The Achilles' heel of the big jets

JUST BEFORE 10.30 on a grey September morning in 1980, Captain James Brown radioed the control tower at London Heathrow airport that Pan American's flight to Miami had begun its take-off run: "Clipper 99 is rolling". The DC-10 jet, with 237 people on board, began accelerating down runway 28Right. Neither the captain nor the mechanics who had just inspected the airliner had any way of knowing that it was unsafe.

In the conditions that day, Flight 99 had to reach a speed of about 200 mph to get airborne. It had accelerated to 160 mph, and used up almost half the length of the runway, when one of the DC-10's 12 tyres burst. The chain of events that followed exemplify an increasing hazard of the jumbo jet era.

With hindsight, experts from the Accident Investigation Branch (AIB) of the Department of Trade had no difficulty in establishing the "probable cause" of the burst. The tyre was six years old, it had been retreaded *seven times*, and its ageing carcass had almost certainly been subjected to "overload" during a landing the previous day. But three out of four airline tyres are retreads. And hidden imperfections in the carcass of even a new tyre will not be discovered by routine inspection.

So the risk of tyre failure is always present. And actual bursts are a surprisingly frequent occurrence: for instance, the past three monthly issues of British Airways' internal Safety Review report nine tyre-burst "incidents" which escaped public attention because they did not lead to accidents.

What is more alarming, and what the AIB investigators describe as a "highly unsatisfactory state of affairs", is the fact that a tyre burst on a jumbo jet is liable to set off a domino effect which can turn simple mishap into possible disaster.

CAPTAIN Brown and his crew did not know a tyre had burst: like all airliners except Concorde, the DC-10 has no warning system to monitor the undercarriage. They therefore allowed the 230-ton jet to continue accelerating towards the critical point known as V-1. Beyond this point, according to careful pre-flight calculations, the take-off *must* continue,

Alarm raised

because there is not enough runway left for the aeroplane to stop.

Analysis of Clipper 99's cockpit voice-recorder shows that the alarm was raised too late. The driver of a runway inspection van, which happened to be nearby, radioed the warning, "DC-10's burst its starboard tyre" at exactly the moment one of the flight crew called out "V-1."

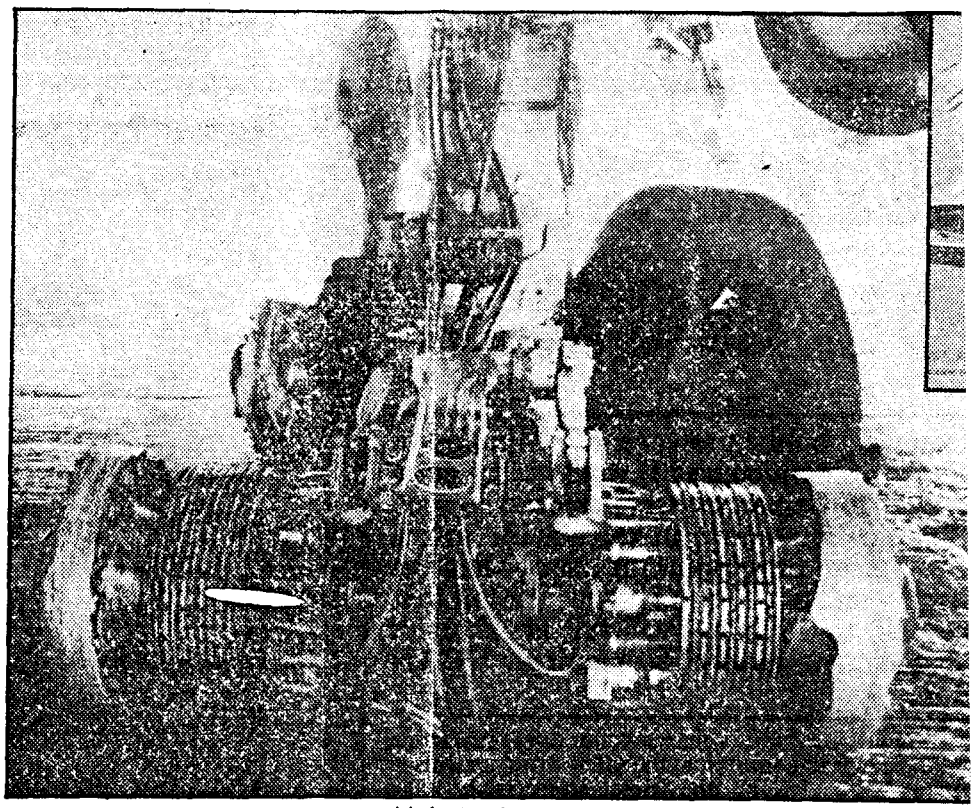
Everything in the rule book said that the crew should have tried to get the DC-10 into the air, where they could assess the damage, dump fuel to lighten the load and give the airport authorities time to prepare for an emergency landing. Indeed, the co-pilot, who was at the controls, lifted the nose to put the airplane in the correct take-off attitude.

But Captain Brown could not know how much damage had been done, or what was causing the severe vibration that was by then shaking the plane. Employing "inspired guesswork aided only by experience", he decided the less dangerous course was to abandon the take-off, and he seized the controls. At that moment, the domino effect set in.

Because of their sheer scale, the big jets can afford to carry more back-up systems than conventional airliners, and are therefore likelier to survive an emergency. For example, a Boeing 727 has two hydraulic systems to provide power for control surfaces such as the rudder; a Boeing 747 has *four* hydraulic systems, any of which can provide the necessary power.

But simply by increasing the number of wheels on the big jets – there are only six on the main undercarriage of a 727 but 16 on a 747 – rather than re-designing undercarriages from scratch, the jumbo jet designers arguably made "critical failures" *more* likely.

The problem is that current tyre technology can barely cope



with the huge weights and the comparatively high take-off and landing speeds of the big jets. The tyres are built to withstand no more than one-and-a-half times the normal load. But tests carried out in the United States have proved that if one tyre fails, then its "mate" on the same axle is put under twice the normal strain – and is likely to burst as well.

As Captain Brown made his decision to abandon the take-off at Heathrow, that is exactly what happened.

The DC-10 was still hurtling towards the end of the runway, at 198 mph, when debris from the second burst tyre punctured a third. At that point, Brown put the engines into reverse thrust and slammed on the brakes, which sent the plane veering to the left. The strain caused the fourth and last tyre on the right-hand undercarriage to fail.

Finally, as Clipper 99 came to a shuddering halt, with just 360 feet of runway to spare, the control tower could see that the undercarriage was ablaze: "You have a fire," a controller told Brown. "Yes, You have a fire. I should get out if I were you."

Brown's unorthodox decision to abandon take-off was justified by the result. The only injuries occurred when the passengers evacuated the ing jet via the emergency and the worst of those broken leg. But other placed in jeopardy by bu tyres have not been so nate.

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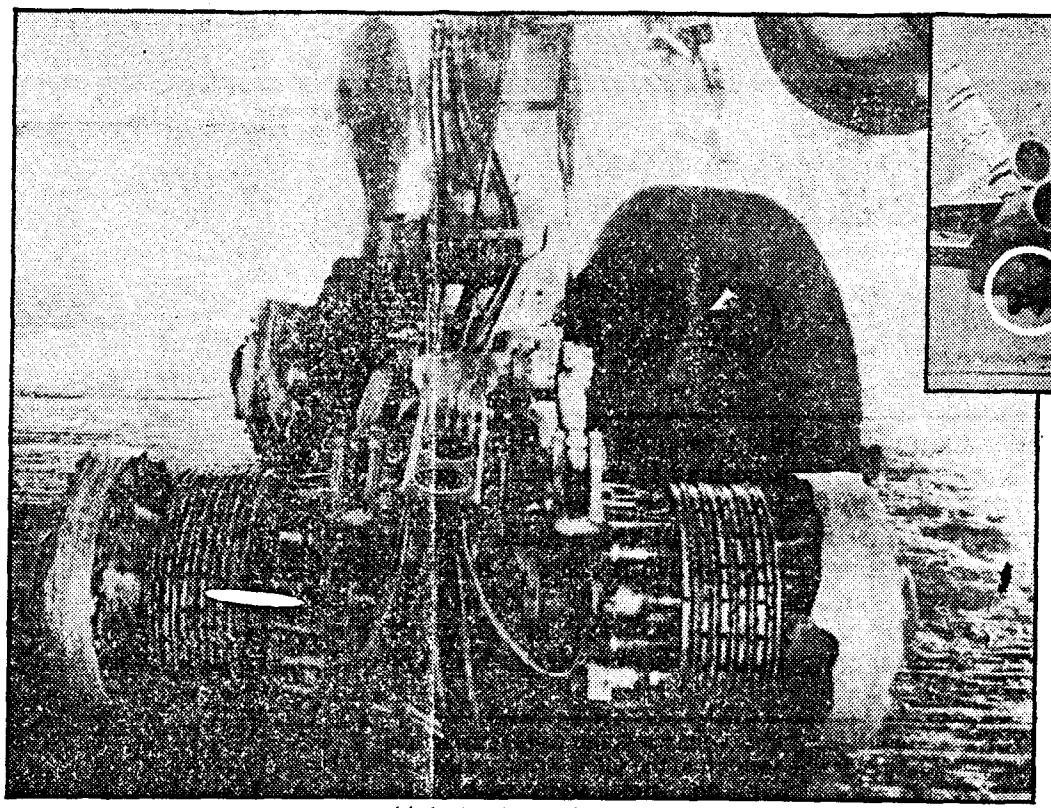

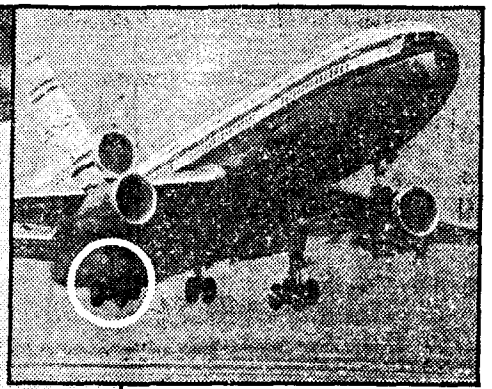

Left: damage caused to the right undercarriage of a DC-10 after a tyre-burst on take-off set off a chain reaction. The location of the tyres is ringed above on a similar plane

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Brown's unorthodox decision to abandon take-off was justified by the result. The only injuries occurred when the passengers evacuated the burning jet via the emergency shutes, and the worst of those was a broken leg. But other pilots placed in jeopardy by bursting tyres have not been so fortunate.

In March 1978, a Continental Airlines DC-10 burst three tyres during take-off at Los Angeles. The plane was *below* V-1 speed

Collapsed

and so, in theory, the pilot should have been able to stop it. Instead, part of the undercarriage collapsed, and the plane finished up 600 feet beyond the end of the runway. Two people died in the resulting fire.

Last September in Malaga, a Spanish DC-10 pilot elected to abandon a take-off after tyre failure even though the book said he was too far down the runway and travelling too fast. In his case, the book was right. The plane careered off the end of the runway and 55 people were killed.

SO WHEN a jet tyre bursts at a critical moment, the margin between survival and disaster is extraordinarily slender. This has led some airlines to throw away the rule book on V-1 speeds and introduce arbitrary – and much lower limits – for the point of no return in all emergencies except engine failure. As one British 747 captain told me: "We just hope the co-pilot does not report any weird bangs or thumps until we get to 100 knots (115 mph). Then, its all go whatever happens."

The AIB says that this precaution has "considerable merit". But it is not a guaranteed remedy because the domino effect set off by a single tyre burst can cause the undercarriage to collapse or catch fire, or, at the very least, greatly reduce an aircraft's braking ability.

Rather, says the AIB, there is a "patent need for action" to improve the design of big-jet undercarriages, and the strength of their tyres. There is also a need to establish if retreaded tyres are less safe than new ones, as some experts suspect.

For example, Professor Geoffrey Scott, of the department of chemistry at Aston University in Birmingham, has carried out research which, he claims, suggests that the airlines' use of retreads – at a saving of about £400 a tyre – is "a serious risk to passenger safety".

He believes that the "safe life" of a carcass is not much more than the life of its first tread. This claim is disputed hotely by the airlines, and by the tyre manufacturers. But the Civil Aviation Authority is now considering funding a research programme into tyre safety at Aston.

Meanwhile, the AIB says that, "as a matter of urgency", jumbo-jet pilots need a warning device in their cockpits to tell them when a tyre has burst.

Nothing better underlines how important that is than one "incident" reported by British Airways. On April 28 last year a British Airways 747 lost a tyre on take-off from Singapore. The debris punched a hole in the fuselage almost 2ft square. The crew knew nothing about it until the plane landed in Sydney.

Patrick Forman

THE SUNDAY TIMES
JANUARY 30, 1983

Plane tyres

THE ARTICLE by Patrick Forman (page 14, January 16) attributes to me the statement "the safe life of a carcass is not much more than the life of its first tread". I have in fact never said this.

What I have said is that in the case of car tyres, the carcass may become unprotected against the effects of fatigue due to loss of antidegradant during the first retread life.

I have been at pains to point out that the safe retread limit for aircraft tyres is not known, and this is why I have urged the need to establish both the service usage and retread limits for aircraft tyres which, as Patrick Forman points out, must be a major potential source of accidents in the modern aircraft.

In the absence of such experimental evidence, however, I have advocated that the retread limit should be less than six. In my opinion, in the case of the wide-bodied aircraft it should not be more than four.

However, I emphasise again that judgment is no substitute for experimental evidence which, in the present case, is readily accessible, given appropriate funding. Ironically, the cost of this research is only a minute fraction of the cost of a modern aircraft.

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