BRITISH ARMY APPROACH TO ROBOTICS AND AUTONOMOUS SYSTEMS

Generating Human-Machine Teams

ARMY

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This British Army Approach to Robotics and Autonomous Systems is OFFICIAL.

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- Army HQ Information Directorate
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- Defence Autonomy Unit
- Defence Concepts and Doctrine Centre
- DE&S Future Capabilities Group
- Defence Science and Technology Laboratory
- Engineering Delivery Partnership

PURPOSE

The British Army's Approach to Robotics and Autonomous Systems (RAS) provides the direction required to exploit emerging technologies to see the realisation of the Future Army by 2035. The objectives and required capabilities within this approach will inform force structure and equipment programmes to ensure the British Army remains abreast of changes in technology, threats and higher Defence concepts.

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FOREWORD

The context in which the Army operates continues to become ever more dynamic, complex and rapidly changing. Against a backdrop of societal and environmental change, adversaries are investing heavily to challenge our technological edge and threaten our national interests.

The adoption of innovative technologies, commercial and military, at the pace of relevance is critical to achieving competitive advantage as the British Army modernises and transforms. The key research and experimentation areas the Army is focussed on are:

- Artificial Intelligence & Machine Learning
- Robotics and Autonomous Systems
- Networked Sensors and Effectors
- Battlefield Electrification
- Novel Weapons

This document describes how we will generate operational advantage for our Land forces by integrating Robotic and Autonomous Systems within Human-Machine Teams, to generate mass and tempo whilst reducing risk.

It sets out our aspirations for widely integrating RAS across the force over the coming decade or so, based on current technological maturity forecasts. We will actively seek opportunities to accelerate the programme, regularly reviewing and refreshing our approach to ensure it remains ambitious, relevant and at the crest of the wave of technological development.

As well as increasing our capability, tasking machines to carry out the dull, dirty and dangerous jobs allows our brilliant soldiers to concentrate on the parts of the mission that demand human judgement and wisdom. Fielding these Human-Machine Teams will be an exciting part of the British Army's transformation.

Brigadier Matthew Cansdale MBE
Head of Future Force Development

PART 1: CONTEXT

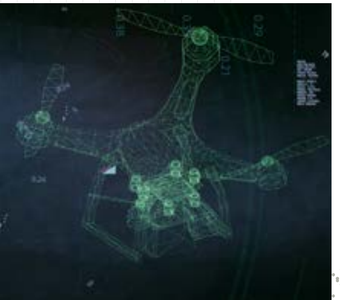
CONTEXT

The strategic context in which we operate continues to become ever more dynamic and complex. As the pace of change further accelerates in the Information Age, Defence is responding to retain its competitive edge.

This British Army Approach to Robotics and Autonomous Systems (RAS) provides the direction required to respond to this change.

Trends in the increased accessibility of RAS necessitate production of this approach as the British Army seeks to responds to:

- **Continued advancements in Technology.** RAS is commercially available and pervasive in many areas of society; with the exponential rate of change of technology it will become increasingly challenging to adopt and fully integrate this technology at a later date;
- **Agile Threat Landscape.** Our adversaries are taking advantage of low cost but highly capable RAS technologies;
- **Maintaining ability to train and fight together.** The integration and interoperability of RAS is essential to remain aligned with other Front Line Commands and our principal allies.



SCOPE

This approach considers the use of RAS in two categories: operational and mission support.

- **Operational RAS.** The employment of RAS to support the physical and digital systems that directly affect the battlefield in real time.
- **Mission Support RAS.** The employment of RAS to support the execution of the operations, including decision support tools.

This approach does not consider the employment of RAS across wider defence. Whilst the employment of RAS within the home base and back office is essential for digital transformation, it is not within the scope of this strategy.

CENTRAL IDEA

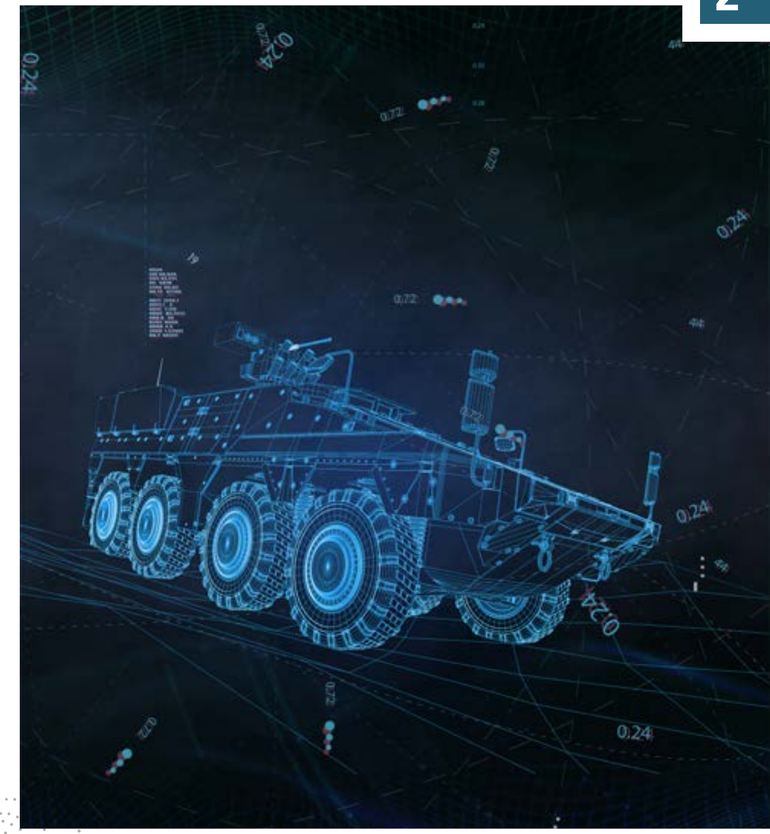
Generating **operational advantage** for Land forces by integrating adaptable Robotic and Autonomous Systems **within Human Machine Teams**, to generate mass and tempo whilst reducing risk.

DOCUMENT OUTLINE

To deliver RAS into the British Army requires a coherent and holistic approach. This RAS approach sets a strategic direction to deliver viable RAS capabilities into the Bde Cbt Team (Light Forces) by 2025, and widely integrated into the Division by 2035. The Strategy has two distinct objectives:

1. **To provide the technological context and bound the military problem.**
2. **To describe the Ends, Ways and Means that are required to deliver RAS as an integrated military capability.**

This approach therefore provides a clear statement of intent at OFFICIAL level, directly in support of the Modernisation and Transformation objectives of the British Army. It will facilitate the production of a series of RAS Capability Implementation Plans, refreshed on a frequent basis, in line with subsequent direction, investment opportunities and technology development.



PART 1: CONTEXT

WARFIGHTING TRANSFORMATION

Technology alone will never deliver genuine warfighting transformation, it is only when technology is evolved into a new way of fighting when true opportunities are realised.

- The tank first saw action in 1916, used to provide intimate support to the infantry, whilst initially causing shock within the German ranks, its vulnerabilities were quickly exposed and it failed to deliver the war winning capability expected.
- In contrast, tanks used by skilled commanders following Blitzkrieg doctrine employed by the German Army in 1939 pioneered combined arms manoeuvre to such success that most of the overarching principles remain the cornerstone of todays battle.

Technological development in the tank enabled speed and reliability, however this wasn't the driver of success. Where the British used technology to improve the way they fought, the Germans exploited the advantages of the technology to transform and define an entirely new way of operating.

The change from trench to manoeuvre warfare was a paradigm shift in fighting to which many parallels can be drawn to the impact of RAS, therefore the lessons of history must be heeded.

RAS alone will not deliver transformation, we must learn how capitalise on its advantages, to enable us to fight differently to realise its full potential.

THE SECOND NAGORNO KARABAKH CONFLICT SEP-NOV 2020

Nagorno Karabakh demonstrated the potential of emergent technology and supporting C2I systems. Leveraging a decade's Turkish and Israeli experience with, and investment in, UAS, LM, and PGW–consolidated by lessons from Ukraine, Syria & Libya–the Azeris used sensor-cued depth fires to defeat better trained Armenian forces in established defensive positions.

The conflict highlights the democratisation of advanced un-crewed systems and C4ISTAR technologies, their availability to nation states, and their capacity to rapidly elevate a force equipped with legacy materiel to a peer/near peer status.

Facing such an adversary, UK forces should expect to be contested throughout a highly transparent battlespace with threats that overmatch much of our existing technology and TTPs.

RAS offers an opportunity to mitigate the risks inherent in fighting against this level of capability; increasing our mass and improving our dispersal whilst detecting and engaging the enemy in the most dangerous parts of the close and deep battle.

2035 VISION

- The integration of RAS has transformed the character of conflict and how the Army now organises, Operates and Fights.
- Generational change in our ability to generate mass and tempo was achieved through early gains in Support and Information which provided the foundation to build increasingly complex, capable and lethal systems.
- Underpinned by robust and resilient networks, RAS operate as part of Human Machine Teams, providing and exploiting data from which faster, better decisions are made and actioned.
- Soldiers have a digital skillset that has enabled understanding and genuine trust in the machine component of the team. Although retained where necessary, the density of human soldiers is reducing, in favour of small, cheaper and plentiful platforms that increase combat mass and force protection and reduce risk to life.
- The Army, with Allied and Industrial partners, is well-positioned to accelerate into the technologically enabled future. With convergence of technology now apparent, the Army has undergone generational and transformation change.

PART 2: TECHNOLOGICAL CONTEXT

THE POWER OF RAS

RAS refers to the combination of technologies and components which provide a series of autonomous and robotic systems. The successful integration of RAS will require a common understanding of its constituent elements, which are summarised below.

RAS AS A CAPABILITY.

RAS, as the name suggests, must be designed as a system. Considering robots or platforms as 'RAS' is to disregard the other elements of the system, including AI, data, algorithms and architectures.

Taken together, RAS can be considered as a system capable of offering an infinite number of combinations based upon the degree of autonomy and robotics in both the physical and virtual. However, any system is dependent on the following enabling components:

TECH

ROBOTICS

A robot, or robotic system, is a machine which provides mechanical assistance to a user; the physical component of RAS. Robots do not inherently hold intelligence, but are tools designed to complete specific tasks. Robotic systems in the military are frequently used to undertake dull, dirty or dangerous tasks on behalf of humans.

AUTONOMY

Can be considered as the characteristic of a system, most often using AI, to determine its own course of action by making its own decisions. Autonomy of varying levels may be conveyed upon on either hardware or software.

ARTIFICIAL INTELLIGENCE

AI can be considered as technology that allows machines to think or act in a human way. Modern AI is usually, but not exclusively, linked to Machine Learning (ML). Both ML and more recently, deep-learning enable machines to learn in much the same way as a human would.

DATA

DATA

Data powers AI and as such, is perceived as a strategic asset. Without data that is accurate, formatted, structured and accessible, there is no possibility of AI performing the task asked of it.

ALGORITHMS

Algorithms are the coded set of instructions that AI uses to perform a function. As a task-specific set of rules, algorithms are inherently narrow and prevent machines from understanding the subtleties or context which humans can appreciate.

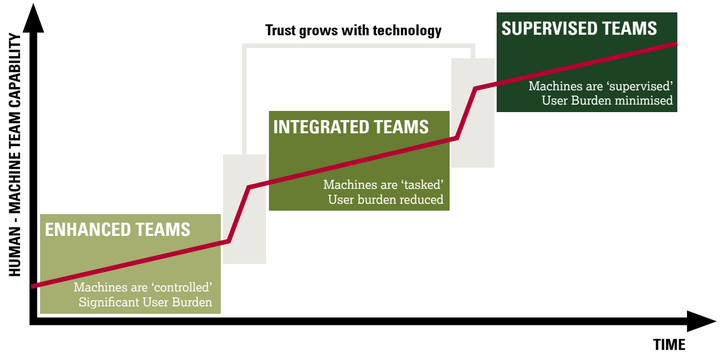
ARCHITECTURES

Architecture defines how data is passed throughout a network of hardware and software in accordance with a set of common standards. The architecture therefore defines how all elements of the system are able to operate together.

PEOPLE

PEOPLE

Successful adoption of RAS requires a cultural change that is underpinned by an appreciation of what the whole system – bound by regulation and policy – is capable of. It will require robust management of expectations to balance the hyperbole with technical understanding.



HUMAN MACHINE TEAMS

Until AI enables broader comprehension by machines, humans will remain at the heart of all HMT. Integrating the optimum blend of humans and machines alongside existing military capability will be required. As HMT evolve in stride with technology, the nature of the relationship between humans and machines will change driven by communication these include, for example: transparent AI; reinforcement learning; swarm robotics; Verbal Command Enabled Technologies; and Low / No code applications. The evolution of HMT will see us introduce new capabilities at the speed technology allows.

- **RAS Enhanced Teams**
  Machines are used in a transactional sense, as tools, limited by human levels of trust and machines' levels of autonomy. RAS will be employed in addition to an existing force structure which enables an increase in performance of a human task.

- **RAS Integrated Teams**
  As both technology and trust grow, so will the relationships, with humans ceding more control to increasingly powerful AI which requires less supervision.
  RAS will be embedded by design in the force structure, where both humans and machines perform tasks that integrate to achieve a combined outcome.

- **RAS Supervised Teams**
  Machines are able to outperform humans and therefore require only supervision to retain meaningful human control.

THE TRANSFORMATIONAL CHALLENGE

Both friendly and adversary forces are in a race to exploit the same technology, often available to both. There is also a similar competitive tension between militaries that seek to exploit powerful AI, and regulators whose intent is to ensure the ethical, safe and assured use of RAS which may yield lethal force. The future force will have to learn not only to fight alongside but also against our adversaries RAS.

Harnessing the power of RAS has the potential to equip our forces to defeat capable enemies and maintain overmatch through increasing the combat mass and tempo of operation whilst reducing the levels of risk imposed and the cognitive burned to our soldiers and commanders. Within the future force RAS will be continue to be employed within HMT.

Autonomy and AI bring new challenges to security, exacerbated by their lack of 'sense' or 'suspicion'. A systematic approach to vulnerability identification, hardening and system survivability will better prepare the Army for the likely threats. Protecting systems from attack is vital to prevent erosion of human trust in machines.

PART 3: THE ENDS

INFORMATION AGE.

Although the visceral nature of warfare remains a constant, by 2035 the character of warfare will have been transformed by the pace of technological change and pervasiveness of information.

Strategic Context.
The traditional boundaries between war and peace will blur and require the UK and our allies to respond rapidly to sources of instability such as pandemics and humanitarian crises. Western militaries will face local overmatch through massed attacks where numerous low-tech devices act in concert.

The Threat.
Adversaries will avoid the complexities of the Information Age battlefield by aiming to win without fighting. Threats will be typified by cheap commercial technologies, deployed in large numbers in fast, small and stealthy teams.

By contrast, the most dangerous threat remains warfighting in Europe for which we must be prepared for, when escalation replaces deterrence. In a competition for global influence, the UK will also be forced to compete in Africa and Indo-Pacific regions against an amalgam of traditional military hardware and low-cost technology in both the physical and virtual dimensions.

Urbanisation.
Urban environments in the Information Age present a confluence of factors which make land operations highly likely and exceptionally demanding. High human density, a congested electro-magnetic spectrum, complex terrain and huge constellations of sensors and data all converge to create the most challenging operational scenario for the employment of RAS.

THE BENEFITS OF RAS.

Building on a decade of investment in people, data and technology, fielding new RAS technology to any part of a digitally upskilled Field Army will become faster and easier. Increasingly lethal, survivable and mobile systems will push further forward in the direct fire zone with a generation of junior Commanders who have no experience of operating and fighting without RAS.

A RAS enabled force will use technology to gain operational advantage in the Land Domain in three areas:

1. **Mass.** Increasingly autonomous ground and air systems, including those of our allies and partners, will allow the Army to aggregate greater combat power through integrated HMT whilst reducing human density in close combat roles. In the future RAS will offer greater political choice with a larger range of military options available.
2. **Tempo.** RAS will bring opportunities to deliver more rapid and concentrated effect, measured relative to an adversary. Speed and quality of decision making are not sufficient in isolation, action must follow. RAS will allow for the integration of multiple sensors with the most appropriate decision maker and the best effector to gain and hold the initiative by dominating the decision-action cycle.
3. **Risk Reduction.** The introduction of RAS will enable soldiers to increasingly stand-off whilst still delivering precision effect. Metal before flesh will become the norm as robotic or autonomous systems conduct a wider range of dull, dirty and dangerous roles. Considering some RAS as sacrificial in this way will also create opportunity to reduce risk of mission failure.

15 – Year Horizon
This approach sets a 15-year horizon , benchmarked against the Integrated Operating Concept and Future Land Combat System. Realising the goals of both will require a Generational and Transformation Change to have been achieved by 2035.

PART 3: THE ENDS

EMPLOYMENT OF RAS.

RAS is expected to deliver a number of significant functional and operational advantages.

Across all Protect, Engage, Constrain and Warfighting operations there will be significant growth in the situational awareness and understanding generated by AI enabled sensors, which when coupled with rapid decision making and highly capable effectors, will increase operational advantage.

Software, not hardware, will increasingly become where competitive advantage is gained.

The advantages described here are illustrative and will be tested and quantified through demonstration and experimentation.

PROTECT

- Un-crewed systems are deployed to provide situational awareness and deliver aid to remote regions in response to civil emergencies.
- Hardening critical infrastructure with rapidly deployable counter-drone capabilities and long range ISTAR to survey UK borders.
- Networked sensors provide persistent coverage to understand areas of vulnerability, with data fused and analysed by flexible and adaptable AI-based mission systems.

ENGAGE

- Forward-deployed Human-Machine Teams influence, deter or reassure across the globe.
- A series of human-machine networks integrated through forward-based global hubs gather, assure and fuse data.
- Training and exercising with allies and partners enhance our collective ability to integrate combat power by aggregating increasingly capable un-crewed systems.
- The deployment of cutting edge UK technology for development on operations, the Army underscores Global Britain's credibility and contributes to prosperity.

CONSTRAIN

- Proactively and assertively preventing adversaries from achieving their aims by dominating the decision-action cycle.
- Harnessing an resilient digital backbone, autonomous targeting Air and un-crewed systems Defence act offensively.
- Covert and overt activities utilising small, AI enabled ground and air sensors. Enabling rapid escalation to the use of force by contesting across domains by linking a constellation of sensors with effectors.
- AI enabled decision-support tools enable commanders to make nuanced judgements about risk.

WAR FIGHT

- Un-crewed systems provide a flexible network to deliver deception operations across the multi-domain operating environment.
- Reducing the physical and cognitive burden for soldiers and commanders so increasing tempo.
- Enhancing the sustainment of troops through autonomous resupply by ground and air.
- Increased lethality by the integration of un-crewed systems with armour, PM and aviation enhanced through swarming AI and autonomy.
- RAS has the potential to bring about decisive effects in a substantially shorter timeframe than has been previously possible.

PART 4: WAYS

To leverage the full potential of RAS requires an integrated approach to capability development.

Interdependent and mutually supporting themes of people, data and technology will undergo generational change to deliver a modern capability that can be constantly adapted in response to both threats and opportunities.

Key to aligning and delivering these themes are development of suitable **processes** and **trust**, all of which underpin the effective employment of technology.

THE CENTRAL ROLE OF TRUST

Trust is a complex and multi-layered concept, which must be optimised rather than simply maximised. Too much trust and operators become reliant upon a system they may not fully understand or agree with; too little and highly capable machines will not be permitted to compensate for the inadequacies of human intelligence.

The military has a challenge to overcome due to the inherent distrust created by the narrative surrounding 'killer robots'.

The solution requires action on three fronts:

- Soldiers must trust machines to optimise human-machine team performance;
- Military regulators must trust soldiers, to enable suitable policy and permissions;
- Society must trust the military regulators.

"The UK will only feel the full benefits of AI if all parts of society have full confidence in the science and the technologies, and in the governance and regulation that enable them."

UK AI Strategy

PEOPLE

The Army will develop a diverse new generation of men and women who, whilst retaining a warfighting ethos, are equipped with a digital skillset that enables the whole force to operate and fight modern conflict.

Understanding why and how data must flow at machine speed to integrate sensors, deciders and effectors will be baseline from which education and professionalisation continues through service.

Operating Concepts

- Operational employment of RAS will require new ways of operating and fighting, well beyond a 'like for like' replacement of legacy crewed platforms
- Ongoing iterations of experimentation and open Systems Architecture will ensure new technology can be continually added and improved, creating revised operating concepts that take full advantage of more capable systems and sub-systems.

Ethical and Trustworthy AI

- Military commanders will remain wholly accountable for the actions taken by RAS, with increasing confidence in AI and ML, military systems will always retain a 'safety catch'.
- An AI ethical framework will describe the principles the Army uses to ensure its AI respects the rules, conventions and protocols of war by complying with the existing ethical foundations that underpins our fighting power.
- AI assurance must be explainable, demonstrably trustworthy and secure.

Governance, Safety and Assurance

- The Army will work closely with the Defence Safety Authority and all subordinate Regulators, to develop agility in its Test & Evaluation processes that will have to match the rate of technical development.
- A significant cultural shift is required to manage the risks of 'prototype warfare' and unpredictable innovation. This will allow the Policy and Legal permissions to be in place ready for operational use of new systems.

DATA

The Army will develop a digitally aware culture that recognises the strategic importance of all our data. Managing the data that will be decisive in the next war and should have already started.

With clear governance in place, the Army will ensure its data is: Sovereign where necessary; enduring; curated; standardised; exploitable; secure and digital by design. Anything less is to build in critical flaws that will reduce operational advantage.

Digital Skills

- The Army will produce a force with the right skills, roles and mix of people that are able to deliver and sustain the capabilities of the information age.
- Digital skills will be developed through a service career with increased options for talent management whilst benefitting from strengthened relationships with industry, other Government Departments and academia.

Data Management

- A data-driven Army will require common protocols and the ability to safely establish shared cryptographic protocols. The publication of these will allow allies to integrate securely into the existing network, allowing for deeper integration of different nations assets.
- A robust set of Data Management principles will be developed to shape the ownership, management and exploitation of data.

Resilient Digital Backbone

- HMT and RAS are critically dependent on the timely exchange of appropriate data via sufficiently robust and reliable communications bearers and networks. Gateways between systems will be required to enable data transfer from RAS to secure communications systems.
- Operational data flows will be designed for interoperability and efficiency; early effort in defining and realising appropriate information architectures is essential.

TECH

The Army will develop a wide array of physical sensors and effectors that can see, shift or shoot across the whole battlefield. This hardware will have varying degrees of autonomy but never at the expense of meaningful human control.

Expensive, crewed platforms that cannot be quickly replaced will be increasingly reliant upon autonomous ground, air and subterranean systems to increase mobility, lethality and survivability.

Power

- The proliferation of sensors, computers and RAS systems, coupled with the option for increased stand-off ranges and endurances, will greatly increase the demand for electrical power.
- New capabilities for power harvesting, power generation and power distribution will be necessary. Reducing charge times will rely on advanced power cells. RAS power limitations will necessitate a trade-off between its sensing and processing ability and its operational endurance.

Level of autonomy

- Iterative development of new Operating Concepts will allow for varying levels of autonomy at different stages of the decision-action cycle.
- Levels of autonomy will be determined by the environmental complexity, mission complexity and distance from human control.
- Iterative development of autonomy in line with refined Operating Concepts will be crucial to design the appropriate level of autonomy into the correct stage of the system.

Procurement Process

- A portfolio-based approach, with a refined definition of 'in-service' will enable spiral acquisition, informed by high-quality evidence gained through a stable multi-year experimentation plan.
- Introducing RAS as a core capability will require wholesale digital transformation as the focus swings from bespoke hardware to COTS software.

PART 5: MEANS

The RAS Capability Head marks provide clear and incremental direction of the implementation of RAS. The Capability head marks have been designed as an iterative approach to capability development, by identifying realistic challenges that need to be addressed, and the subsequent capability enablers that need to be put in place.

A prioritised and iterative programme of work following the **discover, develop, deliver** approach is outlined below to achieve each 5-year capability head mark. This is intended to be a broad overview, and over time the programme of work will be refined based on the maturity of Technology, Data and People.

EPOCH 1

By 2025, a RAS enhanced Brigade Combat Team (Light). In 2025 a Bde will be teamed with organic tactical RAS, fully integrated into a tactical mesh network. The Bde will be RAS augmented, with ambition to mature Urban CONOPs, TTPs and inform Balance of Investment decisions for the 2030 integrated Bde Combat Team (Deep Recce Strike) concept.

2025

EPOCH 2

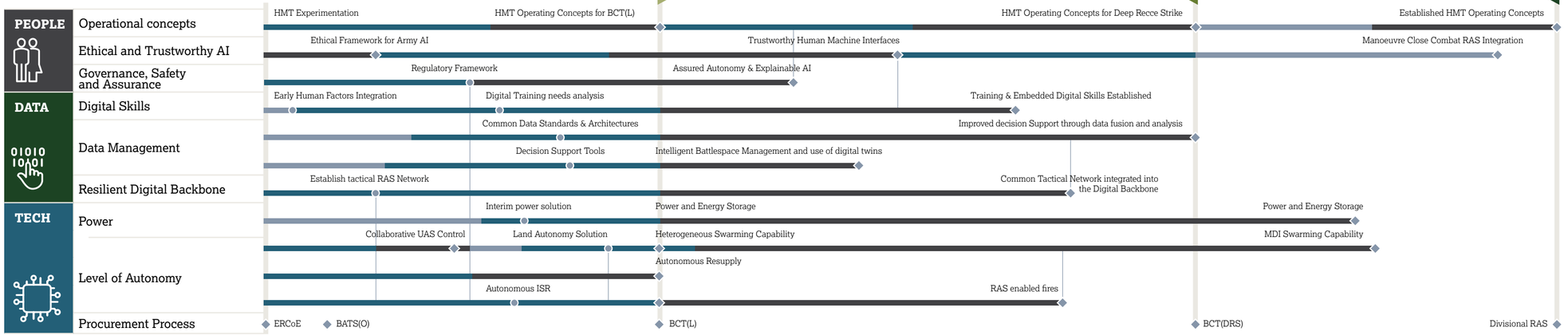
By 2030, RAS integrated Brigade Combat Teams. In 2030 RAS BCTs will see a new generation of medium-weight vehicles and robotic systems that are networked and sustained to fight independently at reach, as an integrated, self-reliant 'system of systems'. This enables a formation to operate dispersed at high tempo with lethality at reach through networked capabilities.

2030

EPOCH 3

By 2035, RAS widely integrated across the Division at every level. Building on a decade of investment in people, data and technology, fielding new RAS technology to any part of a digitally upskilled Field Army will become faster and easier. Increasingly lethal, survivable and mobile systems will push further forward in the direct fire zone with a generation of junior Commanders who have no experience of operating and fighting without RAS.

2035



A POSITIVE CHANGE IN OPERATIONAL OUTCOMES

It is expected that the implementation of these capability head marks will enable the following operational outcomes:

- **Command.** Reduced cognitive load on the soldier through faster, more effective decision making.
- **Intelligence**. Increased situational awareness enabled through greater fusion and exploitation of data.
- **Manoeuvre.** Increased tactical mobility through pre-emptive manoeuvre support and a more agile and adaptable force.
- **Fires.** Improved survivability through greater dispersion and an intelligent and faster sensor-shooter loop.
- **Capacity Building.** Increased awareness and capacity at reach.
- **Information activities.** Ability to rapidly generate credible deception.
- **Sustainment.** Better resourced force using predictive sustainment.
- **Protection.** Reduced physical signature through smaller force elements and passive protection.

Key

- Minimum viable capability
- Mature capability
- Discover
- Develop
- Deliver

PART 5: MEANS

There is a need to build momentum; laying the organisational foundations for a systemic approach to RAS adoption, building knowledge and confidence, and increasing the evidence to inform plans.

This will require co-ordinated approach across governance, Research and Experimentation, data and collaborative effort. This section sets out the delivery principles which will need to be adopted to achieve progress over the next 5 year period.

DELIVERY PRINCIPLES

- Focus on fielding capability for mission success
- Concurrent Delivery, Development and Discovery
- Conduct daring but rigorous experimentation
- Insist on a Systems approach to integrate RAS design
- Integrate with industry, allies and partners

Governance.

From within the Army HQ Futures Directorate, the Head of Future Force Development will be the lead proponent for the adoption and integration of Robotic and Autonomous Systems. This will include the co-ordination across existing CONDEV, CAPDEV and WARDEV, in line with the Modernisation and Transformation Strategy. Direction and oversight will be provided on a regular basis through the Army Force Development Committee, with the necessary Safety, Policy and Permissions being assured as when appropriate.

Measuring Progress.

A benefits framework will be used to assess progress against quantifiable operational advantage gained by the stated headmark capabilities, and the subsequently costed implementation plan for the first Epoch.

Fielding Capability.

An obsessive yet precise pursuit of the technology which can be rapidly fielded to deliver immediate benefit in response to specific military challenges. Research, Concept Development and Experimentation programmes will have engaged sponsors with clear exploitation routes to deliver capability on operations.

Concurrent Discovery, Development and Delivery.

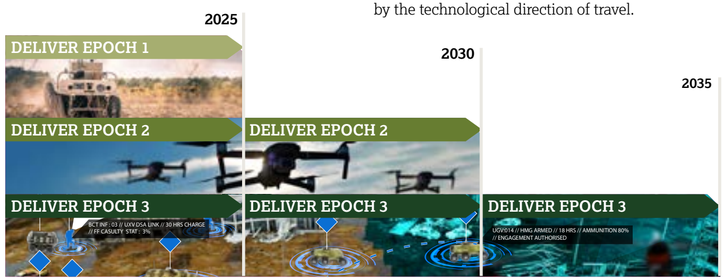
The growth of technology in both Defence and the civilian sectors means a different procurement approach is required to ensure capability delivery at the pace of technological relevance.

This approach must ***discover***, ***develop*** and ***deliver*** concurrently driving forward each 5-year epoch in series, with each influencing and supporting the other.

In each 5 year period, it will:

- Deliver mature capability for Epoch 1;
- Develop the technology and key enablers for Epoch 2;
- Discover the emerging technology which can be accelerated to enable Epoch 3.

Concurrency will ensure that mature capability can be delivered with the future at its core, it is both prepared for and driven by the technological direction of travel.



Experimentation.

Continual innovation will be the dominant quality of the future force; through experimentation in representative environments commands can better understand the operation of RAS and its enabling technologies, gaining vital insights to not only support new TTPs, CONOPs and empower the operator to fail faster – learn - adapt and ultimately succeed faster.

Evidence outputs can influence changes in procurement, legislation, regulations and acceptance to create a more agile and energised route into service. This will only succeed if appropriate links and collaborative opportunities are made.

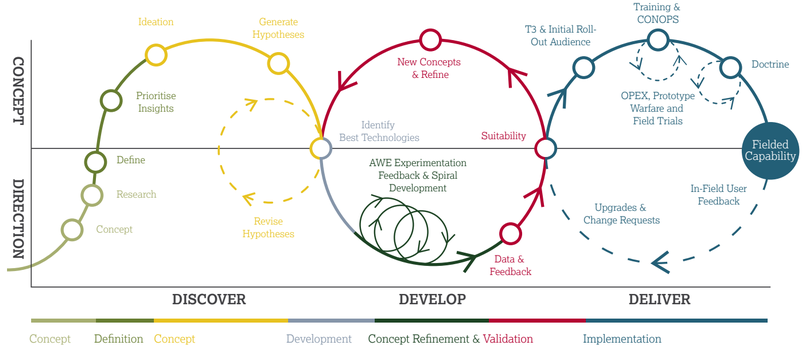
Done well, iterative concept development and experimentation will mature concepts into capability.

Capability as a system.

Substantially increased digital skills across the delivery organisations will allow prioritised resource to be applied across the system, with investment balanced across people, data and technology.

Integration with Industry, Allies and Partners.

The Army's new industrial strategy will reset the relationship with industry, providing transparency and certainty, to enable investment. Delivering capability now, while developing those needed for the future and researching the areas of greatest potential. Investment in the skills that are critical to the development of the future force to nourish the UK industry. A stable resource baseline will underpin strengthened relationships.



DELIVERY AGENTS

The Army will adopt an integrated effort from land facing delivery agents in focused Research and Development, Capability Development and Experimentation and Exploitation of RAS into the Future Force. Delivery Agents will inform requirements, build knowledge and evidence, build confidence and demonstrate candidate capabilities at pace. The Army will collaborate and consult widely to accelerate RAS into the force.

DRAFT TECHNICAL TERMINOLOGY

Pending official Defence Terminology, this approach has utilised the below technical terminology. It is caveated that this terminology will change based on Defence guidance.

Anti-Access Area Denial (A2AD)	By 2035, many of our potential adversaries will have capabilities designed to prevent our access to the maritime, air, land, space and cyber/electromagnetic domains. Defence will need to overcome the challenges of anti‑access area denial, potentially fighting through to deliver the required effect. The range, resilience and survivability of our capabilities in every environment will become critical factors in maintaining access and our freedom of manoeuvre. (FOE 35)
Artificial Intelligence (AI)	For over half a century, the definitions of AI have necessarily evolved as technology develops. In simple terms AI can be considered as technology that allows machines to think or act in a human way. Modern AI is usually, but not exclusively, linked to a field of data science called Machine Learning (ML). Both ML and more recently, deep-learning – a further sub-field of ML – enable machines to learn in much the same way as a human would.
Algorithm	Algorithms are the coded set of instructions that AI uses to perform a function. As a task-specific set of rules, algorithms are inherently narrow and prevent machines from understanding the subtleties or context which humans can appreciate.
Architecture	Architecture defines how data is passed throughout a network of hardware and software in accordance with a set of common standards. The network architecture defines how all elements of the system are able to operate together.
Automation	An automated system is one that has been instructed to perform a set of specific tasks or series of tasks within well understood parameters. This type of technology is designed and built to perform a specific function repeatedly and efficiently.
Automated System	In the un-crewed vehicle or platform context, an automated or automatic system is one that, in response to inputs from one or more sensors, is programmed to logically follow a predefined set of rules in order to provide an outcome. Knowing the set of rules under which it is operating means that its output is predictable. (JDP 0-01.1)
Autonomy	The characteristic of a system use a combination of Data Science, machine learning and artificial intelligence to determine its own course of action by making its own decisions. (DSTL/PUB126301)
Data	Data as a general concept refers to the fact that some existing information or knowledge is represented or coded in some form suitable for better usage or processing. Data is measured, collected and reported, and analysed, whereupon it can be visualized using graphs, images or other analysis tools. (KiD)
Data Science	The extraction of useful insights or knowledge from structured and unstructured data from a multi-disciplinary field that uses scientific methods, processes, algorithms.
Digital Backbone	A secure, singular, modern Digital means to connect sensors, effectors and deciders across military and business domains and with partners, driving integration and interoperability across domains and platforms. (20210421_-_MOD_Digital_Strategy_-_Update_-_Final)
Digitisation	The process of converting information into the digital codes stored and processed by computers. (KiD)
Digitalisation	Digitisation is a transformational process referring to the collective technological advances and exploitation in computing power, data collection, advanced data analytics, artificial intelligence, processing and storage and networking between computer devices, which may alter how defence plans for future wars and conflict. (FFD working definition)
Expeditionary Robotics Centre of Expertise (ERCoE)	The ERCoE will bring together robotics and autonomous systems experts from across defence, government, academia and industry and aligns with DE&S' strategy to deliver the edge through people, technology and innovation. (DE&S FCG Definition)
Experimentation	Controlled and directed activities designed to discover new information about an idea or concept, test a hypothesis or validate a solution or choice, with the primary purpose of generating evidence for force development. (UK Defence Force Development Board definition - Oct 19)
Hybrid Warfare	A form of warfare combining conventional and unconventional military and non-military actions to achieve a specific goal. (This definition is currently proposed and awaiting NATO agreement).
Human Factors (HF)	A scientific discipline concerned with the understanding of interactions amongst human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance. (KiD)
Human Factors Integration (HFI)	A systematic process for identifying, tracking and resolving human-related issues to ensure a balanced development of both technological and human aspects of capability. (KiD)
Human-Machine Team (HMT)	Human-machine teaming articulates the challenges and opportunities that robotic and artificial intelligence (AI) technologies offer, and identifies how we achieve military advantage through human-machine teams. (JCN 1/18)
Interoperability	The ability to act together coherently, effectively and efficiently to achieve Allied tactical, operational and strategic objectives. (NATOTerm)
Information Advantage	The competitive advantage gained through the continuous, adaptive, decisive and resilient employment of information and information systems. (JCN 1/18)
Information Environment	An environment comprised of the information itself; the individuals, organisations and systems that receive, process and convey the information; and the cognitive, virtual and physical space in which this occurs. (AJP-3.10.1 – not NATO Agreed)
Machine Learning (ML)	Machine Learning is used to create systems which can automatically learn the relationship between input data and defined outputs without being explicitly programmed to do so. In simple terms it allows the system to learn as it goes. (DSTL/PUB115968)
Multi-Domain Integration (MDI)	The posturing of military capabilities in concert with other instruments of national power, allies and partners; configured to sense, understand and orchestrate effects at the optimal tempo, across the operational domains and levels of warfare. (JCN 1/20)
Quantum Technologies	A quantum computer is one that makes use of the quantum states of subatomic particles to store information. (JCN 1/17)
Standards (Compliance)	The quality, exhibited by systems / solutions designs, of complying with the relevant standards. Standards compliance drives interoperability and coherence between systems.(KiD)
Systems of Systems (SoS) approach	An approach to doing SoS analysis, systems design and systems and equipment acquisition based on proven (field-tested and found to be successful) SoS and related methods and disciplines that is tailored to the UK Defence Enterprise. MOD SOSA includes methods and techniques from Systems Engineering, Project Management, Engineering Management, Requirements Engineering and a range of related disciplines. (KiD)
RAS Enhanced	RAS employed in addition to an existing force structure to enable an increase in performance of a human task. (FFD working definition)
RAS Integrated	RAS embedded by design in a force structure, where both humans and machines perform tasks that integrate to achieve a combined outcome. (FFD working definition)
Robotic or Un-crewed System	Machines that carry out complicated actions independently of, or in conjunction with, humans. Robotic systems usually provide the physical aspect of autonomous systems which are fuelled by the data processing techniques such as AI and Machine learning. (JCN 1/17)
Swarm (behaviour / intelligence)	Swarming is the collective behaviour of multiple of the same (homogeneous) or different (heterogeneous) system types, working together to achieve a combined objective and employing an element of shared intelligence. (FFD working definition)
Tempo	The rate of military action relative to the enemy. (NATOTerm)
Trust	The willingness to accept one's vulnerability for relying on the behaviour of another; if the risks and the uncertainty that this interdependence imply are counterbalanced by the positive expectation on their intentions and actions… and irrespective of the ability to monitor or control that other party.

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