TECHNICAL ANALYSIS REPORT No: 02/02

OCCURRENCE No: 199905562

REFERENCE No: BE/200100025

Examination of Aircraft Wreckage

Cessna Aircraft Co. U206A VH-XGR

EXAMINATION OF AIRCRAFT WRECKAGE

CESSNA AIRCRAFT COMPANY U206A, VH-XGR

Executive Summary

The partial wreckage of a Cessna 206 aircraft was recovered from an area in the Gulf of Carpentaria, near where an aircraft of this type disappeared on 24-November 1999 (ATSB Occurrence number 199905562).

Photographs and video footage of the wreckage were supplied to the ATSB and reviewed with a view to gathering further detail regarding the accident. The ATSB subsequently requested that the propeller and attitude indicator instrument from the aircraft be shipped to the bureau's Canberra laboratories for further study and analysis.

On the basis of damage to several aircraft articles recovered during the initial search, the original investigation concluded that the aircraft had impacted the water at high speed. The findings of the recent study concurred with this. From the attitude indicator and propeller it was possible to conclude with good probability that the aircraft impacted the water at high speed in an uncontrolled, inverted attitude. Evidence indicated that the propeller was rotating at impact, although it was not possible to determine whether the engine was developing power.

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Senior Transport Safety Investigator
Technical Analysis

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1. FACTUAL INFORMATION

1.1 Introduction

On 24 November 1999, the pilot of a Cessna U206A aircraft (VH-XGR) on a charter flight from Mornington Island to Normanton advised that he was diverting to Burketown because of unsuitable weather conditions on the track to Normanton. When the aircraft failed to arrive at either Burketown or Normanton, a search was commenced and subsequently recovered articles from the aircraft in the water to the south of Bentinck island. Damage sustained by these articles indicated that the aircraft had struck the water at high speed.

In late 2001, Queensland police recovered aircraft wreckage items from an area near Sweers Island (east of Bentinck Island). Photographs and video footage of these items were sent to the ATSB for identification and analysis.

1.2 Wreckage photograph and video survey

From the supplied video and photographs, twenty major pieces of wreckage could be studied in some detail. Appendix A lists these items. Each piece was examined as closely as possible from the photographs and where necessary, image enhancement techniques were employed to assist closer inspection.

1.2.1 Structure

Many of the wreckage items were consistent with having originated from a Cessna 206 aircraft. While positive identification of the wreckage was not possible, on the balance of probability it is likely that the wreckage originated from VH-XGR. Many of the structural and fuselage sections showed extensive mechanical distortion and overload fractures that were consistent with the aircraft forcibly striking the water. From the recovered wing struts and elevator sections, it was evident that the general physical damage was greater on the right side of the aircraft.

1.2.2 Instrumentation

Study of the photographs identified a conventional VHF Omni-Range navigational instrument (VOR), an artificial horizon / attitude indicator (AI) and a directional gyroscope (DG). The VOR was tuned to a frequency of 117.5 MHz, which was the frequency of the Mount Isa VOR station. The attitude indicator was readable from one photograph and appeared to indicate an inverted right wing down, nose down attitude. For that to have been a valid indication of the attitude of the aircraft on striking the water, the indication would have to have resulted from entrapment of the indicating sphere at impact. The directional gyro was not readable from the photographs supplied.

1.2.3 Propeller

The aircraft's propeller was a Hartzell three-bladed constant-speed (non-feathering) unit. The photographs showed that one blade had broken away from the hub and was not present. The other blades showed varying levels of bending and deformation, including some local damage to the tip regions. Both blades appeared to be in different pitch positions.

1.3 Laboratory examination

Based on the information gained from the photographic examination, it was decided that further study of both the propeller and the attitude indicator was warranted, to confirm the conclusions drawn from the photographs. Accordingly, those items were forwarded to the ATSB laboratories in Canberra.

1.3.1 Attitude indicator instrument

On receipt, initial inspection confirmed the indication presented by the attitude indicator sphere and bezel was the same as that shown in the original photographs. When viewed face-on and compared with an identical, undamaged instrument (figure 1), the indication represented a bank angle of 135 degrees right wing down (ie. 45 degrees inverted) and 35 degrees nose down. Other than in aerobatic manoeuvres, that attitude was not consistent with normal controlled flight.

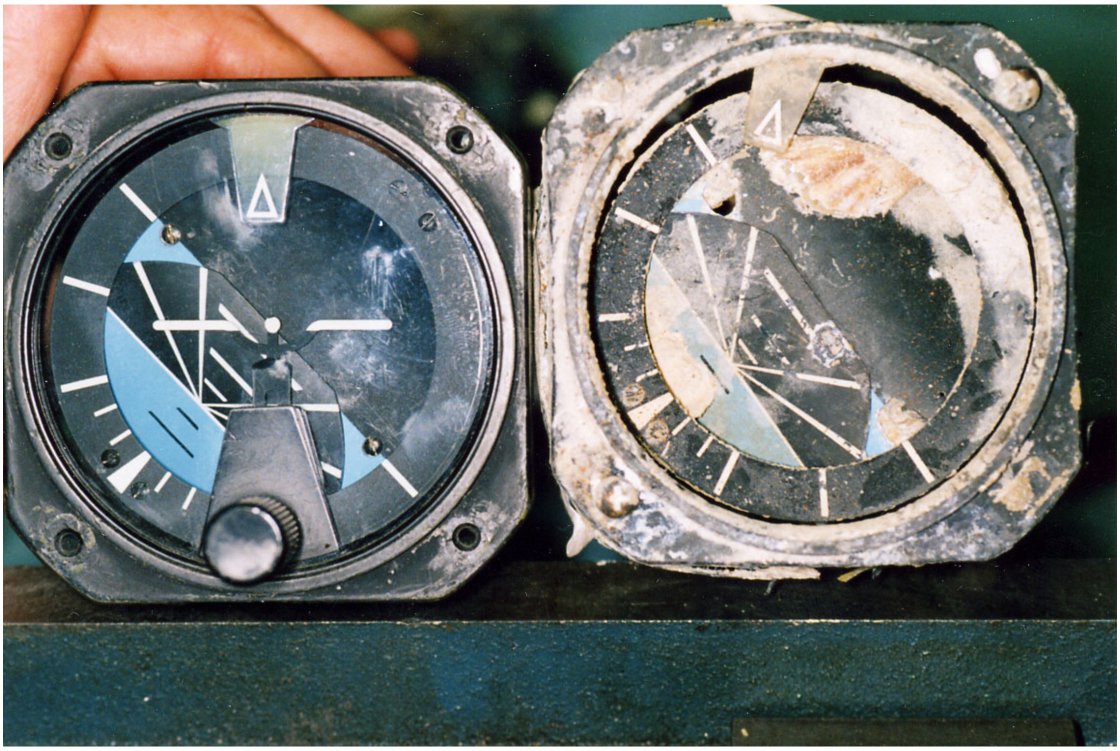
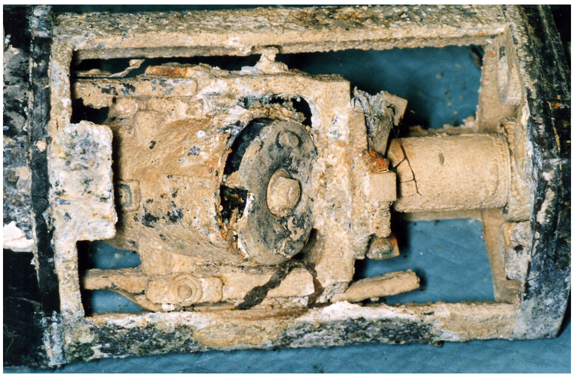
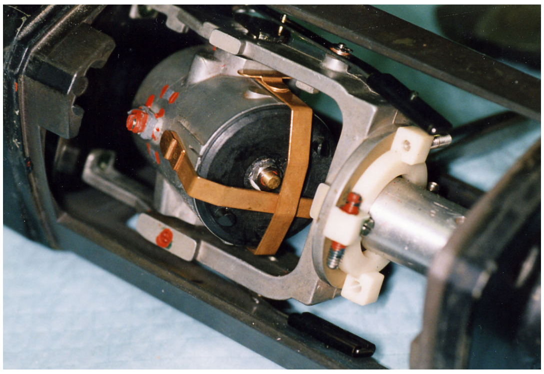


Figure 1. Attitude Indicator instrument recovered from the aircraft (right), compared to a similar demonstration instrument (left). The indication on the demonstration instrument has been set to match that shown on the recovered unit.

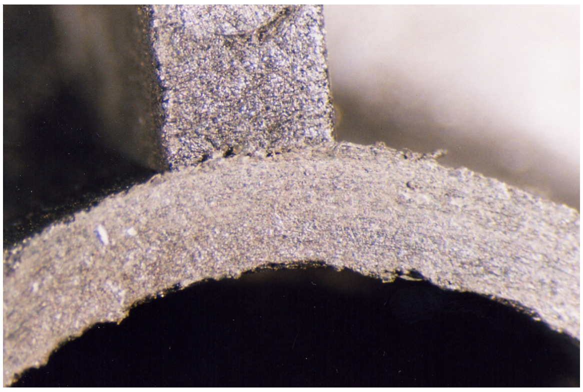
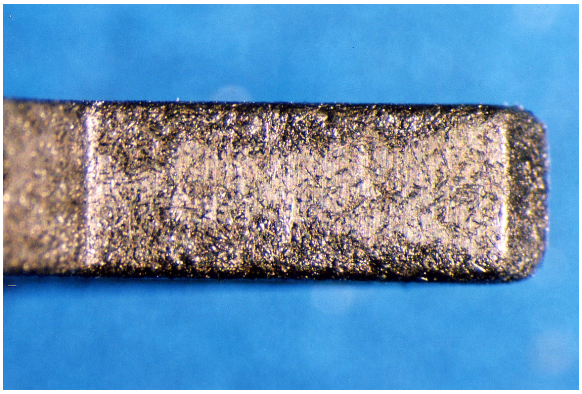
Removing the case from the instrument showed that the rear cap of the gyroscope housing had moved out of position, trapping the movement against the base of the fork mount (figure 2). Both pendulous arms, normally sitting behind the gyro housing (figure 3), were recovered loose within the instrument case. Close inspection of the gyroscope revealed a small fragment of glass lodged within the housing; between the end plate and the rotor (figure 4). The glass was similar to that used on the face of the instrument. Further disassembly of the gyro housing found the rotor shaft fractured at a point adjacent to the rear bearing, allowing the end cap to move outward. The rotor itself had also been displaced axially by several millimetres (figure 5) and evidence of rotational contact against the inside edges of the end cap was clearly observed after cleaning and microscopic study (figures 6 and 7). Evidence of rotational scoring was also found around the outer end of the gyro rotor (figure 8).

Figures 2 & 3. Internal gyroscope from the recovered instrument (left) and the demonstration instrument (right).

Figure 4. Gyro housing, showing the fragment of instrument glass inside

Figure 5. Gyro housing, showing forward movement of the inner bearing.

Figures 6 & 7. Rotational damage on the housing end plate and ribs – evidence that the rotor was spinning at impact.

Figure 8. Gyro rotor end face, also showing evidence of rotational scoring.

1.3.2 Propeller

The propeller unit was extensively damaged, having one fractured blade and the remaining two severely bent (figure 9). Remnants of the spinner mounting plate remained on the hub and all surfaces were covered by an accretion of marine growth and deposits (figure 10). Examining the hub rear face after cleaning found that several of the mounting-bolt holes had sustained sideways distortion damage, consistent with the separation of the propeller hub from the engine crankshaft under bending loads (figure 11). One of the two locating dowels set into the hub had also broken away in a similar manner. The internal threads of all mounting-bolt holes were stripped. Both blades remaining within the hub were loose and able to be rotated by hand. The most severely bent blade had rotated through approximately 180 degrees in its mount, with the leading edge facing backward. The separated blade had fractured in an angular manner immediately above the thrust-bearing seat and entirely within the hub mount (figure 12). Fractures of that nature are typical of gross, out-of-plane bending overloads.

Figure 9. Propeller unit as-received.

Figure 10. Level of marine growth and accretions typically present over the entire unit.

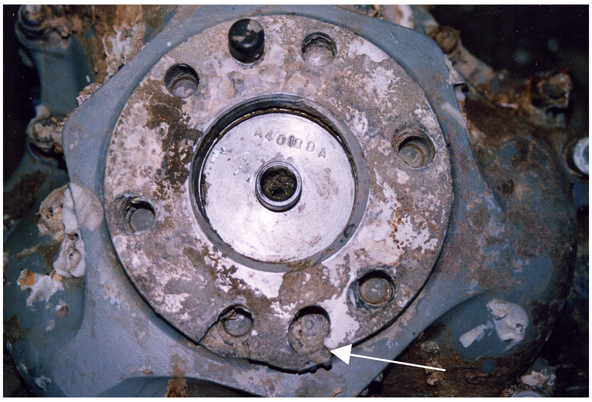


Figure 11. Propeller hub mounting face (after cleaning), showing lateral distortion of the mounting bolt holes.

Figure 12. Blade fracture surfaces, giving some indication of the direction of failure.

A third-party organisation carried out the disassembly of the propeller hub in the presence of a representative from the ATSB. During the disassembly, it was evident that the thrust bearings and hubs from all blades had sustained heavy impact and bending damage. The thrust bearing races exhibited multiple fractures and roller indentation (brinelling) over one-half of the circumference (figure 13), while the blade hubs displayed the partial shear fracture of the lip beneath the bearing seat (figure 14). The obvious bias in the damage toward one side of the blade hubs was indicative of severe bending loads between blades and hub. The position of the damage with respect to the hub axis suggested that the bulk of the bending forces acted to bend the blades backward; that is, to displace the plane of rotation in a rearward direction. Flattening of an edge around the base of each blade supported this finding, with the size of the flattened area proportionate to the degree of bending sustained by the blade aerofoil sections (figures 15,16 & 17). The largest area of flattening (greatest bending loads) was found on the base of the fractured blade. All three pitch-change lugs on the base of the blades had fractured under shear loads, with the direction of fracture consistent with the blades being forcibly twisted to a finer pitch.

Figure 13. Thrust bearing race from the fractured blade. The crushing damage was found on the forward-facing side.

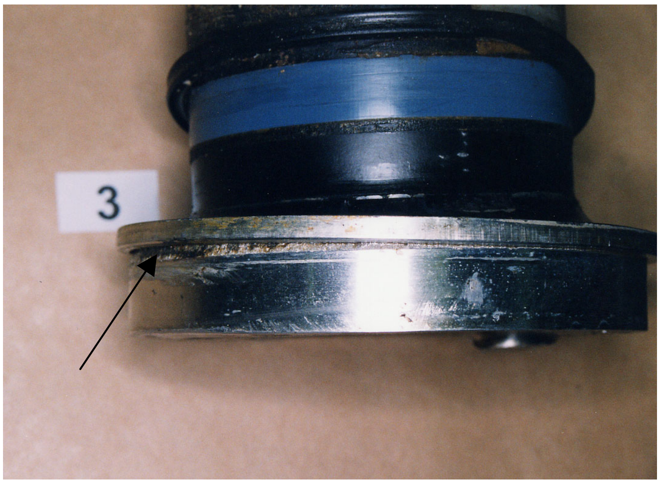
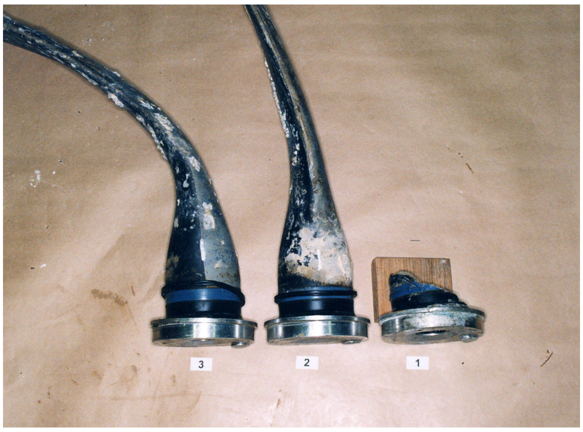


Figure 14. Blade base flange, showing the shear failure of the rim edge under bending loads.



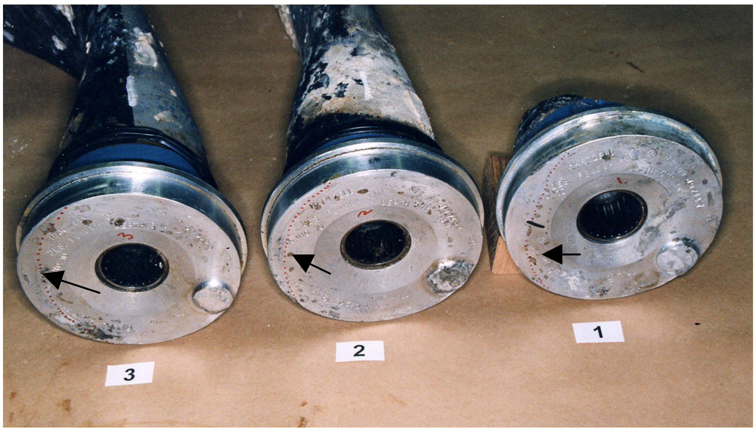


Figure 15 (top L). Three blades as removed from the hub – note the variation in bending.

Figure 16 (top R). Blade 1 end face, showing the flattening damage typical of excessive blade bending loads.

Figure 17 (left). Base of the three blades showing the variation in the extent of the flattened area on each (red dot outline).

Examining the three blades along their axial plane (figure 18) allowed comparison of the extent of out-of-plane distortion. The examination showed that the degree or severity of bending decreased with the sequence of rotation. Given that blade number-one had fractured under bending loads and also showed the greatest degree of base flattening, it was likely that the blade had experienced the most severe bending loads. Blade number-three was the next most severely bent and blade number-two the least. These findings were consistent with propeller rotating at the time of impact.

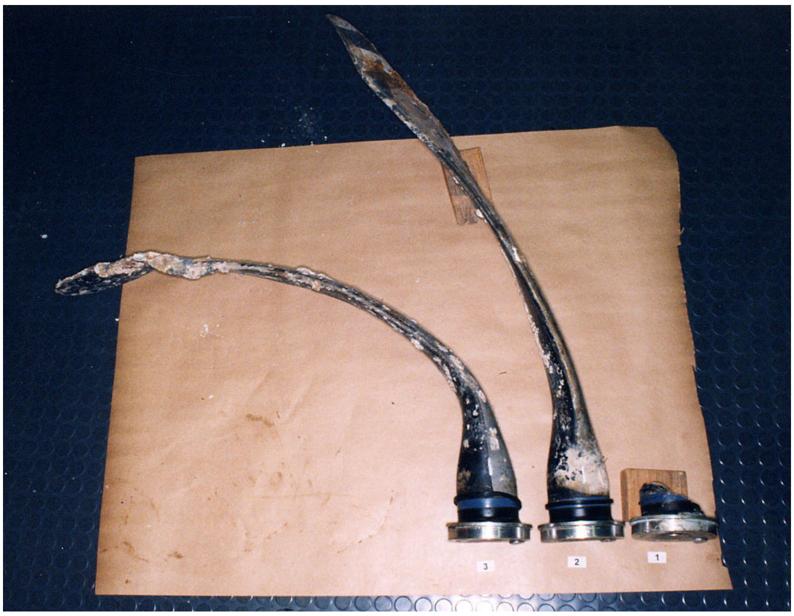


Figure 18. A Comparison of the extent of bending, with all blades in the same axial orientation. The failed blade probably sustained the greatest level of bending and fractured as a result.

Blade number-two showed a region of shallow forward bending at the tip (figure 19). The forward bending of blade tips is sometimes indicative of the engine developing power at the time of impact. In this case, however, the bending was considered insufficient to represent a positive indication of the aircraft being under power at the time of the accident.

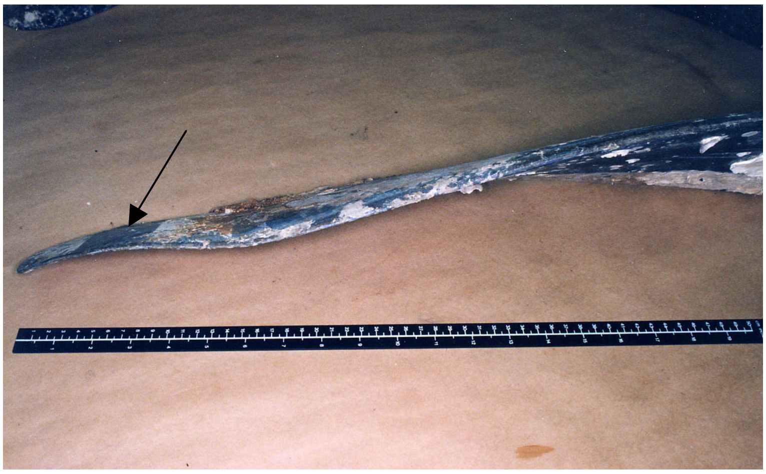


Figure 19. Forward bending of the immediate tip of blade 2.

The outer leading edge of blade number-three showed a region of missing material and associated evidence of rotational impact against a solid object (figure 20). Given the degree of rearward blade bending, it was likely that this impact was with the engine or fuselage of the aircraft.

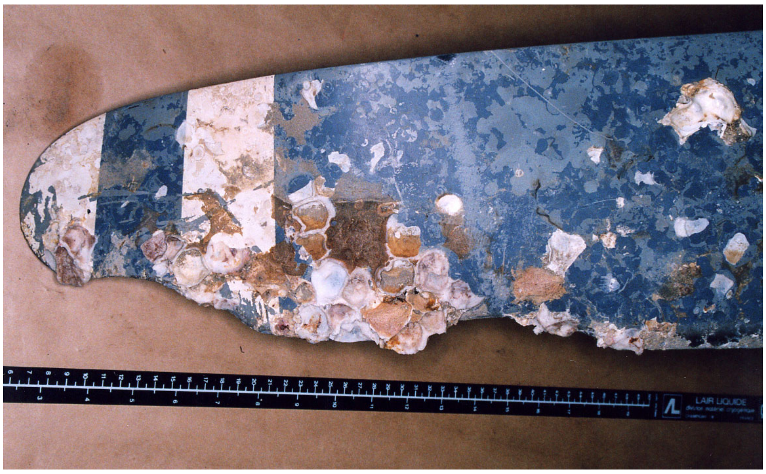


Figure 20. Impact damage and material loss from the leading edge of blade 3.

The propeller hub carried the serial numbers 'EE2662A' stamped on the side of the housing and 'A40188A' within the bore of the mounting face. Blades one, two and three carried the serial numbers J07447, J07454 and J07445 respectively. From features associated with its construction, the propeller unit was formally identified as a Hartzell Controllable (non-feathering) model, type HC-C3YF-1.

2. ANALYSIS

2.1 Aircraft attitude

Examination of the attitude indicator from the accident aircraft was successful in confirming that the indication present on the instrument was most likely a valid indication of the attitude of the aircraft when it struck the water. Physical entrapment of the mechanism had occurred from the movement of the gyroscope rotor against the back of the housing during impact. The indicated attitude (inverted, 45 degrees right wing down and 35 degrees nose down) shows that control of the aircraft had been lost prior to it striking the water.

In the event of the failure of the attitude indicator instrument in poor visibility conditions, where reference to a visual horizon cannot be maintained, the pilot is deprived of the main means by which the aircraft can be kept in controlled, stable flight. This scenario has been implicated in previous accidents where control of aircraft has been lost in conditions of reduced visibility. In this event however, score marks present on both the housing and rotor indicated that the rotor was spinning at the time of the accident and thus the instrument was probably in a serviceable condition when the accident occurred.

The bias in structural damage toward the right side of the aircraft represents further evidence of the aircraft striking the water in a right wing down attitude.

2.2 Propeller damage

Physical evidence found during the examination of the propeller unit was consistent with the aircraft impacting the water at an angle similar to that displayed by the attitude indicator instrument (see above). The progressive backward bending of the blades and the damage to the pitch-change lugs indicated the propeller entered the water with a significant forward velocity and an appreciable rotational speed. It was not possible to conclude whether the engine was developing power at the time of impact.

Appendix A. Wreckage Photograph Evaluation

Occurrence No: 199905562, VH-XGR

Item No.	**Identification**	**Assessment**
1	Door, cabin, left (pilots) side	Twisted along length, window frame fractured at top rear. Both hinges torn from airframe.
2	Elevator, left side	Control surface fully intact, no major distortion.
3	Wing strut	Suspected from right side (position of anti-abrasion strip). Single bend at mid-point, possibly from compression forces.
4	Propeller, 3 bladed variable pitch.	One blade missing from hub, other two in coarse position. Blades show varying levels of rearward bending.
5	Elevator, right side (partial)	Fractured approx ¼ – 1/3 along length from inside end. Fracture shows rearward bending characteristics. Trim tab absent.
6	Fuselage section	Partial box section from mid or forward fuselage. Partial bulkheads evident, with significant distortion associated with fractures.
7	Avionics – Transponder	Identification decal legible. Front panel / squawk code etc not shown.
8	Instrument - VOR	Tuned to 117.5 – this is the frequency for the Mt Isa VOR. Decals on casing not legible.
9	Instrument - Attitude Indicator	Front glass appears missing. Indicated attitude is approximately 95 degrees right bank, approximately 25 degrees nose down.
10	Manifold - unidentified	
11	Component - unidentified	
12	Component - unidentified	
13	Seat belt & anchorage	Webbing soundly attached to mount.
14	Structure - heavy bolted section	Extensive fracture damage, consistent with overload forces.
15	Structure - scraps	Mechanical damage and distortion.
16	Structure - scraps (riveted)	Mechanical damage and distortion.
17	Structure - scraps with insulation	Mechanical damage and distortion.
18	Structure / Fuselage	Origin location unknown. Area of external panelling shows white base colour, with gold band trimming and a small painted Australian flag.
19	Instrument – Directional Gyro	Reading not visible, minimal casing damage.
20	Structure – unidentified	Marked with ‘S/N 10341??’