Composites For Aerospace and Defence

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Presentation to

"Composite Materials"

for Aerospace, Defence and Security Applications

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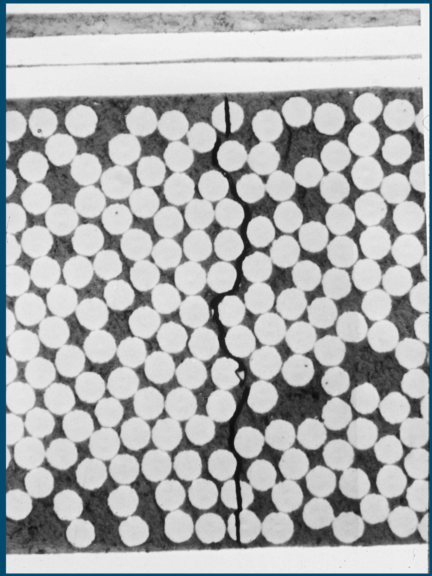
Defence Technology Strategy

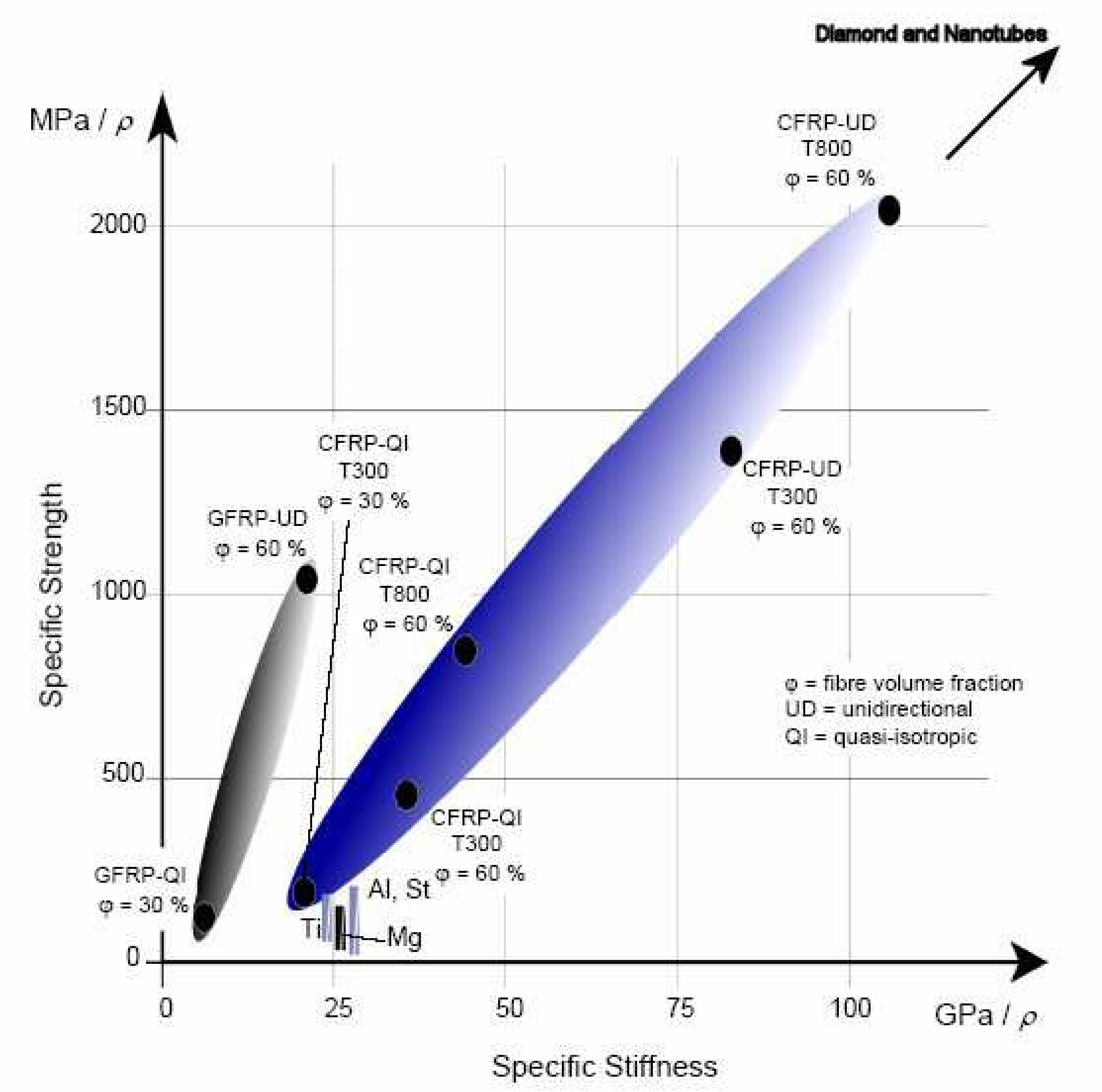
- Cross-cutting technologies - Platforms and Structures
  - Integrated Survivability
    - Design and Modelling
  - Power Sources and supply technologies
    - Fuel Cells, Structural Power
  - Advanced Materials
    - Smart Materials, Design and Modelling
    - Composite Materials, Environmental Issues
- Fixed Wing Aircraft and UAVs
  - Cost Effective and affordable solutions
  - Novel structures and control solutions
  - Rapid prototyping
  - Lean and cost effective manufacturing
  - Reduced/appropriate certification
- MoD also wants low observability

What are Polymer Composites ?

- Two or more materials combined on a macroscopic scale to form a useful material
  - Usually exhibit best qualities of their constituents
  - Often some qualities that neither constituent possess
- What Goes into a Composite ?
  - Fibres
    - Carbon, glass, Kevlar …
  - Matrices
    - Epoxy, Polyester, Thermoplastic ….



The Materials Revolution



Performance Benefits

- In terms of strength and stiffness for weight they outperform any other engineering material
- *Strength* - greater than strongest metals, *Stiffness* - similar to steel
- *Density* - light weight - half aluminium, fifth steel
  - Even in conservative designs, 30% weight saving is easily achievable
- Excellent *fatigue* and *corrosion* resistance
- *Manufacture* of complex shapes, reduced parts, easier assembly, reduced machining
- Modified *radar* response compared to metallics
- Dimensional *stability* - eg space structures
- Potential for embedded *functionality* (damage sensing, health monitoring etc)
- BUT – materials typically 5x cost light alloys, but with major savings in fabrication they compete on cost at the component level

History of UK MoD Composite Structures

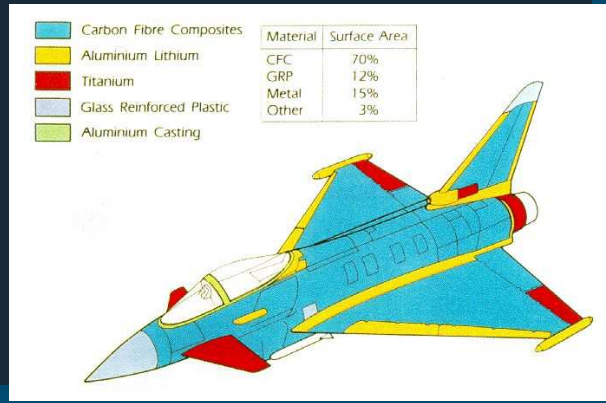
- 1960's
  - RAE Carbon Fibre Process, Initial composite evaluations
- 1970's
  - Materials Development, Design Data generation
  - Development items in service (Tornado Taileron)
  - Manufacturing demonstrators (Jaguar Wing), Airworthiness data
  - Spall liners on inside of armoured vehicles
- 1980's
  - Repair technology, Second generation materials (Fibres/resins)
  - AV8B/GR5 Harrier, Eurofighter Design
  - Westland composite rotor blades in service, Lynx and Sea King
  - Westland thermoplastic tailplane demonstrator
  - Radomes
- 1990's
  - First flight Eurofighter
  - Composite propeller blades in service
  - Aeroengine structures
  - Satellite structures
  - Lightweight military vehicles (CAV100)
- 2000's
  - EH101/Merlin in service
  - Eurofighter in service
  - C130J tail and propellers
  - Low cost fabrication routes developed
  - A400M composite wing and propellers
  - ACAVP armoured vehicle demonstrator
  - Joint Strike Fighter

Evolution of Aerospace Structural Materials

- Early aircraft design used a type of composite – a combination of wood, canvas & high tension wires with flight control achieved by twisting the tips of the wings and employing the use of a rudder (high DT and low mass). A composite design !
- Carbon fibre and glass fibre reinforced polymers first included in aircraft during the 1970s
- The Aerospace industry is, however, inherently conservative resulting in a small step by step approach – composites have taken a long time to really 'take-off'
- Conservatism in design has also limited platform shape and construction to that of proven metallic designs rather then embracing and designing for the new materials, but this is changing.
- But composite usage is now increasing rapidly

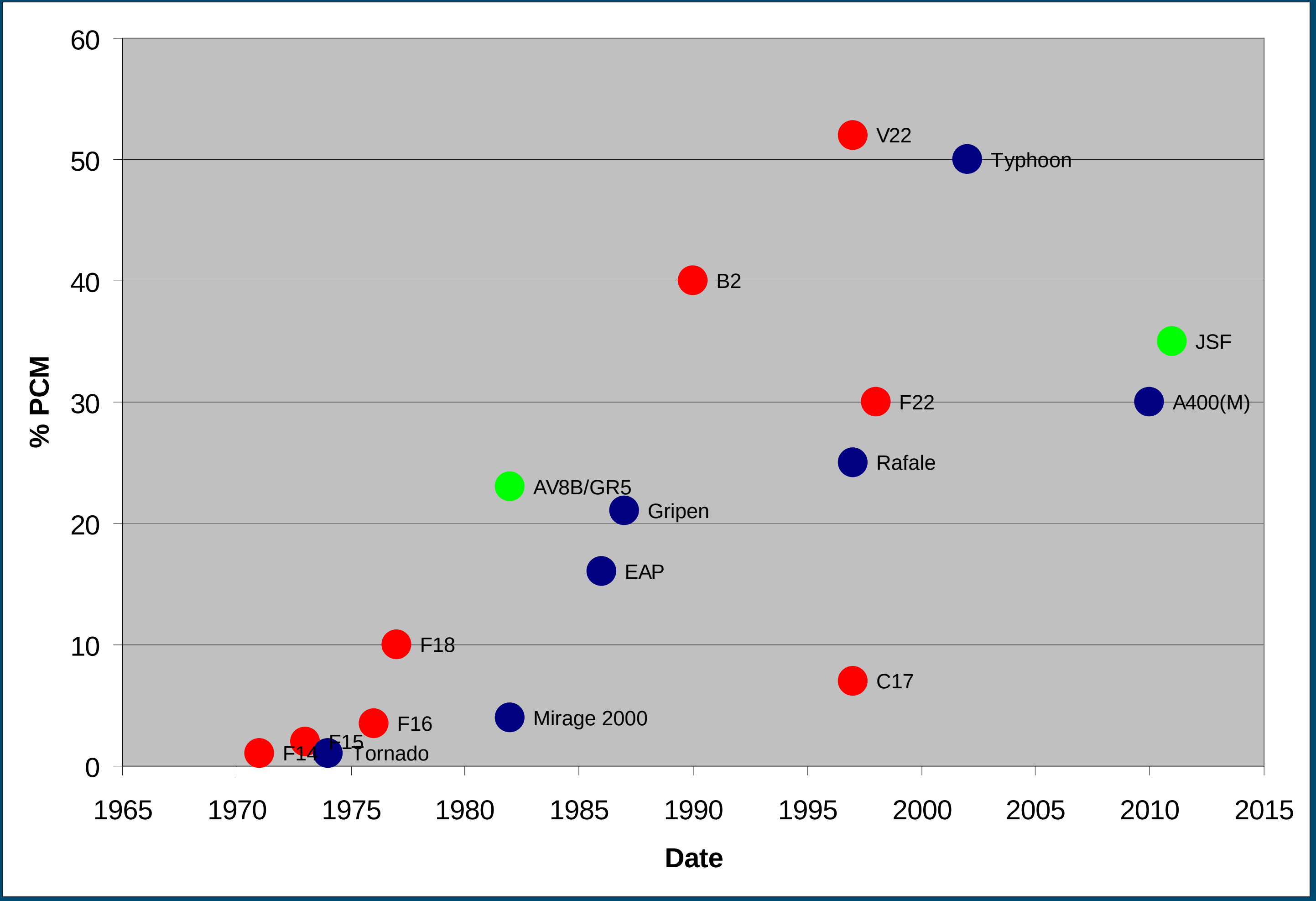
British Army Aeroplane No. 1 1908
Swan Inn Plateau near Farnborough

Military Aerospace Composite Usage

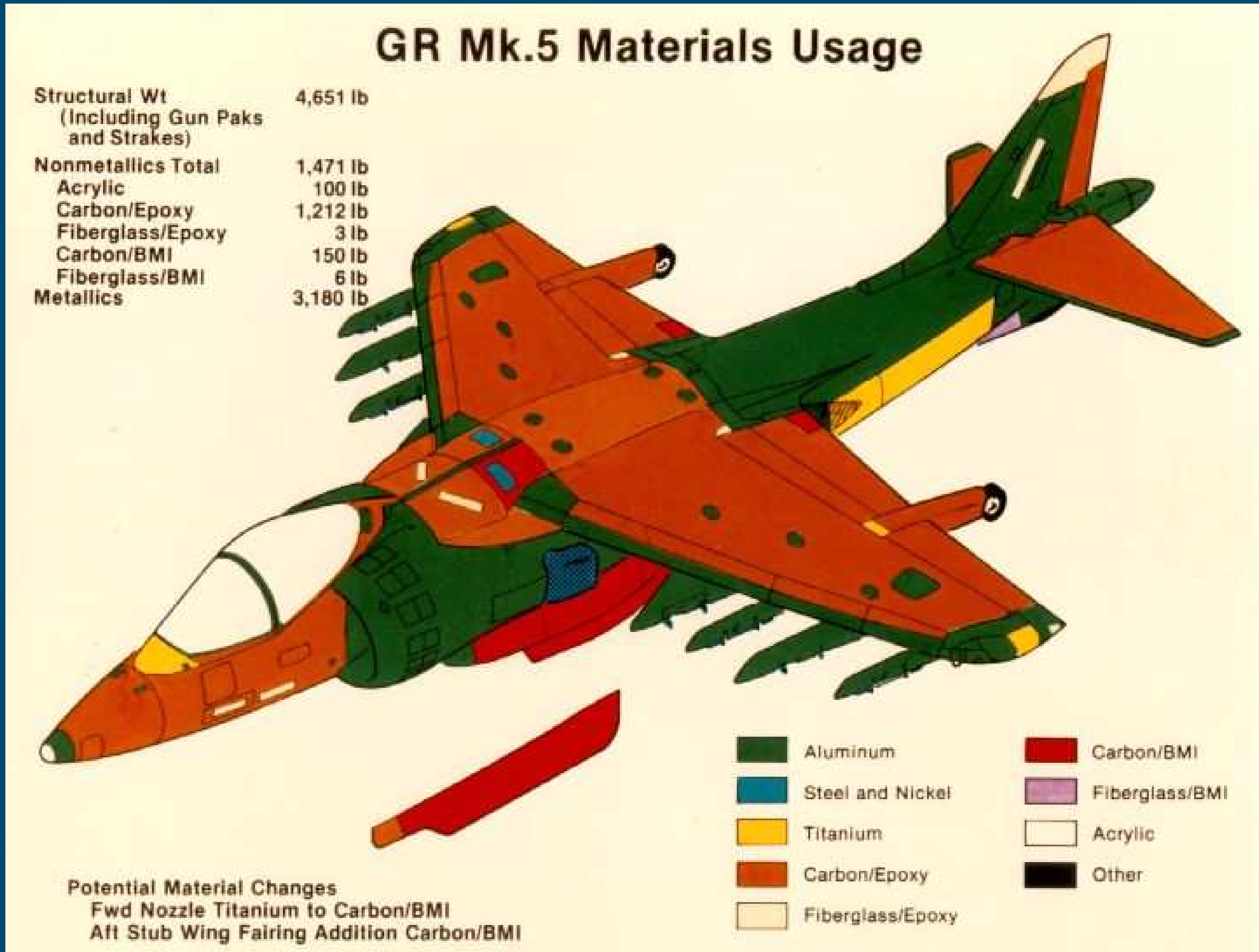


- Composite materials displacing conventional metallics
  - Within airframes the largest R&D thrust is in the greater use of composite materials.
  - The first choice for military airframe structures
  - Eurofighter Typhoon more CFRP than any other material
  - A400M – composite wing
  - Joint Strike Fighter - large fraction of polymer composites
- Trend will accelerate in future
  - Smart and Stealth based on polymer composites
  - UAV/UCAVs may be mainly composite construction

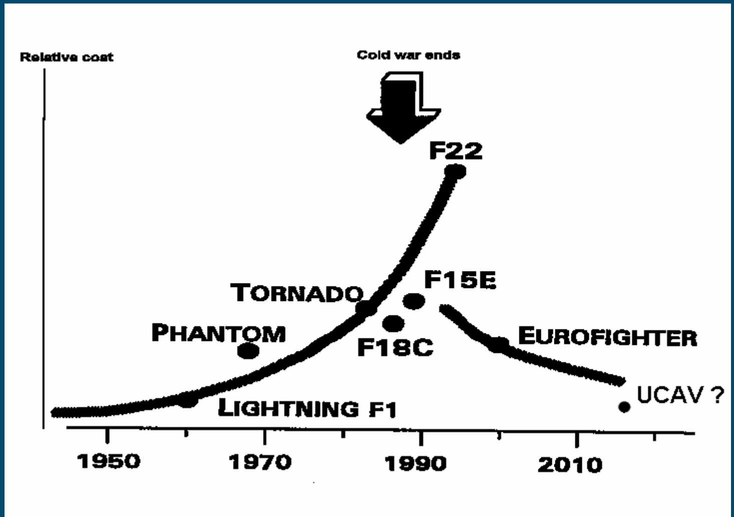
Military Usage of Composites



Harrier


GR Mk.5 Materials Usage
Structural Wt (Including Gun Paks and Strakes) 4,651 lb
Nonmetallics Total 1,471 lb
Acrylic 100 lb
Carbon/Epoxy 1,212 lb
Fiberglass/Epoxy 3 lb
Carbon/BMI 150 lb
Fiberglass/BMI 6 lb
Metallics 3,180 lb
Aluminum
Steel and Nickel
Titanium
Carbon/Epoxy
Fiberglass/Epoxy
Carbon/BMI
Fiberglass/BMI
Acrylic
Other
Potential Material Changes
Fwd Nozzle Titanium to Carbon/BMI
Aft Stub Wing Fairing Addition Carbon/BMI

So what are the challenges?



- Without doubt management of cost is the biggest challenge faced for future platforms
- F22 is the pinnacle of cost and unlikely ever to be repeated
- JSF and A400M are now well into their development phases and thus fundamental R&D requirements are not large
- The future focus is on UAVs

Future Military Airframes

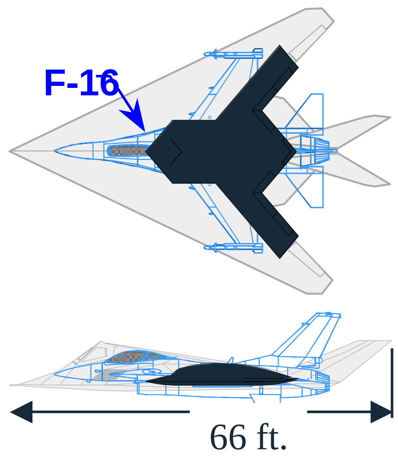
- There is an ever increasing interest in use of Unmanned Air Platforms (UAVs)
  - Applications include combat, surveillance, ground attack
  - No crew enables use in higher risk scenarios than with conventional manned platforms
- Must consider
  - new materials (both development and off-the-shelf types)
  - new design and manufacturing options, including the Through Life Capability Management (TLCM) for different configurations

X47A Pegasus– Courtesy of Northrop-Grumman

X45 – courtesy of Boeing

UCAV Issues

- Size
- Performance
  - High g, low stealth or Low g, high stealth
- Stealth
  - Through shaping in design and use of LO materials
- Cost – the biggest factor
  - Balance is LO versus agility versus cost
- Manufacture and Materials
  - Dependent on size
  - High level of composites likely
  - Low cost manufacturing routes
- Support Issues
  - Boxed around ? - Awareness of storage issues
  - Low flying hours, less repair issues ?



X45 UCAV

X47A Pegasus– Courtesy of Northrop-Grumman

Naval and Land Usage

- GRP Minehunters, MCMVs
- Naval top deck structure and masts
- Ships doors
- ACAVP
- Composite Armour
- Body Armour
- LAW80 launchers
- Lightweight bridging

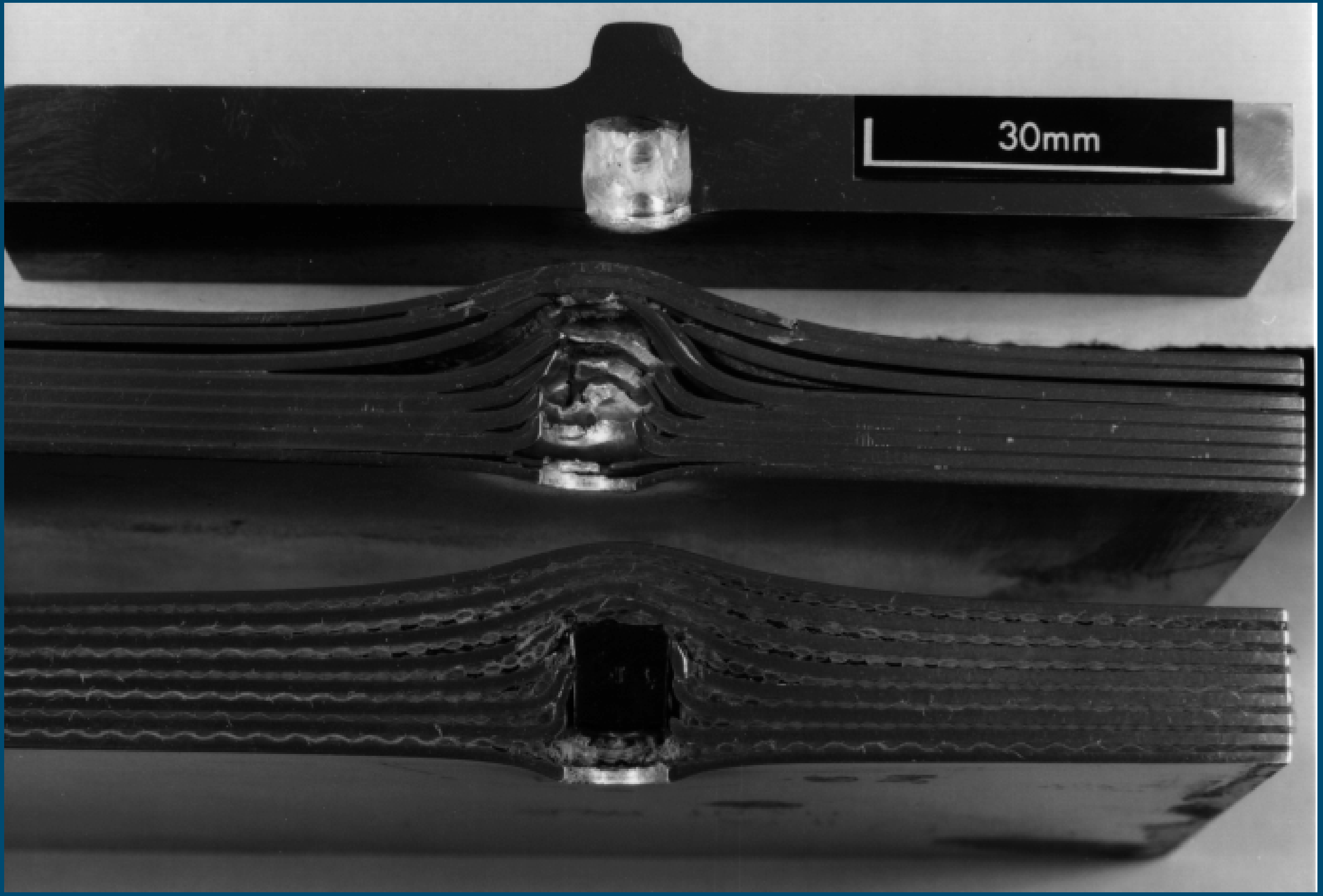
Future Naval Vessels

- UK Triton
  - Composite superstructure
  - Metallic hull (for low cost)

- Swedish Visby Corvette
  - Mainly composite construction
  - Designed for low signature

ACAVP – GRP Light Armoured Vehicle

Composite Armour



Law 80

Materials & Structures Challenges 1

- Novel Materials –
  - Interchangeability - to reduce qualification costs & encourage new materials
  - Hybrid solutions – metal where appropriate
  - Nano-particles / Hollow fibres / micro spheres
  - Embedded hybrid materials (SMA)
  - Pre-cured components (macro – structure)
- Environment
  - Weight Reduction
  - Environmental stability - temperature, moisture, long term exposure & solvents
  - Compatibility of composites & metals. Poor design can lead to galvanic corrosion.
- Through life capability management
  - Damage management – Resistance to damage and survivability
  - Improvements to reliability and life
  - Repair – in-service support, Uncertainties with repair techniques
- Reduce cost of all stages through materials, design and fabrication

Materials & Structures Challenges 2

- Manufacturing
  - Low cost manufacturing routes and processes
  - Reduced lead time manufacturing (prototype and production)
  - Assembly – tolerance & duration (typical metal military wing has 6000 fasteners & takes 50 days)
  - Improved jointing technologies key to further expansion, especially metal/composite assemblies
  - Inspection methods needed to detect flaws such as substandard bonds.
- Improved techniques of modelling and analysis
  - improved design tools to cover local stress details but also life prediction and damage and damage growth
- Structural design
  - Design for new materials
  - Novel configurations eg morphing, structural power, health monitoring
  - Future trends to small unmanned vehicles (mainly military)
  - Improved survivability (mainly military)
- Lack of understanding and Reluctance to change

Conclusions

- Composite Materials properties are outstanding
  - But still challenges to be met, especially in fabrication & design
  - Usage of Composites is growing at a rapid rate in Military Aerospace
  - Composite materials are becoming the first choice materials
  - New materials, however, bring new problems and challenges, for the materials engineer, designer and operators
- Future military strike aircraft may be unmanned
  - Significant consequences for materials and structures
- Reducing cost at all stages remains a major challenge
- Composite materials offer ability to build in smart and stealthy functionality
- Novel structural designs and configurations are promising
  - Morphing structures, Health monitoring, Structural Power

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Dstl is part of the Ministry of Defence