Pierre Robin DR400/180, G-DELS, 22 July 1996

AAIB Bulletin No: 12/1996

Ref: EW/C96/7/10 Category: 1.3

Aircraft Type and Registration:	Pierre Robin DR400/180, G-DELS
No & Type of Engines:	1 Lycoming O-360-A3A piston engine
Year of Manufacture:	1990
Date & Time (UTC):	22 July 1996 at 1605 hrs
Location:	Tockington Park Farm near Almondsbury, Bristol
Type of Flight:	Private
Persons on Board:	Crew - One - Passengers - Nil
Injuries:	Crew - One (Fatal) - Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	750 hours (of which 577 were on type)
	Last 90 days - 11 hours
	Last 28 days - Not known
Information Source:	AAIB Field Investigation

History of the Flight

The aircraft involved in this accident was wholly owned by thepilot who had used it to fly extensively throughout the UK andmainland Europe since purchasing it in 1990. On the afternoonof the accident he had taken off from his home base at Wadebridge,Cornwall, to fly a family friend to Kemble. The weather for theroute flown was fine with a strong south-westerly wind of 170ºto 200º at 10 to 15 kt, with gusts up to 25 kt on the surfaceand a temperature of 29ºC. At 2000 feet the wind was 200º/10kt with a temperature of 20ºC. Due to the strong diurnaldifferential heating a 'heat low' had developed over England by1700 hrs and there were reports from pilots of turbulence at lowaltitudes. During the flight north, the pilot had advised hispassenger to fasten her seat harness more tightly because of theturbulence.

On arrival at Kemble at approximately 1530 hrs, the wind was reportedby Royal Air Force Lyneham to be 190º/18 kt with gusts ofabout 7 kt. Kemble ATC tower was unmanned and the pilot electedto land on Runway 27. The passenger later stated that, due tothe strong crosswind and turbulence, the pilot experienced considerabledifficulty in making an approach and had to work hard to maintainwings level during the touchdown and subsequent landing roll. Witnesses reported hearing a prolonged squeal of the tyres, anda brief but large increase in engine power, suggesting that thepilot was having difficulty in controlling the aircraft at thisstage, and may have inadvertently landed with the toe brakes applied.

When the aircraft arrived at the parking area the pilot, aftergreeting waiting relatives of his passenger, made a careful inspectionof the aircraft with particular attention to the left wing. Hispassenger recalled him giving the wing a "tug". Hemade no comments about the condition of the aircraft during thisinspection.

At approximately 1550 hrs, the aircraft took-off to return toWadebridge. At 1600 hrs, the pilot contacted Filton ApproachControl and advised them that he was routed from Kemble to Wadebridgein Cornwall and would like to overfly the airfield and then proceeddown the Bristol Channel at 2000 feet under Flight InformationService (FIS). Filton acknowledged this call and allocated theaircraft a secondary radar transponder code.

At 1603 hrs, Filton Approach called the aircraft and advised thepilot that the QNH was 1013 mb and that he was identified on radar. The tone of the pilot's voice when he answered this call wascalm and business-like, implying that the flight was proceedingnormally. It is of note that when making both these radio callsto Filton, the pilot was very precise in his transmissions, prefacingall calls with the correct radio callsign. However, at 1604 hrsthe pilot spoke to Filton again and asked for their surface wind;this transmission was made without a callsign and it was possibleto detect a note of anxiety in the pilot's voice. Filton repliedthat the wind "is one nine zero, one five knots, it's beenup to two one zero , one eight knots".

As soon as Filton had ended this transmission, the pilot madethe following radio call: "I'm having trouble with my controls,I think I better declare a PAN and try and get into you. Havinga job to turn left so if that's alright with you I'll make anapproach for...., what's your runway, two one?...." at thispoint the pilot stopped talking, but the transmission switch wasleft on for seven seconds before he made the single statement"Oh God" and the transmission ended.

At about this time, a witness who lived in the vicinity reportedthat whilst working in his garden he noticed a light aircraftflying overhead at about 2000 feet. Shortly afterwards he hearda sound which he compared to that of a stout piece of timber breaking,followed by the engine throttling back and then power being reapplied. Other witnesses in the area reported hearing a 'dull crack' similarto the noise made by a leather hammer. A number of witnessessaw the aircraft descending in a spiral similar to that of a 'fallingsycamore leaf' and observed that one wing was damaged, if notmissing altogether. The descent was accompanied by a small cloudof debris. Emergency services were called to the scene and foundthe wreckage of the aircraft in a field, with the body of thepilot some ten metres away.

The wreckage trail

Debris from the aircraft was distributed along an elliptically-shapedwreckage trail some 900 metres in length, orientated approximatelynorth-south, starting with a few isolated fragments of left

wingrib to the north and terminating at the main impact site at thesouthern end of the trail. Figure 1 is a sketch plan of the wreckagetrail, showing key items of wreckage and the main impact site.

Main wreckage

The wreckage at the main impact site comprised the whole of theaircraft, except for the left wing and some fragments of cockpitperspex; otherwise, all extremities were present and the aircraftappeared intact at the time of ground impact. The pattern ofimpact damage, and the 'throw' of wreckage from the point of impact,was consistent with a high speed descent into the ground in anapproximately 70° nose down pitch attitude, whilst in a widespiralling motion to the right.

The body of the pilot lay separate from the main wreckage, approximately10 metres to the west. The pattern of damage to the seats andinstrument panel suggested that he was not in the cockpit whenthe aircraft struck the ground, and subsequent post mortem examinationrevealed a pattern of injury consistent with a free-fall impact. The pilot's lap strap harness was unbuckled prior to impact butthe (keyhole-type) attachment of the shoulder harness to the lapstrap buckle was still engaged. The canopy was unlatched, butit was not possible to establish how far it had been opened priorto impact.

Airborne separation debris

The left wing, comprising the outer wing panel and aileron withalmost the whole of the top and bottom fabric skins still attached,but with the structure extensively disrupted and reduced in partsto fragments of ribs and spar, had separated from the aircraftin flight and was found in the central part of the debris trail,toward the eastern edge. The remaining fragments of the disruptedleft wing spar and rib structure, together with the aluminiumcover-strip fairing from the outer end of the left wing tank,pieces of pitot tubing, and sections of trailing edge flap werescattered across the central region of the wreckage trail. Severalpieces of canopy perspex were lying at the northwestern end ofthis debris region.

Maps, headphones, and other items of cockpit equipment were foundscattered over the fields on the more westerly side of the trail,towards its southern end. These items had evidently been releasedfrom the aircraft during the latter part of its descent.

The left wing fuel tank had been released from the aircraft duringthe initial wing separation, but due to its concentrated masshad travelled further than the wing debris generally, coming torest at the far end of the trail, slightly to the east of themain wreckage.

Runway investigation at Kemble Aerodrome

In light of the evident difficulty the pilot had experienced duringthe landing at Kemble, and the possibility that a heavy landingmay have damaged and weakened the wing structure, the runway atKemble was subsequently examined carefully in an effort to establishthe nature of the landing.

A solid black tyre mark was found at a point approximately 180metres from the threshold of Runway 27, beginning near thecentreline and diverging to the left at a shallow angle. A second,less clearly defined, black tyre mark was found to the right ofthe first, but running parallel with it; both extended forwardalong the runway in a sensibly straight line for a distance ofapproximately 40 metres, after which they disappeared. Thespacing between the marks corresponded precisely with the mainwheel track of a Robin DR400, and their characteristics were consistentwith *locked*

wheel tyre marks produced by an aircraft touchingdown with the brakes applied. The width of the individual marksincreased progressively from the initial contact points, and therewas no evidence to suggest that the touchdown had been at a highsink rate. Overall, the character of the marks implied a gentletouchdown at relatively high speed, slightly left wing low, closeto the centreline but tracking slightly to the left; the aircraftthen becoming airborne again. Having regard to the witness evidenceof a sustained 'shriek' from the tyres of the landing aircraft,the transient increase in engine power, and the correspondenceof the tyre mark spacing with the mainwheel track of a Robin DR400,it was concluded that the marks on the runway were produced byG-DELS.

A close examination of the paved runway forward of the point wherethe aircraft had apparently become airborne, after its initialtouchdown, failed to reveal any further tyre marks which couldbe attributed with confidence to G-DELS. However, much of thispart of the runway comprised the taxiway intersection and wascovered with numerous tyre marks from a recent motor race meetingwhich had been held at the airfield.

The grassed area adjoining the left edge of the runway, just beyondthe taxiway intersection, was also examined carefully and a setof rolling wheel tyre tracks were found in the grass which hadevidently been produced by an aircraft with a nosewheel undercarriage. The distance between the mainwheel tracks also matched the trackof a Robin DR400, and the position where the tracks began wasconsistent with the projected path of the aircraft following touchdown,as indicated by the angle of the initial tyre marks on the runway. There was little doubt that the marks had been produced by GDELS.

The tracks in the grass initially comprised just the left andright mainwheel tracks. These ran in an approximately straightline for about 15 metres, after which the left wheel track disappearedand the right became significantly heavier, consistent with asudden transfer of weight from the left to the right main wheelat that stage. Some 5 metres further on, the left mainwheel trackreappeared and the right wheel track lightened and reverted backto its original character. A nosewheel track also became visibleat this stage, very close to the left mainwheel track, consistentwith the aircraft having been yawed grossly to the left at thatpoint, directional control evidently having been lost at thatstage. Thereafter, the tracks followed a tightly curving arcto the left through approximately 180° of heading, crossingover the taxiway in the process, with the nosewheel continuingto track close to the left mainwheel throughout. Some 25 metresafter having crossed over the taxiway and onto the grass on thefar side, the tracks straightened for a period, suggesting thatdirectional control had been recovered at that point, before assuminga more gentle curve to the left and regaining the main runwayat the southern corner of the taxiway intersection, opposite thepoint where the aircraft had originally departed the paved surface. The sketch at Figure 2 shows the approximate path followed bythe aircraft during its excursion off the runway, together withthe yaw angle at key stages implied by the proximity of the nosewheelto the left mainwheel track.

The airfield been harvested for hay prior to the accident, andlarge cylindrical bales of hay were distributed across many ofthe grassed areas adjoining the runways. These bales had subsequentlybeen cleared from parts of the airfield, including the grassedarea where the tyre tracks were found. However, the positionswhere the bales had originally been sited were indicated by associatedimpressions left in the grass, one of which was identified some2.5 metres outboard of the left mainwheel track, adjacent to thepoint where the aircraft had suddenly yawed to the left. Furtherinquiries, and comparison with photographs taken on the day afterthe accident, confirmed that a hay bale had been present at thisposition when the aircraft had landed.

Measurements were taken of a number of typical hay bales, andcompared with the dimensions of the aircraft and its landing geartracks. This showed that the left outer wing must have impactedthe bale at the position shown in Figure 3. Such an impact wouldhave yawed the aircraft violently to the left whilst at the sametime causing the left wing to 'ride up' over the bale, liftingthe left mainwheel clear of the ground and throwing additionalweight onto the right mainwheel, and causing the violent yaw beforethe aircraft dropped back onto all three wheels on the far sideof the bale, consistent with the evidence of the tyre tracks. An attempt was made to identify the bale in question from amongstthose stacked on the far side of the airfield. One bale was foundwith damage consistent with the scenario described, but it wasnot possible to make a positive identification.

It was later confirmed by the passenger that the aircraft hadindeed run over the grass during the landing at Kemble. She hadalso been aware of roll-type bales of hay in the vicinity, butwas not conscious of the aircraft having struck any of them.

Examination of wreckage

The Robin DR 400 has a wood and fabric wing built around a thin-walledwooden box spar, comprising plywood side and top panels bondedto corner elements of rectangular section timber, a form of constructionwhich confers excellent bending and torsional rigidity when intact,but very little stiffness in the event of loss of integrity atthe joints of the box. The outboard part of the spar is crankedupward to accommodate the dihedral of the outer wing panels, thisbeing accomplished structurally by scarfed joints in the variousspar elements. Separate box structures attached to the aft sidesof the main spar at the inboard end of each wing carry the mainlanding gears, these being intended to break away from the mainspar box under excessive loading, without compromising the integrityof the spar. The remaining structure is built around the mainspar and comprises sheet ply nose ribs forward of the spar andconventional latticework ribs aft, the latter supporting a lightweighttrailing edge spar on which the ailerons and flaps are mounted. The nose ribs are skinned with thin plywood extending back tothe spar on the upper surface, and approximately 30% to the sparon the lower surface. The depth of the main spar is slightlyless than the maximum thickness of the wing, and the rib capsextend around the top and bottom of the (rectangular section)spar box to provide the required curvature for the wing section.

The wreckage from the separated left wing was laid out and partiallyreconstructed at the AAIB, Farnborough. It was apparent thatthe wing had been in excellent condition overall and there wasno evidence of deterioration due to moisture ingress, fungal growth,or bond deterioration. The quality of the materials used andthe standard of construction was extremely high, and none of thefractures had resulted from glue failure or any apparent materialweakness or defect.

It was apparent that the outer panels of the left spar box hadsplit away from their corner members, destroying the integrityof the *box structure* and substantially reducing both thebending and torsional stiffness of the wing, and would have resultedin bending and torsional loads during flight being transferredto the individual corner elements of the spar box as bending loads. This had resulted in overload failure of these elements nearthe region of maximum bending moment at the root of the wing,followed by consequential further breakup of the wing structureand separation of the left wing. The progressive loss of torsionalstiffness as damage propagated through the spar would have tendedto cause adverse twisting of the wing in response to aileron deflections,and a consequent reduction in aileron effectiveness. This wasconsidered to have been the cause of the pilot's reported difficultyin turning the aircraft.

The left wing lower skin, just outboard of the dihedral break,exhibited a uniform 'scuffing' of the painted surface, comprisingminute chordwise scratches extending from the leading edge backover the plywood skinned nosing. The nose ribs in this regionwere heavily crushed and fragmented, consistent with a *sandbag*type impact against the lower part of the leading edge. Thisregion of damage coincided with the extent of damage expectedfrom impact with the straw bale, and the scuffing was also consistentwith such an impact. There were indications that the main sparhad also suffered localised disruption immediately inboard ofthis region, almost certainly as part of this impact process;however, it was not possible to determine exactly what damagewas due to the impact with the hay bale and which was due to thesubsequent airborne breakup.

In summary, it was apparent that the breakup and airborne separationof the left wing had occurred as a result of spar damage sustainedduring the impact with the hay bale whilst landing at Kemble,this damage propagating further into the spar structure duringthe initial stages of the return flight and culminating in a sparfailure at the inboard end of the wing, and wing separation inflight.

Implications of the wing impact

The witness evidence of the pilot inspecting the outer left wingvery carefully, and *tugging* the wing, was consistent withan attempt by the pilot to assess the extent of damage followingthe impact with the hay bale. However, it is likely that externalvisible signs of damage would most probably have been limitedto the light scuffing of the lower wing skin at the point of contactwith the bale.

A metal monocoque wing structure with deformed ribs or spars willusually exhibit associated deformations of the external skins,providing a clear indication of the damage within. The woodenstructure of the DR400 wing, however, whilst being both strongand damage tolerant, is less likely to show external signs ofcritical damage within. In this case, due to the complianceinherent in the plywood leading edge skinning and the in-planestiffness of the nose ribs, the impact loads would have been transferreddirectly into the spar behind, until the nose ribs became crushed. After the event, the nose skins would have sprung back leavinglittle, if any, visible evidence of the crushed ribs and possiblespar damage within. Because the spar box sits *inside* thewing profile, damage in the form of partial dislocation of thespar panels from the corner elements of the spar box would, inall probability, not have been apparent. It is therefore entirelyconceivable that the pilot may have been misled as to the extentof the damage sustained, finding only light scuff marks underthe leading edge and believing that it was safe for him to makethe return journey before having the wing professionally assessed.