Discriminatory Autonomy: Operating Faster, Smarter and With Purpose

- **Author: James Garth, BAE SYSTEMS Australia**
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- **Location:** ICAS 2026 Congress, Sydney, Australia September 13 to 18, 2026.
- **Abstract**: In the past few years of global conflict, resilient, connected and trusted autonomous capabilities are proving to be the difference between victory and defeat. This paper will explore what truly discriminatory autonomy means for multi-domain uncrewed systems operating in the battlespace of the future. It is proposed that what constitutes genuinely discriminatory capability depends to a significant extent on the level of autonomy provided, and the tailoring of these levels to the relevant size, performance, affordability and attritibility characteristics of the platforms and systems being deployed. Various levels of taxonomy will be critically explored regarding definitions of the Levels of Autonomy, with their strengths and weaknesses assessed in the light of emerging understandings of how autonomous systems can operate most effectively within a joint force. The technological underpinnings of BAE SYSTEMS' multiple decades of experience in developing high-integrity, goal-based, discriminatory autonomous systems will be used as a backdrop to this analysis.

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2. Autonomy History and Portfolio
3. Autonomy Taxonomies
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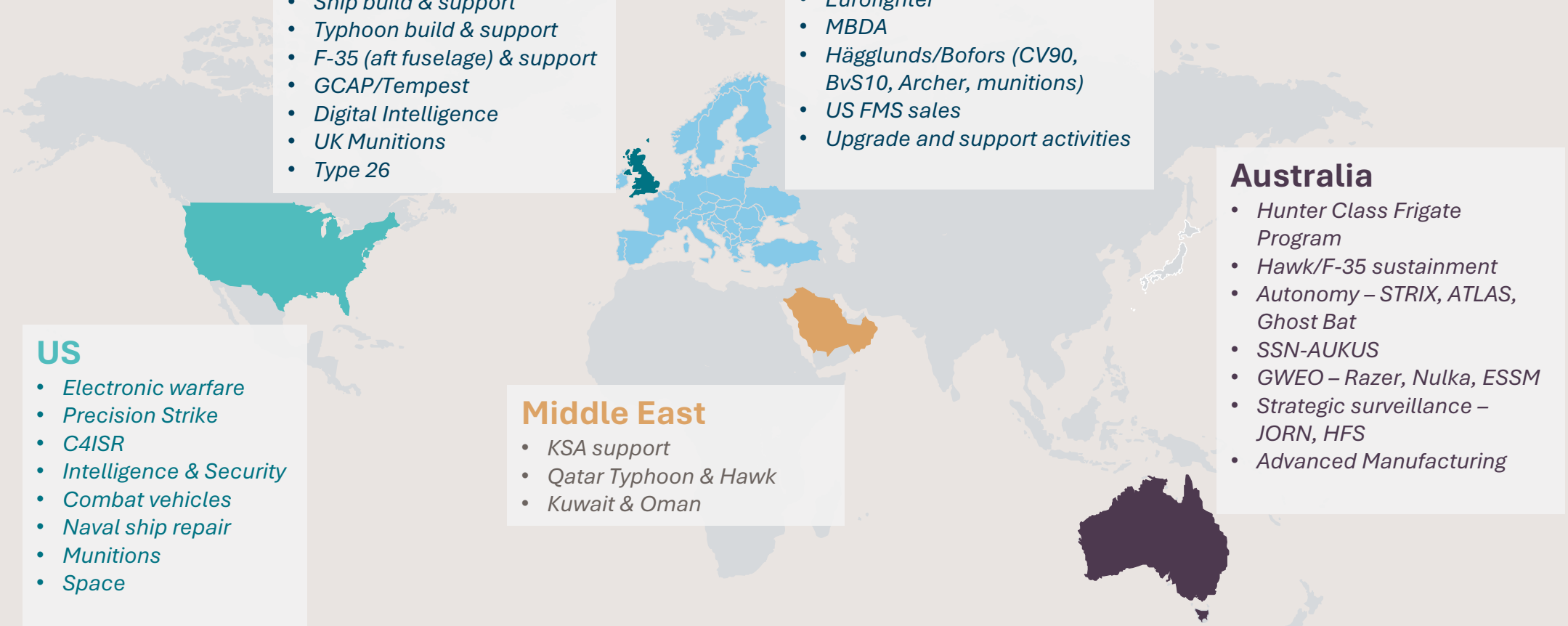


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BAE Systems - A global portfolio aligned to meet current and future threats

UK
- *Submarine build*
- *Ship build & support*
- *Typhoon build & support*
- *F-35 (aft fuselage) & support*
- *GCAP/Tempest*
- *Digital Intelligence*
- *UK Munitions*
- *Type 26*

Europe and RoW
- *Eurofighter*
- *MBDA*
- *Hägglunds/Bofors (CV90, BvS10, Archer, munitions)*
- *US FMS sales*
- *Upgrade and support activities*



US
- *Electronic warfare*
- *Precision Strike*
- *C4ISR*
- *Intelligence & Security*
- *Combat vehicles*
- *Naval ship repair*
- *Munitions*
- *Space*

Middle East
- *KSA support*
- *Qatar Typhoon & Hawk*
- *Kuwait & Oman*

Australia
- *Hunter Class Frigate Program*
- *Hawk/F-35 sustainment*
- *Autonomy – STRIX, ATLAS, Ghost Bat*
- *SSN-AUKUS*
- *GWEO – Razer, Nulka, ESSM*
- *Strategic surveillance – JORN, HFS*
- *Advanced Manufacturing*

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BAE SYSTEMS Australia - A nation-wide endeavour

OUR PEOPLE

7,000 skilled employees

3,000+ new employees over the last three years

10,000+ Australian jobs sustained through our supply chain

OUR BUSINESS

$2.2bn Revenue (2025)

$1.6bn Australian industry content (2025)

LOCATIONS

46 operational sites across Australia

JORN

LAVERTON WA, ALICE SPRINGS NT, LONGREACH QLD

ANZAC CLASS FRIGATE

HUNTER CLASS FRIGATE

CAPABILITY HUB

HENDERSON SHIPYARD, WA

HAWK LEAD-IN FIGHTER TRAINING SYSTEM

RAAF BASE PEARCE, WA

HUNTER CLASS FRIGATE

HOBART CLASS DESTROYER

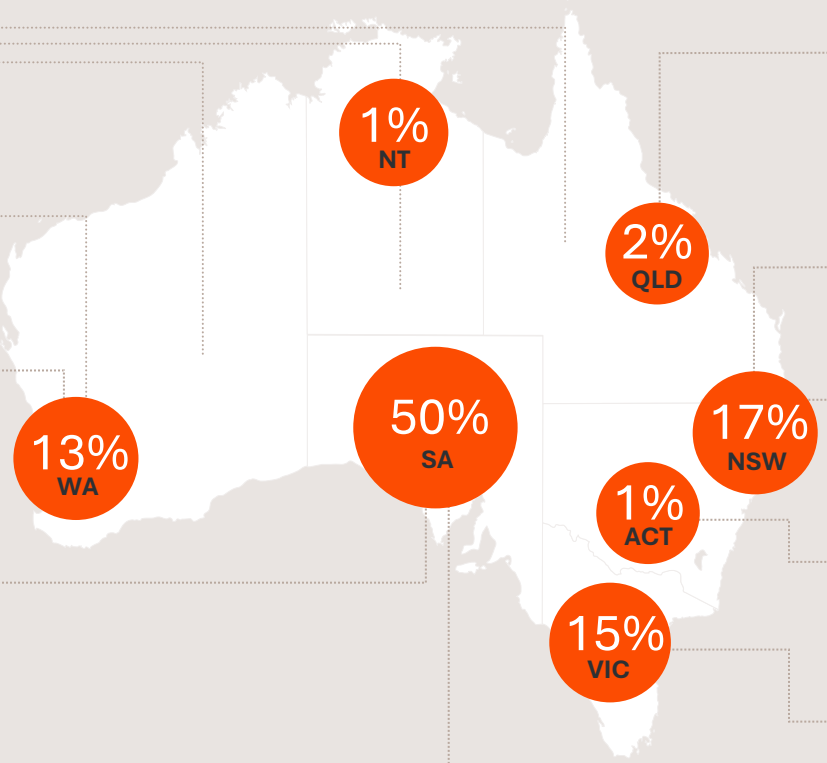
SSN-AUKUS SUBMARINE

OSBORNE NAVAL SHIPYARD, SA

JORN STRATEGIC SURVEILLANCE CENTRE

ADVANCED MANUFACTURING

EDINBURGH PARKS, SA



Employees by location*

CAPABILITY HUB

CAIRNS, QLD

F-35 SUSTAINMENT & MRO FACILITIES

HAWK LEAD-IN FIGHTER TRAINING SYSTEM

WILLIAMTOWN, NSW

HOBART CLASS DESTROYER

GARDEN ISLAND, NSW

CYBER AND DIGITAL INTELLIGENCE

CANBERRA, ACT

NULKA MISILE DECOY

AUTONOMY

MELBOURNE ENGINEERING HUB, NAGAMBIE TEST FACILITIES, VIC

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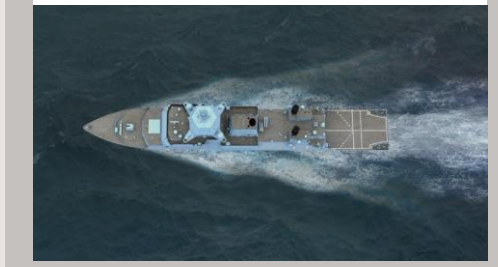
This is the subject of this paper!

Strategic pillars

MULTI-DOMAIN EXPERTISE ACROSS ACQUISITION, SUSTAINMENT, AND RESEARCH AND DEVELOPMENT PROGRAMS

Naval Surface Combatants

- Hunter Class Frigate Program
- Destroyer Capability Enhancement program
- Anzac class sustainment



Underwater Battlespace

- SSN-AUKUS nuclear-powered submarines
- Undersea surveillance



Aerospace

- F-35 sustainment
- Hawk Lead-In Fighter
- Aviation Technical Training



Strategic Surveillance

- Jindalee Operational Radar Network (JORN)
- High frequency surveillance exports
- Ship Air Defence Model
- Electronic warfare



Integrated Defence & Autonomy Systems

- ATLAS
- CCA VMS
- M113 OCCV
- Nulka
- Evolved SeaSparrow Missile

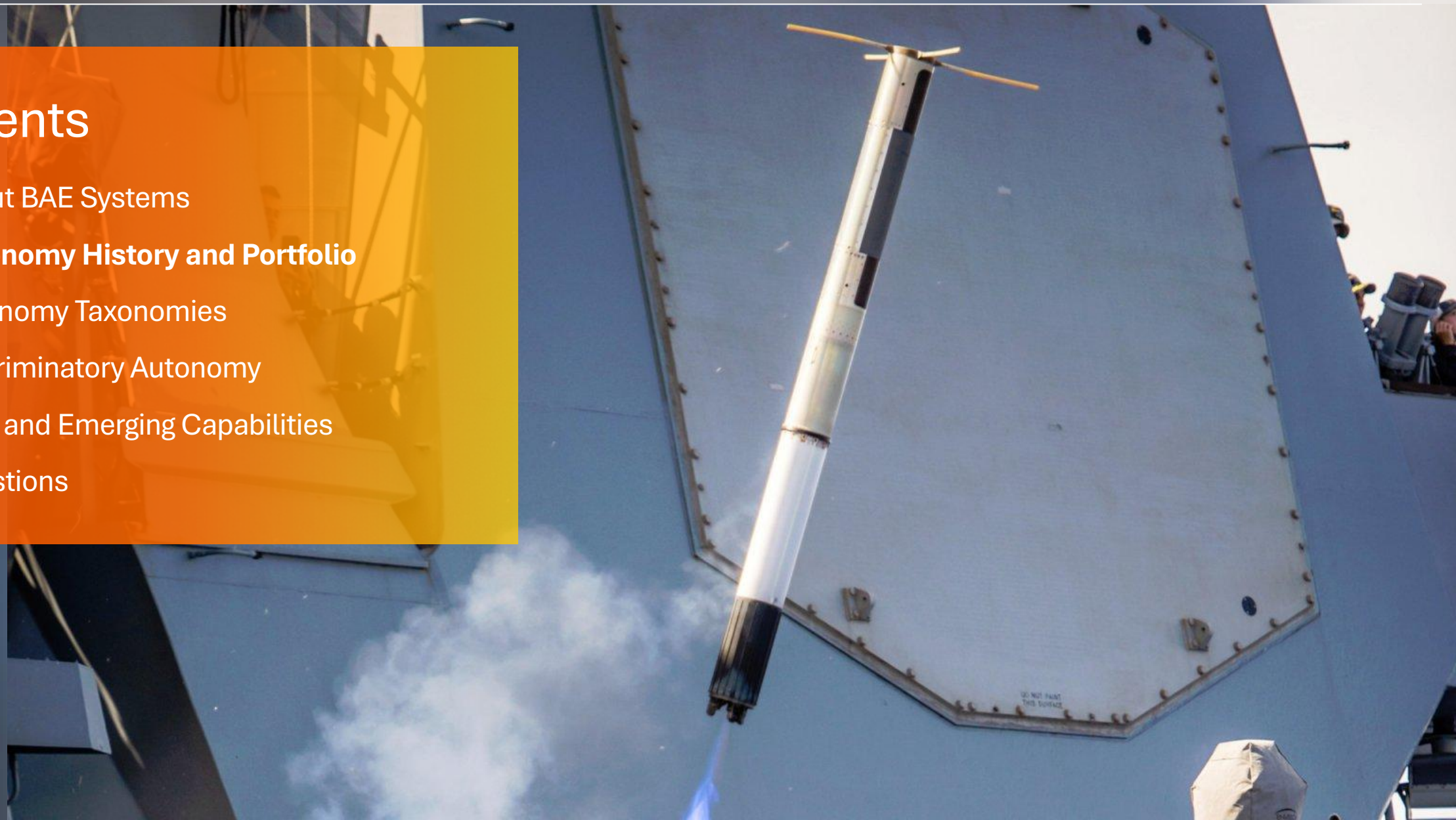


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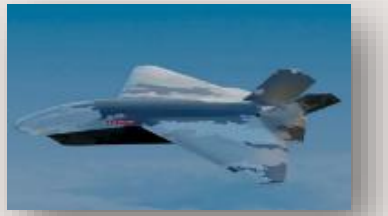
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Autonomy: The BAE SYSTEMS Portfolio

Australia

International


















Acquisitions & Joint Ventures

Partnerships

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Standing on the Shoulders of Giants



ESSM Team 1995





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Standing on the Shoulders of Giants

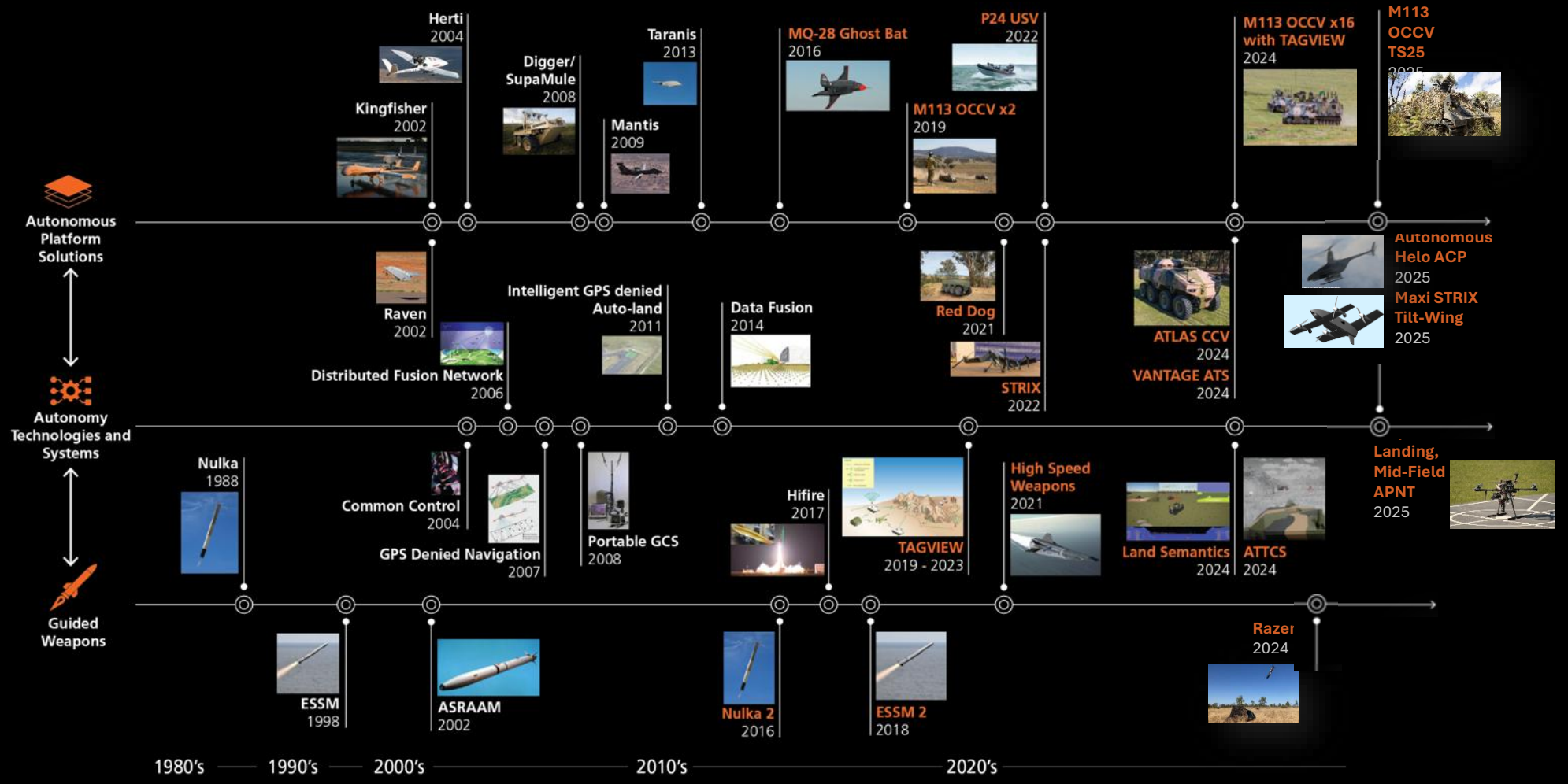


Kingfisher Team, Puckapunyal, 2006

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BAE SYSTEMS Australia - Autonomy Technology



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Deep capability in Discriminatory Autonomy doesn’t just appear overnight

It is nurtured over decades of sustained investment in people, programs and facilities

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Where does this autonomy capability end up?

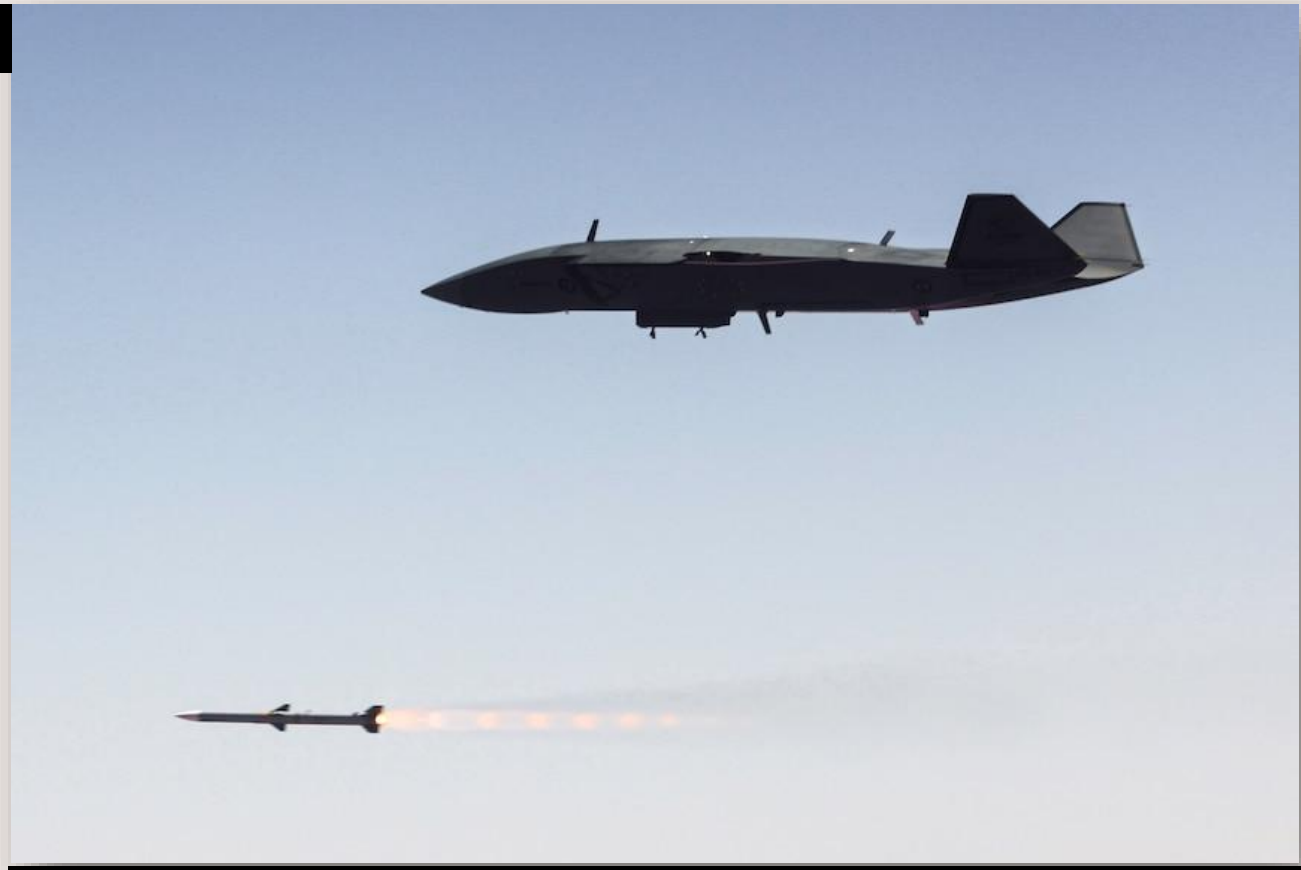
Export interest from USA, Japan, Germany





The world's most advanced CCA autonomy technology is in ***Ghost Bat***

Flight testing in USN base, Point Mugu, California



Weapons Firing and HUM-T

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MQ-28A Ghost Bat Missile Test

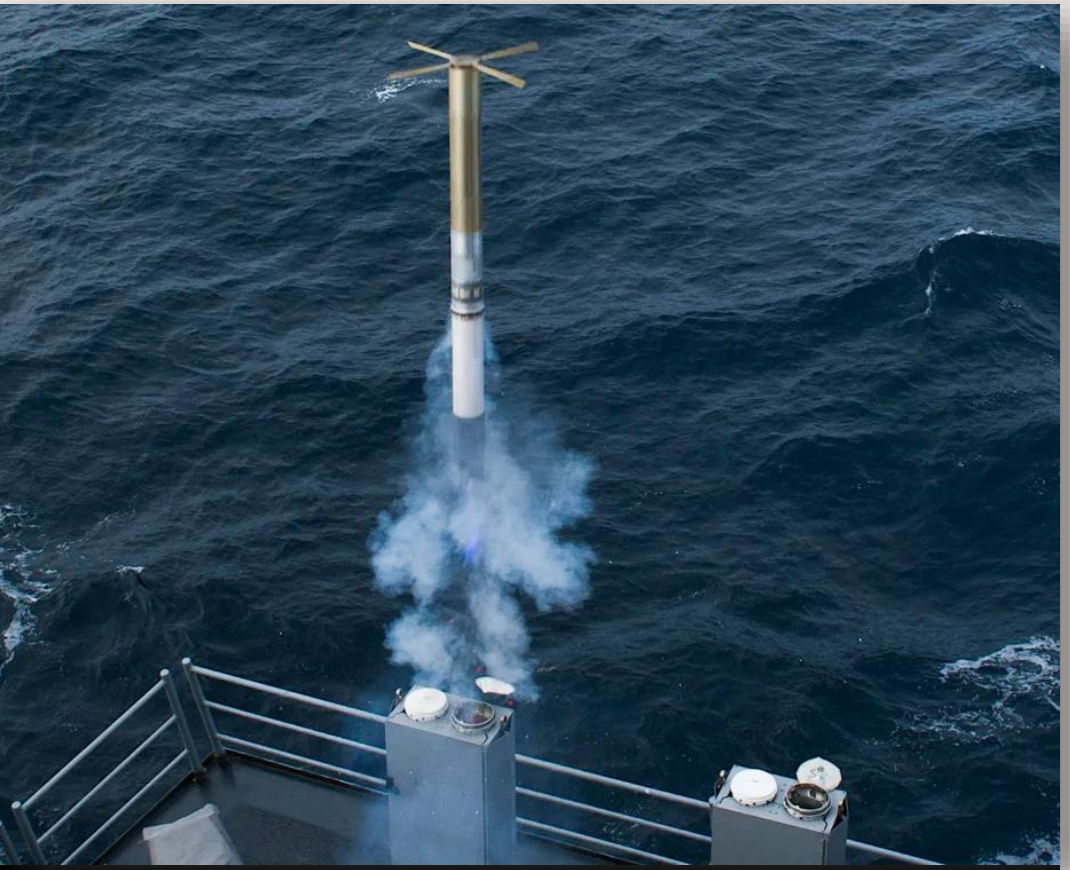


James Garth

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Where does this autonomy capability end up?



> 1000 sold, integrated on > 150 ships

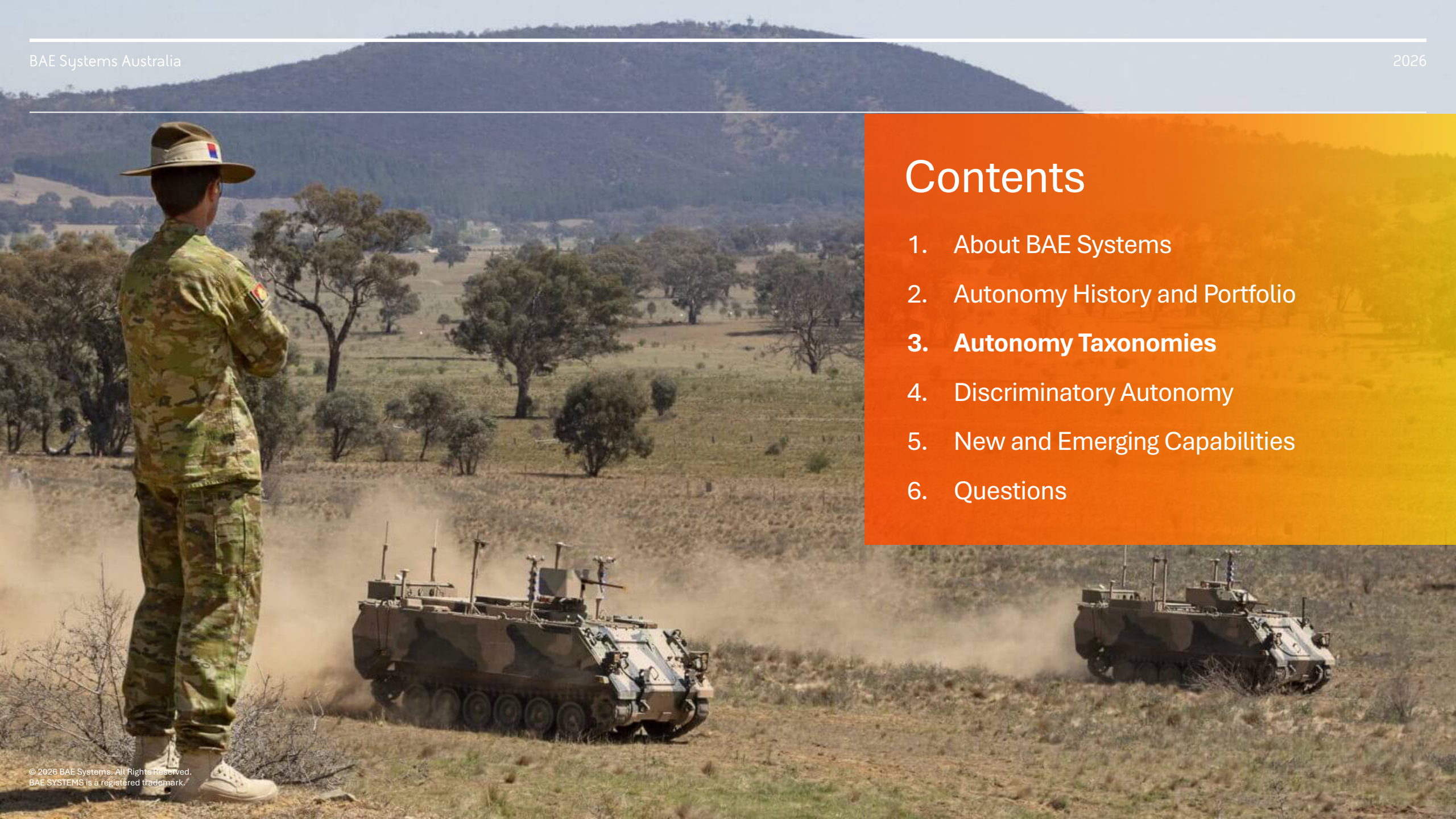
Advanced autonomy has underpinned the > ***1 billion dollars*** *in Nulka exports from Australia*



Battle-proven against Red Sea attacks

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But what sort of Autonomy is required? And how much?

- It depends what you're trying to achieve!
- Which in turn is influenced by…
- …the desired levels of **size**, **performance**, **price point,** and **survivability**

Exquisite **Attritable** **Consumable**

- ..and the applicable **domain** (Air / Land / Surface / Sub-Surface / Multi)
- ..and the **number of assets** you are commanding / controlling

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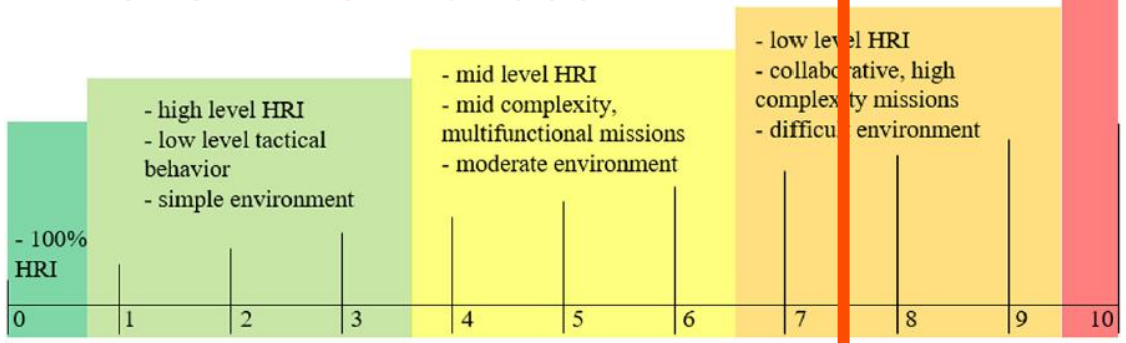
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Autonomy Taxonomies and Models – where BAE SYSTEMS focuses

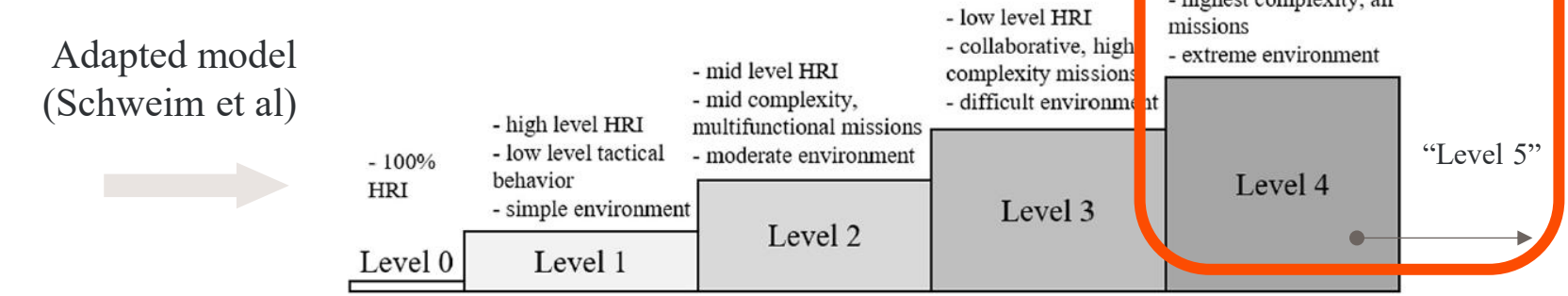
The ALFUS Levels

- Developed by NIST to provide a common reference for evaluating autonomy capabilities of uncrewed systems
- Aims to **standardize definitions, metrics and processes** related to autonomy

ALFUS Summary Model Overall Concept



Adapted model (Schweim et al)



Map to ALFUS	No Autonomy	Assistance	Partial Automation	Conditional Automation	High Automation	Full Automation
BAE Sysetms / DSTL "Staircase" definitions	No Automation	Human Controlled – Remote Control / Teleoperation Operator Assistance	Task Automation	Conditional Autonomy	Highly Autonomous	Fully Autonomous

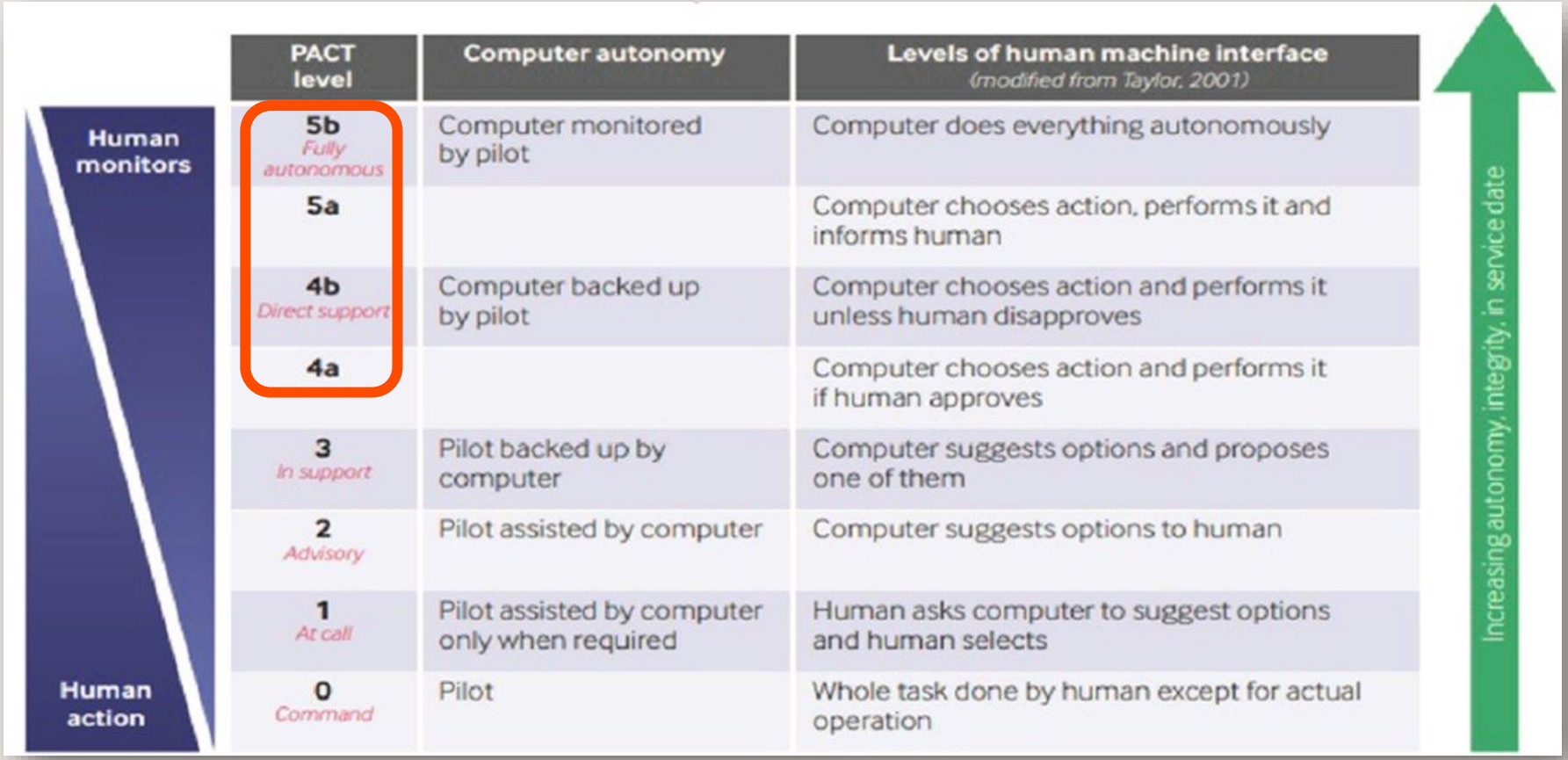
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Autonomy Taxonomies and Models – where BAE SYSTEMS focuses

The PACT Levels

- Published scale to reflect **pilot and machine interaction** levels
- Referenced by UK MOD
- Externally produced scale (Taylor 2001)
- Not as widely known or used as STANAGs
- Less industrial or military buy-in



PACT level	Computer autonomy	Levels of human machine interface (modified from Taylor, 2001)
5b *Fully autonomous*	Computer monitored by pilot	Computer does everything autonomously
5a		Computer chooses action, performs it and informs human
4b *Direct support*	Computer backed up by pilot	Computer chooses action and performs it unless human disapproves
4a		Computer chooses action and performs it if human approves
3 *In support*	Pilot backed up by computer	Computer suggests options and proposes one of them
2 *Advisory*	Pilot assisted by computer	Computer suggests options to human
1 *At call*	Pilot assisted by computer only when required	Human asks computer to suggest options and human selects
0 *Command*	Pilot	Whole task done by human except for actual operation

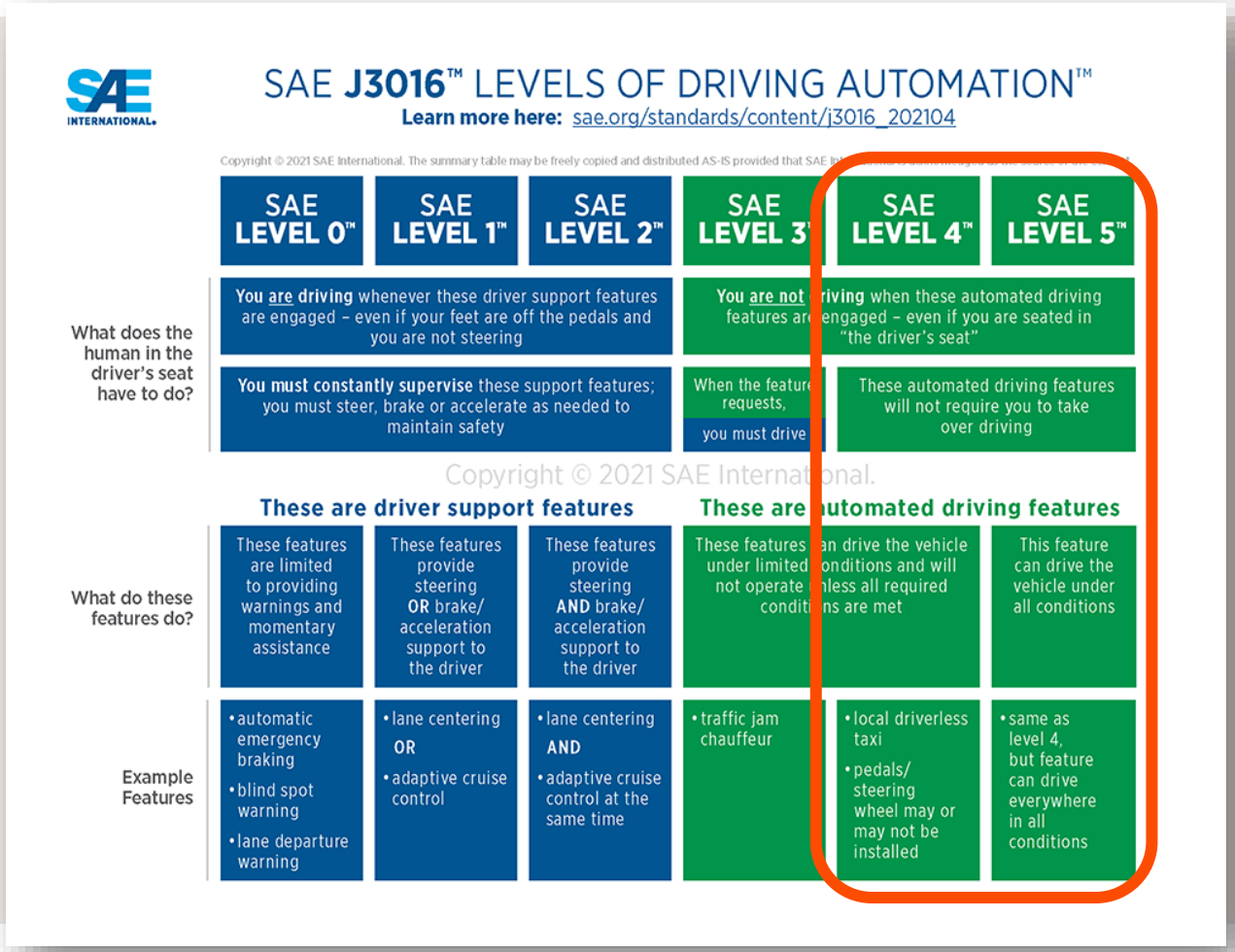
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Autonomy Taxonomies and Models – where BAE SYSTEMS focuses

The SAE Definitions

- Area of focus: Operator input
- The SAE J3016 levels of autonomation are primarily **driving focussed** and are driven by the automotive industry.
- They have widespread general usage, but care must be taken when applying their levels to piloting as opposed to driving.
  - e.g. nuances with ‘remotely piloted’, ‘tele-operation’ or ‘follow-the-leader’



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Autonomy Taxonomies and Models – where BAE SYSTEMS focuses

The LOI Definitions

- Area of focus: Levels of interoperability
- The LOI levels are defined by NATO STANAG 4586 and reflect increasing levels of interoperability between a crewed asset and a UAV.
- These are widely used within Human-Machine-Teaming (HUM-T) discussions, e.g. Apache crewed asset controlling uncrewed assets.

2.1 Level of Interoperability

This standard also identifies five levels of interoperability (LOI) to accommodate operational requirements [4]. The respective operational requirements and CONOPS will determine or drive the required LOI that the specific UAV System will achieve.

- Level 1: **Indirect receipt and/or transmission of sensor** product and associated metadata, for example Key Length Value Metadata Elements from the UAV.
- Level 2: Direct **receipt of sensor product data** and associated metadata from the UAV.
- Level 3: **Control and monitoring of the UAV payload** unless specified as monitor only.
- Level 4: **Control and monitoring of the UAV**, unless specified as monitor only, less launch and recovery
- Level 5: **Control and monitoring of UAV launch and recovery** unless specified as monitor only.

LOI 2 monitor is conditional on the type of payload (station) and the number of payloads (stations) implemented onboard the UAV. It is also conditional on the type of payload data format used by the UAV [4].

LOI 3 monitor only or control and monitor is conditional on the type of payload (station) and the number of payloads (stations) and the payload data format used by the UAV [4].

LOI 4 monitor only or control and monitor is not affected by the payloads onboard the UAV [4].

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Conclusion - How BAE SYSTEMS provides Capability at Multiple Levels of Autonomy

Software

- **Command Layer -** Human intent and natural-language tasking for autonomous operations.
- **Multi-System -** Multi-asset autonomy management & coordination
- **Mission Layer -** Edge-based mission execution & local adaptation
- **Platform Layer -** Robust vehicle control and mobility autonomy LOI Definitions







Services

- Strategy and Mission Design
- Digital Engineering and MBSE
- Synthetic Environments and Simulation
- LVC Test and Mission Rehearsal
- Verification, Validation and Assurance

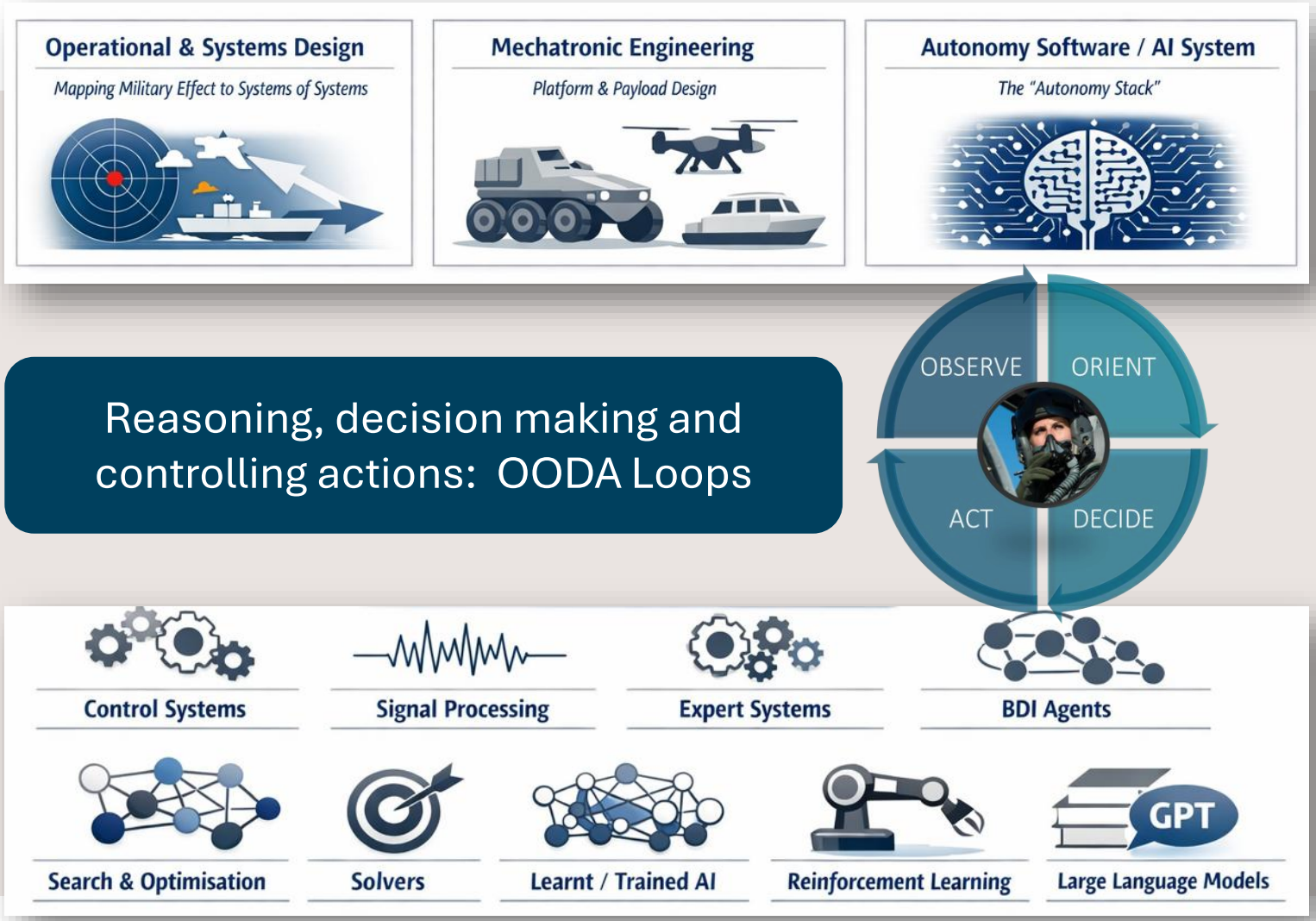
- Trials, Test ranges and Operational Evaluation
- Data, AI, and Autonomy Governance
- Product Security and Resilience
- Training, Adoption and human integration
- Deployment, Operations and Sustainment

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Building an Autonomy Solution

- Autonomy is a **systems integration engineering** challenge that is a mixture of:
- The **Autonomy Stack,** which responsible for reasoning, decision making & controlling actions, often **through nested OODA loops**
- **AI technologies** for autonomy cover multiple fields
  - Often the last few are now referred to as just "AI"



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Discriminatory Autonomy – Core Themes

Discriminatory Autonomy is capability which is “set apart” from others in the wider landscape.

- The right autonomy is not always the **most autonomy**; it is the **most useful autonomy** the platform can responsibly carry.

Discriminatory Autonomy:

- Understands the mission
- Respects the limits of the platform
- Collaborates with humans and other machines
- Survives contested environments
- Dynamically replans and updates
- Remains **trusted enough** to be used when the stakes are real

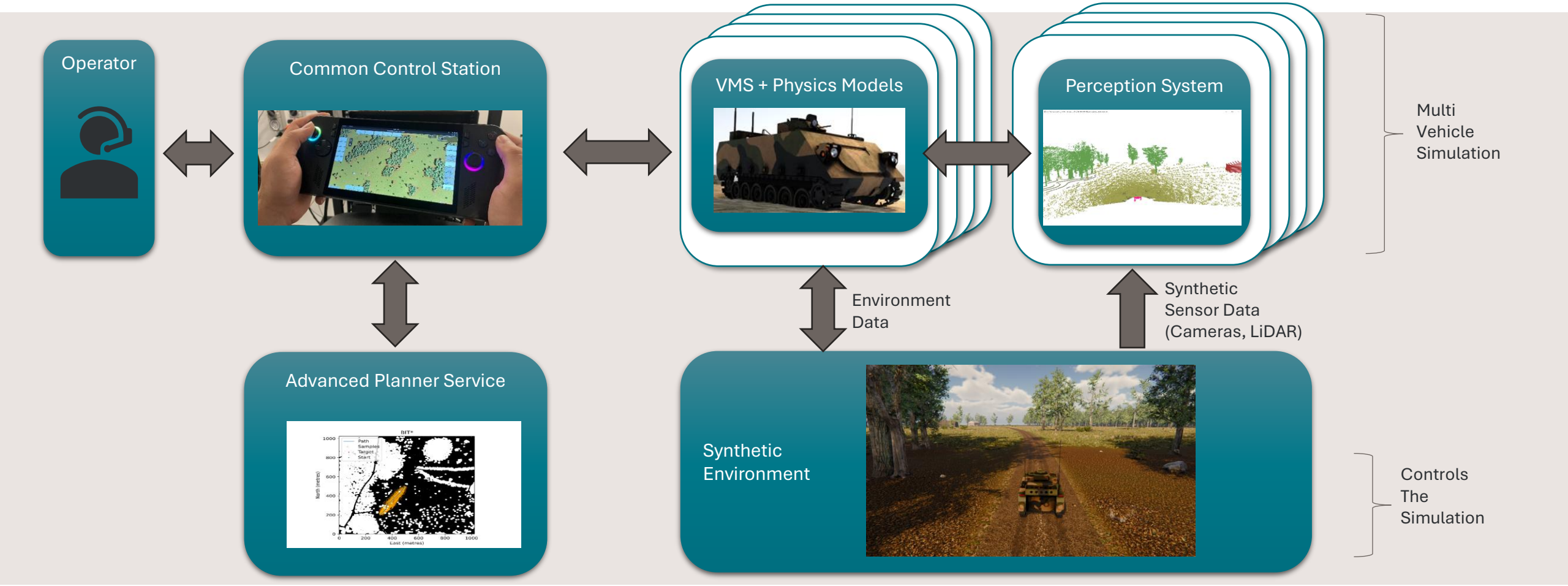




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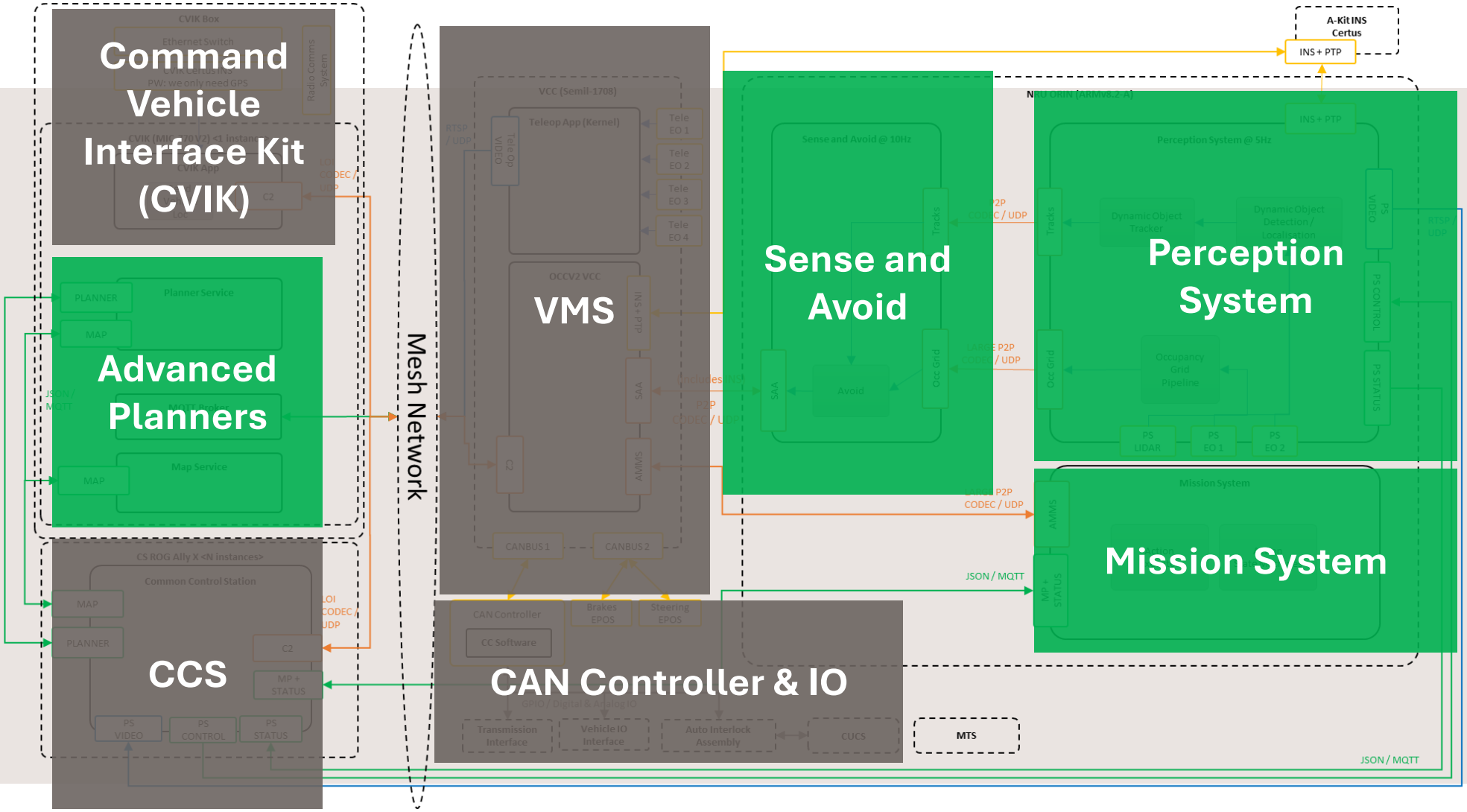
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Example: Land Autonomy



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Land Autonomy – Technology Building Blocks



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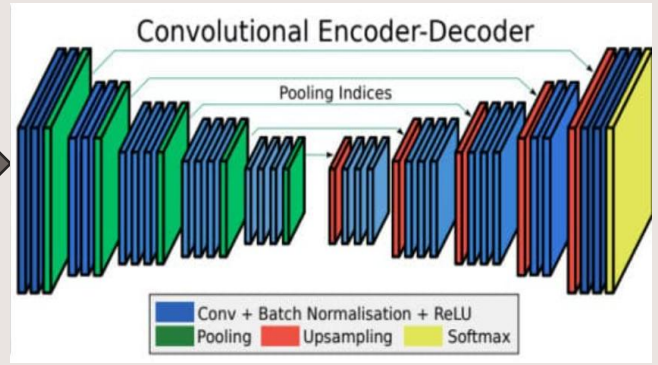
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Perception System - Motivation

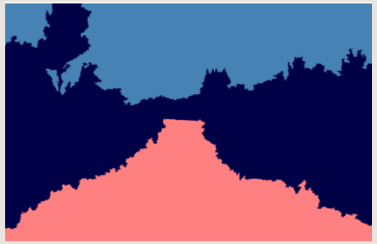
PROCESSED DATA



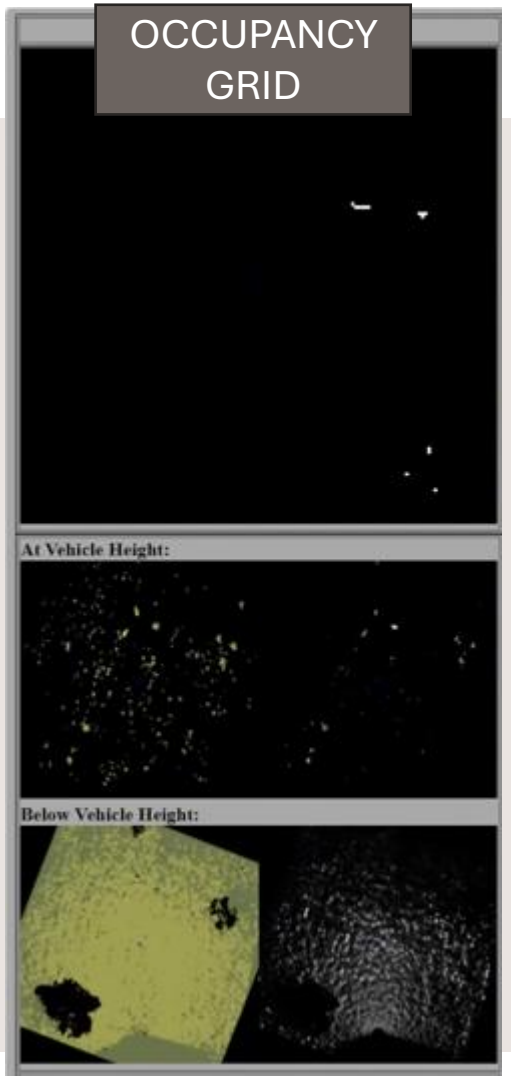
TRAINED AI MODEL



SEMANTIC INFORMATION



OCCUPANCY GRID



Why do we need perception?

- The perception system is the “eyes and ears” of the autonomous system
- Allows the system to interpret and adapt to the changing environment in real time.
- Fuses sensor observations into useful information to ensure the mission outcome

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Common Control Station - HMI ID: 0x8002
Mission System
CONTROL GRANTED VEHICLE:
OCCV2-2
OCCV2-1
OCCV2-2
271.2
Relative Track Path received successfully,
Plan ID: 50
Scale: 11 m
OCCV2-1
OCCV2-2
State
Relative Tracking - Running
CUCS
UNCREWED
MTS
INACTIVE-ARMED
Take Control
Follow Route
Stop
Pause
Resume
Follow
Leader
ID: OC
Platform Control
Startup & Shutdown
Route Control
Teleoperate
Routes
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Test success: ATLAS Uncrewed Ground Vehicle put through its paces

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Optionally Crewed M113 Australian Army

Think Defence

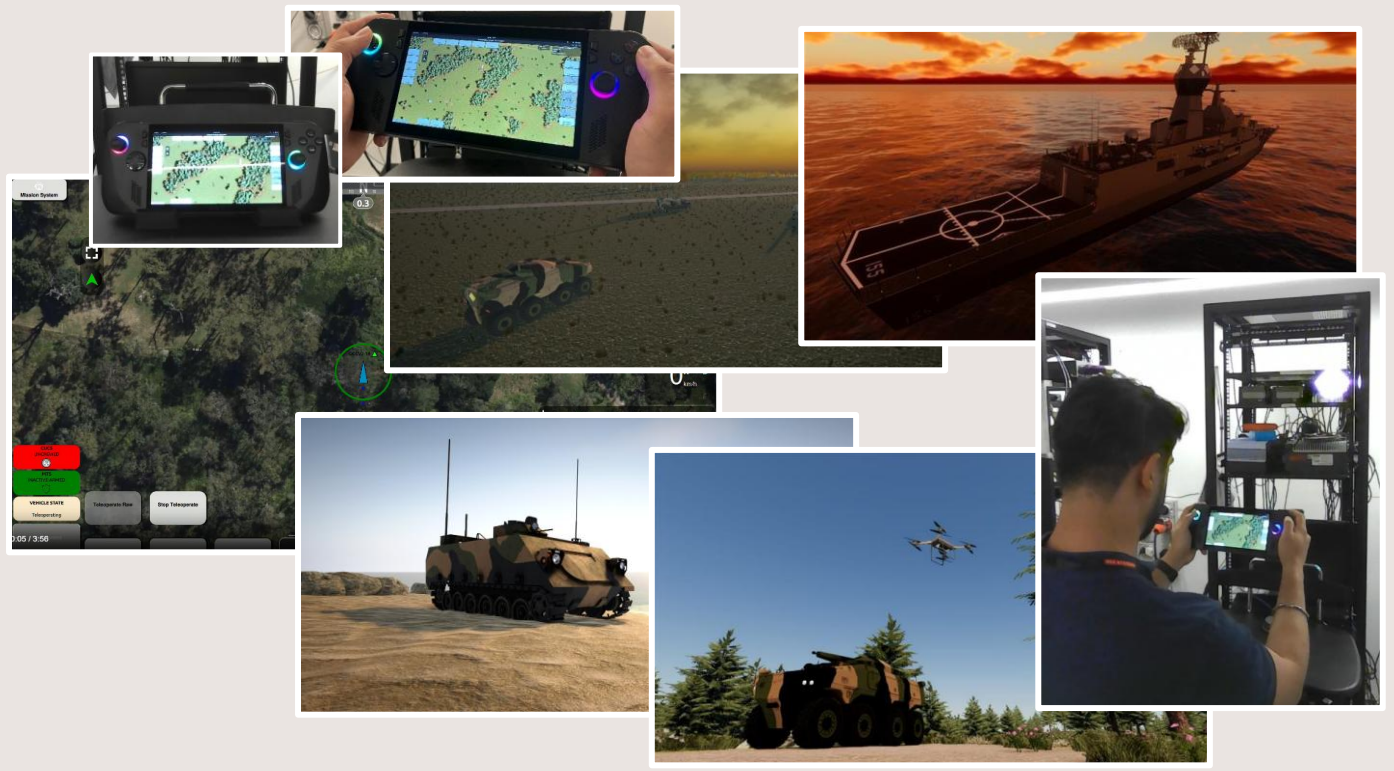
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Interlude: The Importance of the Synthetic Environment

Rapid iteration **requires** Synthetic for integration & testing, not just data generation

1. De-risks everything from AI datasets to complete autonomous systems software, fast and at low-cost
2. Fast implementation, early testing and demonstration of meaningful capability
3. Build trust with autonomy gyms, image classifier gyms, etc. – from sensor level to teaming level



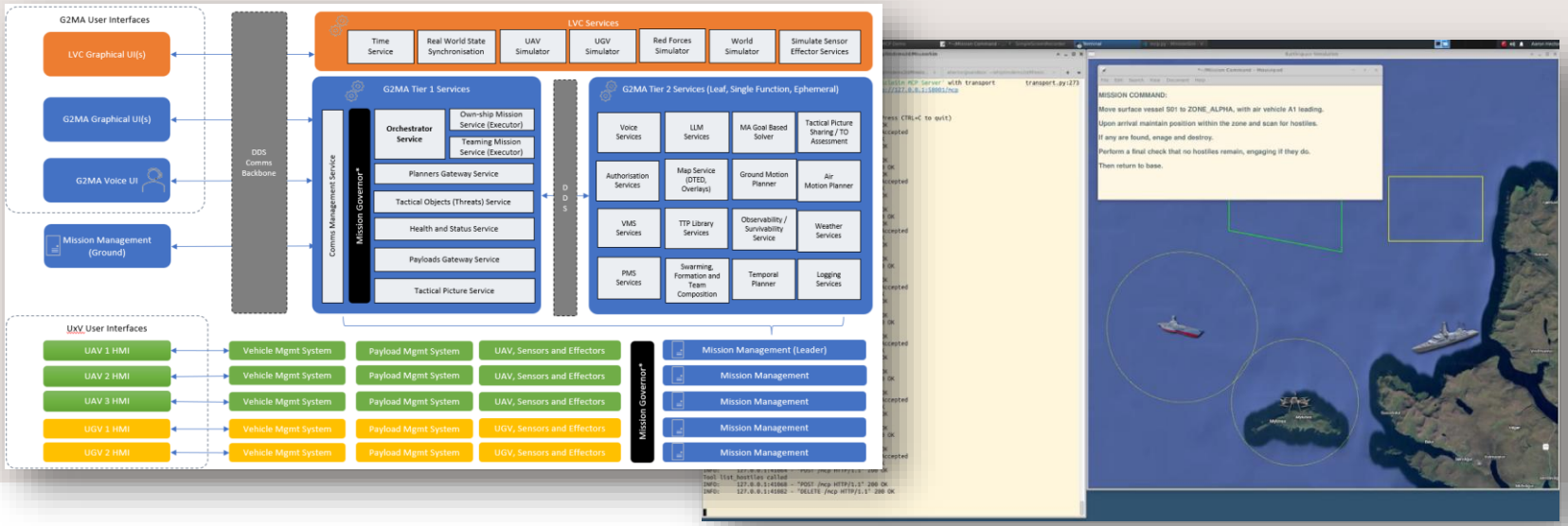
BAE SYSTEMS Australia's **Land Autonomy System (LAS)**

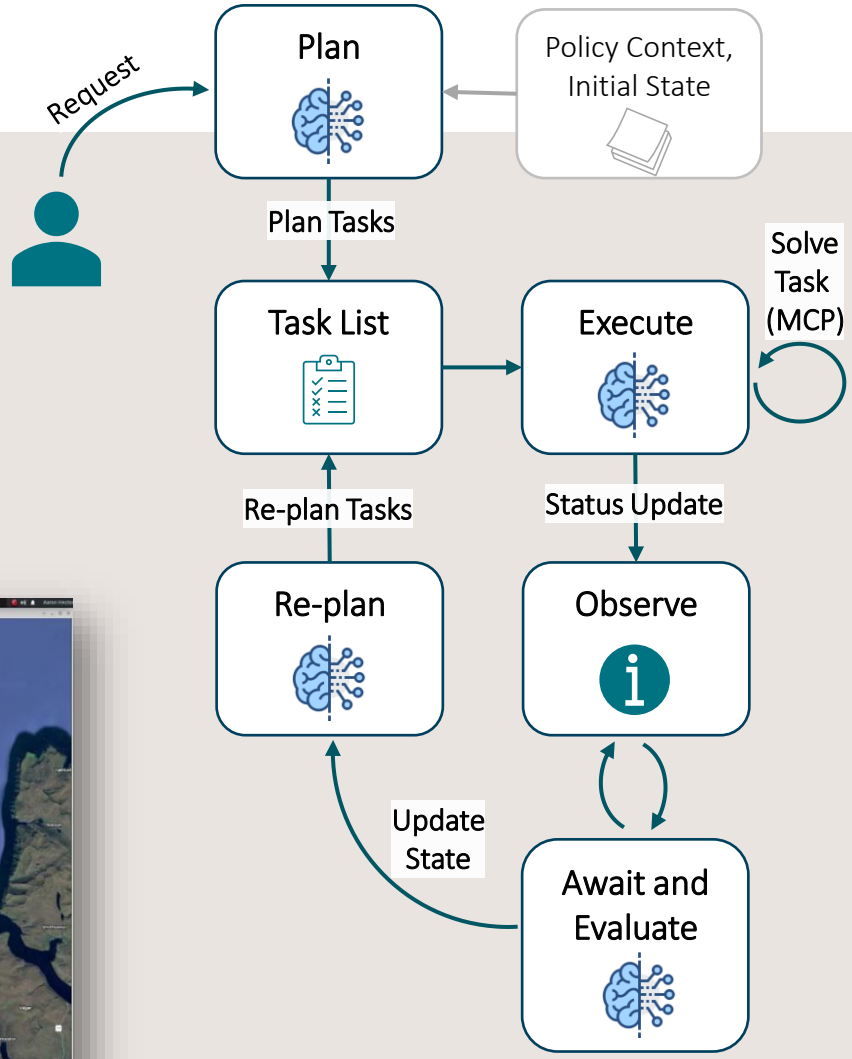
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Example: Mission Autonomy Orchestrator

1. Agentic orchestration through LLM (upgradeable)
2. Mission **adaptation and re-planning** capability is the key
3. Run Time Validation ‘governor’ for assurance
4. Modular updates of Tier 1 & 2 Services (mission functions)

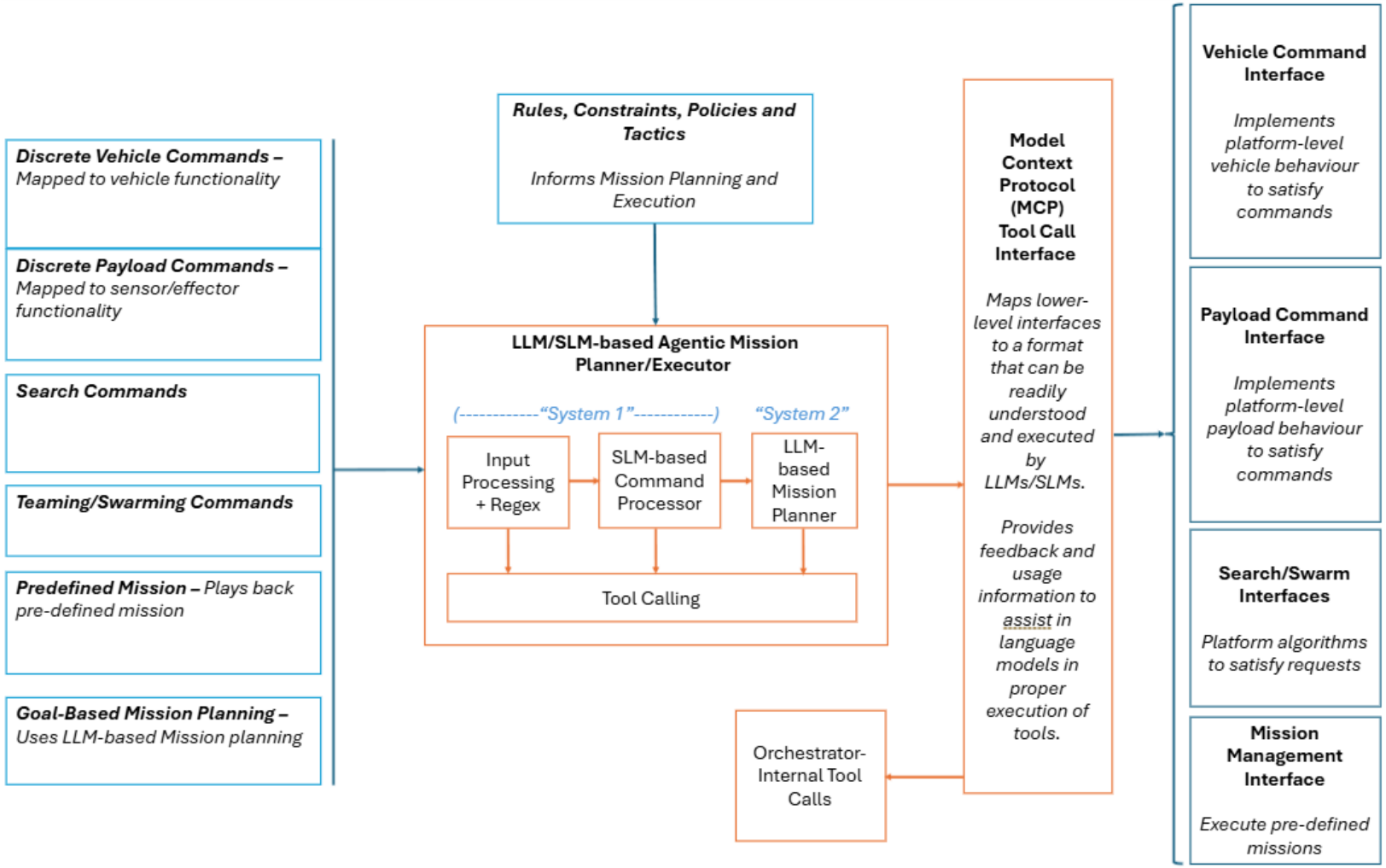




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“Thinking Fast and Slow”



REACT

THINK FAST

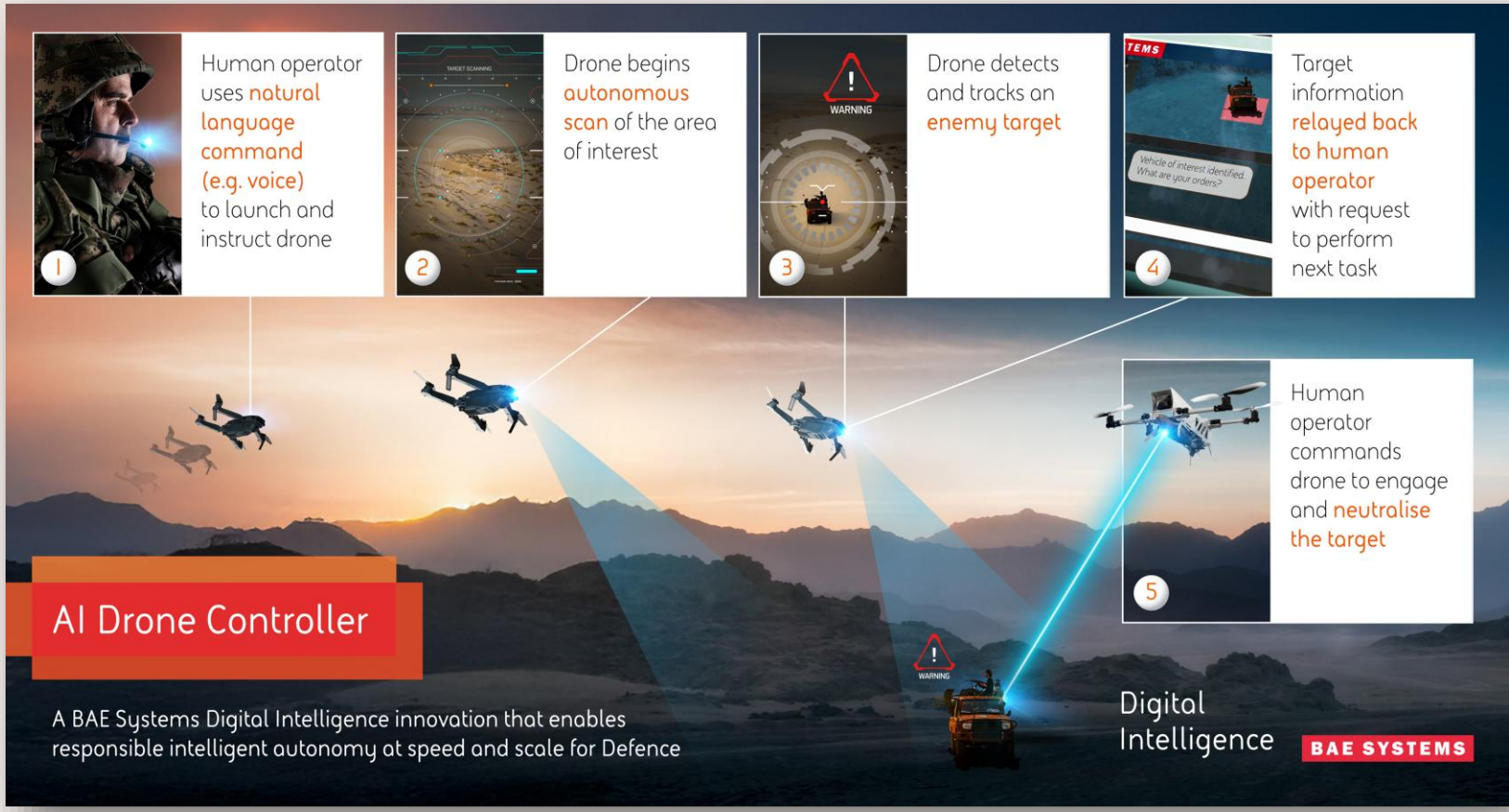
THINK SLOW

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Voice input - “Commanded Not Controlled”

1. A global development effort multiple BAE SYSTEMS units, in both Australia and the UK
2. Leveraging the power of natural language for voice command
3. Tested in flight to validate operational concept
4. Being matured and implemented within the **“React, Think Fast, Think Slow”** construct



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Inside the Future of AI Drone Control - Mind of the Innovator | BAE Systems

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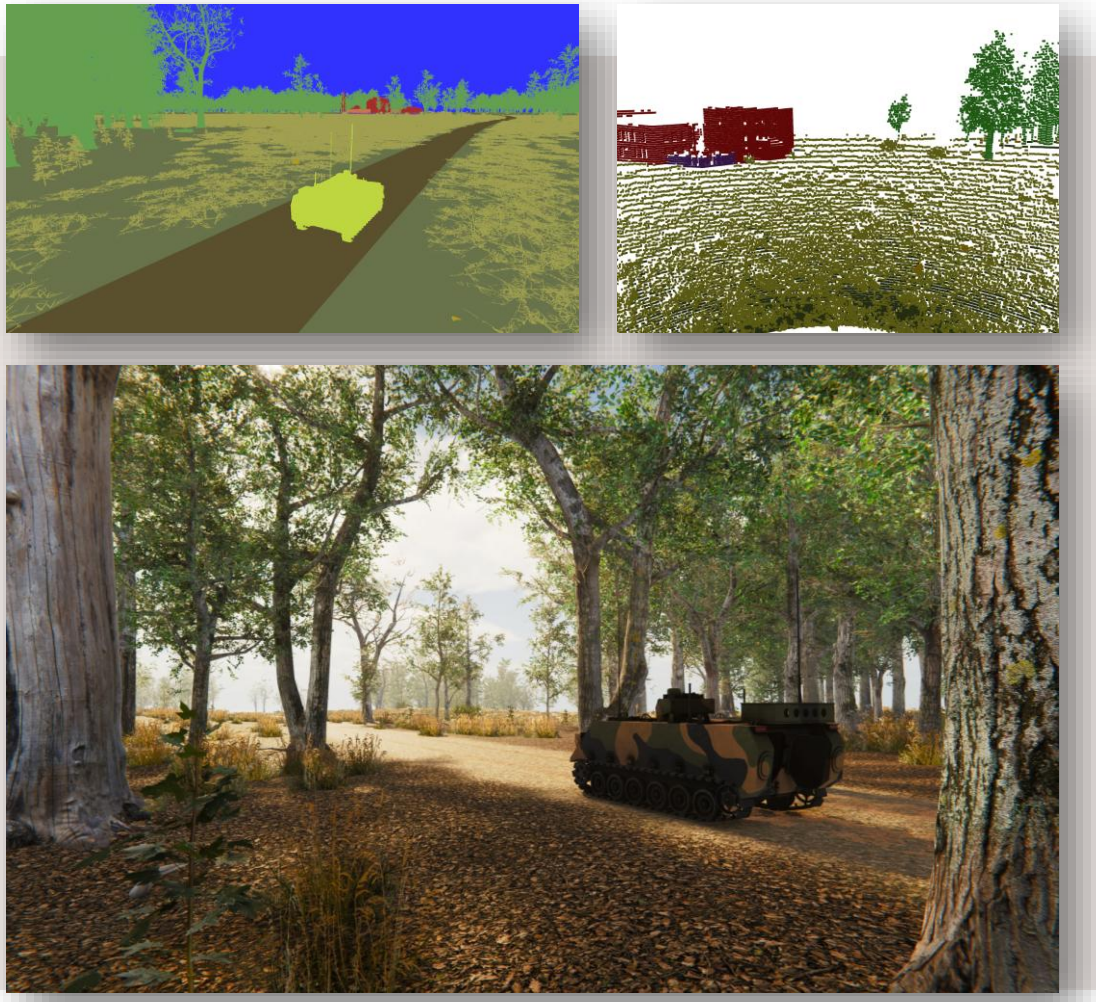
Example: Vision Language AI and Synthetic Data

Supplement hard-to-find data with synthetic data produced by generative AI.

1. **Generate Synthetic Data:** create candidate images with VLAI (text prompts) or synthetic environments to cover diverse operational domains and scenarios
2. **Automatic Labelling**: segmentation masks as truth labels using open vocabulary VLMs
3. **Validate:** Measure quality of segmentation masks before adding to final dataset.

This could also be applied to decision-making AI, not just classification AI

Minimal "new threat" input images required



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Interlude: What is distinctive about BAE SYSTEMS' approach? An Analogy

- "Move Fast and Break Things"



- "Disciplined Model-Based Systems Engineering"



BOTH APPROACHES ARE IMPORTANT

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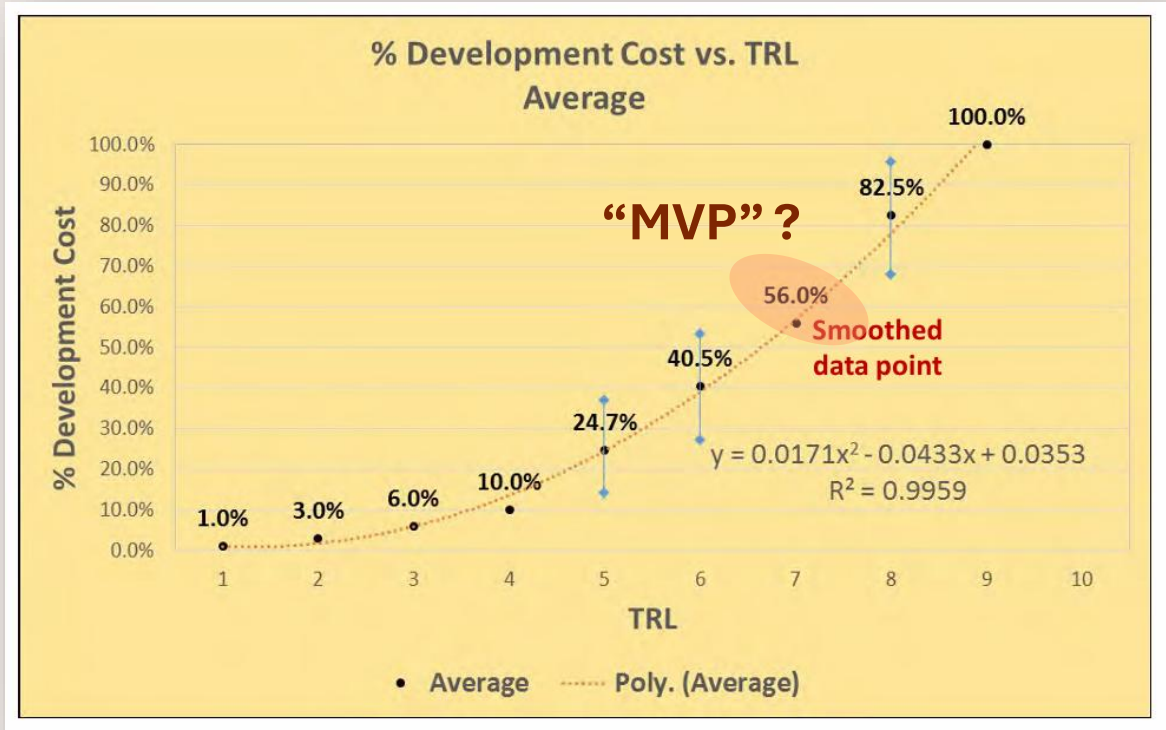
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Technology Readiness Levels and Tailoring the Design Approach

- Agile SME / subcon partnering at lower TRLs
- “Skunking” to validate platform concept
- Leverage high-fidelity 6 DOF synthetic environment







- Importance of high-integrity software & iteration thru software-defined capabilities at higher TRLs
- The realm of the Prime



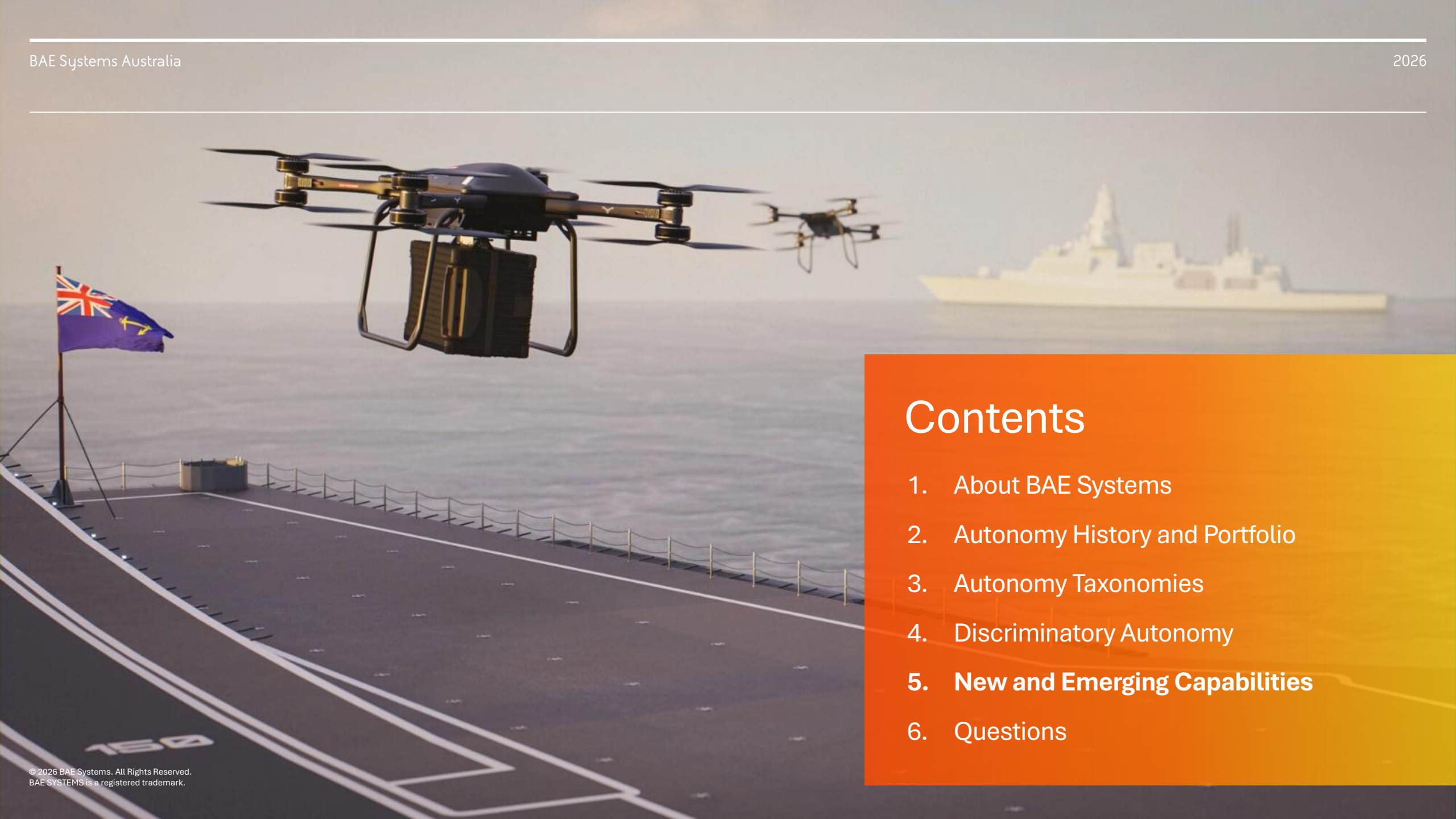


Better architecture and systems engineering accelerates trust and assurance

High integrity software with common tools accelerates early testing

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Examples: Integrating Autonomy into new and emerging small-medium UxVs







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Certo CAPSTONE – Land ACP

- BAE SYSTEMS has offered Certo CAPSTONE to Project Nyx (UK Army Apache Land ACP), down-selected for Stage 1 demo to UK Army in Sep 2026
- Platform has also demonstrated ASW detect, locate and track capabilities at RN Atlantic Bastion
- Certo CAPSTONE carries up 300kg of payload, has an endurance of up to 10 hours, and a maximum range of approx. 483km.
- It can be transported in standard containers.
- Hellfire missiles have been fitted to the platform in synthetic environments and ground-tests, de-risking this weapon for employment in a “Loyal Wingman” scenario





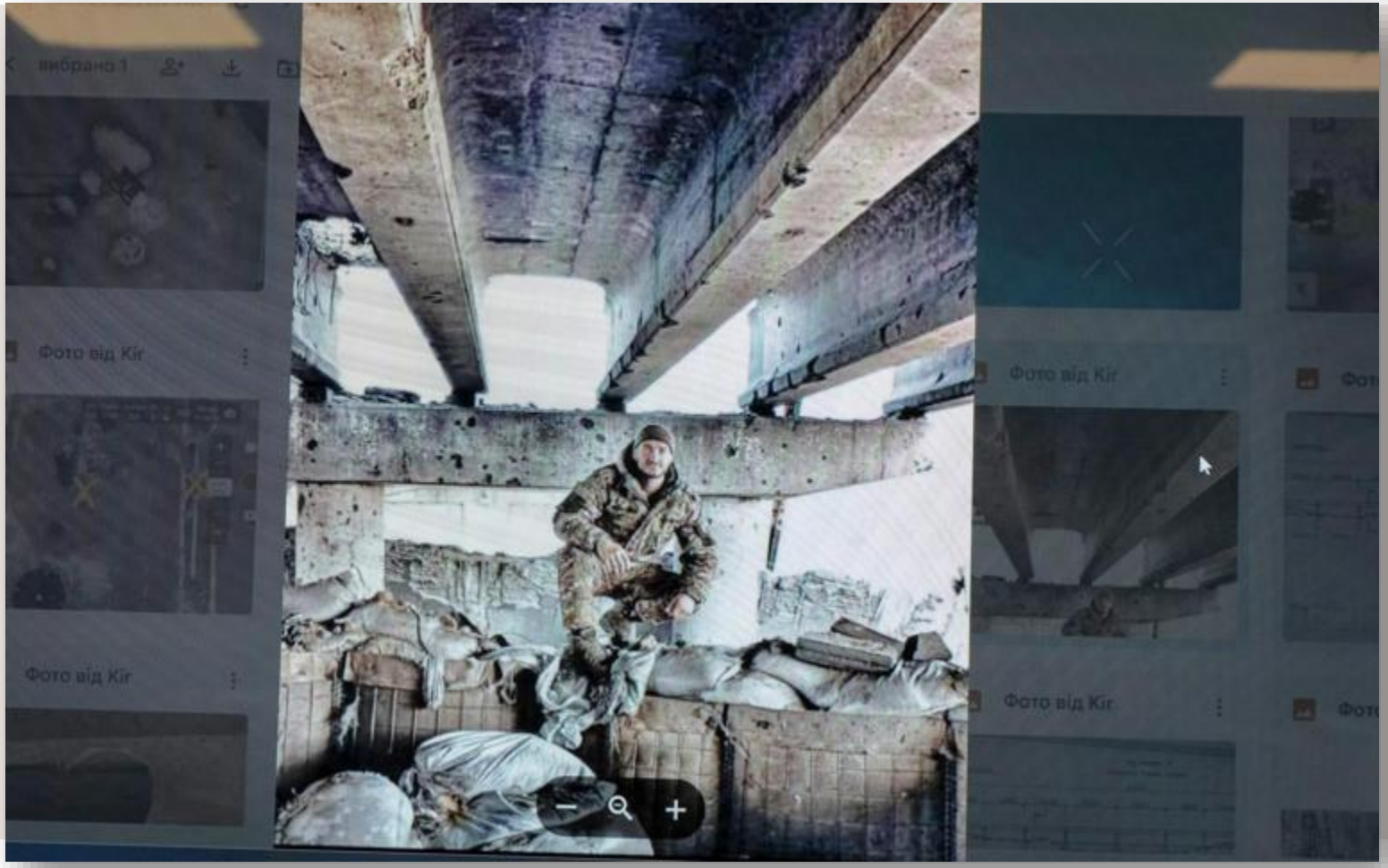




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T150 Dnipro Bridge Attack



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Moment British drones ‘destroy Russian-held bridge’ in first-of-its-kind Ukraine operation

The Sun

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TRV150 with APKWS II

- TRV-150C tested at NAVAIR Pax River
- Major difference between TRV-150 and T-150 configurations is the addition of software to **reduce operator workload and complexity**; facilitating operation by a “19yo truck driver”
- **Multiple APKWS rocket firings** have been undertaken at Fort Rucker, exploring platform’s utility as a potential ‘Shahed Hunter’









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XPERIMENTAL

Callen Lenz ‘Nyan’ One-Way Effector

- Callen Lenz, wholly-owned by BAE SYSTEMS, has revealed its TRL 9, low-cost, low-observable, “NYAN” one-way-effector
- Procured by the UK to enhance Deep Fires Capability
- NYAN is the only off-the-shelf product of its type registered on the Military Aircraft Register. It has a UK MOD Article 3 legal review, and incorporates common GFE







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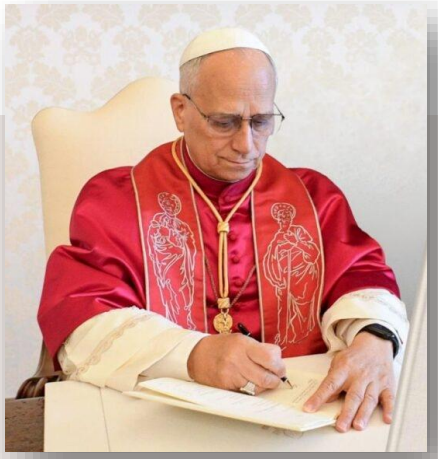


One Final Point – The "Ethical Debt"

"Concrete criteria for discernment must be established. The first such criterion concerns ***personal responsibility.*** *When a decision to strike becomes automated or opaque, the risk of abdicating responsibility increases. For this reason,* ***the chain of responsibility must be identifiable and verifiable; those who design, train, authorize and employ technology must be held accountable for their decisions.***

The second criterion pertains to the ***moral timeframe for making judgments.*** *While AI tends to expedite the decision-making processes, speed and efficiency should never be the supreme motivating force for the irreversible decisions made in the context of war.*

The third criterion is the ***identification and protection of civilians.*** *Any technology that facilitates attacks without seeing the face of human beings lowers the moral threshold of conflict. Target selection and the use of force must not confuse combatants and non-combatants, nor ignore the impact on defenseless populations."*







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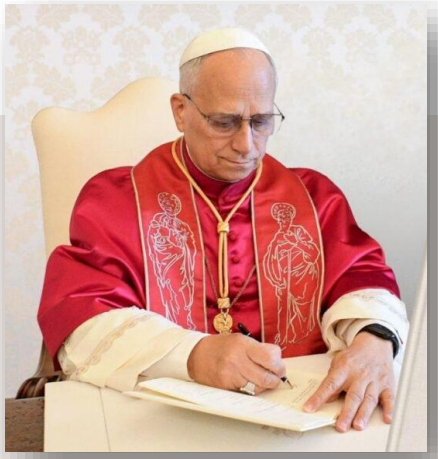
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One Final Point – The "Ethical Debt"

"These criteria give rise to certain non-negotiable requirements.

*First, all systems used in a war setting must **guarantee the possibility of retracing and reconstructing decision-making processes**, so that accountability and blame are not collapsed into "the machine."*

*Second, the decision to use lethal force cannot be delegated to opaque or automated processes, but must **remain under effective, self-aware and responsible human control**. Finally, it is imperative to establish a shared framework - also at the international level - in order to curb the technological arms race and ensure **robust protection for civilians** and the infrastructures necessary for their survival."*







This underscores the importance of truly "trusted autonomy": properly trained, high-integrity software, governance, traceability, transparency and control over the sovereign tactics, techniques and procedures which inform the operation of the AI – all core parts of our **"Discriminatory Autonomy".** Used properly, these can uphold and enhance the principles of **necessity, distinction and proportionality** at the heart of International Humanitarian Law.

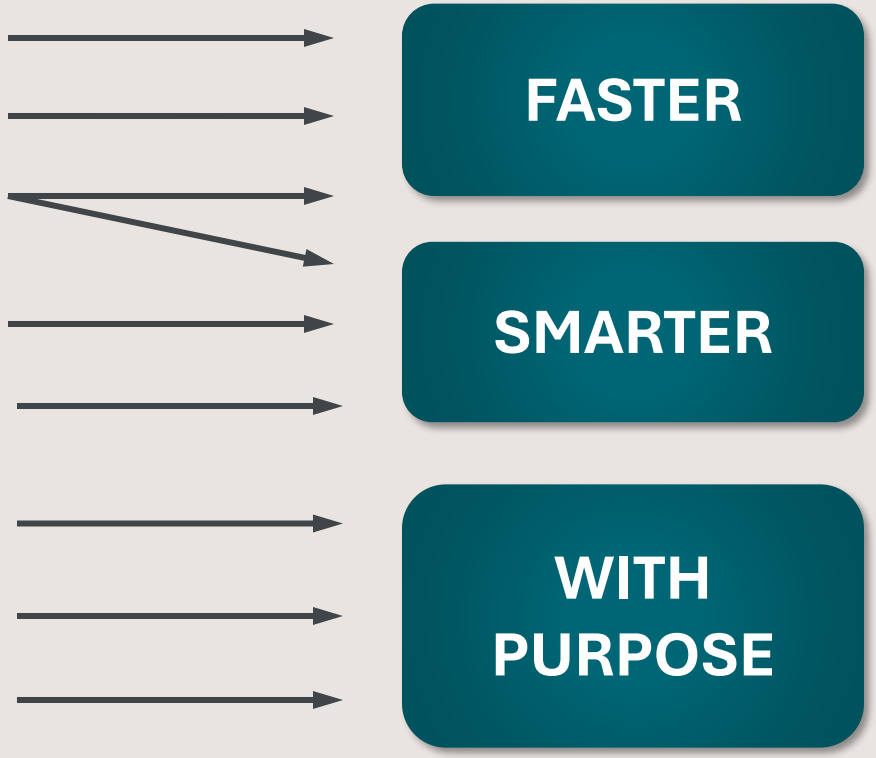
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Summary: What makes BAE SYSTEMS' Autonomy technology "Discriminatory?

Discriminatory by:

- **Natural Language** and **AI-empowered** adaptive orchestration and HUM-T
- **SWAP-appropriate Automation** – tailored for the Mission
- **Robust Architecture** – adherence to Reference Architectures, facilitating rapid upgradability through the "MOSA Mindset"
- **Deep Battlespace Integration** – into legacy systems, e.g. BMS and CMS
- **Resilience under Contest** – including higher levels of robust perception, higher levels of autonomy, reversionary behaviours
- **Trust and Assurance** – built through process and synthetic iteration
- **Ethical and Lawful Control** – including human-on-the-loop
- **Sovereignty** – non vendor-locked, non-ITAR, modular incorporation of sovereign tactics, techniques and procedures



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“The Cutting Room Floor”













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Thank you!

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