JCO Mission Gaps

JOINT COMMERCIAL OPERATIONS
SPACE PROTECT AND DEFEND (P&D)
JCO/DOK

UPDATED 12 JUNE 2025

JCO Mission Gaps: Space Protect and Defend

Version Updates and Changes

The table below provides a summary of updates and version changes to the JCO P&D Gaps document. Version updates and non-administrative changes require approval by the Director, JCO/DOK.

Version Numbering Guidance: The first digit of the version number represents a major document revision. The second digit represents minor updates or an additional appendix.

Version	Implemented By	Revision Date	Approved By	Approval Date	Reason for Update / Changes
1	Michael Taylor	2 June 2025			Initial Document

Table of Contents

Joint Commercial Operations Mission Gaps

Updated 24 May 2025

JCO/DOK

This document is intended to communicate JCO mission gaps to existing and potential JCO vendors, as well as JCO operations and staff personnel. The goal is to better share focus areas so that vendors can align their efforts with JCO mission needs. The gaps are aligned under the following categories reflecting the same categories as the JCO Mission Essential Tasks document:

1. Plan and Direct
2. Collect
3. Process and Exploit
4. Analysis, Estimation and Production
5. Disseminate and Integrate

This document will be periodically updated to reflect evolving mission needs and operational lessons learned. Vendors and stakeholders are encouraged to maintain an active dialogue with JCO Weapons and Tactics (DOK) to ensure mission alignment and effectiveness.

1. Plan and Direct

The JCO supports both dynamic and deliberate planning to enhance the effectiveness of the space Protect and Defend mission. Dynamic planning refers to adaptive, real-time decision-making in response to changing conditions or threats in space. Deliberate planning involves more structured, long-term strategies that are developed in advance. Planning requires in-depth understanding of potential threats, internal sensor capabilities and architecture

1.1. Gap: Generate and Display Steady State Collection Plan

1.1.1. Reference: METS task 1.1, Measures 1, 2, 3.

M1	Yes / **No**	Is a current collection plan for tactical monitoring of HRR satellites available on the UDL?
M2	Yes / **No**	Is the collection plan being published at a specified recurring

		interval/cadence?
M3	Yes / **No**	Are sensor providers sending collect responses to the HRR tasking and can the JCO display these responses to identify sensor gaps?

1.1.2. The JCO currently uses a High-Rate Revisit (HRR) method of tasking, providing a prioritized list to sensor providers through a Unified Data Library notification message. Objects are added and prioritized on the HRR based on information from publicly available information and the satellites on-orbit behavior.

1.1.2.1. The HRR notification message is received by JCO sensor providers and executed based on the object priority on the HRR list, driving object revisit rates. Sensor tasking is not optimized across the commercial network. In addition, the JCO does not have highly accurate predictions on overall sensor gaps to report future collection plans internally and externally.

1.1.3. Ongoing Efforts: The JCO is actively working with Space System Command's (SSC) Machina Program to implement a phased approach to address this mission gap. The solution includes sending UDL collect requests to sensors and commercial sensor architectures for the HRR list and receiving a collect response that forecasts sensor visibility from both individual sensors and sensor providers.

1.1.4. Gap: Although the Machina effort is working to support HRR dissemination and response, the JCO currently does not have an interface to monitor sensor availability or status. The JCO has prototyped a capability in the past that may be shared to provide insight into JCO needs for this specific gap. The JCO requires a UI that provides the following:

1.1.4.1. Display sensor locations, FOV and status on a 2D/3D map. Sensor FoV should be accurately reflected and allow toggle on/off. Data to support this UI is available in the UDL schema, and metric observation monitoring provides insight into sensor status (time of last observations).

1.1.4.2. Overlay HRR object states (ground trace) on the 2D/3D map to better understand sensor access to high interest objects. Generate tabular timeline charts to show when sensors have visibility to a specific HRR object to include collection probability based on sensor specifications.

1.1.4.3. Incorporate weather and cloud over forecasts for sensor sites to predict collection probability. This includes forecasted preciptionation percent and wind sppeds along with cloud density.

1.1.4.4. Receive and display collectresponse messages to forecast sensor visibility to HRR Objects and specific solar exclusion periods for optical capabilities.

1.1.4.5. Model JCO space-based collection platforms and sensor visibility to HRR objects.

1.1.4.6. Monitor UDL status and health messages from individual sensors and display status.

1.1.4.6.1. Monitor data receipt trends from individual sensors and other data sources and provide alerts if data trending is violated, indicating a potential data outage.

1.1.4.7. Apply day and night status and reflect optical sensor solar exclusion.

1.1.4.8. Make available satellite characterization data in the UI for selected satellites in an effort to pair satellite characteristics with sensor collection capability.

1.1.4.9. Trend data collection by specific sensors to inform sensor capability and incorporate into sensor/object pairing based on sensor detection capability, geographic location, etc.

1.2. Gap: Satellite Characterization Database

1.2.1. Reference METS task 1.3, Measures 1-4.

M1	Yes / **No**	Are satellite characteristics populated in appropriate UDL schemas?
M2	Yes / **No**	Are the satellite characteristics considered in collection planning?
M3	Yes / **No**	Do the satellite characteristics inform alerting thresholds and threat determinations?
M4	Percent	Completeness of characteristic data

1.2.2. The JCO requires a capability/service to develop and publish satellite characterization information to support mission planning, including pattern of life (PoL) information. This information must be maintained in a readily accessible location to support dynamic threat determination. The UDL supports satellite characterization schemas.

1.2.3. Ongoing Efforts: The JCO is integrating new threat determination processes that may incorporate satellite maneuver pattern of life, passive RF sensors that require understanding of satellite RF emissions, and other capabilities that may rely on understanding satellite characteristics.

1.2.4. Gap: Although the UDL contains schemas to support satellite characterization, the data is not populated nor maintained. In addition, maneuver pattern of life is not stored or readily available. The below outlines the initial JCO requirements to address this gap:

1.2.4.1. Monitor and store HRR object maneuver PoL to help distinguish between nominal station-keeping maneuvers and larger, potentially nefarious maneuvers outside of pattern-of-life. These values may also be used during threat determination for reachable volume assessments (paragraph 4.2).

1.2.4.2. Identify and store RF emissions for HRR satellites

1.2.4.3. Identify and store signature data, to include Visual Magnitude over time and Radar Cross section values.

1.2.4.4. Identify and store spectral signatures.

1.2.4.5. Identify and store solar Array information.

1.2.4.6. Identify and store propulsion and thruster information.

1.2.4.7. Identify and store satellite payload information and bus type.

1.2.4.8. Identify and store satellite mass.

1.3. Gap: Develop Satellite Patterns of Life

1.3.1. Reference: METS task 1.5, Measures 1-6.

M1	Number	Number of confirmed maneuvers that have been included in maneuver pattern of life collections by satellite on the HRR list (ranks 1-3)
M2	Histogram	Distribution of maneuver types included in maneuver pattern of life collections by satellite on the HRR list
M3	Percent	Percentage of active EOIR sensors providing sufficient data for visual magnitude and RCS history by provider
M4	Percent	Percentage of active RF collectors that are providing sufficient data for a history or fingerprint using signals, frequencies,

		TDOA/FDOA, etc. by provider
M5	Percent	Percentage of active radars providing sufficient data for an RCS history or fingerprint by provider
M6	Yes / No	Fuel consumption per satellite maneuver is tracked and maintained on satellite dossier

1.3.2. The JCO requires a capability/service to develop and publish satellite pattern of life information to support planning, threat determination and maneuver alerting criteria. This requirement is related to satellite characterization (previously described gap, paragraph 1.2. where characterization data is available). The pattern of life must be readily available and integrated into JCO planning and alerting solutions. The pattern of life must include maneuver trends (date/times, magnitude, direction) to enable identification of station-keeping, station-change or other maneuvers. In addition, the pattern of life should include attitude changes, RF emissions, close approaches, remote proximity operations (RPO) activity, and any plane matching or other behavior.

1.3.3. Ongoing Efforts: The JCO currently has little or no efforts underway to capture this information and apply it to real-time operations or planning.

1.3.4. Gap: The JCO does not have access to PoL information to apply to planning and real-time operations to support maneuver characterization, attitude (signature) data characterization or to predict or identify anomalies in RF. The below outlines the initial JCO requirements to address this gap (prioritize efforts on HRR objects):

1.3.4.1. Monitor object maneuver pattern-of-life and identify maneuvers that are inside or outside satellite pattern of life. Predict maneuver activity based on pattern of life. The pattern of life should be available to support real-time operations. For example, the capability should provide the operator with a determination (and confidence value) on whether an HRR satellite maneuver is station-keeping (inside PoL) or non-station-keeping (outside PoL).

1.3.4.2. Characterize and predict:

1.3.4.2.1. Station keeping maneuvers

1.3.4.2.2. Station change maneuvers

1.3.4.2.3. Ingress for RPO

1.3.4.2.4. RPO characterization

1.3.4.3. Identify RF emission anomalies for HRR satellites and identify RF emissions or cadence that violate PoL. This information should be available to support real-time operations, alerting operators of violations of RF emission PoL.

1.3.4.4. Identify signature data, to include Visual Magnitude over time and Radar Cross section and identify PoL based on attitude changes reflected in RCS/VisMag values. These changes may be seasonal or conducted to support specific purposes or simply based on different sensor locations (e.e. north vs. south hemispheres). Characterize the PoL of the signature changes to predict and characterize activity. Provide an assessment of the specific change in a JCO operator alert.

1.4. Gap: Dynamic Launch Processing

1.4.1. Reference: METs task 1.10, Measures 1-4

M1	Percent	Percentage of sensors that acquire and associate to the launch hypotheses / nominals
M2	Time	Time from tasking to sensor receipt of tasking
M3	Percent	Percentage of tasking achieved to include metric, characterization, features, and reporting criteria
M4	Percent	Percentage of launch custody and characterization plans that discover / recover the launch vehicle

1.4.2. The JCO requires a capability that detects unexpected launches and generates launch hypotheses to support sensor tasking for custody and characterization of newly launched objects. Upon detection of an unexpected launch, launch hypotheses should be generated or a set of launch nominals are selected from a database, and sensors in view of the estimated launch trajectory should be dynamically tasked to search and discover the launch vehicle and any deployed objects, along with characterization tasking once the objects have been detected.

1.4.3. Ongoing Efforts: The JCO currently has the capability to generate non-dynamic launch nominals. These nominals are generated for known launches ahead of the launch event. The nominals are generated to an epoch of the expected launch time. Should the launch occur outside of the expected time, the JCO has a capability to rotate the nominal based on the new launch time

1.4.4. Gap: The JCO does not have a method to dynamically generate launch vectors or states and task sensors to support launched object tracking and characterization. The JCO does not have a way to generate reliable nominals or hypothesis states for real-time operations around the clock, nor to task sensors to support launches outside of Americas dayshift (some sensors are tasked via chat and MMB). The JCO does not have OPIR or other capabilities to detect launches and generate initial states to support initial cues for sensor tasking.

1.4.4.1. The JCO does not have sensors that are taskable 24/7 to support dynamic launch task receipt and execution to acquire, track and characterize launches.

1.4.5. The following outlines the needs for this task:

1.4.5.1. Detect initial launch and generate immediate hypothesis state vectors or TLEs to support JCO sensor tasking. This may be based on historical launches, OPIR information, or other phenomenology.

1.4.5.2. Identify stage burn-out to ensure accurate propagation of launch states. Generating a launch state during boost introduces errors.

1.4.5.3. Sensors are required to support dynamic launch acquisition and tracking based on initial launch tip.

1.4.5.4. Deliver launch states to UDL using pre-defined candidate state numbers to support sensor ingestion and tasking, or (preferable) generate collect requests (UDL schema) to dynamically task sensors in view to collect launched objects.

1.4.5.5. Receive updated states on launched objects, dynamically distribute to the JCO sensor architecture, and continue tasking for custody.

1.4.5.6. Generate and disseminate tasks for characterization.

1.4.5.7. Initial launch vector generation and sensor tasking to support should be available 24/7.

1.5. Gap: Dynamic Sensor Tasking

1.5.1. Reference: METs Task 1.12, Measures 1-4. METs task 1.13 Measures 1-2

M1	Seconds / Minutes	Time from event detection to publication of updated tasks
M2	Percent	Tracking success rate of updated tasking plan
M3	Percent	Percentage of events where custody is maintained after dynamic tasking is published and executed
M4	Number/Type	Total number and type of phenomenologies contributing to updated sensor plan
M5	Number	Geographic diversity of the sensor plan
M1	Percent	Percentage of providers that are capable of providing cues internally and to external providers; this is defined by a sensor provider dynamically sending states to sensors that will be in view of the object on subsequent passes.
M2	Number	Number of successful tip and cue operations completed

1.5.2. The JCO requires a capability that provides dynamic tasking, preferably through UDL collectrequest schema, to support event custody, sensor tip and cue, and other high priority space events.

1.5.3. Ongoing Efforts: The JCO currently is integrating the SCC program Machina to generate and disseminate dynamic tasks, which will also receive sensor responses to tasking (collectresponse UDL schema) and provide status. This capability remains in development and testing. The limiting factor has been the ability to integrate a network of taskable sensors that meet JCO budgetary constraints.

1.5.4. Gap: The JCO does not currently have a method or sensor resources to dynamically task sensors 24/7. The below outlines the requirements for this task:

1.5.4.1. Provide JCO operators the capability to dynamically task sensors by capability, visibility to a specific object, and weather constraints.

1.5.4.1.1. If dynamic tasking is integrated into sensor schedule, re-allocate HRR tasking to minimize impact to the baseline JCO collection plan.

1.5.4.1.2. Incorporate weather/forecasts of cloud cover and data to understand percent likelihood of collection

1.5.4.2. Provide automated tasking (collectrequest schema) based on HRR 1-2 maneuver alerts/notifications from diverse sensors to buy down maneuver recovery timelines. The UDL maneuver alerts receipt should drive a follow-on tasking (collectrequest) to appropriate sensors in view, preferably tasking geographically (and phenomonolgy) diverse sensors to support rapid maneuver recovery.

1.5.4.3. Generate collect requests for sensors in view of events to support dynamic, automated tip and cue for high interest events including:

1.5.4.3.1. Reentry events (uncontrolled)

1.5.4.3.2. De-Orbits (controlled)

1.5.4.3.3. HRR 1-2 maneuver events at LEO and GEO

1.5.4.3.4. Launch events

1.6. Gap: Status of Forces Monitoring and Alerting

1.6.1. Reference: METS task 1.15, Measures M2, M3, M5

M2	Percent	Percentage of critical operational elements providing heartbeat messages
M3	Accuracy (Percent)	Accuracy of the status messages (i.e., are we receiving data when they are up, and not receiving data when they are down?)
M5	Alert	Percent of alerts that are created from outages (total outages vs. alerts)

1.6.2. The JCO requires a capability that provides monitoring of JCO systems and automated alerts for system/sensor/data outages. The alerts should be delivered to a common JCO operations environment and obvious to the operator.

1.6.3. Ongoing Efforts: The JCO currently uses Grafana dashboards to manually check the status of data and systems and relies on JCO providers to alert the operations teams if data is not received. Each of these approaches relies on human-in-the-loop processing and is prone to error.

1.6.4. Gap: The JCO does not currently have a method or solution to automatically notify operators of system, sensor, and/or data outages. The below outlines the requirements for this task:

1.6.4.1. Provide JCO operators with an alert if a data feed is not available. An additional alert should be provided for return to operations.

1.6.4.2. Proactively provide the JCO operators with insight of scheduled outages for individual sensors and systems.

1.6.4.3. Option to use UDL status messages to convey this information; the JCO has not yet mandated providers to send outage notifications for scheduled or unscheduled outages but may require this if armed with a solution to use the messages.

1.6.4.4. Option to trend data over time (states, obs, other) and alert operator if trended data receipt is violated.

1.6.4.5. Alerts must be provided in a way that is obvious to the operator. This may be a pop-up in a common environment, operational chat, or other means.

1.6.4.6. Alerts for sensor outages should be integrated into any sensor support plan for modification of the plan if necessary.

1.7. Gap: Calibration Satellite Access

1.7.1. Reference: METS task 1.17, Measures 1-2

M1	Frequency	Frequency of metric calibration tasks
M2	Number	Number of unique calibration satellites tracked by each sensor

1.7.2. The JCO conducts sensor calibration by tasking sensors on calibration satellites. These calibration satellites (calsats) are resources that rarely maneuver and provide precision ephemeris data to the JCO curation frequently to support both single day, weekly, and 14-day calibration efforts. The JCO provides its sensor providers guidance on how and at what frequency to collect on this specific list of calsats. This effort ensures that the JCO sensors maintain a high level of accuracy.

1.7.3. Ongoing Efforts: The JCO currently relies on its curation teams to gain access to specific curation sources to support JCO calibration efforts.

1.7.4. Gap: The JCO Curation teams do not have access to enough calibration satellites to maintain 100 percent calibration of the JCO sensors. The below outlines the needs for this gap:

1.7.4.1. Provide JCO with sensor calibration sources that deliver precision ephemeris on a timely (daily is desired) routine basis to support LEO and GEO sensor calibration efforts.

2. Collect

The JCO manages and directs commercial entity collection of data on space objects focused on the space Protect and Defend mission. This involves establishing revisit rates to maintain threat custody, clearing high value assets, orchestrating sensors to support object discovery and closely spaced object detection, tracking launches, and detecting breakups. The JCO strives to establish persistent coverage of the Space AOR, initially focused on the LEO, MEO and GEO orbit regimes. The JCO relies on the UDL to store sensor characteristics and capabilities, collects metric and signature data, and distribute collection tasking.

2.1. Gap: Sensor Coverage

2.1.1. Reference: METS task 2.4 (impacts several additional tasks), Measures 1-5

M1	Percent	Percentage of tasks by provider whose latency causes the task to arrive beyond the boundaries of the revisit window.
M2	Percent	Percentage of the day where revisits on a single satellite are maintained (using Revisit Rate Interval and Total Violation Time methods at a minimum)
M3	Percent	Percentage of the day where combined revisits for a group of satellites are maintained (using RRI and TVT methods at a minimum)
M4	Percent	Percentage of successful revisit bins (RRI) on a single satellite supported by multiple phenomenologies
M5	Percent	For individual satellites, the percentage of revisit bins (RRI) supported by multiple geographically diverse sensors

M6	Percent	Percent of diverse sensors (both geographic and phenomenology) that support HRR collection on specific satellites.

2.1.2. The JCO stives to maintain defined revisit rates for high priority space objects. This can only be supported by a robust sensor network with global coverage. Geographic dispersion and multi-phenomonology support rapid event recovery, signature change detection and PoL generation.

2.1.3. Ongoing Efforts: The JCO is actively working to onboard a LEO Space-to-Space collection capability that will likely address optical coverage at LEO for large payloads above 500 km (smaller payloads, 1 meter or less and lower altitude payloads will remain undetected). Radar and other phenomenology at LEO are required. The JCO GEO architecture is heavily supported by electro-optical capabilities that introduce a gap in solar coverage.

2.1.4. Gap: The JCO currently does not have a view of the entire space AOR to support rapid detection and response to nefarious activity in space. The JCO has a goal to maintain revisits of 30 minutes for high priority objects at LEO, and to gain 24/7 access to GEO objects, eliminating the solar gap. The JCO is focused on radar and space-based commercial capabilities to close these sensor gaps.

2.1.4.1. Currently, the JCO LEO gap results in collection of only 5% of the total collection need of the JCO high interest objects. The gaps are primarily over oceans and land masses where it is restrictive for the JCO to host sensors. The ongoing effort for space-to-space integration will likely address most of this gap with the exception of objects in the earth's shadow, objects below 500 km, and objects smaller than 1 meter. LWIR, radar, small objects (smaller than 1 m) detection, low altitude object detection (below 500 km) and other phenomenology are required to fill this gap.

2.1.4.2. Gaps in geostationary orbit are due to electro-optical sensors and limitations to perform day-time collections. JCO can only achieve consistent custody of high-interest objects at GEO local night, leading to gaps in coverage of 8-12 hours per day of high interest objects, resulting in only 50-67% GEO coverage for JCO HRR objects. Current solar gaps at GEO are focused on 45-115 deg East. RF capabilities, delivering TDOA / FDOA data in C, KU, X and S band currently supplement the JCO EO capability for some of the HRR objects.

2.2. Gap: Negative Reporting and Revisit Violations

2.2.1. Reference: METS task 2.3, Measures 1-3

M1	Percent	Percentage of negative reports received compared to data receipt
M2	Time	Time to report negative acquisition following expected collection time.
M3	Time	Time from reporting to mitigation action taken on negative acquisition

2.2.2. The JCO Operators must be notified when a task is not fulfilled to ensure immediate action may be taken to re-task, potentially prevent prolonged lost objects, and support threat determinations. In addition, if a revisit violation occurs NOT due to weather or sensor visibility, this should drive an alert to the JCO; this could be indications of a large maneuver, and the object is no longer correlating to the expected state.

2.2.3. Ongoing Efforts: The JCO has manual processes to verify task completion, and the UDL supports collect response messages for dynamic task requests (although this has not been implemented, reference paragraphs 1.1.4. and 1.5.3.). To monitor daily revisit violations, the JCO executes manual processes through exploring residual plots and Grafana/Tableau dashboards.

2.2.4. Gap: The JCO currently does not have a solution for automatic notification or follow-on tasking for revisit violations or negative reporting. The below outlines requirements for this gap:

2.2.4.1. Develop a way to read the JCO HRR tasking and monitor metric data receipt. Generate alerts to the operator if an object revisit is violated due to an unsuccessful collection that is not due to weather or sensor visibility on the object.

2.2.4.1.1. Alerts should be published to a common operating location for the JCO.

2.2.4.2. Receive notifications of negative reporting and generate a dynamic re-task.

2.2.4.2.1. Dynamically re-task objects that are in revisit violation by generating a collectrequest message for revisit violations or negative reporting (UDL collectresponse) alerts.

2.3. Perform Automated UCT Processing

2.3.1. Reference: METS task 2.7, Measures 1-2 and METS task 2.8, Measures 1-4.

M1	Time	Time between identification of a UCT and publication of an alert, for UCTs that meet alerting criteria
M2	Percent	Percentage of UCTs that have resulted in alerts by provider
M1	Time	Time between initial identification of UCT, and follow-up action
M2	Percent	Percentage of follow-up actions successful in finding and tracking the UCT by provider and sensor type
M3	Yes / No	Does follow-up tasking include geographically diverse sensors or sensors of a different phenomenology?
M4	Yes / No	Is follow-up criteria provided to all sensor providers?

2.3.2. The JCO mission to support P&D operations includes the discovery of potential on-orbit threats. Adversaries may employ Camouflage, Concealment, and Deception (CCD) techniques to mask the presence, behavior, or intent of space-based systems. These methods may be used to deliberately evade detection and tracking, posing a direct risk to the safety of high-value national and allied space systems. JCO operators to achieve timely awareness of newly discovered space objects, support custody and threat evaluation, and provide early warning to JCO consumers if the object meets defined threat criteria. This capability supports supporting HVA Clearing, Tactical Search and Recovery and CCD (Camouflage, Concealment, and Deception (CCD) alerting.

2.3.3. Ongoing Efforts: The JCO is working to integrate the TapLab capability called Dungeons and Dragons (DND) which uses developed UCT processing algorithms, along with integration of UDL candidate states to counter CCD. The program performs automated Uncorrelated Track processing to generate candidate states. These states are propagated backwards to determine a point of origin. If the point of origin is unknown, the discovered state is filtered through a set of triage criteria to determine if it is a potential threat.

2.3.3.1. The DnD program maintains its own catalog composed of objects that are not listed in the Mission Delta 2 (18 SDS) catalog. The DnD program identifies objects through a triage approach that identifies them as “BOGEYs.” These objects have been deemed as a potential threat and do not have an established origin. The DnD catalog continuously identifies object origins in an effort to reduce false alarm rates. The DnD program distributes a routine SITREP that outlines BOGEY objects.

2.3.3.2. The DnD program can identify BOGEY states and alert the JCO of these states that could drive additional tasking and characterization efforts. In some cases, the BOGEY may drive notifications to JCO consumers, like the NSDC.

2.3.3.3. The DnD program conducts conjunction assessments on the BOGEY states and can generate notifications to the JCO. These conjunction notifications may also drive additional JCO tasking and notifications.

2.3.4. Gap: The JCO currently does not have a solution for receipt and automatic notification or automated follow-on tasking for the alerts received from the DnD program. Below outlines the requirements to address this gap:

2.3.4.1. Develop a way to read the DnD alerts published to the UDL and notify operators of each of the two types of alerts:

2.3.4.1.1. The first alert is the DnD identification of new candidate states that meet characterization requirements for further investigation and tasking. This alert not only should be published to an alerting UI for the JCO operator, but also generate appropriate tasking (collectrequest) to continue to attempt to characterize the object.

2.3.4.1.1.1. Working with the JCO, develop and integrate rulesets on when to add the BOGEY object to the HRR and when to remove. Newly discovered objects must be assigned a specific analyst number that must be communicated across the JCO and ingested by sensor providers to support additional tasking and provided to fusion providers to support threat assessment. This data should be transferred via UDL.

2.3.4.1.2. The second alert is conjunction assessments on the BOGEY states and can generate notifications to the JCO. These conjunction notifications may also drive additional JCO tasking and notifications. The capability should alert the operator of the conjunction and support dynamic tasking to support additional monitoring and analysis.

2.3.4.2. Alerts should be published to a common operating location for the JCO.

3. Process and Exploit

The JCO must effectively manage and use data originating from multiple commercial sensor sources. This data may provide insight into metric positions and signatures to enable understanding of specific space objects. Data must be processed into formats compatible with common data standards and facilitate decision-making and further analysis. The JCO must associate metric and signature data with specific space objects to support state updates, maneuver detections, change detection, characterization, and ultimately threat determination.

3.1. Gap: Advanced Maneuver Processing

3.1.1. Reference: METS task 3.4, Measures 1-2. METS task 3.5 , Measure 1. METS task 3.6. Measures 2-3.

M1	Time	Time from estimated maneuver time to alert of possible maneuver?
M2	Time	Time from estimated maneuver time to alert of verified maneuver?
M1	Time	Time from maneuver execution to establishing the initial estimation of the magnitude, direction and time of the maneuver, along with the post maneuver state error.
M2	Percent	Percentage of HRR object maneuvers that were recovered to within the accuracy and timeliness criteria
M3	Speed	Time for JCO to receive or develop a new post-maneuver state with the required recovery accuracy (measured from event detection).

3.1.2. The JCO benefits from accelerated metric data delivery from sensors to UDL, and from UDL to fusion systems—providing precise position and velocity data of space objects. This rapid data delivery supports the fusion of metric data and state generation. In addition, the data supports maneuver alerting and recovery.

3.1.2.1. Maneuver alerting: The JCO has a requirement to identify maneuvers as early as possible for HRR objects. This usually requires advanced approaches like reviewing metric observation residual data rather than waiting for post maneuver states.

3.1.2.2. Maneuver recovery: In addition, the JCO requires as rapid maneuver recovery as possible. Maneuver recovery is the generation of a post maneuver state to drive additional notifications to the NSDC and other operational centers. It is imperative that the post maneuver state estimation includes an operator-readable covariance value along with a shelf-life of that value.

3.1.3. Ongoing Efforts: The JCO current fusion providers have some advanced capabilities to provide maneuver alerts to the UDL.

3.1.4. Gaps: This specific gap is separated into three additional sub-gaps. The below outlines the sub-gaps and requirements for each:

3.1.4.1. Maneuver alerting: When a high-interest satellite maneuvers, the JCO is responsible for notifying elements of USSPACECOM in support of the Space Protect and Defend mission. Such maneuvers may signal nefarious intent, potentially positioning a satellite on an intercept trajectory toward a U.S. or allied high-value space asset. To mitigate this threat, it is imperative that the JCO rapidly identify the maneuver, providing timely alerts to operational centers to enable proactive defensive posturing.

3.1.4.1.1. Although the JCO has fusion providers who send maneuver alerts to the UDL (maneuver alert schema), the JCO has not refined requirements for these alerts, nor does the JCO have an alerting infrastructure to warn the operator of the potential maneuver or dynamic task to support rapid maneuver recovery. This is currently a manual process between operators and providers in JCO chat.

3.1.4.1.1.1. The JCO must define maneuver alert requirements for providers defining when to send UDL alerts and the required data in each alert.

3.1.4.1.1.2. The JCO requires a capability to receive these alerts for situational awareness and potential follow-up (further investigation, tasking, notifications)

3.1.4.1.1.3. The maneuver alerts should drive additional tasking to geographical diverse sensors to drive down maneuver recovery timelines. Automated generation of a collectrequest message may drive additional tasking.

3.1.4.2. Maneuver recovery: Maneuver recovery is essential; requiring the JCO to swiftly determine the post-maneuver state of the satellite and accurately characterize its new trajectory. Traditionally, the operator waited for enough observations over enough of an orbit period to solve for the new orbit state to within the accuracy requirements for the ongoing event. But today, advanced techniques must be applied to decrease recovery times.

3.1.4.2.1. The JCO requires advanced techniques to be applied to produce a post maneuver state as quickly as possible to begin to understand the threat object trajectory.

3.1.4.2.2. Post maneuver states should update the maneuver alert in the UDL, as a verified maneuver, and include maneuver parameters (time, magnitude, direction and post maneuver state) as well as the error value.

3.1.4.3. Covariance/error growth: The post maneuver state must include the covariance value in an operator-understandable format. This information should not only include the error at epoch, but also a depiction of the error growth over time. Operators should be able to define accuracy thresholds and understand when that threshold will be violated if a sensor collection is not accomplished. This supports required sensor tasking timelines to ensure state accuracy is improved and/or maintained.

3.1.4.3.1. Covariance values should be included in the UDL maneuver alert schema.

3.1.4.3.2. The maneuver alert should be populated in a JCO alerting infrastructure and be accompanied by a product that displays covariance growth over time.

3.1.4.3.3. The results may also include recommended sensor tasking to achieve or maintain an operator-defined value of error for the post maneuver state.

3.2. Gap: Automated Signature Change Detection

3.2.1. Reference: METS task 3.9, Measures 2,3,7,10. METS task 3.10 , Measures 2,3,5,6. METS task 3.1. Measures 2,3,5,6.

M2	Yes / No	Do photometry changes that break thresholds generate alerts automatical-ly?
M3	Time	For cases where photometric change occurred before a maneuver, how much time was between the photometric change and the maneuver
M7	Number	Number of indications of changes in visual magnitude that fell outside of the pattern of life

M10	Percent	Percentage of maneuver events that were determined to be Mv pattern of life violations prior to the execution of the maneuver (i.e. attitude changes)
M2	Yes / No	Do signal changes that break thresholds generate alerts automatically?
M3	Time	For cases where signal change occurred before a maneuver, how much time was between the signal change and the maneuver
M5	Percent	Percentage of identified maneuvers within a determined period of time that were detected before or during the maneuver due to signals being outside expected pattern-of-life
M6	Percent	Percentage of maneuver events that were determined to be pattern of life violations prior to the execution of the maneuver (i.e., attitude changes)
M2	Yes / No	Do radar signature changes that break thresholds generate alerts automatically?
M3	Time	For cases where radar signature change occurred before a maneuver, how much time was between the signature change and the maneuver
M5	Percent	Percentage of identified maneuvers within a determined period of time that were detected before or during the maneuver due to RCS being outside expected pattern-of-life
M6	Percent	Percentage of maneuver events that were determined to be pattern of life violations prior to the execution of the maneuver (i.e. attitude changes)

3.2.2. The JCO data schemas from sensor sources not only support metric information, but also signature information. This includes Visual Magnitude from telescopes, frequency information from RF sensors, and RCS (radar cross section) values from radars. This available sensor information may be trended over time and provide a PoL. Violations of the PoL for satellite signatures may indicate (or predict) specific activity that is of interest to the Space P&D Mission.

3.2.3. Ongoing Efforts: The JCO fusion providers generate light curves by plotting solar equatorial phase angle over visual magnitude. These light curves are generated based on prolonged plotting of the vismag data values posted in the Electro Optical UDL schema for individual sensor observations. Anomalies along these light curves indicate a change in attitude, deployment, or other activity that the fusion providers alert to the JCO. Most of these alerts are generated through manual identification of the anomaly, although some fusion providers have efforts underway to automate.

3.2.4. Gap: The JCO does not have a capability that provides automated alerts for signature changes, does not have an alerting capability to M2M alert of the event, nor does the detected change include potential activity, by HRR satellite, associated with the signature change (pending maneuver due to attitude change, deployed antenna, other).

3.2.4.1. The JCO requires capabilities that automatically detect anomalies in visual magnitude, RF and radar data and generate alerts based on these changes. The alerts should be published to the UDL for JCO consumption.

3.2.4.1.1. The JCO requires a UI or alerting dashboard to notify operators of these signature changes.

3.2.4.1.2. False alarm rates must be maintained to reduce operator complacency.

3.2.4.1.3. To reduce false alarms, consider sensor checks like hemisphere, sensor historical sensitivity at different solar equatorial phase angles and usual reporting on the object at the same phase angle.

3.2.4.2. Change events/alerts should include purpose for change.

3.2.4.2.1. Attitude changes that precede a maneuver should be identified

3.2.4.2.2. Changes that show an antenna deployment

3.2.4.2.3. Changes that show an attitude adjustment supporting payload mission (example: optical on-orbit inspection), also showing close approaches around the time of change that are set to defined distances by the JCO operation team.

4. Analysis, Estimation and Production

The JCO plays a crucial role in analyzing data and performing comprehensive analysis to support decision-making processes in the protect and defend mission. JCO responsibilities in evaluating threats and forecasting future events are essential for ensuring proactive responses and maintaining situational awareness in dynamic space environments. This role requires strong analytical skills and a deep understanding of the systems involved to effectively predict outcomes and generate accurate reports and warnings.

4.1. Gap: Sensor Gap Assessments

4.1.1. Reference: METS task 4.1, Measures 1-2.

M1	Minutes / Hours	Network coverage gaps at GEO orbit regime and HRR ranks 0-3 objects by time of day and longitude
M2	Minutes / Hours	Network coverage gaps for LEO orbits by HRR ranks 0-3 objects satellite

4.1.2. The JCO sensor architecture objective is to maintain persistent coverage of all orbit regimes (prioritizing LEO and GEO), with redundancy and multi-phenomenology. The JCO requires analysis capabilities to assess sensor gaps to inform mission planning, analysis tool development, sensor tasking and to inform recommendations for sensor investments.

4.1.3. Ongoing Efforts: The JCO weapons and tactics team uses STK with HRR states integrated to identify sensor gaps.

4.1.4. Gap: The JCO does not have the capability to provide in-depth modeling of JCO sensor gaps and assessments of new sensor architecture. The JCO requirements to address this gap are listed below:

4.1.4.1. Provide an environment that reads the JCO sensor information and HRR list to create a modeling environment.

4.1.4.2. Provide the ability to ingest new sensors to the environment along with analysis on HRR collection performance metrics.

4.1.4.3. Provide the ability to generate simulation scenarios to understand sensor performance during wartime / contingency operations.

4.1.4.4. Provide a model to incorporate sensor capability and cost to inform investment decisions.

4.2. Gap: Threat Determination

4.2.1. Reference: METS tasks 4.2, 4.3, 4.4, 4.5, 4.6. All associated Measures.

M1	Percent	Percentage of threat events identified and reported compared to those missed.
M2	Time	Time from trigger to threat determination and alerting

M1	Frequency	Frequency of computation of susceptibility of MAL satellites versus ACL, and BCL satellites
M2	Number	Number of times action was taken because of a susceptibility window
M3	Yes / No	Are JCO thresholds defined that govern the susceptibility window criteria?
M1	Percent	Percentage of proactive tasks resulting in collection that were achieved
M2	Percent	Percentage of susceptibility windows that resulted in tasking
M1	Time	Time from detection of maneuver to computation of updated susceptibility windows
M2	Number	Number of times dynamic susceptibility is updated between routine susceptibility computation
M1	Yes / No	Are there established criteria and thresholds for evaluating orbit trajectory attack viability?
M2	Percent	Percentage of events when viability is determined, and warnings disseminated.
M3	Time	Total time between detection of an event and the determination of attack viability
M4	Number	Total number of viable trajectories identified
M5	Number	Total number of times viability computation was executed

4.2.2. The JCO requires a robust, automated threat determination process that can evaluate threats posed to BLUE satellites on the JCO HRR list. Threat determination is an evaluation of analysis results, combined with alerting thresholds, to determine when alerts are provided to the JCO team and the associated follow-up action (notification, tasking, other). The threat determination process consists of three levels of threshold alerting: Vulnerability, susceptibility and viability. These are defined below. The JCO should have a planning interface to define these alerts, which should monitor HRR satellite behavior and orbital elements to drive automated alerting.

4.2.2.1. Vulnerability is the capability assessment for the threat satellite against the BLUE satellite. If the threat is kinetic, then every BLUE satellite is vulnerable. If the threat is a jammer, then the BLUE satellite must be in line with the RF jamming capability. If the vulnerability assessment fails (BLUE is not vulnerable to the threat) then that BLUE object is removed from threat determination processing for the specific threat.

4.2.2.2. Susceptibility is the next assessment, and it includes establishing loose thresholds based on threat capability. These thresholds include the reachable volume of a threat, solar exclusion angles (for threats with optical payloads), relative velocity, plane matching, and other criteria. An example of a susceptibility threshold is that a threat HRR satellite can perform a 20 m/s maneuver and intercept a BLUE HRR object in 12 hours.

4.2.2.2.1. Violations of susceptibility thresholds usually drives additional tasking at expected maneuver times.

4.2.2.2.2. Reachable volume is attained by assessing the likely maneuver magnitude of a threat (based on PoL and any available PAIR data for fuel capacity) and the likely maneuver times to reach specific BLUE HRR objects.

4.2.2.3. Viability is the final threat determination step and drives JCO notifications. These thresholds are more stringent than the vulnerability thresholds. An example is that a threat HRR satellite can perform a 20 m/s maneuver and intercept a BLUE HRR object in 12 hours, AND it has executed a maneuver that is outside of its PoL.

4.2.3. Ongoing Efforts: The JCO recently integrated a capability that supports reachable volume assessments.

4.2.4. Gap: The JCO currently uses a threat determination process that largely ignores the maneuverability of threatening satellites. The JCO focuses on point and time of closest approach of a threatening satellite along with matching planes (inclination and right ascension) to assess potential threats. This application ignores the maneuverability of threats. The outcome desired is to assess the reachable volume of a threat based on a fuel capacity or maneuver pattern of life for the specific spacecraft. By incorporating these values (along with other criteria), the JCO can assess when a high-value asset is in reachable volume of a threat and provide alerting as well as increase sensor tasking to detect potential maneuvers. The JCO cannot appropriately conduct realistic threat determination of maneuverable threats to drive early alerting.

4.2.4.1. The JCO requires a maneuver "score" based on pattern of life (PoL). This score would be very low if the maneuver is common and predictable, e.g. a station-keeping maneuver every week. The lack of a routine maneuver should also drive an alert. A large maneuver, very outside PoL would drive a high score. The score allows the operator to determine if a maneuver is nefarious. The resulting score must be available in the JCO alerting UI.

4.2.4.2. The JCO requires a planning environment to create tiered trigger conditions (vulnerability, susceptibly, viability thresholds as an example). Those conditions must include alerts based on:

- 4.2.4.2.1. Point and distance of closest approach
- 4.2.4.2.2. Reachable volume, or an operator defined delta-V and an operator defined time
- 4.2.4.2.3. The defined delta-V should be informed by the maneuver history of the specific threat object
- 4.2.4.2.4. The defined delta-V and time should inform a lambert solution, and the operator should have options to minimize delta V or minimize time to target
- 4.2.4.2.5. Solar angle
- 4.2.4.2.6. Relative velocity
- 4.2.4.2.7. Plane matching (inclination and RAAN)

4.2.4.3. The operator defined alerting conditions should apply to a list of HRR "red" objects and HRR "blue" objects, and upon violation, the operator should be alerted and the alert may drive automated tasking.

4.2.4.4. Violated alerts should be evident to the JCO operator through an alerting dashboard or other common JCO interface.

4.2.4.5. The threat determination process may also include maneuver or behavior characterization; an example is an automated process to characterize RPO posturing.

4.2.4.6. Trigger violations should drive automated sensor tasking; generation of a UDL collectrequest message with appropriate tasking based on the threat scenario.

4.3. Gap: Satellite Identification

4.3.1. Reference: METS tasks 4.15. Measures 1-2.

M1	Number	Number of lost objects that were identified through photometry, signatures, signals and/or fingerprints
M2	Percent	Percentage of maneuvered HRR satellites that were identified as the same satellite as before the maneuver

4.3.2. Upon any maneuver outside of active tracking, a determination of the satellite must be performed to ensure the photometry, signatures, signals, and/or fingerprint of the satellite identify the satellite as the same one as before the maneuver. Every satellite should be able to be identified through a combination of parameters obtained through characterization and pattern of life to a reasonable level of confidence. Upon maneuver or any change to the satellite that is not lost, it's imperative to ensure the satellite is the same one as before the maneuver. If the satellite is a new discovery, both origin tracing and satellite identification should be used to ensure the satellite can be traced back to any missing spacecraft based on historical photometry, signatures, signals and/or fingerprint data.

4.3.3. Ongoing Efforts: The JCO currently uses light curve information and metric data to manually perform positive satellite identification.

4.3.4. Gap: The JCO does not have satellite characteristics readily available to perform positive satellite identification for recovered satellites or newly identified satellites. The below outlines the requirements for this task

4.3.4.1. The JCO requires a database of satellite characteristics (reference paragraph 1.2).

4.3.4.2. The characteristics for each satellite must be readily available to support specific tasking phenomenology to include

4.3.4.2.1. Visual magnitude

4.3.4.2.2. RF signature

4.3.4.2.3. RCS

4.3.4.2.4. Spectral signature

4.3.4.2.5. Metric information

4.3.4.3. The data resulting from tasking should drive an automated process to identify the likelihood of the satellite being a specific object with an assessment score.

5. Disseminate and Integrate

The JCO must ensure, to the fullest extent possible, that commercially provided data and data products are available to appropriate operational centers for use in the protect and defend mission. This data could include metric observation data, state data, signature data, sensor status, sensor capabilities, satellite cards, data products, and analysis results. In addition, the JCO must provide notifications of space events under mission-relevant timelines.

5.1. Gap: NOTSO Generation Timelines

5.1.1. Reference: METS task 5.2, Measure 3. Task 5.3, Measure 3. Task 5.4, Measure 2. Task 5.6. Measure 2.

M3	Time	Time from event detection to publish the initial notification.
M3	Time	Time from event detection to publish the initial notification.
M2	Time	Time from satellite meeting threat criteria to notification being sent.
M2	Time	How long after an IOD is attained is a notification sent with the updated ELSET?
M3	Time	How long from event update/change notification criteria being met did it take to publish the event update/change notification?

5.1.2. The JCO requires timely messages to be sent to external users to support critical decision-making. The primary method for JCO messaging is the JCO NOTSO (Notice to Space Operations). The generation of the NOTSO includes manual typing of event descriptions and manual integration of associated products. The NOTSO is generated and disseminated as quickly as possible to notify recipients of JCO detected space events.

5.1.3. Ongoing Efforts: The JCO development team (Dragon Army) continuously updates the Mission Management Board (MMB) to support faster NOTSO generation experiments for the JCO.

5.1.4. Gap: The JCO timelines to generate a NOTSO require improvement. The process to type details into the NOTSO message and attached products is manual and time consuming. The JCO requires:

5.1.4.1. Integration of JCO provider products into NOTSO generation; an easy interface to allow the operators to rapidly select relevant products.

5.1.4.2. Use of automated NOTSO detail generation based on the specific event. Currently the operator copies and pastes data from procedures; an AI capability may enable more rapid generation of the message information only requiring operator review and minor modifications.

5.2. Gap: JCO Machine to Machine Messaging

5.2.1. Same as gap description above; focus on external messaging

5.2.2. The JCO currently sends unclassified email NOTSOs to external classified and unclassified consumers for space events related to the space protect and defend mission. The JCO has identified the need to improve its ability to convey live operational space events using M2M connections. Multiple users in different locations, and possibly using disparate software need to be able to reconstitute events and have a common operational picture. The capability is needed for systems operating at the commercial or unclassified level, as well as the ability to transfer 'the event picture' up to tactical units and operations centers at higher classification levels.

5.2.3. Ongoing efforts: The JCO is pursuing an "Event Ledger" effort to use the UDL cross domain solutions to message from low to high classification levels. Dragon Army, the JCO development arm, is developing a prototype capability to support message generation. Details of this approach may be found here: https://docs.google.com/document/d/140LgZ1xNYekFxhxD582eRE_FjdYf_LmO4mho--pTBns/edit?usp=sharing

5.2.4. Gap: The ability to transfer event vignettes between disparate operational environments, including higher level classified systems (not only US, but also AUS, UK and NATO) , is a high priority JCO task and enables the ability to receive critical information for display on the user's unique application set. Current operations only support an email message to report these warnings;

the update to this schema, enabling the machine-to-machine messaging, postures the units to better maintain situational awareness of their AOR.

5.2.4.1. The JCO requires the capability to package the NOTSO messages into the UDL eventevolutions schema. This schema supports the transfer of relevant information to communicate the space event identified by the JCO. Additionally, this solution only applies to the US UDL low-to-high messaging; a gap exists for low-to-high messaging to UK, AUS and NATO classified environments.

5.2.4.2. The data transferred must include:

5.2.4.2.1. Relevant state vector information with covariance values

5.2.4.2.1.1. Covariance values should be displayed in an operator digestible way by the receiving system.

5.2.4.2.1.2. States associated should be dynamically updated by state updates using the eventevolution schema

5.2.4.2.2. Event type (maneuver, launch, etc)

5.2.4.2.3. Event start and stop times

5.2.4.2.4. Text information describing the event

5.2.4.2.5. Orbit display information

5.2.4.2.5.1. Orbit visual on map (yes/no)

5.2.4.2.5.2. Orbit color

5.2.4.2.5.3. Tail and lead time for orbit propagation

5.2.4.2.5.4. Covariance display

5.2.4.2.5.5. Radial, In-track and cross track distances for alerts involving RPOs or close approaches

5.2.4.2.5.6. Labels for objects

5.3. Gap: Alert Integration

5.3.1. Multiple METs

5.3.2. Throughout this document there have been references to an alerting dashboard, or a way to integrate alerts into the JCO infrastructure. This includes alerts for maneuvers, RPOs, signature changes, outages, pos/neg reporting, and other events. Automated alerting is essential to situational awareness and rapid decision-making.

5.3.3. Ongoing efforts: There are not ongoing efforts addressing this gap.

5.3.4. Gap: The Joint Commercial Operations (JCO) has identified an operational gap in the dissemination and use of alerts and notification for JCO-detected space events. The JCO leverages the Unified Data Library (UDL) as its primary distribution platform for data and alerts; these alerts are currently underutilized by JCO operators during real-time operations.

5.3.4.1. JCO vendors publish timely and relevant alerts to the UDL, and continue to mature rapid reporting capabilities. However, the JCO does not have a way to alert operators on these events to support immediate situational awareness and decision-making. The UDL's Machine-to-Machine (M2M) interface offers an efficient mechanism for delivering automated notifications, significantly reducing reporting timelines and minimizing human error.

5.3.4.2. JCO currently receives metric data from sensor providers under operational relevant timelines, which positions the team to issue early warnings on critical space events—such as satellite maneuvers, uncorrelated track detections, or relevant space events. To fully realize this potential, the JCO must operationalize and integrate the UDL's notification and alerting architecture into routine workflows, exposing vendor alerts to the operations team.

5.3.4.3. Mores specific requirements for an alerting dashboard may be found here: https://docs.google.com/document/d/1d3x_bhN_GS3xBRX_VTGkgvtrm5es_uKsCUhFXkppse4/edit?usp=sharing