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GOAL 3

RETHINKING COLLECTION MANAGEMENT TO BETTER TRACK MOBILE TARGETS

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With the recent release of the 2023 National Intelligence Strategy (NIS), MITRE is publishing a special series of Intelligence After Next papers aligned to each of the six NIS goals the Intelligence Community will pursue over the next four years in support of U.S. national security strategies and priorities. Each paper will focus on an aspect of an NIS goal and offer a road map for success. This paper is aligned to Goal 3: Deliver Interoperable and Innovative Solutions at Scale.

We Need More Innovative Collection to Track Mobile Targets

Air Force Secretary Frank Kendall announced during the 2023 Air and Space Force Association's Air Warfare Symposium in Colorado that the Department of Defense's (DoD's) fiscal 2024 budget request includes plans to use both air and space sensors to track targets.[1] His comments, in line with the Intelligence Community's (IC's) and DoD's quest to answer the increasing demand for Intelligence, Surveillance, and Reconnaissance (ISR) in the face of an ever-expanding anti-access area-denial (A2/AD) environment, highlight the commitment to new innovative collection capabilities. But will traditional concepts for tasking and mission management of collection assets be successful in tracking mobile targets? If not, what innovative concepts should be considered as we move forward in solving our thirst for ISR data?

The emerging urgent mission need to maintain custody of large numbers of mobile military targets—simultaneously—makes the traditional collection tasking and management processes increasingly obsolete. Currently, these processes are fractionalized by individual intelligence sources[2, 3] and organized around static geographical areas of interest (AOIs), making it difficult to provide persistent target custody. Increasing numbers of collection (or access) options further add to the complexity of the problem, as ISR and other collection Mission Managers struggle to identify and hand off targets between potential collectors. IC and DoD collection authorities, governance, and procedures, including the Joint Collection Management Board and the National Intelligence Management Council, drive integration of collection resources at the macro level but are not directive nor prescriptive, by design, to effectively enable tactical collection operations.

We propose an alternative Object-Based Collection Management approach, aligned to current IC and DoD governance and authorities but organized around specific target types, characteristics, and behaviors, that potentially offers a more effective method of tasking and managing collection. The result would be a library of mini-collection strategies that could be dynamically applied as needed for the targets and conditions encountered. Controls and constraints could be identified within each strategy, which could activate, deactivate, or modify collection plans based on different activity and/or environmental centric scenarios, to appropriately balance sensor resource utilization. This approach will enable effective management of collection tradeoffs between sensor types and access opportunities, diversifying collection plans and increasing the probability of meeting Essential Elements of Intelligence (EEIs) requirements.

THE EMERGING URGENT MISSION NEED TO MAINTAIN CUSTODY OF LARGE NUMBERS OF MOBILE MILITARY TARGETS—SIMULTANEOUSLY—MAKES THE TRADITIONAL COLLECTION TASKING AND MANAGEMENT PROCESSES INCREASINGLY OBSOLETE.

Challenges in Tracking a Mobile Target

Traditional collection tasking and management processes are built to satisfy EEIs. However, ISR availability, access, and duration criteria, which are predominately sensor and platform specific, bind collection to focus geographically, limiting tasking and collection management processes to specific AOIs, often bounded within specific geographic Combatant Commands.[4] A primary example of AOI-bounded collection concepts is derived from the Defense Intelligence Agency's (DIA's) Modernized Integrated Database's (MIDB's)[5] use of Basic Encyclopedia (BE) numbers—corresponding to static locations—by the IC and DoD to identify collection needs. This is particularly problematic because MIDB is one of the primary sources of information used to track mobile targets. Concurrently, MIDB's planned replacement, Machine-Assisted Analytic Rapid-Repository System (MARS), is set to follow the same methodology and depict "foreign military unit hierarchy in the context of units' geographic location."[6]

However, maintaining custody of a mobile target necessitates the ability to assess, plan, and execute future collection respective to the target's future whereabouts, often outside of designated BE locations or established access points. Current collection planning methodologies to help this shortfall have included location planning, interval planning, and mix of sensors planning.

Location Planning. This planning option identifies all locations to which a target of interest might travel, taking into consideration mode-of-transport specifications and environmental factors, and implements a predictive collection search criterion. If the target and its behavior are well understood, this method can work, but it is unlikely to be efficient unless the number of potential search locations is small. More critically, if the target and operating environment are not well understood or the target's movement behavior changes, a pre-planned location survey will almost certainly fail to find or track the target to the accuracy desired.

Interval Planning. A second option is to establish strict collection intervals for specific sensors based on their abilities to collect on the specific object, but unconstrained by its location. This method sets limits on the number of allowable collections per time period, in a similar fashion to the location-based methods. Moreover, it allows for collection coverage to wherever that target might travel—although location could also be restricted within an operating AOI if desired. This method can be more effective than searching based on predictive geographical locations. However, it restricts planners to a predetermined type (sensor mode) of collection and collection time-window(s), which may not be sufficient depending on the target behavior, mode of transport, and environmental conditions.

- Some sensors, for example, are very good at locating objects but are not good at verifying identity and can be easily confused when multiple similar objects are in the same area. Other sensors are very good at identification but less accurate at geolocation. Still others are good at both but have a small collection footprint and therefore are not suitable for wide area search tasks.
- Consequently, a mix of sensors is ideal but is difficult to orchestrate in advance, as priorities may differ based on Collection Management Authorities (CMAs).[7]

Mix of Sensors Planning. A third option is to task a mix of sensors, which can vary depending on the type of target, the environment in which the target operates, and the specific behavior of the target. This method may prove to be far more effective in maintaining situational understanding of a moving target; however, the challenge is to effectively orchestrate the required collection across all available sensors and CMAs in a manner in which each target attains the prescribed collection focus;

no more and no less. Maintaining equitable resource allocations across all desired targets becomes more of an art than a science in this case.

Though these methodologies offer opportunities to track mobile targets, the probability of success is highly dependent on specific scenarios and is predicated on a predictive and known set of target actions and behaviors. In an A2/AD environment, we need a new way of tasking and managing collection that provides the necessary flexibility for tracking moving targets in all conceivable situations, while allowing for a manageable allocation of collection resources and balancing a multitude of competing mission needs.

Maintaining Situational Awareness Dynamically

Planning the collection required to dynamically maintain situational understanding of a mobile target of interest—whether that consists of merely tracking the target's current location, determining what the target is currently doing, or both—is difficult. Because the target activity/motion is fluid, the collection must be continually adjusted over time. Current collection scheduling systems are designed to optimize resource allocation against static geographic locations, not against moving targets.

One approach is to assign all the collection planning responsibility to a single scheduler that commands and controls collection sensors and assets. We use the term "scheduler" here to identify a central process which can be performed by personnel or "human in the loop (HITL)", machine automated or "human out of the loop (HOOTL)", or a hybrid of both options referred to as "human on the loop (HOTL)". Unfortunately, this central, command and control process would represent a significant increase in complexity when applied globally, or even at Combatant Command level, and is not designed for mobile targets.

For example, if a ship of interest is in port, infrequent updates to verify that it remains in port are likely all that is needed. If the ship is traveling in a straight line in the open ocean, more collection is needed to verify that it has not changed course, but no more than that. If the ship is maneuvering rapidly in a high-traffic area, we may need to look quite often and with different sensors to distinguish it from all the other ships.

Similar arguments can be made for understanding different types of activity. A vessel undergoing basic maintenance is not particularly interesting, but one that might be about to engage in armed conflict requires a lot more attention. Depending on the activity, or the operating environment, different sensors may be required to fully understand the situation. Very often, these sensors are managed under different CMAs, which greatly complicates the timely appropriation of desired resources. Introducing a new collection request into a different tasking authority's approval process can be a lengthy ordeal, and by the time approval is granted, the target is likely gone.

A better approach would be to incorporate an external coordination process and/or system, referred to in this document as an "orchestrator", which could analyze and determine when and where a collection would be most useful and then inform or direct the scheduler to assign the appropriate resource. Similar to our definition of a scheduler, this paper refers to the "orchestrator" as a process which can be performed by HITL, HOOTL, or a hybrid of both options referred to as HOTL. The orchestrator reduces the demands on the scheduler and allows it/them to focus only on the aspect of effective control of collection assets based on availability of resources. The scheduler would need to know only the characteristics of the collection needed, the time and location, and the relative importance of that collection.

In this fashion, the orchestrator and scheduler would operate as an integrated and coordinated unit, preferably in near real time, or machine-to-machine when automation is applied, to maintain custody of an object over time via a sequence of feedback-driven collections, performed often enough that the knowledge gathered satisfies the user's need. Consequently, this process drives the orchestrator to build multi-sensor/multiasset hand-off strategies, also referred to as Tip-to-Cue strategies, that the scheduler can implement, enabling effective and efficient target tracking solutions in a fluid environment.

To exemplify how these orchestrator/scheduler functions are best applied, we need to decompose step-by-step decisions, or sub-functions. Initially, we will assert that once the location of a target is identified, the certainty of that location decreases over time, relevant to target behavior and environmental factors. This assumption will drive a two-phased collection strategy approach in which the near-term (e.g., less than 60 minutes to access target location) and non-near-term (e.g., more than 60 minutes to access target location) available collection is integrated through the development of collection strategies. Near-term collection strategies will be driven by the scheduler's insight into available and capable assets, while non-near-term collection strategies, asserting that the accuracy of the target's future location is degrading, will be planned by identifying a series of collection time windows and prescribed conditional actions (i.e., complex "if/then" algorithmic programming).

Within each window, one or a combination of sensors will be provisionally tasked through this strategy by the orchestrator to cover a geographic area of likely location. The scheduler would commit to collecting the strategy (i.e., planned but not tasked) but postpone tasking the specific sensor, time, and aim point until the prescribed conditions materialize; assuming priority and environment/operating factors remaining constant. If near-term collection discovers surprising aspects of the object's behavior, then the plans need to be altered accordingly.

These collection strategies might also be federated and managed by more than one sensor owner, or CMA. In this case, sensor owners would need to unanimously bond and coordinate their collection plan, committing their assets' availability to the proposed strategy in advance. This incurs a potential inefficiency risk that a collection might be canceled when the time gets closer due to the target moving in a way that invalidates the use of the committed collection assets. Additionally, federating and coordinating mission management in this manner tends to incur a lengthy pre-approval process, is mostly generalized above the operational employment detail needed (i.e., how to communicate commitments and act on feedback), and often challenges timely adjustments to predefined agreements (i.e., asking for more than originally agreed upon).

Factoring In Relative Importance and Information Gain

An additional factor critical to enabling the whole system is relative importance. The current collection prioritization process is quite static, with governance in place mandating that the "mechanism for the development and communication of overarching national intelligence priorities" is the National Intelligence Priorities Framework (NIPF). "The NIPF includes the means to establish, disestablish, manage, and communicate national intelligence priorities … for national intelligence support, … ensuring that both enduring and emerging national security issues are effectively prioritized."[8] This process has proved to be effective in meeting strategic intelligence needs, but its generalized approach coupled with its protracted amendment process does little to drive effective collection prioritization against high-interest mobile targets in a volatile dynamic environment.

The NIPF, including the Office of the Director for National Intelligence's (ODNI's) Integrated Mission Management functions,[9] guides the national collectors in assigning resources to address policy goals but does not include any of the contextual or real-time information necessary to objectively determine what sensor collection is most critical at a particular instance in time. Without an objective measure on which the entire DoD and IC can agree, there is no way to sort all the alerts and collection opportunities in any way that is remotely optimal. The need for a common assessment of intelligence value is well recognized across the community, and there have been multiple attempts at defining it. However, no one, to date, has been successful at establishing a standard to which everyone can agree beyond the NIPF.

In the near term, one option to consider would be to use the existing NIPF structure, including ODNI's Mission Management functions, for general target importance but add secondary factors to modulate a given target's priority based on the current criticality the target poses, and the expected information gain aligned to that collection.

The criticality would be largely a function of the estimated activity of the target and the relative situational uncertainty. For example, an adversary's transporter erector launcher (TEL) undergoing fueling operations in a scenario where hostile actions are not expected (e.g., in garrison and expected to participate in an advertised exercise) would be deemed far less important than in a scenario where hostile will and intent have been deemed highly probable.

Information gain, sometimes referred to as opportunity value, would identify the assessed value, or loss, of collecting or not collecting. In the case of tracking a moving target, this can be as simple as calculating the probability of detection— a readily quantifiable measurement for most tracking problems; average speed, plausible direction (e.g. roads, rail, river), environment interference (e.g. mountains, clouds).

To use these two factors effectively, we need to convert NIPF priority rankings into a more precise quantitative value framework, enabling a non-time-sensitive, moderate-information-gain collection on a high-NIPF target to be postponed in favor of a time-sensitive, high-information-gain collection on a moderate-NIPF target. The sensor's ability/likelihood to observe the target should also be factored in (e.g., radar shadow* is avoidable).

Recipes for Persistent Custody

The above discussions highlight the complexity of collection management and make a strong case for a consolidated, multi-disciplinary/multi-domain approach for solving persistent target custody. They also identify the need for redesigning the collection management processes necessary to enable appropriate resource allocation to ensure mission goals. We have shown that different targets require different types of collection at different frequencies and at different priorities, depending on the situation. However, the scenarios at play and appropriate combinations of sensors are limited. We can enumerate a small number of target classes (e.g., Carrier, Destroyer, Frigate, Bomber, Fighter, Tank), target states (e.g., in garrison, routine transit, training operations, combat operations), and environmental conditions (e.g., open ocean, busy port, rural desert, dense urban area, cloudy, night/day). Then we can specify desired sensor types, priority, and frequency of collection necessary to achieve different levels of uncertainty think in terms of probability of success versus failure.

A modest level of modeling and simulation would be appropriate to define initial bounds on collection type and frequency, which could be regularly updated based on operational results. A set of bounds associated with a target type, target state, and environmental condition would then define a mini-collection strategy. These strategy components can then be combined dynamically to provide an overall plan for persistent custody that a tasking authority—or better yet orchestrator—could use for guiding resource allocation.

THE COLLECTION MANAGEMENT PROCESS COULD EVOLVE TO AN OBJECT-BASED—VERSUS LOCATION-BASED—PROCESS, WITH THE IMPLEMENTATION OF PRE-APPROVED FRAMEWORKS FOR TARGETS AND CONDITIONS.

** Radar shadow occurs when the radar beam is blocked from illuminating the desired location.*

Given a desired list of targets, or rather general classes of targets and relative numbers, tasking authorities could use this type of framework to determine how many and what type of targets they potentially could support—and to what degree of fidelity/frequency—and select the most critical to which to assign resources. The resource assignments would consist of loose bounds on collection rather than strict sensor assignments by time and location. Automated orchestration and scheduling systems would then have flexibility to adjust collection as needed to meet the desired situational uncertainty levels for the approved targets.

Further flexibility could be provided by allowing different combinations of targets and states (e.g., 10 vessels in port, five in transit) or for tradeoffs in uncertainty based on target state and environmental conditions. In all cases, the collection bounds would restrict the maximum proportion of sensor resources committed to a target under various conditions. If all uncertainty thresholds are met, then additional lower-priority targets could be automatically considered.

This process could also be extended to more traditional static (not mobile) intelligence targets by defining states for those targets, desired uncertainty levels, and bounds on frequency and type of collection for each state. In all cases the target behavior would need to be assessed and provided to the orchestrator and scheduler, which could be done either machine-to-machine or via human judgment.

Using this methodology, the collection management process would evolve to an object-based—versus location-based—process, with the implementation of pre-approved frameworks for targets and conditions. Viable frameworks, and respectively aligned collection strategies, would include mixes of sensor types, across multi-domains when possible, driving the corresponding tasking authorities to coordinate collection orchestration to plan and execute the directed strategy. Resources would be apportioned effectively, efficiently, and dynamically to meet intelligence needs of approved targets, and collection actions would be communicated via near-real-time feedback across all mission owners. This would increase overall performance and align collection management functions more explicitly to dynamic intelligence needs.

A Move to Greater Collection Efficiency

Appropriate next steps might be a pilot effort for a particular target of interest. This could even be demonstrated with commercial satellite and Automated Information System sensors for tracking commercial maritime traffic. Appropriate sampling rates for various conditions could be established and verified under realistic conditions. This process could then be replicated on government systems with the involvement of the appropriate sensor owners and tasking authorities, starting with easier targets such as commercial vessels and aircraft and proceeding to increasingly difficult targets and conditions. The goal of the experimentation will be to establish the bounds on collection needs for all the identified combinations, informed by either situation or observed operational performance. Those bounds would constitute a recipe for different levels of situational uncertainty that could be used to assign collection resources by each tasking authority. This would preserve the current authorities of each sensor owner but enable greater flexibility, improve mission performance, and increase collection efficiency for the entire DoD and IC enterprise.

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