AAIB Bulletin No: 11/93 **Ref: EW/C93/6/5** **Category: 1.4**

Aircraft Type and Registration:	Thruster TST MK1, G-MTVU
No & Type of Engines:	1 Rotax 503 piston engine
Year of Manufacture:	1988
Date & Time (UTC):	27 June 1993 at 1625 hrs
Location:	Sandown Airport, Isle of Wight
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - Fatal Passenger - Fatal
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence (Aeroplanes) with Instructor's Rating
Commander's Age:	42 years
Commander's Flying Experience:	About 1,000 hours (of which some 200 were on type)
Information Source:	AAIB Field Investigation

History of the flight

The purpose of the flight was not clear, but was probably to provide instruction for a student pilot wishing to revalidate his Private Pilot's Licence on microlight aircraft. The aircraft departed Thorney Island on the morning of the accident and completed an uneventful flight to Sandown. After some time on the ground, the aircraft was refuelled with 10.7 litres of 100 LL aviation fuel and it is thought that the instructor later added some 2-stroke oil, which he had purchased locally. The engine was started without difficulty and appeared to be operating normally as the aircraft taxied for the runway. After a short distance, however, the tailwheel spindle failed and the engine was shut down while repairs were made. After the fitment of a replacement tailwheel spindle, the aircraft again taxied for Runway 23. The weather at the time was fine with a light westerly wind and a surface temperature of +22°C. The instructor, who was operating without the benefit of radio, had warned the airport manager that the performance of the aircraft on take off would be poor, but had not stated the reason. Although the take-off weight of the aircraft could not be determined to a high degree of accuracy, it was reported that the fuel tank was full and subsequent evidence indicated that the combined weight of the occupants was 189 kg. When the weight of the pilots' clothing and equipment found in the wreckage were added, this weight increased to 200 kg. The maximum cockpit load permitted was 180 kg.

The take off from Runway 23 appeared normal with the engine apparently developing high power, but several witnesses commented on the poor rate of climb and unsteady flight after take off. Evidence from a video recording of this part of the flight indicated that a significant amount of down elevator, probably about 15°, was being applied by the pilot. At this stage of the flight, the elevator should normally have been close to neutral. Approaching the upwind end of the runway, at a height of about 50 feet agl, the aircraft turned to the left against the circuit direction, before turning to the right into wind. It was still flying unsteadily, but appeared to gain a little height before again turning right onto a downwind heading. On completion of the downwind turn, at a height of between 50 and 80 feet agl, the aircraft was very close to the runway and several witnesses thought that it was about to land downwind on Runway 05. However, it continued to fly downwind in an unsteady manner without gaining height and several witnesses reported that its speed was low, despite the fact that the engine appeared to be at a high power setting. As the aircraft flew downwind, witnesses observed that the elevator had a large downward deflection, and one of them reported that it was fully down. Other witnesses saw the instructor with his right arm raised, as if touching something above his head just below the wing. Before reaching the downwind end of the runway, the aircraft was seen to start a right-hand turn towards the runway with the engine still developing high power. After it had turned through about 150°, the angle of bank reduced momentarily before the aircraft rolled rapidly to the right and impacted the ground some 50 metres south of the runway. There was no fire.

Post- mortem examinations of both occupants did not reveal any medical condition that could have caused, or contributed to, the accident.

The impact

Evidence at the impact point indicated that the aircraft had struck the ground whilst pitched approximately 45° nose down, banked some 20° to the right, and with a high rate of yaw (rotation) to the right. The impact resulted in the total disruption of the *cockpit pod* and forward section of the fuselage tube, together with extensive break-up of the right outer wing. Following the primary ground impact, the aircraft had rotated clockwise (from above) through an angle of some 40° about the engine impact point before coming to rest.

The depth and general characteristics of the ground marks left by the propeller were consistent with a substantial degree of engine power at impact. However, it was not possible to establish whether there had been sufficient power to comfortably maintain level flight at the high all-up-weight involved in this case.

Examination of the wreckage

Engine and propeller

The impact damage precluded functional testing of the engine to establish its power potential. A visual inspection of the engine revealed no evidence of a mechanical failure. However, the forward spark plug was found to be in a partially unscrewed condition, by approximately ⅓ of a turn, and the plug was very loose in its threads. The condition of the electrodes on this spark plug suggested that the forward cylinder had been firing cleanly, but the external surface of the cylinder head in the area around the seat of the plug was contaminated with oil, consistent with long-term leakage of cylinder gases, confirming that this plug had been loose at the time of the accident, and had probably been so for some time previously. The leakage past the loose plug would have reduced the power developed by the forward cylinder by a small, but possibly significant, amount. The rear spark plug was tight but the electrodes were rather sooted and oiled, suggesting that the rear cylinder had not been firing as cleanly as it should have been prior to the accident.

Cranking the engine by hand with both plugs removed from the cylinder heads, but otherwise undisturbed from their post-accident condition, produced sparks at each of the spark plug electrodes, suggesting that the ignition system was serviceable. However, this did not establish the performance of the ignition system under conditions of high power operation.

The carburetter choke tube rubber connecting sleeves were badly degraded and cracked partially through in several places, consistent with typical degradation due to prolonged exposure to ultraviolet (sunlight). On the sleeve from the forward carburetter, these cracks had extended to form a split through the sleeve over a significant part of the barrel circumference. It is likely that this split resulted from the extension, during the impact, of one or more of the pre-existing partial cracks in the rubber, but the possibility that it had been present prior to impact, with an associated possibility of an air leak and a weak mixture at the forward cylinder, could not be ruled out completely.

The engine mountings were examined for any evidence of pre-impact failure which could have given rise to a change in the aircraft's longitudinal trim requiring a down elevator deflection, as observed by certain witnesses, to restore the aircraft to balanced flight. The engine had separated completely from the engine mounting frame but this had clearly occurred during the impact and no evidence was found to suggest that any displacement, or partial failure, of the mountings had occurred during flight.

Fuel system

The fibreglass fuel tank had broken apart in the impact, releasing all its contents except for a small residue which remained in a part of the tank remains. This residue, which was of an unusual milky appearance, was recovered and submitted for laboratory analysis. The analysis established that the sample comprised mainly *4 star* motor fuel and mineral oil in approximately the proportions expected of a normal 2-stroke mix, together with suspended matter and sediment, and a small quantity of water. The suspended matter was extremely fine and is unlikely to have affected the performance of the engine. The fuel system filters were clean.

The fuel on/off valve was located to the left of the pilot's seat squab and was found in a partially shut position. However, it was considered probable that it had moved during the impact. *As found*, there was an adequate passage of fuel through the valve.

A plastic bottle of commercial 2-stroke oil was found in the wreckage. The base of the bottle had ruptured due to internal pressure caused by the bottle being crushed in the impact whilst full, or partially full, of oil. It was not possible to determine where the bottle had been stored during flight, there being no designated storage or baggage space on this aircraft. It is considered unlikely that the bottle could have become lodged or jammed in the controls, but this possibility could not be ruled out completely.

General structure

The cockpit pod, together with the forward section of the fuselage tube and associated bracing tubes, were totally disrupted in the impact and the left outer wing and wing support struts were buckled and broken.

All wing attachments, bracing tubes and wires were connected and secure at impact, and the tailplane and fin units were also securely attached. All flying control surfaces were present and their connecting cables and linkages intact and properly connected prior to impact. The elevator trim was set to the full nose down position.

The right wing suffered extensive impact damage, but the left wing survived the impact largely intact. The fabric on both wings had degraded as a result of prolonged exposure to ultraviolet light, and small tears and abrasions had been locally patched with proprietary self-adhesive fabric at several locations along the leading edges, and elsewhere. However, there was no evidence of pre-impact tearing or failure of the fabric.

The lower battens on the outer part of the left wing showed a distinct tendency to rotate out of position under moderate hand pressure, applied locally to the wing lower surface. This tendency may have been due in part to the loss of wing tension caused by the accident; however, small *stretch-pips* were found in the wing fabric at the forward ends of each of the affected battens but not elsewhere, which strongly suggested that whilst in flight, but not necessarily on the accident flight itself, these battens had rotated out of line under the aerodynamic positive pressure acting on the wing lower surface, bringing the corners of the batten end fittings up into contact with the fabric to produce the *stretch-pips*.

Had batten rotation on the left outer wing occurred during the accident flight it would have resulted in a reduction in lift from the left wing with an accompanying rolling moment to the left. Overall lift, and hence climb performance, would have been further reduced due to the aileron deflection required to counter the rolling moment. The extent to which batten rotation of this kind might have affected the overall performance is difficult to assess, and it is possible that its effect may have been minimal. However, it is understood that in at least one case reported to the British Microlight Aircraft Association (BMAA) the effect of batten rotation was significant.

Rear fuselage tube damage

In general, all of the damage to the aircraft was entirely consistent with the impact. However, two local areas of damage were found which, whilst they may have been produced in the accident, could not positively be ascribed to the main impact. This damage comprised:

1 a bending upwards and sideways of the fuselage tube through an angle of approximately 4° at the point where the bracing tubes attach to the fuselage tube, ahead of the tailplanes.

2 gross bending to starboard of the lower fin at the rear spar.

It is possible that the latter damage was caused by a secondary ground impact as the aircraft finally came to rest. It is also possible that the bend in the rear fuselage tube may have been produced in a similar manner, but this was judged less likely. No ground witness marks were found which could resolve this question; however, due to the hardness of the ground the absence of such marks was not, in itself, significant.

Potential significance of the bend in the rear fuselage tube

Had the slight bend in the fuselage tube been present prior to impact, the resulting misalignment of the tailplane and fin would have caused the aircraft's nose to rise and turn to the right. The nose up tendency associated with such a condition was potentially significant in view of the evidence from witnesses suggesting that a large down elevator deflection was applied during the latter stages of the accident flight, since it would have required the application of significant down elevator to restore the aircraft to balanced flight. (An essentially neutral, or very slightly nose up, elevator setting would normally be expected during steady flight). All of the available evidence was therefore analysed in an effort to determine whether the rear fuselage had been bent prior to the impact.

The BMAA, in conjunction with the manufacturer, carried out a series of simple static load tests on sections of fuselage tube to determine the approximate load on the tailwheel required to produce a fuselage bend of the type observed in the wreckage. They found that a tailwheel load of approximately

1.78 kN (399 lbf) was required to initiate failure, with subsequent deformation requiring a reduced load of only 1.11 kN (250 lbf). It was reported that during one of these tests, the initial buckling failure was *felt* as a shock through the structure but the actual point of buckling occurred beneath the bracing strut attachment collar and was not visible, except by careful inspection.

An estimate of the strength of the tailwheel leaf spring, based on simple bending theory, indicated that a typical Thruster tailspring meeting the manufacturer's material and dimensional specifications would potentially be capable of transmitting a load of the order 1.7 kN (382 lbf) into the rear fuselage before failure of the spring occurred, broadly comparable with the load required to initially buckle the fuselage tube and significantly in excess of that required to produce subsequent bending. These data suggested that it might have been possible for a heavy tailwheel strike, prior to the final flight, to have produced the observed deformation of the rear fuselage tube.

Witnesses who observed the aircraft landing at Sandown said that the landing appeared normal, and video film of the aircraft taxiing prior to the take off revealed no indications of fuselage distortion at that stage, suggesting that the fuselage tube was not bent significantly out of line at that time.

The take-off area of the runway was examined closely for evidence of possible tailwheel strikes, or the presence of ruts or pot holes which could have shock loaded the tailwheel. The ground surface was hard and in good condition, and there were generally very few indentations of any kind other than the normal undulations typical of any grass runway. However, approximately 200 metres from the *start* of the runway, on the centreline, a faint line of recently crushed grass was found extending for a distance of approximately 0.5 metres. The width of this mark matched the width of the Thruster's tailwheel, and the position of the mark along the runway coincided approximately with the area where a Thruster would be expected to become airborne from the *start of roll* at, or near, the end of the runway. However, whilst this mark may have been produced by the accident aircraft as it was getting airborne, this could not be confirmed because a number of other aircraft with small tailwheels, including one other Thruster, had also used the airfield during the preceding two days.

The video film taken of the aircraft as it taxied out also included a few frames of the aircraft during the climb out. The latter part of the video was filmed at too great a range to allow a subjective assessment to be made of possible structural deformations of the rear fuselage and tail, nor was it possible to determine the elevator position. In an effort to clarify these issues, a frame of the video which clearly showed the aircraft during climb out was printed and digitised, and the digitised image then compared with images generated by a 3-D CAD (Computer Aided Design) program, having a comparable *viewpoint* and *perspective* to the video image. Three computer generated models were produced, one with a normal (undeformed) fuselage and tail, a second incorporating the observed bend in the rear fuselage tube, and a third incorporating the observed bending of both the rear fuselage tube and the lower fin. In each case, the computer models allowed elevator deflections of neutral (0°), 50% down (-15°) and 100% down (-30°) to be displayed for comparison with the video-derived image. Figures 1 to 3 show the resulting image overlays, and figure 4 shows the video frame from which the video image outline was derived.

It was not possible to perfectly match the perspectives of the two images, but within the limitations of the method a reasonable overall match could be obtained for the aircraft as a whole. Simulation of the bent rear fuselage tube resulted in minimal change in the overall image with the result that it was possible to obtain a reasonable match for both the *fuselage tube undamaged* and the *fuselage tube bent* conditions, as shown in figures 1 and 2, and therefore this analysis was unable directly to resolve the question of whether or not the rear fuselage tube was bent prior to impact. However, in both of these cases a down elevator deflection of between 15° and 30° most closely matched the video image, with neutral elevator in each case matching very poorly.

Figure 3 shows the image overlay with both the *fuselage tube and lower fin bent*. In this condition, it can be seen that the tailwheel and lower fin project outside the video image boundary sufficient to confirm that the lower fin damage was produced during the secondary ground impact.

To summarise, the image analysis tended to confirm the witness evidence of a large down elevator deflection whilst the aircraft was in flight which, by implication, suggested that the fuselage tube had been bent at some time during the final take off.

Other instances of fuselage tube damage during landing

Anecdotal evidence recently obained by the BMAA suggests that at least three instances of Thruster rear fuselage failure have been induced by heavy tailwheel ground contacts, not all of which were perceived by the pilots involved as being *damaging*.

Maintenance history

The sole documentation made available to the AAIB comprised the aircraft log book together with Permits to Fly and Certificates of Validity, the most recent of which was dated 8 September 1992, valid till 7 September 1993.

The log book indicated that the aircraft had been constructed in 1988 and a total flight time of 291:40 hours was recorded as of 30 November 1991. Ownership passed to the current owner in February 1992. Prior to 30 November 1991, entries into the log book had been made on a regular basis but technical details were recorded only in the scantest detail and there was a complete absence of supporting paperwork. Between January 1989 and January 1991 only three entries carried any name or signature, each being in the name of the of the pilot of the accident flight, and each in connection with renewals of the Permit to Fly. The log book was completely devoid of entries subsequent to 30 November 1991 with the exception of a single entry covering the inspection for its most recent Permit to Fly renewal which was carried out, and signed for, by an independent inspector on 30 August 1992.

Safety Recommendation

In view of the findings of this investigation, it is recommended that:

93-58 The CAA and the BMAA should review the strength of landing gear components on the Thruster and similarly configured microlight aircraft with a view to ensuring that damaging loads cannot be transmitted into critical parts of the aircraft structure as a result of associated ground contact forces, as required by BCAR Section 'S' which states *'Tail wheel and skids shall be weaker than the aeroplane structure to which they are attached.'* [Issued 21 October 1993]

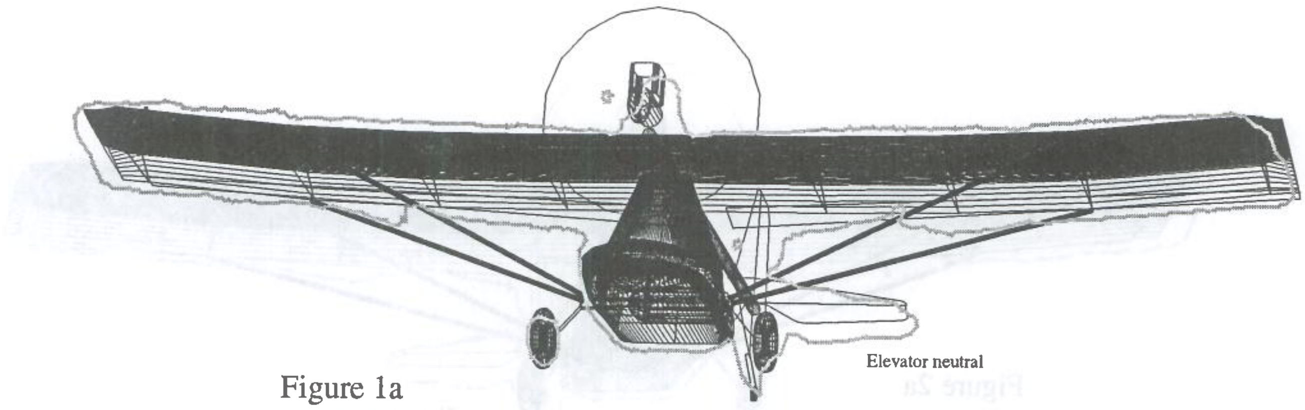

Figure 1a

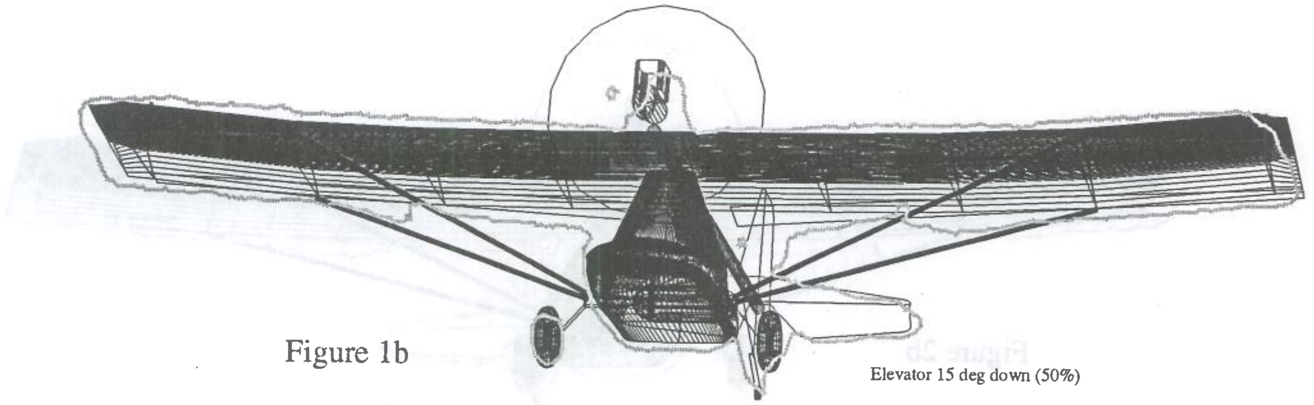

Figure 1b

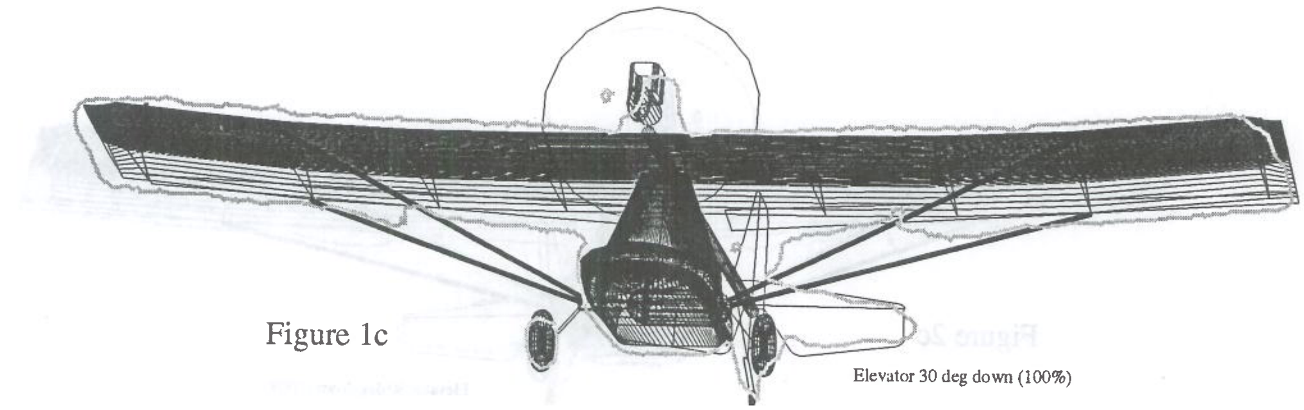

Figure 1c

Figures 1
Condition: FUSELAGE TUBE STRAIGHT
Comparison between video image outline and 3-D CAD model of Thruster TST

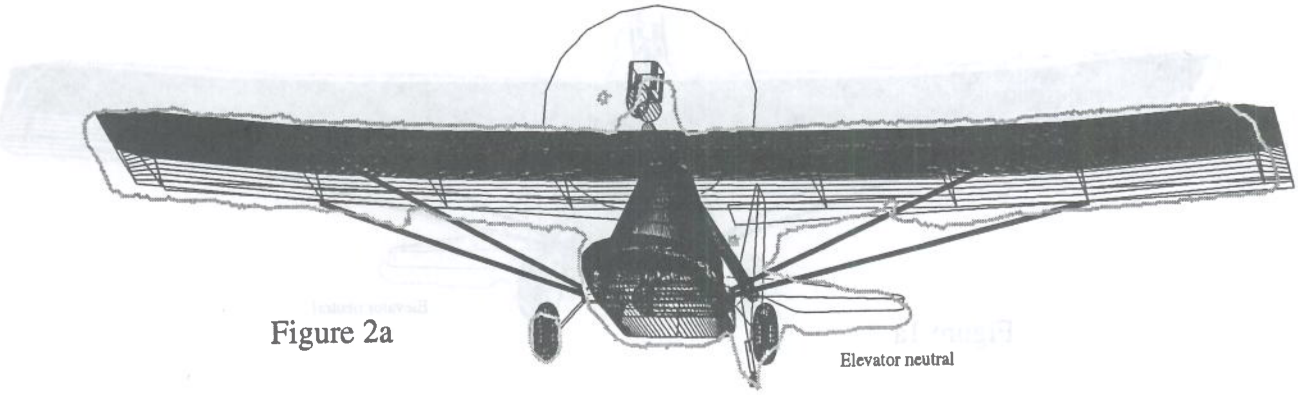

Figure 2a

Elevator neutral

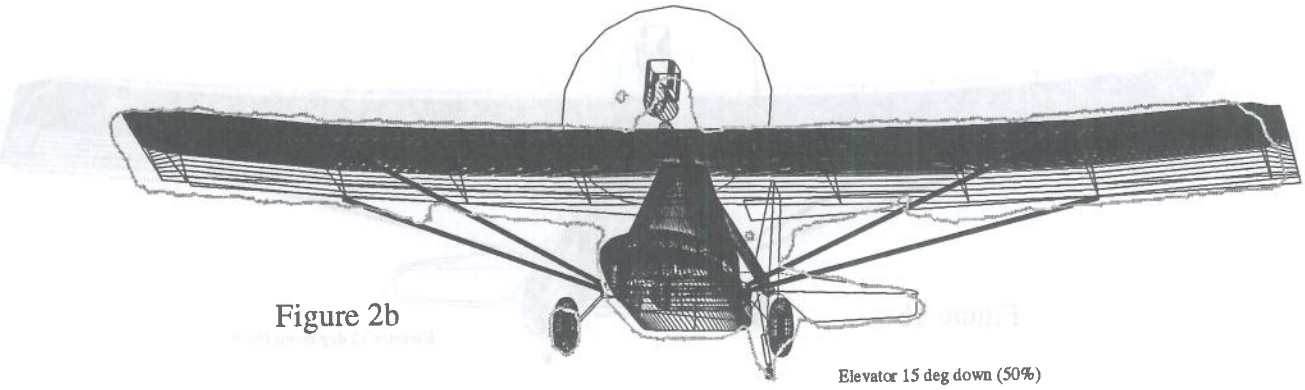

Figure 2b

Elevator 15 deg down (50%)

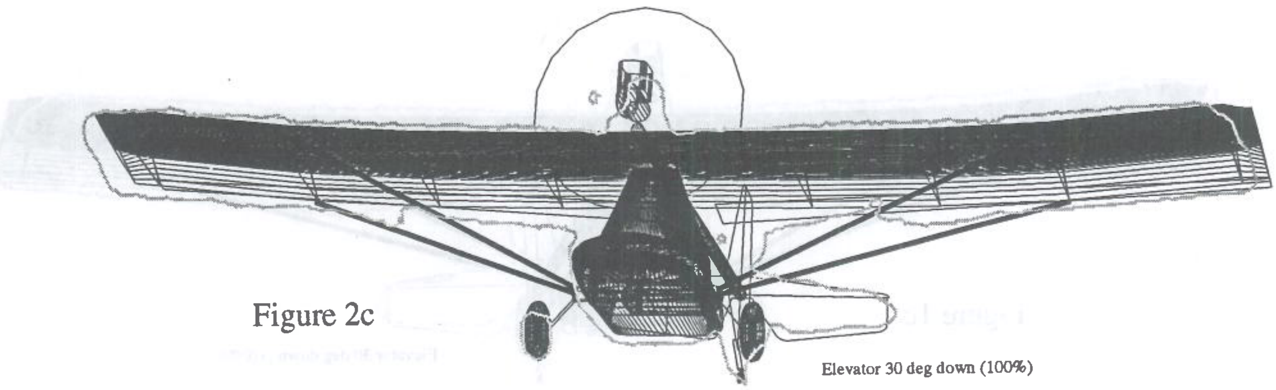

Figure 2c

Elevator 30 deg down (100%)

Figures 2

Condition: FUSELAGE TUBE BENT "as found"

Comparison between video image outline and 3-D CAD model of Thruster TST

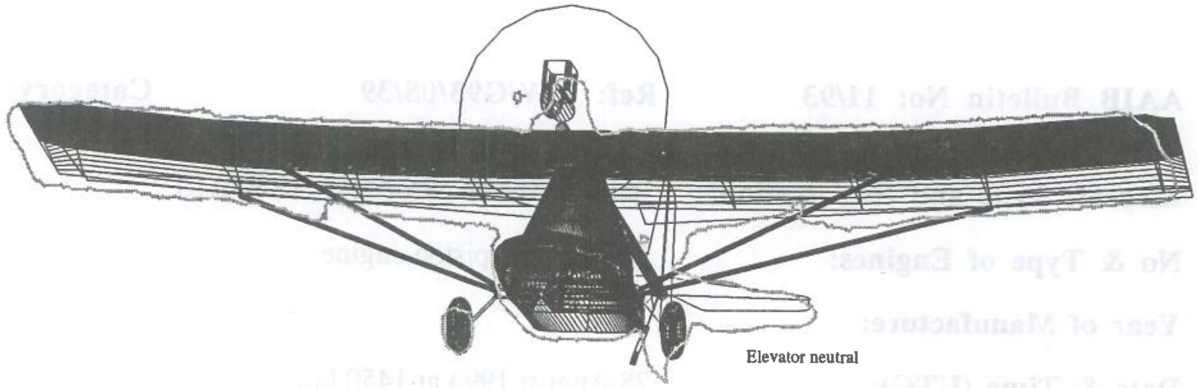

Figure 3
Condition: FUSELAGE TUBE AND LOWER FIN BENT "as found"
Comparison between video image outline and 3-D CAD model of Thruster TST

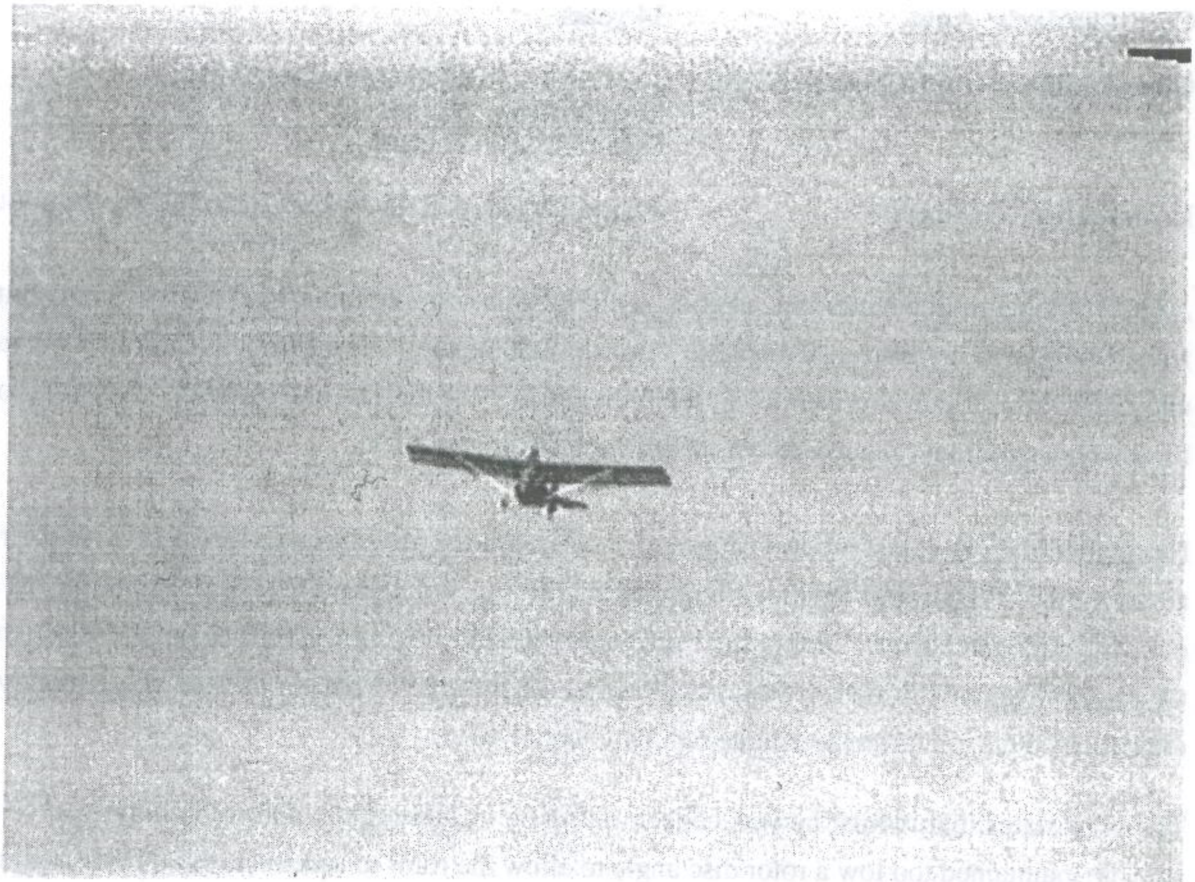

Figure 4
Original video frame