Focus Area 2.0 – Battle Damage Indications / Battle Damage Assessment Collection, Aggregation, and Analytics Improvement

Focus Area Overview

Develop integrated collection, aggregation and analytics capabilities to improve Battle Damage Indications (BDI) and Battle Damage Assessment (BDA) processes in support of Joint Targeting Cycle (JTC) and Space Tasking Cycle (STC) Phase 5 (Mission Planning & Force Execution) and Phase 6 (Assessment) steps. These developed capabilities also improve the Tasking, Collection, Processing, Exploitation and Dissemination (TCPED) lifecycle with specific focus upon the BDI and BDA outputs within the TCPED lifecycle.

Current operational environments use fragmented Telemetry, Tracking & Command (TT&C) feeds, connected sensor systems, processing workflows, and intensive data fusion activities across multiple Mission Unique Software (MUS) sets. These processes require increased immediacy for operational understanding to reduce decision advantage during contested-space operations. The intent is to increase timely BDI and BDA to adjudicate targets.

BDI/BDA requires tight collaboration across the *Strategic* (e.g. United States Space Command), *Operational* (e.g. Space Forces-Space, National Space Defense Center, Combined Space Operations Center) and *Tactical* (e.g. Space Force Deltas and their Squadrons) warfighting levels; along with partnerships with the Intelligence Community (IC).

High Level Operational Context

The BDI process occurs during execution of combat operations (STC Phase 5), largely at the operational level between Space Forces-Space (S4S) and assigned Operations Centers such as the National Space Defense Center (NSDC) and Combined Space Operations Center (CSpOC). As BDI are adjudicated favorably to conclude an assigned effects task, operations centers are tasked with crafting BDA Phase 1 reports (STC and JTC Phase 6) against tight timelines, which support requirements to submit a BDA Phase 1 Combat Assessment report that feeds United States Space Command (USSC).

USSC then submits a refined BDA Phase 2 Combat Assessment (JTC Phase 6) over a moderately longer timeline to support the IC.

The IC receives and improves this assessment into the BDA Phase 3 Combat Assessment, which generates IC consensus regarding specific targets and removes or modifies the Joint Integrated Prioritized Target List (JIPTL) accordingly.

Space BDA operations require rapid correlation of TT&C, sensor, orbital, RF, radar, cyber, and mission operations data across systems across classification levels. While the BMC3I TAP Lab is seeking unclassified proof of concepts, final correlation and aggregation will reside at the TS//SCI level. Current processes require manually intensive processing and limit the ability to maintain decision advantage during contested-space operations.

High Level Requirement

Develop capabilities that automate disparate data product collection into a unified Battle Damage Indication/Assessment data store Ontology, support multiple source data aggregation against defined collection timing requirements, correlate cross-domain events against BDI and BDA information requirements, score collection confidence including multiple phenomenology techniques, provide user-friendly and/or user defined explanations which provide context and understanding to Artificial Intelligence/Machine Learning (AI/ML) assisted data correlations and scoring to aid user analysis, identify prioritized collection activity which correlates to BDI and BDA specific information requirements, and accelerate threat-event processing in support of TCPED-aligned BDA execution.

Stakeholders

- Sensor owner/operators
- All specific specialty Intelligence Subject Matter Experts (SMEs)
- Operations Centers & Battle Management operators
- Major Command and Combatant Command (CCMD) commanders and subordinate staff

Context & Assumptions

The following assumptions should inform solution development and demonstration.

1) BDI/BDA occurs at 4 levels simultaneously:

    a. BDI typically occurs across tactical and operational units and is highly time sensitive and must inform operational requirements with immediate and dynamic needs.

b. BDA Phase 1 occurs across the tactical and operational units. It is highly time sensitive and must inform the BDA Phase 1 Combat Assessment report within minutes to hours.

c. BDA Phase 2 occurs at the strategic level, informed by operational level. It is time sensitive and must inform the BDA Phase 3 Combat Assessment report within days.

d. BDA Phase 3 occurs at the IC level, informed by combat command. It is time sensitive and must remove or modify targets in as timely a manner as possible, upon IC consensus achievement.

2) The SMEs at each echelon may be performing workflow in the context of each BDI/BDA level and should be able to differentiate via User Interface which level of workflow they are supporting.

3) No single analytic tool performs all required functions, and novel improvements are always possible.

4) No single collection source possesses all required data.

5) Each collection source possesses more data than is being procured or used. BDI and BDA processes can be improved by procuring and using more of what is already available.

6) Data fusion and data aggregation across phenomenology increase confidence ratings more than reliance on single phenomenology data sets.

Problem Statement 1.1 – Holistic Data Ontology

Problem Statement

Collection systems rely on fragmented data products, many of which do not always improve a collective knowledge data base, such as a Battle Damage Indications/Assessment (BDI/A) data store system, making existing structures in need of improvements for space enterprise and Intelligence Community requirements.

Operational Context

The creation/improved utilization of the BDI/A data store system is supposed to be a single source of intelligence data products where the incremental and systematic improvement of information against a defined target folder allows the IC to develop knowledge and assessment. Because the current system is fragmented, Intelligence SMEs spend excessive time crossing between Mission Unique Software systems and classification levels to create assessment products.

Requirement

Develop an aggregation and normalization capability that ingests all data sources into a BDI/A data store Ontology, improves data products within the event streams, preserves source traceability for operational use by Intelligence SMEs, and provides user-friendly and/or user defined explanations which provide context and understanding to AI/ML assisted data correlations to aid user analysis.

Data Sources

- TT&C feeds
- Ground-based sensor data (All phenomenologies)
- Space-based sensor data (All phenomenologies)
- Commercial space domain awareness (SDA) data sources (All phenomenologies)
- Mission Operations Systems

Operational Value

Improves TCPED Collection and Processing synchronization through automated ingestion and normalization.

Desired Capability Outcomes / Acceptance Criteria

- Ingests and normalizes data from multiple heterogeneous telemetry and sensor sources
- Supports automated schema mapping into a common BDI/A data store Ontology definition data model

- Maintains source metadata and timestamp traceability for all ingested records including:
  - Sensor identification of a collection data product
  - Effect observed with quality of observation metric
  - AI/ML supported “meaning and explainability” context for why a data product collates
- Supports BDI/BDA analyst retrieval of data products and allows analytic assessments

Problem Statement 1.2 – Multi-Phenomenology Collection & Aggregation

Problem Statement

Passive RF, Radar and Electro-Optical / Infra-Red (EO/IR) collection systems rely on fragmented data products, across multiple classification boundaries, and many of which do not always improve a collective knowledge data base, such as the BDI/A data store system, making existing structures in need of improvements for space enterprise and Intelligence Community requirements. Commercial sources integration represents a large potential for Passive RF, Radar and EO/IR data pool for integration.

Operational Context

Space Battle Damage Assessment (BDA) requires a synchronized understanding of events across multiple phenomenologies. Currently, within the Radio Frequency (RF), Electro-Optical/Infra-Red (EO/IR), and Radar Mission Unique Software (MUS) spectrums, BDI and BDA analysts are forced to navigate multiple disparate systems across various classification boundaries to assess collected data. While capabilities such as EO/IR represent massive pools of available data ripe for multi-phenomenology correlation, existing workflows will reliably connect these elements into a unified timeline. Consequently, this highly manual analysis process requires excessive user time and needs to scale effectively to bolster the space enterprise's ability to support combat tempo operations.

Requirement

Develop legacy and novel Mission Unique Software (MUS) improvements that enhance the user experience by automating data product retrieval, increasing data details on par with commercial products, and introducing refined analytic techniques. These improvements must publish analysis and assessments back to source repositories via a defined BDI/A data store ontology and enable the synchronization of Electro-Optical/Infra-Red (EO/IR), Radio Frequency (RF), and Radar data analytics to generate higher-confidence assessments. Although Pattern of Life (PoL) establishment remains outside the scope of this Focus Area, the system should facilitate access to historical data repositories to aid BDI/BDA change detection assessments. Ultimately, this cross-domain synchronization may occur within a specific sensor's MUS (EO/IR, RF, or Radar) or within another multi-phenomenology MUS.

Data Sources

- Resolved observation data
- Unresolved observation data
- Orbital event data
- Radar data products
- Telemetry streams and repositories
- Historical event repositories
- Threat signature libraries
- Simulated operational events (for analytic comparison)
- Mission operations logs

Operational Value

Accelerates Processing and Exploitation timelines for BDI/BDA assessment for Passive RF, EO/IR and radar sensor collections, leverages multi-phenomenology approaches as appropriate to provide highest confidence to operational users.

Desired Capability Outcomes / Acceptance Criteria

- Detects predefined anomalous behaviors using configurable threat signatures
- Introduces novel radar collection data products such as Doppler Residual and Area-to-Mass Ratio data sets (these two mentioned are not required, but descriptive of current data product capabilities currently underutilized)
- Displays event relationships and sequencing dependencies
- Enables drill-down traceability to originating data sources
- Generates confidence-scored alerts within operational timelines
- Supports replay against historical and simulated events

- Provides the operator the ability to compare and contrast anomalous signatures between EO/IR data products.
- Provides the operator the ability to define and refine anomalous behaviors to associate with configurable threat signatures.
- AI/ML recommendations achieves ≥80% agreement with Government analyst validation

Problem Statement 1.3 – Scoring and Confidence Improvements

Problem Statement

Analysts require standardized methods to evaluate collection source reliability and confidence and with standardized methods to incorporate multiple phenomenology data products together to improve higher confidence assessments and techniques.

Operational Context

Analysts require consistent methods to assess source reliability, confidence, and uncertainty across collection sources. Without standardized confidence scoring, collection prioritization and analytic judgments remain inconsistent.

Requirement

Develop legacy and novel MUS improvements which create more effective user experiences by automating data product retrieval, increasing available data product details in line with commercially available data products, introducing refined and novel data analytic techniques, publishing data analysis and assessments back to source repositories via defined BDI/A data store ontology, provide user-friendly and/or user defined explanations which provide context and understanding to AI/ML assisted data correlations and scoring to aid user analysis, and allows multiple phenomenology analytic techniques which generate higher confidence observations. Historical data repository retrieval aids in Pattern of Life (PoL) establishment, which is outside the scope of this Focus Area, but the access to such repositories aids change detection assessments for BDI/BDA.

Develop a dynamic confidence scoring framework that evaluates collection-source reliability, allows operator threshold adjustment, and exposes rationale tied to source metrics.

Data Sources

- Collection source performance history

- Analyst validation records
- Sensor reliability metrics
- Telemetry quality indicators
- Mission event outcomes

Operational Value

A synchronization product improves confidence scoring and Collection prioritization and creates a BDI/BDA framework tool which is greater than the sum of individual source analytic tools and products.

Desired Capability Outcomes / Acceptance Criteria

- Assigns dynamic confidence scores to collection sources
- Adjusts weighting based on historical source reliability
- Provides operator-adjustable scoring thresholds
- Displays confidence rationale traceable to source metrics
- Maintains source metadata and timestamp traceability for all ingested records including:
  - Sensor identification of a collection data product
  - Effect observed with quality of observation metric
  - AI/ML supported “meaning and explainability” context for why a data product assessment is delivered to the user
- Provides novel multi-phenomenology confidence scoring techniques
- Provides user interfaces which assist Subject Matter Experts in each of the 4 distinct portions of BDI/BDA workflows
- AI/ML recommendations achieves ≥80% agreement with Government analyst validation