ACCIDENT

Aircraft Type and Registration:	DG505 Elan Orion, BGA 4432 JDN
No & Type of Engines:	None
Year of Manufacture:	1997
Date & Time (UTC):	22 April 2007 at 1542 hrs
Location:	North Hill Airfield, Broadhembury, Honiton, Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Gliding Certificate with Silver Badge
Commander's Age:	48 years
Commander's Flying Experience:	144 hrs / 414 launches (of which 5 hrs were on type) Last 90 days - 3 hours Last 28 days - 3 hours
Information Source:	AAIB Field Investigation

Synopsis

The accident occurred during a solo flight, the purpose of which was to convert an experienced glider pilot on to type. On approach, the glider was seen to enter a steep dive and strike the ground, seriously injuring the pilot. The dive was caused by the failure of a piece of electric cable being used to restrain the hinged rear cockpit headrest. This allowed the headrest to fall forward, restricting the rearward travel of the rear cockpit control column resulting in a loss of control. The electrical cable had been fitted as a replacement for the original nylon cord, installed by the manufacturer, which had become damaged. Two Safety Recommendations have been made.

History of the flight

The pilot was in the process of being cleared to fly his club's two-seat DG505 glider, JDN, when the accident occurred. Earlier in the day, he had flown three dual flights with a club instructor before being cleared for a solo flight under the instructor's supervision. The dual flights had been handled well by the pilot and included a practice cable break and short circuit, during which the pilot demonstrated good handling and awareness. Weather conditions were fine, with a light south or south-westerly wind and no significant low cloud. There was no turbulence affecting the circuit or landing area, and the day had been declared suitable for ab-initio solo flying.

After the third dual flight, the instructor vacated the rear

seat and the glider was towed back to the launch area whilst the pilot remained in the cockpit. The instructor briefed the pilot and then prepared the glider for solo flight. This included securing the rear seat four-point harness, which the instructor fastened in the normal manner before pulling the straps tight. He also checked that the seat cushion was secure.

The instructor then assumed the role of club duty instructor in the launch control vehicle. The winch launch was uneventful and the glider was seen to carry out a few turns before joining the circuit in a normal manner. The glider's position and height seemed normal in the circuit, and the turn onto final approach appeared co-ordinated and at approximately the correct speed and height.

Several witnesses saw the subsequent events, and their accounts matched closely. The glider quickly adopted a steep nose-down pitch attitude and descended rapidly with little change in attitude until it struck the ground. The front fuselage struck the ground first and the canopy shattered. The glider then pitched up, the tail struck the ground with force and the 'T' tailplane detached. The glider bounced some distance into the air again and began to roll to the right before descending steeply into the ground.

The pilot survived the accident, but sustained serious injuries. An air ambulance and other emergency services arrived on the scene and the pilot was flown to Exeter hospital.

Pilot information

The 48-year-old pilot started gliding with the club in 2002, and had first flown solo in June 2003. Subsequently he had flown regularly at the club and, since April 2006, had flown a Cirrus single-seat glider as part of a syndicate. He was regarded as an experienced and competent club pilot and had been selected for training as a Basic Instructor. The club operated a colour rating system, with a Blue rating being the highest, allowing its holder to fly in the most restrictive or demanding weather conditions. The pilot held the next highest rating, and had completed the majority of the club's requirements for issue of a Blue rating.

The pilot was interviewed in hospital three days after the accident. His recollection of the three dual flights was complete, as it was for the majority of the accident flight. He recalled the turn onto final approach and achieving a satisfactory clearance over trees on the approach path. He also remembered extending the airbrakes, and then partially retracting them to maintain an accurate approach to the normal aiming point. He did not recall any control difficulties but was unable to remember the steep final descent or the initial impact, though he was aware of the second impact and some of the events afterwards.

The pilot held a valid medical declaration and had no known medical condition which could have affected his ability to control the glider.

Wreckage distribution and initial examination

The first ground markings made by the glider were approximately 40 m from the tree line bordering the eastern perimeter of the gliding site. There was no evidence to indicate that the glider had passed through the trees during its descent. Ground markings indicated that the glider initially struck the ground in a nose-down attitude with the wings relatively level. The horizontal stabiliser, including the elevator, had detached from the tail during this impact. It was found approximately 30 m from the initial point of impact, with the elevator jammed in a nose-down position, having been forced beyond its control stops. The glider had become airborne again, travelling for a further 230 m before striking

the ground for a second time. These ground markings confirmed that the glider had hit the ground in a steep nose-down attitude with some degree of right roll. A large proportion of both the front and rear canopies were recovered between the first and final impact points.

Examination of the glider at the accident site confirmed that there were no disconnections within the control circuits. However, the rear cockpit headrest was found to have pivoted forward and was resting on the top of the control column (Figure 1), the restraining wire having broken at the point where it was secured to the shoulder harness attachment. A smear of a black plastic-like substance was found on the headrest cover where it had been resting on the control column. The gliding club confirmed that JDN had been kept permanently rigged and club records indicated that it had rarely been flown solo. However, the rear headrest would have been moved forward to install the main battery prior to the first flight of the day and to check the security of the wing rigging pins.

Detailed examination

The glider's instrumentation was examined and showed no evidence of a pre-accident failure. One of the rear mounting pins for the horizontal stabiliser had been distorted which allowed it to be released. The distortion of the pin and damage to the elevator input arm indicated that the force had been produced by the elevator control rod running inside the fin. The mounting points for the control rod within the fin had failed in overload. No evidence was found of pre-impact damage or restriction to the control circuits within the wings, rear fuselage or under the cockpit floor.

The black plastic material on the rear headrest cover originated from the hand grip on the rear control column. Detailed inspection of the hinged seat back in the rear cockpit showed that it had failed approximately half way along its length and the foam at the top of the headrest had been distorted. The failure indicated that a large compressive force had been applied between

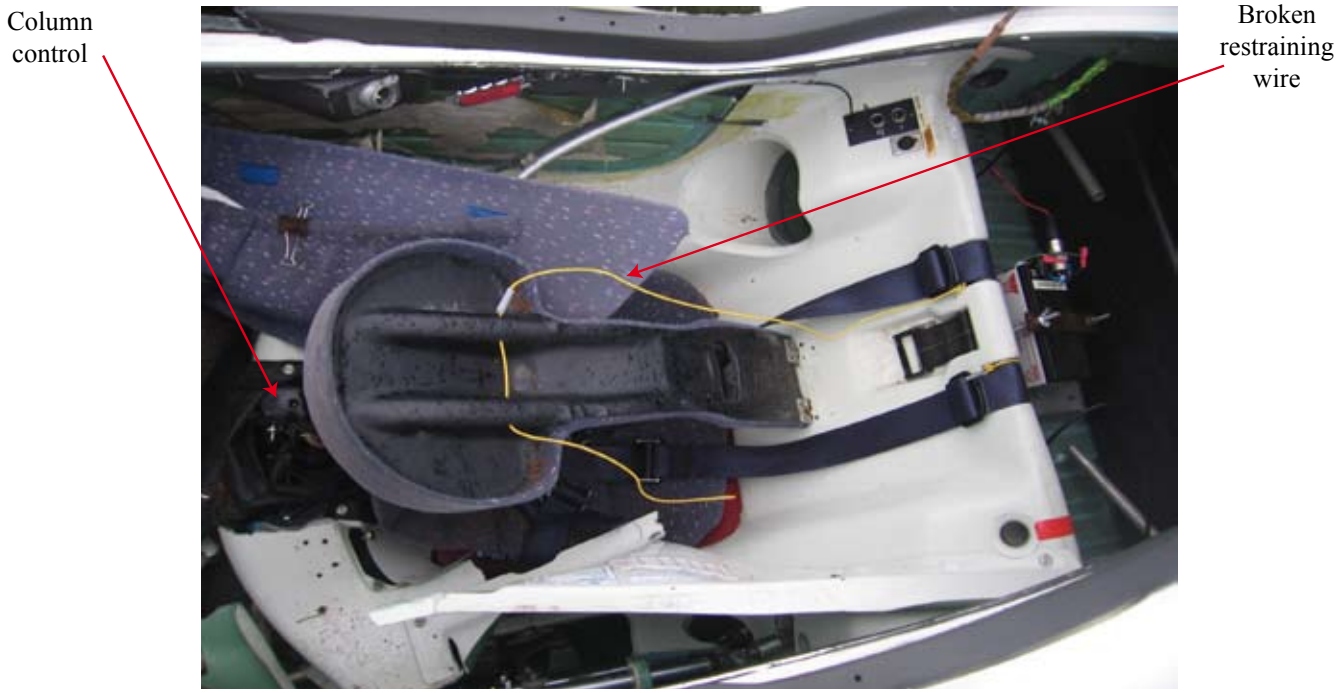

Figure 1

Rear seat headrest in 'as found' condition

the top of the headrest and the hinge point. The distortion in the foam matched the shape of a collar at the base of the control column. The length of the headrest was such that, if unrestrained, it would sit on top of the control column when the column was in the neutral position. If the column was then moved forward, the headrest would drop behind it, preventing any rearward movement of the column. In order to prevent the headrest dropping onto the control column, it had been restrained by a length of electrical cable which had failed where it had been secured to the rear shoulder harness location points. The wire was 2.4 mm in diameter, with a conductor made up of 14 x 0.3 mm diameter copper strands.

Manufacturer's Technical Notes

The glider's log book confirmed that it had been delivered 'new' from the manufacturer in 1997. Several modifications were incorporated during the build process, including Technical Note (TN) 348/5 (issued in Feb 1994), regarding the installation of a hinged headrest in the rear cockpit. The hinge was required to allow access to the glider's battery and wing rigging pins. The installation instructions for TN 348/5 stated that the headrest should be restrained by two 3 mm nylon or perlon cords, knotted to prevent the headrest interfering with the control column. The TN made no mention of the minimum strength requirement of the cords. As the release date of TN348/5 pre-dated the date of manufacture of the glider, the gliding club did not hold a copy of the TN nor was one supplied with the glider's delivery documentation.

In March 2001, TN 348/15, titled "*Greasing Schedule/Manual Revision*" was released by the glider's manufacturer, which included the reasons for issue:

> *'The securing ropes of the head rest in the rear cockpit must prevent the head rest from interfering with the rear control stick when the head rest is moved to its most forward position.'*

Item two of the compliance instructions stated:

> *'Check the securing ropes of the head rest in the rear cockpit for wear and correct length. The securing ropes must prevent the head rest from interfering with the rear control stick when the head rest is moved to its most forward position.'*

The manual revisions introduced by TN 348/15 included revisions to both the Maintenance and Flight Manuals, the latter of which introduced a daily inspection of the 'headrest ropes'. The revised sections of the Maintenance Manual made no reference to the 'headrest ropes'. There were two copies of the DG500 series Flight Manual in use at the gliding club; a copy kept permanently in the cockpit of JDN, and a further copy, kept with the maintenance manual, for reference during ground servicing and maintenance. It was noted that the copy kept in the glider had not been amended to reflect the extra daily inspection check.

Annual inspections

From delivery, JDN's annual inspections had been carried out by a single BGA-certified inspector. Shortly after the glider's annual inspection in February 2006, he found the original headrest restraining cord damaged and replaced it with the yellow electrical cable which he believed to be of comparable strength to the nylon cord, although he was aware that the prescribed material for the cord was nylon or perlon.

In early 2007 the same inspector carried out the annual inspection of JDN during which several repairs were

carried out, as well as a modification to the rear seat arrangement. The inspector stated that throughout the inspection process he had made use of BGA Form 267 *(Glider Maintenance Schedule Report*), the DG505 Maintenance Manual and the applicable TN's issued by the manufacturer.

When reviewing the Technical Notes, the inspector noted that TN 348/15, titled "*Greasing Schedule/ Manual Revision*", was listed as applicable to JDN. However, as the required greasing had been completed earlier in the inspection, he did not read the content of this TN. He also stated that no reference was made to the Flight Manual (the 'hangar' copy of which contained the reference to the security and condition of the 'headrest ropes') during the inspection process, although he was aware of the requirement to check the headrest cord during each daily inspection. The amendment state of the Flight Manual(s) was a required check under item 62 *("Flight Manual Revision"*) of the BGA Form 267 but this was not carried out in respect of the copy kept in the glider, which did not contain the revised instructions regarding the 'headrest ropes'.

Other members of the gliding club (including some responsible for completing the glider's daily inspections) were not familiar with the requirements to inspect the headrest cord. Although they were aware that the electric cable was not an approved item and its continued use had been raised in discussions, they commented that they had accepted the yellow cable as a suitable means of retention.

Tests of the rear-seat headrest

Examination of a DG505 owned by another Gliding Club showed that the headrest would fall forward at 9.5 degrees of aircraft nose-down pitch. In the event of the glider decelerating, such as during airbrake deployment, the headrest could fall forward at a lower nose-down angle. Attempts to provide an additional method of securing the headrest using the rear-seat harness proved unsuccessful. Club members confirmed that after solo flights the seat back was always found in the forward position, restrained by the cable. It was discovered that with the headrest 'unrestrained' and in its lowest position, the control column, if displaced forward, was prevented from returning to the neutral position and the elevator could not be moved up past 4º nose down.

Tests were carried out using electrical cable with the same number and diameter of conductor strands as the cable fitted to JDN's headrest. In the first test a tensile load was applied to a length of test cable and this showed that it was capable of holding a tensile load of 343.4 N. This was equivalent to suspending a 30 kg mass from the cable before the cable deformed. The mass of the headrest when measured was 1.1 kg. As the original nylon retaining cord had not been retained, it could not be tested and as no material specification for the nylon cords were given in TN 348/5, no estimation of the tensile load capabilities of a similar cord could be made.

In the second test, the headrest was allowed to fall forward until restrained by a cable attached to a load cell. The maximum recorded load was 43 N. In the final test, the headrest was restrained by a matching length of test cable, and repeatedly allowed to fall forward until the cable failed. This test was repeated five times. During the final test, the test cable failed in the same place as the cable fitted to JDN, at between 32 and 36 'falls' of the headrest. The physical properties of copper are such that under repetitive bending it becomes locally 'work hardened' and prone to fracture. The position of the break in the wire fitted to JDN, where it was tied to the

shoulder harness attachment, corresponded to a point where the wire would be subject to repetitive bending and straightening when the headrest was moved.

Safety actions

The BGA contacted all owners of DG500 series gliders to highlight the hazard a poorly restrained rear cockpit headrest could present. They also reminded owners of the correct method of restraint and the inspection requirements contained within the Flight Manual.

As a result of this accident, the gliding club concerned carried out a review of its procedures for approving members to carry out daily inspections, to ensure that they are fully conversant with the manufacturers' requirements for each glider type.

Analysis

It is clear from the eye-witness reports and evidence from the accident site that the glider flew an abnormally steep final descent, with little or no change in its attitude until it struck the ground. Considering that the pilot was an experienced and respected club member and that he had demonstrated his ability to control the glider safely under both normal and emergency conditions, it is extremely unlikely that the accident was a result of mishandling or poor judgement.

The pilot held a valid medical declaration and was in good health on the day of the accident. Although he could not recall the final dive and initial impact, this is not unusual in traumatic events such as accidents. Consequently it was considered that sudden pilot incapacitation was not a factor in this accident.

The engineering investigation established that there were no disconnections within the control circuits, and that the glider's instrumentation was functioning normally immediately before the accident. The damage to the horizontal stabiliser locating pins, elevator control arm and the elevator control rod in the fin indicated that the initial impact drove the control rod up with sufficient force to distort the rear mounting pins, which then allowed the stabiliser to be released. The loss of the stabiliser and elevator during this impact would have made the glider uncontrollable in pitch when it became airborne for the second time.

The damage to the top of the rear headrest and the compressive fracture of the headrest structure, indicated that the headrest had dropped behind the rear control column and that the column had been pushed against the headrest with considerable force. The black deposit on the headrest confirmed that it had also come into contact with the top of the rear control column with some force. It is unlikely that sufficient force would have been exerted by the pilot before impact to fracture the headrest itself, so it was probably already in its lowered position when the accident occurred and would have restricted rearward movement of the control column. Examination confirmed that the headrest would readily fall forward when the type is flown solo and if unrestrained could fall behind the control column causing a restriction.

The use of two nylon restraining cords, as detailed in TN 348/5, would have provided some degree of redundancy, although the inspector who carried out JDN's annual inspections believed that it was delivered with just a single restraining cord. This would account for the fact that, when it was replaced, only a single loop of wire was used, replicating the existing arrangement.

The lack of a specification in TN 348/5 for the nylon cords and the reliance on 'knotting' to form the loops meant that it was not possible to make a comparison between the tensile strengths of the nylon cords and the electrical

cable used on JDN. The tensile strength of the electrical cable used in the tests indicated that it appeared to be more than capable of restraining the headrest. However, the physical properties of copper make the use of a 'copper cored' cable unsuitable in an application were it would be subject to repeated bending. The repetitive 'drop' tests confirmed that the installed wire would fail after relatively few 'drops' of the headrest.

Regardless of the restraint system, the hinged headrest, introduced by Glaser Dirks Technical Note 348/5, represents a potential restriction to the movement of the rear cockpit control column when the glider is flown solo. The following Safety Recommendation is therefore made:

Safety Recommendation 2007-127

It is recommended that the Luftfahrt-Bundesamt and the EASA require DG-Flugzeubau GmbH to review the design of the hinged headrest introduced to the DG500 series glider by Glaser Dirks Flugzeubau GmbH Technical Note 348/5 to remove any possibility of a control restriction in the event that the headrest becomes unrestrained.

The inspector who carried out the glider's 2007 annual inspection did so without reference to the content of TN 348/15, believing it to be related to greasing requirements, a task he had already carried out. However, TN 348/15 did contain significant safety information regarding the headrest securing ropes but this was contained only in the body of the text and not reflected in the title.

The use of a single Technical Note to publish instructions regarding multiple subjects, including those with implications to operational safety, leads to the possibility that the significance of information related to the safety of the glider may be overlooked. The following Safety Recommendation is therefore made:

Safety Recommendation 2007-128

It is recommended that DG-Flugzeubau GmbH review their document publication procedures to ensure that safety related information is published in an independent document.

Although TN 348/15 referred only to the security of the headrest ropes and not to their material or method of attachment to the glider's structure, the inspector was aware that the wire he had previously substituted for the original restraining cord did not meet the manufacturer's specification. Although he believed that the existing arrangement was fulfilling the requirements of TN 348/15, and therefore certified the glider for continued service, he did so with the knowledge that a non-approved part had been fitted for at least 12 months.

The Flight Manual kept in JDN was the primary reference for pilots flying the glider and conducting daily inspections. Because of its incorrect amendment state, club members were not aware of the changes to the daily inspection in respect of the 'headrest ropes'.

Manufacturer's follow-up actions

The manufacturer considered that the information introduced in to the AFM by TN348/15, concerning the check of the headrest ropes, was clear and unambiguous. It also observed that owners or operators of their aircraft had a responsibility to address all items raised in each TN. The manufacturer stated that the correct installation of the headrest ropes is regarded as fail-safe as only one is actually needed to secure the headrest. Advice or guidance regarding the correct method of headrest restraint would have been readily available from the manufacturer had it been sought by the BGA inspector

concerned. As a precaution against similar oversights in the future, the manufacturer re-published TN348/15 in its last pilot information publication.

Conclusion

The accident was caused by the failure of a piece of electrical cable used to restrain the hinged rear cockpit headrest. This fell forward at some stage of the flight and, as the pilot manipulated the controls during the approach to landing, became lodged behind the rear control column, denying the pilot the pitch control necessary to recover from the ensuing dive. The electrical cable that had been fitted was a replacement for the original nylon cord, installed by the manufacturer, which had become damaged. The cable did not meet the manufacturer's specifications and the mechanical properties of copper wire made it unsuitable for this purpose.