A Frost & Sullivan White Paper

Artificial Intelligence and Cloud Computing for Defense and Intelligence

Leveraging commercial technology to improve military operations

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EXECUTIVE SUMMARY

Implementing proven commercial solutions in the deployed environment

The digital transformation of military operations taking place globally is driving exciting growth and capabilities. There are many opportunities for defense and intelligence organizations to improve their day-to-day operations while benefiting from cost efficiencies. The Internet of Things (IoT) concept is helping to rapidly mature sensors, networks, data analytics, and visualization tools. Artificial intelligence and cloud computing are key technology enablers for IoT, and are improving the effectiveness and safety of deployed military forces.

To enhance mission accomplishment and troop safety, defense and intelligence agencies around the world are increasingly turning to commercial information technology (IT). The unexpected and wide-spread requirement for remote work due to the COVID-19 outbreak has accelerated the use of commercially available web-based conferencing and collaboration tools. Advances in computing power, mobile networks, software, security, sensors, cloud computing, artificial intelligence (AI), and a variety of other innovative technologies are helping improve day-to-day operations for military base personnel, remote home workers, and troops in deployed locations. Defense and Intelligence agency users find that AI and cloud computing systems help free up time so they can complete essential tasks quicker and more efficiently.

Initially adopted by defense and intelligence agencies for enterprise networks, AI and cloud computing are now increasingly contributing to operational success for troops in remote and austere environments with limited infrastructure.

The need to adapt for the COVID-19 response, including social distancing and increased remote working, has pushed the adoption of commercial cloud-based audio/video and data sharing conferencing tools. Defense and intelligence organizations have quickly adapted, and like many large civilian companies, have been able to quickly expand the scale of these networks to maintain critical functions and work flexibility, using proven and secure commercial solutions.

By adopting mature commercial AI capabilities, defense and intelligence units, deployed forces, and personnel are enhancing their missions and learning opportunities. In addition, deployed units are able to decrease communications network complexity, gain more reliability, reduce security gaps, scale resources up or down depending on requirements, and upgrade to advanced software and hardware as

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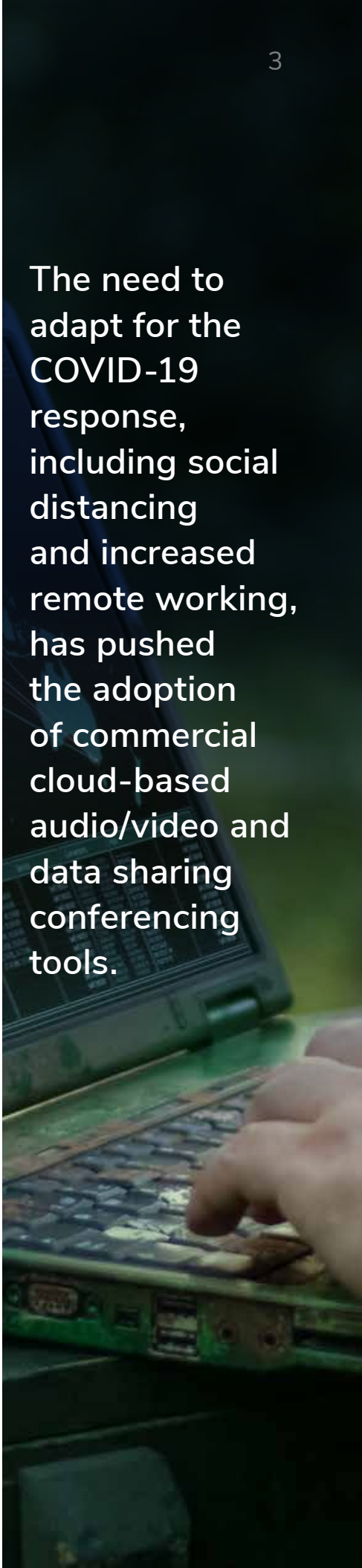
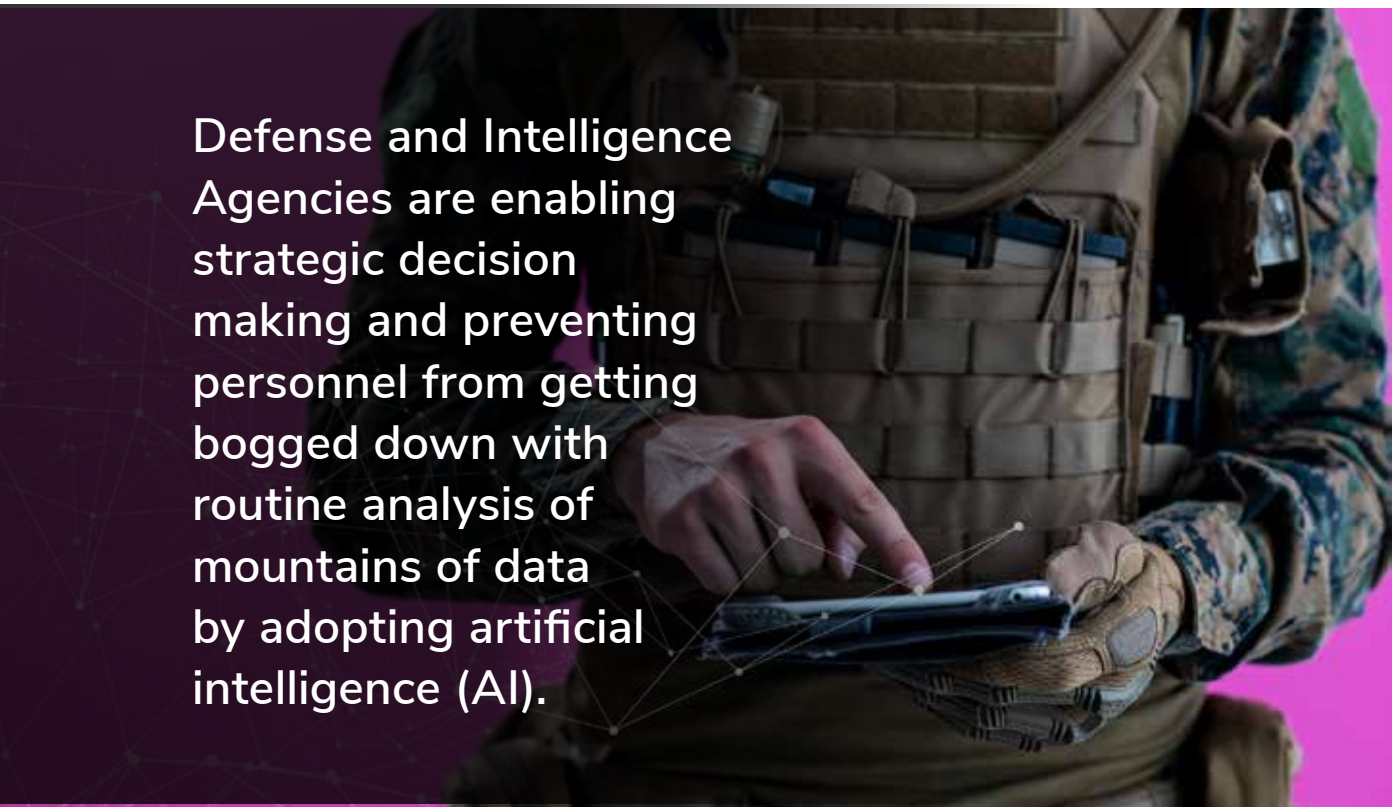


it becomes available. Currently, due to legacy and siloed IT systems, organizations often find they have a wealth of data available, but cannot leverage it properly, because it exists in various formats and is not well organized. Modern commercial products can help make sense of their existing data and improve collaboration.



PART 1: INTRODUCTION TO ARTIFICIAL INTELLIGENCE (AI), CLOUD COMPUTING, AND DEPLOYED USERS

General Definition of Artificial Intelligence

Machines are informing human decision-making by classifying and organizing an exponentially increasing amount of data gathered by various systems. To enable strategic decision-making and prevent personnel from getting bogged down with routine analysis of mountains of data, defense and intelligence agencies are adopting artificial intelligence (AI). To better grasp the capabilities of AI, it is useful to understand machine learning (ML), deep learning (DL), and computer vision (CV) concepts.

Artificial Intelligence (AI)—AI is essentially programming computer systems to act with human intelligence. Behaviors associated with human intelligence that can be demonstrated through AI include: learning, reasoning, planning, solving problems, recognizing motion, perception, tool manipulation, and to a lesser degree, creativity and social skills. Information that enables AI can

be gathered from a number of different sources including sensors, communications devices, and computer networks.

Machine Learning (ML)—This is the practice of using algorithms to parse, process, and learn from huge amounts of data, and then make predictions or forecast based on patterns. At its core, ML is the method for achieving AI. ML is normally divided into three elements: supervised learning, unsupervised learning, and semi-supervised learning.

- Supervised learning is a common technique where AI models are trained by inputting large amounts of labeled data. Supervised learning algorithms search for patterns in labeled data that correlate with the desired outputs. Once trained, a supervised learning algorithm can take in new, unlabeled inputs and determine how to label the new inputs based on prior training data. Essentially, supervised learning is learning by example. This is the methodology used for the process of object identification and, in general, for instances where the expected output is known.

- Unsupervised learning refers to ML algorithms that search for patterns in unlabeled data. This is more complex than supervised learning because there are no training data sets or specified outcomes. AI is left to determine what it thinks are similarities and group data as it sees fit. Clustering algorithms are used to determine patterns and group similar sets of data. AI can determine the likely number of clusters in the data as well as the granularity required when separating data into clusters. Unsupervised learning is the preferred methodology when data needs to be categorized. This is the methodology used when people say a computer is "teaching itself."

- Semi-supervised learning is a mix of supervised and unsupervised learning. This occurs when AI is programmed to work with both labeled and unlabeled data. An example of this might be a photo archive that requires descriptions of photos, perhaps to enable a search function, with some being labeled as "cat", "dog", "person", while other photos contain no information at all. Many current problems are solved with this method because labeling data normally requires human input and is time consuming and expensive. Utilizing a small number of labeled items can, in essence, help supervise an otherwise unsupervised AI.

Deep learning and neural networks—Deep learning is a technique for implementing ML wherein brain-inspired neural networks made up of a massive number of layers are infused with interconnected algorithms that can be trained to carry out very specific computational operations. This happens by modifying the importance of input data as it passes between the network layers. It is akin to a gold prospector using a series of progressively smaller filters to separate pebbles from rocks, then granules from pebbles, until all that remains are the gold flakes. This type of computing was not practical until the emergence of graphics processing units (GPUs) and their parallel processing architectures.

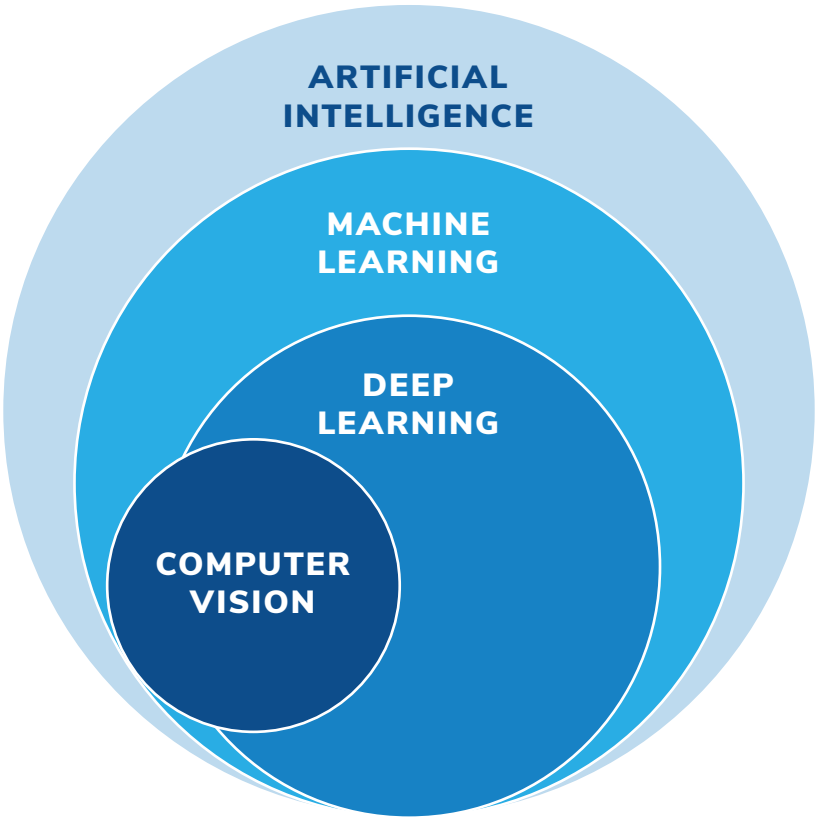
Computer vision (CV)—CV is the ability of a machine to understand visual data and process it like a human eye would. It is essentially applying AI to the visual world. While CV is AI, it is a subset

because it only applies to video and images. ML and more specifically deep learning have rapidly advanced the capabilities of CV. CV generally consists of:

- Acquiring the image
- Processing the image
- Analyzing and understanding the image

Today's AI systems can now take actions after they understand the image. These actions include, but are not limited to: information retrieval, image analysis, edge detection, pattern detection, and object detection.

FIGURE 1: HIERARCHY OF ARTIFICIAL INTELLIGENCE, GLOBAL, 2020



How artificial intelligence and cloud computing enable vision and collaboration

AI for defense is made up of algorithms that help identify, categorize, and provide indications and warnings. AI can help improve the ability of automated systems to aid in complex tasks. Data provided by sensor and communications systems is analyzed based on pre-determined focus areas. Cloud computing allows troops in geographically separated areas to access sensor and communications systems. Existing and newly collected data can be integrated and processed. Cloud computing provides deployed units with a secure, accessible, and flexible environment. AI tools help process data stored in the deployed cloud and provide the unique essential elements of information demanded by each commander.

Deployed commanders and analysts on the edge are often overwhelmed with data derived from a large variety and number of sensors, communications links, and systems. These unit leaders need AI and cloud computing technologies to help analyze and visualize the data, so they can make decisions quickly and communicate orders. Commercial software and networking tools help to quickly clarify and prioritize actions. In addition, since the onset of the COVID-19 Pandemic, on-line team meeting solutions are in high demand and are an essential part of mission accomplishment.

Artificial Intelligence and Cloud Computing deployed user concept of operations

Advances in commercial IT technology are enabling defense and intelligence agencies to take advantage of artificial intelligence and cloud computing. Deployed troops and staff users at the edge of the network are also taking advantage of small form factor advanced computing power and scaled analysis and reporting tools. Modern commercially available IT products enable the inherent speed and scalability of artificial intelligence and cloud computing to improve sensor and network operations in the field.

The concept for deployed forces is similar to the adoption of the civilian Internet of Things (IoT). Defense and intelligence agencies are also networking sensor nodes to scalable cloud systems and applying artificial intelligence to analyze sensor data, and present results in a way that enables rapid and accurate decision making. An additional benefit for deployed users is the mobility and efficient use of limited bandwidth that deployable and scalable IoT technology provides.

PART 2: OVERVIEW OF ARTIFICIAL INTELLIGENCE AND CLOUD COMPUTING SOLUTIONS FOR DEPLOYED MILITARY USERS

Operational Imperatives

Advanced defense and intelligence organizations around the world are taking advantage of scalable commercial artificial intelligence and cloud computing products. Military operations normally utilize three levels of cloud computing and artificial intelligence tools; the base enterprise, the deployed unit, and the specific-mission edge levels.

Enterprise Cloud Computing—These systems have the computing power and IT architectures that can make use of the most advanced cloud services and artificial intelligence applications available. Large scale transportation, logistics, maintenance, healthcare, planning, and intelligence are some of the missions that have this type of high level analysis and collaboration.

Deployed Cloud Computing—For deployed units, smaller form factor computers and a medium-scale cloud and artificial intelligence architecture is used. The systems are very capable and can be networked via satellite communications to the larger enterprise as required. A local deployed commander is able to analyze data from their systems and collaborate up and down the chain-of-command.

Edge Cloud Computing—Small form factor computers and smaller scale cloud and artificial intelligence resources are placed with key units and systems where increased mobility and reduced power and bandwidth requirements are important. By dispersing the cloud and analysis capability, sensor data and analysis needed for immediate use is quickly available and can be efficiently shared without eating up limited communications bandwidth available at the edge. Very specific artificial intelligence algorithms are leveraged to help decision making, and the data is shared quickly with those who need it most.

Global defense and intelligence agency leaders and acquisition officials recognize that standards-based commercial IT products provide easier integration, technology upgrades, and training. Commercial products offer more purchasing options and contract vehicles and can be scaled to the level of the environment required. Commercial hardware and most other types of software are now routinely used in the design and function of most platforms, systems, and communications at all levels. Now, both enterprises with many users, as well as small groups of users at the edge can have access to powerful artificial intelligence and cloud computing tools.

Future commercial integration for deployable defense and intelligence IT Systems

Current and future military IT systems designers are working to leverage commercial products to improve their digital posture. By integrating commercial IT, they can build networks that are less complex, and still gain security, mobility, and bandwidth efficiency advantages. Artificial intelligence and cloud computing solutions for deployed users are a high priority. Sensor data, AI algorithms, and cloud-based networks are required to help deployed edge staff members accomplish a wide variety of tasks and missions.

Artificial intelligence and cloud computing are the key to empower defense and intelligence digitization and multi-domain operations while enhancing security and network survivability. Data from sensors is the foundation for fast and accurate decision making. Commanders at all levels benefit from automated data analysis and cloud computing flexibility and scalability. Deployed troops need these technologies to help anticipate potential problems and develop solutions quickly and early.

PART 3: COMMERCIAL TECHNOLOGY USE CASES IN THE DEPLOYED ENVIRONMENT

Artificial intelligence and cloud computing are utilized in almost all aspects of defense and intelligence operations. Use cases include:

Logistics/MRO	Just-in-time delivery	Test & Measurement-Predictive Analytics
Command & Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR)	Bridging the national level-deployed level coordination gap	Systems, Teaming, and Edge users
Special Operations	Intelligence responsiveness and accuracy	State-of-the-Art commercial technology applied to immediate problems
Ground Forces	SWaP for ad hoc, seamless, self-healing, locational mobile data/voice/video networks	Apps for Troops
Air Forces	Deployment Management Systems	Engine, Sensor, and Airframe efficiency
Naval Forces	Digital Twins	Unmanned Networked Sensors
Allied Forces/ Disaster Relief	Weather Prediction & Scientific Modeling	Situation Assessment, Coordination, and Asset Deployment Prioritization
Learning & Simulation	Distributed Education	Gaming & Augmented Reality
Healthcare	Telehealth and remote consultations/surgery CBRNE detection and mitigation	Embedded uniform sensors for biometric data/health monitoring-predictive analytics

The following scenarios provide insights into how AI and cloud computing can be used to enhance deployed operations.

Scenario 1

LOGISTICS, MAINTENANCE, REPAIR & OVERHAUL (MRO)—ARTIFICIAL INTELLIGENCE AND CLOUD COMPUTING FOR PREDICTIVE ANALYTICS AND MAINTENANCE

What is the challenge?

How can units gather, analyze, and share data that will help predict which spare parts and repair expertise will be needed to minimize down-time and expense for a wide variety of platforms, disparate systems, and technologies?

Why is it a challenge?

Deployed units must transport many different types of equipment and high-tech systems to the field. Ensuring there is an efficient supply and delivery system, available spare parts, and people with the right repair skills in remote and austere environments is very difficult. A way to predict what parts will be needed in advance, and to visualize and communicate readiness status up-and-down the chain of command will help ensure mission accomplishment and troop safety.

How can AI be implemented to meet the challenge?

Embedded sensor data, unstructured text data such as maintenance logs and after action reports, inspection reports, and other data can be provided to commercially artificial intelligence tools and stored on scaled commercial cloud computing services. Algorithms that record equipment temperature, pressure, and a problem parts historical life expectancy can be applied to help indicate expected system failures. A user interface and application were developed, and training conducted.

What is the expected outcome?

Task lists and maintenance data sharing over the deployed cloud network will enhance the unit's ability to monitor and identify problems early and order parts. Anticipation of unscheduled maintenance events and faster response adjustments and repairs become possible. Artificial intelligence tools and a scalable cloud infrastructure will allow edge units and staff members to access the network and provide data input. Many defense and intelligence organizations recognize the practical benefits of a scalable cloud computing infrastructure, and intend to continue to implement this type of predictive maintenance approach across a variety of platforms and systems.

Scenario 2

MULTI-DOMAIN OPERATIONS—ARTIFICIAL INTELLIGENCE AND CLOUD COMPUTING TO UNDERSTAND AND DISSEMINATE INFORMATION

What is the challenge?

How to make sense of and share enormous amounts of data across the space, air, sea, land, cyber, and electromagnetic spectrum domains. The armed forces have a large number of sensor nodes in each domain that provide indications and warnings data in many different formats. The challenge is how to employ artificial intelligence and machine learning to rapidly synthesize that information into usable insights for commanders. In recent months, due to the pandemic situation, the challenge to maintain network contact with an unexpectedly high number of remote users is also a major concern.

Why is it a challenge?

Deployed defense and intelligence sensors and communications systems are often not interoperable. Many are "stove-piped" proprietary systems with different types of data. Standards-based commercial tools for anomaly change detection and a common cloud-based network are required. They can provide faster insights and allow commanders to quickly recognize unusual situations and coordinate responses. Another challenge is that many existing networks may not have the inherent scalability to include a large number of remote users.

How can AI be implemented to meet the challenge?

Several defense organizations are working to improve multi-domain operations. Commercial solutions have often been included first, because the technology is mature, with proven use cases among business and industry. For example, communication systems can be improved with neural networks that classify interference and optimize frequency spectrum usage. Scalable artificial intelligence and cloud computing products have been implemented across many defense and intelligence enterprises and deployable IT networks.

What is the expected outcome?

Artificial intelligence and cloud computing technologies can help improve joint operations and real-time warnings for deployed units. Commercial IT providers help with data interface and sharing, and use open architectures that will integrate across domains. Scalable commercial collaboration tools can enable leaders to quickly maintain an effective and robust collaboration with their remote "at home" workers.

Scenario 3

SMALL UNIT OPERATIONS—USING ARTIFICIAL INTELLIGENCE TO PROTECT GROUND FORCES

What is the challenge?

Forces in a deployed location are required to search an unfamiliar building to find an unverified threat, like an improvised explosive device (IED), which could affect a large area of the town if detonated, and there is a short window of opportunity to disarm it.

Why is it a challenge?

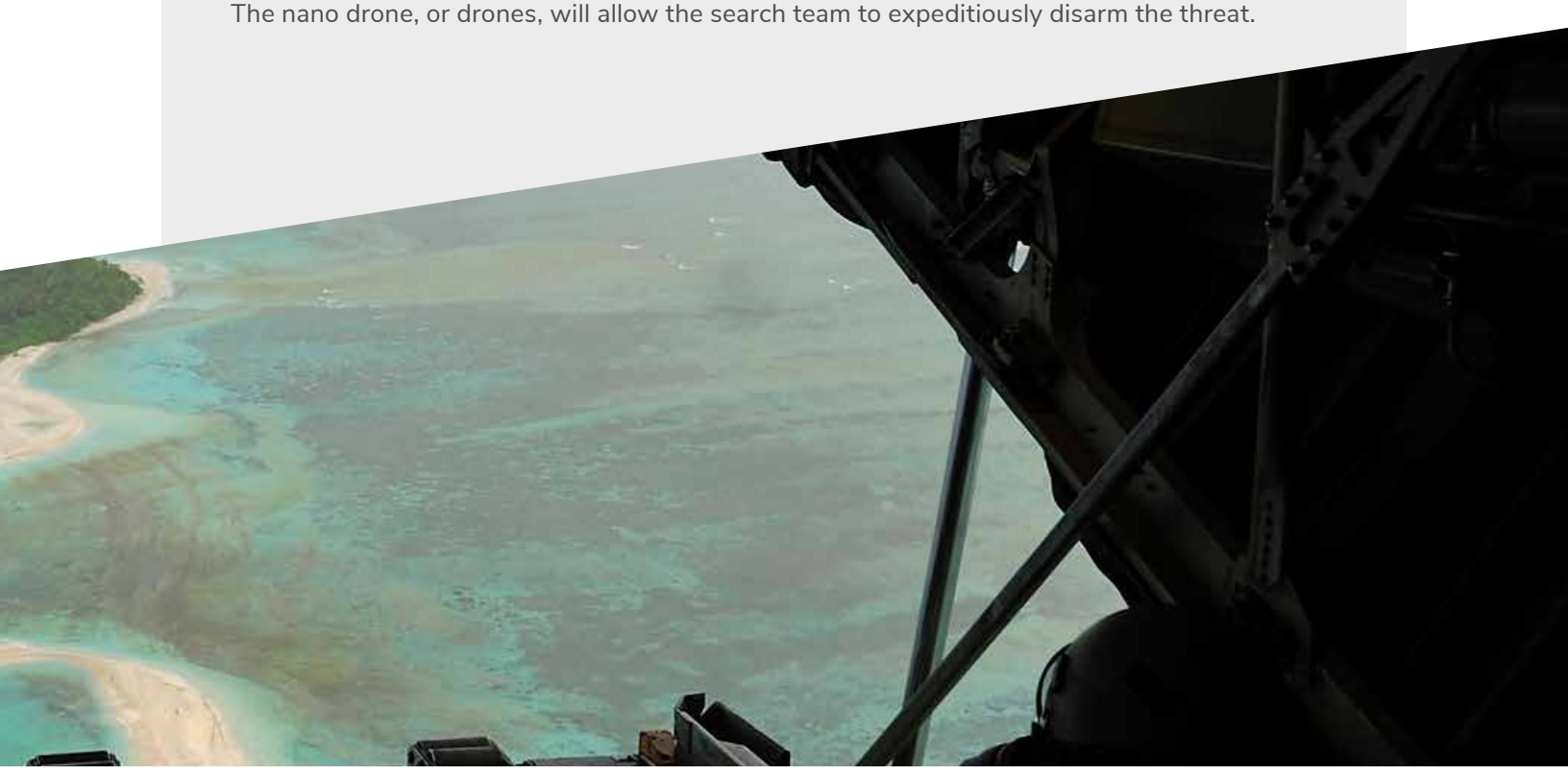
There are several pieces to this challenge as there is potential the threat is false and was actually reported to get friendly forces into a position where they could be ambushed. If the threat is credible, you would not want a team of soldiers to enter the building and be exposed to harm, but there is still a need to conduct the search in a short amount of time.

How can AI be implemented to meet the challenge?

A nano-drone with Computer Vision (CV) is sent into the building. CV allows it to navigate the building. As a result of ML algorithms, the drone already knows the most likely hiding places are under desks or in closets and tags these areas. It then sends the info to the team leader via a control station. The drone skips past open areas where an IED is least likely to be placed. As it flies through the building, the drone's sensors build a digital twin 3D map that is relayed back to a cloud computing platform on the search team's mobile control station. In addition, the AI-enabled cloud is able to communicate with the nano drone to give it specific information about what features an IED might have, gained through supervised ML, so it can more easily identify the threat. Multiple nano drones communicating with the deployed cloud, and each other, can expedite the process.

What is the expected outcome?

The nano drone, or drones, will allow the search team to expeditiously disarm the threat.



PART 4: SOLUTION EVALUATION AND ASSESSMENT

The expanded use of commercial Artificial Intelligence and Cloud Computing solutions is needed by defense and intelligence organizations immediately.

Commercial firms are meeting defense requirements for scalable artificial intelligence and cloud computing products. Several deployed units have found that Microsoft tools are a straightforward and uncomplicated way to meet core collaboration capability goals. This standards-based software makes installation and training easier. Deployed organizations with a wide variety of mission tasks, and at all operational and budget levels, are enhancing their operations with Microsoft products.

Additional commercial artificial intelligence and cloud computing resources are required as deploying units modernize their network infrastructures. Because they are standards-based, commercial solutions are often more readily integrated with existing IT systems. Microsoft products help defense and intelligence agency users improve their ability to analyze and share essential time-sensitive information.

Microsoft is an Artificial Intelligence and Cloud Computing market leader

Mature and trusted artificial intelligence and cloud computing technologies are applicable at all organizational levels and enhance a deployed unit's ability to plan and execute missions. When deployed, units gain the inherent ability to analyze data and seamlessly communicate securely over ad-hoc networks. Unit commanders, troops on the edge, and supporting organizations can all be kept informed with accurate and actionable information and communications.

Microsoft solutions are widely used by a variety of deployed organizations with diverse mission responsibilities. Users are currently improving their performance and productivity, while helping reduce overall costs. These products help visualize the status information of all resources, both at bases and dispersed operation centers. Microsoft artificial intelligence and cloud computing products are scalable, web-based, secure, platform agnostic, and accessible from mobile networks. Implementing Microsoft tools enables deployed unit commanders better situational awareness and control. Only essential information and tools required by the individual unit users are displayed, and dynamic operational/procedural changes can be quickly and easily updated and applied. Historically stove-piped data and legacy server systems can be integrated, so that commanders can fully leverage all of their IT resources.

PART 5: THE LAST WORD

Enhance mission success and troop safety through adoption of artificial intelligence and cloud computing solutions

The opportunity for deployed defense and intelligence units to quickly integrate advanced networks and data visualization capability with cost-effective, user friendly and innovative solutions is here. Commercially-based IT products that have been successfully leveraged at established bases are now being applied to deployed and remote units in the field as well. Commercial tools are essential for defense organizations to meet transformational digitization and multi-domain operational goals. Technology alone does not ensure successful operations. To be effective, AI must be applied to use cases that truly fit the capabilities and mission of each user.

Organizations with an agile mindset can leverage the new insights that AI can uncover, and build new and improved ways of working. Fundamental to the process for defense and intelligence organizations, even before considering what technology or application to deploy, is the responsible use of AI.

Each defense and intelligence organization is working to improve situational awareness and collaboration. To help keep people healthy during events such as the recent COVID-19 pandemic, remote team meetings have now also become an essential aspect of daily defense and intelligence operations. Platforms, systems, and mission areas are leveraging advanced computing, multi-level cloud-based networks, and machine-aided data analysis. Cloud computing technology is scalable and allows for collection, analysis and sharing of AI augmented data, while making the most efficient use of limited bandwidth. Commercial artificial intelligence and cloud computing technologies are enhancing mission success while keeping troops safer.

Exciting growth and a wealth of opportunities

The rate of commercial IT adoption by advanced defense and intelligence organizations around the world is increasing. Digitization advancements are essential for mission accomplishment. Commercial IT companies contribute to defense missions by providing unified solutions and specific technologies that help military commanders reach operational, remote meeting, systems integration, security, cost, life-cycle, and training effectiveness goals. Deployed unit leaders are demonstrating how to comply with service-level mandates to modernize IT systems. Flexible, scalable, and high performance artificial intelligence and cloud computing technology are vital components to enhanced data analysis and collaboration. It is also imperative that AI is utilized ethically and responsibly, especially in the wake of growing negative sentiment derived from the growing use of AI.

Microsoft's Azure data and AI tools are enabling defense and intelligence organizations around the world to solve complex data analysis and collaboration problems. Scalable Microsoft products such as Azure Cloud and Dynamics 365 AI can aid in decision making and operations at large base organizations, deployed units, or at the operational edge. Microsoft products are reliable, open source, secure, and supported by a team of technical experts. Defense and intelligence customers can maintain their preferred software languages, frameworks, infrastructure, and data centers when integrating Microsoft products.

To learn more about how Microsoft's scalable artificial intelligence and cloud computing solutions can help your organization, please visit the following links:

- www.microsoft.com/industry/government/defense-and-intelligence
- https://docs.microsoft.com/learn/paths/ai-business-school-government/?WT.mc_id=sitertzn_homepa
- https://www.microsoft.com/ai/responsible-ai
- https://azure.microsoft.com/overview/ai-platform/
- https://dynamics.microsoft.com/ai/overview/
- https://www.microsoft.com/microsoft-365/microsoft-teams/online-meetings

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- **Schedule a meeting with our global team** to experience our thought leadership and to integrate your ideas, opportunities and challenges into the discussion.

- Interested in learning more about the topics covered in this white paper? Call us at 877.GoFrost and reference the paper you're interested in. We'll have an analyst get in touch with you.

- Attend one of our **Growth Innovation & Leadership (GIL)** events to unearth hidden growth opportunities.

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