

Artificial Intelligence and Machine Learning Delivering Military Support – A Def Logs Concept Note

What does the future Defence Support Network look like?

The vision is for a strategically prepared, globally responsive and operationally precise Defence Support Network (DSN). This requires the network to be agile, with a high degree of real-time asset visibility and a capacity to move mass over several strategic distances within short timescales. The network will be distribution-based, where information replaces inventory, minimising the need for stockpiles and requiring a smaller deployed materiel footprint, enabled further by interoperability between UK Military, industry and international partners. The network will exploit its digital backbone, connecting people, machines and information, providing accurate situational awareness across the whole network and enabling effective Command and Control (C2) and timely decision-making at all levels.

Artificial Intelligence & Machine Learning Definition

There is no military definition of AI & ML but an accepted Mil/Civ one is: ¹.

AI - ‘The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.’

ML – ‘Techniques where the algorithm creates the rules that it will operate on to achieve a given goal.’

AI & ML solutions will help provide Defence with the essential competitive edge, not only by equating human intelligence, but by doing so much more precisely and where feasible, by surpassing it. – even if only within a narrow domain, such as information analysis or reaction time. The seizure of the Information Advantage² through relevant networks and the gathering of appropriate and timely data, needs to be carried out by the creation of the best algorithms for the process, then collecting the insights from those. The findings and insights should then be executed via a solution(s) implemented at the optimal time.

Three elements are pivotal to creating AI systems:

- 1. Computing capability (processing power) – hardware.*
- 2. Developing advanced algorithms – software.*
- 3. Access to the sufficient quantities and quality of data; both the data to train the system and the data to be exploited.*

What does AI&ML include in Military Support terms?

For this note, the use of AI & ML is limited to the Support Network but it is expected that AI & ML use within Defence will be widespread, Cyber protection and security will underpin and overarch all capabilities as they appear to be the most pressing set against current known threat.

AI & ML could benefit logistics in various ways, from optimising supply networks and resupply routes to avoid hotspots and enhancing security by reducing the predictability of supply lines, to analysing stocks to improve the efficiency of inventory management or automating the quality

¹ The definition of AI & ML for this note is the dictionary definition.

² The competitive advantage gained through the continuous, adaptive, decisive and resilient employment of information and information systems.

assurance and standards of compliance of new and existing suppliers and items. In short, AI & ML can deliver benefits realisation spanning policy, stockpiling, readiness, pre-positioning, and assured global support networks whilst improving interoperability with Partner Nations.

AI & ML is one of the Chief Scientific Advisor's 'Big Bets' so is a key focus across wider Defence.

The Framework of AI & ML

The effective use of AI & ML can be categorised as follows:

1. Technological:
 - a. Internal safety and reliability.
 - b. External exploitation.
2. Organisational:
 - a. Trust and Ethics (both elements).
 - i. Mechanical understanding.
 - ii. Predictability.
 - iii. Familiarity.
 - iv. Context.
 - b. Singularity of control.

Ethical, policy and security considerations require further investigation before employing machine learning on safety-critical Defence systems. It can be challenging for humans to understand and explain machine learning outputs. This may not be tolerable for some Defence applications and the risks need to be understood. Risk is assessed within context, and will remain a human responsibility. Mission Command will change in an AI & ML age and will demand variable autonomy in remote and automated systems.

AI & ML and Human interface

Future applications will vary considerably in the functional role divisions between humans and AI systems, the nature of the interactions between humans and AI systems, the number of humans and other AI systems working together, and how humans and AI systems will communicate and share situational awareness. Functional role divisions between humans and AI systems typically fall into one of the following categories:

1. AI performs functions alongside the human:
AI systems perform peripheral tasks that support the human decision maker. For example, AI can assist humans with working memory, short or long-term memory retrieval, and prediction tasks.
2. AI performs functions when the human encounters high cognitive overload:
AI systems perform complex monitoring functions (such as ground proximity warning systems in aircraft), decision making, and automated medical diagnoses when humans need assistance.
3. AI performs functions in lieu of a human:
AI systems perform tasks for which humans have very limited capabilities, such as for complex mathematical operations, control guidance for dynamic systems in contested operational environments, aspects of control for automated systems in harmful or toxic environments, and in situations where a system should respond very rapidly (e.g., in nuclear reactor control rooms).

An AI & ML enabled Defence Support Network of the future.

The DSN of the future will be achieved by utilising high volume manual and repeatable support functions incorporating AI & ML capabilities throughout the Defence Logistics Enterprise, including the digital backbone where algorithms will automate many decisions.

The application of AI & ML will be most notable in several key areas³:

Plan & Prepare

Through exploiting big data and IoT, AI & ML will help analyze, monitor and update all the elements of the PMESII⁴, 4 Ds⁵ and 5Vs⁶. It will encompass working within protected networks with known and trusted sources⁷ using information which is sharable with Partner Nations and provide an ability to detect, repel, spoof, cyber-attacks and threats.

AI & ML will monitor social media and run modelling at Logistic bases and nodes which will automatically flag early indications of potential problems. AI & /ML will be able to run multiple simulations for flow rates, consumption against time and forecasting whilst offering the ability to interact with industry and Depots to covertly sense availability and respond accordingly. Coupled with this will be the ability to transmit “clutter” to confuse and misinform a potential adversary whilst remaining masked and/or undetectable.

Automated warehousing exploiting AI & ML will pick, pack (smart packaging) and configure loads, whilst maintaining asset and consignment visibility within the Joint and Partner Nations arena. This will enable cooperative use and the ability via acquisition agreements to “buy down” lead times and coordinate effective distribution this will achieve the delivery into the hands of the user of the right item, to the right place, at the right time, to the right quantity and in the right condition. Smart packaging and the exploitation of its data will verify location, condition and improve the user experience and confidence whilst reducing demand and its associated resupply and footprint.

Project

AI & ML will automatically synchronize, the Force Outload, and In-load, whilst optimising flow rates, and Capacity. Overcoming C4I threats by re-routing consignments, re-configuring loads; with connectivity sufficiently able to allow AI /ML to deliver the logistics plan and monitor all Logistic activities and data.

The Force Movement Coordination Centre will optimize all transport asset options through exploiting AI &ML, automatically achieve POGO⁸ through ensuring the minimum essential logistic deployed footprint. It will also permit UK Defence to forecast and coordinate requirements with Partner Nations, while optimizing the employment of tactical and strategic lift assets to their full capacity.

³ Processes and actions including acquisition, storage, movement, distribution, maintenance, recovery and disposal (JDP 4.00).

⁴ Political, Military, Economic, Social, Information and Infrastructure

⁵ Demand, Destination, Distance and Duration

⁶ Volume, Velocity, Variation, Variability and Value

⁷ Block chain, IoT homoeomorphic encryption

⁸ Proof Of Good Order: a clear audit trail that would pass external scrutiny It consists of a series of End-to-End processes.

Through the meshing of AI & ML and C4ISR Defence will conduct deception planning and masking activities on a global scale⁹, whilst retaining the ability to monitor enemy activity and disruption activities.

Sustain.

AI & ML will facilitate optimal smart storage and distribution capability exploiting real-time visibility of the total Multinational Logistics and Supply Picture, encompassing factory (industry) to foxhole support network visibility. Furthermore, it will enhance the processing capability of assured global and connected electronic communications, including those in austere or denied environments.

It will manage automatically replenish and ordering tasks and deliver to the commander a real-time sustainment dashboard covering all nodes. AI & ML will drive autonomous delivery which will reduce the potential number of nodes, gathering data from HUMS and PME like systems automatically linked to repair and replenishment facilities. Furthermore, it will enable the integration of Tele-medical / metric / maintenance to maximise the deployed footprint and the associated cost of deploying scarce highly skilled SMEs.

In summary, the adoption of AI & ML methods has the potential to reduce, demand, footprint, and cost, whilst increasing velocity, (both cognitive and through action) standardisation and logistic decision support across the Defence Support Network.

Restore Combat Power

Through AI & ML's contribution to reduced logistic footprint and connected automated warehousing, smart packaging, real-time asset management and improved visibility; the Recuperation, Rehabilitation, Reconstitution and Refurbishment of equipment and materiel will be revolutionised; informed disposal decisions will influence the restoration of combat power that is visible and tracked throughout the life of the capability, closing the POGO loop.

Supporting Benefits.

The use of AI & ML, as described in this concept note and compared to current practices, relies on several hypotheses that need verifying:

- *AI & ML:*
 - *The ability to scale physical mass; extend reach and persistence; and enable better exploitation of information for advantage.*
 - *Can reduce error-rates and ultimately reduce annual Defence support costs.*
 - *Can meet operational demands whilst significantly reducing inventory.*
 - *Can sustain, or enable an increase in, operational tempo.*
 - *Can enable more agile Forces and hence greater freedom of action.*
 - *Can reduce the physical and cognitive burden on individuals.*
 - *Can reduce unnecessary risk to life.*
 - *Can reduce head count.*

Assumptions.

- *Develop effective methods for human AI & ML collaboration.*
- *Understand and address the ethical, legal and societal implications of AI & ML.*
- *Ensure the safety and security of AI & ML systems.*
- *Develop shared public datasets and environments for AI & ML training and testing.*

⁹ Use of Global reach/power to influence En FoM.

- *Measure and evaluate AI & ML technologies through standards and benchmarks.*
- *AI & ML will increasingly outperform humans in activities that can be codified and have clearly defined goals.*
- *Suitable funding and high-level sponsorship, support and leadership will be secured from both Defence and industry partners.*
- *All info sy and tech issues have been overcome and DX has been achieved to a sufficient level to support successful Logs AI & ML implementation.*
- *AI & ML solutions will encompass sufficient redundancy to provide assured service delivery.*
- *AI & ML implementation will benefit all environments including Maritime, Land, and Air and Space*
- *All solutions will deliver improved interoperability, including with allies and partners, through standardisation and joint COMEMPs/CONOPs.*
- *Human intervention will be minimised across the DSN for repeatable functions.*
- *AI & ML will ensure that a maximum number of logs transactions are automated.*
- *Data collection, quality and data set dependencies will be resolved and of sufficient quality to permit value to be drawn from it to transform support operations.*
- *UOR/unplanned demand will be minimised.*
- *AI & ML will be part of a 'system-of-systems' approach, delivering a networked capability that is revolutionised, optimised, smart, effective and efficient and integrated with other capabilities.*
- *Cyber protection with data assurance will underpin the connected assured network.*

Current Evidence – Supporting Examples

Many elements of the DSN of the future already exist or are being developed through global commercial organisations, academic institutions and Defence. Some key areas where AI & ML has delivered proven benefits include:

- *The HMRC Data Science and Technology (DSaT) team is analysing bulk unstructured textual information to develop better targeting models for tax that is at risk. HMRC data scientists are analysing tax that is at risk across more than 15 million tax returns and attachments. They have developed applications and systems with predictive algorithms, which predict who is likely to go into debt. This has resulted in a multi-million pound reduction in debt during a three month trial, and is now a Business as Usual capability.*
- *In 2014, the Department of Health asked the NHS Business Services Authority (NHSBSA) to help save £1 billion by 2018. They set up the Data Analytics Learning Laboratory (DALL) to inform policy and help eliminate waste from NHS systems and services. Through data science and analytics, the DALL has been able to identify £581 million of savings for the NHS to date.*
- *BAE Systems' SEA-CORES technology which is being trialled in both a commercial and a Royal Navy vessel at sea. The technology monitors the ships' equipment, fuel and energy performance and combines that with external data on weather and shipping routes in real time, to determine the most efficient speed, route and trim. BAE estimates that optimising a ship's trim and speed can deliver fuel savings of up to 30%.*
- *Tesco has also been applying sophisticated analysis to its supply chain data for some time. By identifying opportunities to cut waste, to optimise promotions and to match stock to fluctuations in demand, the supply chain analytics function saved Tesco £16 million in the first year of the project. Since then, Tesco's supply chain analytics team has grown from five people to 50. Successes include a statistical model that predicts the impact of the weather on customer buying behaviour. By comparing historical weather data with*

sales records in its 3,000 plus stores, Tesco can adjust its stock levels based on the weather forecast, so its stores do not run out of the goods people want.

- *Ocado was one of the first companies to use Hadoop and Apache Spark software on Google Compute Engine, but then saw the benefits of using Google BigQuery to create and display complex real-time analytics. The data team lets Ocado's business analysts avoid the complex setup and workflow required to run queries against Hadoop and Spark, and also helps them expand data analytics out to its supplier and partners. Since moving to the cloud and adopting the latest solutions from Tableau and other big data suppliers, Ocado has saved on operations costs and headcount, and provided consumers with a more intuitive shopping experience.*

International / multinational approach.

NATO partners are looking to implement AI/ML solutions, however from the recent TTX Trilateral it is clear that many of the initiatives are aimed at the tactical level with a large focus on "last mile delivery" and autonomous vehicles. Efforts should be focused on the harnessing of Partner Nation's data to improve multi-national decision support and drive recommendations for the Commander to better utilise finite resources.

Future Planned Activity.

Effort should aim to build increased autonomy throughout the DSN over three timeframes:

Near-Term (0-2yrs) "Do better":

- *Focus on steadily integrating suitable COTS solutions:*
 - *for those functions that are currently conducted by humans and are quick, cheap and easy to replicate for mass effect.*
 - *that increase situational awareness at all levels across the Logs Enterprise through improved human interfaces.*
- *Exploit the Defence Exercise Programme (DXP) as far as possible to test AI & ML concepts for military support tasks and verify the stated hypotheses, noting that the next suitable event available is Exercise SUSTAINABLE WARRIOR in Apr 2019.*
- *Seek solutions that reduce the physical and cognitive burden on individuals.*
- *Develop solutions to address last (maritime) mile resupply since it has been identified throughout Strategic Force Development activity as a key challenge, especially in the 2030+ timeframe.*
- *Make maximum use of the Dstl-led Autonomy Benefits Realisation Group forum and US/UK/FR TriLat work, cognisant that work should also be aligned with the TDInfo Digital Strategy.*
- *Optimise and exploit the work of (but not restricted to) Defence Joint Artificial Intelligence (AI) Centre, Dstl AI Lab, RN Programme NELSON, US National Artificial Intelligence R&D Strategic Plan, Artificial Intelligence, Automation, and the Economy¹⁰,*

Mid-Term (3-5yrs) "Do differently":

- *Inculcate AI & ML within the DSN for decision support activities at the earliest opportunity the specific challenges that Defence faces in the provision of support in this epoch.*

Long-Term (5-10yrs) "Do something else":

¹⁰ Executive Office of the President of the US, Dec 2016

- *Aim to optimise sustainment through adoption of AI & ML across the Logs Enterprise at all levels and to the greatest possible extent, including the use of techniques to facilitate and enable an immediate automated decision support capability.*

References.

Joint Concept Note 1/18 Human Machine Teaming

The National Artificial Intelligence Research and Development Strategic Plan, Oct 2016

Joint Concept Note 1/17 Future Force Concept, Jul 17

AI in the UK: ready, willing and able? HL Paper 100, 16 April 2018