AIRCRAFT ACCIDENT REPORT 4/95

Air Accidents Investigation Branch

Department of Transport

Report on the accident to Antonov AN 28, HA-LAJ at RAF Weston-on-the-Green, Oxfordshire on 28 August 1993

This investigation was carried out in accordance with
The Civil Aviation (Investigation of Air Accidents) Regulations 1989

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Department of Transport
Air Accidents Investigation Branch
Defence Research Agency
Farnborough
Hampshire GU14 6TD

21 April 1995

The Right Honourable Dr Brian Mawhinney
Secretary of State for Transport

Sir,

I have the honour to submit the report by Mr E J Trimble, an Inspector of Air Accidents, on the circumstances of the accident to Antonov AN 28, HA-LAJ, which occurred at RAF-Weston-on-the Green, Oxfordshire, on 28 August 1993.

I have the honour to be
Sir
Your obedient servant

K P R Smart
Chief Inspector of Air Accidents

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIB	-	Air Accidents Investigation Branch
agl	-	above ground level
AN	-	Antonov
ANO	-	Air Navigation Order
AOC	-	Air Operator's Certificate
BCARs	-	British Civil Airworthiness Requirements
°C	-	degrees Celsius
CAA	-	Civil Aviation Authority
C of A	-	Certificate of Airworthiness
C of R	-	Certificate of Registration
DoT	-	Department of Transport
EEC	-	European Economic Community
ERG	-	Economic Regulation Group
FARs	-	Federal Aviation Requirements
ft	-	feet
HAA	-	Hungarian Aeronautical Association
hrs	-	hours
ICAO	-	International Civil Aviation Organization
JARs	-	Joint Airworthiness Requirements
kg	-	kilogram(s)
km	-	kilometre(s)
kph	-	kilometres per hour
kt	-	knot(s)
mb	-	millibar(s)
OAO	-	Air Detachment
RAF	-	Royal Air Force
RAFSPA	-	Royal Air Force Sport Parachute Association
SARPS	-	Standards and Recommended Practices
SRG	-	Safety Regulation Group
TO	-	takeoff
TOW	-	take-off weight
UK	-	United Kingdom
USSR	-	Union of Soviet Socialist Republics
UTC	-	Co-ordinated Universal Time

Showing damaged aircraft on site after forced landing

Air Accidents Investigation Branch

Aircraft Accident Report No: 4/95 (EW/C93/8/5)

Registered Owner:	Petrozavodszki OAO (Petrozavod Air Detachment)
Operator:	Magyar Repülõ Szövetség (Hungarian Aeronautical Association)
Aircraft Type:	AN 28
Nationality:	'Hungarian' (see section 1.6.1)
Registration:	'HA-LAJ' (see section 1.6.1)
Place of Accident:	RAF Weston-on-the-Green, Oxfordshire
Date and Time:	28 August 1993 at 1520 hrs
	All times in this report are UTC

Synopsis

The accident was notified to the Air Accidents Investigation Branch (AAIB) at 2020 hrs on 28 August 1993 and an investigation commenced on 31 August 1993. The AAIB team consisted of Mr E J Trimble (Investigator in Charge), Mr D S Miller (Operations), Mr P R Coombs (Engineering) and Mr P F Sheppard (Flight Recorders).

The Antonov AN 28 was on a 'wet lease' hire to the Royal Air Force Sport Parachute Association (RAFSPA) for parachute operations from RAF Weston-on-the-Green, from the 27 August 1993 to 6 September 1993. On Saturday 28 August 1993, the aircraft had completed twelve flights, each of approximately 15 minutes duration, carrying up to 17 parachutists involved in 'free fall' parachuting over the airfield.

On the thirteenth flight the aircraft departed from Runway 36 with 17 parachutists and 2 crew on board. As the aircraft reached a height of approximately 500 feet above ground level (agl) both engines simultaneously suffered total power loss. With no time to resolve the situation, the crew carried out a forced landing in a large field of cut crop adjacent to the airfield. The aircraft landed heavily and was damaged beyond repair, however the passengers and crew vacated the aircraft without injury.

The report identifies the following causal factors:

(i) A latent defect in the electrical system caused a simultaneous total power loss as the flaps were retracted at 500 feet agl on climb out, with automatic operation of both asymmetric spoiler systems.

(ii) The latent defect had been caused by progressive loosening of a single earthing screw, which provided a common earth point for the flap electric signalling and propeller autofeathering systems. This induced a high resistance to earth at this point and caused feathering of both propellers when flap retraction was selected, in addition to automatic closure of both engine fuel shut-off valves (within the fuel control units) and extension of both outboard spoilers.

(iii) At manufacture in Poland a single earthing point had been installed which was not in accordance with the design requirements for this aircraft type as issued by the Antonov Design Bureau, which had required dual combined earthing terminals for the flap signalling and propeller autofeathering systems.

(iv) The Antonov Design Bureau had never cleared this type of aircraft for flight with the aft clam-shell doors removed, or for parachute training.

(v) This aircraft had been incorrectly granted an Aerial Work Permit for parachuting operations in the UK by the Department of Transport, assisted by the CAA, as a result of implicit reliance upon submitted documentation which was subsequently proven invalid.

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

1 Factual Information

1.1 History of the flight

At 0700 hrs on Friday 27 August, ie the day before the accident, the aircraft had departed Budapest, Hungary, with two Russian pilots and refuelled at Maastricht, Belgium, before landing at White Waltham Airfield, near Maidenhead, for customs clearance. It then continued to RAF Weston-on-the-Green, where it landed at approximately 1500 hrs.

At 0830 hrs on the following day, with the Russian crew well rested, the aircraft commenced a series of flights, each lasting approximately 15 minutes, operating from the north/south orientated grass runway at Weston Airfield. For several of these flights the crew were accompanied by a parachute club official who observed the crew procedures to ensure that operations were being conducted in accordance with the British Parachute Association Operations Manual. The weather was fine, with excellent visibility and light northerly winds.

The Hungarian aircraft Flight Manual supplement permitted the aircraft to be used for parachute jumping and also gave clearance for flight with the rear clam-shell doors removed. The Ukranian Antonov Design Bureau which designed the aircraft type has since, however, stated emphatically that the aircraft had not been evaluated for flight without the rear doors fitted and considered it unsuitable for such operations. They stated that their Guide on Flight Operation for the type prohibited its use for parachute training. These doors were nonetheless removed and the normal passenger seats were stowed against the cabin walls to allow the parachutists to sit on the floor for takeoff and during the climb to the 'jump' height. After each takeoff the aircraft climbed to the west before running in on a northerly track, at the pre-planned height, to drop the parachutists overhead the airfield. Liaison between the crew and the on-board jump-master was conducted, in the normal manner, by hand signals.

The aircraft was refuelled at regular intervals throughout the day. Fuel was supplied from the on-site bowser and approximately 600 litres (750 kg) of Jet A1 aviation turbine fuel was uplifted each time. The final refuelling before the accident, consisting of 500 litres (625 kg), was carried out after the tenth flight. The crew reported that after this refuelling the aircraft fuel state had been 400 kg in each outer wing tank (total aircraft fuel tank capacity approximately 1,570 kg).

Three flights later, on the thirteenth flight of the day, the aircraft departed from Runway 36 with 17 parachutists on board. It carried out a normal takeoff, rotating at a speed of 120 kph (64.8 kt) according to the crew and became airborne at its normal speed of 150 kph (81 kt), with 15° of flap selected. The aircraft then climbed at 150 kph, and at a pitch angle of approximately 18° to 20°, before the flaps were retracted at 500 feet agl. During flap retraction, which was carried out by three quick successive selections of the electric flap switch, the aircraft's pitch attitude was reduced and the aircraft accelerated to 180 kph (97 kt). The crew stated that as the flaps became fully retracted both engines simultaneously suffered a total power loss. The commander reported that the simultaneous failure did not induce any yaw and that the only two warning lights which illuminated in the cockpit were those indicative of double engine failure.

Following the power loss, the aircraft's speed decayed rapidly leading the commander to suspect that the automatic outboard wing spoilers had also deployed. Realising that a forced landing was the only option available to him, he initiated a steep descent to maintain airspeed and a turn through 90° to the right to position the aircraft for a forced landing in a large field of corn stubble.

The aircraft landed heavily in a slightly nose up attitude, banked slightly to the right, at an estimated speed of 170 kph (92 kt) and slid to rest with substantial damage to the fuselage, landing gear, wing struts, propellers and wings. There was no fire and since disruption to the cabin structure was not very severe the 17 passengers were able to evacuate the aircraft immediately through the rear opening without injury. The co-pilot, who switched off the batteries, escaped through the right-hand side cockpit window. The commander selected the fire cock switches to 'OFF' and left the aircraft through the rear opening, after the passengers. Both pilots escaped uninjured.

Observers standing close to the runway witnessed the event and raised the alarm. The officer-in-charge of RAF Weston-on-the-Green initiated the aircraft crash procedures and within two minutes a vehicle equipped with fire extinguishers and emergency equipment arrived at the scene.

One witness positioned under the aircraft's flight path on the road adjacent to the airfield took several photographs of the aircraft during its descent after the power loss and with both propellers stationary. These showed that the right propeller was feathered and that both outboard spoilers had deployed.

1.2 Injuries to persons

Injuries:	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor/None	2	17	-

1.3 Damage to the aircraft

The aircraft suffered very substantial damage to the landing gear, wings, fuselage and propellers which rendered it beyond economic repair.

1.4 Other damage

None.

1.5 Personnel information

1.5.1	Commander:	Male, aged 40 years
	Licence:	USSR Civil Aviation Pilot's Class I Licence valid until 27 October 1993 with Hungarian Civil Aviation Inspection endorsement dated 25 June 1993. Valid Instrument and Night Ratings. Endorsed for Parachute Operations.
	Medical Certificate:	Issued on 27 October 1992 and valid until 27 October 1993
	Total flying hours:	9,400 hours
	Total hours on type:	1,200 hours

1.5.2	Co-pilot:	Male, aged 26 years
	Licence:	USSR Civil Aviation Pilot's Class III Licence with valid Instrument and Night Ratings
	Medical Certificate:	Issued on 24 September 1992 and valid until 24 September 1993
	Total flying hours:	2,310 hours
	Total flying on type:	510 hours

1.6 Aircraft information

1.6.1 General information

Manufacturer:	PZL WSK Mielec, Lengyelorszag, Poland
Type:	AN 28
Engines:	2 TVD-10B turboprop engines
Constructor's number:	IAN 005121
Date of manufacture:	1988
Certificate of Registration (a):	Issued 27 May 1993 by Hungarian Republic Ministry of Transport, Civil Aviation Administration owned by (in dispute) Petrozavodski OAO, Oroszorszag; operated by Magyar RepuloSzovetseg, 1093 Budapest, Lonyay U44
NOTE:	The Hungarian registration document stated that the aircraft has been declared airworthy for transportation of freight and passengers, and for parachuting. However representatives of the Department of Air Transport of the Ministry of Transport of the Russian

	Federation who participated in the investigation stated that the aircraft had been registered in the USSR and was still registered in Russia following the collapse of the USSR. They stated that aircraft could not be transferred to another register without cancelling the USSR/Russian registration.
Certificate of Registration (b):	No 2030, issued on 07-02-1986 by the Union of Soviet Socialist Republics, Ministry of Civil Aviation, General Inspection of ICA. The State Registration Identification Sign had been quoted as CCCP 28778, but 'CCCP' had been crossed out and replaced by 'RA' (ie current Russian national marking). The aircraft type and purpose, was stated as 'AN-28 passenger'. The name and address of aircraft holder was noted as 'Leningrad Board of Civil Aviation'. The section entitled 'Notes of Changes of Aircraft Holder' was blank.
Certificate of Airworthiness (a):	Issued in Hungary on 27 May 1993 and valid until 23 August 1993. Extended until 23 September 1993 (see section 1.17.4)
Certificate of Airworthiness (b):	Issued in Russia on 20 September 1988 and originally valid until 9 September 1990. This certificate was subsequently extended a number of times following 'Application of Head of ATB and the Aircraft Technical Report' of appropriate dates. Final extention to 23 November 1993 followed a report dated 09-081993. In the section entitled 'Category', the aircraft was described as a 'Passenger Aircraft.'
Total aircraft flying hours:	1,616 hours
Total aircraft landings:	1,384

NOTE: The chief representative of the Russian Department of Air Transport stated that the type had not been evaluated for flight with the rear clam-shell doors removed and hence could not be considered suitable for parachuting. The Antonov Design Bureau, on being informed of the circumstances of this accident, wrote to the Russian Civil Aviation Authorities, stating that "Serious infringements of the basic documents were committed with regard to ensuring flight safety."

The Antonov Design Bureau further stated that the dropping of parachutists on training jumps was prohibited by the 'Guide on Flight Operation' for the AN 28 and that flight with the rear doors removed was unacceptable; no strength, fatigue or flight tests having been carried out in that configuration. They also suspected that damage to structure and equipment could result from turbulence and vibration arising from flight with the doors removed. They stated that they were categorically opposed to this change in operating conditions and refused to accept any liability for the flight safety of the type when operated in this condition.

1.6.2 Weight and performance

Aircraft documentation gave limited information as to aircraft weights and performance data. The information listed below was obtained from specialist aviation publications:

Weight empty (approx):	3,500 kg
Normal payload:	1,550 kg
Maximum payload:	1,700 kg
Normal TOW:	5,800 kg
Maximum TOW:	6,100 kg

Max TOW stalling speed, flaps up:	73 kt
Max TOW stalling speed, flaps down:	67.5 kt
Estimated weight at time of accident:	5,440 kg
Centre of gravity at time of accident:	Within approved limits

1.6.3 Maintenance history

The aircraft was apparently overhauled at the Petrozavodszk aircraft factory before travelling to Hungary. This overhaul appears to have been completed before issue of the Technical Inspection Report of 09-08-1993 and the application by the head of PTZ OAO ATB for extension of the Russian Certificate of Airworthiness to 23 November 1993. According to the Hungarian Aeronautical Association (HAA), the aircraft was subjected to an inspection for the purpose of extending its Hungarian C of A for three months prior to the aircraft entering the UK. This inspection was apparently carried out by a representative of the Russian CAA (Moscow) and an engineer from the authorised overhaul workshop at Petropavlosk. Engineers from the HAA were also involved in this inspection after which the Hungarian CAA extended the C of A.

1.6.4 Aircraft type history and description

The AN 28 type was designed by the Antonov Design Bureau of Kiev (then in the USSR, now a part of the independent Republic of Ukraine). The prototype first flew in the USSR in 1969. The type was subsequently selected to be produced as the standard aircraft in this category for use throughout the USSR and other former satellite states. It entered production at the WSK-PZL Mielec factory in Poland in approximately 1980.

The type is a twin turboprop, strut braced high-wing aircraft having fixed landing gear, the main units of which are mounted on sponsons which also support the lower ends of the wing struts. The aircraft has provision for a crew of two and may be used to carry freight or up to 20 passengers.

The type is of conventional metal construction with fabric covered control surfaces, the ailerons being mass balanced by means of external weights mounted below the surfaces. It has automatic leading edge slats over the wingspan outboard of the engine nacelles.

1.6.5 Aircraft systems

The aircraft was equipped with hydraulic brakes, hydraulically driven flaps and spring loaded hydraulically driven spoilers positioned just forward of the ailerons.

It had 28 volt, 36 volt and 115 volt electrical systems, performing a variety of functions. It was also equipped with a system which detected engine failure. In addition to feathering the relevant propeller, this system automatically shuts off the appropriate engine fuel supply, by means of a valve in each of the engine fuel control/pump units. This system operates under the following conditions:

(1) At high power lever angles, if the compressor pressure ratio falls below 4.5 and the compressor rotor speed falls below a pre-determined figure.

(2) In certain other flight modes, if the compressor pressure ratio falls below 2.6 and the compressor rotor speed falls below 56 %.

(A further automatic feather/shutdown mode occurs when overspeed of the free turbine rotor is detected; manual feathering and engine shutdown can also be carried out as a single action by the crew using either electrical or mechanical systems)

Operation of the engine failure detection system also deploys the upper surface spoiler on the outer wing on the opposite side of the aircraft. The total system eliminates large yaw and roll deviations following engine failure and helps to prevent sustained engine bay fire should the power loss cause, or result from, a major disruption of the hot sections of an engine.

The flaps are operated hydraulically, with electrical signalling from a flap selection switch mounted on the control console. Flap up and flap down operating signals each route via the flap operating solenoid to one of two cable terminals each secured to a single terminal block (designated A6X1), one of four similar terminal blocks situated on a panel forming the forward facing surface of the control console, as shown in the diagram at Appendix A, Figure 1.

Terminal block A6X1 also forms part of other circuits including left and right propeller autofeather systems and hence the fuel shut-off/asymmetric spoiler deployment circuits described above. The terminal block incorporates four threaded posts to each of which is secured a number of cable tags by means of a nut screwed onto each post. No 4 post carries tags M7E13 and M756 which are connected respectively to the normally closed contacts of switches 7S19 and 7S20. These switches are operated by the manual feathering control levers. The switches are connected to the two emergency feathering relays 7K6 each of which is then connected to earth, see Appendix A, Figure 2. All the circuits arriving at terminal block A6X1 are combined as a result of all four posts being joined by a metal strap. The strap is mounted within an insulated housing and is earthed to the terminal block mounting panel by means of two cables leading to individual tags, designated MO1 and MO2. These two tags are both screwed onto the mounting panel by a common single screw.

A simplified schematic diagram of the flap and feathering system wiring is shown at Appendix A, Figure 2, with a photograph of the terminal block mounting panel arrangements and earthing system shown at Appendix A, Figure 3.

1.6.6 Fuel system

The aircraft fuel system consists of four tanks, two inboard and two outboard of the engines. Each inboard tank feeds fuel to the corresponding outboard tank by jet pumps and booster pumps and thereafter fuel is delivered to the corresponding engine via jet pumps, delivery bays and centrifugal booster pumps (two on each side of the aircraft). Before reaching the engine mounted fuel control units, fuel passes through fuel shut-off valves which may be operated by means of the flight deck switches (known as Fire Cocks). Solenoid operated shut-off valves within the fuel control units are closed automatically by signals from the engine failure detection systems.

The Russian technical manual states that in the event of the second two booster pumps failing, fuel is supplied by gravity to the engines from each outboard tank. There is no reference to any associated limitations brought about by aircraft attitude. Fuel cannot be transferred by gravity from the inboard tanks.

1.7 Meteorological information

Actual weather

The actual conditions at 1450 hrs, observed at RAF Brize Norton, situated 13 nm south west of Weston, were:

Surface wind:	330°/07 kt
Visibility:	30 km
Weather:	Nil
Cloud:	4 octas at 5,000ft and 7 octas at 25,000ft

Temperature:	18° C
Dew point:	8.5° C
Sea level pressure:	1,027.7 mb

1.8 Aids to navigation

Not applicable.

1.9 Communications

The aircraft was in communication with the drop-zone (DZ) controller at RAF Weston-on-the-Green but did not make any transmissions.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

1.11.1 Cockpit Voice Recorder

The aircraft was not fitted with a cockpit voice recorder, nor was one required to be fitted.

1.11.2 Flight Data Recorder

A Pribor model BUR-1 Flight Data Recording system was fitted to the aircraft. This consisted of two separate elements; an acquisition unit, which accepted information from the sensors and assembled it into a serial data stream; and a 12 track re-cycling crash protected recorder with a duration of 50 hours. A total of 20 parameters were recorded, and an additional 29 discrete (on/off) parameters.

The recorder was taken to the premises of the Interstate Aviation Commission in Moscow for replay. No information regarding the accident flight was present on the recorder. The last recorded information was identified as having occurred on 21 August 1993. After this time the recorder had continued running but no information was being input from the acquisition unit. The entire record was examined and it was confirmed that the recorder had not prematurely changed track. Tests indicated that the recorder itself was functioning correctly. The reason for the failure to record was therefore probably due to a fault within the acquisition unit, or in the wiring connecting it to the recorder. The precise nature of the fault was not determined.

1.12 Wreckage and impact information

1.12.1 Examination of the wreckage on site

The aircraft was found to have struck the ground in a nose up, slightly right-wing low attitude with a high rate of descent and sufficient forward speed to achieve a ground slide of some 120 metres. All three landing gear units appeared to have collapsed on initial ground contact. Structural failure within the sponsons caused disruption of the struts supporting the outer wings and consequent gradually increasing anhedral of the wing structure as the aircraft slowed during the ground slide. This resulted in both wingtips and both aileron mass balance weights contacting the ground. The latter contact caused the outboard sections of both of the fabric covered ailerons to be torn off.

Although the damage was such that the underside of the fuselage was disrupted (particularly in the region of the main landing gear sponsons) and the cross-sectional shape of the fuselage was considerably altered, the floor remained almost intact and no significant penetration of the cabin occurred.

The disruption of the sponsons appeared to have caused fracture of the hydraulic lines associated with the brakes, leading to leakage and total loss of system hydraulic pressure. It was assumed that this had allowed the wingtip spoilers to retract, under spring loading, at some stage between the end of the ground slide and the time at which the wreckage was first examined by the AAIB. (Witnesses stated that the spoilers were seen to be open immediately after the accident)

The left propeller was found in the feathered position, whilst the right propeller was found to be nearer the flight range. Examination of ground markings however showed that, whilst clearly feathered at impact, this right propeller had been driven away from the feather position by forces exerted on one blade during the ground slide. A blade of this propeller had penetrated the fuselage skin to a depth of approximately 1 inch on two occasions during the ground slide. These two penetrations had occurred whilst the propeller was not rotating under power and with the penetrating blade at two different pitch angles, the first having clearly occurred with the propeller in the feathered position. The blade had not punctured the interior trim.

The final disrupted state of the wing strut attachments resulted in both wingtips being in contact with the ground when the aircraft came to rest. Accordingly, the fuel tanks were steeply inclined and precise measurement of the fuel contents could not be made. It was established during defuelling, however, that the inboard tanks were empty, whilst approximately 80 imperial gallons were present in each of the outboard tanks.

1.12.2 Detailed examination after recovery

Electrical checks were carried out in the console area with the assistance of the representatives of the Russian Department of Air Transport, after the wreckage had been recovered to Farnborough. It was found that a resistance of over 100 ohms existed between earth and connections of the terminal block A6X1 of the flap signalling system and the autofeather/fuel shut-off/asymmetric spoiler system. This resistance should have been of the order of 1 ohm if the terminal block A6X1 was correctly earthed.

Further examination showed that the immediate cause of this high resistance was the fact that the screw securing the two earthing tags of the terminal block A6X1 was loose. This was clearly not an effect of the ground impact.

A more detailed examination of the engines and propellers was carried out in conjunction with Russian specialists during the visit of a second delegation in May 1994. This confirmed that there was no evidence of pre-impact component failure in the engines or propellers.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

There was no fire.

1.15 Survival aspects

Both crew members and all 17 passengers vacated the aircraft without injury.

The aircraft was certificated for flight in the high density passenger role with 20 seats fitted in the rear cabin. On this occasion the seats had been stowed against the cabin side walls allowing the parachutists to sit unrestrained on the cabin floor.

The aircraft, which was normally fitted with twin rear 'clam-shell' doors aft of the cabin, had not been cleared for flight with these doors removed, although a Hungarian Flight Manual supplement described procedures for operation without the doors. In the event, these doors had been removed to allow for the parachuting operations. (See section 1.6.1)

Although the parachutists were not restrained, the deceleration forces during the forced landing were such that they were able to maintain their position on the floor and evacuate the aircraft, through the rear aperture, immediately the aircraft came to rest. During the impact the parachutists, who were lying in semi-reclined positions, were afforded some degree of protection by the padding of their back mounted parachutes.

Disruption to the cockpit floor in the area of both seats had occurred and the fuselage had been penetrated by the right propeller some six inches to the rear of the co-pilot, at shoulder height. However, since this propeller was not rotating under power at the time, this penetration caused only minor damage. The co-pilot evacuated the aircraft via the right-hand cockpit side window which was close to this stationary propeller blade.

1.16 Tests and research

1.16.1 The initial technical hypothesis

The representatives of the Russian Department of Air Transport visited the AAIB shortly after the accident and paid a second visit in May 1994. They had stated that after their first visit they had received a telephone call from the pilot shortly after his return to Russia, describing the details of the event.

In the light of the information relayed in his call, they had studied the wiring diagrams and system schematics of the aircraft type and had carried out discussions with the Antonov Design Bureau. As a result they evolved a hypothesis as to a possible cause of the double power loss occurring in conjunction with operation of the flaps.

The hypothesis relied on the fact that signals from the electrical flap selection switch are routed via a terminal block (A6X1), at which point this circuit became common with the circuits of the two fuel shut-off /autofeather /asymmetric spoiler deployment systems (one such circuit being energised when an engine loses power during operation at a high throttle angle). Completion of these circuits to earth is achieved by earthing of the complete terminal block via two cables and tags (MO1 and MO2) secured to the structure by a single screw. (ie as described in section 1.6.5).

According to the pilot, the two engines lost power at the same moment, just after the flaps were retracted. During such an operation the flap system is signalled electrically. Should the earthing of the flap system terminal block be unsatisfactory, the current will seek an alternative earth path.

The system negative cables M16ZH1 and M16ZH2, for respectively raising and lowering the flaps, share a common terminal block and earthing point with that of the M7E13 and M756 negative cables from the H3 contacts of the final circuit breakers 7S19 and 7S20 (of the two autofeather systems) together two further pairs of negative cables from position switches and circuit-breakers (the latter were thought not to be associated with flap or emergency system operation).

Should a high resistance exist between the terminal block and the earth, the flap current would flow to earth via the lower resistance path through the circuit breakers 7S19 and 7S20 and the two relays 7K6 of the autofeather system, thus also operating the fuel shut-off/asymmetric spoiler deployment system (see section 1.6.5). Thus, on flap selection, both propellers would feather and the fuel shut-off valves in the fuel-control units of both engines would be driven to the closed position. Fuel supplies to both engines would therefore cease, causing complete loss of power and in addition, both wingtip spoilers would extend.

The Russian Department of Air Transport representatives stated during their second visit that they had carried out a trial on another AN 28 aircraft in an attempt to reproduce the hypothetical situation described above and they subsequently supplied a report on their findings. This trial was carried out by initially disconnecting the two earthing terminals MO1 and MO2 from the structure. The resistance between the terminals and earth was then found to be 20 ohms or more, depending on the positions of engine control levers and hence the switching within the electrical circuits.

The practical trial was carried out with the flaps initially set at 15 degrees, the autofeather armed and the engines ground running under appropriate takeoff conditions. The team had then disconnected the wires MO1 and MO2 and had operated the flaps. This had achieved feathering of the two propellers, shutdown of both engines, and deployment of both outboard wing spoilers in accordance with the system logic.

Tests then showed that if manual movement of the cockpit feathering levers was not carried out, the propeller blades could be moved away from feather with the application of only slight force, whereas if the cockpit feathering levers were operated as specified in the drill for engine shutdown, movement of the propeller blades away from the feathered position required considerable force.

1.17 Additional information

1.17.1 Dropping of persons

Article 44 of the Air Navigation Order (ANO) 1989 specifies the regulations concerning the dropping of persons from an aircraft. Relevant paragraphs of this article are as follows:

> '(1) A person shall not drop, be dropped or permitted to drop to the surface or jump from an aircraft flying over the United Kingdom except under and in accordance with the terms of either a police air operator's certificate granted or a written permission granted by the Authority under this article.
>
> (4) An aircraft shall not be used for the purpose of dropping persons unless:
>
> (a) the certificate of airworthiness issued or rendered valid in respect of that aircraft under the law of the country in which the aircraft is registered includes an express provision that it may be used for that purpose and the aircraft is operated in accordance with a written permission granted by the Authority under this article; or.....
>
> (5) Every applicant for and every holder of a permission shall make available to the Authority if requested to do so a parachuting manual and shall make such amendments or additions to such manual as the Authority may require.....'

1.17.2 Aerial Work

Article 107 of the ANO 1989 specifies when a flight is considered a Public Transport flight or Aerial Work. Paragraph (9) of Article 107 is reproduced below:

> 'A flight in respect of which valuable consideration has been given or promised for the carriage of passengers and which is for the purpose of:
>
> (a) the dropping of persons by parachute and which is made under and in accordance with the terms of a written permission granted by the Authority pursuant to article 44 of this Order;

(b) positioning the aircraft for such a flight as is specified in sub-para (a) hereof and which is made with the intention of carrying out such a flight and on which no person is carried who it is not intended shall be carried on such a flight and who may be carried on such a flight in accordance with terms of a written permission granted by the Authority pursuant to article 44 of this Order; or

(c) returning after such a flight as is specified in sub-paragraph (a) hereof to the place at which the persons carried on such a flight are usually based and on which flight no persons are carried other than persons carried on the flight specified in sub-paragraph (a);shall be deemed to be for the purposes of aerial work.'

1.17.3 Restriction with respect to aerial work in aircraft registered outside the United Kingdom

Article 92 of the ANO 1989, reproduced below, details the restrictions with respect to aerial photography, aerial survey and aerial work in aircraft registered outside the United Kingdom:

'An aircraft registered in a contracting State other than the United kingdom, or in a foreign country, shall not fly over the United kingdom for the purpose of aerial photography of aerial survey (whether or not valuable consideration is given or promised in respect of the flight or the purpose of the flight) or for the purpose of any form of aerial work except with the permission of the Secretary of State granted under this article to the operator or the charterer of the aircraft and in accordance with any conditions to which such permission may be subject.'

1.17.4 Commercial arrangements and documentation

The aircraft was originally owned and operated by the Petrozavod Air Detachment. It was leased to a Moscow based company and re-leased, along with a crew and mechanics, to 'G92 Commerce' a Hungarian commercial company which had entered into a contract with the Hungarian Aeronautical Association (HAA) which was to act as the new operator. The aircraft, which held the Russian registration RA 28778, was re-registered on the Hungarian register as HA-LAJ and a Hungarian Certificate of Registration (C of R) issued, dated 27 May 1993. The Hungarian authorities, however, omitted to inform the Russian authorities that the aircraft had been re-registered. The aircraft was still therefore on the Russian register. A temporary Hungarian Certificate of Airworthiness (C of A), pending a full C of A, with a clearance for parachuting was also issued dated 27 May 1993 which was valid until 23 August 1993, but was subsequently extended until 23 September 1993.

Information obtained by the Russian Department of Air Transport representatives after the accident revealed that, although the Hungarian authorities had cleared the aircraft for parachuting and issued a Fight Manual supplement detailing the procedures to be used, the manufacturer and design authority were never consulted. The manufacturer had in fact never carried out flight trials for parachuting or for flight with the rear clam-shell doors open.

Avia Special Ltd, a UK based aircraft agent, was approached by the RAFSPA to provide an aircraft capable of carrying up to 17 parachutists for a special event being organised in August 1993 at RAF Weston-on-the-Green. Since no aircraft with this capability was available in the UK, Avia Special arranged through 'G92 Commerce' for the provision of an Antonov AN 28 for this requirement. Before the aircraft was to be sent to the UK, the HAA organised an inspection of the aircraft by representatives of the Russian Civil Aviation Authorities, an engineer from the authorised overhaul workshop at Petropavlosk, in addition to engineers from the HAA, in order to extend the validity of the C of A. This was completed and the temporary C of A, valid for one month, extended until 23 September 1993. The aircraft was insured on 5 July 1993 by the Hungarian Insurance Company and insurance cover, valid from 5 July to 30 September, which was originally for Belgium and France only, was extended to cater for operations within the UK.

1.17.5 UK regulations and procedures

In order to carry out aerial work in the UK with a foreign registered aircraft, the UK agents had to apply to the Department of Transport (DoT) International Aviation Directorate for an Operating Permit in accordance with the requirements of Article 92 of the ANO, 1989.

The normal procedure upon receiving such an application for an Aerial Work Permit involving parachuting is for the DoT to establish the nature of the work, the make and registration of the aircraft and the period of time during which it would be operating in the UK. The Certificates of Registration, Airworthiness and insurance also have to be presented for examination. Once the Certificates have been checked, the application is passed to the Civil Aviation Authority (CAA) Economic Regulation Group (ERG) for their comments. The ERG in turn pass the application to the CAA Safety Regulation Group (SRG) Operating Standards Division for their comments on the particular type of operation for which the application is being made. The SRG, having satisfied themselves that the aircraft is cleared for parachute operations, ie has been used recently for such operations in its country of registration, that the crew are competent and qualified, and that there is a Flight Manual supplement detailing parachute operations, reply through the ERG to the DoT and, subject to a satisfactory examination of the documentation, the DoT issue the Permit. Overall monitoring of parachute operations once the aircraft arrives at its operating base is overseen by the British Parachute Association which ensures that operations are conducted in accordance with their CAA Approved Operations Manual.

1.17.6 Monitoring of safety standards of foreign registered aircraft

Foreign aircraft operators conduct their operations under the authority of the state of registry. This state, if it is a contracting state of the International Civil Aviation Organization (ICAO), has a responsibility to ensure that the laid down standards and recommended practices (SARPs) concerning all aspects of aircraft operations are adhered to and maintained.

The AN 28, which was not subject to such a lease agreement to a UK Air Operator's Certificate holder, was registered in Hungary, a member state of ICAO, and as such was required to comply with ICAO SARPs. These were the responsibility of the country of registry and not of the UK CAA. The UK authorities were only concerned with those aspects relating to parachute operations and bestowed authority for the monitoring of this specific type of operation to the British Parachute Association.

Aircraft, however, that are subject to a lease agreement with a UK air carrier holding a UK AOC are subject to different regulations. These are specified in EEC Council Regulation No 2407/92 dated 23 July 1992 concerning the licensing of air carriers. The relevant extract is reproduced below:

'Article 10:

> 1. For the purpose of ensuring safety and liability standards an air carrier using aircraft from another undertaking or providing it to another undertaking shall obtain prior approval for the operation from the appropriate licensing authority. The conditions of the approval shall be part of the lease agreement between the parties.
>
> 2. A member state shall not approve agreements leasing aircraft with crew to an air carrier to which it has granted an operating licence unless safety standards equivalent to those imposed under Article 9 are met.'

In summary, only those aircraft that are subject to a lease agreement with a UK air carrier which holds a UK AOC come under the UK CAA in as much as they must comply with the same operating standards of safety as those imposed on the UK air carrier itself. The AN 28 was not subject to such a lease agreement and therefore was the responsibility of the state of registry for all matters relating to normal operations and safety.

1.18 New investigation techniques

None.

2 Analysis

2.1 General

The commander and co-pilot had previously operated the aircraft in a parachute dropping role in Hungary. Both were properly qualified, held the appropriate licences with the required endorsements and were adequately experienced on type. The aircraft had been issued, by the Hungarian authorities, with Certificates of Airworthiness and Registration, and held a valid Certificate of Insurance. The UK Department of Transport International Aviation Division, with advice from the Civil Aviation Authority Operating Standards Division, had satisfied themselves that the documentation was in order and issued an Operating Permit for parachute operations to be conducted in the UK.

However, it became apparent during this investigation that the Hungarian authorities had not notified the Russian authorities of the transfer of this aircraft from the Russian aircraft registry system, and it had thus remained upon the Russian registry. The Hungarian registration of the aircraft as 'HA-LAJ' was therefore technically invalid. Although this aspect may be considered merely an unintentional lapse in the preparation of the associated documentation, particularly since the aircraft had been subjected to an inspection in Hungary during May 1993, the validity of which was subsequently extended to 23 September to cover the proposed operations within the UK, the significance of the failure to notify the Russians of the registration of the aircraft in Hungary was that it denied the Russians the opportunity of informing the Hungarian authorities that this type had not been cleared for flight without the clam-shell doors or for parachutist training. The effect of these lapses were that the UK decisions, by the Department of Transport and CAA ERG/SRG departments, were based on documentation which was flawed and technically incorrect in terms of operating with the clam-shell doors removed, or parachuting clearance. This aspect is further discussed later.

The aircraft had successfully completed twelve flights, from RAF Weston-on-the-Green, on the day of the accident. It had been refuelled several times that day with fuel supplied from the on-site fuel bowser, and had uplifted an adequate amount of fuel and completed two successful flights prior to the accident.

On the thirteenth flight of the day, ie the third flight after refuelling, the aircraft suffered a simultaneous total power loss to both engines at approximately 500 feet agl during the flap retraction sequence. The total power loss, combined with the automatic deployment of the wing spoilers, led to a rapid decay in the aircraft's airspeed. The commander had to immediately decrease the aircraft's pitch attitude and sacrifice what little height was available in order to maintain adequate flying speed. There was no means of restoring power in these circumstances on this aircraft although there was a means of retracting the wingtip spoilers. However, with such little time available the commander's only option was to carry out a forced landing.

2.2 Aircraft performance

The aircraft became airborne with 2 crew, 17 passengers and an estimated 500 kg of fuel on board, at a reported speed of 81 kt. The estimated weight at takeoff was 5,440 kg (consisting of the following estimated weights: empty weight approximately 3,500 kg; 17 passengers at 81.7 kg each; 500 kg of fuel; 2 crew at 75 kg each; clam-shell doors removed, ie a reduction of 100 kg). At its maximum take-off weight of 6,100 kg the aircraft's stalling speed with flap selected was 67.5 kt. It was therefore estimated that the aircraft took off below its maximum take-off weight and with an adequate performance margin.

The aircraft was reported to have climbed at 81 kt to a flap retraction height of 500 feet. At this point the aircraft was accelerated to 97 kt. The stalling speed, at maximum weight and with no flap was 73 kt. During the flap retraction sequence, therefore, the commander operated the aircraft to maintain an adequate speed margin above the stall to ensure safe flight.

2.3 Crew actions

According to the commander, the takeoff and climb were flown in accordance with the recognised procedures and at the correct speeds. At the flap retraction height of 500 feet agl the co-pilot selected the flap 'in' by three rapid selections of the flap selector switch. During this selection, both engines suffered simultaneous power loss. This failure came as a complete surprise to the crew who had a very little time in which to analyse the situation. Loss of power combined with a increase in aerodynamic drag from the automatic wing spoilers meant that the commander's only course of action was to immediately establish the aircraft in a controlled descent, maintain flying speed and carry out a 'power off' forced landing.

The commander had a limited choice of landing sites because of his very low altitude. He managed, however, to select a large level field of stubble and carried out a safe landing, although in the event the aircraft was damaged beyond repair. Damage to the airframe was consistent with a high rate of descent at touchdown, which was understandable given the conditions. The total power loss, combined with the increased drag from the spoilers, had led to a lower than normal pitch attitude and higher rate of descent. The slipstream effect over the elevators, normally provided by the propellers, was absent thereby making them less effective. Being placed in this unusual situation at short notice, the commander would have commenced the flare to land at normal height above the ground and with the same elevator deflection as for a powered approach. A reduction in control effectiveness from the elevators, but more importantly the greatly changed wing lift/incidence relationship in addition to the high descent rate before touchdown, would have produced the very heavy landing evident in this accident.

After the aircraft had come to rest, the crew carried out the emergency shutdown drills. The commander did not have time to order an evacuation as the passengers, being experienced parachutists, had already left the aircraft by the aft aperture.

During the initial flights that day a parachute club official had accompanied the crew to ensure that operations were being carried out in accordance with the British Parachute Association Operations Manual. Communications, in this highly specialised task, between the crew and jump supervisors were by hand signals. This is normal procedure since noise levels within the cabin are high and intercom facilities often limited. It was also essential in this case as the crew could speak only limited English. The emergency situation experienced that day was straight forward and the actions required of the passengers were obvious. There must be some doubt, however, in the effectiveness of the crews communications and lack of English, had the emergency situation been more complex, requiring more complicated inter-cabin liaison.

2.4 Cause of double engine failure

2.4.1 Validity of technical hypothesis

The hypothesis presented by the Russian Department of Air Transport representatives during their visit was a convincing theory as to a cause of a sudden total power loss, given the arrangement of the automatic fuel cut-off system in the AN 28 type, the particular details of the earth wiring arrangements described in section 1.16 and the defect found in HA-LAJ. The delegation also stated that they had carried out a practical trial on an AN 28 aircraft to verify the hypothesis. The trial was carried out with both earth connection leads of terminal block A6X1 disconnected from earth and it is understood that the engines were operated at take-off power. Operation of the flap switch then resulted, as expected, in propeller feathering, engine stoppage and deployment of both spoilers.

Examination of the relevant area of the wreckage, after the results of the above trial were described, confirmed that the screw attaching the two earth leads to the terminal-block mounting panel was loose (see section 1.12.2). Electrical tests confirmed that this resulted in a very high resistance between the terminal block A6X1 and earth. Looseness of the screw was clearly not an impact feature.

This looseness created electrical conditions which were exactly as simulated by the conditions of the reported trial. The increased resistance of the normal earth path from terminal-block A6X1, (approximately 100 ohms as opposed to a normal figure of approximately 1 ohm) arising from the loose screw, was greater than the minimum possible resistance to earth via the autofeather system relays. (The exact resistance of this path depends on the position of switching in the autofeather circuits). Hence the earth current took the lowest resistance path available, in the absence of a direct earth connection, energising both autofeathering relays as it did so, leading to feathering of both propellers and operation of the emergency automatic shutdown systems on both sides of the aircraft.

This hypothesis was confirmed by the results of the reported trial, providing clear confirmation that it was indeed an accurate representation of what had happened to the aircraft.

Although the earthing screw was loose at the time it was examined, it is reasonable to suppose that progressive slackness had developed over a period and that the resistance between the cable ends (MO1 and MO2) and earth would have varied with conditions of acceleration and vibration. The slackness may therefore have been present for a period before the critically high resistance between the terminal ends and earth occurred co-incident with flap retraction.

Crew, occupants and ground witnesses all stated that both engines lost power at the same moment. Examination of the aircraft and ground marks indicated that both propellers were in the feathered position by the time of impact. A photograph taken of the aircraft during its descent showed both spoilers to be in the open position and witnesses confirmed that the spoilers were open on the ground immediately after the accident.

Since a spoiler can only be opened as a result of a propeller feathering and engine shutdown sequence occurring and both spoilers were open during the final descent of the aircraft, both left and right propeller feathering/engine shutdown systems must have operated inadvertently, causing complete loss of thrust.

The analysis of the wiring arrangements and the results of the Russian trial both showed that the loose earthing screw would cause inadvertent thrust loss and spoiler deployment as the flaps were operated. The aircraft took off with flaps deployed in the normal way; the flaps were found to be retracted after impact and the crew reported that the power failure occurred as the flap retraction was in progress.

An assessment of the fuel system arrangements, in the context of the measured amount of fuel remaining after the accident, was carried out. This did not suggest that fuel starvation due to fuel shortage, fuel system failure or system mismanagement was a factor in the loss of engine power. It was not possible to visualise any other scenario which could cause such a sudden double power loss.

There could thus be no doubt that the flap operating current had energised the feathering relays, as a result of the slackening of the screw securing cables MO1 and MO2 to the panel and this was the direct cause of the thrust loss and spoiler deployment.

2.4.2 Design features of wiring

The original design of the wiring, incorporating two earth cables MO1 and MO2, appears to have been carried out with the intention of ensuring an element of redundancy, to safeguard against a loss of continuity between earth and those circuits arriving at terminal block A6X1. At some stage between the original evolution of the wiring system design and the production of detail manufacturing drawings, however, the earth redundancy of the design was lost and a single point failure mode became possible.

In practice, combining the earthing of a number of circuits on a single terminal block, which was then separately earthed, was not a sound design philosophy. Even had two separate earth lead attachment screws been used, no means of detecting loss of continuity via one screw would have been readily available, leaving a dormant failure possible.

Widely used design principles for identifying common-mode failures, if applied at the stage when manufacturing drawings were available, should have revealed the potential hazard of any common earth arrangement in this area. Automatic safety systems such as the autofeathering/engine shutdown arrangements on the AN 28 demand a high level of integrity. This, in practice, requires individual earthing of each system and/or provision of effective reverse current protection.

Internationally recognised independent certification processes such as European Joint Airworthiness Requirements (JARs) and Federal Aviation Requirements (FARs) have for many years required manufacturers to demonstrate that their designs for production aircraft have been evaluated to ensure that multiple failure modes or inadvertent operation of critical systems due to single defects cannot occur, or that their occurrence is a very remote possibility.

Study and elimination of common mode failures was normal practice in the design of western built aircraft after approximately 1950, and more sophisticated fault-tree analysis became routine after about 1960.

Electrical functions considered vulnerable to inadvertent operation from stray current flow in miscellaneous failure situations have been protected by reverse-current diode systems as a fundamental feature of aircraft electrical design for over 40 years.

It is not known if corresponding philosophies were in routine use in the USSR in general or in the Antonov Design Bureau at the time that the AN 28 was designed. It is unlikely, however, that any corresponding process was applied to the systems design and construction of the AN 28 once the alteration to cable routing was made (apparently after the Antonov Design Bureau ceased to have total control of the production standard). Effective reverse current protection is not incorporated in the relevant part of the autofeather/engine shutdown/spoiler deployment systems, although diodes are present in other parts of the system, presumably as a form of protection effective in some failure conditions.

Antonov design drawings, although not to a convention familiar in the FAA/JAA states in the west, appeared to show that independent earthing points were originally intended to be provided for the cables MO1 and MO2, hence duplicating the earthing of terminal block A6X1. However, this independence was lost by alteration to a single earth point at some time between initial system design and entry into production.

The international aspects of systems design philosophies are defined in ICAO document Annex 8, Airworthiness of Aircraft, which states, in summary, that aircraft of a contracting state shall be acceptable for operation in airspace of another contracting state provided they are designed to comply with the standards of the country of manufacture. This generally, in western operation, involves design in accordance with widely accepted standards such as FARs, JARs, British Civil Airworthiness Requirements (BCARs) etc.

In cases where these are not used, particular national regulations of the country of manufacture are used. It is understood that the AN 28 (although built in Poland) was designed either in accordance with an early issue of the NLGS code used in the USSR, or was a military design which had been issued in the USSR with a certificate accepting its military design standard as being suitable for civil use. The ICAO ruling basically enables foreign manufactured aircraft to operate in UK airspace without undergoing any airworthiness evaluation outside the country of design.

The precise design/constructional features of the AN 28 which led to this accident could be construed as not being in compliance with certain provisions of ICAO Annex 8, in particular section 4.1.6 (a) which states that 'The design of the controls and control systems shall be such as to minimise the possibility of jamming, inadvertent operations and unintentional engagement of control surface locking devices' and section 7.1.1 which states that 'The powerplant installation shall comply with the standards of Chapter 4......' It is not known how these ICAO provisions were addressed in the design code used for the AN 28 type.

2.5 UK regulations and procedures

The operators of the AN 28 wished to conduct specific aerial work operations within the UK. Thus they had to apply, through their UK agent, to the Department of Transport (DoT) International Aviation Directorate for an Aerial Work Permit. The DoT, in processing the application, had to ensure that they received and retained copies of the aircraft's Certificates of Registration, Airworthiness and Insurance. They also considered the economic implications of allowing a foreign registered aircraft and crew into the UK to conduct operations which might have had a detrimental effect on similarly equipped UK companies. All the documentation presented appeared in order, but before the Permit could be issued the DoT had, as was customary, to approach the Civil Aviation Authority (CAA) for advice on the suitability of this particular type of aircraft to carry out the operations applied for on the Permit.

The DoT approached the CAA, making their first contact with the CAA Economic Regulation Group (ERG). This division of the CAA (whose function in this regard has since ceased), however, merely acted as a 'post-box', and forwarded the request to the CAA Safety Regulation Group (SRG). The SRG, with the assistance of personnel with parachuting expertise, confirmed that the aircraft had been used for parachuting operations in its country of registration (ie 'Hungary'); that the crew had been involved in parachuting operations previously; inspected the documents submitted with the application; and confirmed that the Flight Manual contained a supplement detailing the procedures and limitations for parachute operations. In reality the documentation was incorrect in that the aircraft had never been cleared for the parachuting role by the Antonov Design Bureau and furthermore the aircraft was not cleared for flight with the rear clam-shell doors removed. The CAA have since stated that "the SRG had no reason to doubt the validity of the documents submitted". Whilst this was evidently the case in this instance, when the documents appeared to meet normal requirements, the fact that such a process of assurance could be so easily thwarted by incorrect documentation gives rise for concern.

Having received a response from the SRG confirming that the aircraft and crew were suitable, the DoT duly issued the Permit.

The Permit application process concerned, in the main, examination of documents presented to ascertain that the aircraft was correctly certificated, insured, suitable for parachute operations and that the crew were qualified and experienced in that role. Operations, once the aircraft had arrived in the UK, were overseen by personnel representing the British Parachute Association. They were only concerned with the parachuting element of the flights, as were the CAA SRG. Engineering design practices, aircraft maintenance, crew competence and the day-to-day operations of the aircraft were deemed to be satisfactory by virtue of the fact that the aircraft was registered in a Contracting State of the International Civil Aviation Organization (ICAO) and as such would be airworthy, maintained and operated to recognised standards. However, evidence from this accident suggests that certain elements of these perceived standards fell short of those presumed by the UK authorities. As a result of such findings, the following safety recommendations are made:

The Civil Aviation Authority Safety Regulation Group should enhance their existing procedures and consider checking directly with the corresponding regulatory authorities in the countries of design, manufacture and registry of aircraft from former USSR states before issuing associated Aerial Work Permits in order to verify that the submitted documentation correctly reflects the registration, airworthiness certification and technical status of such aircraft.

and

The Civil Aviation Authority should develop an increased awareness of the aircraft design and manufacturing philosophies which have been, and are being, utilised in the former Soviet Socialist Republics.

3 Conclusions

a) Findings

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

(ii) The Aerial Work Permit which was issued by the UK Department of Transport International Aviation Directorate was based on submitted documentation which was technically invalid in that the aircraft had not been deleted from the Russian aircraft registry before being registered in Hungary, and had not been cleared by the Antonov Design Bureau for flight with the cabin clam-shell doors removed, or for parachutist operations.

(iii) The aircraft had both Russian and Hungarian Certificates of Airworthiness at the time of the accident.

(iv) The estimated weight and loading of the aircraft were within limits at the time of the accident.

(v) The aircraft suffered a simultaneous power loss from both engines, in addition to automatic deployment of both outer wing spoilers, as a result of the effects of intentional retraction of the electrically signalled flaps upon the propeller autofeathering systems, engine fuel shut-off valves and wing spoilers.

(vi) The presence of a dormant loose earthing connection at a common earth terminal permitted an electric current to flow from the flap signalling system, upon flap retraction selection, to both propeller autofeathering systems, which caused automatic closure of both engine fuel shut-off valves and operation of both asymmetric spoiler systems.

(vii) The AN 28 had apparently been designed with dual earthing points for the flap signalling and propeller autofeathering circuits but during manufacture of this type in Poland a single earth installation for both systems had been implemented locally as the build standard.

(viii) The reason for the flight data recorder's failure to record the accident flight, or any previous flights after the 21 August 1993, was not determined.

(ix) The procedures used by the UK Department of Transport International Aviation Directorate in conjunction with the CAA Economic Regulation and Safety Regulation Groups to validate the granting of Aerial Work Permits to aircraft from former USSR states, whilst completely in accordance with accepted practice were nevertheless flawed due, essentially, to implicit reliance upon submitted documentation without any associated independent checking of aircraft status with the Departments of Transport of the countries of design and manufacture.

b) Causes

The investigation identified the following causal factors:

(i) A latent defect in the electrical system caused a simultaneous total power loss as the flaps were retracted at 500 feet agl on climb out, with automatic operation of both asymmetric spoiler systems.

(ii) The latent defect had been caused by progressive loosening of a single earthing screw, which provided a common earth point for the flap electric signalling and propeller autofeathering systems, which induced a high resistance to earth at this point and caused feathering of both propellers when flap retraction was selected, in addition to automatic closure of both engine fuel shut-off valves (within the fuel control units) and extension of both outboard spoilers.

(iii) At manufacture in Poland a single earthing point had been installed which was not in accordance with the design requirements for this aircraft type as issued by the Antonov Design Bureau, which had required dual combined earthing terminals for the flap signalling and propeller autofeathering systems.

(iv) The Antonov Design Bureau had never cleared this type of aircraft for flight with the aft clam-shell doors removed, or for parachute training.

(v) This aircraft had been incorrectly granted an Aerial Work Permit for parachuting operations in the UK by the Department of Transport, assisted by the CAA, as a result of implicit reliance upon submitted documentation which was subsequently proven invalid.

4 Safety Recommendations

The following Safety Recommendations were made during the course of this investigation.

4.1 The Civil Aviation Authority Safety Regulation Group should enhance their existing procedures and consider checking directly with the corresponding regulatory authorities in the countries of design, manufacture and registry of aircraft from former USSR states before issuing associated Aerial Work Permits in order to verify that the submitted documentation correctly reflects the registration, airworthiness certification and technical status of such aircraft.
[Safety Recommendation No. 95-8, made March 1995]

4.2 The Civil Aviation Authority should develop an increased awareness of the aircraft design and manufacturing philosophies which have been, and are being, utilised in the former Soviet Socialist Republics.
[Safety Recommendation No. 94-34, made September 1994]

E J Trimble
Inspector of Air Accidents
Air Accidents Investigation Branch
Department of Transport

March 1995

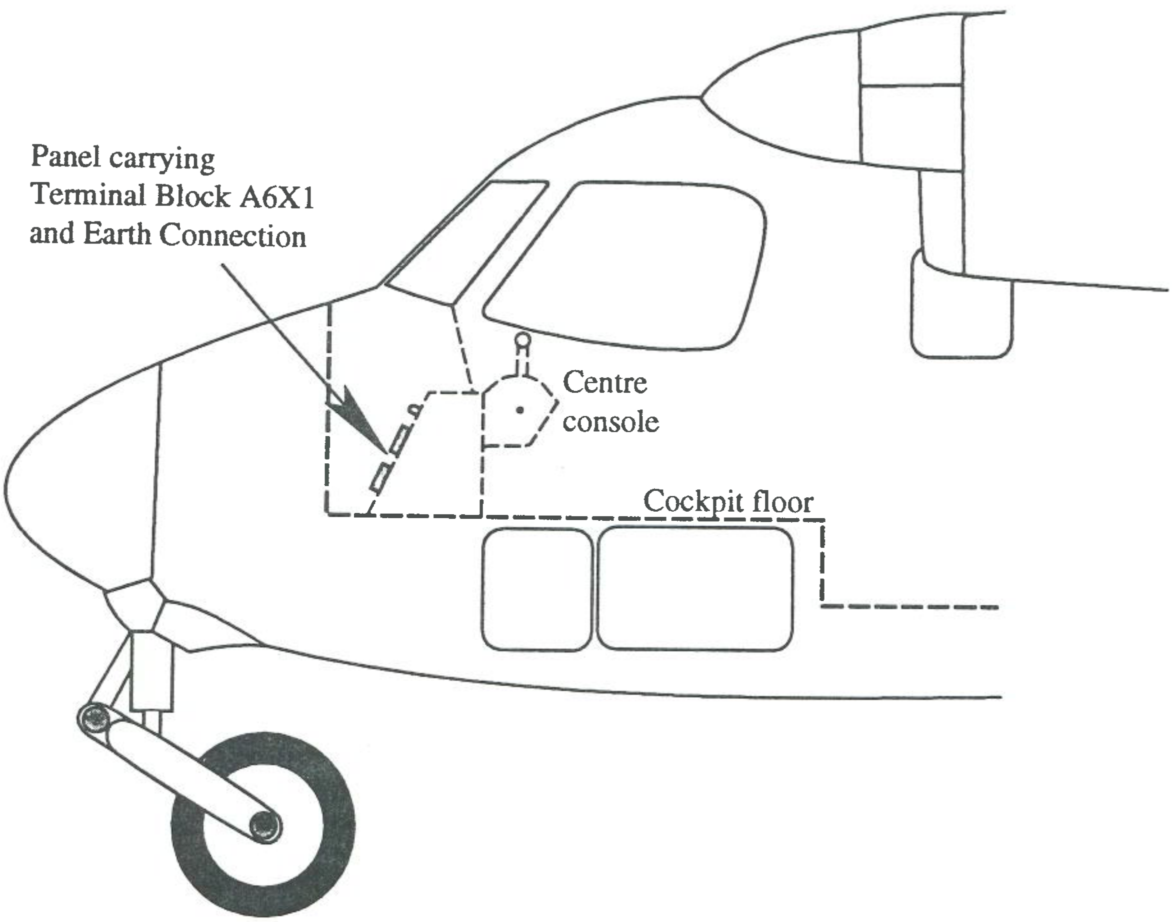

Figure1 Diagram showing location of terminal block A6X1 and associated earth connection on forward face of centre console in cockpit

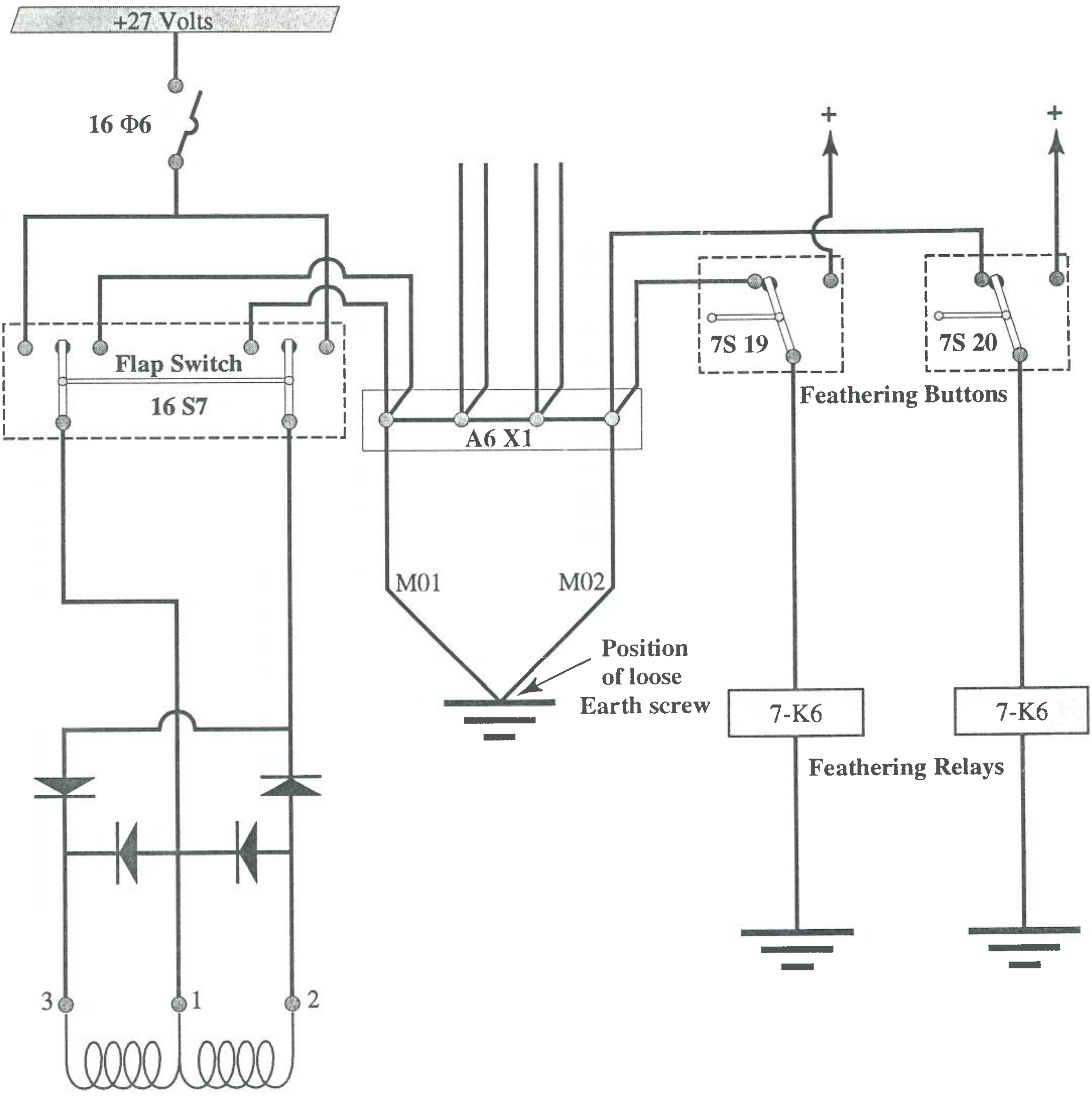

Figure 2

Showing schematic diagram of wiring connections between the flap selection and propeller feathering systems and the terminal block A6 X1 combined earthing point.

Figure 3 Showing terminal block A6X1 with loose earthing screw arrowed

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