Kalkara Investigation

A Kalkara Target Aircraft was lost during an operational flight.

A DSTO investigation determined the cause of the failure and provided recommendations to prevent similar occurrences.

A complete teardown inspection of the aircraft is under way, primarily to determine the effects of long term salt water exposure.

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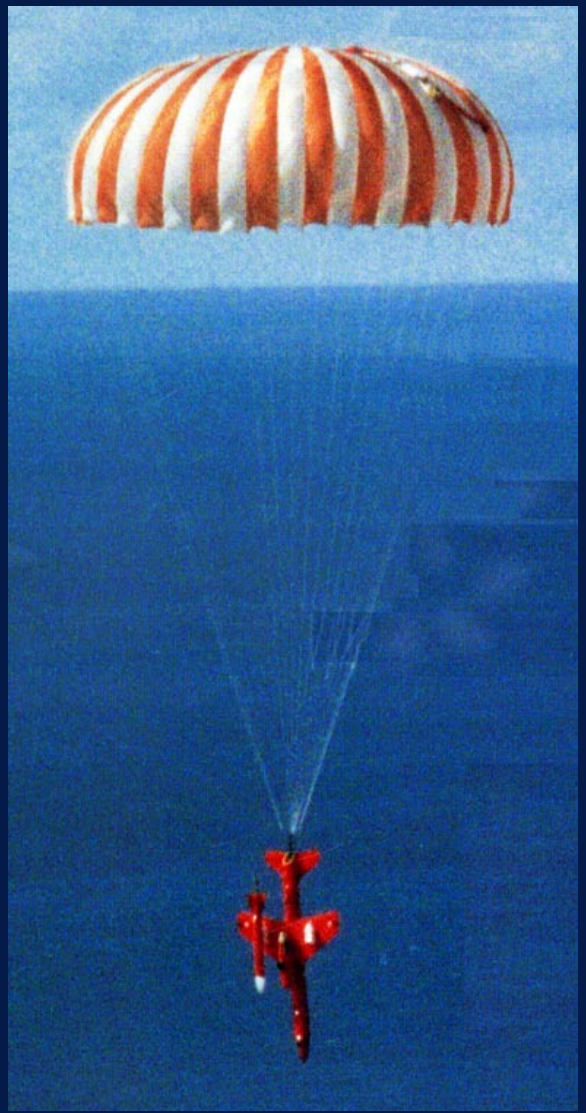
The Kalkara Target Aircraft

- Kalkara - a recently commissioned, unmanned target aircraft used for gunnery practice.
- Launched from mobile platform using rocket assistance.
- Operates under pre-programmed and radio controlled instructions.
- Range of missions as a drone - towing targets.
- After a few flights, the aircraft itself may be used as a target.
- In Australian service, more flights per aircraft than in the US.

Kalkara - Service History



A Kalkara was “lost” while flying over the sea near Jervis Bay.

After being fired upon, control was lost and the aircraft flew erratically, before communication was lost.

Normally a recovery parachute would deploy automatically and electronic locating gear would become active.

Aircraft or debris not located by an extensive Sea/Air search.

Initial RAN investigation suggested that the aircraft had been hit when fired at and broke up with all debris sinking.

Kalkara - Recovered

Barnacle

Six months later the aircraft was found washed up, upside down, on a beach 150km north of the original target area.

The aircraft was in remarkably good condition - the only significant damage was:

- Both plastic wing-tip caps missing
- Port aileron missing
- Rudder missing
- Substantial marine growth

Unit Investigation - DSTO Analysis

Preliminary failure analysis conducted by OIC Kalkara flight LCDR R. J. Ferry.

- Concluded that the aircraft failed due to loss of the port aileron during flight, and
- Proposed a mechanism by which the aileron became detached.

DSTO requested to :

- Provide scientific support to the failure analysis
- Conduct a full teardown inspection of the aircraft (to determine effects of extended exposure to the seawater environment).

Kalkara - Inspection

Inspection at Jervis Bay Range Facility (JBRF).

Marine growth showed which components departed when the incident occurred and which separated later when the aircraft beached itself.

Absence of marine growth showed that the wing tip caps became detached and the rudder broken when the aircraft was beached.

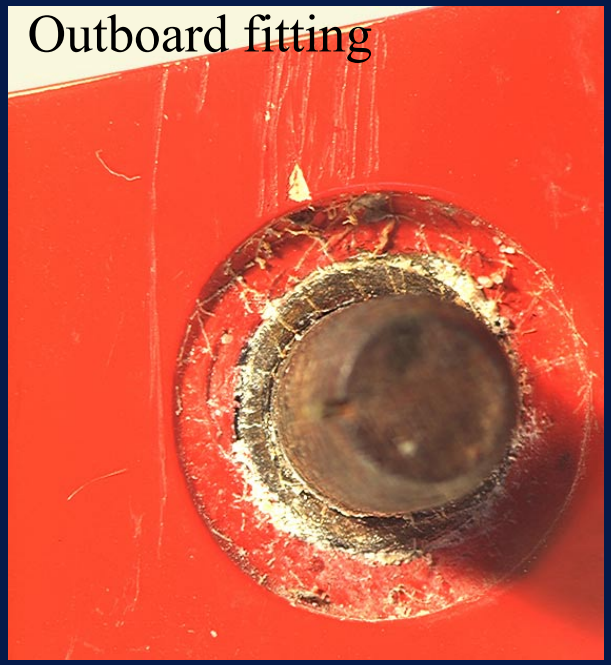
Kalkara - Missing Aileron

The area normally occupied by the port aileron had barnacles as large as any found elsewhere on the aircraft.

This indicated that the aileron detached at the time of the incident (possibly a significant event in the failure sequence).

However, the aileron attachment bolt was still present

Kalkara - Witness Marks

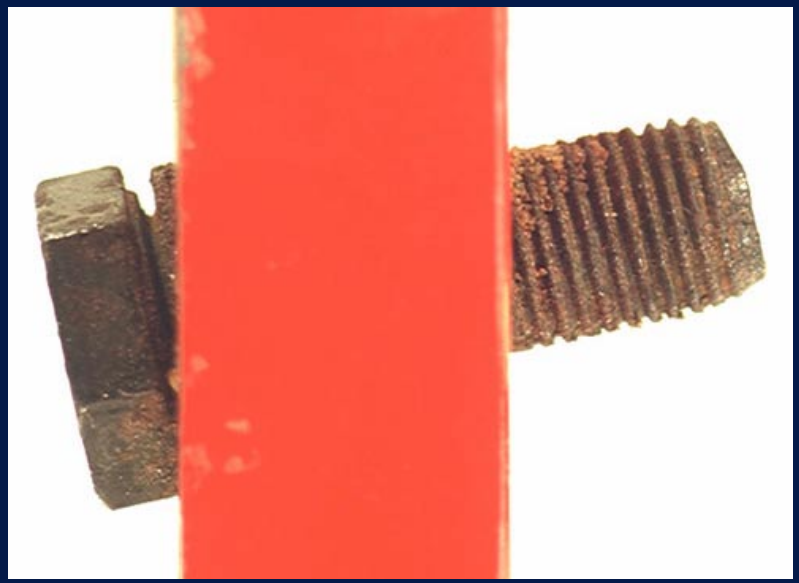


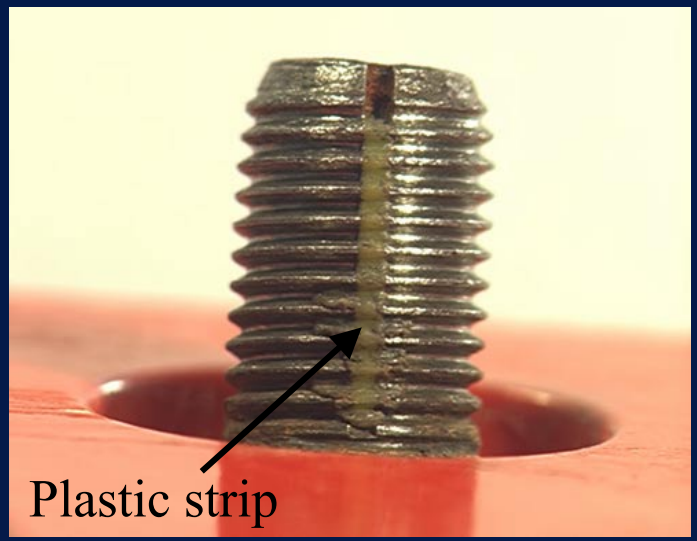
Witness marks (scratches) showed that the aileron first became detached at the outboard end (the attachment bolt end).

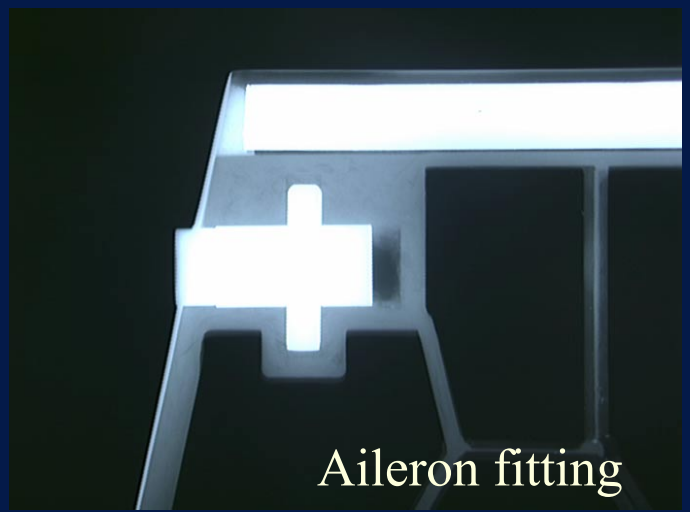
The aileron then moved outwards and upwards, pulling out from the inboard fitting where a square shaft that located the aileron caused damage.

No other damage marks were observed in this area suggesting that the aileron had departed intact rather than breaking up while the target was shot at.

Kalkara - Aileron Attachment Bolt





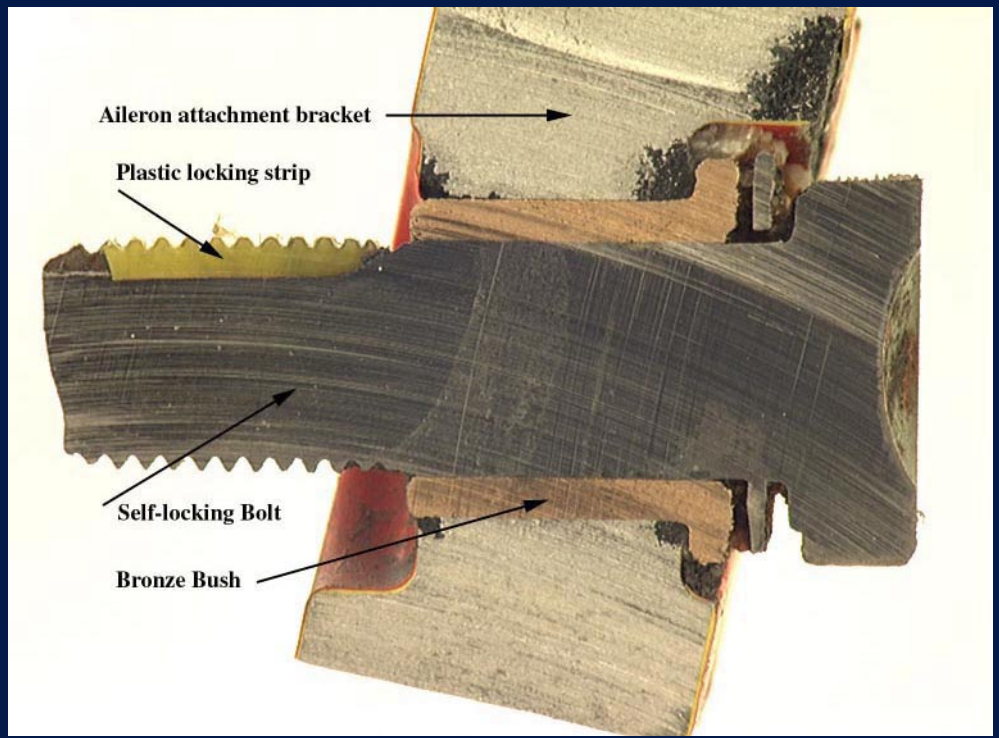


The aileron attachment bolt was present, but slightly displaced from its normal position

A plastic locking strip which locks the bolt to the aileron was clearly visible after the bolt was cleaned.

The aileron attachment bolt normally fits to a substantial fitting within the aileron.

Kalkara - Locking Attachment Bolt

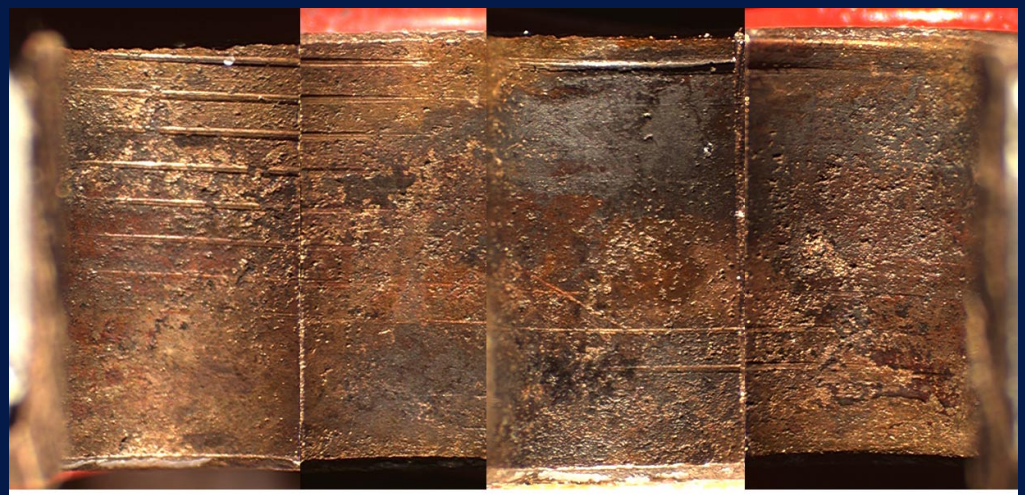


Cross-section of aileron attachment bolt showing:

- that the bolt was not in the correct location
- the plastic strip which locks the bolt to the aileron
- the bronze bush which provides a bearing surface for the shank of the bolt as it rotates with the aileron.

Screw thread marks visible on the bearing surface of the bush after the bolt was removed.

Kalkara - Thread Marks in Bush



Top/Forward Bottom/Forward Bottom/Aft Top/Aft

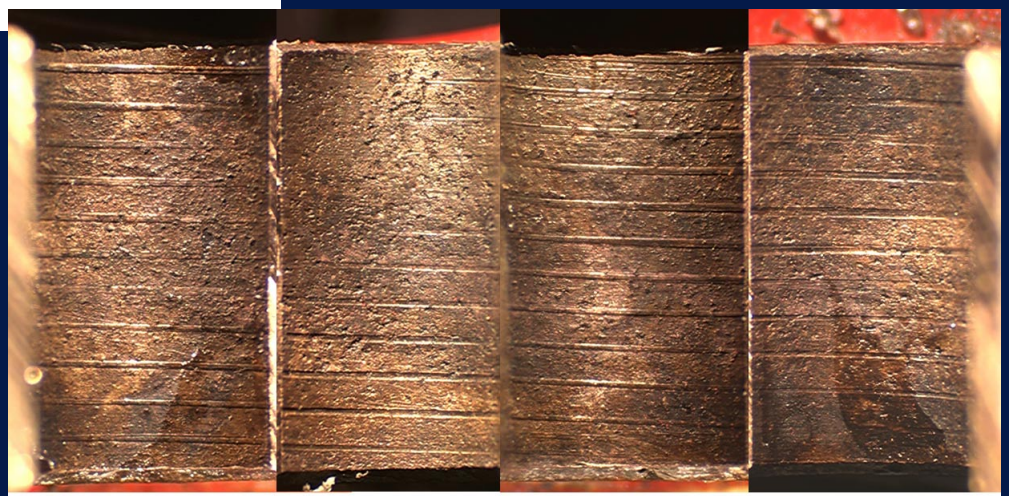
Port aileron bush - Aileron missing
Outer end of bush (collar) at bottom

There was a single set of thread marks on both the port and starboard bushes.

Thread marks are produced when a new bolt with undeformed locking strip is forcibly screwed through the bush.

This indicates that a new bolt was fitted only once, even though the aileron was removed several times.

Port Aileron Bush
(missing aileron)

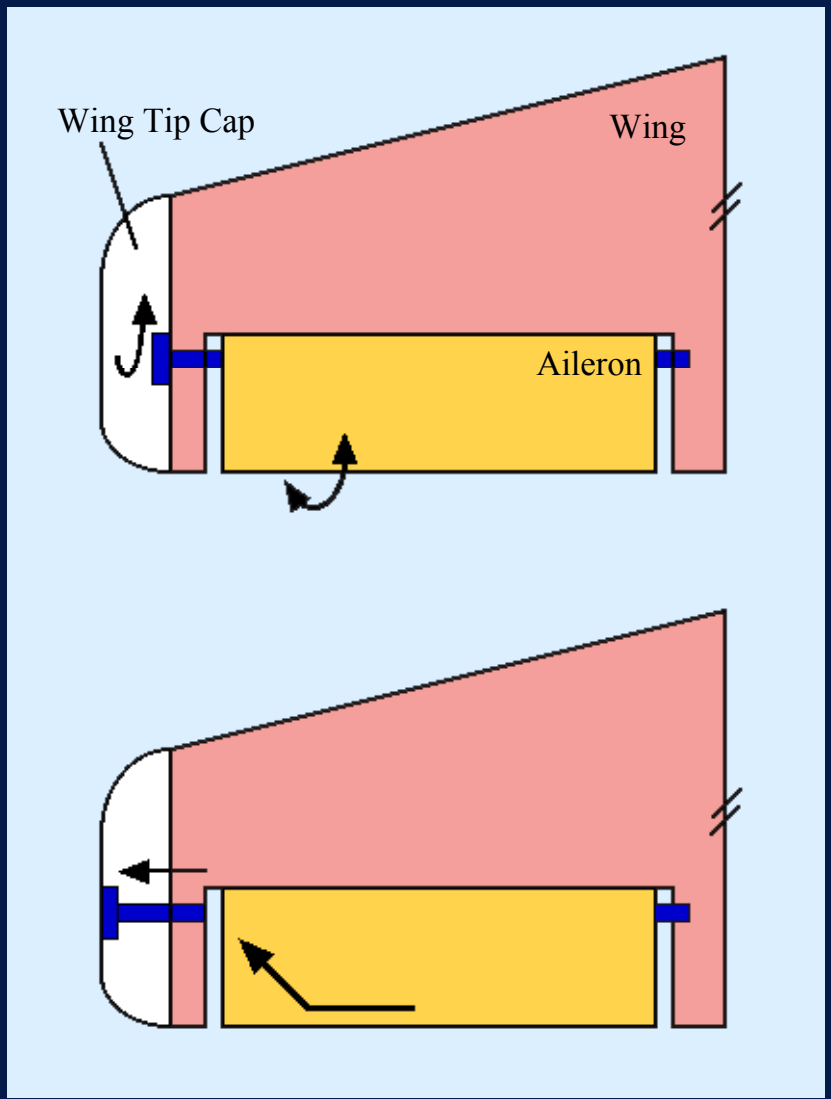


Top/Aft Bottom/Aft Bottom/Forward Top/Forward

Starboard aileron bush - Aileron present
Outer end of bush (collar) at bottom

Starboard Aileron Bush
(aileron present)

Kalkara - Failure Sequence



The multiple use of a “single-use” lock-bolt reduced its effectiveness, allowing the bolt to unscrew with aileron movement.

The bolt unscrewed until fully detached, allowing the aileron to depart in an upward and outward direction.

The plastic wing tip cap retained the bolt within the bush allowing it to fall back to near its original position, after the aileron had departed.

Kalkara - Teardown Issues

Destructive Testing or Teardown

Possibility of test-to-failure load tests on the whole airframe or selected structural elements and components, to support the certification of the aircraft. Teardown inspection approach was preferred for reasons including:

- This aircraft had an extremely unrepresentative service history
- A more representative aircraft could be made available after it had performed the required number of towing missions
- The unique history is an:
  - advantage to corrosion evaluation
  - disadvantage to strength determination
- A complex and expensive test rig would be required to adequately apply test loads to the aircraft.

Kalkara - Teardown

Purpose

- Identify corrosion hot spots
- Examine the condition of critical structure
- Identify areas susceptible to water ingress
- Evaluate the performance of bonded composite honeycomb structure

Procedure

- Disconnect fuel lines and electrical looms
- Dismantle aircraft into major components:

Wing section	*Tail assembly*	*Control surfaces*
Fuselage sections	*Engine*	*Control & instrument assemblies*

- Radiograph appropriate major components
- Disassemble/section/inspect the major components

Teardown - Wing and Control Surfaces

The centre wing section, the wing tips, and the control surfaces are to be:

- Radiographed
  - To assess whether radiography can detect water ingress and/or the resultant corrosion damage.
  - To determine the internal structure to assist in sectioning components
- Sectioned
  - allow visual inspection of the internal structure
- Inspected
  - Survey damage/condition

Teardown - Control & Instrument Assemblies

All electronic control and instrument assemblies will be opened and examined to determine:

- If water ingress has occurred.
- Location and cause of any water leaks detected.
- The resultant damage.

Teardown - Engine

The engine will be stripped down to components to determine:

- Extent of corrosion caused by the long exposure to seawater
- Possible effects of temperature cycling which may occur in normal operation when the motor enters the sea during a sea-based recovery of the aircraft.

Kalkara - Conclusion

Failure Analysis

- Successfully determined the cause of the aircraft failure
- Provided a probable failure sequence
- Provided recommendations to prevent further occurrences.

Teardown and Inspection

- Identify areas susceptible to water ingress
- Identify corrosion hot spots in the aircraft structure
- Examine the condition of critical structures
- Evaluate the performance of bonded composite honeycomb structures