Hawker Sea Fury FB11, G-EEMV

AAIB Bulletin No: 1/2002	**Ref: EW/C2001/5/2**	**Category: 1.2**
Aircraft Type and Registration:	Hawker Sea Fury FB11, G-EEMV	
No & Type of Engines:	1 Bristol Centaurus 18 piston engine	
Year of Manufacture:	1951	
Date & Time (UTC):	12 May 2001 at 1359 hrs	
Location:	Sywell Aerodrome, Northamptonshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (fatal)	Passengers - N/A
Nature of Damage:	Substantial	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	52 years	
Commander's Flying Experience:	916 hours (of which 55 were on type)	
	Last 90 days - 8 hours	
	Last 28 days - 4 hours	
Information Source:	AAIB Field Investigation	

History of the flight

The pilot was the owner of a collection of historic tailwheel aircraft which comprised a DHC-1 Chipmunk, North American T-6G Texan, North American P-51D Mustang, FG-1D Corsair and the Hawker Sea Fury. All of the aircraft were based and hangared at Sywell aerodrome.Maintenance of the Sea Fury was carried out by an engineering company at North Weald aerodrome.

Between October 2000 and April 2001, frequent rainfall rendered Sywell's grass runway surfaces too soft to support the operation of the relatively heavy Sea Fury and Corsair aircraft, but during this period the pilot maintained his flying currency on the lighter Chipmunk and Texan aircraft.

On 15 April, the Corsair was delivered from Sywell to North Weald for maintenance, returning to Sywell on 4 May. The Corsair was then flown on local flights from Sywell on 5 and 6 May. The Sea Fury also had a requirement to visit North Weald for inspection prior to the renewal of its annual Permit-to-Fly. The first flight of the Sea Fury after the winter break occurred on 5 May. During a 10 minute local sortie, operating from Sywell's Runway 03, the pilot indicated that the aircraft was suffering from a rough running engine and made a priority recovery to the airfield for an uneventful landing.

During the following week, the ignition system of the aircraft was checked at Sywell and the spark plugs cleaned and replaced. Ground running of the engine did not reveal any further problems.

On the day of the accident, the pilot booked out for a local sortie. The aircraft departed from Runway 03 at 1326 hrs. The pilot then requested to rejoin the airfield circuit for landing at 1356 hrs. The runway in use by other light aircraft was Runway 07. In order to fit in with the traffic flow for a right hand circuit for Runway 07, the Sea Fury was initially positioned right hand downwind for that runway. Preferring to take advantage of the longer runway length available on Runway 03, the pilot entered a right base leg for Runway 03 and proceeded onto final approach.

Because of the rarity of the aircraft, it attracted significant attention from witnesses on the ground. The consensus of opinion indicated that the aircraft touched down beyond the intersection with Runway 07 on its two main wheels, with the fuselage horizontal. The aircraft then proceeded up the runway in a horizontal attitude. Towards the end of the landing run, the tail still had not lowered to the 'three point' attitude. The aircraft was seen to skip slightly and become airborne again very briefly. As it touched down again, the tail was seen to rise and the aircraft nosed over and came to rest inverted.

The airfield emergency vehicles were immediately dispatched to the scene by the Aerodrome Flight Information Service Officer. There was no fire, but on arrival at the aircraft, the attending staff attempted to communicate with the pilot but heard no sign of life. They did not have any equipment immediately available which could have lifted the aircraft in order to evacuate the pilot from the cockpit.

Local emergency services had also been alerted and arrived on the scene at 1411 hrs. Because of the presence around the cockpit of electrical wiring, fuel and hydraulic pipes, it was decided not to use cutting equipment to access the cockpit. The aircraft was finally lifted sufficiently to remove the pilot by use of air bags and an excavator used as a crane, but the pilot was pronounced dead at the scene at 1510 hrs.

It was estimated that the aircraft would have had at least 170 kg of fuel on board at the time of the accident, giving an aircraft weight of some 4,500 kg.

Runway 03 has a declared Landing Distance Available of 909 metres and a width of 30 metres, 15 metres each side of a marked centreline. The lateral boundaries of the grass runway area are marked with dashed white lines. Grass surfaces also extend outward beyond the boundaries of the runway.

Pilots of other, significantly lighter, aircraft who had used Runway 03 earlier that afternoon reported no abnormalities on landing or difficulties with the runway surface condition, although their operations did not extend to the area where the Sea Fury came to rest.

The weather at the time was CAVOK with a surface wind from 080°M at 10 kt, giving a crosswind component of about 8 kt from the right when using Runway 03.

Engineering Investigation

Examination of the runway revealed a series of intermittent but clearly defined tyre tracks from the mainwheels of G-EEMV, produced during the accident landing. These showed that the aircraft touched down briefly on the mainwheels at a position approximately 175 metres beyond the threshold, some 11 metres left of the runway centreline, and tracking very slightly towards the left edge of the runway. It then became airborne again, touching down briefly for a second time on the main wheels some 85 metres further up the runway. Thereafter, it progressed in a series of long skips on the mainwheels, moving progressively towards the left edge of the runway. This drift to the left was contained after a distance of approximately 350 metres, by which stage the aircraft was 16 metres to left of centreline and moving onto softer and more uneven ground containing several transverse undulations, which appear to have exacerbated the aircraft's already existing propensity to bounce. It continued parallel with the centreline for a further 90 metres, still skipping on the mainwheels at intervals of around 14 metres, during which period the mainwheels cut increasingly deep ruts in the turf, before nosing over onto its back and coming to rest 450 metres from the initial touchdown point, straddling the left hand edge of the officially declared runway grass area.

All of the tyre tracks up to the area of the runway where the aircraft started to nose over were produced by rolling wheels, with no evidence of braking action except for a series of brief kinks in the right mainwheel tracks, consistent with differential braking in an effort to control the aircraft's drift to the left. In contrast, the final length of right main wheel track showed clear signs of a locked wheel, with the turf layer exhibiting a series of characteristic tension-fissures together with tearing and smearing of the grass caused by tyre drag, and visible rubber deposits on the compacted soil forming the sides of the rut. Corresponding light score marks and soil deposits were noted on a sector of the right mainwheel tyre, consistent with it sliding briefly in a locked condition. No evidence of braking was apparent in the track from the left mainwheel in this region.

Very shortly beyond the start of the final locked wheel tyre track from the right wheel was a series of propeller cuts, the dimensions and orientation of which were consistent with the aircraft pitching onto its nose. These cuts merged into a series of deeper and more generalised gouges, produced as the aircraft nosed over onto its back. Both the spacing and general character of the final ground marks and the pattern of damage to the aircraft was consistent with a low forward speed as it started to nose over, the aircraft virtually having come a halt by the time the fuselage reached the vertical. As the aircraft fell onto its back the fin and rudder were crushed, generating severe bending loads in the rear fuselage which resulted in localised structural failure just aft of the cockpit. This had allowed the forward fuselage to sink down into firm contact with the ground, crushing the canopy.

An analysis of the aircraft's attitude at the onset of the nose-over sequence, based on the spacing, orientation, and relative positions of the propeller cuts in relation to the start of the final locked-wheel track from the right mainwheel, showed that by the time this wheel had locked the aircraft was already tipped into an extreme nose down position, with the propeller blades on the verge of ground contact. It was apparent, therefore, that the locked right wheel did not cause the aircraft to nose over; rather, the lock-up was most probably a symptom of the event, caused by an inadvertent application of brake as the aircraft was already tipping over. An examination of the right landing gear tended to confirm this assessment. Although some stiffness of wheel rotation was apparent, it was possible to turn the wheel by hand and a strip examination of the brake pack in situ showed that the hydraulic piston was in its relaxed state, and that there was a discernible clearance between the brake piston and each of the adjoining pucks. Progressive disassembly of the pack revealed no evidence of binding, or of any other defect or malfunction of the pack, and it was concluded that the stiffness was most probably the result of a small movement of the inboard set of pucks against the associated disc segments during the accident, due to inertial loading as the aircraft fell onto its back. In summary, there was no evidence to suggest that the aircraft had nosed over as a result of any technical malfunction. However, there was evidence indicative of high wheel drag in the region prior to the start of the nose-over.

As the landing progressed, and the interval between skips shortened and more of the aircraft's weight came onto the mainwheels, the tyres had progressively penetrated the turf layer producing distinct ruts in the surface. This rutting was particularly severe towards the end of the landing roll where the runway surface was generally more uneven, and where a series of transverse undulations appear to have exacerbated the already present tendency for the aircraft to bounce. The ground was also noticeably softer in this area, and the aircraft's wheels had penetrated into the ground by as much as 15 cm (6 inches) in places, over distances of several metres. The character of these deeper ruts differed from those made earlier in the landing, and it was apparent that the depth of penetration was caused, in part at least, by an interaction between the wheels and a series of deep longitudinal cuts in the turf, which had been made previously to improved surface drainage in that area. It is understood that the runway has a long history of poor drainage, particularly in the mid region, and that it had been subject to regular *moleing* treatments to improve drainage. These treatments involved towing a plough-like device behind a tractor, fitted with a series of vertical blades each of which had a torpedo shaped bulge at its lower extremity. This device produced a series of parallel cuts in the turf, aligned with the runway axis and spaced approximately half a metre apart, and typically about 15 cm in depth with a *mole-hole* drainage channel at the base of each cut. Where the mainwheel tyre tracks had coincided with one of these cuts, the tyre had pushed down into the cut, forcing the turf layers aside and opening out the existing channel; where the tyre had run along between cuts, the turf layer had generally remained intact but had been forced down into the softer soil beneath, the edges of the turf strip then *wrapping up rolling* against the sidewalls of the tyre.

The soft ground alone, even without the rutting, would have increased the rolling resistance significantly, and this effect was clearly discernible whilst driving a vehicle along the affected area of the runway. Whilst it was not possible to quantify the effect of the deep ruts, there is no doubt that they would have increased the wheel drag significantly because of the greater interaction between the soil and the tyre sidewalls, and also the reduction in effective rolling radius associated with this interaction. The result would have been to increase significantly the forces tending to pitch the aircraft onto its nose. Any tailwheel configured aircraft in a pitch-level attitude at low speed will be finely balanced between falling back onto its tailwheel and tipping over onto its nose: the particular outcome will be depend on the balance achieved between the destabilising moments tending to tip the aircraft forward, due primarily to the combined effects of momentum, propeller thrust, and wheel drag, and the stabilising moments tending to bring the tail down, which derive primarily from the aircraft's weight and the position at which this acts in relation to the ground/tyre contact position. Because the relationship between the CG and the wheel contact position is itself dependant on fuselage attitude (the distance reducing as the aircraft pitches nose down and the CG moves towards, and ultimately ahead of, the wheel contact point), it follows that the margin of pitch stability on the ground will reduce as the tail comes up, even without any changes to the overall forces acting on the aircraft. Therefore, if the aircraft had still been in a tail-up attitude when it encountered the softer ground, it would have been especially vulnerable to the resulting increase in rolling resistance.

It is understood that prior to its import into the UK from the USA, this aircraft had been modified to remove protective structures installed by the manufacturer immediately behind the pilot's station, and which historically have provided pilots with a measure of protection during turn-over type accidents. This was apparently done in order make space available for the installation of a *jump* seat behind the pilot, within the original canopy glazing, allowing a passenger to be carried. A similarly modified aircraft suffered a fatal landing accident in similar circumstances in the United States during 1996. However, in both accidents, the aircraft came to rest inverted on unprepared surfaces and the effectiveness of such a protective structure in these circumstances is not proven.

Analysis

In summary, the physical evidence at the accident site was consistent with the aircraft landing slightly deep, to the left of the centreline, whilst tracking slightly towards the left edge of the runway in a normal wheeled (tail up) attitude and carrying some excess speed. Thereafter, it progressed in a tail-up attitude along the left side of the runway, in a series of light bounces without ever settling into to a three point attitude, before encountering a region of soft ground with transverse undulations where the tyres broke through the surface and sank to depths of up to 15 cm. It appears that the consequent increase in wheel drag altered the balance of forces on the aircraft to an extent which caused it to tip irretrievably nose down and turn over onto its back.

The wheel brake system fitted to this aircraft was modified prior to its importation into the UK, the original system being replaced by one derived (it is believed) from an F102 jet fighter. Whilst there is no evidence that the brakes caused or contributed to this accident, the practical effects of these modifications in terms of overall braking effectiveness and controllability remain unclear.

Assuming an engine idle speed in the range from 700 to 800 rpm, the spacing of the propeller cuts in the soil corresponded to an aircraft ground speed of 40 to 50 kt at the time that the aircraft started to tip onto its nose. The aircraft's stalling speed in the landing configuration, power off, was around 87 kt. It is therefore likely that the elevator would have been aerodynamically ineffective, leaving the pilot with no means of preventing the aircraft from nosing over once the propeller strikes had occurred.