Multi-INT Capabilities & Autonomous Mission Support

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GENERAL DYNAMICS
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Introduction

General Dynamics Mission Systems (GDMS), a trusted partner for over 30 years across the DoD and IC, develops and deploys Multi-INT capabilities directly supporting mission operations and requirements. Advances in technology across operating environments (air, space, land, sea, and cyber) and intelligence sources (imagery, signals, geospatial, signatures, and open source) provide a wealth of data requiring timely identification of relevant information in complex environments and efficient analytical assessments for effective decision-making. Machines are improving the identification of contextually relevant data, but there is still too much burden on the user to configure the machine. Machine-driven processes must continue to evolve to anticipate user needs and to seamlessly identify useful information in increasingly complex environments. This paper presents our vision for an anticipatory paradigm achieved through a strategy of data dominance that strives to automate data classification, accelerate complex analysis processes, enable event forecasting, and facilitate rapid decision making for successful mission execution.

Our vision for Multi-INT capabilities is to accelerate the creation of actionable intelligence and facilitate decision making through machine-assisted event forecasting and decision process automation.

To achieve our vision, our Multi-INT exploitation strategy sets four goals:

- **Anticipate:** Reduce timelines and cognitive burden for Analysis and Decision Making through model-driven AI/ML workflow predictions and user-need forecasting
- **Identify:** Validate information, derive contextually relevant data, and present actionable intelligence through automated extraction and correlation services
- **Collaborate:** Increase situational awareness, enhance analytic value, and deliver coordinated responses seamlessly across Multi-INT, Multi-Domain, and Multi-Security environments
- **Facilitate:** Optimize and accelerate actions and decisions through role-based, streamlined human-machine interaction
The Figure above showcases the anticipatory paradigm we envision by distilling extensive data across domains into actionable information for immersive collaboration. This paradigm is achieved by leveraging Artificial Intelligence/Machine Learning via human-machine teaming for event forecasting, and by facilitating use of the right data, at the right time, with the right security controls for anticipatory tasking and pre-emptive actions. At any step in the process, data can be presented to users or be leveraged to drive analytics and determine potential outcomes. Throughout the process feedback loops improve the algorithms and techniques performing the various capabilities. Finally, High Performance Computing and cloud assets accelerate this process.

**Anticipate**

The Anticipate goal reduces timelines and cognitive burden for Analysis and Decision Making through model-driven AI/ML workflow predictions and user-need forecasting. Anticipate starts when a system understands the context of a user’s objectives within a mission environment. A mission environment consists of systems and enterprises required to execute a mission.

The systems within a mission environment employ deep learning to build their understanding of mission context, including Areas of Interest, Priority Intelligence Requirements, and desired results. This deep learning process is passive and tracks user activities including the usage of tools, websites, data sources, etc. As the system gathers usage details it identifies and suggests other capabilities, services, or data sources that could benefit the user or mission.

The system also tracks daily activity patterns within PII guidelines. For example, the system knows a user arrives at 8am every morning, so it actively scrubs data sources and pre-stages data within associated tools prior to the user’s arrival. Similarly, the system learns activity patterns that indicate user preferences between data sources and tools. This means the system initiates preferred tools and loads data when a user views a data source. This anticipatory workflow can be intrusive, where the UI automatically displays, or unobtrusive, where the tool runs in the background until the user requests it.

With anticipatory workflows, the system understands each user may require different data and different tools when an event or series of events occur. The system automatically identifies data sources for the event(s) and links or stages that data in user preferred tools and templates. This optimizes Analysis-to-Action process in the Observe, Orient, Decide, Act (OODA) loop to achieve mission objectives. For example, for an imagery analyst responding to a Magnitude 7.0 Earthquake in a populated area, the system identifies relevant data (e.g., historical imagery, population and infrastructure maps, shock and impact data) and stages GEOINT applications. For a collection manager, the system is aware of the manager’s tradecraft and identifies appropriate assets providing situational awareness (e.g., imagery collection, weather forecasts) and recommends collection strategies to maintain target custody, using pre-defined requirements.

The system continually learns and adapts to ongoing patterns, preferences, and responses. For example, if an unusual event occurs within a user’s area of interest, the system leverages knowledge gained from similar events in other areas to parse, stage, and recommend relevant data and tools.

**Anticipatory Intelligence reduces the Cognitive Burden for the Analyst.**
Identify

Our Identify goal validates information, derives contextually relevant data, and presents actionable intelligence through automated extraction and correlation services. Identify is composed of three phases: Extract, Correlate, and Derive.

Extract

The Extract phase identifies and integrates community algorithms and data sources to extract and deliver the right information to users for their mission need. With the projected growth in sources of Multi-INT, there will not be enough human resources to view, examine, and extract relevant, actionable data. Automated data extraction efforts are underway to provide automatic change detection, object identification and tracking, user-defined content indexing and cataloging, and Structured Observation Management (SOM) support. Our challenge in supporting users will be ensuring the right information is being extracted and delivered in a useful way to meet their mission needs.

Extract goes beyond static algorithmic processing of data sources and encompasses a brokering concept. In this strategy, brokering is defined as determining the best inputs into the automation process and ensuring the right data is being delivered. For input, brokering enables a user to, a-priori, identify the right data sources, algorithms, and analytic models to meet mission need. This strategy can also be reversed, where a user enters their mission need and the service identifies sources/algorithms/models that best fit the mission.

Algorithms will be dynamic and adapt to user needs and mission requirements including mission-specific processing. In some cases, algorithmic chaining or pre-processing of data sources is performed (for example, sharpening a video under low-light conditions to improve detections). For output, once the high veracity, contextually relevant data is identified, brokering ensures that it gets to the user in the right format for their further use, e.g., exploitation, product development, collaboration, or decision making. The brokering will be performed by a series of micro-services within a framework that orchestrates the various services.

Essential to the success of automated algorithmic extraction is user trust. Insight is required into how the algorithm processes data, which means automation cannot occur in a “black box”. Users need visibility into the process and algorithms to build trust in the output and validate findings. A continual feedback process must be in place to constantly tune the algorithm for the work it performs. In other words, the algorithm will be trained with a set of pre-qualified training data, but as a User uses the output, positive identification can strengthen the training set. False positives can be examined to determine whether the algorithm misidentified the extracted data because of faulty training data or outdated underlying assumptions. Algorithm revalidation and quality assurance checks will ensure algorithm results remain trusted. As trust is gained, user acceptance of machine capabilities will increase. Acceptance will lead to capability adoption, which can be further driven by policies that allow for a “human-in/on-the-loop” for some data validation stages in the process.
**Correlate**

The Correlate phase automatically correlates data across multiple INTs to improve object discovery, recognition, and extraction. The advent of algorithmic extraction of data and machine learning increases the amount of information available to classify and characterize an object of interest. While automation can identify that an object exists, it is the correlation of data from other INTs that increases the probability that the object belongs to a specific category, class, type, function, or possesses an inherent operational capability.

Correlation can occur across multiple sources with one algorithm or across the same source using different algorithms. This algorithm-correlation methodology allows for data discovery across different phenomenologies, timeframes, or object features. While correlation across the different data sets increases confidence in the data and facilitates discovery of previously unknown dataset interactions, like extract, this process cannot occur in a black box. These correlation services can get very complicated and any errors can have a cascading effect, so humans must be able to interrogate the processes, services, and data being utilized. Potential ways to interrogate include building UIs that provide insight into the process or provide outputs for each step of the process for user review.

The correlation services will orchestrate the discovery of data common across different repositories, correlate it, and then determine the probability that the objects are the same. The challenge is that the sources of data do not always adhere to the same ontology standards for labeling the data, nor is the accuracy of the detected object at the same level of fidelity, e.g. time captured and where it was captured. This “impedance mismatch”, which we define as the inconsistent representation of a single object or observation across systems, usually results in modifications to services or extensive database mappings to enable the transfer of information from one system to the next. To reduce or eliminate data mappings, minimal data correlation fields will be utilized. Correlation will occur at the service tier without modifying the underlying legacy services or creating a new database of correlated data.

The goal is to increase the veracity and confidence of object identification and correlation between multiple sources and algorithms. By working across multiple reporting and observation repositories, the high-confidence information is presented to the user or to other machine interfaces, such as services performing Activity Based Intelligence (ABI). The increased classification and characterization of an object will drive deeper analytics and provide more detailed understanding of a specified area of interest, which helps provide insight and context for a specific object, area, or activity of interest.

**Derive**

This phase leverages probabilistic and mathematical inference to align data with key indicators and analytic models to derive meaning from the data and support predictions of future situations. There are a variety of machine learning techniques. Our ML focus has been in the application of Bayesian inference. “Bayesian” refers to Thomas Bayes, a 17th century statistician who developed the theorem which describes the probability of an event based on prior knowledge of conditions that might be related to the event. Bayesian inference is the application of Bayes’ theorem for statistical inference to update a hypothesis as more evidence or information becomes available. For Multi-INT exploitation, this means that hypotheses, in the form of analytic models or key intelligence questions, can be validated or invalidated as more data is accumulated.
Benefits of the implementation of this phase include the system’s ability to monitor and track multiple hypotheses using statistical data and then pivot or tweak indicators as more information is known. The main benefit is to provide anticipatory analysis, which can either alert a User that something has a high probability of occurring or cueing other machine resources to gather more new data or dig deeper into existing data. For threats, this includes threats from the physical battlespace, threats from the cyber/virtual battlespace, and threats from bad actors within an organization. Other benefits are the ability to validate known patterns of life and notify users when the “not-normal” occurs. As machine learning and artificial intelligence capabilities continue to mature, they can be used to adapt the models as patterns change, or more importantly, identify new patterns of life that may not be readily apparent by a human.

These three phases combined provide actionable intelligence and contextually relevant information that drives the other processes. While the Identify goal focuses on the ability to derive information from a sea of data, the next section discusses how it is exposed to maximize collaboration across users, services, and domains.

**Collaborate**

The Collaborate goal is to increase situational awareness, enhance analytic value, and deliver coordinated responses seamlessly across Multi-INT, Multi-Domain, and Multi-Security environments. A key element of Collaborate is to ensure data is trusted through advanced access control, provenance, and pedigree data protection capabilities. Data and network access control mechanisms must be resilient to tampering and fault tolerant, ensuring the integrity of stored data. For example, the advent of Block Chain technology captures cryptographic evidence of every action taken on a datum. Tamper detection and tamper checking techniques are employed to verify the record’s integrity. Data provenance in combination with data pedigree captures the origin and history of ownership as the data is used or updated. This allows a user to know how the data was captured, who has used it, and if it has been referenced or included in any finished intelligence product. By securing the integrity of data at rest, assured access control enables and supports data discovery, data access, and cross-domain data dissemination to authorized users.

For operation across security boundaries, the system must provide effective and efficient methods to secure all data elements within the data environment. Data must be marked correctly for security, author provenance, and synchronization to ensure it is only accessible to entities with appropriate security authorizations. Digital identities then allow individuals and nonhuman entities to discover, access, and disseminate data across multiple security environments.

Once data is secure and accessible across domains, users can collaborate across an ecosystem of relevant data, services, and tools within their preferred exploitation environment. This provides pertinent content and situational awareness within a user’s preferred interface without leaving the context of a mission to conduct cumbersome searches across multiple data stores. The benefit is increased efficiency and faster contextual understanding for enhanced analysis, collaboration, and decision making. For the Warfighter on the edge, data tailoring can support lower bandwidth environments so that only the pertinent data directly impacting the mission is delivered.
Facilitate

The Facilitate goal is to optimize and accelerate actions and decisions through role-based, streamlined human-machine interaction. Interactions can include spoken commands, hand movements, head/eye movements, haptic environments, and improved visual presentation. There are multiple capabilities on the market today for interacting with a system, but we envision further refinement both in language understanding, gestures, presentation, and anticipating needs. The need for simpler interaction increases the more these capabilities are pushed to the front line soldier. Manually inputting a command via a touchscreen or virtual keyboard takes time. Soldiers need to tell the system what they need and it needs to be executed immediately. This means the system must understand multiple ways to receive a command and still provide the same outcome.

By incorporating capabilities from the Anticipate goal, the need for interaction is reduced. For example, instead of a soldier telling the system to identify red forces in the local area, the system already knows the soldier has started a patrol and is already providing that information. Easier interaction with the system is one aspect to improve mission effectiveness. The system must also help users utilize or employ the contextually relevant data to effectively gain situational awareness, generate intelligence, and make decisions.

Summary

The National Defense Strategy states that, “We face an ever more lethal and disruptive battlefield, combined across domains, and conducted at increasing speed and reach—from close combat, throughout overseas theaters, and reaching to our homeland.”

GDMS’ vision for the future of Multi-INT combines automation, machine learning, and computer vision to create services that automate data classification, accelerate complex analysis processes, enable event forecasting, and facilitate rapid decision making for successful mission execution. Services are built on a flexible, extensible open architecture, which is further built on micro-services that are orchestrated using open source and cloud technologies. When robust processing power is needed, High Performance Computing techniques can be employed on bare metal, cloud assets, or a hybrid of both.

GDMS is a leader in Multi-INT capabilities to support the mission both today and in the future. Our offerings today include the Fusion Analytics Core Element Transaction Services (FACETS), Multi-INT Analysis and Archive System® (MAAS®), Tactical MAAS (TAC-MAAS®), Mission Monitor, and Image Data Conditioner (IDC). We also provide Multi-Level Security services, Blockchain, Analytic Workflow, and our enterprise Mission-Management ToolKit (eMTK). Finally, we lead and develop HPC and Bayesian Analytics capabilities for Intelligence Community Partners and we are investing in new technologies in automation, user interfaces, and mission management.

All of our offerings provide agile, flexible multi-mission and multi-source support to users and applications in cloud, native, or hybrid environments. We welcome the opportunity to discuss this strategy and our capabilities to meet your critical mission needs.