
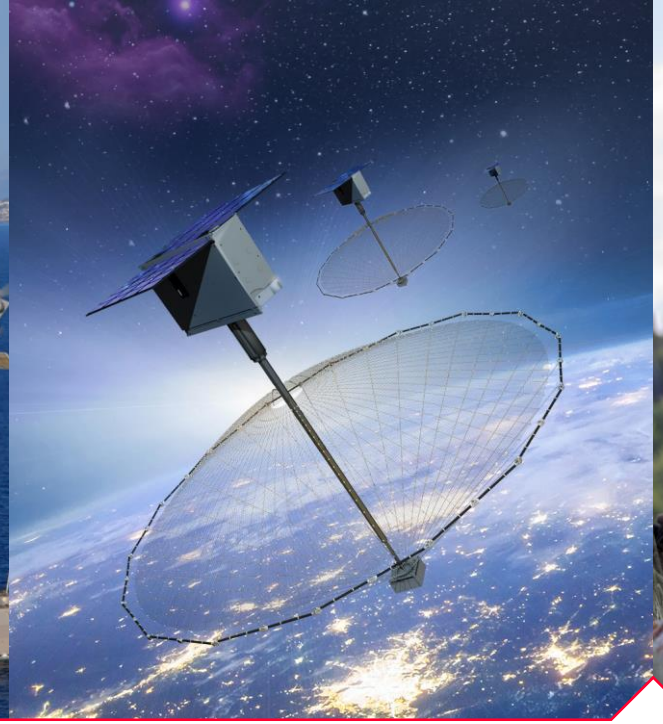
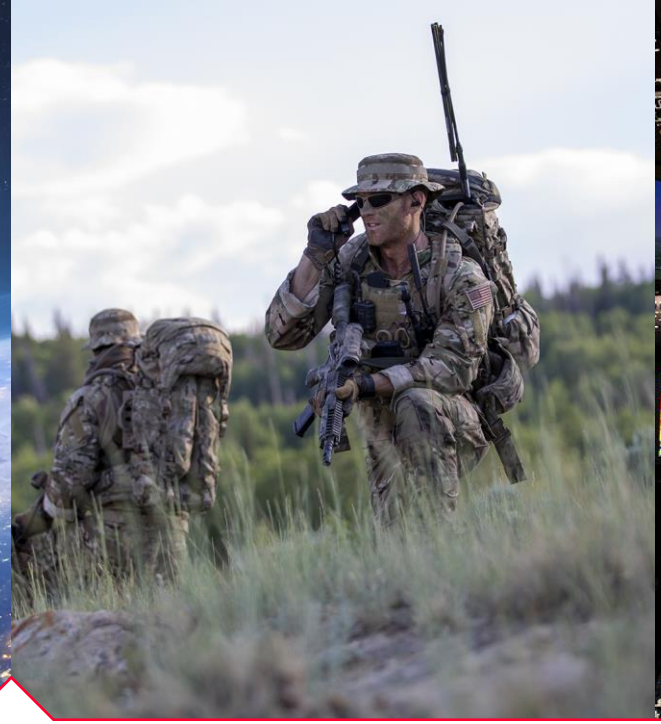


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MACHINE LEARNING AND BATTLEFIELD DECISION MAKING

September 11, 2019

Prof Paul Brittan | Chief Scientific Officer at TRL

Introduction: Machine Learning and Battlefield Decision Making

Role: Chief Scientific Officer at TRL Technology, a subsidiary of L3HARRIS, specializing in AI&ML for CEMA.

Background: +30 years of Machine Learning applied to CEMA, Analytics, Speech Recognition and Image Processing

Objective: Discuss why and how Machine Learning will have to assist in the Delegation of Intent

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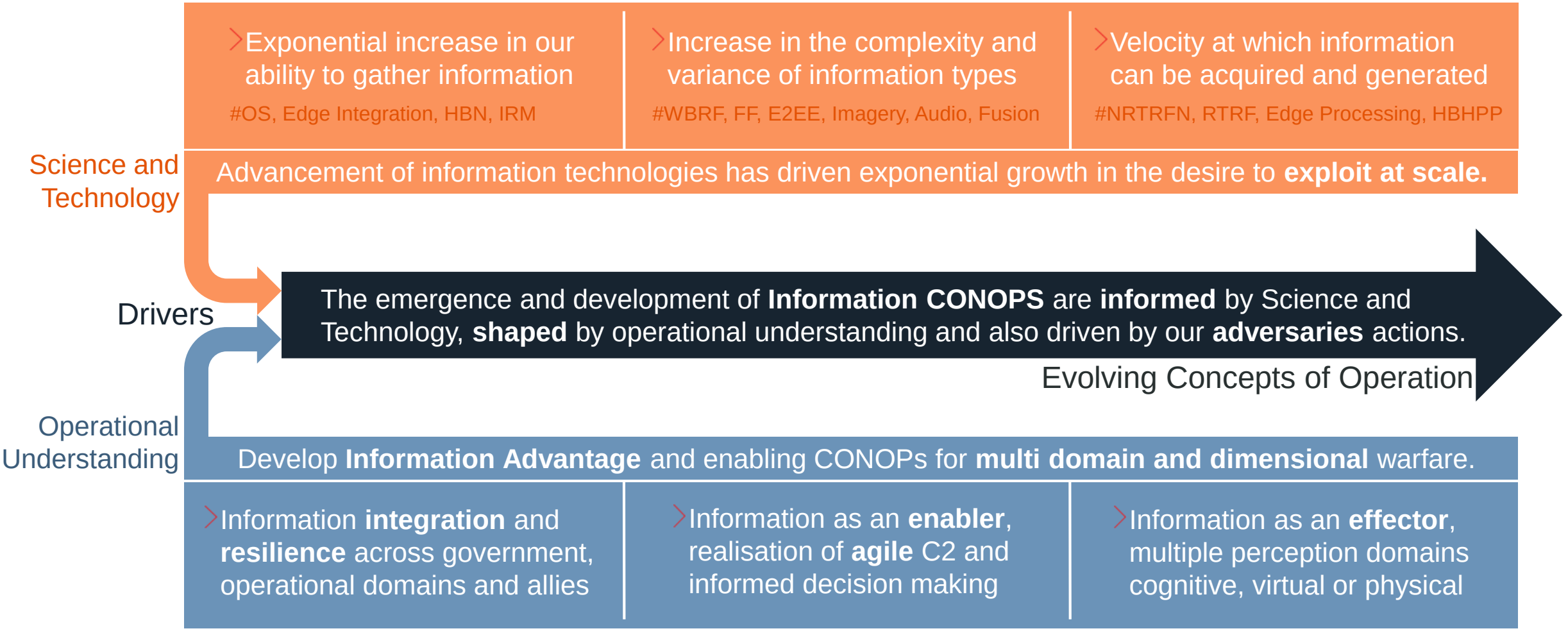
L3Harris Technologies is an agile global aerospace and defense technology innovator, delivering end-to-end solutions that meet customers' mission-critical needs.

Stuart Gardiner spoke about “Drivers for Evolving CONOPS”



…and the Impact on CONOPS

The evolution of the Information domain impacts both S&T and OU

Impacting Information Characteristics

- Collection
- Complexity
- Velocity

Environment	Technical	Cognitive
Information Storm	Obsolete Solutions	Overloaded Users
#Cross Domain, Dynamic Inter-relationships, Traded as a commodity, Used as a Resource, Facilitates Attack Vector for Adversaries, Open Source, Constantly Changing	*#Tactical and strategic Networks Links, Storage, Inter-Relationships, Pattern of Life and Behaviour, Edge and Enterprise, Real Time, Legal , Labelling, Security, X Domain.*	*#What Information is Relevant?, What skills are needed?, Training, Distraction, dispirit approaches, Multi Dimensional, Time dependant, Information Gap, Gather*

Bi-directional Impact

Bi-directional Impact

Denied, disrupted and or degraded ability to make informed tactical and strategic decisions.

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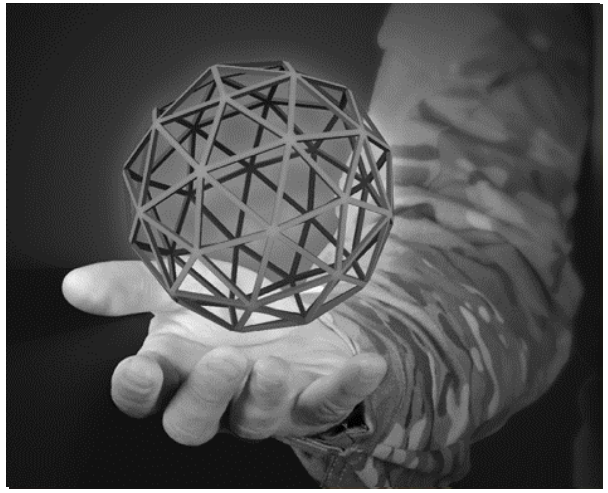
Tempo at the Fighting Edge



Pre Deployment → Deployment → Operations → Recovery → Post Mission

The tempo of modern warfare is dependent on Networking, Bandwidth, and PNT.
Defining: Order of Battle, Chains of Command, and Decision Making

But what if the “Network” disappears?

Machine Learning and Battlefield Decision Making

Operating Scenario:

- **Autonomous CEMA Adversary**
  Well equipped and devolved chains of command
- **Contested and/or Congested Environment**
  - Loss of Strategic Backhaul
  - Disrupted Tactical Communications
  - Loss of Position, Navigation, and Timing
- **Information Overload from Big Data**
  Volume, velocity, diversity, and sparsity

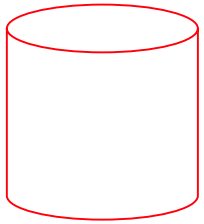
Operational Needs:

- **Automated Decision Support**
  Reduced Cognitive Burned
- **Utilise increased Situational Awareness**
  Every soldier and platform is a Sensor
- **Legal, Accountable, and Proportional Actions**
  Driven by Rules of Engagement
- **Threat Signal Prioritisation**
  Automate or support faster decision making

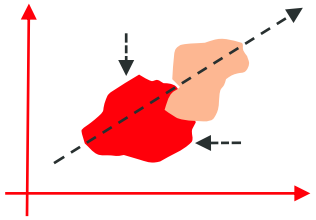
Benefits of Machine Learning:

- **Distributed Analytics**
  To support Situation Awareness
- **Decentralised Decision Support**
  To support loss of communications
- **Authorised Autonomous Decision Making**
  To expedite decisions
- **Trusted Edge based Computing**
  To support Machine Learning

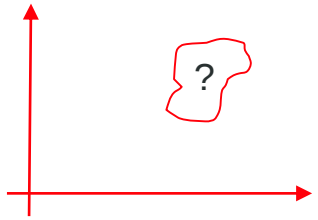
Where does Machine Learning and AI Fit?



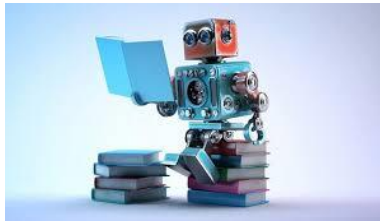
Big Data



Model Trends
and Cluster



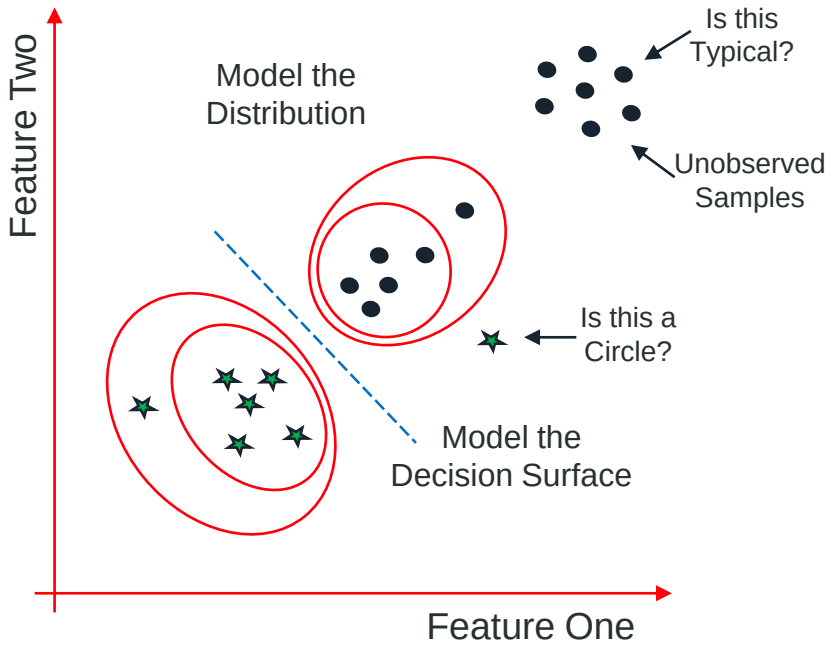
Classify
and Predict



Aware, React
and Evolve

- **Big Data**
  Volumes of data that exceed memory and/or traditional processing techniques
  - **Data Science**
    Modelling trends and clusters (classes) within big data
    - **Machine Learning**
      Use of models to classify or predict trends or classes within data
      - **Artificial Intelligence**
        Use of Machine Learning techniques to automatically react to evolving situations

The Challenges of Machine Learning



Challenges:

- Outliers
- Dependencies
- Chaotic and/or Noisy systems
  - Non-linear data
  - Hidden variables
  - Perturbation
- Too little (sparse) data
- Too much (big) data
- Curse of Dimensionality
- Regularisation and Quantisation
- Training Bias

A Long History of Machine Learning

	First Established	Example	Advantages	Disadvantages
Bayesians	1763	Refinement Hypothesis and a-priori Knowledge	Measurement of Uncertainty	Need for Good Data Coverage
Connectionists	1951 2006	Neural Networks Deep Learning	Automatic Feature Extraction	Accountability
Analogises	1967 1995	Nearest Neighbour Support Vector Machines	Good out-of-sample Generalization	Model Selection
Symbolists	1970s	Inverse Deduction Rule Based	Potentially Short Learning	Brittleness & Scalability
Evolutionists	1992	Genetic Algorithms	Avoid Local Minima Adapt to the Unknown	Dependency on Encoding

The unspoken truth: There are few new ideas in Machine Learning!

Operational Timeline - Evolving CEMA Environment

		Pre Deployment	Deployment	Operations	Recovery	Post Mission
Dependencies	Networking & Bandwidth	• Structured • Known	• Mobile • Dynamic	• Localised • Limited	• Disrupted • Limited	• Structured • Known
	Position, Timing & Navigation	• Established • Trusted	• Disrupted • Known	• Denied • Unreliable	• Limited • Known	• Established • Trusted
CEMA Tasking Pipeline	Situation Awareness	• Establish • Disseminate	• Validate • Update	• Maintain • Distribute	• Maintain • Consolidate	• Achieve • Analyse
	Decision Making	• Centralised • Disseminate Intent	• Distributed • Dynamic	• Decentralised • Inform	• Distributed • Dynamic	• Centralised
	Action	• Exploratory	• Pro-active	• Support	• Defensive	• Validation
Machine Learning	Detect, Locate, Classify, & Predict	• Centralised • Planning	• Distributed • Optimisation	• Decentralised • Inform	• Distributed • Dynamic	• Centralised • Classification

Operational Timeline - Potential ML Application Areas

Machine Learning Tasks	Pre Deployment	Deployment	Operations	Recovery	Post Mission
Detect	• Emitters • Sensors	• Emitters • Sensors	• Emitters • Sensors	• Emitters • Sensors	
Locate	• Adversaries • Disruptors	• Adversaries • Blue Forces	• Adversaries • Blue Forces	• Blue Forces • Adversaries	
Classify	• Participants • Patterns of Life	• Behaviours	• Behaviours • Responses		• Analysis
Predict	• Effectiveness • Mission Outcomes	• Reactions • Alternatives	• Reactions • Alternatives		• Alternatives
Optimise	• Routes • Asset Placement	• Evolve Response • Evolve Assets	• Adapt Response • Adapt Assets	• Expedite	
Change Detection	• Characterisation	• Anomaly • Evolve	• Monitor • Respond	• Monitor • Protect	• Monitor • Protect
Network Characterise	• Detect • Enumerate	• Refine • Monitor Response	• Feed SA Picture		

Loss of Strategic Backhaul, Tactical Comms, and PNT

Need for Decentralised Edged-Based Machine Learning

The majority of modern large scale Machine Learning techniques are distributed, but not decentralised

Any Questions?

Need for Decentralised Edged-Based Machine Learning

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