

UK MILITARY COMPOSITE MATERIALS TRAINING AND ISSUES

Mr Steven Arrowsmith MSc CEng MRAeS
UK Military Aviation Authority
Certification Division - Structures (Large Aircraft)

Scope

- Introduction
- Threats to Composite Materials
- Addressing the threats
 - Repair
 - Training
 - Regulation

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Introduction - Our role

■ Certification & Structural Integrity advice for MOD:

- A400M Atlas
- Hercules C130J
- C-17
- Voyager
- Sentinel R1
- E3 Sentry
- Rivet Joint RC135
- BAe 146
- King Air B200 / B350
- BN Islander & Defender



Introduction - Our role

- **Developing the Policy & Regulation for:**
 - **Structural examination and sampling procedures**
 - **Ageing Aircraft Structural Audit & Teardown**
 - **Composites**

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Threats to CM

- **Overload**
- **Fatigue**
- **Accidental/Environmental Damage (AD/ED)**
- **Maintenance/Supply Errors**

Threats to CM - Overload

- **Exceeding allowable flight or loads envelope:**
 - Limit, proof or ultimate loads exceeded
 - Pilot reported or automatic monitoring system
- **Examples:**
 - Exceeding manoeuvre / g limit
 - Extreme gust event
 - Overspeed / overtorque
 - Configuration outside mass / C of G limits
 - Heavy landing (sink rate or AUM)

Threats to CM - Overload

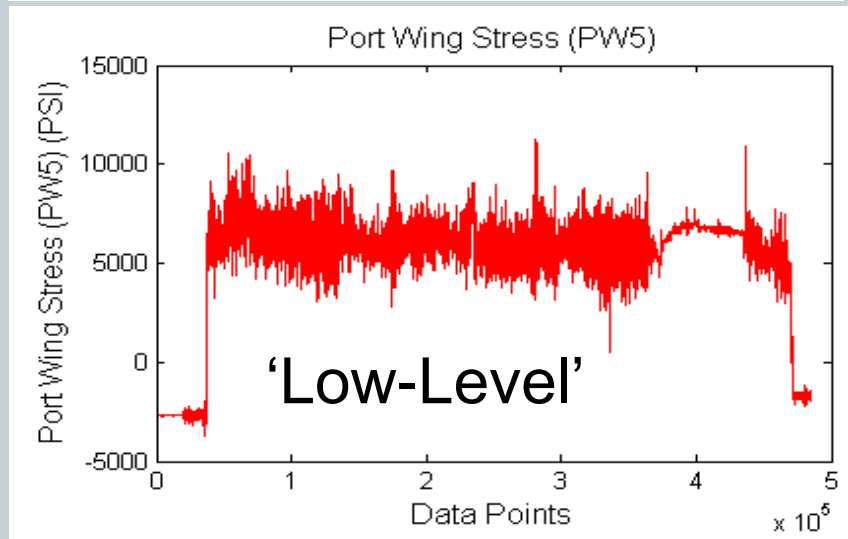
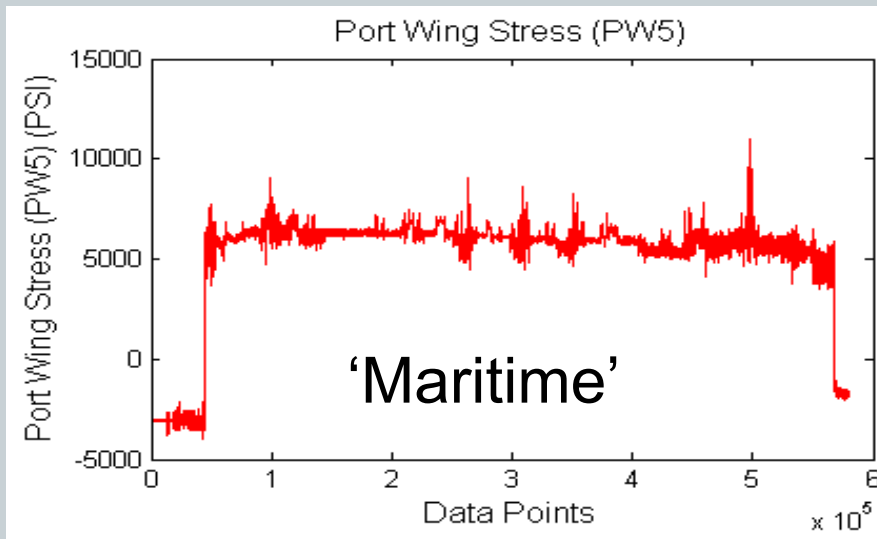
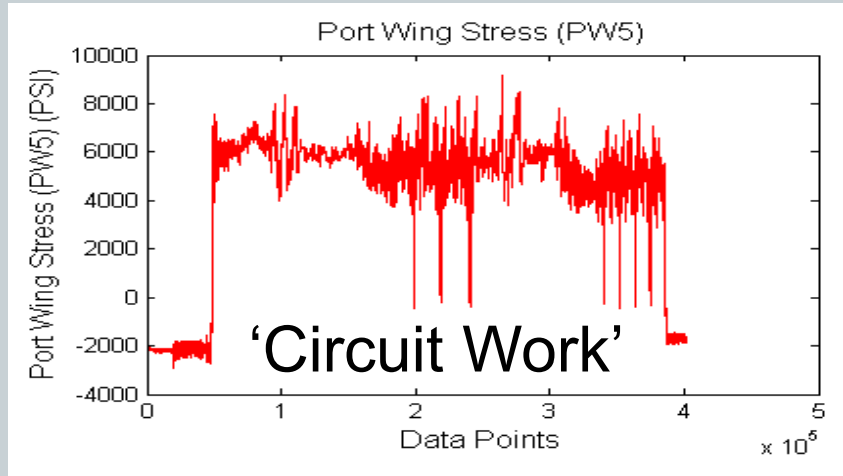
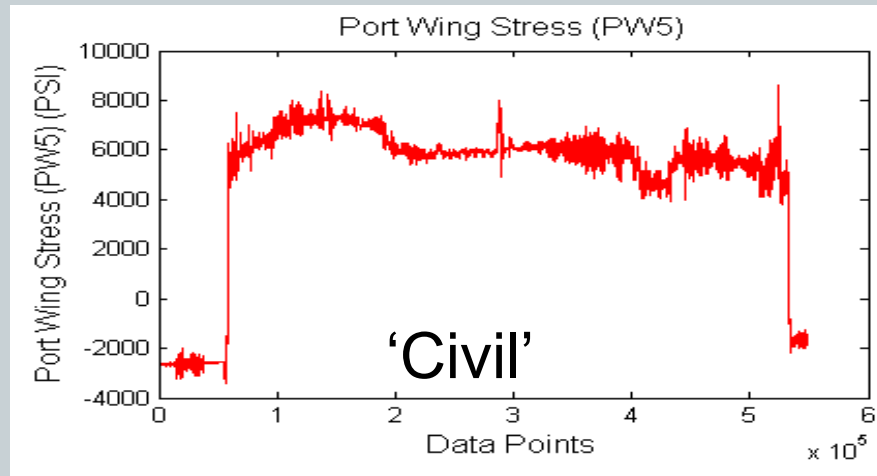


Threats to SI - Fatigue

- Undetectable permanent changes in material structure caused by repeated stresses
- Can result in cracking or complete failure
- Metals and Composites
- CM design below endurance limit
- Change in usage may affect 'tailored' CM structures
- Loads generated during flight and transportation in storage container



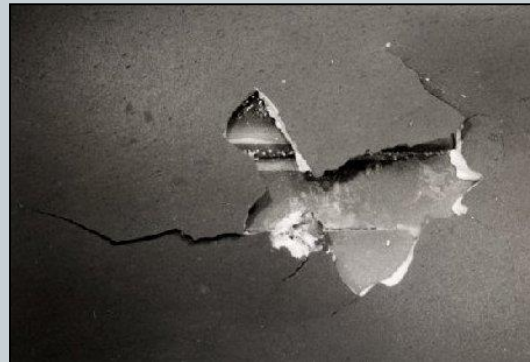
Threats to CM – Fatigue & Changes in Usage



Threats to CM – Accidental & Environmental Damage

■ Accidental Damage

- Ground incidents
 - Ground handling
 - Foreign Object Damage (FOD)
 - Maintenance activities
 - Dropped tools
 - Hot tools (scorch damage)
- Air collisions (mid-air, bird strike, weapons, hail)
- Solvents spillage



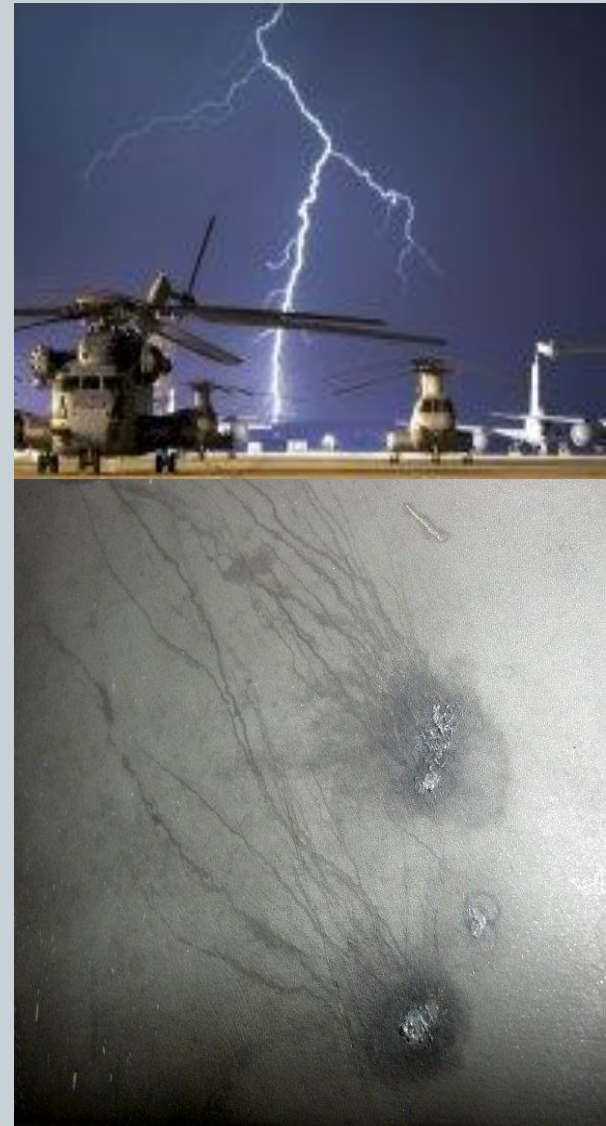
Threats to CM – Accidental & Environmental Damage

■ Environmental Damage

- Lightning Strike



Typhoon Lightning Qualification

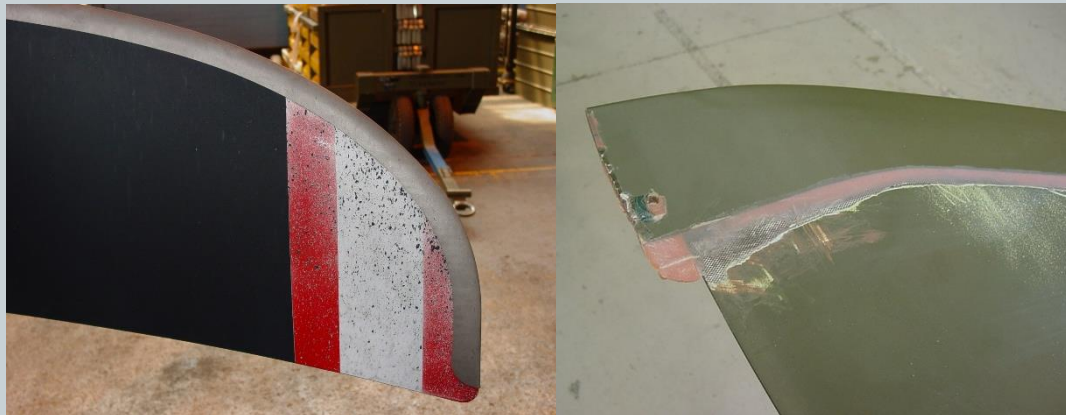


Threats to CM – Accidental & Environmental Damage

■ Environmental Damage

Erosion – In particular leading edges

- UV degradation
- Change in Material Properties:
 - Hot gas impingement
 - Fluid absorption in resin



Threats to CM – Accidental & Environmental Damage

Typhoon gun-bay door
in-to-wind step edge
delamination



Threats to CM – Accidental & Environmental Damage

■ Erosion

Tapes & coatings
a key defence
against erosion



Threats to CM - Maintenance Error

- Incorrect procedures
- Procedures not followed correctly
- Poor understanding of CM
- Non-reporting of Damage

Typhoon centre fuselage
fuel tank - surface ply rips
from drill breakout



Threats to CM - Maintenance Error

Case study 1 - Typhoon

- Panel 171AL (Left Hand Avionics Bay Door).
- Panel is a stressed skin. No damage is allowed.
- Strake was removed for surface finish maintenance.
- Removing the strake resulted in damaging the panel external skin.

**Typhoon Panel 171AL – (Left Hand
Avionics Bay Door).**



Threats to CM - Maintenance Error

- Three areas of surface breaking delamination found to the external skin.
- Associated areas of missing material
- Skin had also been punctured within the delaminated areas.

Threats to CM - Maintenance Error



Area A

**Surface breaking Multi
Layer Delamination
(MLD)**



Threats to CM - Maintenance Error

Area B

**Surface breaking Single layer
Delamination (SLD)**

Depth 0.5mm
15mm x 11mm

Missing material

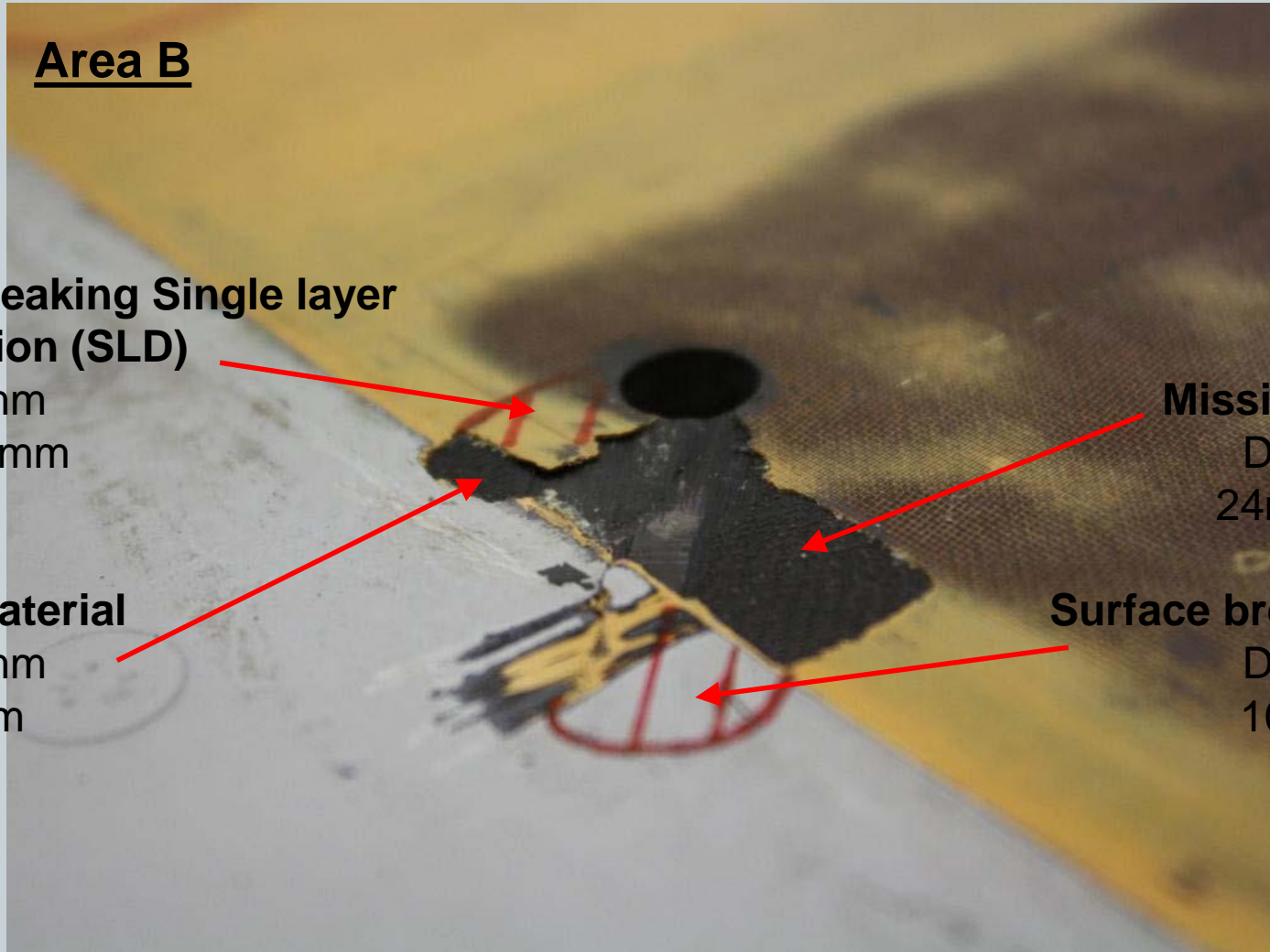
Depth 0.5mm
8mm x 4mm

Missing material

Depth 0.5mm
24mm x 12mm

Surface breaking SLD

Depth 0.5mm
10mm x 8mm



Area C

Surface breaking MLD

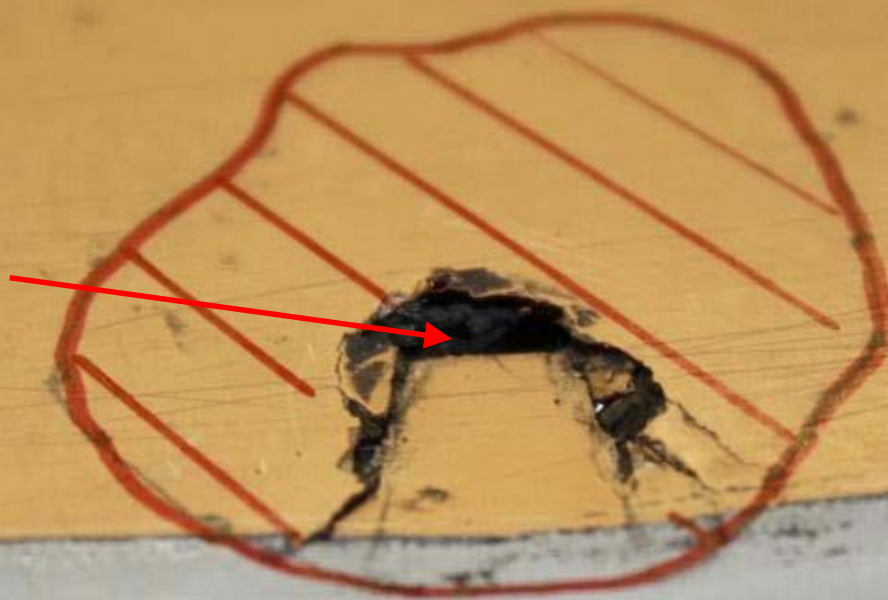
Depth 0.6mm to 1.0mm

37mm x 31mm



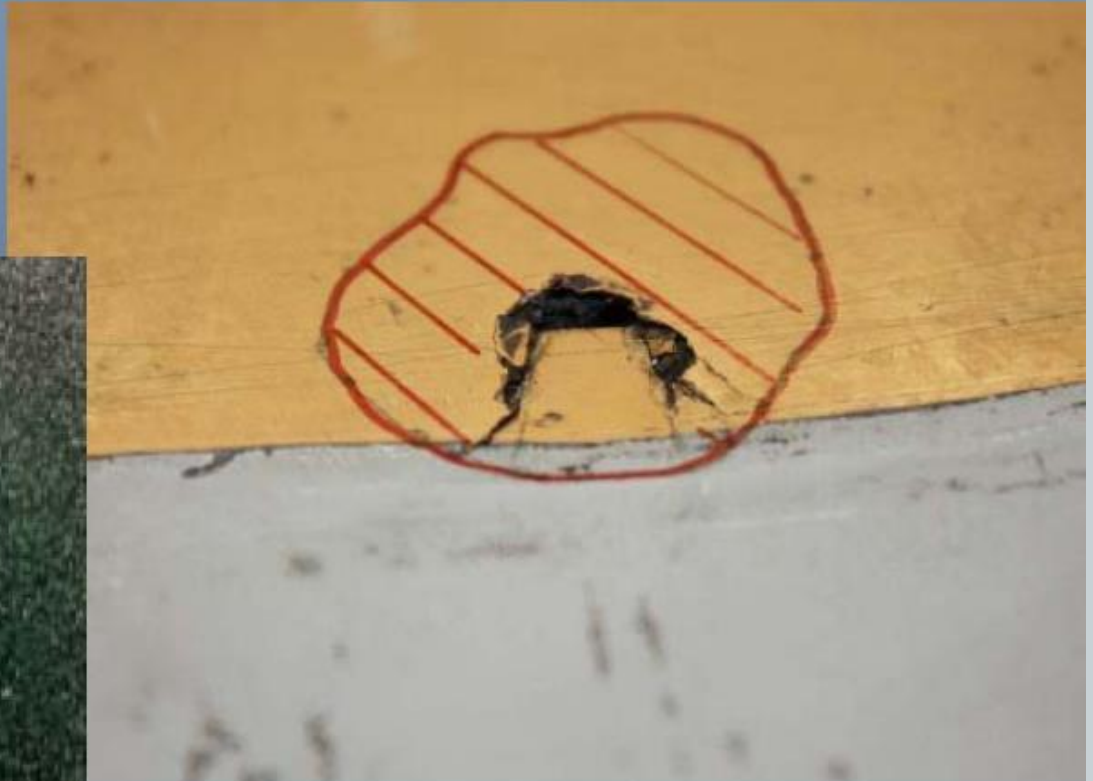
Skin puncture

15mm x 10mm



Maintenance/Supply Error

Cost of panel- £31,880
- Scrapped



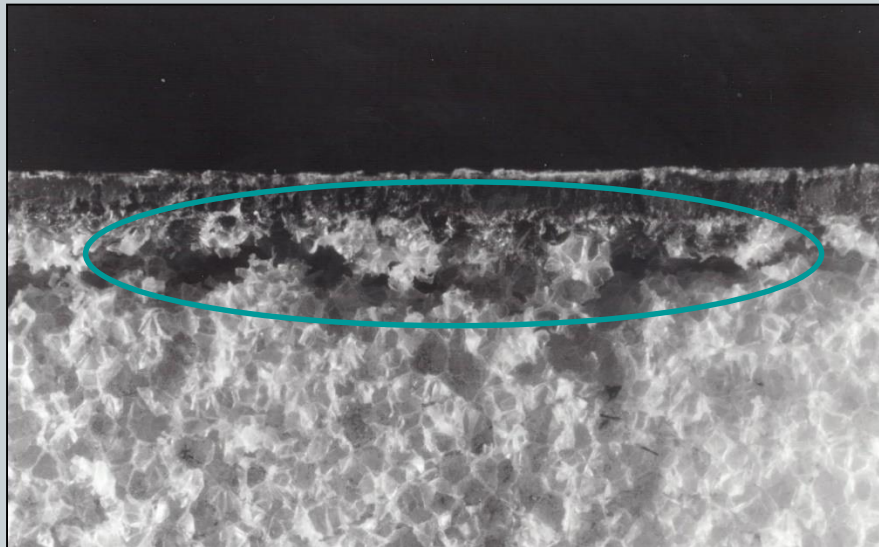
Threats to CM - Maintenance Error

Case study 2 – Lynx Tail rotor

- Increase Tail Rotor Blades (TRB) rejected following NDT for disbond 5/6 per month
- CM with foam core sandwich structure
- No damage is allowed
- No current repair schemes for composite TRB
- The damage on the blades was mapped using NDT
- Clearly defined areas of approx. 2-3 sq in. identified as possible disbonds or defective cores
- Sections taken through the damage revealed damage to the foam core of the blades

Threats to CM – Maintenance error

- Damaged area matched shape of human hand print

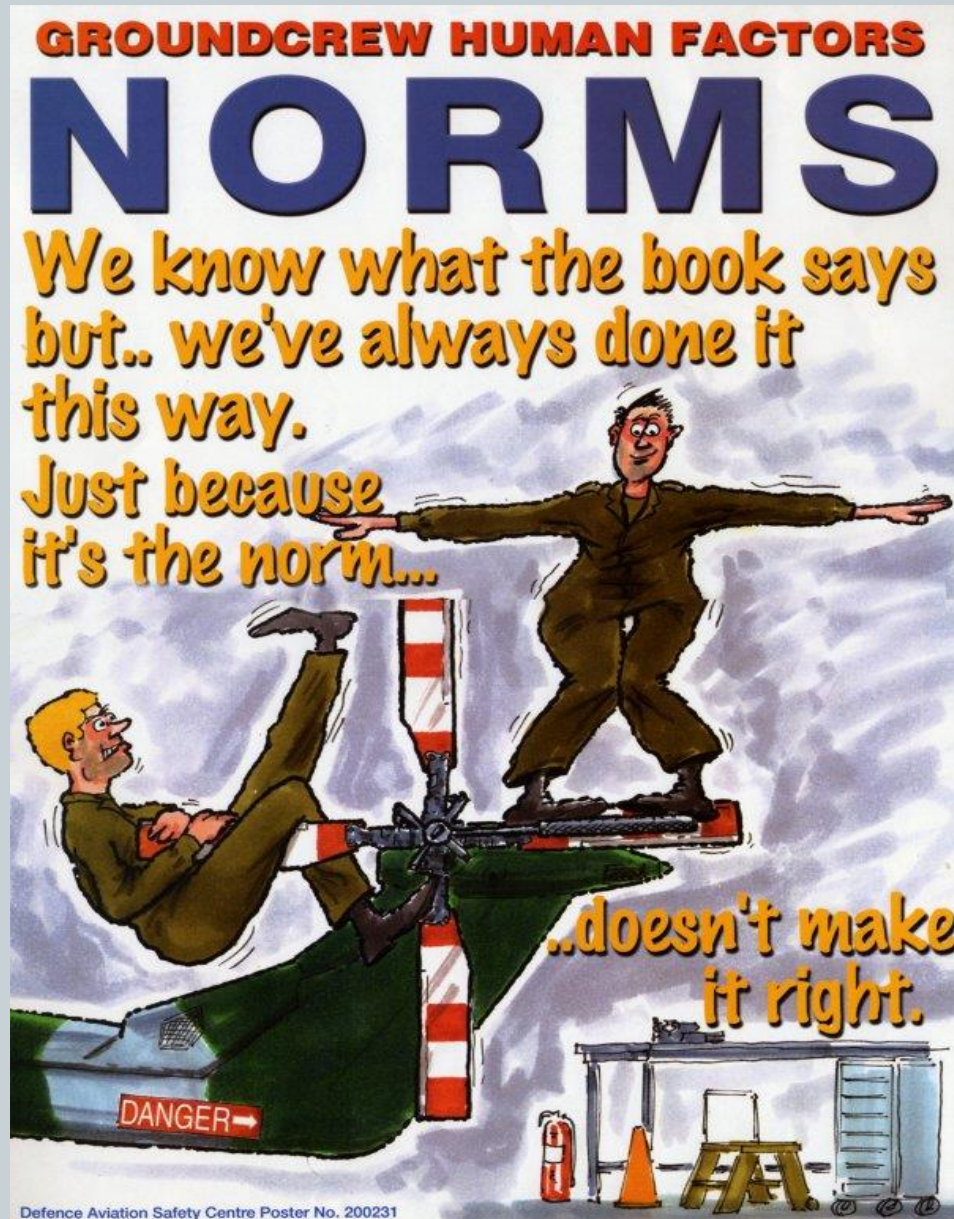


Threats to CM – Maintenance error

- Maintenance manuals call for hydraulic power to allow the rotor brake to be applied during the work on the TR hub
- Not always convenient in the field so two men resist while one tightens/loosens the assembly



Case Study: Result





**Accidental Damage & Maintenance Error
currently biggest threat
to composite structures**



Scope

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Addressing the Threats

- Repair philosophy

- Where possible repair at Main Operating Bases only

- Damage Assessment Process

- Report suspected damage
- Determine and assess the extent of damage
- Determine recovery solution. Factors include:
 - Extent of damage
 - Impact of damage eg reduction in residual strength, loss of structural integrity
 - Need for environmental protection
 - Operational Imperative
 - Repair facilities available
 - Operational risk to aircraft
 - Repair schemes

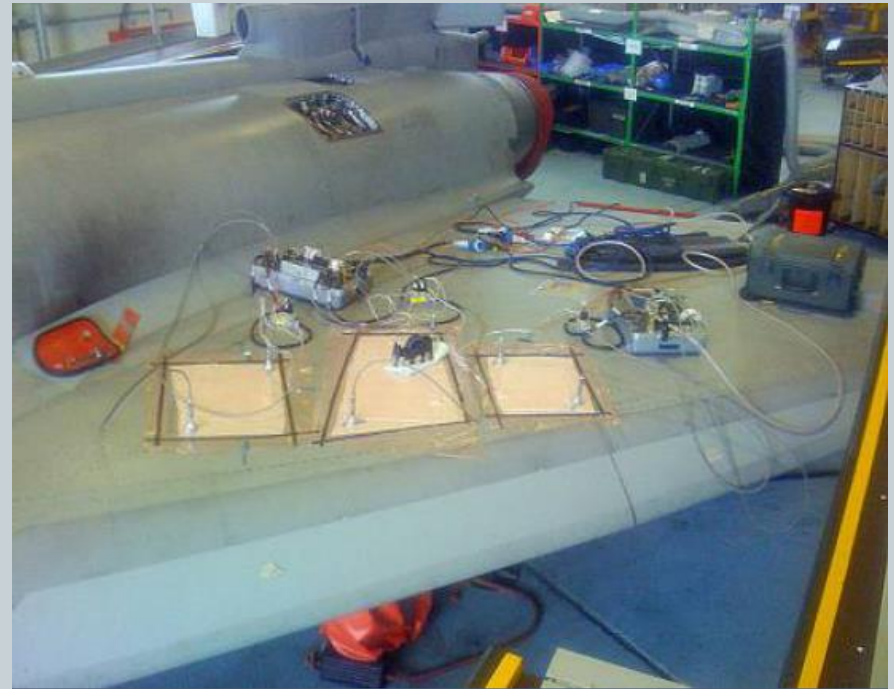
Type 1 Repairs

- E.g. manual resin application to dry fibres with an ambient temperature cure in accordance with the ADS
- Training & Authorisation Required:
 - Mechanical Phase 2 training (or Generic FRP Module A) + specific-to-type FRP repair training (if provisioned)
 - MAP-B-129 supervised by MAP-C462



Type 2 Repairs

- E.g. pre-impregnated fibres cured at elevated temperature in accordance with the ADS.
- Training & Authorisation Required:
 - Generic FRP Repair Training (2-week) + specific-to-type FRP Repair training (if provisioned)
 - MAP-B460 supervised by MAP-C462



Type 3 Repairs

- Similar to Type 2, but particularly complicated or not iaw ADS.
- Training & Authorisation Required:
 - Same training as for Type 2 but authorisation MAP B-461 supervised by MAP C-462.
 - Repair Organisation tradesmen with MAP-B463 supervised by MAP C-462.



Addressing the Threats - Training

- **CM training at entry into Military/Aircraft environment**
 - **Engineers**
 - Generic aircraft CM repair course - Monolithic, sandwich, bonded patch repair techniques
 - Specific aircraft/Component repair course
 - **Aircraft Ground Support Personnel (Bowser Drivers)**
 - **Logisticians (Suppliers)**



Poor storage of panels may cause further damage

Awareness

- **RA 4201(2):** *To ensure the continued structural integrity of aircraft structure and components constructed using Fibre Reinforced Plastics (FRP), and to reduce maintenance costs, Project Teams, FLCs and user units shall put in place procedures to establish and maintain appropriate levels of awareness and husbandry.”*



Panels protected with 25mm Bubble-wrap



Awareness

- The awareness training is to be specific the Unit / Station.
- Training must include support workers, e.g. Suppliers, Movers, MT Drivers, etc.




Panels protected with 25mm Bubble-wrap



Regulation

- The regulation on composite materials maintenance can be found in RA 4201 and MAP Ch 5.1.1.

UNCONTROLLED COPY WHEN PRINTED		Regulatory Article 4201
RA 4201 - Maintenance Philosophy - Composite Materials		
Rationale	<i>The use of Composite Materials (CM) within the Military Air Environment (MAE) is continuing to grow because they offer high specific strength, that is, a high strength to weight ratio, high specific stiffness and excellent fatigue resistance, combined with increased design flexibility when compared with traditional aerospace alloys. Consequently, for CM there are aspects that may require more care, additional husbandry or different processes as compared to those employed in the maintenance of aircraft structure and components constructed from more traditional materials.</i>	
Contents	4201(1): Composite Materials Maintenance 4201(2): Composite Materials Awareness and Husbandry 4201(3): Recording of Composite Materials Related Maintenance	
Regulation	Composite Materials Maintenance	
4201(1)	4201(1) In order that the design properties of Composite Materials (CM) are retained or recovered in a cost-effective and efficient manner throughout the service life of the aircraft, aircraft CM structures and components shall be subject to specific maintenance activity.	
4201(2)	Composite Materials Awareness and Husbandry	
4201(3)	4201(2) To ensure the continued structural integrity of aircraft structure and components constructed using Fibre Reinforced Plastics (FRP), and to reduce maintenance costs, Project Teams, FLCs and user units shall put in place procedures to establish and maintain appropriate levels of awareness and husbandry.	
	Recording of Composite Materials Related Maintenance	
	4201(3) A database shall be used to record all structural concessions, repairs, modifications and accidental damage and environmental damage to CM. Changes to the configuration of FRP structure and components are also to be included in this record.	
Acceptable Means of Compliance	1. Acceptable Means of Compliance is contained within MAP Chapter 5.1.1.	
4201(1)		
4201(2)		
4201(3)		

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 Military Aviation Authority		
Chapter 5.1.1		
Maintenance Philosophy – Composite Materials		
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Any Questions?