The Future of Collection Management in Multi-Domain Operations

by Captain Michael T. Kossbiel

Introduction

The U.S. Army must expedite and prioritize the integration of collection management and sensor management tasks and capabilities supporting multi-domain operations (MDO) capable forces in joint and coalition environments under joint all-domain command and control (JADC2). The U.S. Army, the Department of Defense (DoD), and coalition partners have several competing projects and efforts relating to the development of MDO-capable collection management. If unaltered, these disparate efforts could potentially create redundant data standards and systems that lack interoperability. The DoD, Army, and intelligence community must fully integrate and synchronize collection management efforts to achieve the desired future state of cross-domain sensor convergence.

TRADOC Pamphlet 525-3-1, *The U.S. Army in Multi-Domain Operations 2028,* implies the need for a joint all-domain sensor computing environment: "The ability to employ cross-domain fires provides options to commanders and builds resilience within the Joint Force to overcome temporary functional separation imposed by enemy anti-access and area denial systems."[1] MDO convergence specifically requires "the rapid and continuous integration of capabilities in all domains, the [electromagnetic spectrum] EMS, and the information environment that optimizes effects to overmatch the enemy through cross-domain synergy and multiple forms of attack all enabled by mission command and disciplined initiative."[2] The ability for the intelligence warfighting function to support the employment of cross-domain fires is dependent on multi-domain command and control.

Army Efforts

Army efforts in this area include the following technologies, described in detail below:

- Common Operating Environment.
  - Command Post Computing Environment.
  - Mounted Computing Environment.
  - Mobile/Handheld Computing Environment.
  - Sensor Computing Environment (Sensor CE).
- Tactical Intelligence Targeting Access Node (TITAN).
- Machine learning and artificial intelligence.
- Unmanned aircraft systems (UASs).

Common Operating Environment. To address the need for a multi-domain command and control, the Army developed the Common Operating Environment, which is the Army's effort to solve capability integration issues caused by disparate and disconnected Army Battle Command Systems. The Common Operating Environment uses industry-standard open architecture and commercial off-the-shelf technologies to reduce the burden on the warfighter and reduce costs. Conceptually, the Common Operating Environment effort is similar to Apple iOS or Microsoft Windows, which have unified open architecture software that allows the computing environments and warfighting functions to "play in the same sandbox." The Common Operating Environment decouples the bundled acquisition of software and hardware, which reduces cost and simplifies mission command information systems. For example, applications on commercial off-the-shelf laptops will replace Command Post of the Future and Distributed Common Ground System-Army laptops. Once implemented, translation software and hardware such as the Data Distribution System server will not be necessary. The planned future state converges all warfighting functions' Army Battle Command Systems programs of records onto one suite of software and one server.[3]

The Common Operating Environment has multiple computing environments, including the Command Post Computing Environment, Mounted Computing Environment, Mobile/

Handheld Computing Environment, and Sensor CE.[4] Sensor CE established a unified (sensor) data model that enables Army-wide sensors to feed (directly or indirectly) the common operational picture (COP). Sensor CE's common data model reduces latency and removes the need for workarounds, thereby shortening the sensor-to-shooter linkage by standardizing data across multiple current and future sensor programs of record. Essentially, Sensor CE allows the network to do the hard work of getting data to the customer. Sensor CE enables the interoperability and integration of sensors and sensor data to the network, other sensors, and consuming applications. Furthermore, Sensor CE requires future sensors and sensor data to be discoverable, visible, accessible, understandable, trusted, and interoperable across the Common Operating Environment. The current solution for Sensor CE is the Integrated Sensor Architecture being developed at the U.S. Army Combat Capabilities Development Command's Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, and Reconnaissance (C5ISR) Center.[5]

The Integrated Sensor Architecture is a technically mature, government-owned solution that is low cost and has been fielded with several sensors.[6] In 2019, the C5ISR Center and the Program Executive Office for Intelligence, Electronic Warfare and Sensors hosted a demonstration of this capability in Virginia. During the demonstration, a network of Integrated Sensor Architecture-enabled sensors demonstrated a sensor-to-shooter capability by linking several sensors to a Containerized Weapon System. Sensor data was passed seamlessly from sensors to the Containerized Weapon System, enabling the system to rapidly engage targets. Fielding of the first instantiation of Sensor CE capabilities will occur in fiscal year 2023. After that time, the Sensor CE will integrate with additional Common Operating Environment computing environments.

Tactical Intelligence Targeting Access Node. In addition to the Common Operating Environment, the U.S. Army is developing TITAN. TITAN is a scalable and expeditionary intelligence ground station that will support commanders across the entire MDO battlefield framework with capabilities tailored by echelon. TITAN leverages space, high-altitude, aerial, and terrestrial layer sensors to provide targetable data to the fires networks as well as multidiscipline intelligence support to targeting and situational understanding in support of mission command. Overreliance on continental United States-based intelligence production and data hosting limits the Army's ability to effectively engage dynamic and time-sensitive targets. In the future, resilient multidomain ground stations must integrate sensor data in a seamless, dynamic, and continuous manner to generate effects in and from all domains.[7]

Machine Learning and Artificial Intelligence. The Army is investigating machine learning and artificial intelligence capabilities to support collaboration and mission command. The first goal is to reduce the amount of time between target detection and applied effects in the close fight by an order of magnitude through robust sensor data integration at the tactical edge. Key to this project is a synchronized data management strategy that will enable access to the appropriate data and format assisted by artificial intelligence and machine learning to aid in target detection and decision support. The second goal is by 2028 to deliver multi-sensor, multi-platform target correlation; artificial intelligence-aided decision making; automated system behaviors; and manned-unmanned teaming. Beyond 2028, the goal is to deliver tactical/operational artificial intelligence integration, artificial intelligence tasking of autonomous systems, and whole-theater data integration.[8]

U.S. Army photo by SPC Dustin D. Biven

The Army is trying to move away from runway-dependent and cumbersome UAS in favor of UAS that bring advanced teaming capabilities.

Unmanned Aircraft Systems. Program Manager, UAS is spearheading several projects related to collection management. One project, air-launched effects, is a family of systems designed to provide UAS capabilities launched from aircraft to autonomously or semiautonomously deliver effects as a single agent or as a member of a team. [9] "Serving as an [air-launched effects] ALE mothership, the [Gray Eagle-Extended Range] GE-ER will carry multiple ALEs with a variety of capabilities," and that "launching and controlling of ALEs from the GE-ER could potentially increase the survivability

and effectiveness of current and future manned aviation systems with intelligence, targeting, communications, jammers, decoys, and kinetic effects."[10]

Program Manager, UAS is also developing a new UAS platform interface control software suite that will allow authorized users to control selected assets from a mission command information system via a web application programming interface. The new software provides a capability to request several different levels of control, including monitoring of the platform and payloads, control of the sensor payload while monitoring the platform, control of the sensor payload, and limited control of the platform (single waypoints). The new software eliminates the need for ground control stations by providing flexible control through laptops and tablets that can be anywhere on the battlefield.

Joint and International Efforts

Unified sensor data standards not only create interoperability with U.S. Army sensors but will also enable interoperability for joint and coalition partners. For instance, American, British, Canadian, Australian, and New Zealand (ABCANZ) doctrinal and technical interoperability standards would enable sensor-to-shooter linkages across coalition task forces. Future international agreements on sensor data interoperability and security enclave agreements will enable an integrated sensor-to-shooter linkage within a multinational coalition division headquarters with subordinate ABCANZ force elements. In addition to coalition sensor interoperability, the DoD is developing the JADC2 concept. JADC2 requires any sensor to provide data to any shooter, including joint and coalition partners. The JADC2 cross-functional team is led by the U.S. Air Force, which is developing concepts and requirements for a materiel solution to enable joint sensor-to-shooter links.

The Defense Advanced Research Projects Agency's (DARPA) OFFensive Swarm-Enabled Tactics program is developing UAS swarm technology that "envisions future small-unit infantry forces using swarms comprising upwards of 250 unmanned aircraft systems… and/or unmanned ground systems…to accomplish diverse missions in complex urban environments.''[11] In December 2019 at Camp Shelby, Mississippi, DARPA conducted a demonstration of the OFFensive Swarm-Enabled Tactics technology, including the operational management of swarm tactics that Carnegie Mellon University and Soar Technology are developing. The operational management of UAS and unmanned ground system swarms allows users to define and prioritize swarm reconnaissance tasks, and it uses artificial intelligence to automate resource allocation to complete the reconnaissance tasks.[12] During the demonstration, in near real time, the swarm updated a three-dimensional COP on laptops and on augmented reality headsets.

Future Risks for Collection Management

To achieve "the rapid and continuous integration of capabilities in all domains" necessary for MDO cross-domain convergence, all the collection modernization efforts must standardize data and the command and control of sensors. The standardization of sensor data and command and control technology across the Army and joint force must be integrated and synchronized to achieve the volume and speed of delivery necessary to defeat peer adversaries. In the near future, the number of sensors, volume of data, and collection requirements will overwhelm already undermanned collection management cells. The increase of data and collection requirements with the cognitive overwhelming of collection managers risks a break with the seven fundamentals of reconnaissance.[13] Standardization and automation are necessary to ensure continuous reconnaissance, rapid and accurate reporting of information, and the ability to keep reconnaissance, sensors, and collectors in the fight (and not in reserve). In order to accomplish this, the author recommends that the DoD and the Army establish a collection management cross-cutting capability to fully integrate and synchronize all collection efforts on the MDO battlefield.

The Seven Fundamentals of Reconnaissance

The seven fundamentals of reconnaissance are—

- Ensure continuous reconnaissance.
- Do not keep reconnaissance assets in reserve.
- Orient on the reconnaissance objective.
- Report information rapidly and accurately.
- Retain freedom of maneuver.
- Gain and maintain enemy contact.
- Develop the situation rapidly.[14]

The Army must prioritize the creation of a singular conceptual, doctrinal, and materiel developmental strategy to fully integrate a future collection management MDO-ready capability. The Army should pursue the development of a collection management cross-cutting capability that fully integrates Army Capability Manager Foundation's collection management application and Sensor CE's data standards and services. The collection management cross-cutting capability would create a digital solution to bridge the gap between collection requirements management; collection operations management; and processing, exploitation, and dissemination (PED) across the Command Post Computing Environment, Mounted Computing Environment, Mobile/Handheld Computing Environment, JADC2, and coalition partners.

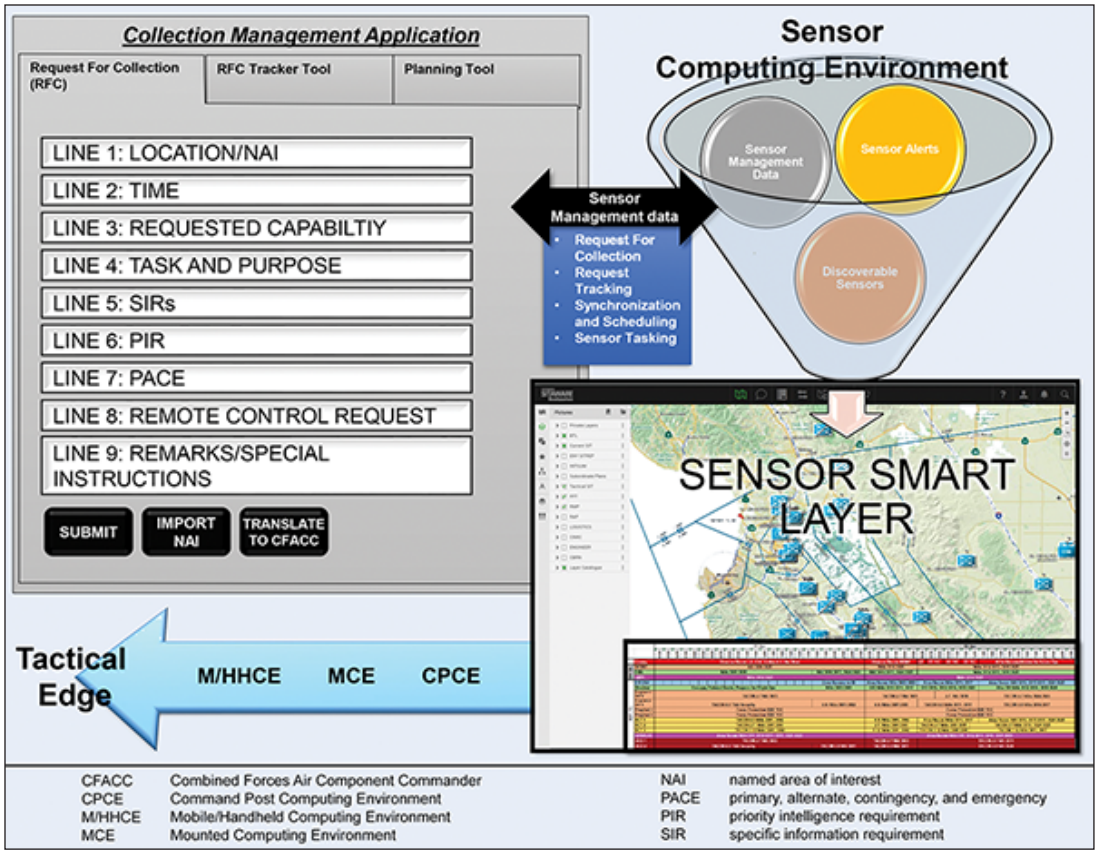

Figure 1. Collection Management Cross-Cutting Capability Conceptual View

The Army should pursue and develop an incremental and holistic strategy for implementing automation and artificial intelligence/machine learning into collection management.

The collection management cross-cutting capability will provide data users (consumers) a direct digital connection with data providers (collectors, sensor managers, and sensors). The collection management cross-cutting capability will reduce the burden on collection managers by standardizing data and digital planning tools and by digitizing a standard request for collection, a sensor COP, and digital collector/sensor tasks through a common collection management application and data standard.

To achieve full operational integration, the collection management cross-cutting capability will fully standardize and link threat data to collection requirements and sensor alerts. Threat data imported from the military intelligence All-Source App must be able to automatically provide enemy order of battle information, including individual object/unit identification. Additionally, technical data must be automatically imported and created into specific information requirements and technical indicators. A common data model must digitally link enemy order of battle, enemy courses of action, event templates, collection plans, and automated collector and sensor tasks. For instance, an analyst creates a named area of interest (NAI) for an enemy tank battalion. The metadata associated with the enemy tank battalion will be digitally linked with specific NAIs and aligned to a priority intelligence requirement. The collection requirement for the enemy tank battalion will then be imported into the Collection Management App for future planning. The Collection Management App will make

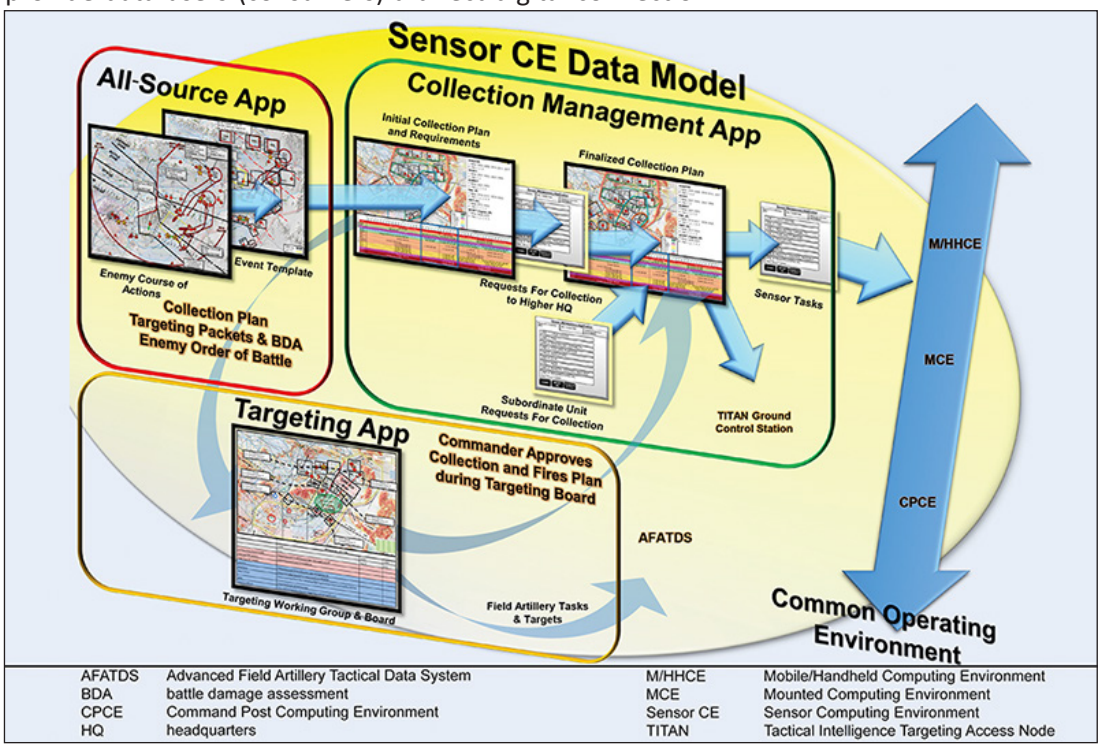

Figure 2. Common Operating Environment Collection Management Conceptual Overview

recommendations on what collection assets and sensors are available to task and what higher assets are available that could collect on the requirement. Once the collection manager assigns an approved collection asset for the tank battalion, sensor tasks, with the associated metadata, are sent to sensor managers via the Sensor CE. An example at a future brigade combat team would be as follows: A terrestrial collection system is tasked with conducting an area reconnaissance of the specific tank battalion's NAI, and the terrestrial sensor operators will have access to all technical metadata related to the associated enemy tank battalion order of battle, course of action, and event template.

The collection management cross-cutting capability will create an end-to-end digital feedback loop for data consumers and collectors to ensure that information is reported rapidly and accurately. This will be achieved by standardizing requests for collection on a single cloud-based application. The Collection Management App will allow requestors, collection managers, and sensor managers to track requests and collection tasks and provide real-time feedback on the status of requests. Additionally, a digital link will be created between data consumers and tasked sensors through Sensor CE's automated sensor alerts and subscriptions. Once a request for collection is approved and a collector or sensor is assigned, the consumer will automatically be subscribed to the sensor's alerts.

The collection management cross-cutting capability will enable the creation of a user-defined COP tailored to the collection mission. Users will have the ability to visually depict sensor and collection management data on a Command Post Computing Environment layer of the COP. The sensor layer of the COP will be visible on the move and at the halt from the Command Post Computing Environment, Mounted Computing Environment, and Mobile/Handheld Computing Environment. The sensor layer of the COP allows leaders and users to understand current collection and sensor operations. In addition, sensor data users will be able to view collection management plans such as a synchronization matrix and NAIs.

The collection management cross-cutting capability will enable the control of sensors via the network rather than "at the sensor source." By digitally linking requests for collection with sensor control software, we will in effect create the "network of things" of intelligence, surveillance, and reconnaissance. The Collection Management App, Sensor CE, emerging sensors or platforms, and future ground control station software will allow consumers such as infantry or armor company commanders to digitally submit requests for collection on their mounted or dismounted end-user devices and receive direct support from higher-level collection assets. The networked control of sensors will allow users to develop the situation rapidly, retain freedom of maneuver, and gain and maintain enemy contact more efficiently.

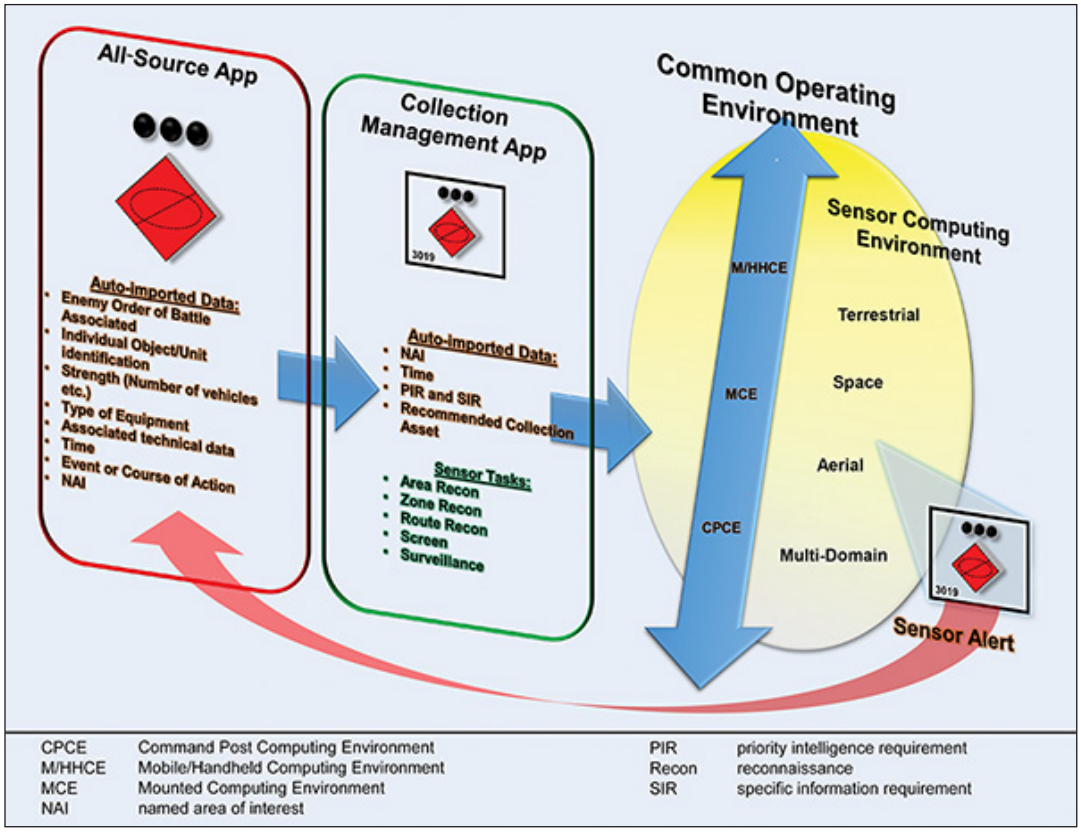

Figure 3. All-Source App to Sensor Data Linkage Concept

The collection management cross-cutting capability will enable sensor-to-sensor automatic cueing. Sensor CE's sensor-to-sensor data exchanges enable sensor-to-sensor automatic cueing. Automatic cueing will allow commanders or authorized users (collection managers and sensor managers) the capability to define sensor-to-sensor cueing relationships. Authorized users will have the ability via the Collection Management App's Planning Tool to plan digital cueing relationships between two or more sensors or collectors. Once collection managers establish a cueing relationship

between sensors, the system will automatically subscribe the cued sensor to the cueing sensor's alerts. Cueing alerts will be sensor-to-sensor automatic and sensor-to-sensor operator/manager for human-controlled sensors.

In the long term, the collection management cross-cutting capability and Sensor CE will provide the underlying data framework and services for automated, autonomous, and artificial intelligence-controlled sensor operations. These will include preprogrammed automated sensors, dynamic autonomous sensors that react to the operational environment, and artificial intelligence-controlled sensors that operate using feedback loop algorithms. Conceptually, users will input information requirements into the Collection Management App where artificial intelligence will resource, task collection, and allocate PED to answer the requirement. The transition to automated, autonomous, and artificial intelligence-controlled collection management will also necessitate the integration of cloud and artificial intelligence-enabled PED. The DoD's and Army's future initiatives, along with private sector innovations, will eventually provide artificial intelligence and machine learning algorithms to identify military targets with a high level of accuracy.[15] For instance, a British company is developing algorithms to apply machine learning to satellites' imagery for the identification of military aircraft with a reported accuracy rate of 98 percent.[16] Additionally, Microsoft has built a sophisticated software capability that allows artificial intelligence/machine learning to detect various patterns that identify snow leopards in snowy terrain using images and data from game cameras (camera traps). Biologists deploy motion-sensing cameras in the snow leopard habitat that capture images of snow leopards, prey, livestock, and anything else that moves. It then sorts through the images to find the ones with snow leopards in order to learn more about their populations, behavior, and range. Over the years, these cameras have produced more than 1 million images. [17] The collection management cross-cutting capability will provide users with edge-to-cloud access and the ability to request/task automated, semiautonomous, and autonomous sensors and to receive automated support with real-time sensor alerts.

The DoD, the Joint Staff, and the Army need to create a joint governing body that develops joint collection management concepts, doctrines, procedures, and technical standards. We can achieve MDO convergence of all sensors and all shooters only through the interoperability of doctrine, data, and network transport standards. Once the DoD establishes doctrinal and technical standard for collection management, it must expand interoperability to coalition partners in support of the mission partner environment. Interoperability with coalition partners, such as ABCANZ, will further enable MDO.

Conclusion

The Army lacks sufficient capability to fully integrate and synchronize all collection assets, sensors, and sensor data in real time to defeat a future peer threat in MDO and large-scale ground combat operations. The increase in the number of sensors, volume of data, and collection requirements will overburden future collection managers and will increase the risk of violating the seven fundamentals of reconnaissance. In order to mitigate this risk and enable collection management, the Army must invest in a collection management cross-cutting capability that standardizes and automates collection management command and control. This will provide the capability to discover, access, and manage interoperable sensor data from all warfighting functions, domains, and joint and coalition partners in support of MDO.

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