at the airfield, either RAF, MOD or non-UK military fixed wing are of similar types to the civilian traffic and are used for a similar purpose, the adoption of such procedures would be convenient, especially as the crews of these aircraft routinely operate into civilian airfields and are well used to ICAO standard procedures. Therefore it is recommended that the Ministry of Defence should consider harmonising its ATC procedures with those laid down in the Manual of Air Traffic Services Part 1 as published by the CAA. This should be done to avoid the use of non ICAO phraseology and procedures when controlling civilian air traffic at RAF airfields. [Recommendation 97-8].

The lack of navigation facilities at Northolt (see paragraph 1.8) contrasts unfavourably with other major airfields serving the London area such as Heathrow, Gatwick, Stansted, London City, Luton and Biggin Hill. All these airfields have ILS installed which affords crews greater accuracy in assessing the approach and has a major advantage in not requiring any greater fluency in the English language than that which would normally be required at an international airport. Therefore it is recommended that the Ministry of Defence, in the light of the total number of movements at the airfield and its close proximity to densely populated areas, should give further consideration to the installation of an ILS/DME system at RAF Northolt. [Recommendation 97-9].

2.6 Airfield safety

In the report on the accident of Cessna 550 Citation II, G-JETB at Southampton (Eastleigh) Airport on 26 May 1993, (Aircraft Accident Report 5/94 published 1994), reference is made to Civil Air Publication (CAP) 168 which details the licensing regulations for airfields involved in all types of flying operations, particularly Public Transport flights. These regulations are not applicable in the case of RAF Northolt due to its status as a Government Aerodrome but should reasonably apply when considering the implementation of public safety standards.

Following the Southampton Eastleigh accident, the AAIB made Recommendation 94-15 to the CAA as follows:

> 'The CAA should review all UK licensed airfields to identify potential safety hazards beyond current Runway End Safety Areas (RESAs) and determine the need for, and practicality of installing, ground arrester systems.'

The CAA accepted the recommendation stating that:

> 'The Authority's licensing process seeks to ensure that all UK licensed aerodromes satisfy internationally agreed requirements. However, the Authority will conduct a specific review on the lines recommended. This will reconsider the dimensions of the RESA and take account of any identifiable additional risks arising from significant hazards beyond the end of the RESAs.'

Current CAA action was published in CAP 652 (July 1995) as follows:

> 'The study into levels of risk and related issues noted in the previous report is being run as a research project within the Safety Regulation Group's R&D programme. The objective of the project is not only the identification of risks but also the development of a consistent and logical tool for use by aerodromes. If such a tool can be produced it will be available to the Authority for use in reviewing assessments made by aerodromes. The project is due for completion in the late Spring of 1996 (see Note below).
>
> In parallel with its own work the Authority is maintaining liaison with the FAA which is also conducting an investigation into the need for, and applicability of, arrester beds.
>
> In addition the Authority is currently exploring outline plans and proposals with two UK airports which have identified a need for the possible use of such devices.'

Note: The project [7.13] is included in the CAA Safety Regulation Group Research Programme 1996/97. The following Timescales/Milestones are listed: Report June 1996 on risk studies. Report May 1997 on engineering aspects.

Since Recommendation 94-15 and the CAA follow up action was directed at UK licensed airfields, those military airfields which provide a service to civil aircraft, such as RAF Northolt, were not included. It is therefore recommended that the Ministry of Defence should take note of the CAA follow up actions on

Recommendation 94-15 with a view to assessing their applicability to those Government Aerodromes having a significant number of movements by civil aircraft and military aircraft with similar characteristics, which are adjacent to public areas such as major roads or railways. (Recommendation 96-67).

Since publication of Recommendation 96-67 on 2 October 1996, the Royal Air Force Inspectorate of Flight Safety have confirmed that they will take note of the findings of the CAA study when they become available. In addition, preliminary work has been carried out to review those RAF airfields where there is a major road adjacent to the runway end. Of the runways identified, RAF Northolt has been singled out as having the most serious problem and plans are currently being progressed to install arrester beds in the overruns of both Runways 07 and 25.

2.7 Reaction of the airfield services

The final approach and landing of EC-CKR was observed by the Local Controller and his assistant from the ATC tower, both of whom were concerned by what they regarded as an abnormally high speed on final approach and a late touchdown. The landing roll was followed closely by the assistant controller using binoculars. The crash alarm was activated by the controller as the aircraft left the runway paved surface and at the same time his assistant telephoned the civil emergency services. The rapid reaction of the Local Controller and his assistant brought about an immediate response by the emergency services. The civil police and civil ambulance service arrived at the scene of the accident within five minutes of the accident occurring.

The prompt reaction of the airfield fire service averted the possibility of a post impact fire. Had this not been the case the first officer and the van driver would have had little chance of survival as both were trapped in their seats.

2.8 Summary of the engineering investigation

The engineering investigation gathered considerable evidence to show that, although the spoiler system had been serviceable, at the time the aircraft came to rest the spoilers were fully stowed. It is unlikely that this would have been a result of a specific action by the crew to stow the spoilers during the overrun, and this, combined with the performance data discussed earlier, suggests that spoilers were not selected during the landing. Close examination and thorough testing was conducted to determine whether the spoilers could have closed themselves fully during the impact sequence and this possibility was eventually discounted. Of most significance was the damage to the right main landing gear retraction jack upper attachment and surrounding structure. If the spoilers had been selected to EXT when the landing gear collapsed and the 'extend' line was broken, the whole area would have been sprayed with high pressure hydraulic fluid from the contents of the hydraulic accumulator. Such evidence could not have been missed because the bay in which the damage occurred is fully enclosed and normally quite clean and dry, as was evident in both the affected bay and the similar bay behind the left main gear. Even without the evidence from the tests conducted on spoiler retraction times, this lack of contamination would be difficult to explain. Overall, the possibility that the spoilers were extended by the time the aircraft hit the road can be discounted.

Within the other aircraft systems nothing was found to indicate any malfunction. The flaps had deployed satisfactorily and although it was not possible to establish fully the serviceability of the anti-skid system, it was clear that emergency braking was fully serviceable and that normal braking was available. The lack of evidence of tyre marks on the runway until close to the end, and the lack of characteristic tyre damage, showed that wheel lock-up due to possible anti-skid failure had not occurred. In any case such a failure would not increase the stopping distance by as large a factor as would the non-deployment of the spoilers. The helical wear pattern on several of the tyres confirmed that lateral slip of tyres, due to turning, had been occurring on the runway but that the wheels were turning during this time. The effect that use of the brake parachute would have had on the stopping distance was considered but for the parachute to be effective it needed to have been deployed early in the landing roll.

The simulation results need to be interpreted with caution but they do generally support the contention that the aircraft left the runway at a speed in the order of 70 kt, or slightly more. This supports the view that spoiler was not selected and no other configuration or failure mode would be likely to result in such a fast overrun. Furthermore this overrun represented a worst case, in that few overrun scenarios would result in a higher ground speed as the aircraft left the runway.

The track of the aircraft towards the road requires explanation. It is significant that the CIC study reproduced the yaw behaviour of the aircraft using only omni-directional drag effects. The limited data obtained from the simulation suggested that the effects of nosewheel steering were small for most of the overrun. With a significant drag force being generated by the nosewheel, this became the dominant factor. It seems that once the yaw reached a large enough value with the nosewheel going outside the track of the main gear, the pilot could not immediately regain directional control, however the forces generated by the slip angle on the mainwheels caused the aircraft to continue turning to the left. Directional control is adversely affected by braking, greater than optimum wheel slip angles, and adverse surface conditions. To have increased the likelihood of regaining directional control the commander would have needed to reduce braking and steer further to the left.

The deceleration predicted by the programme accords with a simple calculation of mean deceleration from the end of the runway, and is similar to the best available documented performance of a gravel arrester bed. However, the arrester bed data is based on a rolling entry without significant yaw; had the aircraft entered an arrester bed it is likely that the deceleration would have been higher still. It is also possible, if the wheels continued to roll, that the aircraft would have followed a similar track curving to the left so that unless the bed was sufficiently wide it might have regained the grass. Even so it is most probable that, had the aircraft entered an arrester bed even briefly, it would have stopped more rapidly and would not therefore have reached the road in what amounts to a worst case overrun accident.

2.9 Summary

The flight was typical of those carried out by this operator and its only unusual feature was that the planned destination was RAF Northolt, which was not familiar to either pilot. In addition, by virtue of its status as an RAF airfield, the ATC phraseology in use did not accord strictly with the ICAO standard.

The crew were well rested and the weather was good. Sensibly, the commander decided to obtain as much training value from the approach as possible since a PAR is not commonly available at civilian airfields. The commander, when accompanied by this first officer, normally operated as the handling pilot when passengers were on board, and it was left to the first officer to carry out the non-handling duties such as conducting the radio communications and monitoring the flight path being flown by the handling pilot. None of this appeared to cause any difficulty until the aircraft came under RAF Northolt control. When at a late stage in the approach the first officer received a radio request which he did not understand it became necessary for the commander to take over the communications.

If the commander had then abandoned his intention to remain on instruments until his decision height, he may well have appreciated his position as being both high and fast on the approach and carried out the missed approach procedure. As it was, having not looked up from the instruments until the decision height and having to request landing flap at this late stage, he became sufficiently overloaded that he neglected to select the spoilers after touchdown.

The first officer demonstrated a complete faith in his commander's flying ability to the extent that he did not at any time feel it was his place to intervene or even to be alarmed until the situation had become irretrievable. His attitude can be attributed to a lack of self-confidence which had been inferred by his declining to accept a command within the company on the grounds that he was not prepared to take on the extra responsibility required by that position. In addition, the company appeared to be over indulgent to this under confidence in that it was prepared to allow him to continue to fly as a first officer although he did not ever act as handling pilot when passengers were on the aircraft. By concentrating his attention on the taxi chart, the first officer prevented himself from monitoring the operation of the commander and therefore did not notice that the spoilers had not been selected after touchdown.

3 Conclusions

(a) Findings

The crew

(i) The flight crew were properly licensed, rested and medically fit to conduct the flight.

(ii) The first officer had some difficulty in understanding certain ATC phrases and requests.

(iii) The necessity for the commander to both interpret for his first officer and then to make the radio calls himself served to distract him from his primary task of flying the approach.

(iv) The effect of an increase in the workload of the commander at a late stage in the approach combined with the operator's standard procedure of late selection of landing flap combined to result in a higher than desired speed as the aircraft reached the runway.

(v) The passenger formed the opinion that, during the approach, a conflict had occurred between the pilots. In normal landing operations the two pilots will both have their hands on the centre console at the same time and this could be misinterpreted to indicate disagreement. This perception is even more understandable considering the passenger did not understand Spanish.

(vi) If the commander had abandoned his intention to remain on instruments until his decision height, he may well have appreciated his position as being both high and fast on the approach and carried out the missed approach procedure.

(vii) The spoilers were not extended during the landing. Without the use of spoilers, even at the lowest estimated touchdown speed of 148 kt, the landing roll required was 4,630 feet (1,411 metres) which is greater than the longest estimated distance remaining at the point of touchdown.

(viii) By concentrating his attention on the taxi chart, the first officer prevented himself from monitoring the operation of the commander and therefore did not notice that the spoilers had not been selected after touchdown.

(ix) Inter-crew co-operation, working relations and decision making could have been more precisely analysed if the aircraft had been fitted with a Cockpit Voice Recorder (CVR) but Spanish airworthiness requirements did not require the fitting of any flight recorder to this class of aeroplane.

The aircraft

(x) The aircraft had valid Certificates of Airworthiness and Maintenance and had been maintained in accordance with an approved schedule.

(xi) The aircraft was below the maximum authorised landing weight and was correctly loaded.

(xii) It would still have been possible to stop the aircraft on the runway had the spoilers been deployed on touchdown. But since they were not deployed it was not possible to stop in the distance available.

(xiii) The aircraft left the end of the runway at a speed of about 70 kt.

(xiv) Examination of the normal and emergency brakes and the spoiler and flap systems showed them to be serviceable prior to the accident.

(xv) Post-accident testing discounted the possibility that the spoilers were extended by the time the aircraft hit the road. Within the other aircraft systems nothing was found to indicate any malfunction.

(xvi) A brake parachute was available but not deployed. For it to be effective it needed to have been deployed early in the landing roll.

The operation

(xvii) The crew had received no formal training in the principles of CRM.

(xviii) The lack of involvement by the first officer in the operation of the aircraft during the last stage of the flight demonstrated a fundamental ignorance of the principles of CRM.

The airfield

(xix) ATC procedures in use at RAF Northolt were to RAF standards.

(xx) The proximity of the trunk road to the end of the runway contributed to the severity of the accident.

(xxi) The overrun distance would have been reduced by a gravel arrester bed.

(xxii) The reaction of the RAF Northolt fire service was highly commendable and prevented a post-accident fire.

(xxiii) The lack of navigation facilities at Northolt compares unfavourably with other major airfields serving the London area such as Heathrow, Gatwick, Stansted, London City, Luton and Biggin Hill.

(b) Causes

The following causal factors were identified:

(i) The commander landed the aircraft at a speed of 158 (±10 kt) and at a point on the runway such that there was approximately 3,125 feet of landing run remaining.

(ii) The commander did not deploy the spoilers after touchdown.

(iii) The first officer did not observe that the spoilers had not been deployed after touchdown.

(iv) At a speed of 158 (±10 kt) with spoilers retracted and given the aircraft weight and atmospheric conditions prevailing, there was insufficient landing distance remaining from the point of touchdown within which to bring the aircraft to a standstill.

(v) The commander allowed himself to become overloaded during the approach and landing. The safeguards derived from a two crew operation were diminished by the first officer's lack of involvement with the final approach.

4 Safety Recommendations

During the course of the investigation the following safety recommendations were made:

4.1 The Ministry of Defence should take note of the CAA follow up actions on Recommendation 94-15 with a view to assessing their applicability to those Government Aerodromes having a significant number of movements by civil aircraft and military aircraft with similar characteristics, which are adjacent to public areas such as major roads or railways. [Recommendation 96-67 made on 2 October 1996]

4.2 The Ministry of Defence should consider harmonising its ATC procedures with those laid down in the Manual of Air Traffic Services Part 1 as published by the CAA. This should be done to avoid the use of non-ICAO phraseology and procedures when controlling civilian air traffic at RAF airfields. [Recommendation 97-8]

4.3 The Ministry of Defence, in the light of the total number of movements at the airfield and its close proximity to densely populated areas, should give further consideration to the installation of an ILS/DME system at RAF Northolt. [Recommendation 97-9]

4.4 The Spanish Dirección General de Aviación Civil should begin to implement the planned requirements for CRM training, in accordance with the ICAO guidance, as soon as possible and in advance of the adoption of the CRM training requirements of JAR OPS. [Recommendation 97-10]

R StJ Whidborne
Inspector of Air Accidents
June 1997

GLARE SHIELD nothing of note

P1 PANEL

Horizon	toppled
Stby Horizon	OFF
RAD ALT	Bugged at 100f t
VSI	zero
Altimeter	set 1015mb 100ft
HSI	Hdg 167°
Turn and slip	nothing useful
VOR/ADF	indicator 165°
ASI	zero, bugged at 127 kt
Emergency Battery	OFF

CENTRE PANEL

ADF1A	277
ADF1B	351
Alt select	set 1800 and OFF
NAV1	115.1
NAV2	115.1
Engine Instruments	all zero
COM2	131.92
COM1	130.35 / 124.97
DME	113.6
Transponder	5330
Flap indicator	Approach
Gear selector	DOWN
Generator switches	GEN
Battery Master	OFF
Stall warning x2	OFF
Anti skid	ON
Inverters Pri and Sec	OFF
Air ignition L & R	OFF
Hyd pump	OFF
Landing gear	selected to DOWN
Nav and beacon lights	all ON

Strobe	OFF
Recog	ON
Aux Inverter	OFF & selected to LEFT BUS
Pitch trim	NORM

P2 PANEL

ASI	zero, bugged at 125 kt
ADF/VOR	165
DI	170
ALT	100ft on 1014 mbs
VSI	zero
Turn & Slip	undamaged, nothing useful

CIRCUIT BREAKERS

all IN except 'toilet' and 'eng synch'

THROTTLE PEDESTAL

Throttles	retarded
Flaps	OFF
Spoiler switch	see report
Jetpumps	ON
Standby pumps	OFF
Fuselage tank feed	CLOSED
Fuel qty selected to	1500 lbs, TOTAL
Primary yaw damper	ON
Secondary yaw damper	OFF

MISC

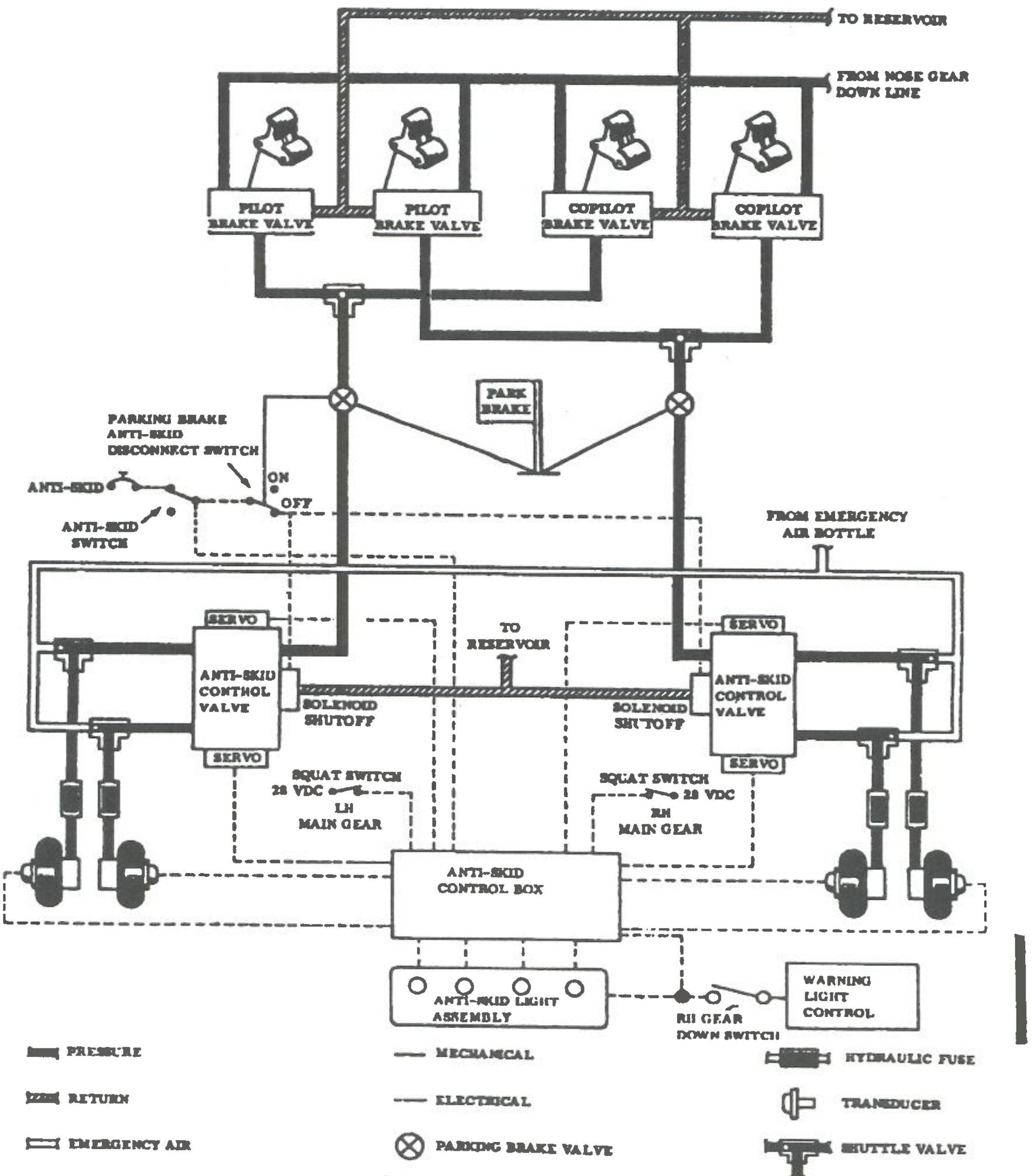
Frangible wire on emergency brake broken.

1/2 scale deflection on emergency air gauge.

Chart for Northolt on P2 column.

(Extract from Gates Learjet Corporation Maintenance Manual)

Gates Learjet Corporation
maintenance manual

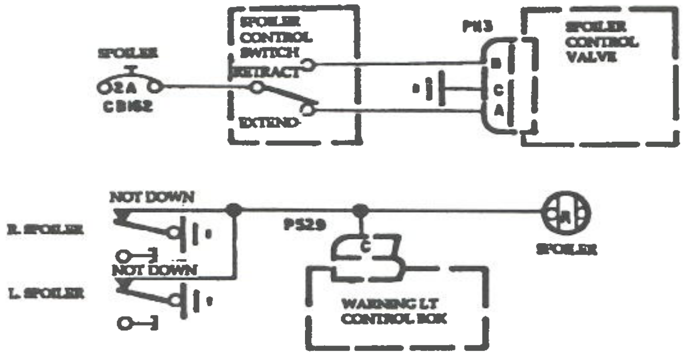


Brake System Schematic
Figure 1 (Sheet 1 of 2)

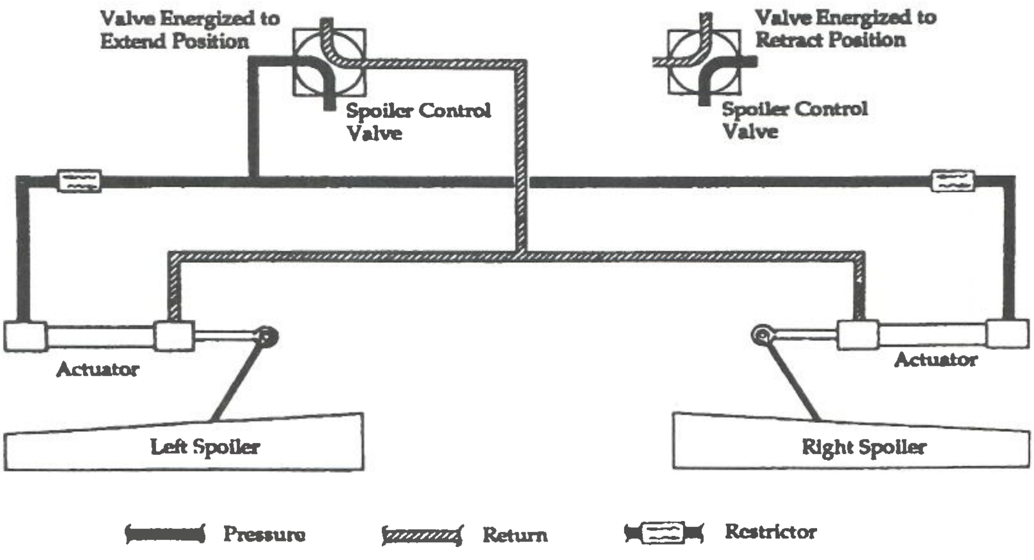
EFFECTIVITY: 25-061, 25-070 THRU 25-184

(Extract from Gates Learjet Corporation Maintenance Manual)

Learjet



Spoiler System Electrical Control Schematic
Figure 1



Spoiler System Hydraulic System Schematic
Figure 2

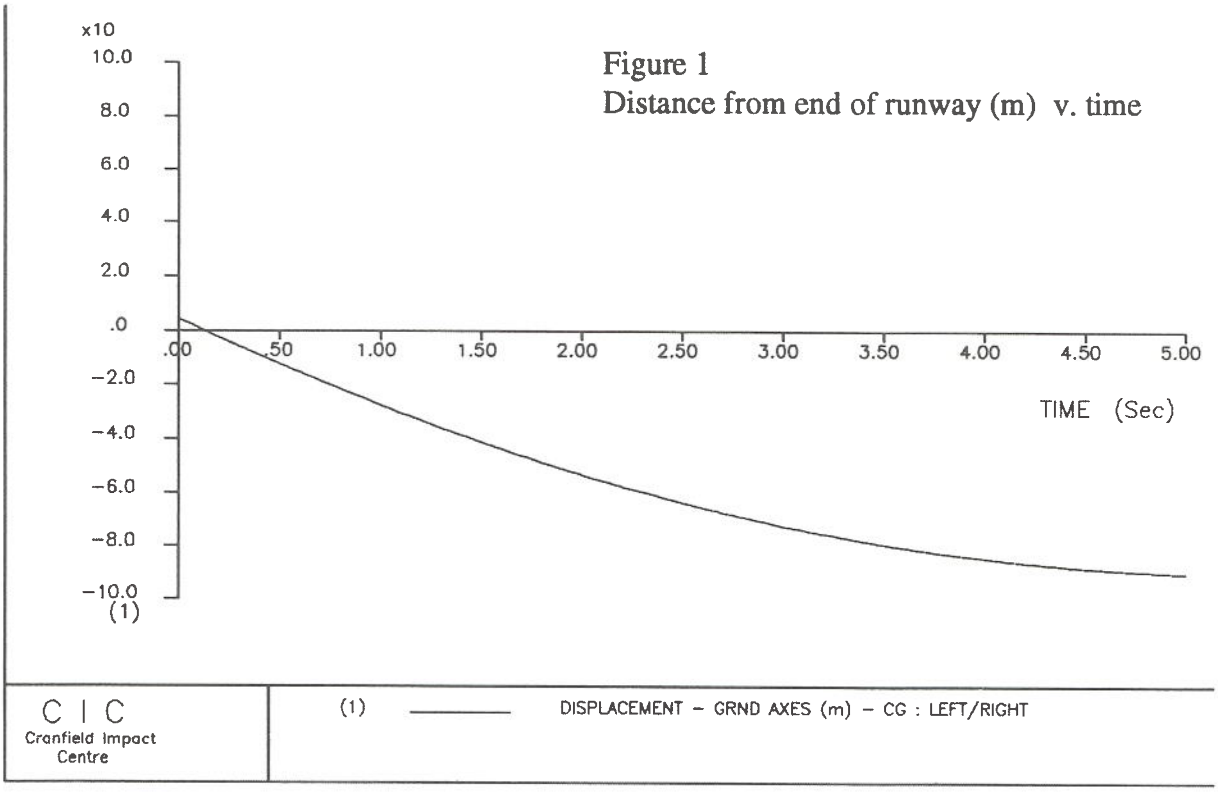


Figure 1
Distance from end of runway (m) v. time

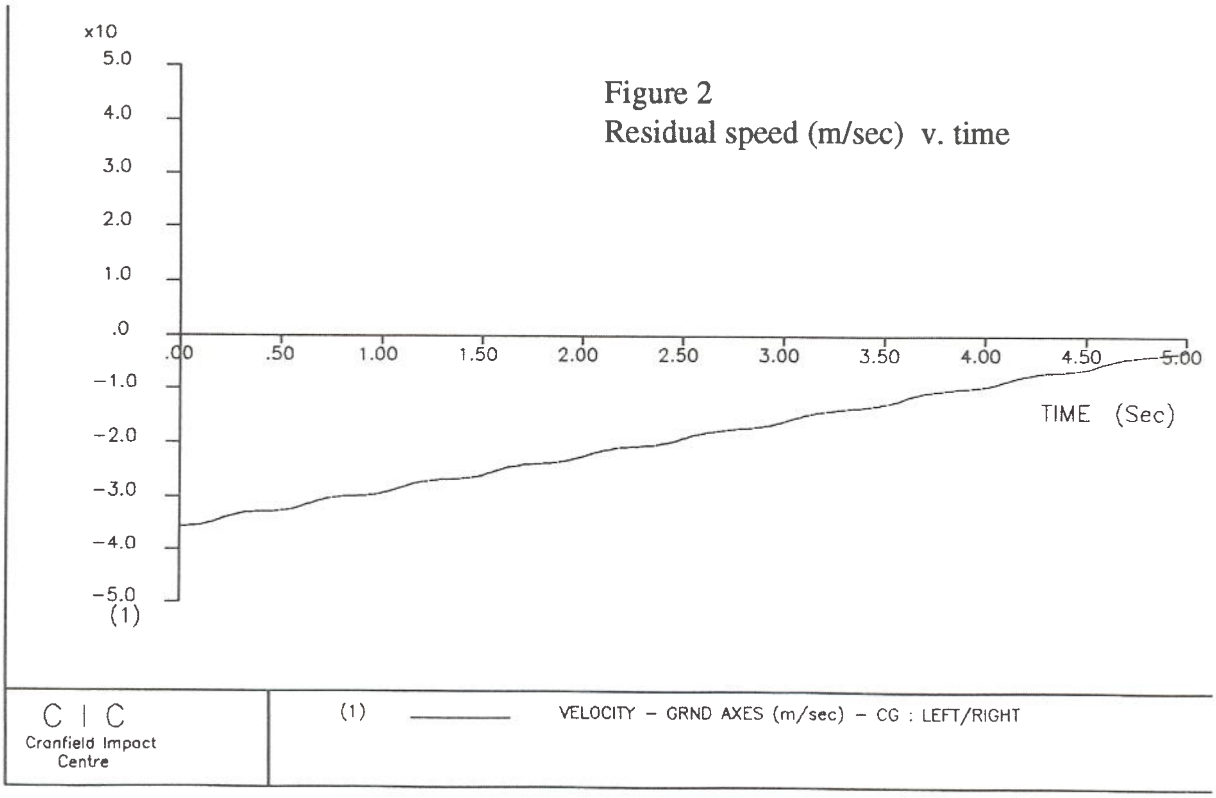
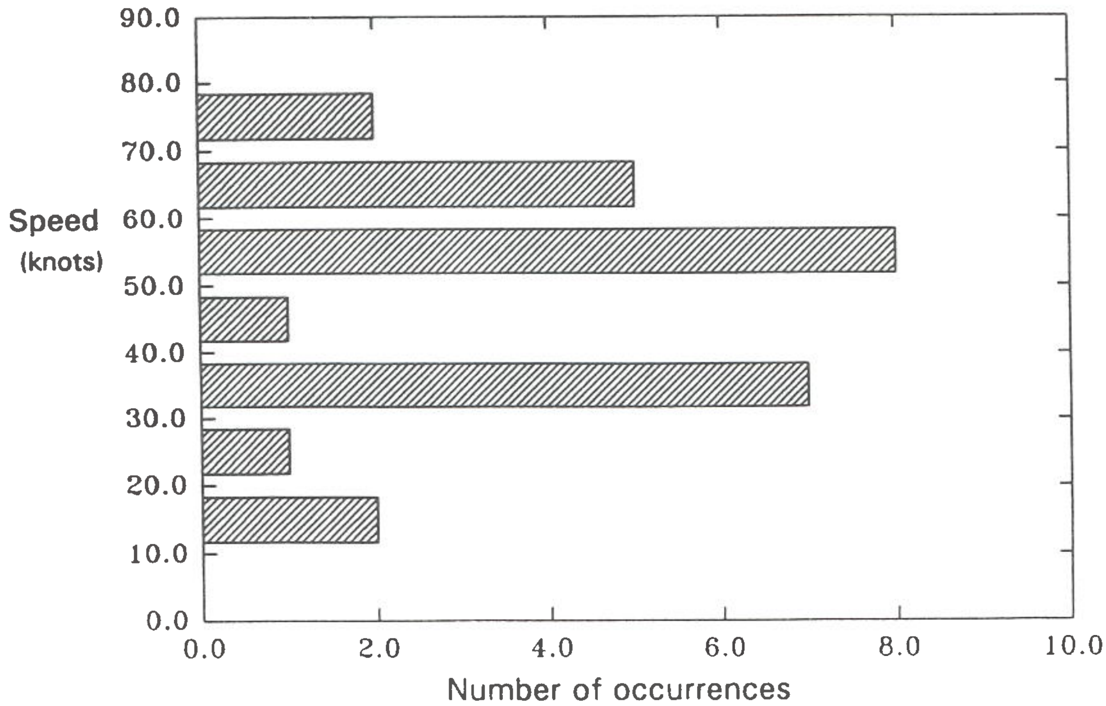


Figure 2
Residual speed (m/sec) v. time

DOT/FAA/CT-93/80
"SOFT GROUND ARRESTING SYSTEMS FOR AIRPORTS"
James C. White/Satish K. Agrawal/Robert E. Cook



Runway Exit Speeds During an Overrun

The diagram above was published in the above report, prepared by the Federal Aviation Administration Technical Center, Atlantic City NJ. The data was drawn from National Transportation Safety Board an International Civil Aviation Organisation sources and the work was credited to David, 1990. The data indicates that there have been few instances when aircraft have left the runway at more than 70 knots, and none found where the speed exceeded 80 knots.

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