Getting the DC-10 under control

The real reason for the Chicago crash, and the present state of the DC-10's safety record: PAUL EDDY, ELAINE POTTER and BRUCE PAGE * report.

WHEN AN AIRLINER CRASHES, trusty reflexes assume command in newspaper and television offices. Swiftly, some slight component – pin, tube or cable – is produced, and illuminated as the author of disaster. And last week's crash at Chicago, making the McDonnell Douglas DC-10 into a kind of grisly record-holder among modern commercial aircraft, evoked a classic response. According to the *Daily Mail,* 200 tons of aeroplane and 273 people had come to ruin because of fracture in a bolt 'the size of a man's finger'.

Two desires are satisfied thus. Pop media like drama along for-want-of-a-nail-the-kingdom-was-lost lines. And – assuming 'human error' cannot be blamed – the aerospace industry prefers any account of an accident which avoids the idea that large, systematic deficiencies might exist in any of the costly machines it builds. But this time, the pretence collapsed quite rapidly. True, the US Federal Aviation Administration (FAA) began with a mild demand that all DC-10s be checked over for the state of their engine-pylon flutter-bolts. These are indeed no larger than a man's finger, but considerably easier to replace, and operators throughout the world – including our own Freddie Laker – were eager to display themselves complying.

Then, four days after the crash, came a thunderbolt. Brusquely the FAA ordered all DC-10s grounded, pending complete examination of the pylon structures which hold their wing engines in place. Evidence of metal fatigue was so grave as to leave the Administrator 'no choice'. Surely it was now clear, we asked the FAA office in Chicago, that they were worried about something more than a bolt? 'We are worried about the whole airplane', said Mr. Neil Callaghan bluntly.

ABOUT TIME, some might say. When a Turkish DC-10 crashed outside Paris in 1974, killing its largely British complement of 346 people, there was the same initial concentration on small bits of metal; there, an ill-designed lock which let a cargo-door blow out. But the Paris plane did not die because of a lost door, any more than the Chicago plane died because an engine fell off – undesirable, aeronautically, as either event must be. Lethality arose each time because catastrophic loss of control followed from the failure of a component which was not in itself essential.

An engine from the American Airlines' DC-10 lies in the foreground as rescue workers flag spots where bodies have been found north west of Chicago's O'Hare airport.

Associated Press

At Paris, loss of the door depressurised the cargo-hold at 12,000 feet: high-pressure air in the passenger-cabin above collapsed the floor between the two compartments. The hydraulic power and control lines running from cockpit to tail are carried under the floor in a DC-10, and they were immediately severed.

At Chicago, similar ends followed from other beginnings. Pylon-mounted engines (as our drawing shows) are slung below and ahead of a wing: the weight of the whole assembly being fixed to the wing in the DC-10, about half-way back along the join, by a tough group of vertical bolts called the 'tombstone'. Of course the engine, thrusting forward, tries to swing upon the tombstone, and will pitch up over the wing unless restrained by other fastenings at the rear.

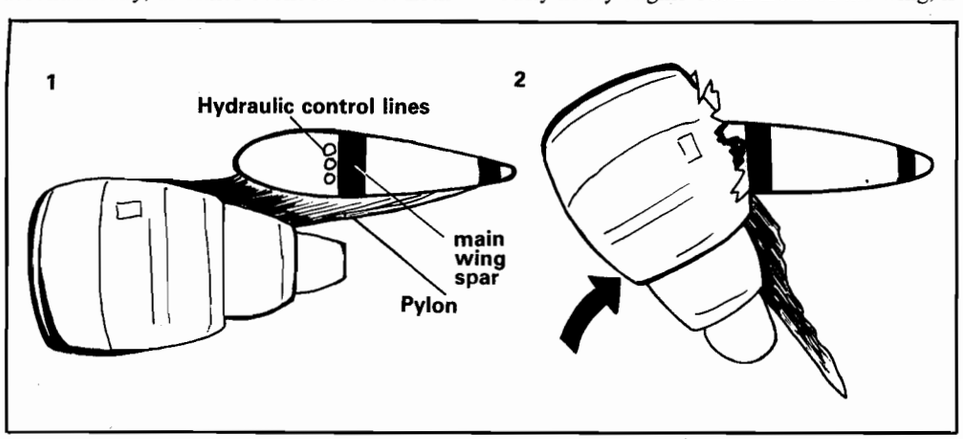
But the pylon assembly, holding an enormously heavy engine out in front of the wing, is also apt to 'flutter' from side to side as the engine pours out its fifteen tons and more of thrust. These movements are restrained by horizontal bolts, or pins at the point where the pylon joins the leading-edge of the wing. One of them broke away from the No. 1 (left-hand) engine pylon as American Airlines Flight 191 passed the 8,000-yard mark in its take-off run last Friday.

Flutter would have built up quickly with the engine at take-off power, and within seconds the vertical bolts at the rear of the pylon snapped. The engine tore loose, pitched over the top of the wing, and fell away. The DC-10 was just lifting off the runway: the point at which the second pilot, watching the instruments, calls out 'VR' to the captain. (On this occasion he said, 'VR-damn', after which the cockpit voice-recorder is blank.)

AIRLINE SPOKESMEN have been swift to explain that loss of one power-source need not prevent a three-engined plane from taking-off safely – which is true enough. They have been less ready to explain why the DC-10 should nonetheless have crashed. But inquiries with crash investigators suggest that it happened because, as the engine reared up (see drawing), it wrecked the control lines carried on the front of the wing's mainspar. Their vital hydraulic pressure can be vented as readily there as under the cabin floor, just as human artery-systems may be opened with deadly effect in many places. Without hydraulic power a big jet is uncontrollable.

The crew must have been quite helpless as the DC-10 climbed for a few crazy seconds, rolled and then smashed into the ground.

Only detailed investigation will show whether loss of *all* control was inevitable. But already there are questions to be raised about the relative vulnerability of the DC-10.



Once metal fatigue allows the DC-10 engine pylon to fail – as at Chicago – the engine at take-off power pitches up over the wing, wrecking vital control lines on the way.

Associated Press

Human remains at Chicago

According to the FAA, urgent inspection has shown evidence of serious metal fatigue not just in 'finger-sized' flutter-bolts, but elsewhere in the pylon (for a time the grounding directive extended to all US examples of the European A-300B Airbus, which uses similar engines mounted somewhat similarly.) So far, however, there has been no directive against the other 'jumbos' – the Boeing 747, and the Lockheed Tristar, which is the DC-10's direct but so far unfavoured rival in the marketplace. Both use pylon engines, but apparently without exhibiting dangerous metal-fatigue. Both have the hydraulic lines in their wings mounted *aft* of the main spar – safer, if it is assumed that impacts will generally come from the front. And, perhaps more important, both have four independent hydraulic systems where the DC-10 carries only three.

The safety of an aircraft is largely about having defences in depth: comparison after Paris showed that both the Tristar and 747 had deeper defences against floor collapse (indeed, the 747's controls were almost immune to such an event), and so far the evidence from Chicago reinforces the message.

SO, IN TWO disasters the DC-10 has killed 617 passengers and crew. In addition, the debris from the Chicago crash wiped out two bystanders, and, in November 1973, one passenger fell 39,000 feet to his death after being forced out of a cabin window which was shattered by shrapnel from a disintegrating engine. All of which means that the DC-10 has proved almost twice as lethal as its three wide-bodied competitors *put together*: the European Airbus has so far killed no one; the Lockheed Tristar killed 99 people in Florida in 1972; and the Boeing 747's toll is 371 from two crashes, one in Nairobi, the other near Bombay. (Our calculations leave aside the March 1977 Tenerife tragedy which resulted in 575 deaths. Since that was caused solely by the decision of the pilot of one 747 to take off while another 747 was still on the runway, the blame can hardly be laid at Boeing's door.)

Of course, to truly compare the lethality of rival aircraft one has normally to take into account various factors – the numbers of each aircraft in service, the total of hours flown, the number of take-offs, and so on. Hence, it is not easy to make a valid comparison between the Tristar and the 747: Lockheed's plane has killed fewer people but there are twice as many 747s which have racked up millions more miles. Equally, the Airbus has a virginal record but then, as a comparatively scarce newcomer, so it should.

No statistics can, however, save the DC-10's performance from being outstandingly bad, not because of the number of its disasters, but their nature. Most aircraft accidents result from an unhappy conjunction of human error, bad weather and, perhaps, sloppy design of a control or an instrument, and that applies, in some measure, to all the 747/Tristar crashes. But twice now a DC-10 has fallen out of a clear blue sky because of catastrophic control failure which left the pilots helpless. And there have been, at the very least, two near disasters which but for grace would have pushed the DC-10 toll to well beyond 800.

In June 1972, in an incident which clearly foreshadowed the Paris tragedy, an American Airlines DC-10 lost a rear cargo door over Windsor, Ontario. The passenger cabin floor collapsed, severing most of the control cables, and only the fact that the aircraft was lightly loaded – and the considerable skill of the pilot – saved the lives of the 67 people on board.

Then, in November 1975, 139 people barely escaped when one engine of their Overseas National DC-10 blew up during the take-off run at Kennedy Airport, New York. The pilot managed to pull up before the end of the runway, although yet another hydraulic failure robbed the plane of 50 per cent of its braking power. The undercarriage collapsed and the fuselage was engulfed in flames; by great fortune the passengers were all airline employees, practised in evacuation procedures, and no one was seriously hurt.

The investigations into these two accidents left deeply worried men. After Windsor, an engineer named Applegate – who worked for a DC-10 sub-contractor – wrote his now famous memorandum predicting that cargo doors would open, cabin floors would collapse and '... I would expect this to usually result in the loss of the airplane'. Post-New York, the investigators for the National Transportation Safety Board came to the conclusion that the DC-10 engine was 'susceptible to catastrophic failure'. It is hard to say how much those worries permeated the McDonnell Douglas boardroom. It is easier to see how, since the day the plane was conceived, an abiding concern there has been whether the DC-10 might support itself not only aerodynamically, but financially.

AND INDEED THE DC-10 was born out of one of the most savage marketing conflicts in civil-aviation history. In the sixties it became clear that big fan-jet engines would make possible a new generation of 'wide-bodied' air-buses, and Boeing established a commanding lead in the long-haul section of that market with the remarkable 747. Two ailing firms were left to struggle for the medium-haul business: Lockheed, which was trying to return to the civil market after years of over-dependence on defence, and Douglas, once the world's greatest builders of commercial aircraft, reduced to chaos and penury by the eccentricities of its founding-family.

Douglas was taken over by the aggressive military-aircraft builders McDonnell, and late in 1967 the new McDonnell Douglas Corporation announced that it was going to try to catch up on the lead of nearly one year that Lockheed had established in the race to get order for a three-engined airbus. This was a contest of 'paper aircraft', in which both sides made larger and larger promises: when Lockheed slashed their price by a million dollars a plane, McDonnell Douglas countered with a half-million cut, and other attractions. Neither firm had decided which make of engine to favour for its theoretical airliner, so rival engine manufacturers entered the field with further promises to airframe firms and airline companies alike. What nobody really expected – or wanted – was that both paper planes would actually be built. For to get both Lockheed and Douglas into profit with actual projects would require 500 tri-jets to be sold. For a moment it seemed that the Lockheed Tristar, fuelled with British government help through the Rolls-Royce connection, might have a decisive lead in orders. But then United, the largest airline in the western world, chose McDonnell Douglas's DC-10. Thus, the paper-chase had been inconclusive: both aircraft would have to be built, with survival likely to go to the firm that got its machine into airline service before the other.

Under McDonnell management, the motto at the old Douglas works became FLY BEFORE THEY ROLL: that is, have the DC-10 flying before the Tristar could even be rolled out of its hangar. And not only did they wipe out Lockheed's initial lead: they produced the DC-10 some nine months earlier. Nobody seriously doubts that this remarkable performance was a major factor in the DC-10's superior market performance, and there are now 274 DC-10s in service compared to 163 Tristars. McDonnell Douglas are into profit with the DC-10, while Lockheed still have a long and weary way to go.

But the promise of the new, big jets was that they might be safer than any aircraft seen before: and it may be doubted whether McDonnell Douglas allowed enough time for all the technologies to mature that could make that promise true. Three hydraulic systems, unlike four, meant no real step forward from previous aircraft (with far fewer lives on board). Notoriously, McDonnell Douglas designed a highly-inadequate system of cargo-door locks. What is still too little known is the firm's inability to perceive the danger-signals which were produced in design, testing and early service, and which pointed to the vulnerability of the control-system.

Casual inspection shows that the DC-10's central engine is stuck up above the fuselage: in some respects, a simpler solution than building the engine into the fuselage, as with other tri-jets. But more subtly, rudder-power is sacrificed, with potentially awkward consequences for directional and lateral control, especially at take-off. Both the 747 and the Tristar could claim, in some respects, to include substantial and wholly-new safety-features: in the case of the DC-10, for all the commercial success attending it, there do not seem to be many improvements upon its smaller and simpler predecessors.

Under the FAA's new dispensation, even those DC-10s which have passed their pylon-fatigue examination will have to be re-checked every 100 flying-hours (or 10 days, if that is sooner). Meanwhile, Lloyd's members are bracing themselves for claims of perhaps $100 million in compensation for the lives of the latest casualties, and the investigation into the nature of the DC-10 continues.

**Eddy, Potter and Page were joint authors of* Destination Disaster *(Granada Publishing, 1976) which resulted from a two year investigation into the Paris DC-10 crash of 1974.*