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Australian Government

Department of Defence
Science and Technology

Aerospace Division

Dr Peter Frith

Overview

DST Group Partnerships Week 2016



DST
GROUP

Science and Technology for Safeguarding Australia

Changing Aerospace Domain



Joint Strike Fighter F-35 Lightning II



F/A-18G Growler



P- 8A Poseidon



Wedgetail AEW&C



KC30B Multi-Role Tanker Transport



C-17 Globemaster



C-27J Spartan



MH-60R Romeo



MRH-90 Taipan

DST Group Roles in the Aerospace Domain



Defence Operations



Sustainment



Acquisition Projects



Strategic Research



DST Group Aerospace Division

Aerospace Division Mission

Lead and conduct aerospace research for Australia's defence and national security, providing expert science and technology advice and innovative solutions.

Aerospace Division Vision

Transforming Australia's air power through world-leading science and technology.

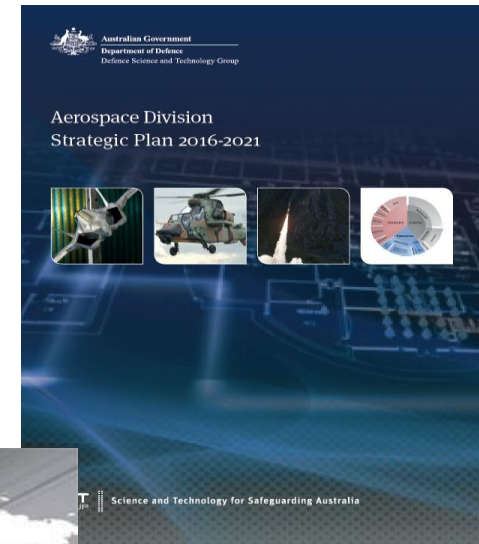
2016

Defence White Paper

- High-speed long-range weapons
- Trusted autonomous systems
- Multi-disciplinary material systems
- Enhanced Human Performance

Aerospace Division Strategic Plan

Support to Plan Jericho



Aerospace Division – Major S&T Capabilities

- **Aerospace Systems Effectiveness**
- **Aircraft Health and Sustainment**
- **Aircraft Performance and Survivability**
- **Aircraft Structures**
- **Airframe Technology and Safety**
- **Applied Hypersonics**

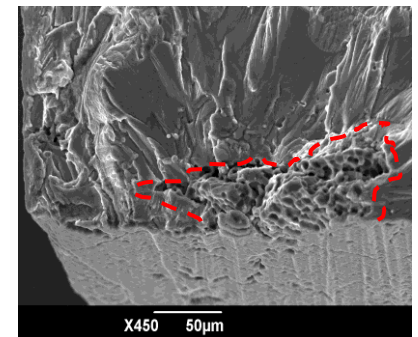
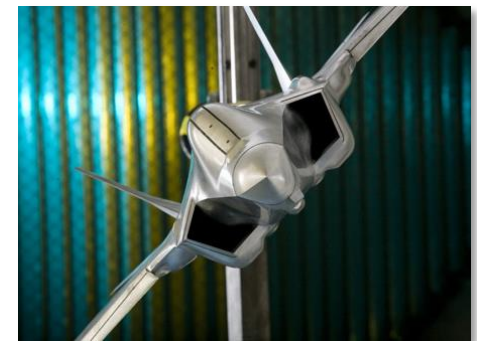
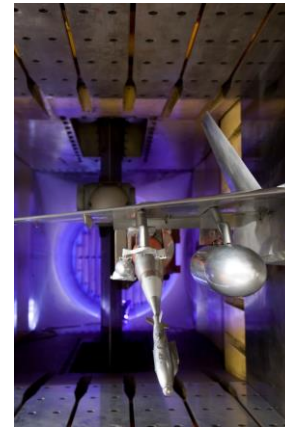


Aerospace Division – Major Recent Projects

- HIFiRE Hypersonics program - HIFiRE 5B
- Live Virtual Constructive Simulation Exercises - Black Skies, Coalition Virtual Flag
- Development of Joint Air Warfare Battle Lab, JAWBL at RAAF Williamtown
- JDAM-ER gliding weapon, extended range
- S&T Support to F-35 System Design and Development Program
- C-130J - Full Scale Fatigue-test, main wing



HIFiRE



Presentations to follow

- **Aerospace Systems Effectiveness** **Dr Michael Skinner**
- **Aircraft Performance & Survivability** **Dr Greg Bain**
- **Aircraft Technology & Safety** **Dr Manfred Heller**
- **Aircraft Structures** **Mr Robert Boykett**
- **Aircraft Health & Sustainment** **Mr David Holmes**
- **Applied Hypersonics** **Dr Allan Paull**



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Aerospace Systems Effectiveness

Dr Michael Skinner



Aerospace Systems Effectiveness

Interaction of humans & systems for optimal performance



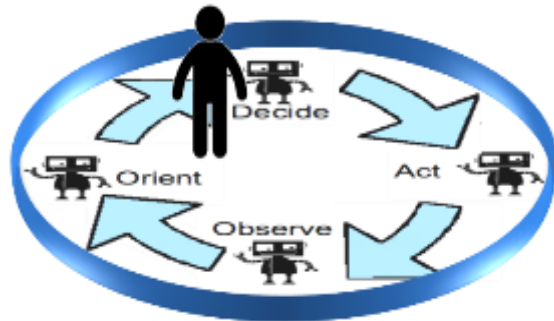
- Synthetic Collective Training
- Live Virtual Constructive Simulation
- Team training in realistic multi-aircraft & multi-national mission scenarios

- Helicopter Systems Effectiveness
- Flight models, ship wakes, slung loads, degraded visual environment
- Human Factors, Vision, Perception, **Autonomy**, Training, Cognitive Modelling



Human Autonomy Teaming

- A focus of our research is the design of interfaces and intelligent agents to support supervisory control of multiple assets = Support **Human-on-the-loop**



- Designing a user interface for the Intelligent Watch Dog



Intelligent Watch Dog



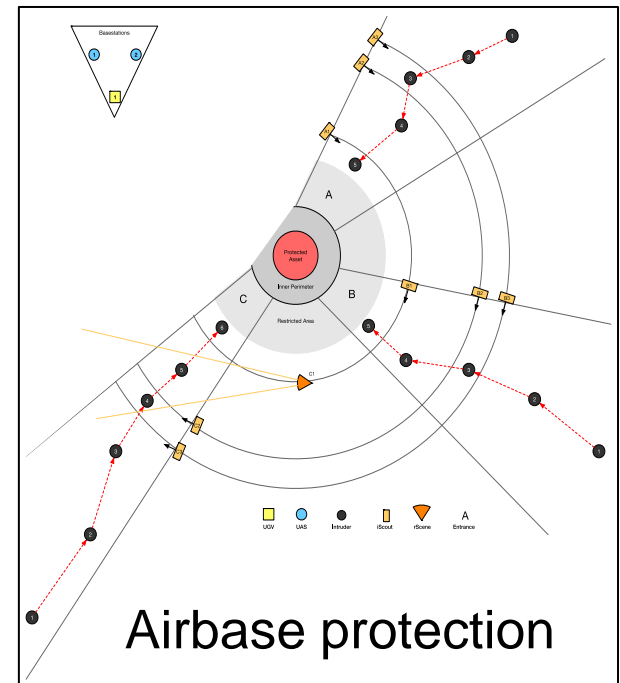
- iWD is an autonomous response system, providing rapid and effective surveillance in unexpected situations
- In response to an intrusion, the system launches an autonomously controlled vehicle to intercept the intruder and provide video surveillance



McQ sensors



Insitu Pacific CT-110



iWOD™ AOS Autonomous Decision Making Software **DST GROUP** ©Agent Oriented Software Pty Ltd 2016

Settings Configuration Exit

0 10 20 min

EMERGENCY STOP

Sort by:

Zone A Zone B Zone C Zone D

A [Progress Bar] [Settings] 1 00:00:00

D [Progress Bar] [Settings] 1 00:12:00

Sort by:

[Fan Icon] 1 [Fan Icon] 2 [Gear Icon] 1 [Fan Icon] 1 [Water Icon] 1

Enabling Future Training

Problem Virtual training is limited by available expertise



Goal Human-Agent teams that prepare & deliver future training

Partnering Opportunities

- Fundamentals of Human Autonomy Teaming
- Machine learning and AI approaches to support adaptive and flexible HAT
- Enhanced supervisory control of multiple unmanned air, ground, and surface vehicles
 - Innovative interfaces
 - Intelligent agent support
- Human-Agent teams to support future training





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Aerospace Division Aircraft Performance & Survivability

Dr Greg Bain



Wind Tunnel Model of F/A-18A/B
and JDAM-ER: UNCLASSIFIED



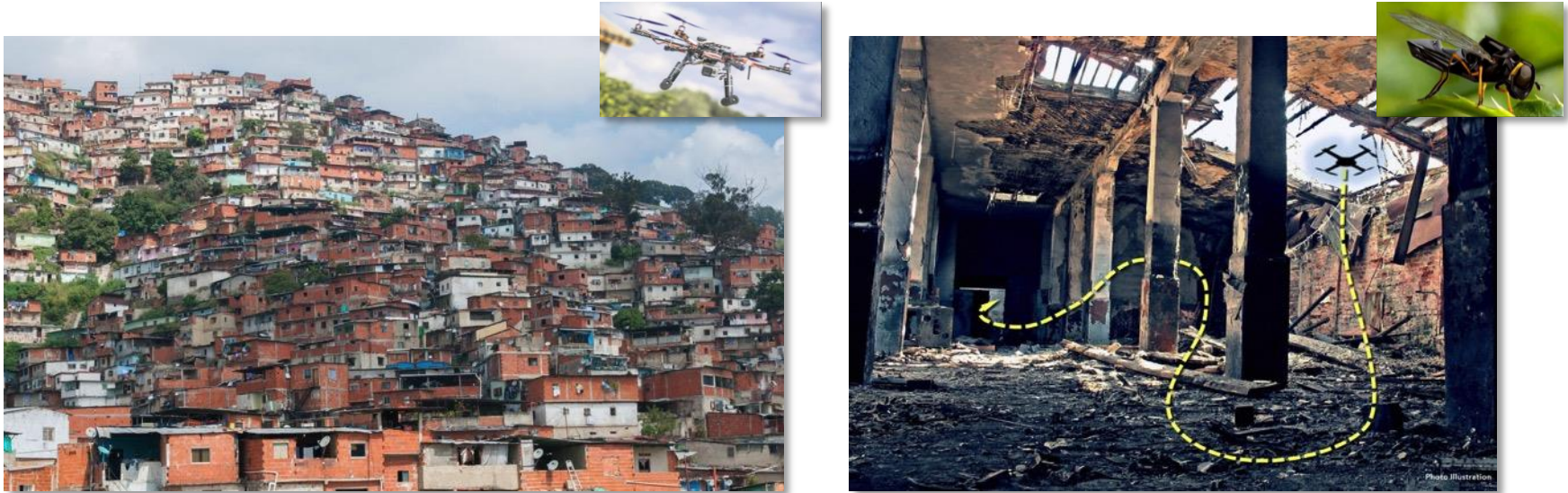
Fixed-Wing and Quadrotor UAV: UNCLASSIFIED



Infrared Image of F/A-18A/B: UNCLASSIFIED

Science and Technology for Safeguarding Australia

Unmanned and Autonomous Aerial Systems for Operations in Complex and Contested Environments



Partnering Opportunities:

- Technologies for contested navigation and autonomous localisation in GPS and communications/RF denied environments
- Autonomous ISR (dynamic collision avoidance, self-localisation and autonomous 3D mapping) in cluttered environments
- Machine reasoning techniques (intelligent agents, Bayesian reasoning, deep learning) to enable human-on-the-loop robotic air-land-maritime teaming

Manoeuvre and Propulsion Performance of Defence Systems through Experimental and Computational S&T



Computational Fluid Dynamic (CFD) Models

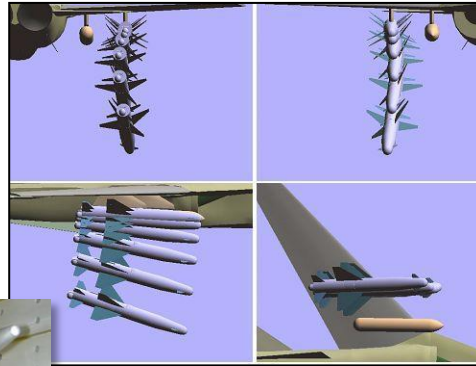
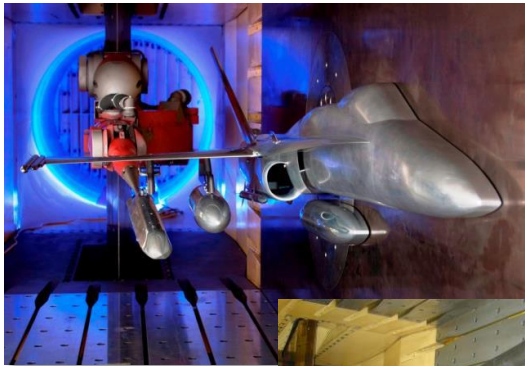
Low-Speed Wind Tunnel Models

Combustion Test Facility (CTF)

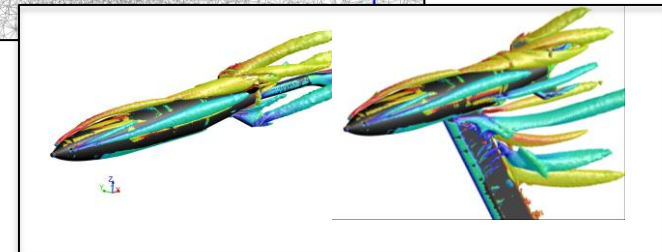
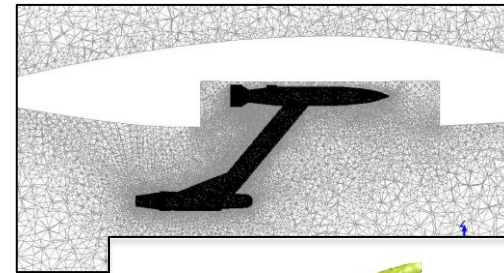
Partnering Opportunities:

- Development of computational and low-speed wind tunnel models to evaluate the flight performance of aircraft and other weapons systems
- Test and characterisation of alternate fuels in gas turbine combustors for operational fuel security
- Test and evaluation of advanced combustor materials for high speed air systems

Integration of Enabling Sub-Systems through Aero-Acoustic, Aero-Thermodynamic, Aerodynamic and Aero-Elastic S&T



Trajectory Prediction Analysis

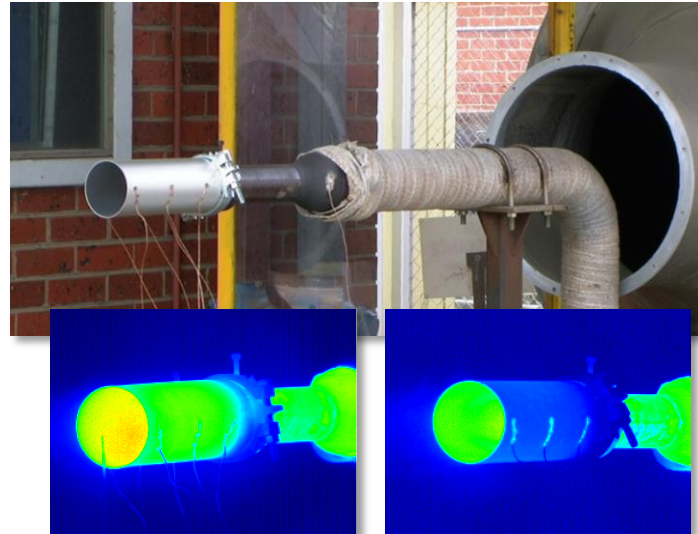


Aero-Acoustic Interaction Analysis

Partnering Opportunities:

- Development of trajectory prediction tools to evaluate the carriage and release of weapons from ADF aircraft
- Development of models to predict the effects of structural, aerodynamic and aero-acoustic interactions on the performance of integrated systems

Airborne Self-Protection through Infra-Red Signature S&T



Uncoated

Coated

IR Signature control through advanced coatings

Partnering Opportunities:

- Design, test and evaluate IR signature management schemes for ADF aircraft to enhance EW self protection (EWSP)
- Research and development into new coatings, materials and technologies to improve aircraft IR signature management effectiveness



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Airframe Technology and Safety

Dr Manfred Heller

Airframe Technology and Safety Major Science and Technology Capability

Enhance the airworthiness, effectiveness and affordability of ADF airframes through

Aerospace Composite Technologies

Conformal antennas



Composite sustainment

Structural and Damage Mechanics

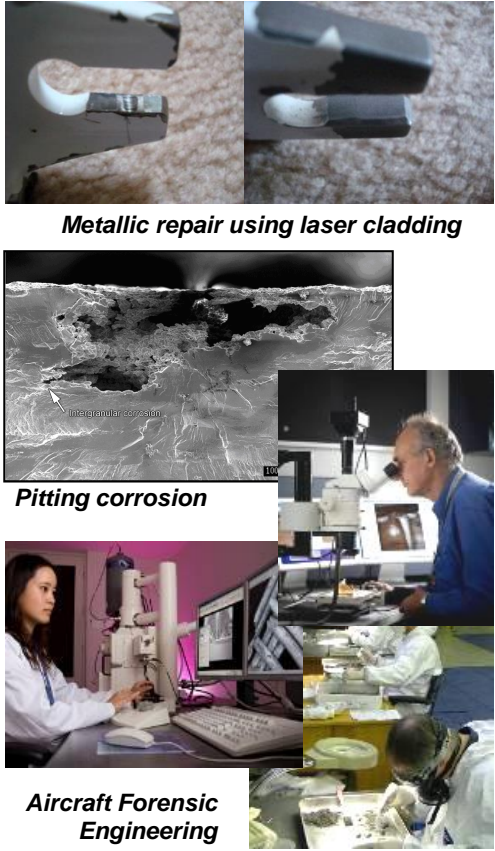


Fatigue modelling

Advanced structural analysis

Shape optimisation for repair

Aircraft Forensic and Metallic Technologies



Metallic repair using laser cladding

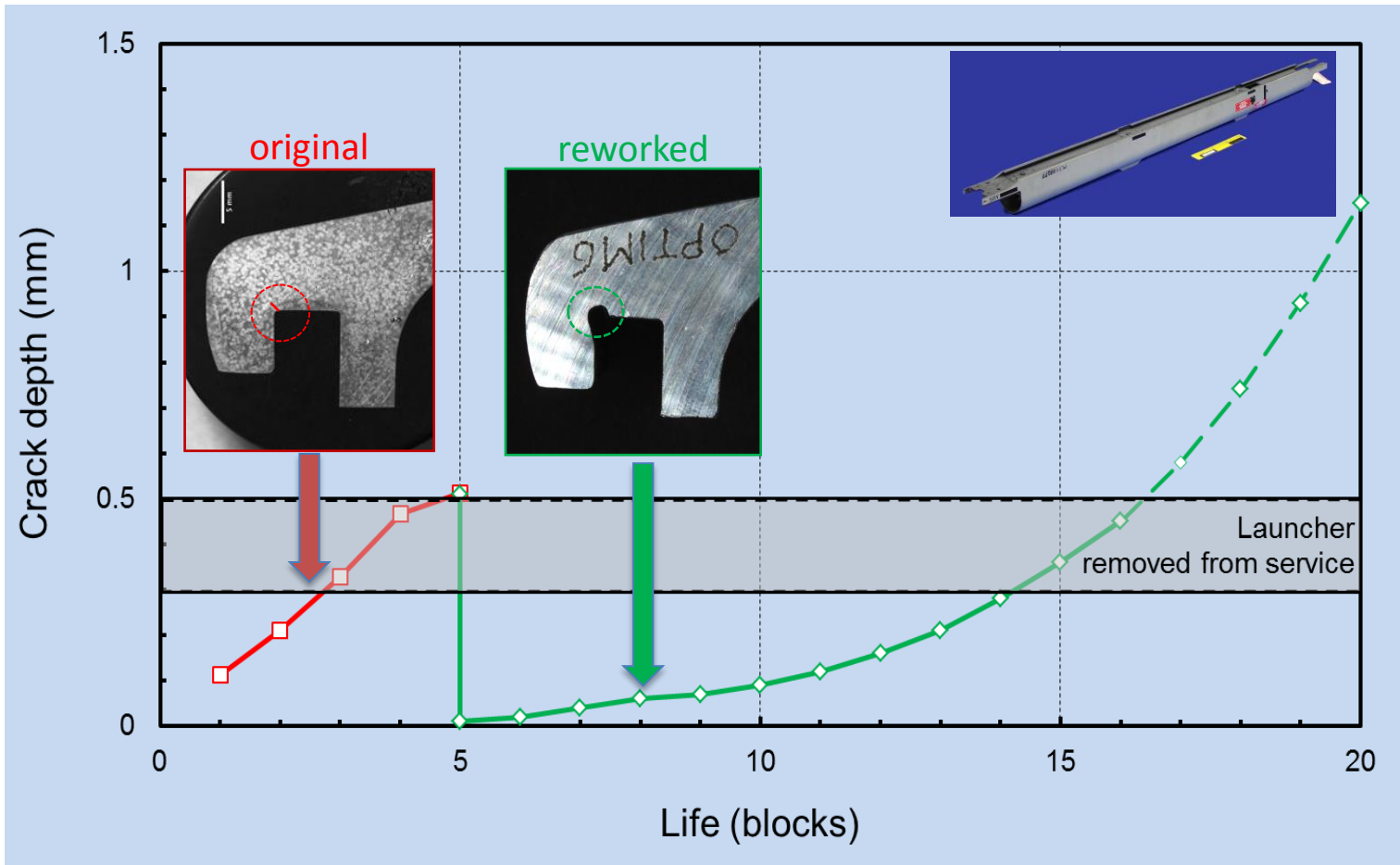
Pitting corrosion

Aircraft Forensic Engineering



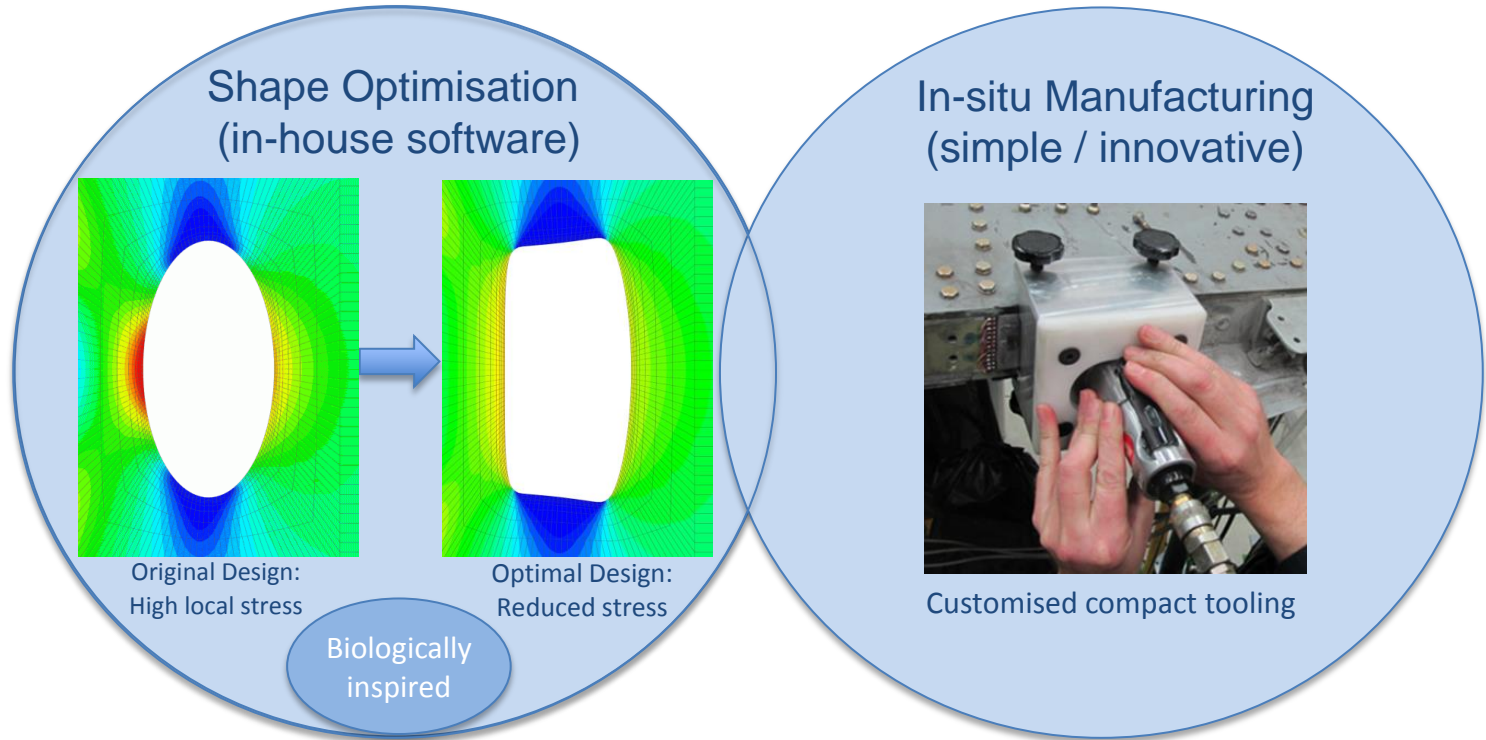
Rebirth of Fatigue Damaged Structural Components

Rework Shape Optimisation Technology



Rebirth of Fatigue Damaged Structural Components

Technology Features



Extend life while removing cracks

Avoid replacement

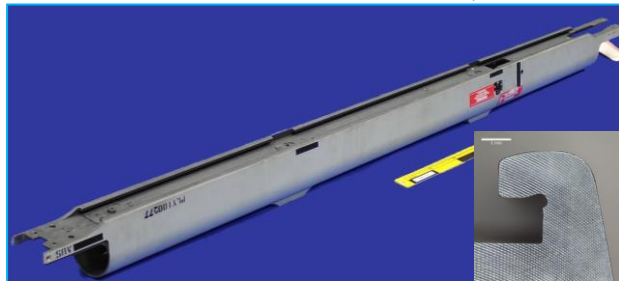
Applicable:
Repair/pre-emptive rework

Robust (tolerating fleet variations)

In-situ & precise machining

Rebirth of Fatigue Damaged Structural Components

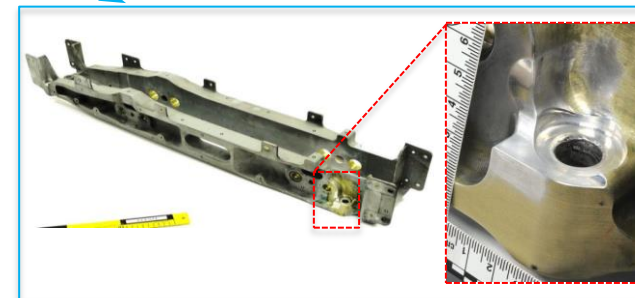
Recent Applications



LAU-7 missile launcher rail



Outer wing front spar grounding hole



SUU-62 centreline pylon

Partnering Opportunities:

- Apply technology more widely, including non-air domains
- Development and further improvement in technology – modelling and manufacture

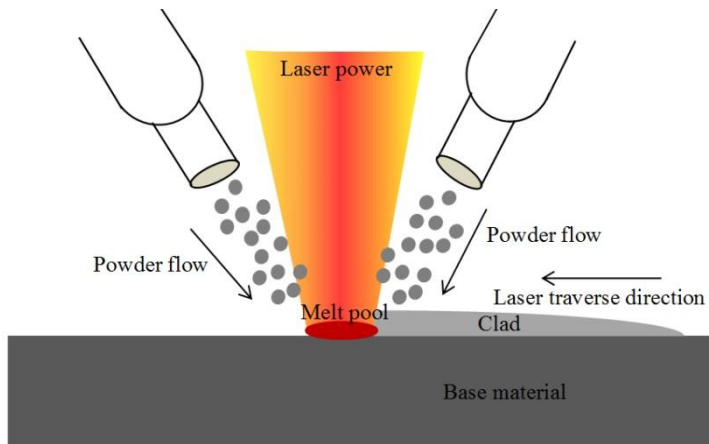
Additive Manufacturing (AM) and Repair Using Laser Based Melting Technology

- Applicable to components which otherwise would be scrapped due to excessive corrosion, wear, other damage
- Enhance availability where replacement component lead times are very long
- Can improve the properties of components, e.g. improve corrosion resistance by adding stainless steel powder



Additive Manufacturing (AM) and Repair Using Laser Based Melting Technology

Laser Cladding Repair



Additive Manufacturing by Laser Selective Laser Melting



*DST Group SLM Solutions SLM500 system
- Dual 400 W fiber lasers*



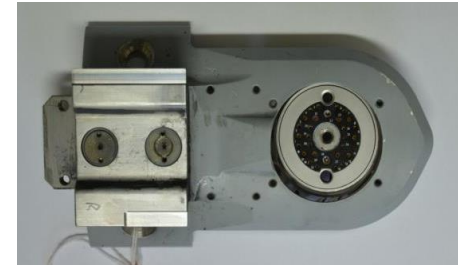
Additive Manufacturing (AM) and Repair Using Laser Based Melting Technology

Recent Applications

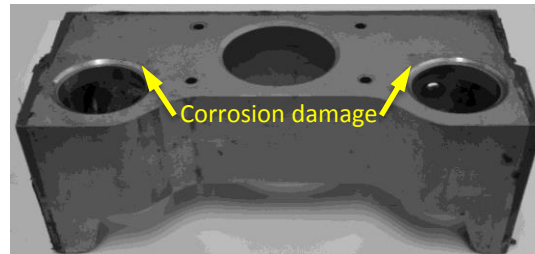
Geometric restoration



F/A-18 Rudder Anti-Rotation Bracket - Certified & accepted by RAAF



F/A-18 AIM-9X Missile Attach Lug - Certification acceptance in progress



C-130J Landing Gear Shelf Bracket - Repair designed & certification in progress

Partnering Opportunities:

- Apply technology more widely, including extension to structural repair
- Development and further improvement in technology – processing parameters



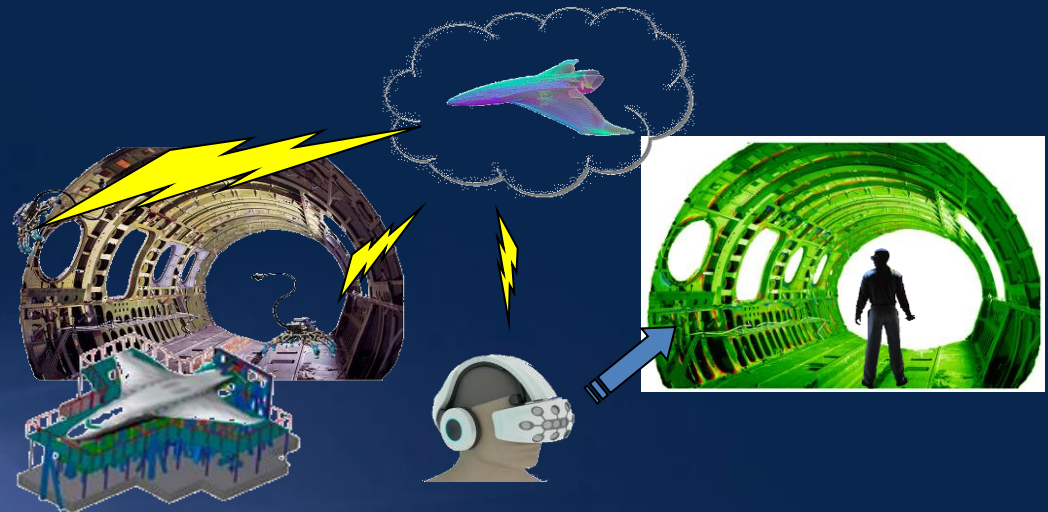
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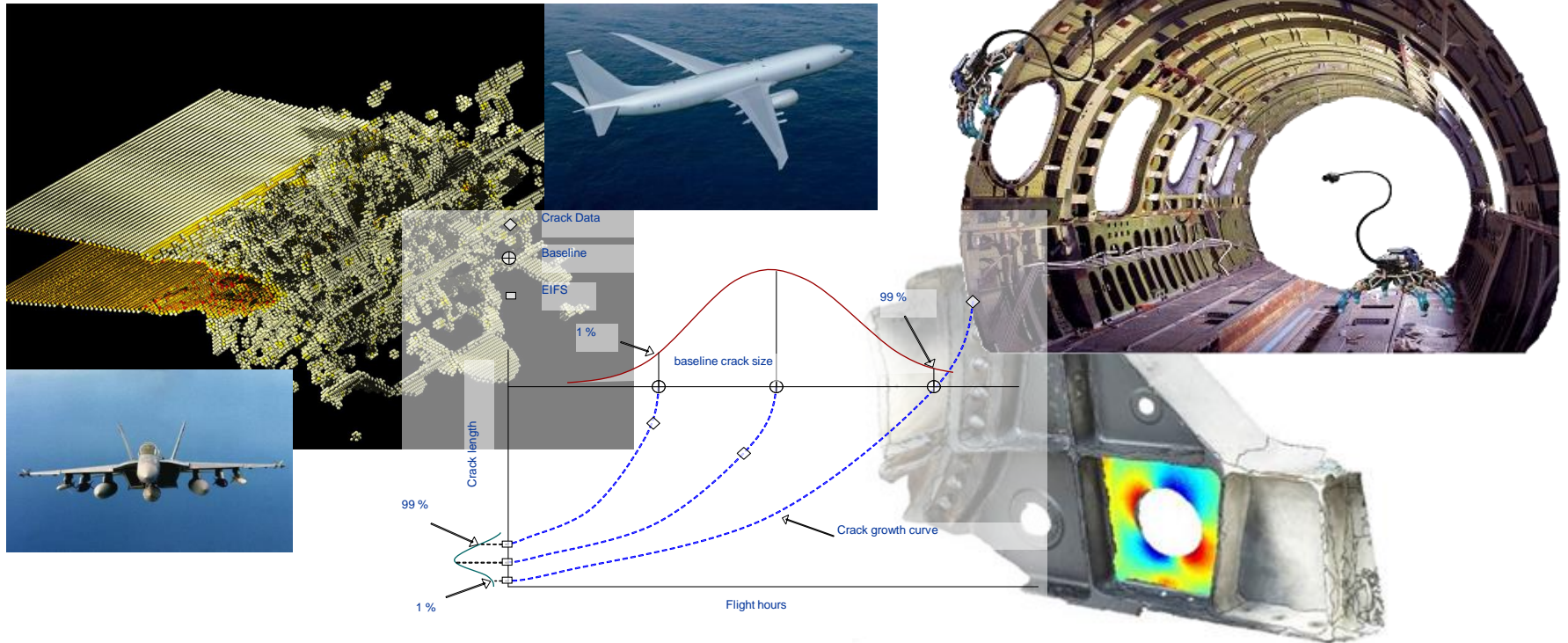
Aerospace Division Aircraft Structures

Mr Rob Boykett

Revolutionise
Airframe Testing



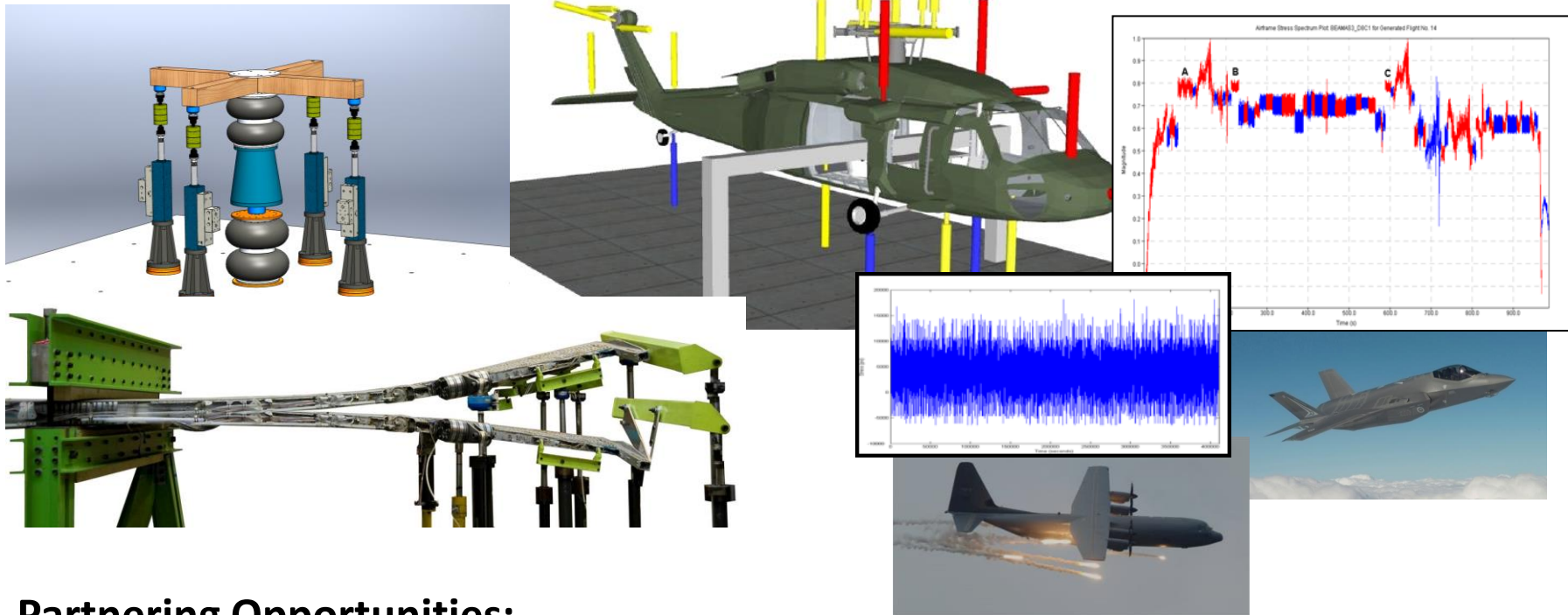
Structural Life Exploitation



Partnering Opportunities:

- Development & Validation of analytic models to predict the effects of fatigue cracks and composite delamination from atomic scale through to full-scale aircraft structure.
- Collaborate on Research, Development and Design of next generation (autonomous) Thermolastic Stress Analysis Robots (TSAR) to find & resolve structural problems.

Experimental Innovation



Partnering Opportunities:

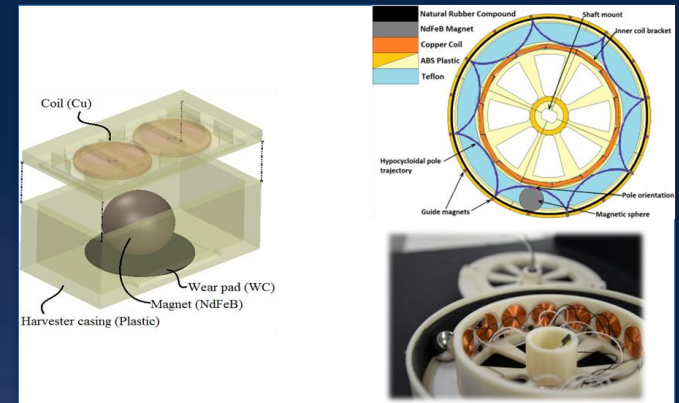
- High Speed Testing – Modelling & Developing of Advanced new Equipment, Instrumentation & Control Systems for faster speeds x10+.
- Load Spectrum Truncation – Developing & Validating new analytical methods to replicate the effect using only 1% of data.



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Aerospace Division Aircraft Health & Sustainment

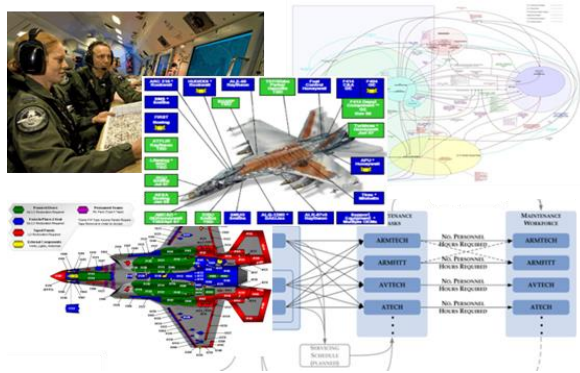
David Holmes



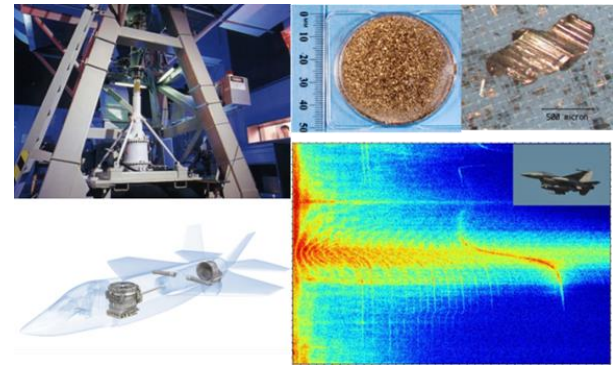
Aircraft Health and Sustainment Major Science and Technology Capability

Enable Safe, Supportable and Affordable operation of ADF Air Vehicles Fleets through a focus on Asset and Health Management Technologies.

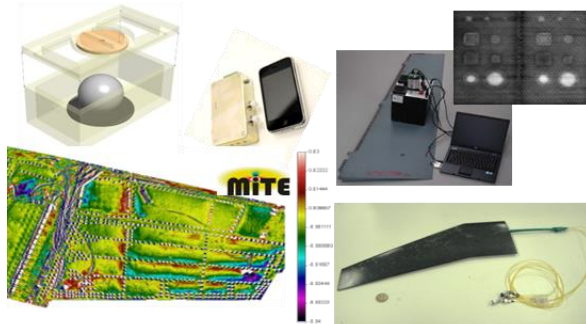
Aerospace Systems Sustainment Analysis



Vehicle Dynamics and Diagnostics



Airframe Diagnostic Systems



Engines and Fuels Integrity



Interdependencies

MISSION VIABILITY

PLATFORM SUSTAINMENT

HEALTH INDICATORS AND TECHNOLOGY

STATE
CHANGES

SAFE
HEALTHY
UNSAFE
UNHEALTHY

EFI

ENGINE STRUCTURAL INTEGRITY
FUEL CHEMISTRY AND SUPPLY
DURABILITY ANALYSIS

VDD

CONDITION MONITORING
ACOUSTIC SIGNATURE
HUMS

ADS

EXPERIMENTAL STRESS MEASUREMENT
NDT OPTICS AND PHOTONICS
FLIGHT TEST INSTRUMENTATION

STATE CHANGES

SERVICEABLE
AFFORDABLE
UNSERVICEABLE
UNAFFORDABLE

STATE CHANGES

VIABLE
SUITABLE

UNVIABLE
UNSUITABLE

ASSA

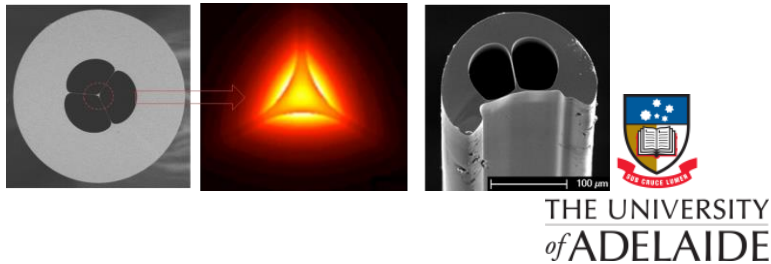
SORTIE ASSUREDNESS
DEPLOYED VS RTS
GLOBAL LOGISTICS
WORKFORCE DESIGN
PBL AND ILS

SUSTAINMENT WARGAMING
INTEGRATED ASSET MGT
MISSION ASSUREDNESS
OWNING THE BASELINE
SERVICE DOMINANT LOGIC

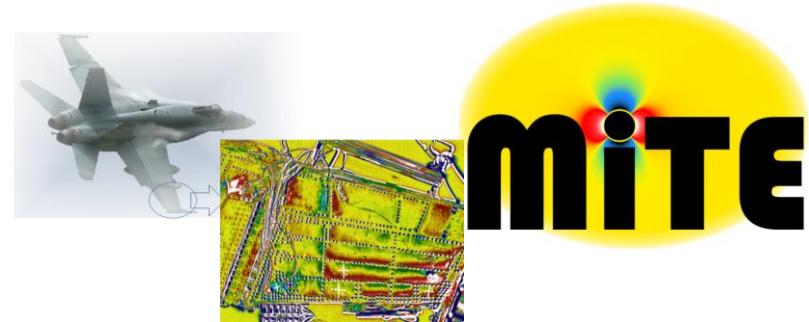


Health Management Technologies

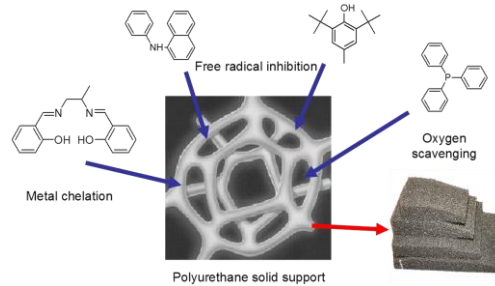
Corrosion Sensing Using Exposed Core Optical Fibre (TRL 3-4)



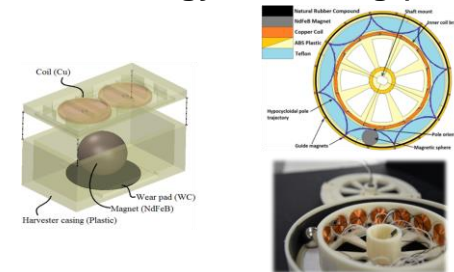
Thermo-elastic Stress Analysis (TRL 9)



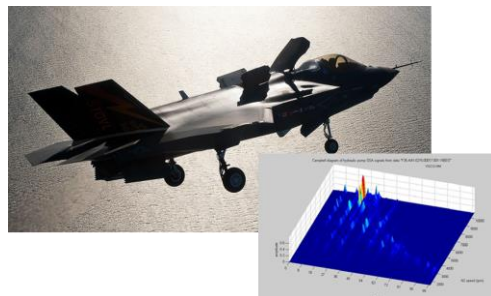
Fuel Additive Technology (TRL 3-4)



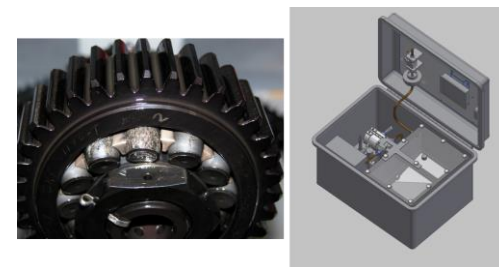
Vibration Energy Harvesting (TRL 1-3)



Vibration Based Prognostics & Health Management (TRL 7)



Enhanced Propulsion Wear Debris Analysis (TRL 7)



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Connect, Partner, Collaborate, Innovate



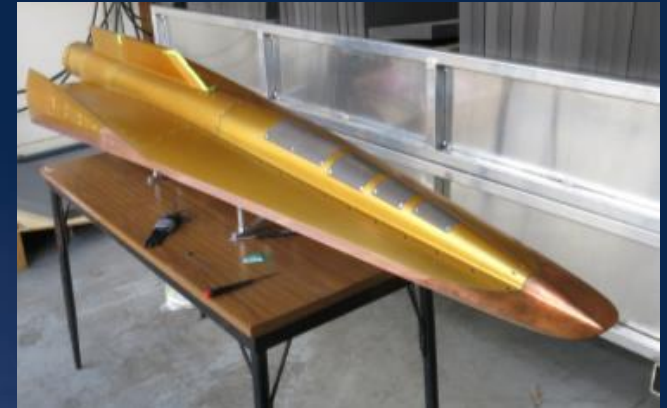
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Applied Hypersonics

Dr Allan Paull



DST
GROUP

Science and Technology for Safeguarding Australia

Applied Hypersonics

■ Hypersonics Enabling Research

Scientific and Engineering fundamentals required for sustained hypersonic flight

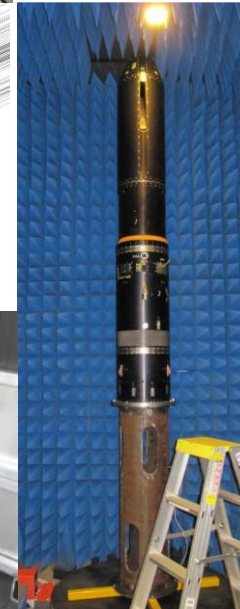
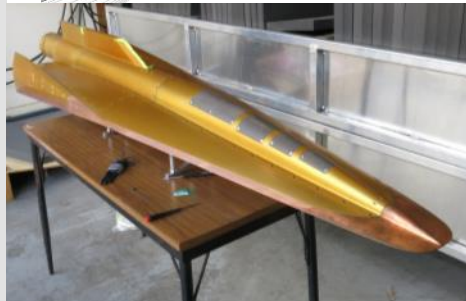
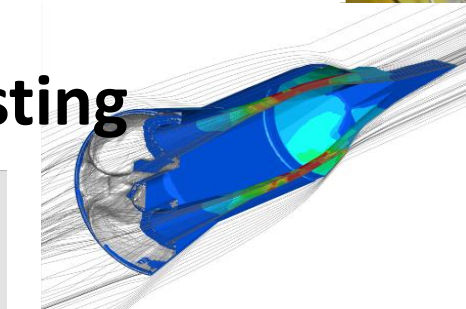
- Hardware
- Algorithm
- Software
- Scramjet



■ Hypersonic Flight Testing

From Science to Flight

- Payload Design
- Payload Ground Testing
- Aerodynamics
- Control
- Flight Testing



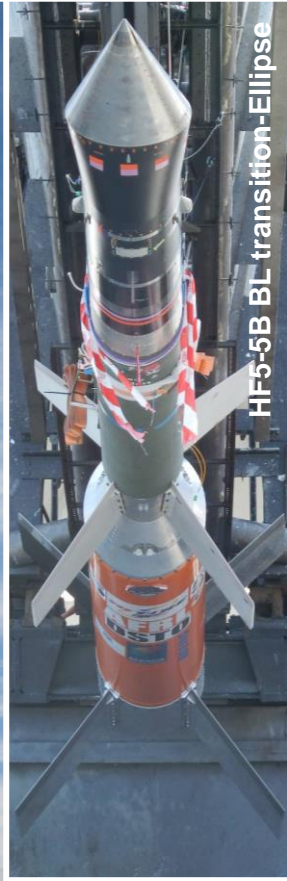
HF0 Exo-Atm. Control



HF1 BL Transition-Cone



HF5-5B BL transition-Ellipse



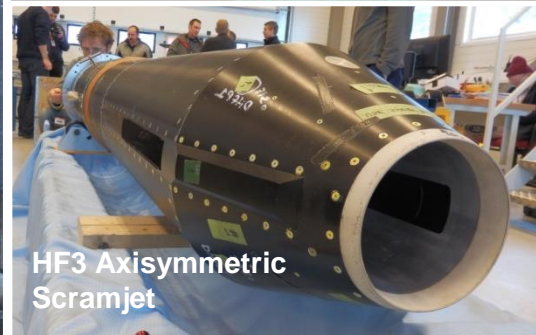
HF2 Dual Mode Scramjet



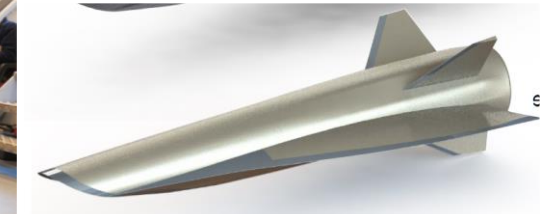
HF4 Aerodynamic Control



HF3 Axisymmetric Scramjet



HF6 Aerodynamic Control



HF7-7B REST Scramjet Thrust



HF8 Sustained Cruise

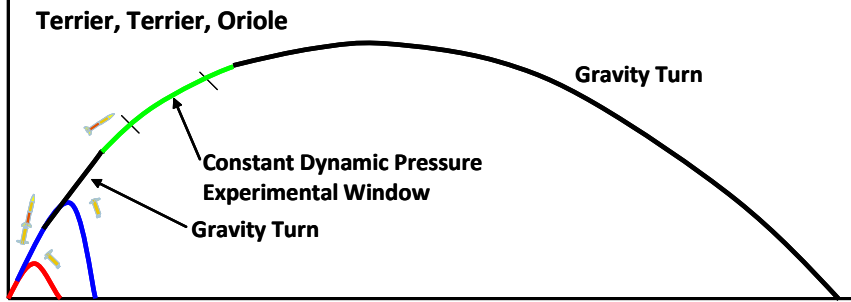


100km

Terrier, Terrier, Oriole

Constant Dynamic Pressure Experimental Window

Gravity Turn



300

Apogee

Stop Attitude Control Maneuver

Start Attitude Control Maneuver Nosecone Eject

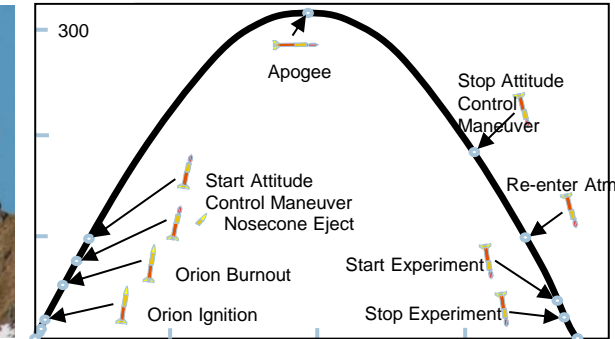
Re-enter Atmosphere

Orion Burnout

Start Experiment

Orion Ignition

Stop Experiment



Aerospace Division

