Spitfire IXT, G-TRIX

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Aircraft Type and Registration:	Spitfire IXT, G-TRIX
No & Type of Engines:	1 Packard Merlin 266 piston engine
Year of Manufacture:	1944
Date & Time (UTC):	15 September 1996 at 1705 hrs
Location:	Chichester Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 - Passengers - 1
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Both main landing gear legs collapsed, right wing tip damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	718 hours (of which 82 were on type)
	Last 90 days - 12 hours
	Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

History of the flight

A curved approach to land on Runway 24 was flown in nil wind,with all indications normal and the landing gear indicator showinggreen. A normal touchdown was executed, after which the stickwas brought progressively back and brakes applied normally. Awitness on the ground described the landing as good, withone bounce of approximately 1 to 2 feet. After touchdown, gentleleft rudder was needed to hold the aircraft straight, but thereafterincreasing amounts of left rudder were required to maintain headingas the speed decayed. As the aircraft crossed the runway intersection,at a speed of 'about 30 mph', the right landing gear was seento collapse and the aircraft slewed rapidly to the right aboutthe grounded right wing tip; it then slid in a curving path towardsthe right hand edge of the runway. As it slid off the runwayto its left, the left landing gear collapsed inboard and the aircraftfinally came to rest on the grass just beyond the intersection,having yawed through approximately 110° from the runway heading. The pilot had shut-off the fuel and magnetos

immediately he feltthe right landing gear collapse, and there was no fire. Therewas no structural damage to the cockpit and the pilot, who wasuninjured, was able to leave the aircraft without difficulty.

The pilot stated that he examined the runway after the accidentand was able to identify the tyre marks from both main wheels. He noted that right tyre mark displayed distinct 'scuff' marksbeginning at a point some 200 metres after touchdown, which persistedthrough the remainder of the ground roll, and which he attributedto a significant toeing-out of the right landing gear wheel.

The wings and the failed landing gear attachments were subsequentlyexamined by AAIB at the repair facility to which they had beentaken after the accident.

Landing gear arrangements

Each main landing gear is carried on a simple pintle housing attachedto the aft face of the main spar by a ring of 6 attachment studsand nuts: see Figures 1a and 1b. The upper part of the mainlanding gear body comprises an actuating horn, which extends abovethe pintle, to which is connected a hydraulic retraction actuator.

Each landing gear is locked into both the extended and retractedposition by a single lock mechanism, carried in a housing boltedto the rear face of the spar. This mechanism comprises a simplespring-loaded lock plunger, the engagement end of which is cutback at an angle of approximately 45°, supported in a plainbushing which allows the lock plunger to be rotated through 180°. As the landing gear extends from the retracted position, thehorn part of the landing gear body comes into contact with thechamfered face of the spring loaded lock plunger, pushing theplunger back against the spring until it comes into line witha recess in the horn; at this point, the spring pushes the plungerinto engagement with the horn, thus locking the landing gear inthe DOWN position. Prior to retraction, both lock plungers arerotated in their housings through 180° by means of a chainand sprocket wheel arrangement connected to the cockpit landinggear selector, reversing the orientation of the chamfer and allowingthe horn to be pulled back, out of lock engagement, by the retractionactuator. As the gear reaches its fully stowed position in thewing, a projecting uplock bracket attached to the landing gearbody engages the (reversed) lock plunger, locking the gear inthe UP position. Rotation of the lock plunger prior to gear extensionallows the retraction actuator to pull the leg out of engagementwith the uplock bracket, and re-positions the plunger in readinessto lock the gear DOWN.

The landing gear is raked forward significantly when the aircraftis in a 3-point attitude, as shown in Figure 2. Vertical groundreaction loads will therefore impose a loading action tendingto wrench the landing gears forward about the pintle attachmentsto the spar, increasing the tensile loading on the pintle upperattachment studs. Drag loads due to braking and rolling resistancewill produce a rearward loading, reducing the tensile loads inthe upper studs and tending to generate tensile loads in the lowerstuds.

AAIB examination

Right main landing gear

The right landing gear pintle had separated from the spar dueto fatigue failure of the two uppermost attachment studs, andsubsequent overload failure of the remaining 4 studs due to acombination of

bending and thread-stripping. The fatigue crackshad started at the threads in the vicinity of the nut back-face,and had resulted in pre-fracture cracking through approximately50% to 70% of the stud cross-sections.

Damage to the spar immediately below the pintle, and the modeof failure of the lower attachment studs, suggested that the leghad wrenched forward and outboard about the lower pintle attachmentstuds, disengaging the horn part of the leg from the downlockplunger. The lock mechanism and its attachments to the spar wereundamaged, consistent with the lock plunger having become disengagedat an early stage in the landing gear collapse.

Left main landing gear

The left landing gear pintle had been wrenched slightly away fromthe aft face of the spar, and the top inboard attachment studhad fractured in fatigue.

There was evidence that excessive side loads had been applied,forcing the landing gear inboard. The leverage forces thus developedhad caused a partial failure of the lock housing attachment tothe spar, which allowed the downlock plunger to disengage. Theunrestrained leg had then pivoted inboard, against the inboardrib structure, partially wrenching the pintle from the spar.

Detailed examination of the failed studs

At the request of AAIB, all of the pintle attachment studs wereindex-marked (to show their orientation) and, after careful removalfrom the airframe, were forwarded to AAIB for more detailed examination.

Metallurgical examination confirmed the presence of fatigue inthe two studs from the right side attachment, and also withinthe single stud from the left side, initiating in each case frommultiple origins in the roots of the threads. Two separate, adjacent, fatigue cracks were found to be present in the fracture throughthe inboard stud from the right side. These had propagated fromadjacent thread roots, and had merged during the final fractureof the stud. The directions of propagation of these two adjacentcracks differed slightly from one another, raising the possibilitythat this stud may have been removed in a cracked condition atsome point in the aircraft's history, and re-fitted in a slightlydifferent orientation. However, this could not be positivelyconfirmed.

The fatigue fracture faces of the right studs each exhibited adark region of discoloration associated with the early periodof growth, followed by a region of clean fracture surface; thesetwo regions being clearly differentiated. This suggested that,after the fatigue cracks had propagated a significant way throughthe studs, the aircraft may have been stored or taken out of servicefor a period before resuming operation again, giving rise to freshfatigue growth.

Differences in fatigue growth characteristics were evident oneach of the fracture faces from the two right side studs. Theearly stages of growth in each case were characterised by medium-cyclefatigue which had progressed into low-cycle fatigue during thelatter period of growth, suggesting a higher loading regime duringthe latter part of the aircraft's history than previously. Thefatigue characteristics on the fracture from the left side studalso showed variations. In this case, the initial medium-cyclefatigue regime changed dramatically into a very low cycle (highload) regime immediately prior to final fracture, the latter regimemost probably being associated with juddering loads on the legas the aircraft was sliding sideways following collapse of theright gear.

A general check for evidence of further fatigue cracks revealedthat cracking had also initiated from a thread root in the loweroutboard stud from the right side pintle attachment.

Stud condition

The threads appeared to have been die-cut, not rolled. Vickershardness tests using a load of 10 kg gave values in the range309 to 336 for the fatigue-fractured studs. Hardness checks onone lower attachment stud from each side revealed somewhat lowervalues, in the range 260 to 299. Neither the original specificationof the stud material nor the correct method of cutting the threadshas been positively established at the time of writing. It hasnot been possible to establish when the studs were installed,or their source.