Australian Government
Department of Defence
Defence Science and Technology Group

Complex Systems Integration – A Defence Science & Technology Perspective

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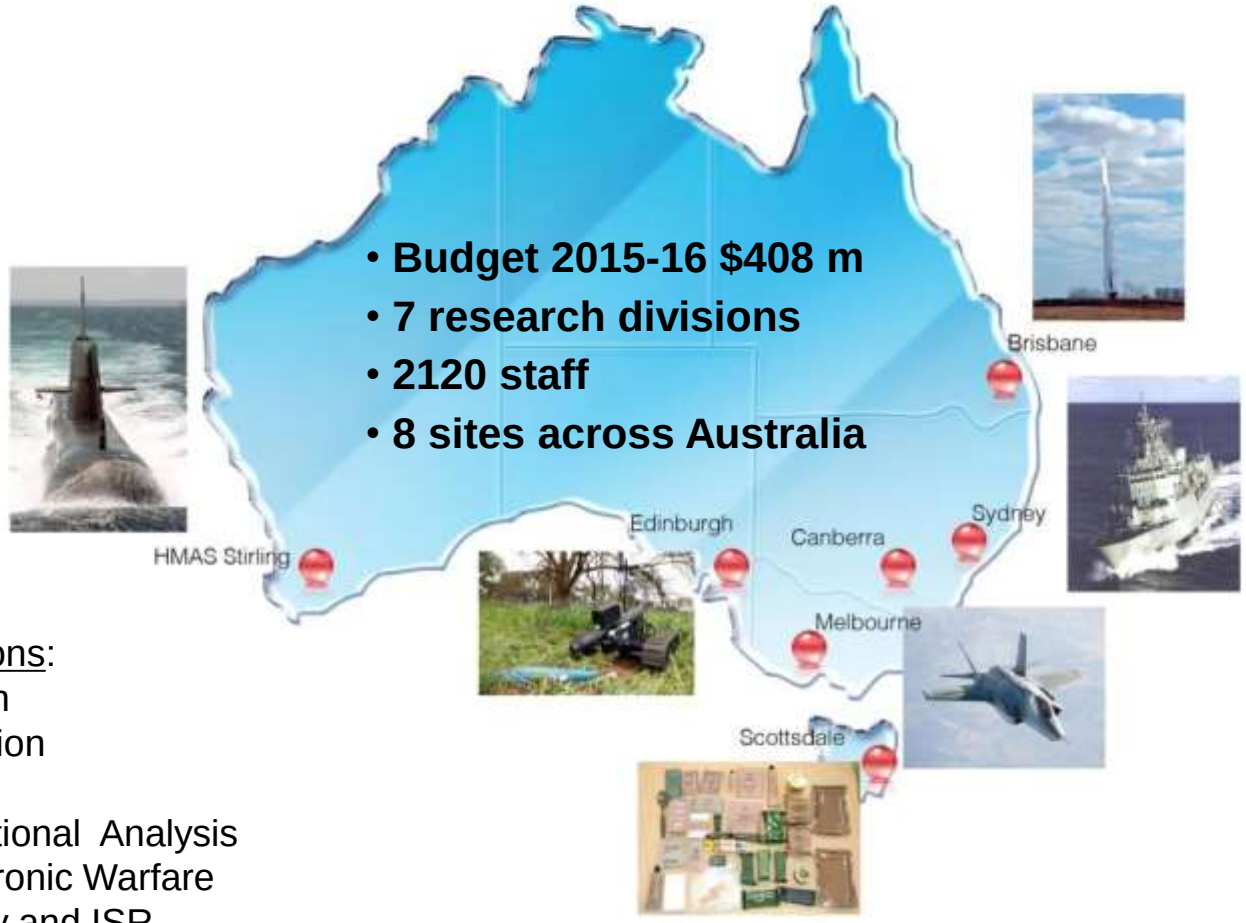
Krakow, Poland August 2015

DST Group at a glance



Research Divisions:
Maritime Division
Aerospace Division
Land Division
Joint and Operational Analysis
Cyber and Electronic Warfare
National Security and ISR
Weapons and Combat Systems Division

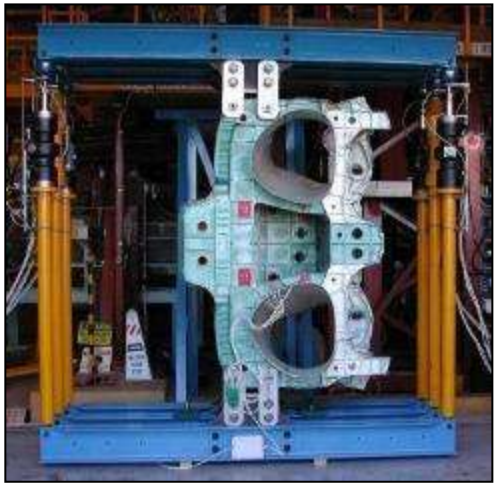
Defence Science & Technology Group

DST Group Strategic Plan 2013-2018

… delivering valued scientific advice and innovative technology solutions for Defence and national security

DST Group - Roles in the Aerospace Domain

Defence Operations

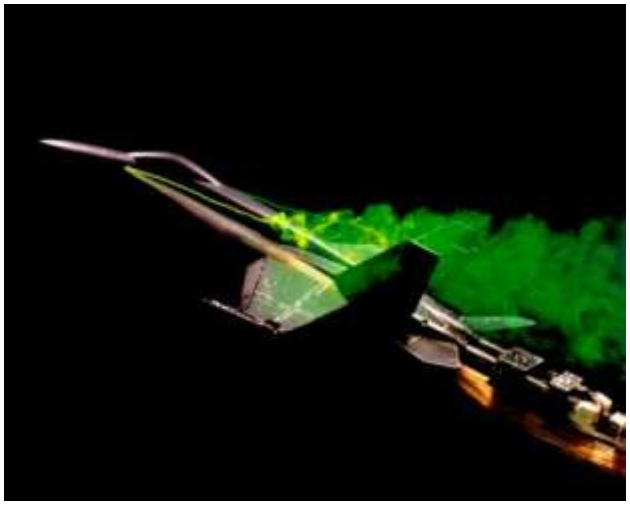


Sustainment

Acquisition Projects

Strategic Research

DST Group - Aerospace Division



Purpose:

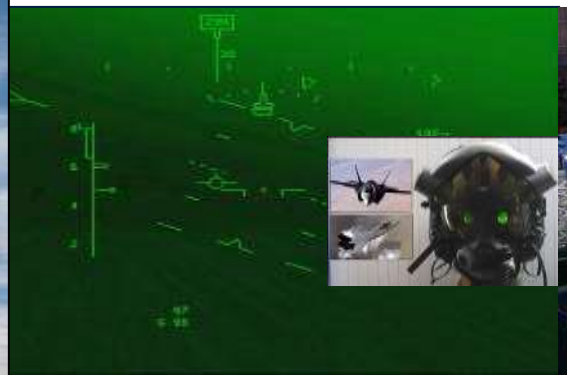
To provide advice on the exploitation of aerospace science and technology in support of Australian Defence Force (ADF), operations, the acquisition of ADF aircraft, the cost-effective sustainment of ADF aircraft and to conduct strategic research in selected areas.

6 Branches:

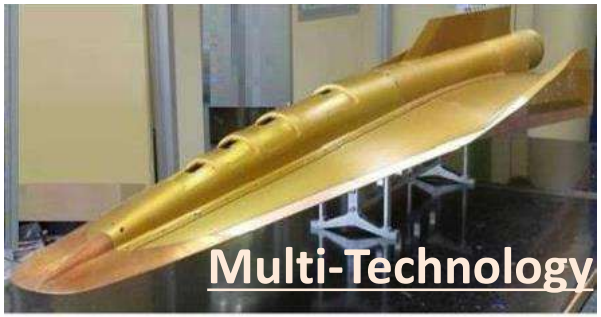
- Aircraft Structures
- Airframe Technologies & Safety
- Applied Hypersonics
- Aerospace Systems Effectiveness
- Aircraft Performance & Survivability
- Aircraft Health & Sustainment
- 300 staff and contractors

Aerospace Division Major Recent Projects

- HIFiRE Hypersonics program 2006->, wins ICAS Von Karman award 2012
- Helicopter gearbox fault diagnosis by application of time frequency analysis
- Live Virtual Constructive Simulation Exercises, - Black Skies, Coalition Virtual Flag
- Development of Joint Air Warfare Battle Lab, JAWBL at RAAF Williamtown
- C-130 J - Full Scale Fatigue test, Main wing
- JDAM-ER gliding weapon, extended range
- F/A-18 - Centre Barrel fatigue life extension
- Hawk Mk127 - Full Scale Fatigue Test



Drivers of Complexity



Integration in Capability and Operations

- Defence Operations have become more complex:
  - Defence needs to be flexible to meet Government objectives:
    - Warfighting
    - Peace keeping and monitoring
    - Humanitarian aid
    - Terrorism
    - Law enforcement
    - Border protection

Defence Projects Are Complex

Airborne Early Warning & Control

Complex innovative technology, relies on networking

Air Warfare Destroyer

Complex system integration

Future Submarine

Complex gov't to gov't relationships

SATCOM

Multiple stakeholders & governments

Joint Strike Fighter F-35A

Multiple stakeholders and governments

Complex innovative technology

Complex system integration

Integration Challenge

- Increasingly Complex Individual Capabilities
- Impact of “off the shelf” acquisition – Many Shelves
  - Many different suppliers over 10+ years
  - No common approach to integration or standards
- Acquisition Process not optimised for Integration
  - Large Number of disconnected Projects/Programs
  - Poor or late integration across Projects
- Inadequate overarching design / architecture
  - Unclear concept for usage and operations
  - Not integrated by design
  - Not designed for change
- Often overlooks the Human Dimension
- Processes not well suited to manage enduring and evolving capabilities

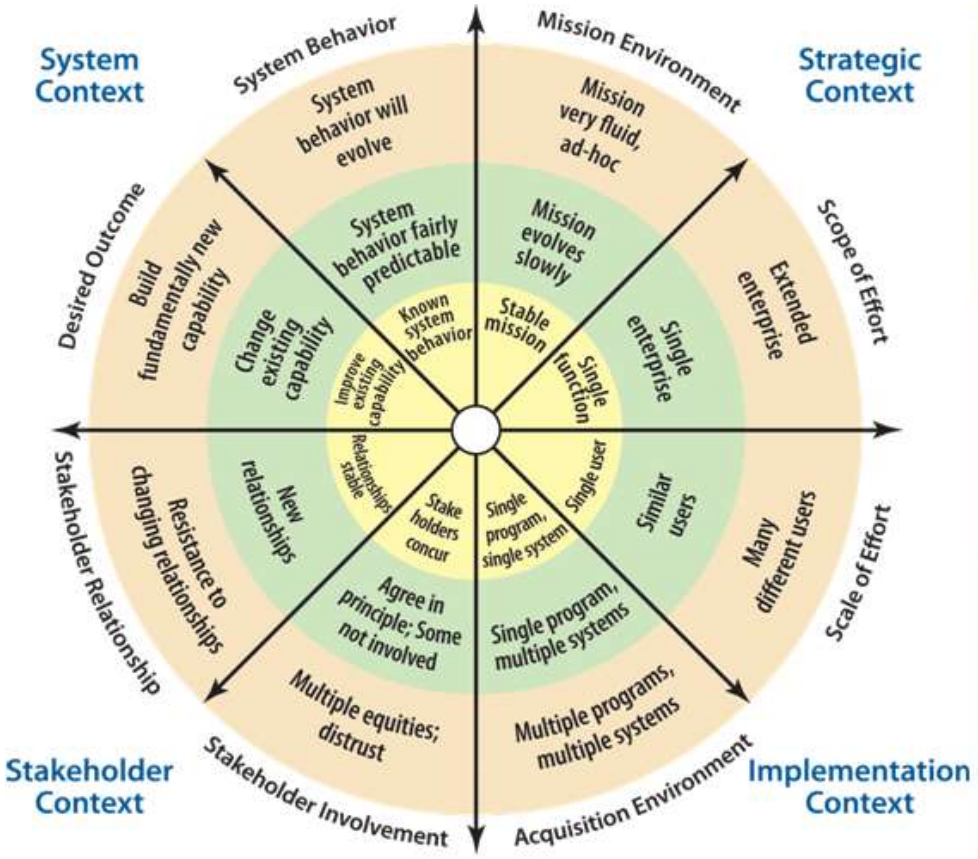
Changing Australian Air Domain platforms

Air Combat Capability

- Multirole/single mission
- Sensors: MS radar, EW,+ Mk1 eyeball
- Display: HUD + 2 single colour screens
- Processors: 2x256k core processor
- Software approx 6m LOC

- Multirole/multi mission
- Sensors: AESA radar, EOTS, EODAS, EW, data fusion, networked
- Display: HMD + MFDs
- Processors: 7 power PC core processors+ 5 signal/data processors
- Software: approx 24m LOC
- Autonomic logistic system

Project Acquisition



- **Traditional program domain**
  - *Well-bounded problem*
  - *Predictable behavior*
  - *Stable environment*
- **Transitional domain**
  - *Systems engineering across boundaries*
  - *Influence vs. authority*
- **Messy frontier**
  - *Political engineering (power, control…)*
  - *High risk, potentially high reward*
  - *Foster cooperative behavior*

From :Stevens R. 2011, Engineering Mega-Systems, ISBN 978-1-4200-7666-0, CRC Press.

Principles for Joint SoS Integration

1. Governance
2. SoS Engineering Best Practice
3. Sys / SoS Architectures
4. Evidence Based for Evaluation
5. Human Systems Integration
6. Capability Life-Cycle Management (CLCM)

Key Changes made to Symbology

Integrating Objectives

- **Networked**.
- **Partnered**.
- **Compatible**.
- **Survivable**.
- **Designed for change.**
- **Individually and collectively**

Plan Jericho to enhance RAAF capability

To develop a future force that is agile and adaptive, fully immersed in the information age, and truly joint.

These three transformation themes guided the development of Plan JERICHO.

- **Harness the combat potential of a fully integrated force**
- **Develop an innovative and empowered workforce**
- **Change the way we acquire and sustain capability** |

Plan Jericho for RAAF

- Enhance the Air-Land Integration
- Enhance Air Force's Maritime Operations Capability
- Establish an Air Warfare Centre
- Enhance Air Force's C4 Capability
- Optimise Air Force Contribution and Access to the Common Operating Picture
- Grow the Air Force Cyber Capability
- Develop an Integrated Fire Control Capability
- Enhance Air Force's Air Base War Fighting Capability
- Implement an Air Force Collective Training Plan
- Enhance Air Force's Live, Virtual and Constructive and Ranges Capability
- Integrate Logistics into the Battlespace
- Develop Capacity to Manage Air Force Security
- Develop Air Force's Strategy Driven Operating Model
- Establish an Air Force Integrated Capability Management Process
- Develop a Workforce Management Strategy

Operational Analysis Supporting Joint Strike Fighter

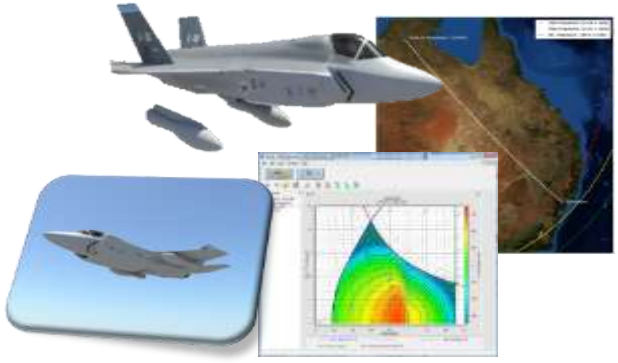
4th and 5th Gen Threat Assessment
+
Concept of Operation/Tactics Evaluation

F-35A Interoperability

Beyond Line of Sight Communications

Radar & Electonic Attack Modelling

External Fuel Tank Assessments



Joint Strike Fighter Science & Technology Support

- S&T Program supports development and operations of the JSF capability, reduces cost of sustainment, offers new capabilities/opportunities for Australian industry and enhances Australia's scientific knowledge base.

Platform: signatures, engines, materials, structures, flight controls, performance, Electromagnetic Environmental Effects, PHM

Mission system: radar, electro-optic, electronic warfare, communications, computing, fusion

Weapons: AMRAAM, Small Diameter Bomb, JSOW, Joint Strike Missile, Meteor

JSF Technologies

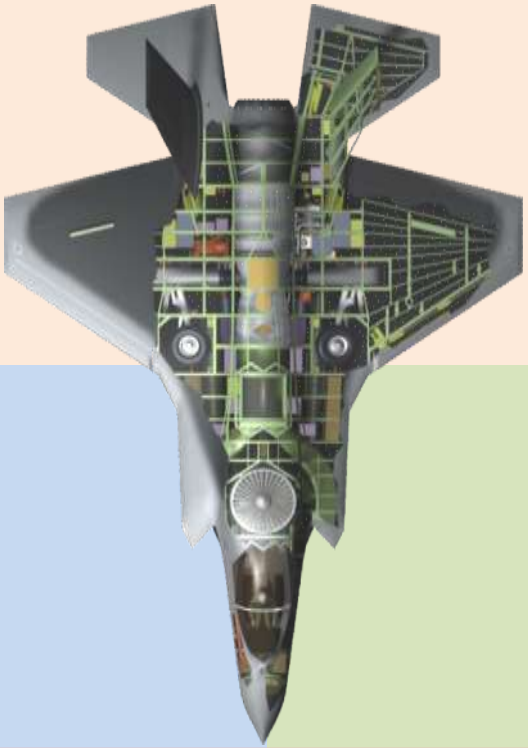
Air Vehicle Systems

Fighter-Optimized Engine
- F-135 is a derivative of the F-119 (F-22)
- One-piece engine/nozzle allows direct removal/replacement
- Lightweight low observable axial nozzle

Wing/Tail Configuration
- Good cruise and maneuver characteristics
- Accommodates large CG range
- Good handling qualities
- Good height for external stores

All Aspect Signature Management
- Designed in stealth
- Embedded antennas
- Internal fuel and weapons
- Low emissions
- Reduced Maintenance
- Conductive layer built into composite skin

Three Variants
- CTOL, STOVL, CV
- Meets the needs of USAF, USN, USMC and Partner Nations
- High level of commonality



Shaft Driven Lift Fan (STOVL)
- Smooth transition to up and away flight
- Cool thermal footprint
- Exceeds all thrust transient requirements
- Margin for growth

Integrated Power and Thermal Management System
- Auxiliary Power & Main Engine Start
- Pressurized Air for On-board Oxygen & Inert Gas Generating Systems
- Cockpit Cooling and Pressurization
- Avionics Cooling
- Bay Ventilation

More Electric Approach
- Flight Control Electro-Hydrostatic Actuation – reduced hydraulics
- 270V electrics
- Li-ion battery technology for back-up power

Autonomic Logistics System

Prognostics and Health Management
- Supports high sortie generation rates
- Fault detection/isolation
- Reduced false alarm rates
- Off board prognostics
- Structural monitoring includes corrosion sensors

Designed for Supportability
- Improved reliability and maintainability
- Low observable health assessment system
- Cooperative sensor and signal insertion for fault detection
- Open system architecture addresses diminishing manufacturing sources

Pilot Vehicle Interface

Single Seat Cockpit
- All sensor fusion and panoramic, touch control display
- Helmet mounted display
- Hands on throttle and stick

Mission Systems

Integrated Systems
- Integrated electro optical targeting system – FLIR, IRST, laser ranging/spot tracking
- Distributed aperture system – 360˚ situational awareness/missile warning
- Advanced multi-mode AESA radar - A/A, A/S, EW, Nav
- Countermeasures – RF/IR
- EW System – Radar Warning, High gain ESM, Emitter geolocation, EA/ECM

Weapons
- Large Internal weapons bay – up to 2000lb class carriage
- 25mm cannon (CTOL Internal)
- External weapons

UAS Example - Focus on Urban Missions

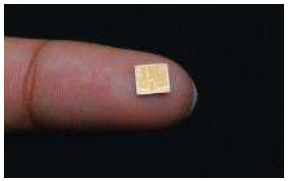
Urban ISR for military or police action

Emergency response

Chemical and biological agent localisation

Humanitarian assistance and disaster relief (HADR)

UAS Technologies Addressing Urban Missions



Urban ISR for military or police action

Chemical and biological agent localisation

Emergency response

Humanitarian assistance and disaster relief

Navigation, command, and control

- Collision avoidance
- Assured communications
- Active mapping and mission planning
- Control in large-scale turbulence

Miniaturised sensors

- Radar
- Night vision (SWIR and LWIR)
- Single-photon avalanche diode array
- Chemical, biological

Teaming and on-board analytics

- Human-machine teams
- Distributed mapping and search by robotic teams
- Semantic labelling of mapped terrain

Multifunctional materials and integrated systems

- Integrated power and energy
- Embedded and structural antennas

Specialised platforms

- Agile, efficient micro platforms for indoor operation
- Specialised rotary-wing UAS (quiet operation; graceful degradation)

Conclusion

- Increasing focus on Integration in Defence acquisition and operations and sustainment.
  - Increased focus on Force Design and analysis
- Elements of Joint Integration
  - Governance
  - SoS Engineering Best Practice
  - Architectures
  - Evidence Based Approach
  - Human System Integration
  - Cap Dev Life-Cycle Management
  - Design for Change
- Processes and artefacts must be Austere & add Value

The End