Australian Government
Department of Defence
Science and Technology

Advanced Materials for Defence

Dr Dong Yang Wu
Chief – Aerospace Division
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Strategic Context: Defence White Paper 2016

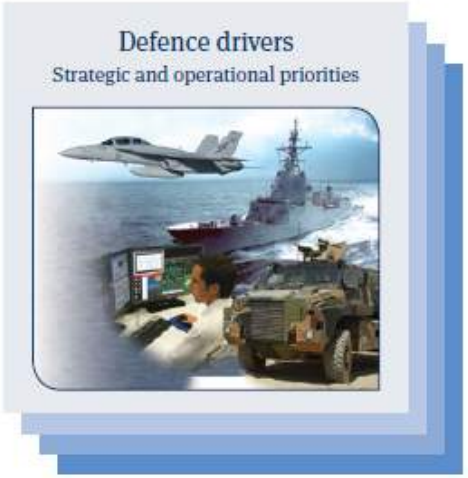
A new approach to Defence Innovation

- Investment in science and technology helps to ensure the ADF remains **resilient to emerging threats, including the possible use of disruptive technologies by adversaries**

- A high priority has been placed on strengthening Defence's ability to understand and respond to **potentially game-changing next generation science and technology-related threats and opportunities**

- Next Generation Technologies Fund
  - $730 million over the decade to 2026
  - to respond to strategic challenges
  - to retain a technology edge
  - provide game changing Defence capabilities
  - **Multidisciplinary Materials Science – transformational technology area**

Approach for DST Materials Strategy Development



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Landscape analysis to understand relevant threats and opportunities

Advanced Materials Strategy for Defence

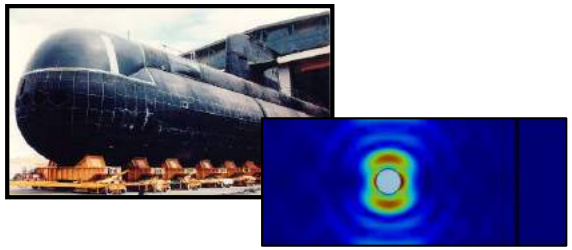
Characteristics of DST Group capabilities			
	Capabilities that *are*:		**Capabilities that *are not*:**
✓	Distinctive	✗	Generic
✓	Sustainable	✗	Easily imitated
✓	Able to create impact	✗	Commodities
✓	Demonstrable	✗	Limited in usefulness
✓	Able to be leveraged	✗	Vague

Considerations for Advanced Materials Portfolio

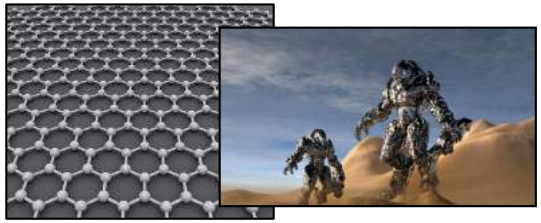
- Advanced materials are critical means to the end
- **Focus** on areas where emerging materials are on a critical path to create disruptive defence capabilities for Australia
- **Defence outcomes-driven** by starting with the end in mind and a portfolio approach in defining the needs and goals
- **Team Australia approach** in planning and delivering the portfolio

Innovation Focus + Outcome Focus + Team Australia = Disruptive Defence Capabilities

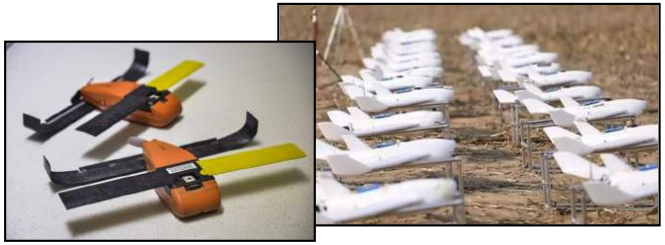
Defence Capability from Materials & Processes



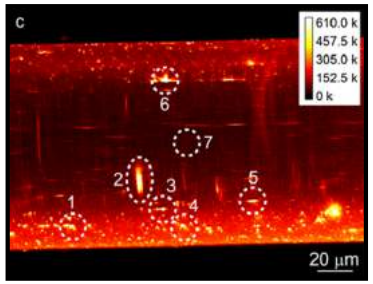
Signature Reduction



Protection



Unmanned Aerial Vehicles

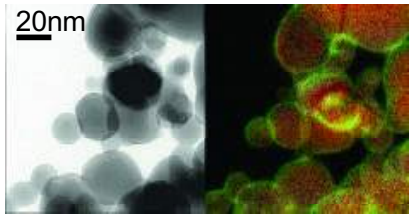


Sensor Systems

Power/Energy

Hypersonic Flight

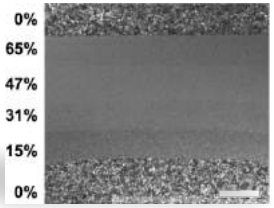
Defence Equipment



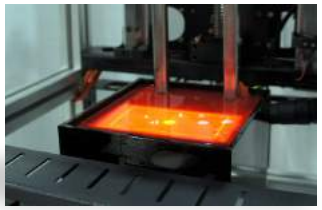
Nano-energetics

Emerging materials and processes are enablers of potentially game changing defence capabilities

Additive Manufacturing



Protection (armour)

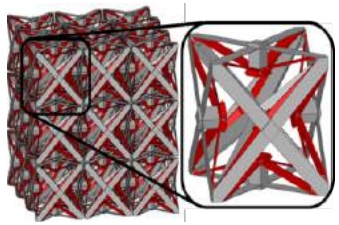


Energetic Materials

Hypersonics

Small UAVs

Metals, Polymers, Ceramics, Metamaterials, Graphene and/or Energetic Materials



Satellites

Deployable Parts Manufacturing

Just in time and on demand

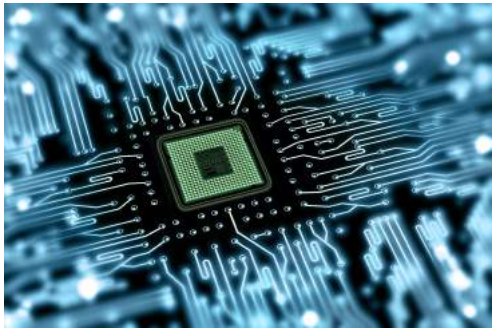
Rapid Prototyping

Metamaterials Defence Applications

Bend light to effectively create an invisibility cloak

Portable, energy-efficient satellite communication units for soldiers on the battlefield.

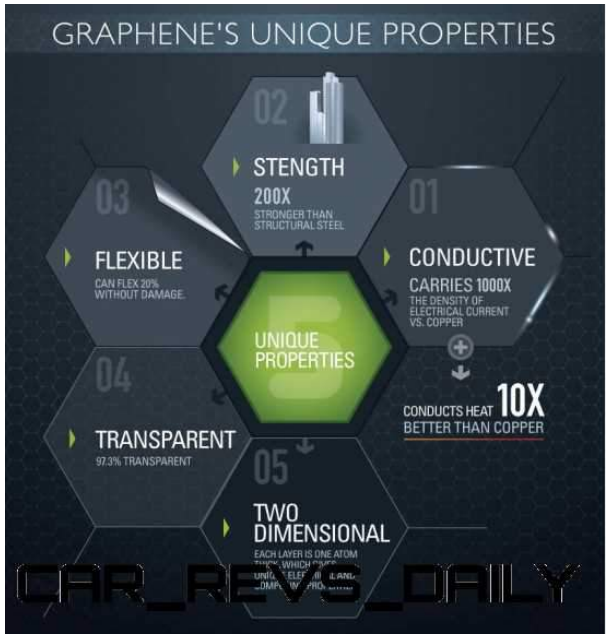
Making efficient solar cells less bulky

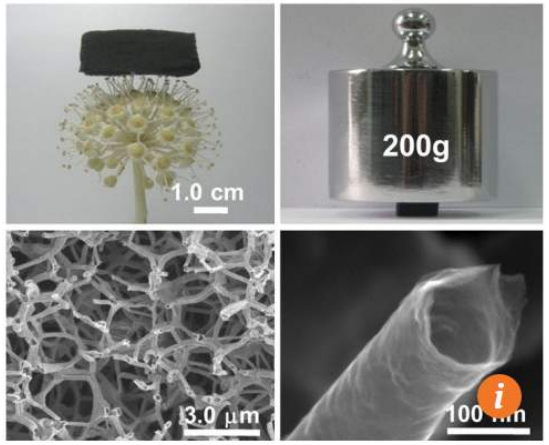


Tiny and speedy chips enabling ultra-fast data processing

Beam broadband connections to planes, trains, ships and cars enabling internet access everywhere.

Graphene Defence Applications





Chinese scientists' new 'super-strong foam' for lightweight tank and troop armour - Oct 2015

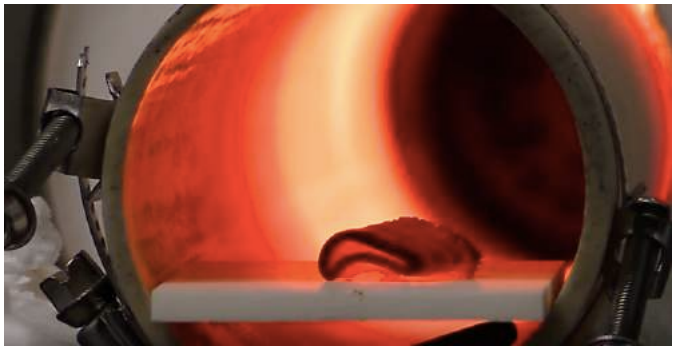
Bluewater Defense Military/Tactical Backpack featuring embedded wearbable next-generation antenna communications technology

US: Next Generation Antennas Offer 200% Increased Coverage Using Patented, Graphene-Enhanced Technology - 2016

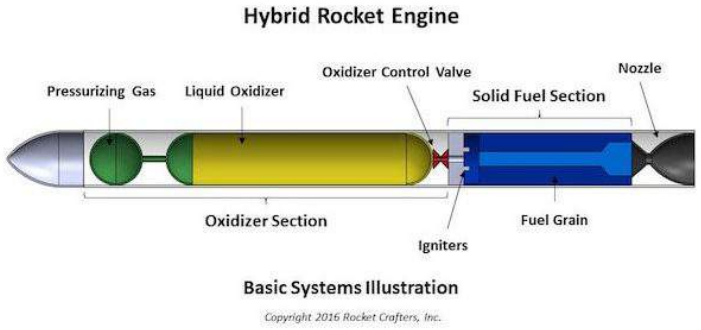
Australia: Graphene oxide supercapacitor on verge of commercialization – June 2017 (Swinburne Uni). Supercapacitor film could be integrated into multiple areas of the vehicle, body panels, roof, floor, and doors

3D Printing - US

First 3D-Printed Submarine Hull Traditional $600,000 to $800,000 and 3-5 months to manufacture. 3D printing reduced production costs by 90 % and shortened time to a matter of days - “on demand” vehicles, saving time, money, and energy - July 2017



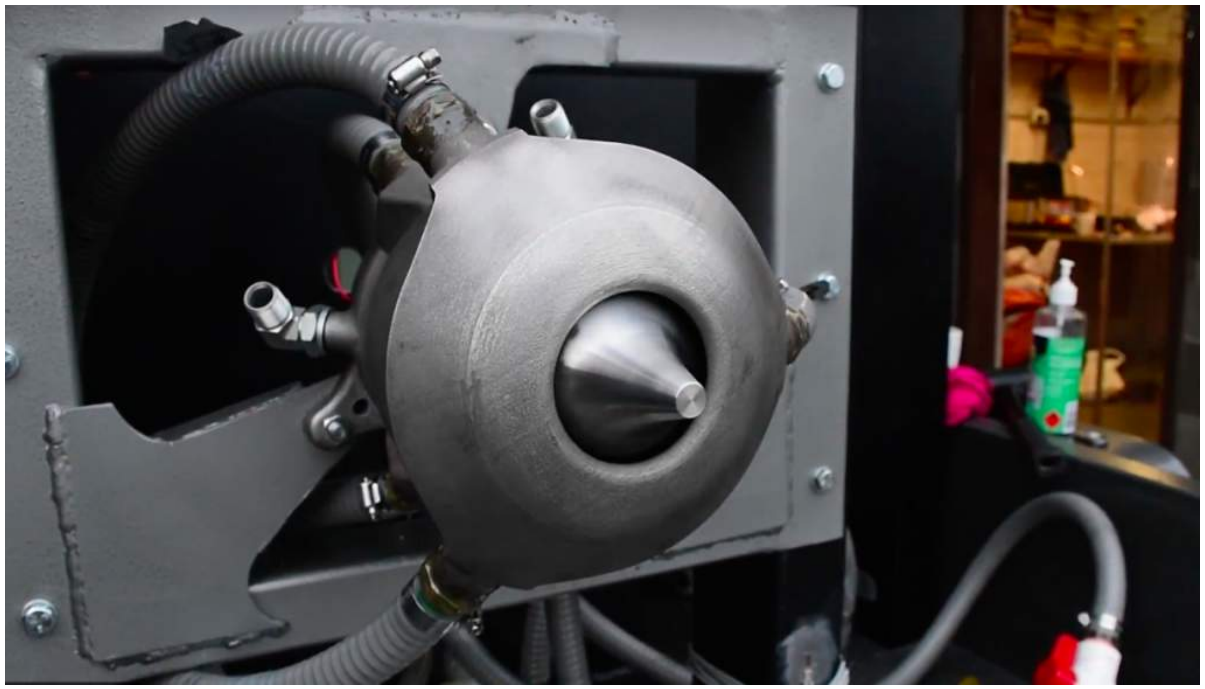
3D printed pre-ceramic engine part. Aug 2017
higher strength, higher resistance to heat (up to 1700 degrees Celsius)



US space company Rocket Crafters Inc (RCI) granted a $542,600 by DARPA to develop its 3D printed rocket fuel engine – 26 July 2017

US marine’s 3D printed drone is 200 times cheaper than production version – 29 Aug 2017

3D Printing-Australia



AMAERO AND MONASH UNIVERSITY 3D PRINTED ROCKET ENGINE PASSES TEST FIRE

Design and production of the engine completed in four months, following previous prototypes unveiled in 2015.

The material used to print the rocket engine was “Hasteloy X”, a “high strength nickel based superalloy”.

3D Printing - India

3D Printed Ku-band NW Feed cluster and final feed cluster assembly of GSAT-19

and IOT Performance Comparison

Cost-effective satellite components - 3D PRINTED COMPONENTS ROCKET WITH INDIAN SATELLITE LAUNCH – SEPT 2017

For space satellites, 3D printing a part enables the design to be adjusted to make it lighter. Since satellite launches are charged according to the payload (mass), more fuel can be placed on the satellite's bus for the same cost.

3D printing technology has been successfully used in space satellite components for over 2 years, with some satellites now entirely 3D printed. 3D printing looks likely to play an even greater role in telecommunications both in the air and on the ground.

3D Printing - China

China launches record-breaking drone swarm of 119 fixed-wing UAVs – June 11 2017

Chinese Astronauts take Flight with 3D Printed Seats June - 2013

3D printing of major load-bearing parts i.e. front landing gear of J-15 Flying Shark

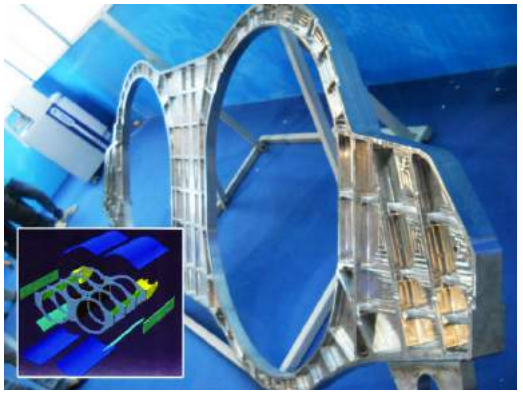
Part production library for 3D printing to replace a damaged part of a vehicle in a remote location - 2015

3D Printing - China

Chinese military tanker used 3D printed replacement parts - 2015

Chinese naval ship “The Harbin” is fully equipped with 3D printing capabilities to create its own spare parts - 2015

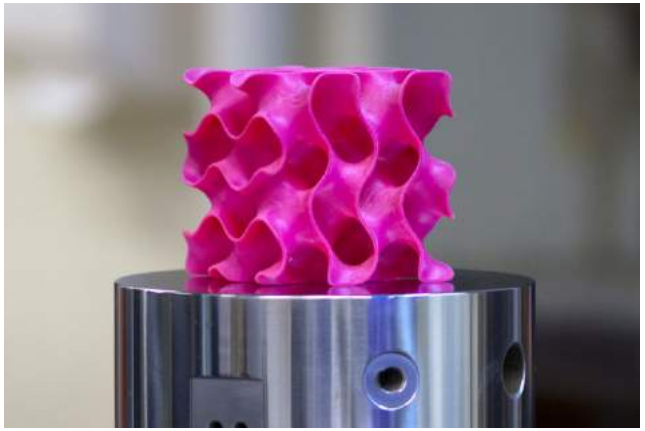
Chinese Military Area Command used 3D printer to create durable, solid 3D models to better visualize landscapes for military planning - 2014



World’s largest 3D printed Ti aircraft part which is a critical component for J-20 or J-31 Chinese stealth fighter-2013

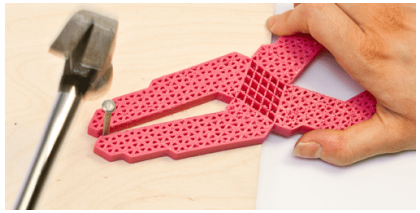
Synergies Between 3D Printing and Emerging Materials

3D Printing of Graphene



MIT creates 3D printed graphene that's lighter than air, 10X stronger than steel – Jan 2017

3D Printing of Metamaterials



"Metamaterials" Allow You to 3D Print Simple Machines
3D design thinking enables designs with the microstructure of materials in mind. And how that structure can be exploited to do useful, amazing things, like change shape and motivate – Sept 2016

Summary

- Clear linkage between cutting edge multi-disciplinary materials science and manufacturing and defence outcomes for Australia
- Fertile ground for innovation and high impact Defence outcomes
- Opportunities for Australia to lead in niche areas by taking a well-targeted, focused and synergistic approach
- Building and shaping Australia's research and industry capabilities in these promising technology areas will also result in economic growth and export potentials

Realisation of disruptive defence capabilities is dependent on advances in material science