AAIB Bulletin No: 3/2005 **Ref: EW/G2004/07/24** **Category: 1.3**

Aircraft Type and Registration:	DH82A Tiger Moth, G-APAO
No & Type of Engines:	1 Gipsy Major 1C piston engine
Year of Manufacture:	1940
Date & Time (UTC):	29 July 2004 at 1132 hrs
Location:	Duxford Aerodrome, Cambridgeshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to right main landing gear, wing tip, elevator, and aileron control arm
Commander's Licence:	Commercial Pilot's Licence with Instructor rating
Commander's Age:	35 years
Commander's Flying Experience:	2,327 hours (of which 115 were on type) Last 90 days - 220 hours Last 28 days - 67 hours
Information Source:	AAIB Field Investigation

Synopsis

During a baulked landing on a temporary grass runway, the right main landing gear of the aircraft struck a proprietary 'Tribox' marker, being used to mark the runway's left edge. This caused the aircraft to decelerate, caused damage to the landing gear and gave the pilot cause to abandon his attempt to go-around. The investigation identified that the marker did not satisfy Civil Aviation Authority (CAA) requirements in terms of size, weight, or frangibility.

History of the flight

The Tiger Moth was part of a small fleet of 'classic' aircraft providing pleasure flights and flying instruction at Duxford and other locations.

A week prior to the accident, the instructor had been on duty at Duxford, and had been made aware that the usual grass runway was closed. He was briefed verbally about a temporary grass runway,

informed of its dimensions, and told that it was only available to his company. He discussed the restricted width of the temporary runway with a colleague, and agreed that while operating from it they would work to a maximum crosswind limit of 10 kt instead of the normal company Operations Manual crosswind limit of 15 kt.

On the day of the accident the instructor arrived for duty and consulted the Terminal Aerodrome Forecast (TAF) for nearby London Stansted Airport which forecast good visibility and light and variable wind increasing to 160º/10 kt by 1400 hrs. He then undertook a training detail with a student and returned to the airfield for a landing on temporary grass Runway 06, handling the aircraft himself. The approach was normal, but as the aircraft touched down a gust of wind caused it to drift to the left. The instructor applied power to go-around and, mindful of the presence of the 'Tribox' runway edge markers, maintained a three-point attitude in an attempt to gain height as rapidly as possible. Very early in the go-around however, with the aircraft still drifting left, the right main landing gear struck a 'Tribox' marker on the left edge of the temporary runway. The collision damaged the aircraft and caused it to decelerate forcing the instructor to abandon the go-around. The aircraft ground-looped and came to a halt a short distance further on, resting on the right wing tip, left landing gear and tail. Both occupants vacated the aircraft without injury.

After the accident, the instructor noted that the hollow 'Tribox' markers each contained water to a level approximately half way up from the base.

Airfield details

Duxford Aerodrome has two parallel Runways, 06/24; one tarmac and the other, grass. The permanent grass runway is 890 metres long by 53 metres wide. The aerodrome operator had planned an open-air concert that required a large stage to be erected on an area between the grass runway and the aerodrome buildings. This stage infringed the protected area around the existing grass runway. Accordingly the aerodrome operator, in agreement with the CAA's Aerodrome Standards Department, marked out a temporary grass runway similar in length to the permanent one but 28 metres narrower (25 metres wide). This was positioned between the permanent grass and tarmac runways. It was agreed that the temporary runway should be marked in accordance with Civil Aviation Publication (CAP) 168 titled '*Licensing of Aerodromes*'.

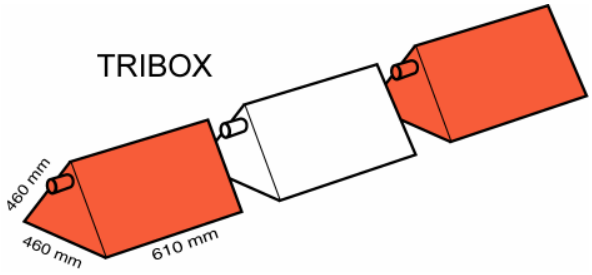
The Aerodrome Standards Department does not give specific guidance to aerodrome operators on issues such as the method of marking temporary runways or equipment to be used. The Department does however, inspect aerodromes regularly to ensure that relevant legislation, standards and recommended practices, are being complied with.

Proprietary 'Tribox' markers were purchased and used to mark the temporary runway and were laid at each runway end and along the sides. Once the markers had been placed, it was recognised that they might be disturbed by propwash, jet-blast, or helicopter rotor-wash, and instructions were given to the Aerodrome Fire Service to partially fill each hollow 'Tribox' with water. No specific instruction was given regarding the amount of water to be used, but the aerodrome operator reported that the 'Triboxes' could be moved 'fairly easily' by one man, even with water in them.

A Notice to Airmen (NOTAM) was published, stating that the permanent grass runway was closed and local arrangements were made for the Tiger Moth operator to have use of the temporary runway, though no formal written briefing was provided. The operator was made aware of the runway dimensions and markings.

The Tribox

Each triangular 'Tribox', constructed of strong medium-density polythene, is 610 mm long, with sides measuring 460 mm in length and standing 398 mm high. Individual boxes may be locked together by means of spigots that locate into holes in an adjoining box.



The manufacturer's website describes the 'Tribox' system as a system of *'Bad ground markers'*, and states that *'Tribox is virtually indestructible being moulded by the Rotational Casting process'*. It also advises that *'the Tribox can be partially filled with water to create extra stability when Jetblast or adverse weather conditions are a problem'.....'Where appropriate, each product meets ICAO, FAA and individual country CAA recommendations'*.

The 'Tribox' itself is relatively light-weight. By calculation however, a Tribox containing water to half its height would weigh some 40 kg more that its empty weight.

Protection of runways

CAP 168 gives guidance and instructions to aerodrome operators on a variety of topics. In the main it is derived from International Civil Aviation Organisation (ICAO) Annex 14 titled '*Aerodrome Design and Operations*'.

CAP 168 contains the following relevant definitions:

(a) 'Runway Strip'

'An area of specified dimensions enclosing a runway intended to reduce the risk of damage to an aircraft running off the runway and to protect aircraft flying over it when taking-off or landing'.

One purpose of a Runway Strip is: *'to protect aeroplanes flying over it during landing, balked landing or take-off by providing an area which is cleared of obstacles except permitted aids to air navigation'.*

(b) 'Cleared and Graded Area'

'That part of the Runway Strip cleared of all obstacles except for minor specified items and graded, intended to reduce the risk of damage to an aircraft running off the runway'.

The following instructions are also given:

(a) 'The Siting of Aids to Navigation within Runway Strips'.

'Any aids to air navigation to be sited within a runway strip should be made as light and as frangible as design and function will permit'.

(b) 'Markings on unpaved runways'.

'Where aircraft performance considerations necessitate the notification of field lengths for a grass aerodrome, the boundaries of unpaved runways and stopways should be delineated by runway edge markers visible from an aircraft on the approach at a range of at least 2 km. Delineation should be effected by either of the following methods: a) white, flat, rectangular markers flush with the surface, 3 metres long, 1 metres wide and spaced at intervals not exceeding 90 metres, or b) frangible markers single-coloured to contrast with their background and firmly secured to the surface spaced at intervals not exceeding 90 metres; the height of the markers should not exceed 36 cm.'

Frangibility

CAP 168 defines frangibility as:

> *'The ability of an object to retain its structural integrity and stiffness up to a specified maximum load but when subject to a load greater than specified or struck by an aircraft will break, distort or yield in such a manner as to present minimum hazard to an aircraft.'*

CAP 168 does not provide any guidance or instruction as to the value of the *'specified maximum load'* nor what constitutes '*minimum hazard'*, and it does not propose any tests for frangibility.

ICAO Annex 14 lays down Standards and Recommended Practices for Aerodromes, with Volume 1 covering Aerodrome Design and Operations. It defines a 'Frangible object' as:

> *'An object of low mass designed to break, distort or yield on impact so as to present the minimum hazard to aircraft',*

The document also contains a note stating:

> *'Guidance on design for frangibility is contained in the Aerodrome Design Manual Part 6 (in preparation)'.*
>
> (The Aerodrome Design Manual Part 6 has been in preparation since approximately 1980, and ICAO hope to publish it in 2005).

In the absence of this publication, ICAO issued 'Interim Guidance' by means of an 'Attachment' to a State letter in October 1991. This Interim Guidance proposes tests for frangibility, requiring two cases to be considered, both using a notional 3,000 kg aircraft as the test example:

> *(1) Collision with the aircraft wing in flight at 75 kt, and*
>
> *(2) Collision with the nose landing gear moving on the ground at 27 kt.*

For these tests, the frangibility requirement is that the structure shall *'break, distort or yield readily'*. The document illustrates equipment to be used in this testing and gives guidance as to how testing should be carried out. It states that:

'The object is considered "frangible" if it breaks, deforms, or yields readily upon impact and it is judged that the resulting damage to the impactor is such that no hazardous condition exists'.

The United Kingdom Civil Aviation Authority received the attachment to the State letter.

Landing gear design

The standards for the design of aircraft landing gear are laid down in British Civil Airworthiness Requirements (BCARs), Joint Aviation Requirements (JARs), Federal Aviation Regulations (FARs), European Aviation Safety Agency Certification Specifications (EASA CS) and other codes. These standards require landing gear to be capable of withstanding loads and stresses encountered during normal ground operations, takeoff and landing. There is no specific requirement to withstand collision with ground objects.

Discussion

ICAO's Standards and Recommended Practices correctly recognise the hazard posed to aircraft by collision with objects on the ground and make it clear that the runway and the cleared and graded area around it should be free of obstacles that might hazard the safe flight of an aircraft taking off, landing and in baulked landing cases.

It is inevitable that there will be occasions when temporary runways must be marked out. In establishing such markings the precise boundaries of the runway must be apparent to avoid confusion with existing markings for nearby permanent runways; although these should be obscured where necessary. The flat markers proposed by CAP 168 would seem to have many advantages and only one shortcoming; that they might be difficult to see in certain light conditions when markers with a vertical element might be more easily perceived.

The aerodrome operator chose the 'Tribox' as a means to mark the temporary runway without taking note of the maximum height stipulated in CAP 168 or assessing the frangibility of the 'Tribox' structure. The decision to partially fill the 'Triboxes' with water is at variance to the CAP 168 requirement for such markers to be lightweight.

The 'Triboxes' used were of a design intended for use on airfields. Their design however, does not satisfy the CAP 168 criteria for use as runway markers within the cleared and graded area as they stand more than 360 mm high. Furthermore, although no testing was carried out, it is clear by inspection that the combination of the structurally-strong triangular-sectioned design, the thickness

of the walls and the dense plastic material makes them unlikely to distort or yield when struck. Indeed, the manufacturer describes them as *'virtually indestructible'*.

The manufacturer's statement that they are designed to be used to mark bad ground illustrates one purpose for which they may be suitable. However, the ICAO or CAP 168 specification for 'Bad Ground' markers differs from that for temporary runway markers and this may not be immediately apparent to a potential purchaser.

The manufacturer states that 'Triboxes' may be partially filled with water but does not specify how much water should be used and it is possible that, had the Tribox in this case contained significantly less water, the consequences of the collision may have been less severe.

The delay in the publication of the Aerodrome Design Manual Part 6 (Guidance on design for Frangibility), is significant. Given this delay, the decision by ICAO to issue interim guidance material was sound but the Guidance however, does not constitute a Standard or Recommended Practice and the CAA, in receipt of the Guidance, appears not to have taken action to communicate it to aerodrome operators. This Guidance could have been incorporated into CAP 168 and would have addressed the fact that CAP 168 does not provide any definitive guidance on assessment of frangibility. Had this been carried out, aerodrome operators would have been able to carry out accurate testing to determine frangibility and this might have set in action a process by which the 'Tribox' could have been identified as unsuitable for use as a temporary runway marker within the cleared and graded area.

The ICAO tests take a 3,000 kg aircraft as the 'baseline' model and it would appear that they consider the Piper PA-31 Navajo as a typical example. The PA-31 is a twin piston light aircraft typically seating a pilot and five passengers. Frangibility requirements derived from tests, which consider a comparatively large light aircraft, are however, unlikely to be appropriate for aerodromes where most traffic is substantially lighter and slower. In particular, it will offer little safeguard to aircraft such as the Tiger Moth or many other light training and touring aircraft, microlights, or gliders.

It is also apparent, that whilst the ICAO Guidance provides means of testing for frangibility, this does not take any relevant standard for landing gear design as its baseline; indeed no such standard exists.

Conclusions

The aircraft struck a runway marker during a baulked landing that damaged the aircraft and prevented the execution of a successful go-around. The runway marker did not meet criteria

regarding height and frangibility specified in CAP 168 and was made significantly heavier than its empty weight by being filled with a quantity of water.

Safety Recommendation 2004-106

It is recommended that the United Kingdom Civil Aviation Authority Aerodrome Standards Department publish advice to aerodrome operators to ensure that obstacles placed within a runway's Cleared and Graded Area are genuinely lightweight and frangible taking into account the types of aircraft that commonly use the runway.

Safety action

The manufacturer of the Tribox informed the AAIB that:

> *'We intend advising new buyers of TRIBOX in future that whilst a small volume of water can usefully be used to weight TRIBOX to prevent it from 'blowing away' one must always consider the frangibility of this or any other product in relation to moving aircraft in Cleared and Graded areas'.*

Similar advice has also been published on the manufacturer's website.