Focus Area 1.0 — Crimson Forge Standup

Technical Specification & Operational Context

Sponsoring Agency:	Space Systems Command (SSC), System Delta 85 (SYD 85), KRONOS
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1. Focus Area Overview

Bottom Line Up Front (BLUF): Focus Area 1.0 – Crimson Forge Standup establishes a secure, standardized technology maturation environment designed to transition commercial Space Domain Awareness (SDA) and battlespace management edge processing software and novel sensor hardware from a prototype baseline (TRL 4) to operational readiness (TRL 7/8). Aligned under the System Delta 85 (SYD 85) Program Management Office (PMO) and the Kronos Program of Record, this focus area defines a repeatable, secure evaluation pipeline to benchmark and validate edge-processing applications and sensor technology, directly bridging commercial innovation and operational deployment.

This maturation process utilizes three integrated, mutually supporting technical capabilities. First, the **Laboratory Test Bed (PS 1.1)** provides physical core hardware nodes to evaluate edge-processing and multi-source data fusion under real-world edge processing constraints. Second, the **Digital Twin and Mission Simulation Laboratory (PS 1.2)** provides a software based proving ground for algorithm development and provides a workspace to evaluate simulated operations of real hardware, threat scenarios, and degraded environment operations. Third, the **Graphical User Interface and Control Panel (PS 1.3)** serves as the unified control plane, providing isolated team sandboxes to run automated secure pipelines and dynamically toggle features during testing.

The transition strategy for this Focus Area ensures both enduring testing infrastructure and rapid software deployment. Upon cohort completion, the developed Crimson Forge testing environment (comprising the hardware core nodes, digital twin simulation frameworks, and GUI control panel) transitions directly to the TAP Lab as an enduring asset under the **Kronos Program of Record**. Conversely, the specific commercial software applications and edge-processing technologies matured by cohort companies transition directly to their respective sponsoring **Programs of Record (PoR)** for operational fielding.

2. High Level Operational Context

Current software solutions supporting Space Domain Awareness (SDA) and battlespace management are developed and evaluated in isolated or non-representative environments that fail to emulate operational conditions, sensor interoperability, or edge-processing constraints. This isolation prevents the accurate validation of software performance, integration readiness, Artificial Intelligence/Machine Learning (AI/ML) model effectiveness, and data fusion capabilities prior to deployment. Consequently, the space enterprise requires an integrated testing architecture combining remotely deployed physical hardware core nodes, cloud-based digital twin simulations, and a secure operational control panel. This integrated environment allows commercial cohort companies (organized as Focus Area Cohort Teams / FACTs) to execute, benchmark, and transition edge-processing solutions through the DevSecOps pipeline, establishing decision dominance for joint and coalition space operations.

3. High Level Requirement

The system shall integrate a physical laboratory-based test bed hosted on core hardware nodes (**PS 1.1**), a cloud-based digital twin and mission simulation framework (**PS 1.2**), and a unified Graphical User Interface (GUI) and Control Panel (**PS 1.3**). The integrated testing architecture shall automate commercial software execution through secure DevSecOps pipelines, support simulated and live data inputs, enable dynamic feature flagging, establish isolated team sandboxes, integrate deep-dive engineering diagnostics, and provide a dedicated test and evaluation (T&E) simulation panel to evaluate and grade matured technologies against ground-truth baselines.

4. Stakeholders

- **System Delta 85 (SYD 85)** (Direct PMO and direct acquisition sponsor)
- **Program Executive Office for Battlespace Management, Command, Control, Communications, and Intelligence (PEO BMC3I)**
- **Space Systems Command (SSC)** (Overarching acquisition authority)
- **Kronos Family of Systems (FoS)** (Sponsoring Program of Record)
- **National Space Defense Center (NSDC)** (and Operational customers)
- **SpaceWERX** (Commercial transition partner)
- **Participating Cohort Companies** (organized as Focus Area Cohort Teams / FACTs)

5. Context & Assumptions

- The core purpose of Crimson Forge is to shepherd edge-processing SDA technologies from Technology Readiness Level (TRL) 4 to TRL 7/8 during the BMC3I TAP Lab Cohort.
- The final delivery of the Crimson Forge Environment (the laboratory test bed and digital twin simulation frameworks) transitions directly into the BMC3I TAP Lab itself, operating under the Kronos Program of Record (PoR).
- Commercial software applications and edge-processing technologies matured by cohort companies using the Crimson Forge Environment transition directly to their sponsoring Programs of Record (PoR) for operational deployment.
- Each cohort team is organized into Focus Area Cohort Teams (FACTs), consisting of one (1) Prime contractor and at least one (1) and up to four (4) Subsidiary companies (for a recommended team size of two to five companies) following the TAP Lab guidance.
- No single analytic tool or collection source possesses all required data; data fusion and data aggregation across phenomenology increase confidence ratings more than reliance on single-phenomenology data sets.

6. BMC3I TAP Lab Stage Expectations

The Crimson Forge standup and maturation pipeline operates within the structured four-stage lifecycle of the BMC3I TAP Lab. These stages are engineered to discover technology, assess commercial viability, mature technical architectures, and transition validated capabilities to the operational users at speed.

- **Stage 0 — Talent Pipeline (Discovery & Teaming):** Focus Area and Problem Statement (FA/PS) announcements are published forty-five (45) days prior to the Phase 1 application window. Participating small businesses attend a three-day industry conference to receive strategic guidance, network with external innovation partners, and form Focus Area Cohort Teams (FACTs). Teams submit white papers and deliver ten-minute pitches to a System Delta-85 Selection Board for Stage 1 down-selection.
- **Stage 1 — Initial Assessment and Integration (Feasibility):** Selected FACTs participate in a six-week, unfunded feasibility phase. The first five (5) weeks focus on system environment integration, technology training, and initial cybersecurity compliance control reviews within the TAP Lab facility. The final week (Pitch Week) culminates in a technical pitch and operational demonstration to secure selection for Stage 2 funding.
- **Stage 2 — Maturing Technology, DevSecOps, and T&E (Maturation):** Funded FACTs undergo rigorous software engineering and maturation. Teams advance their containerized applications, deploy within the lab's secure Kubernetes-based infrastructure, integrate with single sign-on (SSO), and execute automated DevSecOps pipelines. Solutions are subjected to CMMC-compliant security controls and structured developmental test and evaluation (T&E) benchmarks.
- **Stage 3 — Proving Ground (Operational Validation):** Matured applications enter highly representative operational validation. Testing utilizes realistic data feeds, live command-and-control networks, and full operational track volumes. Capabilities must demonstrate sustained interoperability with joint C2 and intelligence systems and run continuously over multiple weeks to establish baseline operational readiness for direct transition to the sponsoring Program of Record (PoR).

7. Problem Statement 1.1 — Laboratory Test Bed

7.1. Problem Statement

To support the rapid advancement and validation of Space Domain Awareness (SDA) and battlespace management capabilities, the space enterprise requires a standardized, representative environment to benchmark and validate software performance, integration readiness, and Artificial Intelligence/Machine Learning (AI/ML) effectiveness prior to operational fielding. Standardizing evaluation architectures and sensor interoperability models ensures that next-generation software applications, data fusion models, and edge-processing constraints are validated against representative operational parameters, accelerating development cycles and reducing transition timelines into active military systems.

7.2. Operational Context

There is a need for a laboratory-based test bed hosted on a hardware core node that provides a controlled, repeatable environment for developing, integrating, testing, and validating SDA and battlespace management applications. JADC2 and Joint Publication 3-14 emphasize SDA mission enhancement, tactical edge computing and distributed processing initiatives, and AI/ML integration into operational command-and-control workflows. This effort supports the development and validation of technologies required for future operational concepts involving autonomous processing, machine-assisted analysis, and integrated battlespace awareness.

7.3. Requirement

- **Functional Verification:** The capability must execute primary functions defined in system specifications, process inputs, and generate expected outputs for a defined dataset.
- **Interface Validation:** The capability must demonstrate data exchange with representative external systems, complying with interface control documents (ICDs) and message formatting standards.
- **Integration Baseline:** The capability must seamlessly integrate with laboratory testbed infrastructure and demonstrate interoperability with representative databases.
- **Performance Thresholds:** The capability must demonstrate repeatable operation under normal conditions, meeting developmental performance success criteria based on industry standards.
- **DevSecOps & Security Compliance:** The capability must align with the TAP Lab's DevSecOps pipeline standards, including containerized deployment (e.g., Kubernetes-based cloud architecture), Single Sign-On (SSO) integration, and adherence to the Cybersecurity Maturity Model Certification (CMMC) framework to facilitate future transition.

7.4. Data Sources

Observatory hardware provided by cohort members, and government assets (on an as-available basis).

7.5. Operational Value

Provides a secure and scalable environment for evaluating software applications that support space domain awareness, tactical decision-making, and battlespace management functions before deployment into operational systems. The environment will enable developers, operators, and mission engineers to assess software maturity, interoperability, and operational effectiveness while reducing integration risk and development timelines.

7.6. Desired Capability Outcomes / Acceptance Criteria

- Development of a functional laboratory test environment hosted on a hardware core node capable of supporting SDA and battlespace management software applications.
- Must support simulated and live data inputs, edge-processing architectures, AI/ML model execution, and multi-source data fusion to evaluate mission software performance under representative operational conditions, including degraded communications and contested environments.
- Modular architecture enabling rapid integration of new software applications, algorithms, and sensor interfaces.
- Delivery of documented laboratory test procedures, architecture documentation, performance results, and recommendations for operational transition and future capability development.

8. Problem Statement 1.2 — Digital Twin & Mission Simulation

8.1. Problem Statement

To enable high-fidelity validation and synthetic training, the space enterprise requires advanced digital twin and mission simulation environments capable of replicating multi-domain battlespace scenarios, system interactions, and mission-level effects. Incorporating secure, model-based systems engineering (MBSE) simulations allow developers and operators to evaluate software interoperability, dynamic telemetry flows, and mission-level decision-making under realistic, scalable operational contexts before operational transition.

8.2. Operational Context

There is a need to establish a digital twin and mission simulation laboratory test bed capable of emulating operational space and battlespace environments, sensor architectures, communications conditions, and adversarial behaviors. JADC2 and Joint Publication 3-14 emphasize digital engineering and model-based systems engineering initiatives, and mission rehearsal and synthetic training environment development. This will directly support efforts to create resilient, interoperable, and operationally representative environments for validating future mission capabilities.

8.3. Requirement

- **Mission Execution:** The capability must execute complete operational mission threads using large, dynamic datasets to simulate real-world scenarios and data flows.
- **Interoperability:** The capability must demonstrate integration with representative operational systems, including command-and-control (C2) nodes and sensor networks.
- **Scalability & Workloads:** The capability must support projected operational growth, such as increased track volumes, additional sensors, and expanded mission areas without exceeding latency thresholds.
- **Reliability:** The capability must support continuous operations within realistic operational environments (operational networks, representative cloud or data centers) to establish reliability baselines.
- **Secure Cloud Deployment:** The capability must deploy within the lab’s secure Kubernetes-based cloud architecture, utilizing the integrated DevSecOps pipeline for automated security scanning, vulnerability mitigation, and CMMC-compliant configuration management.

8.4. Data Sources

Observatory hardware provided by cohort members, and government assets (on an as-available basis).

8.5. Operational Value

Provides a mission-focused test capability that enables developers and operators to evaluate how SDA and battlespace management software perform in realistic operational contexts without requiring live operational systems. The digital twin will accelerate development cycles while improving confidence in software readiness and operational effectiveness.

8.6. Desired Capability Outcomes / Acceptance Criteria

- Capable of simulating representative SDA and battlespace operational conditions.
- Integration of synthetic, recorded, and live data feeds into the mission simulation framework.
- Demonstrates testing of SDA and battlespace management software applications within mission-level scenarios.
- Support for repeatable test scenarios, mission replay, and performance benchmarks.
- Integration with representative hardware core nodes and edge-processing platforms.
- Delivery of documented laboratory architecture, simulation environment configuration, operational test procedures, and recommendations for future operational transition and experimentation.

9. Problem Statement 1.3 — GUI & Control Panel

9.1. Problem Statement

The BMC3I TAP Lab requires a unified, web-based Graphical User Interface (GUI) and Control Panel that consolidates system access, automates DevSecOps pipelines, engineering analytics, and simulation setup for the Crimson Forge environment. Establishing an integrated picture for Crimson Forge, with interactive 3D visualization and diagnostic dashboard tools, enables staff and evaluators to manage role-based system access, monitor live performance metrics, and configure complex validation simulations against ground-truth baselines.

9.2. Operational Context

There is a need for a modern, web-based Graphical User Interface (GUI) that acts as the operational, diagnostic, and evaluation interface to both remotely deployed physical hardware core nodes and assets (PS 1.1) and secure, cloud-based digital twin simulations (PS 1.2). This GUI must support secure role-based system access, pipeline controls, engineering analytics to evaluate software performance, and a dedicated test and evaluation (T&E) simulation panel.

9.3. Requirement

- **System Access and Operations:** The GUI must serve as the primary secure gateway for user authentication, role-based access control (RBAC), and system-level operations, enabling operators to manage sandbox boundaries and configure interface connections to both remotely deployed physical hardware core nodes and cloud-based synthetic digital twin simulation environments.
- **DevSecOps Pipeline and Solution Deployment:** Provide graphical control panels to trigger, monitor, and push commercial cohort applications through the DevSecOps pipeline. This includes automated containerized deployment into isolated sandboxes and seamless promotion of validated software from the cloud-based digital twin (PS 1.2) to the remotely deployed physical hardware core nodes (PS 1.1).
- **Engineering Analysis and Diagnostic Tools:** Incorporate an engineering dashboard to inspect how well commercial solutions are performing in real-time. This must include deep-dive tools for telemetry analysis, real-time log streaming, system resource monitoring, and algorithmic tracking-accuracy evaluations.
- **Test and Evaluation (T&E) Simulation Panel:** Provide a dedicated T&E simulation interface to set up and execute validation simulations. Evaluators must be able to configure threat scenarios, input synthetic or recorded trajectories, inject degraded communications or adversarial effects, and run automated benchmarking against ground-truth data.
- **Dynamic Feature Control:** Provide the capability to dynamically enable, disable, or adjust features, algorithms, or parameters for any given cohort FACT application in real-time during live mission execution and benchmarking.

- **3D Visualization Engine:** Support interactive, high-fidelity 3D rendering of Earth, orbital trajectories, satellite positions, sensor fields-of-view, and threat vectors integrated directly with live simulation feeds.

9.4. Data Sources

Observatory hardware provided by cohort members, and government assets (on an as-available basis).

9.5. Operational Value

Accelerates the technology maturation process by providing a single operational gateway. It allows cohort teams to securely deploy and monitor their applications in isolated sandboxes, gives evaluators deep-dive diagnostic tools to analyze algorithmic and hardware efficiency, and provides a dedicated simulation panel to verify software against ground-truth data in a controlled, repeatable manner.

9.6. Desired Capability Outcomes / Acceptance Criteria

- Demonstrates secure role-based system access, sandbox configuration, and direct operational control of both remotely deployed physical hardware assets and cloud-based digital twin simulation environments through the GUI.
- Demonstrated execution, deployment, and promotion of a commercial application through the secure DevSecOps pipeline from cloud-based simulation sandboxes to remotely deployed hardware nodes via the GUI panel.
- Successful Utilization of integrated engineering diagnostic tools to inspect system resource consumption, real-time log streams, and algorithmic accuracy during a live benchmark run.
- Demonstrates the configuration and execution of a validation simulation via the T&E panel, including loading threat trajectories and outputting automated performance grading against ground-truth baselines.
- Demonstrated dynamic feature flagging (toggling specific application capabilities in real-time).
- Delivery of secure frontend source code, interface control documentation (ICDs), usability reports, and user experience design guidelines.

10. Concept of Operations

The core purpose of Crimson Forge is to shepherd edge-processing SDA technologies from Technology Readiness Level (TRL) 4 to TRL 7/8. Participating companies will bring their early-stage technologies to Crimson Forge at a TRL 4 level, and through the specialized resources, hardware core nodes, and digital twin environments provided, rapidly advance their software maturity to a higher TRL level during the BMC3I TAP Lab Cohort.

The Crimson Forge standup environments—comprising both the Laboratory Test Bed (Problem Statement 1.1) and the Digital Twin/Mission Simulation Laboratory (Problem Statement 1.2)—are operated in an integrated, phased approach to bridge this gap between early-stage development and operational deployment.

Under Problem Statement 1.1 (Laboratory Test Bed), the core hardware node ingests multi-source data (including synthetic scenario feeds, recorded mission logs, and live operational inputs) under edge-processing constraints to test AI/ML model execution, data fusion limits, and modular algorithm integration. Under Problem Statement 1.2 (Digital Twin & Mission Simulation), operators execute realistic mission scenarios, relevant behaviors, and impacted communications profiles within a synthetic mission environment to benchmark performance, conduct rehearsals, and validate tactical readiness without risk to live systems.

Crimson Forge represents a unique focus area within the ecosystem, as the final delivery of the Crimson Forge Environment (the laboratory test bed and digital twin simulation frameworks) will transition directly into the BMC3I TAP Lab itself, which operates under the Kronos Program of Record (PoR). Conversely, the commercial software applications and edge-processing technologies matured by cohort companies using the Crimson Forge Environment will transition directly to their sponsoring Programs of Record (PoR) for operational deployment.

10.1. Maturation Pipeline

The progression of technology through the Crimson Forge environment should be structured as a clear maturation pipeline. As an example, it could begin with Step 1: TRL 4 Entry, where cohort companies bring early-stage solutions to the TAP Lab. In Step 2: Prototyping (Digital Twin), the technology would be integrated and validated within a synthetic, model-based mission environment (aligning with Problem Statement 1.2). Next, in Step 3: Deploying (Hardware Node), the software would be deployed and rigorously tested on physical hardware core nodes under realistic edge-processing constraints (aligning with Problem Statement 1.1). Following Step 4: Maturation (TRL 7/8), where technologies achieve operational readiness, the process culminates in Step 5: Handoff to PoR, where the matured capability is is transitioned to the sponsoring Program of Record for operational fielding, while the Crimson Forge testing environment itself remains delivered to the TAP Lab as an enduring asset.

Step	Phase	Description
Step 1	TRL 4 Entry	Cohort Entry: Cohort company brings technology at TRL 4 to the TAP Lab.
Step 2	Prototyping (Digital Twin)	Synthetic Testing (PS 1.2): Validation in model-based synthetic environment.
Step 3	Deploying (Hardware Node)	Hardware Testing (PS 1.1): Testing on core hardware under edge constraints.
Step 4	Maturation (TRL 7/8)	Operational Readiness: Rapid software maturation via TAP Lab resources.
Step 5	Handoff to PoR	Transition & Off-ramp: Mature technology transitions to sponsoring Program of Record.