



**Australian Government**

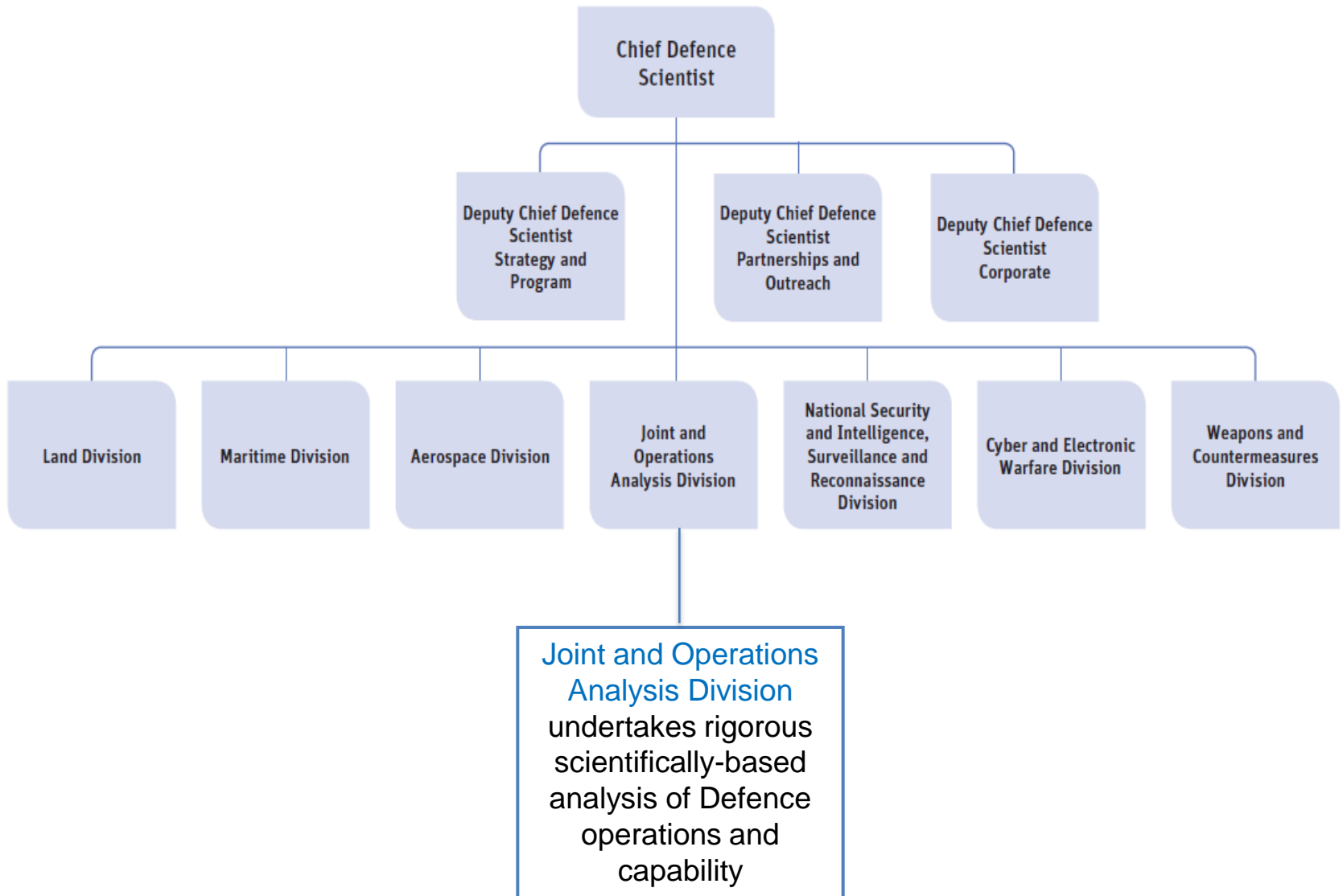
**Department of Defence**  
Defence Science and  
Technology Organisation

# Partnering with Joint and Operations Analysis Division

**DSTO**



**Science and Technology for Safeguarding Australia**



# Major Science & Technology Capabilities

- Maritime Mathematical Science
- Maritime Simulation, Experimentation & War-gaming
- Maritime Systems Analysis
- Australian Maritime Warfare Centre

Maritime Capability Analysis



- Joint Warfare Mathematical Science
- Joint Organisation & Social Science
- Joint Simulation, Experimentation & War-gaming
- Defence Systems Integration
- Defence Operations Support Centre
- Scientific Adviser CJOPS

Joint Capability Analysis



- Land Mathematical Science
- Land Organisation & Management Science
- Land Simulation, Experimentation & War-gaming

Land Capability Analysis



- Strategic Analysis
- Force Design
- Technology Forecasting & Futures
- Strategic Security Risk Assessment

Strategic Capability Analysis



- Aerospace Mathematical Science
- Aerospace Organisation & Management Science
- Aerospace Simulation, Experimentation & War-gaming
- Aerospace Systems Analysis

Aerospace Capability Analysis



- Planning and Logistics
- Situation Assessment
- Command Intent
- Behaviour and Control

Decision Sciences



Trusted Autonomy, Behavior, Complexity and Control

Principal Scientist



# Opportunities for Collaboration: Technology Forecasting and Force Design

## Strategic Analysis

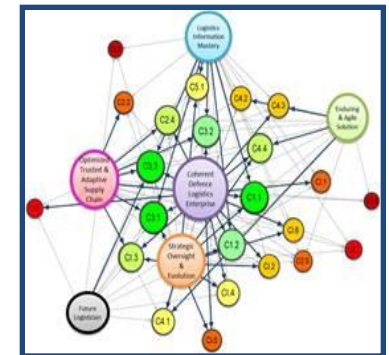
Development of methods for robust future technology forecasting.



## Force Design

Complex Systems Evaluation.

Advanced visualisation.



# Opportunities for Collaboration: Acquisition Support

## Land Combat Vehicle System

War-gaming & Experimentation

Simulation

Development of operations research techniques for comparison of Army mounted combat system options



# Opportunities for Collaboration: Autonomy & Situational Awareness

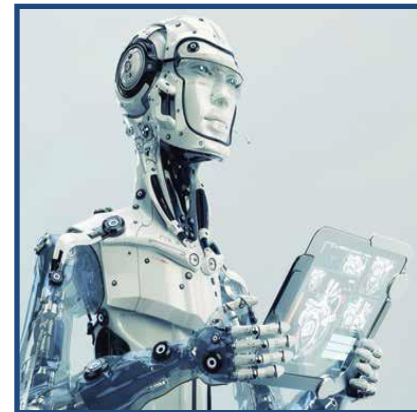
## Trusted Autonomous Systems

Operations analysis to capture need and uncertainty.

New approaches to machine cognition.

Human/Machine interaction.

Technology development and transition.

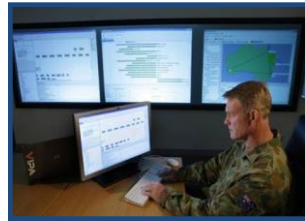


## Enhanced Situational Awareness

Advanced capabilities that can capture the story behind the data.



# Summary



**Joint and Operations  
Analysis Division is  
engaged across the  
capability spectrum**



# Future Technology Forecasting





# TECHNOLOGY FORECASTING & FUTURES

- Strategic Analysis
- Force Design
- Technology Forecasting & Futures
- Strategic Security Risk Assessment

## Strategic Capability Analysis

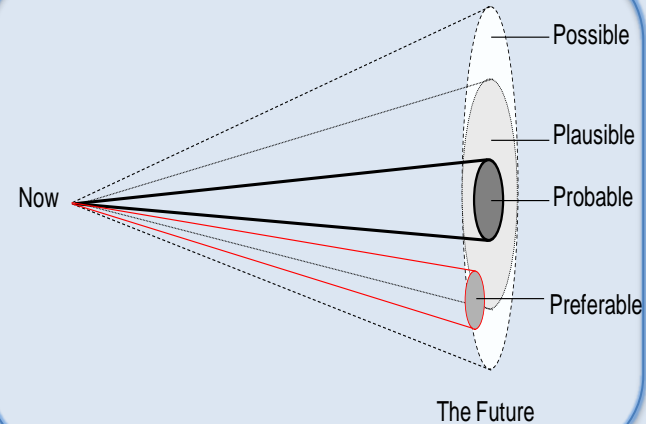


- Provide input to and guidance on:
  - Avoiding strategic surprise
  - Future Operating Environments
  - Inform Investment decisions

## Technology Forecasting & Futures

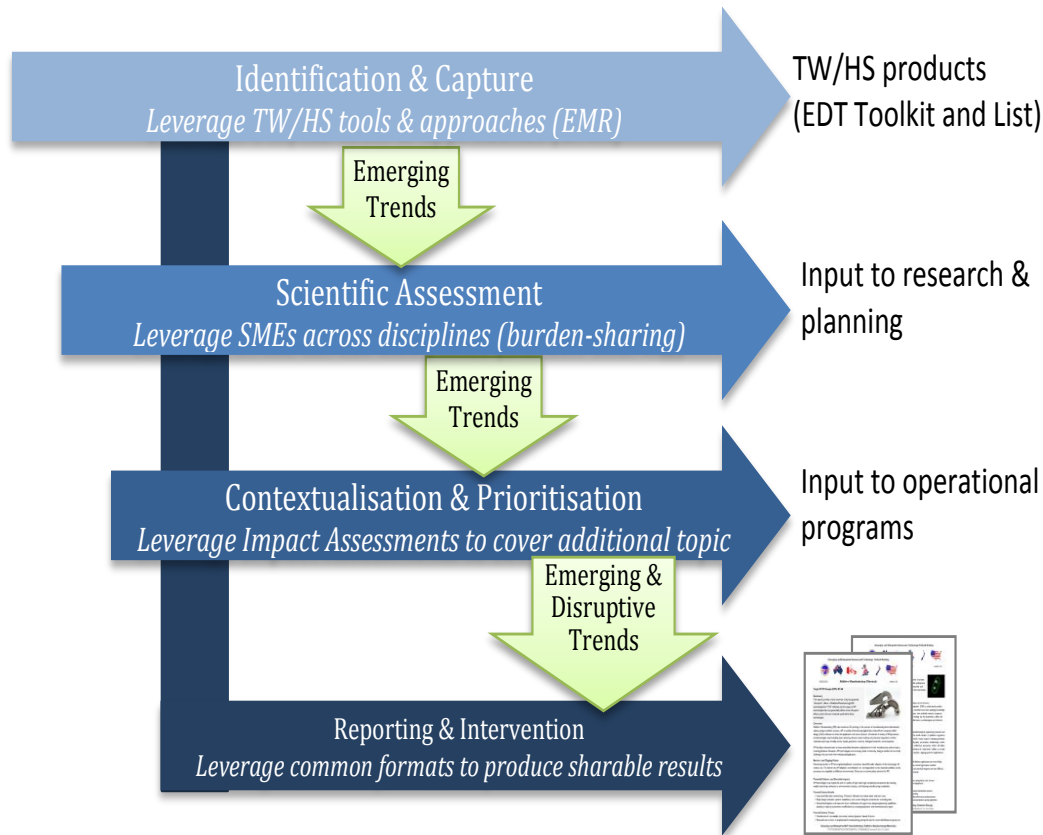


*A systematic process of analysis to describe requirements for emergence of and prospective impact of a technology; to develop insight into possible future technological capabilities and their attributes in relevant scenarios.*



# PARTNERSHIP-CENTRIC FORECASTING AND FUTURES

## PROCESS



General Australian Perspective

Other Countries Defence and Intelligence Perspectives

Academic Literature and patent data

Industry Perspectives and Popular Literature

Global Institutions (UN, OECD, ILO)

## PARTNERSHIPS

- Impact across Defence: DSTO, Strategy group, VCDF, Services.
- External:
  - Universities
    - Emerging and Disruptive Technology Assessment Symposium (EDTAS)
    - Technology Assessments
  - Academy of Science
    - Joint Foresight Assessments
  - National Security
  - CSIRO
    - Mega-trend analysis
  - TTCP JSA TP9
    - International collaborations



# CONTRIBUTING PATHWAYS

## CAPABILITIES

- Depth of knowledge with 'reach-back' into wider DSTO experts
- Ability to leverage from academic partnerships and international communities
- Ability to contextualise technologies in a future environment
- Modelling & simulation test-bed and development environment
- Emerging and Disruptive Technology Assessment Symposium (EDTAS) – Trusted Autonomy
- Red teaming capabilities including workshop and war-gaming support

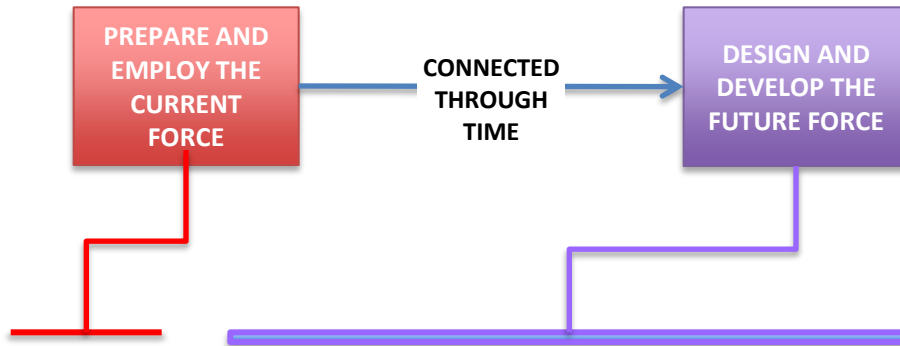
## EXPLOITATION of PRODUCT

- Collaborative 'blue-red' briefs (Joint assessments)
- Emerging technology watch, issues papers and reports
- Capability 'concept' cards
- Biannual Strategic S&T Estimates
- Support to developing future operating concepts and scenarios
- Independent credible assessment of capabilities within defined scenarios
- Input to FSR and Defence Whitepaper
- Contribute to export control considerations

# Strategic Force Design



# Strategic Force Design



## Collaboration opportunities

- capability analysis
- whole-of-force design modelling
- prioritisation and resource allocation
- complex systems evaluation
- cost and benefit-cost investment analysis
- multi-dimensional visualisation

The Force Design	Current	Planned	Future	Conceptual
Force Design Testing	Observation	Assessment	Estimation	Speculation
Force Design Change Actions	Solutions	Adjustments	Initiatives	Hedges
	0yr	10yr	20yr	30yr

Our centre of gravity

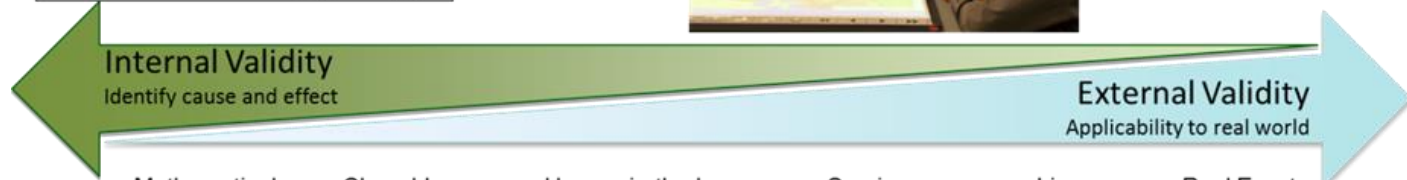
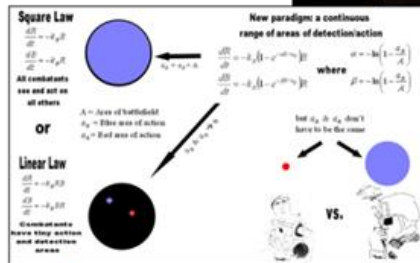


# Acquisition Support



# Simulation-based acquisition

- Capability analysis
- Data representation and visualisation
- Combat simulation
- Cost and capability trade off analysis
- Multi criteria decision analysis



Mathematical Models

Closed-Loop Simulation

Human-in-the-loop Wargaming

Seminar Wargaming

Live Simulation

Real Event Analysis



# Army's Mounted Combat System Transformation

257 x ASLAV



450 x M113AS4



59 x M1A1



**LAND 400**  
**Land Combat Vehicle System**

- \* Reconnaissance, Fire Support & Lift
- \* Enhanced Firepower & Survivability
- \* Enable Future Combined Arms Teams
- \* Acquisition Cost >\$10b

**LAND 907 Tank Upgrade**

- \* Enhanced capability

**Mounted Combat Reconnaissance Capability**

- \* ASLAV Replacement
- \* Request for Tender 2015
- \* ~225 vehicles

**Mounted Close Combat Capability**

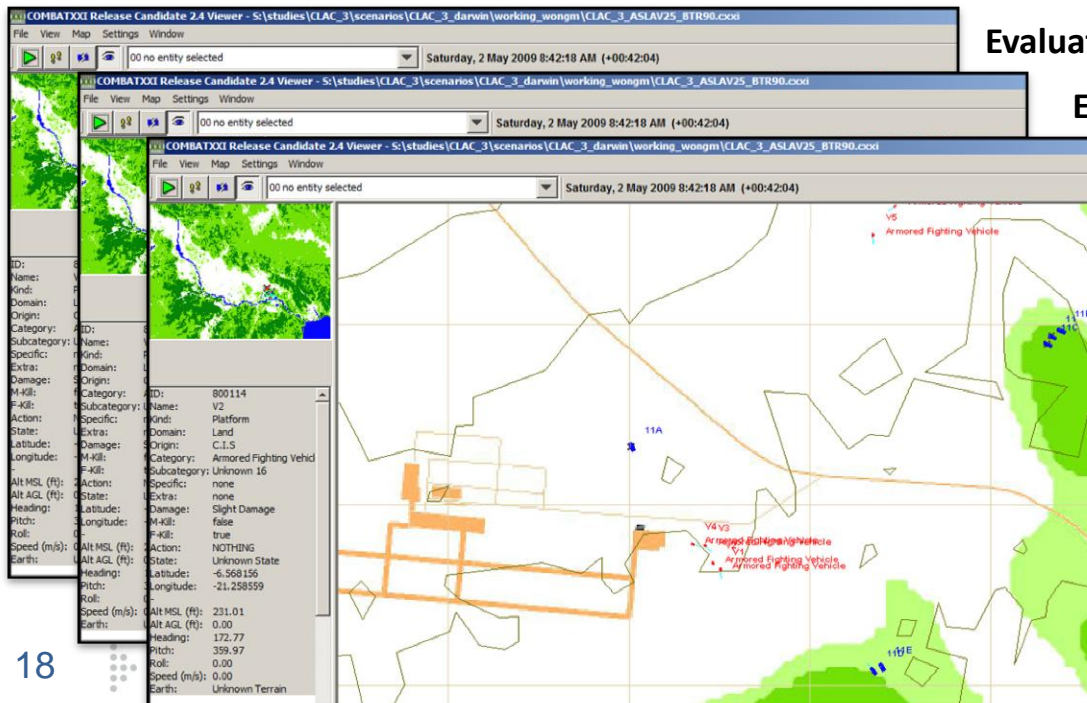
- \* M113 Replacement
- \* Subject to White Paper

**Heavy Assault Capability**

*DSTO explores the operational effectiveness of L400 candidate options*

# Combat Simulation

- **Objective** - Improve combat effectiveness of the combat brigade.
- **Method** - Competing systems are run through a set of battlefield evaluations using a high-resolution simulations of the combat environment to evaluate the trade-offs.
- **Example** - What is the “battlefield impact” of changing the calibre of the cavalry vehicle cannon from 25mm to 40mm?



Evaluation 1

Evaluation 2

Evaluation 3

*Method delivers statistically supported findings ... such as:  
In this test the weapon change made no significant difference.*

**There is an opportunity for industry to partner with DSTO in the delivery of operations research support to Land 400, particularly around combat simulation.**

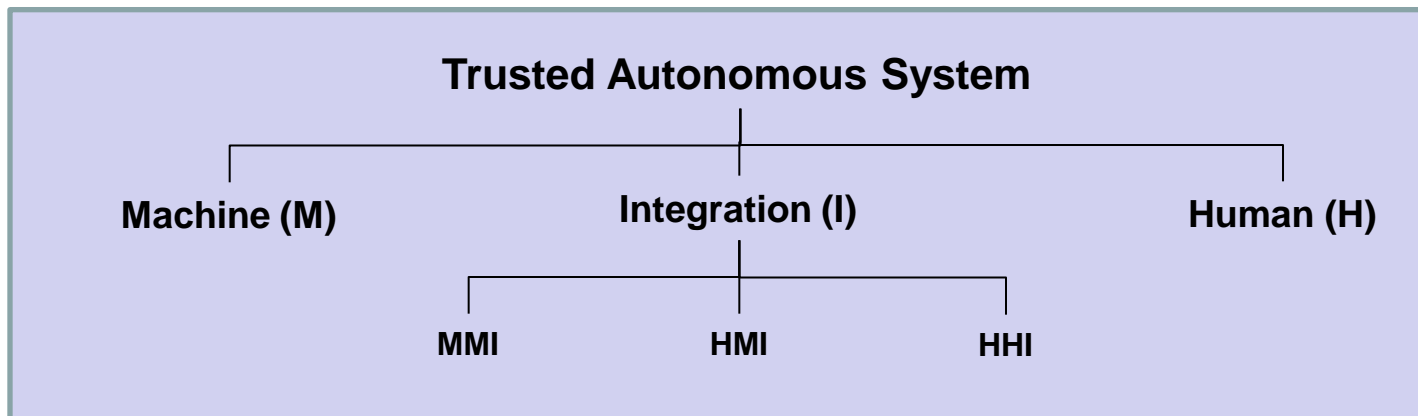
# Trusted Autonomous Systems

## Strategic Research Initiative



## Summary

- Aim for World's Top 5 in *autonomous* systems R&D in 7 yrs
- Coordinated focus on a single unified research question
- Develop new DSTO and academic research capabilities
- Smooth a path for industry and transition to Defence
- Significant outcomes planned in science and technology
- Intention to partner with the best

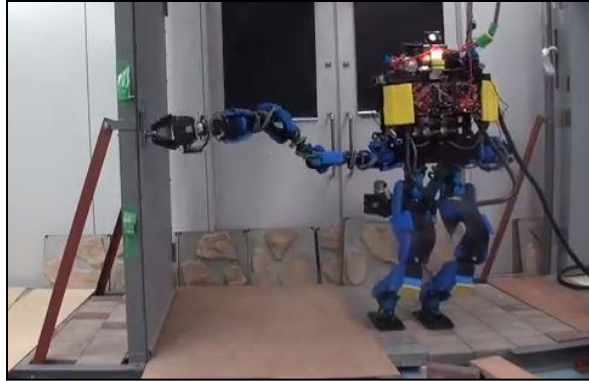


# Automation vs Autonomy

Autonomy has been “*just around the corner*” for 20+ years but ***never*** arrives?



*Hyundai autonomous car competition called off after rain - Oct 2014*



*DARPA Robotic Challenge winner SCHAFT opens a door but gets a surprise - Dec 2014*



*Deutsche Euro Hawk cancelled deemed unverifiable without massive expense - 2013*

- The autonomy we dream about and the automation we currently possess
- “*Four elements make up the climate of war: danger, exertion, uncertainty and chance*” Clausewitz (1834/1984)
- The research question centres on **systems that deal with uncertainty /** unpredicted events.

# Research Themes

## Foundations of Autonomy

Philosophical and mathematical bases for dealing with uncertainty;  
Significantly reduce exposure to harmful consequences;  
Guaranteed to not exceed boundary conditions; new means to certify for ADF use.

## Cognitive Machines

Fast reactive and simultaneous slow logical “thinking”;  
Machine high-level fusion, planning and intent subject to uncertainty;  
Large scale control of machines; Machine-machine interaction and tasking.

## Trustworthy Partners

Interacting hybrid teams more effective than human-only teams;  
Understand organisation changes required to acquire and operate;  
Trust of machines; Mission Command of machines.

## Platforms, Sensors & Effectors

Exploit existing and develop new: sensors, platforms, materials & propulsion;  
Sound validation and test with increasing accuracy of uncertainty (simulation to field);  
Innovations with high technical risk, but low strategic program risk.



## Academic Impact

### New mathematical foundations

- Viability of actions subject to hard constraints
- Resource allocation under uncertainty
- Online verification

### New machine cognition

- Extreme event cognition
- Integrating fast and slow “thinking”
- Metacognitive strategies
- Context-based fusion
- Planning under uncertainty
- Intent creation & policy management
- Information processing role of glial cells

### New machine interaction

- Human trust and acceptance
- Social agreement protocols & teaming
- Mixed initiative decisions
- Organisational plasticity

### Novel autonomous systems

- Legal and ethical decision support
- New forms of OA based on uncertainty

## Defence-Industry Impact

### Autonomous Ops in Urban Environments

- New smart algorithms retrofit OTS platforms
- Situation awareness *inside* cities
- Communicate awareness to C2 centres and traversing forces

### 5<sup>th</sup> Generation Command & Intelligence Systems

- Autonomous agent partners that recognise context, role, intentions, respond to dialogue and generate narratives
- Integrate sensors with dynamic context information
- Identify emerging conflict hot spots, objects and relations of interest

### Autonomous Distribution: warehouse to foxhole

- Reduce signature with smaller payloads, diversify lines of communication.
- Autonomous transport, material handling, drop-and-swap, ordering, routing.

### Anti-Submarine Warfare

- UUV's for persistent surveillance at greater depth
- Long range and endurance, complement future submarine fleet



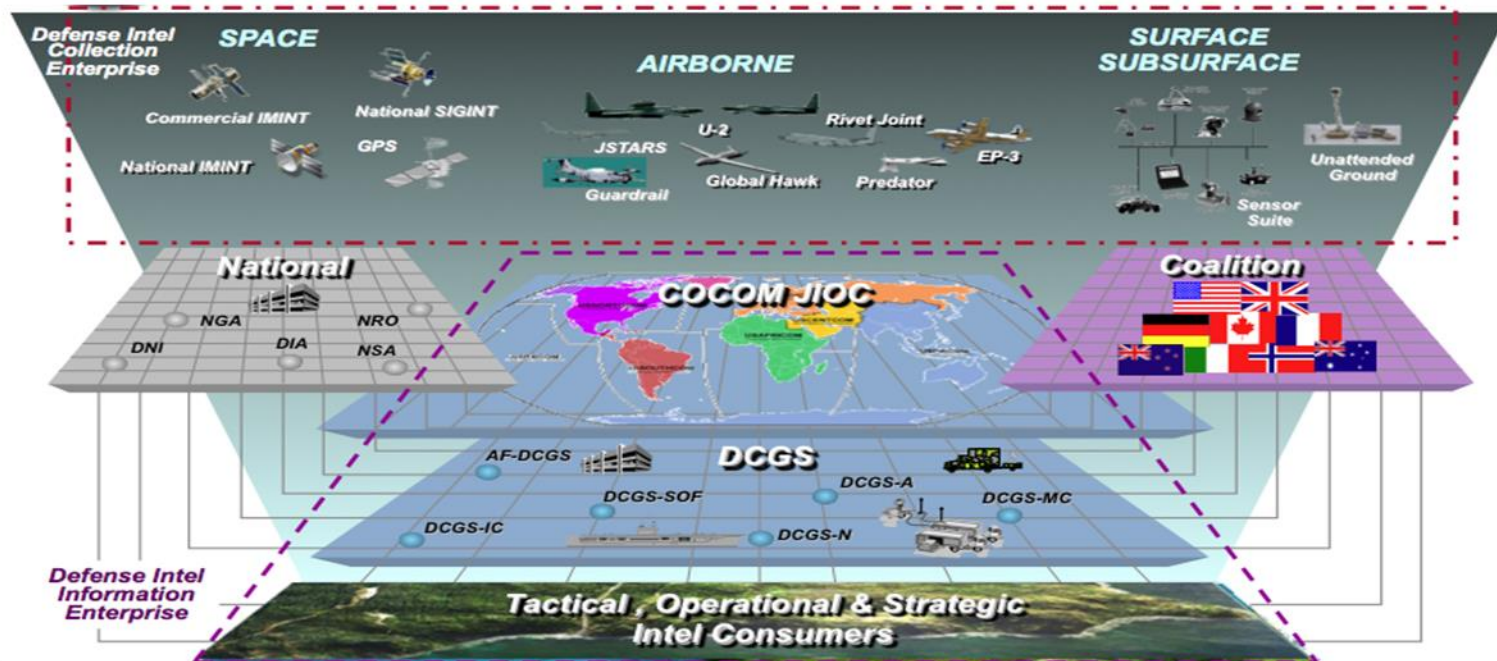


# Summary

- This autonomy R&D program may be a game changer for warfare
- Autonomy for uncertainty is the main research focus, but does allow for automation research in niches
  - Sometime efficiency has effectiveness alone!
- A “Defence CRC in Trusted Autonomous Systems” likely
- Potential for significant value for allies due to focus & scale
- Comprehensive new program starts 1 July 2015
  - Provisional & changing program as new knowledge is uncovered & shared
- Opportunity to get involved from the beginning

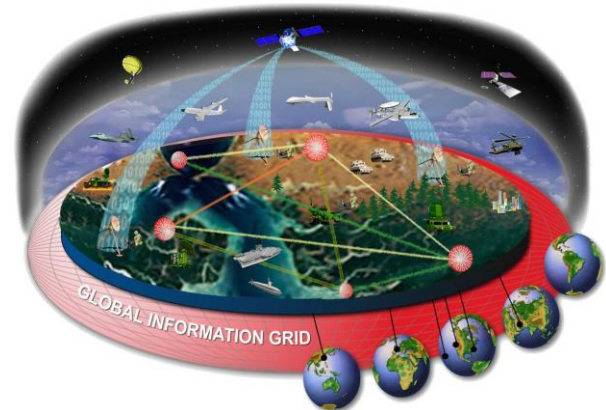


# Enhanced Situational Awareness



# Telling The Story Behind The Data...

- Information fusion technologies automatically identify the nature of an evolving situation (the scenario) from 'the data'
- Automated systems convey this to an audience as tailored multimedia narrative:
  - Intelligent Virtual Agents engage the audience's attention and convey non-verbal cues.
  - Coordinated multimedia content provides aural and visual aids to storytelling.
- Challenges include:
  - Factors affecting audience engagement
  - Modelling audience requirements
  - Dialog and other feedback
  - Content selection
  - Automated narrative generation
  - Media assignment and orchestration
  - Automatic behaviour generation for intelligent virtual agents.



# Questions



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