Addendum 4: Fused Data and Services

12.4 Data Analytics

A. Fused Data Products

1. (Threshold) Provider shall utilize company services to fuse observations from multiple sources of data, including Electro-Optical (EO), passive RF, and radar generated by other providers in support of JCO. In addition, provider shall integrate data from the18th Space Defense Squadron (SDS) distribution. In the proposal response, please describe the service offering to include the following for quantity, quality, and supported data types and phenomenologies. Please identify all sources that the Provider is currently integrating into fusion products.

2. The JCO created the JCO Data Requirements document that **must** be adhered to in support of population of data to the UDL in support of JCO mission operations. Vendors can access the document at: https://docs.google.com/document/d/1WoZlMrf1YHQFV8Gehnw1aQxsFaa3V3lBW7_tkK4LT4E/edit?usp=sharing

3. (Threshold) The JCO will provide an unclassified 'High-Rate Revisit' (HRR) list to the UDL, made available to the providers via the UDL notification message. The providers should price bids for objects in Near-Earth (NE) (defined as a period of less than 225 min), Deep Space (DS) (period greater than 225 min) and super-Geosynchronous Earth Orbit (XGEO) (including cis-lunar) orbits or launches, as supportable by their analytical tools. The JCO Command and Control (C2) operations centers may modify the HRR list at any time and the Provider will have a 10 minutes during duty hours to adjust the focus of its processing outputs.

When responding to the JCO Fused Data and Services PWS, vendors are asked to:

- Describe the cost of each package as a function of the Service License Agreement (SLA) distribution options if multiple service levels are offered.
- Include details regarding surveillance architecture proposed including processing delays from UDL data pull to data fusion to fused product delivery back into UDL, estimated accuracy as a function of noise+bias (arcsecond, millisecond timing), covariance, and orbit determination accuracy.
- Provide a quote for processing of "catalog" by orbit regime, as well as other purchasing variations for additional capabilities, specifically near-earth (period less than 225 min), deep space, XGEO/cislunar separately. Include any cost increase or decrease for rates for catalog maintenance or other variations in separate bids.
- Include a list of all software packages will be utilized to support JCO-related tasks.

The table (starting on page 2) outlines Provider requirements related to data, tasks and products for JCO fusion provider operational support. Responses to this PWS may be provided in the "Provider Response" column in this table for each requirement:

Table 1: JCO Fusion Provider Requirements

The Provider shall:

Para. / Task Name	Threshold (text)	Objective (text)	Provider Response
a. Ingest UDL Data	Ingest data from the JCO data groups as defined in the list below. 1. EOObservations messages 2. RadarObservations messages 3. DiffOfArrival messages. Time Difference of Arrival (TDOA)/Frequency Difference of Arrival (FDOA) 4. Maneuver messages 5. StateVector messages (with covariance information) 6. Elset messages (mean elements) 7. SensorCalibration messages Ingestion should occur through secure messaging API via the UDL and data should be consumed by the fusion provider within 5 minutes of being posted to the UDL.	Ingest data from the JCO data groups defined below (in addition to the threshold data groups and timeliness requirements). 1. Space Based metric data 2. Conjunction messages 3. Sensor records (with the included sensor limits) 4. collectRequest / collectResponse messages (for awareness of tasking status) (in development) 7. Observation Correlation messages (in development) Ingestion of data sets may come through delivery mechanisms, repositories, and sources outside of UDL.	
b. Ingest UDL State Information	Ingest state information (TLEs and State Vectors) to support state comparison capabilities, tip and cue, and threat determination using external state sources available through the JCO data rights. Have the ability to use external states in threat processing as directed by JCO C2. Data shall be ingested withing 5 minutes of being posted to UDL.	Same as threshold, **but in addition**, provider shall have the ability to identify the most recent state updates in the UDL to use for threat determination and identify the most accurate states to support threat determination. Ingestion of additional state information data sets may come through delivery mechanisms, repositories, and sources outside of UDL.	
c. Correlate Metric Data	Correlate metric data to state solutions based on internal capabilities.	*Same as threshold*	

d.	Ingest JCO HRR List	Automatically ingest the JCO HRR notification message from the UDL to support fusion provider state update priorities and threat assessment priorities. Ingest the HRR when posted to UDL within 10 minutes of update to UDL since the HRR list changes dynamically and is posted upon change.	*Same as threshold* Same as threshold but ingest the HRR when posted to UDL within 1 minute of update to UDL.	
e.	Apply Sensor Corrections to Weighted DCs	*Not applicable*	Use and apply information from JCO Curation sensor calibration processing and populated to the UDL sensorcalibration schema. Sensorcalibration information should be incorporated into DC results to inform weighted DC solutions that increase state accuracy. Updates should be made at least every two weeks, but preferably when calibration changes exist in the sensorcalibration schema	
f.	Perform State Updates	Maintain internal state database (or catalog) and update state information as new metric observations are provided. Fuse metric data (RF, EO, Radar) to update object states, prioritizing JCO HRR objects. Post state update cadence (posting state vectors and TLEs to UDL) for HRR objects to UDL upon state update generation, driven by new metric information for a state update. State updates must occur automatically in the fusion system and also have the capability to support manual intervention through residual plots for manual differential corrections. Both State Vectors and TLEs must be generated.	*Same as threshold, and additionally generate* ephem Type 4 SGP4-XP TLEs. In addition, maintain a catalog of "well-tracked UCTs" to include in JCO threat determination processes.	

	Deliver state updates to UDL; must adhere to the UDL statevector and elset schemas defined in the UDL, and include sigma values. Post state update information as requested by JCO C2 to JCO mission systems (MMB and/or chat). Elsets must meet AstroStandards compatibility requirements, to include the below: • Mean elements with Kozai mean motion and ephemType set to 0 • ephemType2 with Brower mean motion is acceptable as well • Coordinate frame is TEME of Date (or TEME of Epoch) • If converting from SP vectors, do not use single point conversions from a state vector to a TLE, instead propagate the vector and fit the TLE over a larger percentage of the orbit		
g. UDL Data Delivery	Provider data must be delivered to the Global Data Marketplace (GDM) endpoint associated with the JCO data purchase.	*Same as Threshold*	

h.	Maneuver Alerting	Identify maneuvers through automated alerting based on metric observation information and their relationship to expected states for HRR 0-3. Provide maneuver alerts via JCO chat or voice via operations channels. Maneuver alerts must be sent within 10 minutes of maneuver identification. False alarm rates should be maintained to under 30%. Maneuver identification depends on the tasking rate and metric data delivery; providers must work to minimize the amount of data required to drive a maneuver alert while maintaining false alarm rates.	Same as threshold requirement but maneuver alerts for HRR 0-5. Alerts must be provided in the same manner as threshold, with the addition of maneuver alerting to UDL and within 1 minute of maneuver identification. False alarm rates should be maintained to under 10%. Maneuver alerts may also be predictive based on photometric changes indicative of pending maneuvers. In addition, providers must score the maneuver based on PoL for each specific satellite (focus on HRR 0-3 initially). This score should be a rating of how close to the PoL the maneuver is based on day and time.	

i.	Maneuver Recovery	Deliver post maneuver state information, to include at a minimum the following: - Time of Maneuver - Delta V of maneuver I m/s - Period change in seconds - Apogee change in km - Perigee change in km - Inclination change in degs - Current drift rate degs per day (for GEO - Post maneuver state - Covariance value For high interest objects (HRR 0-2) the post maneuver information may be provided early with lower accuracy states – covariance values in UDL schema must be populated. As with every state, those post maneuver states must include covariance values. States must be updated to produce more accurate post maneuver state and maneuver estimation results as more metric data is provided. Since post maneuver state generation depends on so many variables (maneuver direction and magnitude, sensors in view, data) it is impossible to require a maneuver recovery timeline requirement; providers must strive to develop a post maneuver state as quickly as possible.	For high interest objects (HRR 0-2) the post maneuver information may be provided early with lower accuracy states as long as those post maneuver states include covariance values. Provide insight into the purpose of the maneuver (station-keeping, station change, unknown, other). In addition, providers must score the maneuver based on PoL for each specific satellite (focus on HRR 0-3 initially). This score should be a rating of how close to the PoL the maneuver is based on day and time.	

j.	Intermittent State Updates	*Not Applicable*	Provide the JCO operations team with near real-time state updates derived from Kalman filter solutions. These solutions represent the current best estimate based on available data but should be considered provisional. Additional data will continue to refine and reinforce the solution estimate over time.	
k.	Early Maneuver Indications	Notify the JCO via Teams or Zoom voice or through approved operational chat if observation residuals appear to diverge from the predicted ephemeris for a Rank HRR 0, 1 or 2 objects. This will enable timely additional tasking and further investigation to assess potential maneuver activity. Explain the indication and follow-up as additional data becomes available.	*Same as Threshold*	
l.	Space Event Reconstruction	*Not Applicable*	Support event reconstruction for high interest events (RPO, launch, maneuver, separations). Implement precision state vectors to support event reconstruction for post analysis and after-action reporting. Products may include charts, videos, state vectors, maneuver information (time, direction and magnitude), proximity distances or other supporting information.	

l. Photometry Change Detection and Alerting	*Not Applicable*	Establish a photometric light curve for HRR 0-3 objects and indicate anomalies from that light curve based on pattern of life. Strive to automate detection of anomalies and automate alerting to the JCO. Report the light curve anomalies with screen shots of the anomalies along with the follow-on activity (maneuver) that may occur. Alerts of anomalies must be provided within 10 minutes of identification, and follow-on activity reporting must be provided within 30 mins of alert. Determine purpose of change: examples of some potential reasons are close approach with another object and what the lighting conditions where between the two objects; historical pattern of life based on the objects activity within thresholds and/or seasonal lighting conditions. This can be unknown as well. Deliveries: - Time window of change: DDMMMHHMMz to DDMMMHHMMz - Solar phase angle window: XX to XX - Vismag pre change: XX.XX - Vismag post change: XX.XX - Close approaches within window - Current longitude: Current drift rate in degs/day	

m.	Display State Covariance	*Not Applicable*	Display values for state covariance from internally and externally generated states. This shall be provided in a numerical value along with a visualization of an error bubble around the satellite in 3D space. Covariance values and visualization must be made available within 1 minute of state generation or external state ingest from the UDL.	
n.	Generate Sensor Visibility Plan	Generate a sensor coverage forecast for specific satellites upon request. The forecast shall be a visual depiction of the propagated state along with the active JCO sensors in visibility of the object. The product shall include sensor visibility parameters found in the UDL sensor cards, along with solar exclusion parameters. The product must be generated within 30 mins following request.	The forecast shall also incorporate any planned sensor outages and weather - weather shall include a percentage of cloud cover. This capability may be a software solution delivered to the JCO C2 team for use and be maintained by the vendor.	
o.	Generate Neighborhood Watch	Deliver a product that displays objects in the vicinity (in plane and longitudinal distance) of an object in question. Following a maneuver of an HRR 0-3 object, JCO C2 will ask for a Neighborhood plot. The product shows potential point and time of closest approach • For GEO, the product shall indicate other space objects that are close in both plane and in proximity across the GEO belt. • For LEO, the product shall display objects that are close in inclination and RAAN, and must propagate those states to report on point and time of closest approach.	Same as Threshold, **but in addition**, shall report on the reachable volume of the threat satellite. This includes a user-defined maneuver magnitude and forecast time for a Lambert solution from the threat satellite to a blue HRR 3 satellite.	

	The reporting thresholds shall be adjustable based on user need. Reporting timeline must be within 30 mins of customer request, maneuver or significant event (maneuver, RPO, launch, multiple headcount, signature change, etc.		
p. Provide Space AOR Visualization	Provide 2D and 3D visualizations of the space AOR to support understanding of space events.	Provider shall receive eventevolution and notification messages to display machine to machine messages.	

q. Alert Planning Interface and Messaging	*Not Applicable*	Provide an interface for the JCO to define alerts. These alerts must be configurable, provide different tiers, and drive automated alerts when violated to a JCO COP. Alerts should include:
		• A list of threat objects and blue assets.
		• Configurable alerts (or a combination of alerts), with operator defined time outlooks for:
		  ○ POCA/TOCA
		  ○ Lambert maneuver solutions for time and delta-V
		  ○ Sun angles
		  ○ Plane matching
		  ○ Maneuver (outside of PoL)	

r. POCA/TOCA Reporting	Alert operator when a rank 0-4 object has a POCA or TOCA with another rank 0-4 object. Alerts shall be sent based on operator defined thresholds	Alert operator when a rank 0-5 object has a POCA or TOCA with any other object in space. Alerts shall be sent based on operator defined thresholds	

s. Maneuver Prediction and PoL Scoring	*Not Applicable*	Provide alerts to JCO when a maneuver may happen based on specific satellite PoL. The predicted maneuver shall be characterized as an expected station-keeping maneuver or other as identified by PoL. In addition, upon a maneuver for an HRR 0-3 object, the vendor shall provide a score to the JCO that outlines if the maneuver was inside or outside PoL, and provide details on the maneuver (station-keeping, other) to support further JCO reporting. This information shall be provided to JCO within 20 minutes of a maneuver alert and updated within 20 minutes of generation of a post maneuver state and maneuver parameters (DV, time, direction, etc.).	
t. Reachable Volume Assessment	*Not Applicable*	Create an asset and threat list and run Lambert solutions each time a state is updated for either list of satellites. The Lambert solution shall incorporate user-defined thresholds for Delta-V and time. In addition, the operator can select the Lambert parameters to minimize fuel consumption or minimize time of flight for the threat to asset computation. If a delta-V and time threshold is broken, the operator is alerted through a M2M interface or a GUI. Ideally the alert, which shall predict the maneuver time, drives automated tasking at the maneuver time to verify if the maneuver happens.	
u. UCT Processing and Triage	*Not Applicable*	Automatically process observations on Uncorrelated Targets (UCT) in an effort to	

		generate candidate states on unknown objects. Candidate states that may be in the vicinity, plane matched or have a reachable volume of nominated satellites that may be consistent with a potential threat should drive warning to the JCO C2 via chat, along with publishing the candidate state to UDL and chat. This involves triage of candidate states and alerting of objects that may pose a threat to US or allied space assets. Observations and candidate satellites may be considered a UCT under the following conditions: • Provider defined UCT: Observations that do not correlate to something in the 18 SDS public catalog at time of collect when tasked on a nominated satellite. Maintain a databased of "well tracked UCTs" that are routinely tracked but not part of the 18 SDS space-track catalog	
v. Ingestion and Processing JCO Sim Data	*Not Applicable*	Ingest simulated data sets from JCO simulation data providers ***Note***: This is an objective requirement but will become threshold NLT Oct 2025. This data must be consumed and processed from the JCO simulation environment (Trogdor) Simulated data must remain segregated from live operational data, but provider shall still provide simulated data in a sim over live environment.	
w. Provide status of JCO Sensors	*Not Applicable*	Incorporate sensor availability based on weather and maintenance into sensor visibility assessments and warn JCO of pending mission impacts due to sensor availability.	

x.	Process DA ASAT to GEO	Perform Initial Orbit Determination to support DA ASAT and other launch events. Propagate generated states to GEO and provide neighborhood assessments based on DA ASAT location at GEO. Fusion and propagation methods shall support ballistic trajectories for DA ASAT events to GEO. Provide an assessment of likely target objects via a neighborhood assessment withing 30 minutes of IOD generation and update the assessment as the state is updated.	*Same as Threshold*	
y.	Fusion Provider Products	Generate the following products (specific criteria may be made available on the JCO procedures): 1. Waterfall plots (GEO obs in longitude over time) 2. Post maneuver delta V magnitude and direction 3. Combo - conjunction assessments 4. COCO - co-planar assessments (RAAN and inclination) prefer to also include vector magnitude differences 5. Seven day outlook to address nodal regression, identifying any co-planar objects based on this regression over time. 6. Neighborhood - GEO object near an object of interest 7. Pass Schedules - JCO sensor in view of a specific satellite 8. Photometry - light curves and anomalies in light curves 9. 3D Plots or TRIC Plots - display two satellites or plots showing distances in range, in-track and cross-track	*Same as Threshold*	

z.	Initial Orbit Determination	Collect new metric observations and generate new orbits that may not correlate to an existing object. Fuse metric data (RF, EO, Radar) to produce initial orbits. New objects must be posted to UDL within 5 minutes of object discovery.	Collect new metric observations and generate new orbits using unique algorithms applied based on the available data. Fuse metric data (RF, Radar, EO including ground-based and space-based) to produce initial orbits. Tag new states to an analyst number provided by the JCO	

B. Orbital Analytics Support

1. (Threshold) Provider shall provide an expert system analyst to utilize its analytical services to process purchased SDA data in support of orbital analytics, feature analytics, and visualization functions across operations. Expert system analyst support must be forward-leaning and proactively support JCO throughout mission execution. This includes but is not limited to the following support:

    a. (Threshold) Analyst will continuously monitor the JCO Mission Systems (MMB and chat) and/or JCO video conferences throughout normal hours of operation during their assigned shifts, with 30 minutes required for changeover receipt on the front end of the time period.
        i. (Threshold) JCO-Americas operating time is Monday-Friday, 1430Z to 2230Z, with 30 min required for changeover receipt on the front end of the time period.
        ii. (Objective) Alternatively, analyst will be available to support another JCO Global site (Pacific and/or Meridian) for 8.5 hours (operations period and change-overs). JCO-Pacific operating time is 2300Z to 0700Z and JCO-Meridian operating time is 0700Z-1500Z in the Nov 2023 period of performance, with 30 min required for changeover receipt on the front end of the time periods.
    b. (Threshold) When Analyst receives a request for information from the Chat or Voice reporting from JCO leads, they shall A) acknowledge receipt of the request in the corresponding Chat Thread within -15 minutes of transmit of the tasker, B) shall briefly describe their anticipated course-of-action (COA) with timelines.
    c. (Threshold) When Analyst receives a request for information from the Chat or Voice reporting from JCO C2 leads, they shall A) acknowledge receipt of the request in the corresponding Chat Thread within 15-minutes of transmit of the tasker, B) shall briefly describe their anticipated course-of-action (COA) with timelines.

d. (Threshold) During crew support hours, the orbital analysis support must include interpreting metric (position, velocity data). Orbital analytics tools will be capable of orbit determination as well as initial orbit determination with no initial seed state.
e. (Threshold) Orbital analyst supporting each crew shall provide feature analysis support, including interpreting imagery, signals, and behavioral analytics.
f. (Threshold) Orbital analyst supporting each crew shall provide graphical / visualization support.
g. (Threshold) Fusion analyst shall provide fused multi-source and multi-provider feature (e.g., VisMag, RCS) analysis
h. (Objective) Should provider deploy software for operator use, provider shall enable remote access for a minimum of 10 users simultaneously *Provider shall provide range pricing for any increasing group of users, if necessary.
i. (Threshold) Provider shall enable network access to analytical processing enclaves on US servers from global outstations with minimal delay
j. (Threshold) Provider shall maintain separation in data sets in accordance with data rights across various user groups (e.g., UK user group may have access to different data sets from US user group). Additional time and materials may be priced to establish separate network enclave(s), as required.
k. (Threshold) Initial tool familiarization training shall be provided for all govt users, though Govt Current Operations leads are battle management / Current Ops personnel focused on prioritization, Space Domain Awareness (SDA) resource allocation, threat and space flight safety event comprehension and implications, and reporting; and not expected to be power users of IODET capabilities, as that role is executed by commercial SMEs in operations. However, govt leads should be capable of understanding all products from tools that may be reported up / out and their application and implications on space activities.
l. (Objective) Advanced / Power user training for full use of all capabilities of tools, including manual piece separation, manual orbit determination, dynamic trajectory update through forced motion circumnavigation, etc. It is understood that several of these functions may be automated/in-the-background during nominal operations, but advanced / SME users are expected to be able to pull the system out of automated processing for manual override and review of complex scenarios, as needed.

2. (Threshold) All data – including processed products - will be published to the UDL data repository or JCO defined interfaces.
   a. (Threshold) Data submission in compliance with UDL formats

b. (Threshold) Providers shall begin working to submit products machine-to-machine using methods defined by JCO Dragon Army as available to be made available in the JCO Mission Management Board (MMB). If posting directly to MMB is unavailable, Providers should use Chat as tertiary backup.
c. (Threshold) Provider shall reach out to the Air Force Research Lab Dragon Army Integration Team to work a single sign on (SSO) log in to the MMB, if one is not already activated, within 24 hours of proposal acceptance.
d. (Threshold) – In event that a processing system is to be offline, the provider will send notifications 2 weeks in advance, or within 2 hours for unexpected outages which will result in an extended outage to JCO Site Lead and program management office.
e. (Objective) Provide UDL status messages to convey planned and unplanned outages, ETROs and system health messages

C. Deliverables

Description	Frequency
Space Surveillance Data – Steady-State Monitoring	NRT through PoP
Space Surveillance Data – UCTs	NRT through PoP
Space Operations Analyst Support – 1 FTE	8.5-hour shifts/5 days per week
Advance Sensor Change/Removal Notification	2 weeks prior to anticipated change
Monthly status reports (MSR) emailed to designated JCO Global Coordinator, Program Management Office, and JCO Ops Integration	Monthly, by the 10th of each month
Processing Issue, Outage Notification	Within 24 hours of Occurrence