Joint Commercial Operations (JCO) Introduction and Way Forward

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ABSTRACT

In 2020, United States Space Command established the Joint Commercial Operations (JCO) cell to augment the National Space Defense Center's (NSDC) mission to protect and defend US and Allied high value assets in space by leveraging commercial capabilities to provide diverse, timely, non-classified Space Domain Awareness (SDA) and alerting services. In 2023, the JCO evolved into a global capability through the stand up of JCO-Meridian and JCO-Pacific to complement the existing JCO-Americas regional cell with a follow-the-sun approach to crew staffing and scheduling, completing a model centered on cooperation and information sharing using a common operations baseline.

Each JCO regional cell is evolving organically towards a similar goal by contributing a unique mix of analytical services, commercial data, staffing support, and sensor availability based on regional cooperative contributions. This diverse set of capabilities is shared with and leveraged by the greater JCO-Global construct to garner new perspectives and approaches for increased analysis confidence across all operations. This approach enables each cell to evolve independently while maintaining operational consistency through a common set of procedures and standards.

As of August 2024, JCO is supported by 18 allied and partner nations operating virtually from geographically diverse locations around the globe. The JCO's core Protect and Defend mission is constantly evolving to harness commercial agility and innovation to meet real world needs, while aggressively working to expand its support to US combatant commands and international partners. JCO is expanding into additional missions and orbital regimes including electromagnetic spectrum operations, space weather, space-based collection, cyberspace security, military space flight safety, and orbits beyond geosynchronous. The JCO is also expanding its international partnerships to strengthen security cooperation with the goal of transparency and shared global situational awareness. In 2025, the JCO will focus on normalizing operations, bolstering its commercial baseline and support infrastructure and increase operational readiness through participation in select military exercises. The vision is to evolve the JCO into a global international operations center for integrating commercial capabilities to augment all-domain military operations.

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1. INTRODUCTION – WHAT IS THE JCO?

In 2020, United States Space Command established the Joint Commercial Operations (JCO) cell to augment the National Space Defense Center's (NSDC) mission to protect and defend the space domain by utilizing commercial capabilities to provide diverse, timely, non-classified Space Domain Awareness (SDA) and alerting services. The JCO has recently organized under the U.S. Space Forces for Space (S4S) Component and the Combined Joint Force Space Component (CJFSC) supporting U.S. Space Command (USSPACECOM). It supports the military forces, U.S. Space Force field components, combatant commands, as well as Allies and Partner Nations.

JCO executes in a virtual environment and leverages trained government personnel from 18 Partner Nations to resource 24-hour operations excluding weekends (i.e., 24/5) global operations using a "follow-the-sun" model. Crew members are aligned daily in three regional cells, (JCO-Americas, JCO-Meridian, and JCO-Pacific) to conduct operations, preferably during their local daylight hours. Partner Nations contribute resources to mission-share and burden-share in support of 24-hour operations. In addition, the JCO receives the majority of its U.S. military personnel through a partnership with the Air National Guard (ANG) or Reserve Component. Through Partner Nation contributions and the ANG, the JCO expects to build adequate resources to conduct 24/7 operations by April 2025. The JCO contracts for multiple commercial sensor phenomenologies to include electro-optical, radar, passive radio frequency (RF) along with data fusion and analysis, publicly available information research (PAIR) and data curation services to persistently monitor a select set of high interest satellites and space-related activities. Sensors collect metric observations and signature data for objects in low earth orbit (LEO), Mid Earth Orbit (MEO) and Geosynchronous Earth Orbit (GEO) to rapidly detect and characterize space launches, satellite maneuvers, pattern of life (PoL) changes, rendezvous and proximity operations (RPO), close approaches and other potentially threatening space activity. The JCO government team curates commercial information, analysis and products characterizing space activity or events and publishes them in Notices to Space Operators (NOTSOs).

2. JCO CELL OVERVIEW

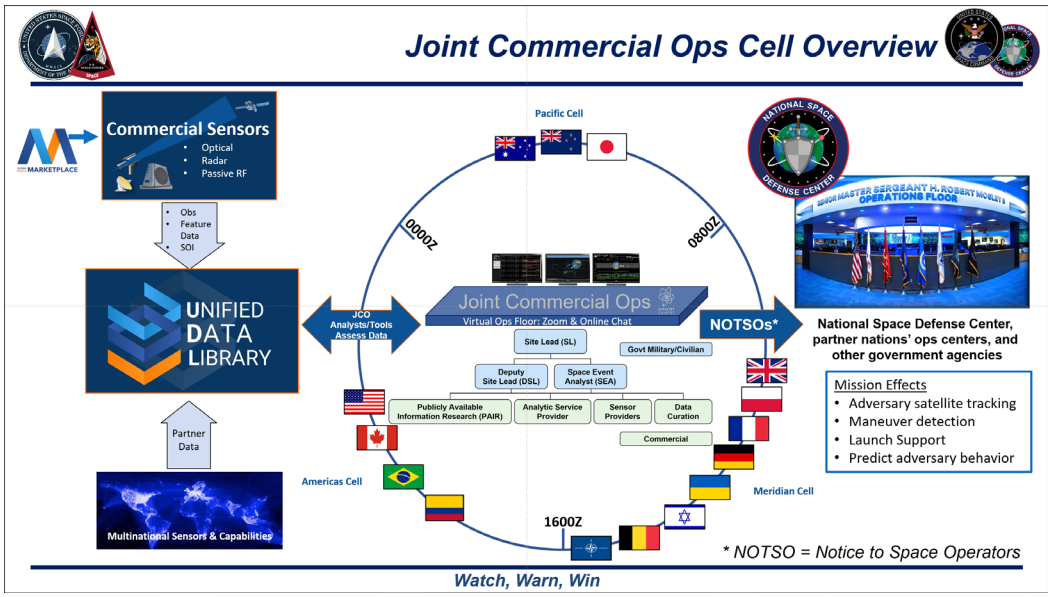

Figure 1: JCO Cell Overview

Fig. 1 provides an overview of how the JCO operates. JCO is a virtual operations floor enabled by virtual video teleconference, an online chat capability, and several JCO applications. The crew consists of three government positions and representatives from several commercial functions. The government positions, depicted in blue, include the Site Lead (SL), Deputy Site Lead (DSL) and Space Event Analyst (SEA). The SL position is exclusively filled by U.S. or Partner Nation government military or civilian personnel and is responsible for overseeing the operations of the JCO. The SL provides leadership and direction, prioritization of events and ensures timely and adequate communication of key events. The DSL manages the day-to-day operations of the JCO and is

responsible for executing crew operations under the leadership of the SL. The DSL coordinates teams of SEAs, analytical service providers, sensor providers, PAIR, and data curators to process active events. The SEA coordinates with the analytical services providers to identify, process and characterize events and prepares the NOTSOs for DSL review and SL approval.

The JCO contracts for several commercial functions, depicted in green, to collaboratively monitor a select set of high interest satellites and space-related activities to rapidly detect and characterize on-orbit activities. The PAIR team monitors various public internet channels to gather key information about satellites of interest, launch indications, event impacts, and public perception of events. The JCO sensor providers are responsible for collecting observations and signature data on high-rate revisit (HRR) list satellites, publishing collected data to the Unified Data Library (UDL) in accordance with standardized schemas and for providing analytical support to the JCO. The analytic service providers pull in the JCO's commercial data from the UDL and perform astrodynamics orbital assessment of satellite behavior and space operations in support of JCO. Analytical service providers are typically subject matter experts (SME) in operating an application or tool suite to provide analytical and event visualization support to the JCO. These providers perform the function of data fusion, astrodynamics analysis and forensics, and satellite activity assessment of potential threat activity. The data curation providers perform quality checks on sensor providers' observations and analytic service providers' orbit determination results, notify the operations crew and the providers when their data is outside of acceptable tolerances and assist with resolution of any discrepancies.

The circle depicts the global nature of the JCO comprising of three regional cells (JCO Americas, JCO Meridian, and JCO Pacific) aligned by longitudinal time zone coverage to enable rotating 24-hour commercial operations. Efficiencies and burden sharing are enabled by blending government resources from the various Partner Nations across each region's local daytime duty hours. The U.S. currently contracts for commercial providers to support each regional cell to ensure a full complement of resources and capability is available. To the greatest extent possible, the JCO seeks qualified commercial providers from within each region, while maintaining consistent performance thresholds and standards of operation.

The regional cells are virtual and not based on specific physical buildings and infrastructure. Crew members trained and certified by the JCO training standards may participate and operate in any regional cell. The U.S. and Partner Nation higher headquarters' operations centers may task, communicate with, and receive notifications from any JCO regional cell within the bounds of pre-contracted service agreements. U.S. or Partner Nation representatives tasking or communicating with JCO adhere to the JCO recommended best practices and communication procedures.

The JCO contracts for commercial data and analytic services through the Global Data Marketplace (GDM). The GDM provides an agile contracting mechanism enabling the JCO to execute contracts resulting in increased commercial competitiveness and innovation and ultimately cutting-edge capabilities in operations. Due to financial constraints, contracts to date have necessarily been of short duration, though the period of performance provides the added benefit of constant upgrades and enhanced commercial motivation due to persistent competition. The JCO also leverages the Unified Data Library (UDL) as its data repository to standardize data formats allowing data fusion providers to focus on optimizing analytic processing across a variety of contributors. Partner Nations also contribute commercial, military, civil, academic non-classified sensor and analytics data to the JCO through the UDL. The data is transported to classified UDL enclaves to support NSDC operations and legacy U.S. SDA systems.

The JCO's contracted network of commercial sensors with multiple phenomenologies allow for persistent tracking and tailored revisit rates to detect changes in their PoL or significant orbital activity. The commercial network of sensors available to the JCO is much larger and more proliferated than the U.S. Space Surveillance Network (SSN) allowing for near-continuous tracking of the highest priority satellites with passive RF and reduced solar exclusion gaps for electro-optical sensors. This commercial sensor capacity, geographic dispersion and key southern hemisphere coverage augments the SSN and, in some cases, serves to cue the SSN and intelligence community to collect more exquisite information regarding satellite activity.

The government crew members and commercial providers collaborate to detect and characterize satellite activity and space events resulting in JCO publication of NOTSOs to inform key recipients to include the NSDC, Partner Nation operations centers, government agencies, and satellite owner/operators. Recipients determine any follow-on actions needed without feedback or consultation with the JCO.

3. AFRL DRAGON ARMY AGILE SOFTWARE DEVELOPMENT OF JCO TOOLS

The Air Force Research Laboratory (AFRL) DRAGON Army serves as the agile software developers supporting JCO operations. Using a government infrastructure baseline, DRAGON Army maintains a stable and secure operational software baseline to keep up with development and version changes across the competitive commercial data sets and analytical services that are integrated for crew operations. DRAGON Army develops and maintains several key integrating applications that monitor health and status of commercial data and analytics and align workflows across commercial providers. These integrating visualizations allow web-based operator access, a graphical user interface, and analytical displays via U.S. controlled servers. Each of these tools are powered by JCO commercially procured data via the UDL and are accessible to JCO operators via web browser, to include personnel from all participating Partner Nations. These tools include:

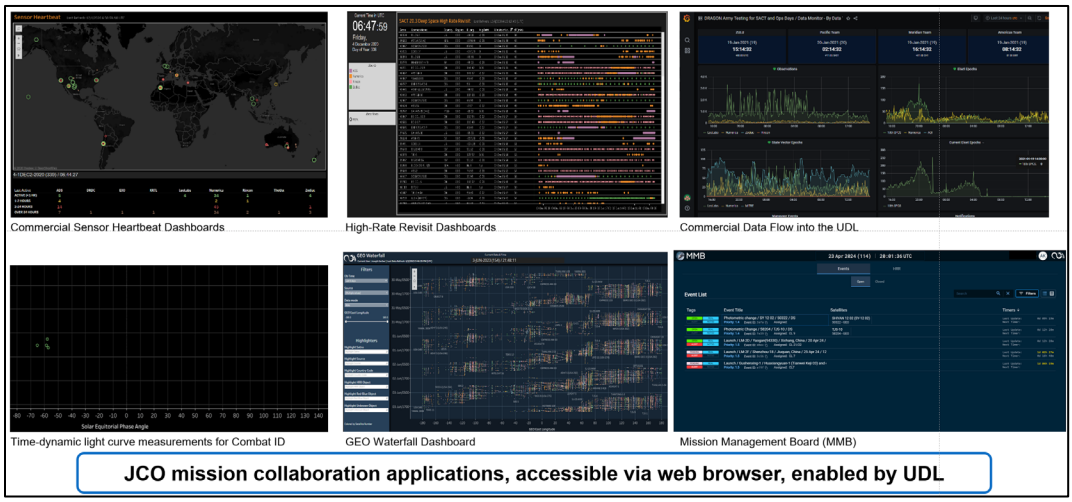

Figure 2: JCO Mission Tools

MISSION MANAGEMENT BOARD (MMB): A capability enabling the JCO operators to manage events, collect analytical products from commercial providers, aggregate and clarify analytical assessments, attach contextual information, provide sensor tasking, and publish NOTSOs and other alerts.

TABLEAU: Framework for quick-reaction DRAGON Army prototype visualization and dashboard capabilities. Operators can easily view and display space operations data and metrics evaluations. Dashboard visualizations include Heartbeat Sensor Map, GEO Waterfall, Light Curves, and the HRR Dashboard.

> **GEO WATERFALL:** A tool used by JCO operators and the analytical service providers to visualize GEO observations in a longitude versus time plot. This is useful to respond to Wide Area Search cues and allows the operator to quickly recognize anomalous activity, uncorrelated tracks (UCTs), close approaches, and potential cross tagging in GEO for subsequent analysis on commercial tool suites.

GRAFANA: Dashboard framework currently leveraged by DRAGON Army and the JCO for monitoring data flow of each sensor provider and data type. Operators can quickly understand and identify communications issues and provider coverage of HRR-designated spacecraft.

LAUNCH ROTATOR: For launch nominals which are typically fixed to a launch site and time (i.e., Earth Fixed), this tool will advance the time of a two-line element set (TLE) to an estimated or reported launch time (or times) while maintaining geometry relative to the Earth. This allows the operator to quickly adjust launch estimates as launch times are announced or discovered. If the launch time is unknown, a list of estimated launch times can be input, providing multiple TLEs corresponding to the launch times that can be used for tracking a region of space rather than an individual trajectory.

4. JCO COMMUNICATIONS

JCO VIDEO CONFERENCING: The JCO virtual operations is enabled through various video conferencing capabilities to maintain an active operations loop. JCO government and commercial crew members sign into its operations loop for continuous voice and shared video communications during their shifts. Twice during each shift, the SL will facilitate an operations standup via the ops loop to review the status of current and future events. Each commercial provider briefs and visually displays details regarding sensor collection results, event analytics, publicly available information, future potential events, changes in the HRR list rankings and data curation results for each provider and associated data. During nominal shifts, the crew members monitor the ops loop in the background and communicate in the chat channels to update taskings and provide analysis on potential, current and future events.

JCO CHAT: The JCO currently uses Rocket Chat hosted within the UDL to collaborate as their primary venue for communicating events, providing analysis results, posting artifacts and reporting to higher agencies. The JCO will soon transition to Mattermost for their chat capability. JCO uses the following JCO chat channels for real world operations and uses a similarly named set of separate mirror chat channels for exercise participation.

- **#JCO_Center**: JCO communications to and from the NSDC and Partner Nations' higher headquarters or operational centers. This is a government and command lead chat channel.
- **#JCO_Ops**: Primary channel for communications between the JCO government team and commercial providers for event thread analysis and graphical data products used in NOTSO generation. Coupled with the JCO video conferencing ops loop, this is considered the "main" virtual operations floor of the JCO.
- **#JCO_PAIR**: Primary channel for the PAIR team to post publicly available information. All non-PAIR users have read-only access to prevent potential data contamination.
- **#JCO_Spaceweather**: Chat channel for posting space weather-related products, to include the UK's MOSWOC and Australia's BOM daily product and any pertinent space weather events.
- **#JCO_C2_Coffee_Shop:** JCO internal communications to discuss potential activity not-yet-meeting criteria to open an event thread in the JCO_Ops chat channel.
- **#JCO_Provider_Feedback:** Chat channel for government crew members to provide feedback on commercial providers' performance and referenced for provider monthly feedback sessions as well as to inform future contracting decisions.

5. DISSEMINATION OF JCO PRODUCTS

The JCO's primary deliverable is the Notice to Space Operators (NOTSOs). These alerts and warnings are distributed via unclassified email for various event types to include launch and orbit inject tracking, maneuvers, close approaches, RPOs, photometric changes, breakups, satellite separations, and other changes in PoL of high interest objects. NOTSOs are also published through the UDL notification service and can be delivered up and out to classified domains to alert operations centers such as the NSDC via SIPR, JWICS, and GWAN.

Additional situational awareness may be gained through observing the JCO chat channels. The chat channels provide real-time situational awareness of all events the JCO is monitoring, some of which may not meet criteria to publish a NOTSO. The primary channel, #JCO_Ops, is organized by event threads where crew members and commercial providers post analysis and graphical products associated with each event. Information posted to the event thread is used in formulating the NOTSO. The JCO 100 online course series provides training to understand the NOTSO as well as appropriate standards for JCO chat. Once personnel have completed the JCO 100 series, they may be granted access to the JCO chat channels and added to the NOTSO email distribution list.

Finally, the JCO publishes a weekly activity report (WAR) via email every Sunday in a PowerPoint presentation summarizing the key events of the week and PAIR top topics. Contact the JCO via unclassified email at JCO@dragonarmy.rocks to request the JCO WAR distribution.

6. JCO NORMALIZED ORGANIZATIONAL STRUCTURE

The JCO is a Named Activity reporting directly to the U.S. Space Forces – Space (S4S) Component Commander and is apportioned to U.S. Space Command under the direction of the Combined Joint Forces Space Component Commander (CJFSCC). The USSF Strategic Advisor for SDA at Space Systems Command is dual-hatted as the lead for the Commercial Integration Office (CIO) under S4S and serves as the head of JCO-Global operations and sustainment. SSC support staff across financial management, contract management, and mission assurance functions are guided on JCO operational requirements primarily by US Air National Guard and Allied personnel supporting JCO, as appropriate, and augmented by SSC contractor support staff, as needed. The mission assurance function ensures the JCO infrastructure and data deliverables meets cyber and information security requirements. The Director of Staff provides day-to-day direction to the JCO Directorates and works closely with the S4S CIO to ensure the staff functions effectively and efficiently. The JCO staff is organized into several functional directorates described below.

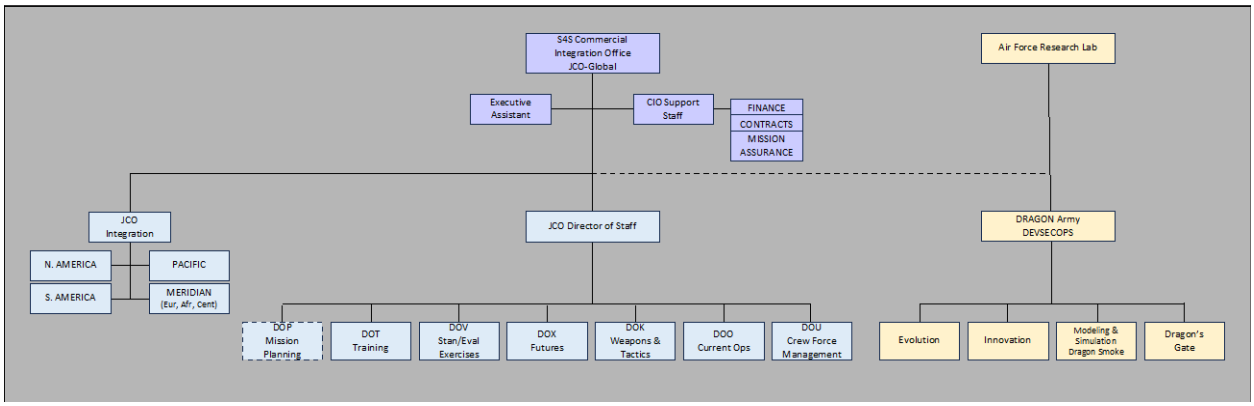

Figure 3: JCO Organizational Structure

JCO INTEGRATION: Advises the S4S CIO and JCO Director of Staff regarding integration of capabilities, missions, international engagements, staff processes and executes Partner Nation Onboarding outlined in Section 13.

JCO PLANS (DOP): Directorate in development as of Summer 2024 to conduct mission planning for future operations such as launch operations, XGEO / cislunar mission support; adjusts sensor tasking or HRR rankings as required

JCO TRAINING (DOT): Executes the JCO training program outlined in Section 8.

JCO STAN/EVAL AND EXERCISES (DOV): Conducts evaluations to certify JCO operators and executes the JCO Exercise program outlined in Section 9.

JCO FUTURES (DOX): On-boards new capabilities and missions into the JCO as outlined in Sections 15 and 16.

JCO WEAPONS AND TACTICS (DOK): Develops operational workflows and procedures, develops tactics for improved operations, assists in executing the JCO training and exercise programs, develops and maintains the JCO Mission Essential Tasks (METS) and the Tactical Standard Operating Procedure (TACSOP), assists DOX in executing the Capabilities and Mission Onboarding processes, conducts technical astrodynamics assessments required within the JCO, and prototypes new software for operations, as needed.

JCO CURRENT OPERATIONS (DOO): Responsible for the operational JCO crews (SLs, DSLs, SEAs and commercial vendors) to ensure JCO operations runs efficiently and effectively.

JCO CREW FORCE MANAGEMENT (DOU): JCO Global, Regional, and National Coordinators; manage crew force scheduling (to deconflict shifts, align continuation training, ensure personnel support for ops and exercises), request training, advocate for operational tool requirements and modifications to tools, advocate for procedure updates, responsible for integrating JCO workflows and products into higher classification level operations within their sovereign national operations. JCO National team leads support the JCO Regional Coordinators by aligning their JCO-trained manpower resources each month to create crews from a mix of all Allied teams to run operations across the three virtual regional JCO cells that cycle through the rolling day-staff operations.

The JCO collaborates closely with the **Air Force Research Laboratory (AFRL) DRAGON Army team** who ensures the integrity and stability of the JCO's operational infrastructure and develops custom software in an agile and innovative approach to support JCO ops by compiling the analytical results across the commercial providers. DRAGON Army's functional teams include **Evolution**, **Innovation**, **Modeling and Simulation** (also known as "Dragon's Smoke"), and the **JCO/DRAGON Army Help Desk** (also known as "Dragon's Gate").

7. JCO TRAINING PROGRAM

The JCO offers a series of courses targeted at specific audiences. The flagship course is JCO 200 – the Operational Integration and Certification course for JCO government crew members. Certified government crew members serve on crew for at least 16 hours of shifts per month for at least six months to remain proficient and provide JCO manpower continuity. In addition, crew members participate in monthly continuation training, upgrade/difference training, and JCO exercises to maintain operational readiness. For more information on the JCO training program and to register for online JCO courses, please access the JCO training site at https://sites.google.com/view/jco-digital-series/home.

JCO 100, 110, 120 COURSES (Core Academics):

- 90-minute online course providing an overview of the JCO's basic mission and reporting to include operational security (OPSEC) considerations for interacting with the JCO
- JCO 100 consists of a virtual tour of the JCO and the mission overview
- JCO 110 provides an understanding of the NOTSO provides distribution of the JCO NOTSOs
- JCO 120 reviews operations and communications protocols to receive access to JCO chat channels

JCO 150 COURSE (Tool/Product Training)

- JCO 150 is designed as a 3-hour online course to provide additional emphasis on JCO tools and products. It is targeted for operational units and users that interact with the JCO products in the performance of their daily missions, often at higher classification levels.
- Application training covers the Mission Management Board, JCO chat, Tableau Dashboards, Grafana Dashboards, Launch Rotator, Warp Core High-Rate Revisit list, ship tracking, Satellite Dossiers, space weather, etc.
- JCO 150 provides more in-depth review of graphical products generated to support JCO event types.
- This course does not cover major analytical tools such as COMSPOC's SSA Software Suite, Saber Astro's Space Cockpit or KBR's Iron Stallion, however it does provide an overview of products from these tools. Training for these tools is provided through a contract with the tool owners/developers or through their requisite analytical service provider SME.

Figure 4; JCO Instructor, William "Z" Zavis, demonstrates orbital elements to JCO 200 class

JCO 200 COURSE (Operational Integration and Certification)

- 4-week in-person course to certify in SL, DSL, and SEA positions
- Crew members will learn and adhere to JCO standards and recommended practices for event type processing procedures, product requirements, and operational reporting criteria
- Crew members will certify as a JCO operator in their respective position at the conclusion of the course

TRAIN-THE-TRAINER (T3)

- T3 is a selective upgrade program to certify JCO operators as JCO trainers
- T3 candidates demonstrate outstanding performance as a JCO operator for a minimum of six months and are nominated through their Regional Coordinator

- T3s will augment JCO 200 course execution with the intent for JCO Regional Cells to instantiate organic training and proficiency capabilities.

8. JCO EXERCISE PROGRAM

The JCO conducts in-house "Live" readiness exercises to ensure operators stay sharp on processing orbital threat events that rarely occur during peacetime operations. These exercises are conducted at least three times per year and are scoped to meet JCO objectives. For example, a live exercise may focus on processing one event type such as the GEO Direct Ascent Anti-Satellite (ASAT) or stress the operational crews with a full-on combat scenario with multiple events taking place in parallel. In addition to the Live exercises, JCO participates in numerous large-scale exercises to include U.S. Southern Command's Resolute Sentinel, Australia's Pitch Black, Japan's Keen Sword and Yama Sakura, and U.S. Space Command's Apollo Griffin. Participation in these exercises integrates non-classified SDA operations into multi-domain global operations and strengthens coordination with joint, Allied and partner nation forces. The JCO exercise program sets the standard for delivering realistic, live, and sim-over-live scenarios to maintain space operator proficiency for wartime operations.

9. JCO SUPPORT TO RESOLUTE SENTINEL 2024

Throughout exercise Resolute Sentinel 2024 (RS24), the U.S. and its allies gathered throughout South America to conduct Space Domain Awareness (SDA) training and collaborate on space operations. Dedication to space domain awareness plays a crucial role in maintaining global security and advancing the capabilities of partner nations. The JCO participated in Resolute Sentinel Exercise through deployed operations in Cali, Colombia; Lima, Peru; Brasilia, Brazil and in garrison for the JCO Americas, JCO Pacific and JCO Meridian cells.

More than 66 combined joint space experts participated in the space portion of RS24, aimed at enhancing interoperability and strengthening partnerships among emerging space powers by leveraging commercial capabilities and fostering open communication. Peru, Colombia, Canada, France, the United Kingdom, Brazil, Chile and the U.S. integrated across multiple hemispheres to enhance integrated deterrence and promote global security.

"Space domain awareness is critical to the fight, because it provides essential near real-time information to the troops on the ground for what space assets they're able to use," said U.S. Air Force Staff Sergeant Dhruva Poluru, 222d Command and Control Squadron JCO Deputy Director for Training and Exercises. "For Resolute Sentinel, we are conducting extensive hands-on training for space events that were pre-simulated to prepare participants for real-world scenarios."

Figure 5: SSgt Dhruva Poluru, JCO's Deputy Director for Training and Exercises, in Resolute Sentinel 2024

Within space operations, there are multiple components, including space launch, satellite operations, and maneuvers. Keeping track of these activities is a key factor in responding to any nefarious actions that might impact satellites and missions.

"Anytime a satellite changes its position or its status, we want to understand the overall space picture," he said. "We're able to consistently track a satellite from the ground all the way up into space and even while it's in space until the end of its lifecycle. Keeping that awareness over the entire space picture is important; not just for overall awareness, but to also keep tabs on activity that may impact the protect and defend mission for U.S. and allied satellites."

Throughout RS24, the teams in Colombia, Brazil and Peru conducted 36 hours of operations with commercially available technologies instead of military

systems, because the U.S. Space Force's imagery and space tracking tools are not readily available to all partners. The USSOUTHCOM partner space teams worked with JCO capabilities provided by USSF and operated with USSPACECOM, which increased the team's ability to conduct space intelligence, surveillance and reconnaissance operations across the globe.

Further partnership with U.S. Southern Command's Enhanced Domain Awareness (EDA) tool enabled the teams to monitor the information in real time, by combining information from JCO and the UDL into one common operating picture. This allowed for discussion and virtual demonstrations of complex space operations concepts.

"We are learning a lot about the space events like RPO (Rendezvous Proximity Observations)," said Brazilian Air Force Major Igor Alves, Space Situational Awareness/Space Domain Awareness Deputy Site Lead. "The training is simulating events that challenge us to react in real ways. Adapting to new challenges in space operations such as interference and jamming is crucial to ensuring the safety and success of missions. By prioritizing communication and collaboration, we can better navigate these challenges."

Large scale global exercises, like RS24, provide the opportunity for like-minded partner nations to exercise globally-distributed and networked space operations centered around enhancing space domain awareness and electronic warfare, while promoting international norms and behaviors in space.

To get in that right mindset, participants completed extensive prerequisite courses before arriving at the training locations, where they worked together to get more in-depth, hands-on training tailored to the exercise.

"This preparatory work ensures that all participants had a basic understanding of the topics, allowing us to build on our knowledge more quickly during the exercise," said SSgt Poluru about the goal of satisfying 23 space desired learning objectives over the course of six days. "We work with multilingual training staff to effectively communicate with different partner nations, overcoming language barriers and ensuring successful training. Seeing participants from various countries gain new insights and capabilities through our training is incredibly rewarding. It reflects our commitment to fostering collaboration and improving the overall readiness of our allied forces."

After the conclusion of RS24, the work to develop space partnerships is slated to continue. Experts from U.S. European Command and U.S. Southern Command have identified that space partners throughout South America can help construct a future operational space coalition of countries in the Western hemisphere that are closely aligned with NATO through space domain operations for a more safe and secure world. [1]

10. JCO SUPPORT TO PITCH BLACK EXERCISE 2024

The JCO Pacific Cell, including operators from Australia, New Zealand and Japan, participated in Exercise Pitch Black 2024 from 12 July to 2 August 2024 by conducting the JCO mission at their deployed location in Darwin, Australia. Pitch Black is an Australian-led exercise held every two years and focuses on large force employment missions. Pitch Black 2024 was the largest in the exercise's 43-year history, bringing together 20 participating nations with approximately 4,435 personnel. For international participants, there is significant benefit in providing experience in how to deploy over great distances, conduct force integration with other nations and their capabilities, and work firsthand with their foreign counterparts. [2] The Australian Defense Force's (ADF) Space Command made significant strides at Exercise Pitch Black 24, displaying its SDA capabilities through a key partnership with the JCO. This initiative underscores the critical role of space in Australia's modern Defense operations and highlights their growing ability in the space domain. During Pitch Black, personnel from the ADF, New Zealand Defense Force, Japan Air Self-

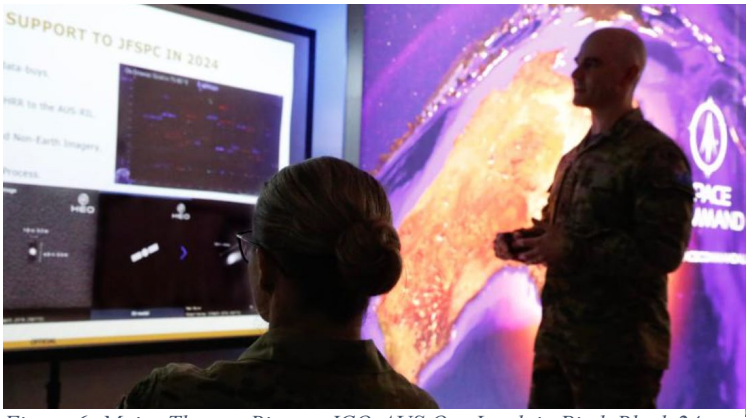

Figure 6: Major Thomas Bittner, JCO-AUS Ops Lead, in Pitch Black 24

Defense Force, and the Australian BOM contributed to the JCO operations floor. The JCO's role at Pitch Black involved monitoring various space activities, including changes in space objects' photometric shifts, maneuvers, and re-entries. Officer in Charge of Joint Commercial Operations at 1 Space Surveillance Unit, Major Thomas Bittner, said this capability also covered direct-ascent anti-satellite missile tests and launches, providing a comprehensive picture of space activities that could influence military operations. "Australia must evolve into a genuinely integrated force across maritime, land, air, space and cyber domains," Major Bittner said. "Exercises like Pitch Black are pivotal in testing and refining our systems and enhancing interoperability with our international partners."

ADF Space Command's involvement in Pitch Black also reflected broader strategic goals. The ADF aims to enhance regional situational awareness by leveraging Australia's geographical advantages and promoting a favorable strategic balance. During her visit to Pitch Black, Chief of Joint Capabilities Lieutenant General Susan Coyle said space was critical to every ADF operation and activity. She continued with, "Investment in space capabilities that enhance intelligence, surveillance and reconnaissance is a top priority under our National Defense Strategy. Collaborating with international partners helps us build a resilient space architecture and fosters mutual understanding and capability development." The exercise also offers valuable international engagement and collaboration opportunities, acknowledging that space is a team effort. During Pitch Black, ADF Space Command's advanced SDA capabilities highlighted Australia's commitment to maintaining a strategic edge in the evolving space domain, and it underlines the importance of continued international cooperation in securing space and cyberspace. [3]

11. JCO GLOBAL INTERNATIONAL PARTICIPATION

As cited in the USSF Commercial Space Strategy published in 2024 [4], "…organizations like the USSF Joint Commercial Operations cell (JCO) strengthen continuity with Allies, partners, academia, and the commercial sector. The JCO was established as a consortium of commercial companies synergistically operating together with Allies to actively monitor the space environment and solve pressing space problems in support of the space superiority mission." Through its extensive international partnerships, the JCO maintains resilient SDA ops, develops international norms for conducting space operations, and shares commercially derived products allowing collaborative transparency. The JCO has trained operators representing 18 partner nations and is in the process of onboarding an additional 15 partner nations.

Figure 7: JCO Global International Participation

The Commander of U.S. Space Command, General Stephen Whiting, advocates the JCO as the first and most accessible opportunity for space security cooperation with international partners. During his remarks during the National Space Symposium 39, in April 2024, themed "Winning in Competition and Conflict," he highlighted the importance of growing international and commercial partnerships and their contributions to a warfighting advantage. "Relationships matter, and space is a team sport," Whiting said. "At U.S. Space Command, we are committed to building a coalition of teammates to achieve a collective advantage, and we're committed to being great teammates ourselves." This commitment is outlined in the command's four focus priorities – showcasing how U.S. Space Command prepares and postures to maximize combat readiness by 2027, improving its capabilities to

counter threats that hold our modern way of life and national defense at risk, and building strong partnerships to not only achieve a warfighting advantage, but maintain and expand that advantage. [5]

12. PARTNER NATION ONBOARDING PROCESS

The JCO Concept of Operations (CONOP) [6] adopted Standards and Recommended Practices (SARPs) modeled after the International Civil Aviation Organization (ICAO) and applied them to JCO Partner Nation participation. Partner Nations agree to uphold JCO's SARPs, training, certification, procedures, and proficiency requirements to maintain the benefits of JCO membership. This unique approach is resulting in a highly effective and disciplined operator cadre, standardized operations around the globe, and is setting international norms for SDA operations. The JCO provides a low barrier-to-entry for combatant commands to conduct unclassified space security cooperation activities with nascent or non-space faring nations. The JCO Integration Team uses a five-step onboarding process to guide and onboard new international partners and to document each Partner Nation's intent to participate in the JCO and to abide by JCO's SARPs.

STEP 1: JCO INTEGRATION TEAM AND PARTNER NATION COORDINATION: JCO Integration Lead and Partner Nation representatives will exchange points of contact and provide introductions for their respective decision makers and key players. JCO Integration will provide JCO's key personnel contact information, to include the JCO Regional Coordinator, to the new Partner Nation and serve as the primary point of contact for Partner Nation onboarding. The Partner Nation will provide key contact information for their general or flag officer command representatives responsible for decisions regarding JCO participation, for their training representative, crew force management representative and technical lead. This step will also include the exchange of documentation and expectations. JCO Integration will provide a copy of the JCO CONOPS and mission overview briefing for review. The Partner Nation will share their intent and motivation for joining the JCO and how they envision JCO integration with their internal space operations, how many operators they would like to receive training, preferred training location and timeframe, and if and where they intend to establish a national cell. All of these areas are tailorable to the unique goals of each Partner Nation; there is no one-size-fits-all expectation to JCO participation. The JCO Integration Lead will document this information and coordinate with USSPACECOM and appropriate combatant command representatives to ensure alignment with security cooperation activities.

STEP 2: U.S. COORDINATION AND PRIORITIZATION: Once a Partner Nation expresses interest in joining the JCO, the Lead Integrator will coordinate with key U.S. organizations to ensure a common understanding of goals, expectations, security cooperation plan objectives, and initial prioritization. JCO Integration will coordinate with JCO leadership to communicate intent of membership and receive initial prioritization of the Partner Nation. USSPACECOM J5 representatives will provide feedback on the country's prioritization within USSPACECOM security cooperation plans. Space Systems Command (SSC) International Affairs (IA) will be notified to ensure synchronization with their efforts, to include possible Foreign Military Sales (FMS) or Foreign Military Financing (FMF) cases in the future. Finally, the JCO Integration Lead will notify the appropriate combatant commands and the U.S. Space Force components to synchronize with their security cooperation activities.

STEP 3: ESTABLISH ONBOARDING PLAN: Once there is a full understanding of the goals of JCO partnership between the Partner Nation, regional partners and key U.S. organizations, the operational Partner Nation onboarding will proceed. The JCO Integration Lead will schedule a Kickoff meeting for Partner Nation representatives and the JCO. During this meeting, the JCO will provide a JCO Mission Overview briefing, introduce key U.S. representatives such as USSPACECOM/J55, SSC/IA, JCO Current Operations, Training, Exercises, Weapons and Tactics, Futures, and AFRL DRAGON Army. The Partner Nation will introduce key representatives and organizational offices that will support the JCO operations and provide an overview of their intent and future goals for membership in the JCO. The JCO Training Team will provide an overview of the training and outline the country's allotted training slots, expectations, and timelines. Current Operations will review the crew scheduling process and crew member proficiency requirements. The meeting will conclude with a discussion about the country's desire to contribute national or commercial sensors, data, and analytical capabilities.

STEP 4: JCO OPERATOR TRAINING AND CERTIFICATION: The Partner Nation will nominate personnel to attend JCO 200 to become certified JCO crew members. This is a four-week course conducted in Colorado Springs or at a Partner Nation site. Certified crew members serve a minimum of 16 hours of JCO shifts per month for at least six months. This step will complete the process of onboarding and allow the Partner Nation full membership in the

JCO. This process will be finalized with a review and signature by both parties with a Partner Nation Letter of Intent. An annual review of the Partner Nation Letter of Intent, key contacts, and JCO participation will be conducted to ensure continued membership in the JCO.

STEP 5: JCO NATIONAL CELL CERTIFICATION (IF REQUIRED): Should a Partner Nation desire to stand up a JCO National Cell, an operational readiness check will be conducted by JCO Integration at the designated site to ensure all aspects of the JCO onboarding have been completed and the JCO National Cell is ready to fully participate in the JCO. This includes but is not limited to the following: Tools, connectivity and IT suitability review; training review; procedures review; data rights review; crew force management review; scenario administration to their crew force; and Partner Nation Letter of Intent review. Once complete, the Partner will be certified as a JCO National Cell with appropriate recognition and release of a joint public affairs article.

13. OPTIONS FOR PARTNER NATION CONTRIBUTION

With an objective to keep the barrier-to-entry low, the JCO encourages Partner Nations to consider several options for joining and contributing to the JCO. The minimum and most prevalent contribution is through provisioning manpower resources. The Partner Nation identifies government military or civilian personnel to attend JCO 200 to become certified as a JCO operator. Once certified, that operator performs JCO shifts as an equitable exchange for training. This manpower resource is crucial to maintaining JCO operations and is the primary way that most nations participate. Partner nations may also consider additional investments by sharing select non-classified sensors along with their collected data to the JCO data pool or by assisting with the purchase of additional commercial data. The JCO also welcomes any analytical services a Partner Nation will contribute. In return, the Partner Nation receives JCO training, SDA procedures, tool access and shared situational awareness of the space domain.

14. JCO CAPABILITY ONBOARDING PROCESS

In April of 2024, the JCO implemented a capability onboarding process to streamline its ability to discover, evaluate, select and prepare commercial capabilities to integrate into operations. JCO partners with the SDA TAP Lab and Space Systems Command (SSC) Commercial Space Office (COMSO) as the "front door' for discovery of needed capabilities. This includes a screening phase to bring on the most mature and promising capabilities, a testing phase to verify functionality, and an operational verification phase to stress the capability under realistic operational conditions prior to contracting it for operations. This process ensures that JCO focuses on the highest priority needs for operations while also ensuring new capabilities are postured for operational success.

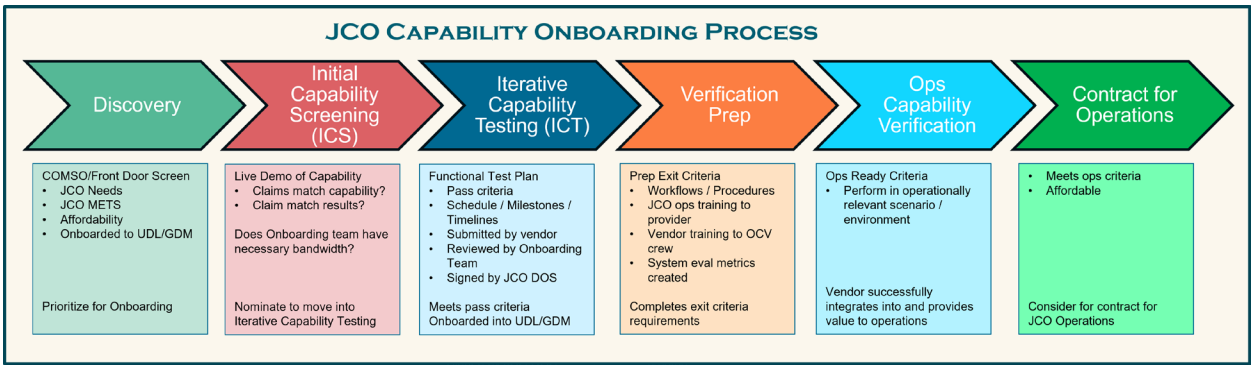

Figure 8: JCO Capability Onboarding Process

DISCOVERY: The first step in the capability onboarding process is discovery of commercial capabilities to meet JCO needs. The JCO partners with the COMSO as the Front Door to discover commercial vendors looking to do business with U.S. Space Force.

Vendors register on the Front Door website at https://sscfrontdoor.experience.crmforce.mil/SSCFrontDoor/s/ and select "Connect", "Share an Idea, Product, or Service", the primary space mission area alignment, verify their email address, enter contact information, organization information, and provide additional details on the capability to include Technology Readiness Level (TRL), mission alignment, and government contact. The key is to select

"other" as the reason for submission and enter "consider for inclusion in JCO process" in the "Provide Further Details" section. COMSO and the JCO capability onboarding team (members from JCO Futures, Weapons and Tactics, Integration, and Current Operations) work together to screen for relevant new commercial capabilities. These members review submissions independently and score them based on criteria pertaining to JCO prioritized mission needs. COMSO and the capability onboarding team convene monthly to review vendor submissions and the scoring results to prioritize the most promising capabilities aligning to JCO mission needs. JCO's prioritized mission needs are documented in the JCO Mission Essential Tasks (METS), Gap Analysis, and JCO Gap Prioritization, all available upon request. The JCO Futures Director will contact vendors in priority order and schedule an Initial Capability Screening (ICS) opportunity in accordance with the capability onboarding team's bandwidth. Capabilities deemed mature enough may skip to an appropriate phase of this process at the discretion of the Futures Director.

INITIAL CAPABILITY SCREENING (ICS): The capability onboarding team will conduct a one-hour virtual ICS session with the commercial vendor to more fully understand its technical readiness. The vendor provides an overview of their capability and demos it in a live or realistic environment to the greatest extent possible. This is a "show me, don't tell me" approach where the capability onboarding team will ask detailed questions and expect live-demonstrated responses to understand the commercial vendor's capabilities and limitations and determine if it is ready for further evaluation. The onboarding team will provide feedback regarding the capability and recommend whether to advance it to the Iterative Capability Testing (ICT) phase. The Futures Director will approve the capability to proceed to the ICT phase. In some cases, vendors will receive feedback to re-enter the onboarding process for consideration once they have addressed key feedback items.

ITERATIVE CAPABILITY TESTING (ICT): The JCO Weapons and Tactics team will lead a vendor through the ICT phase designed to test the technical functionality of their capability. Using information from the ICS, JCO Weapons and Tactics will develop a Test Plan Template outlining functional test objectives with pass criteria and collaboratively work with the vendor to complete and submit it for review. The Weapons and Tactics Director will schedule the vendor for an ICT session. During the ICT, the vendor will demonstrate they can meet criteria for each test objective in a live or realistic environment. In cases where real data is not available or possible, the Weapons and Tactics and DRAGON Smoke teams will work to create a realistic simulation environment with simulated data to conduct the test. The Weapons and Tactics team will also evaluate the accuracy and mission utility of each capability's results. The onboarding team will determine whether the capability meets test objectives and provide feedback to the vendor. Several ICT sessions may be required to complete the Test Plan objectives. Some test objectives may be rejected or accepted with liens to be demonstrated in a future ICT. Vendors desiring to provide data to or process data for the JCO should be onboarded to the UDL (https://www.unifieddatalibrary.com) and demonstrate proficiency in posting data to and pulling data from the UDL. In addition, the vendor should be onboarded to the Global Data Marketplace (GDM) (https://www.globaldatamarketplace.com) to provide an expedient contracting mechanism for their capability. When the capability meets the required test objectives, the onboarding team will recommend it proceed to the Verification Preparation Phase. If the capability continues to fail to meet test objectives or the onboarding team determines it is not ready for JCO use, the JCO Director of Staff will advise the vendor of the outcome. The vendor may re-enter the onboarding process once issues have been satisfactorily resolved.

VERIFICATION PREPARATION: Weapons and Tactics will also lead a vendor through the Verification Preparation phase. The JCO Weapons and Tactics and Training teams will work with the vendor to prototype workflows and procedures to incorporate the capability into JCO operations, train the vendor to integrate into JCO operations, train the Operations Capability Verification (OCV) crew on the new capability, and jointly develop evaluation metrics for the subsequent Operations Capability Verification (OCV) phase.

OPERATIONAL CAPABILITY VERIFICATION (OCV): The goal of the OCV phase is to ensure the capability can perform in an operationally relevant environment and demonstrate effective integration into and its value to JCO operations. The vendor's capability will perform in a scenario-based evaluation using live and/or simulated data and interact with the OCV crew using the prototype workflows and procedures. Several vendors may operate in a single event to maximize the scenario environment opportunity. The onboarding team will provide the OCV results to the JCO Director of Staff who will determine the next steps. Vendors meeting all evaluation criteria or most evaluation criteria with liens can be approved for contract consideration with the JCO. Should a vendor not meet evaluation criteria, the JCO Director of Staff will refer them to the appropriate previous step in the onboarding process or remove them from consideration.

CONTRACT FOR OPERATIONS: The JCO awards new vendor contracts monthly for data and analytic services through the Global Data Marketplace (GDM). The JCO Contracts Manager and Financial Manager will draft the performance work statement (PWS) and place it in an order on the GDM. The vendor may respond to the order with their proposal for work and the associated cost. The JCO Contracts and Financial Management team will consult JCO technical experts to evaluate vendor proposals and conduct a source selection to award the contract. Once on contract, the JCO team will mentor the new vendor through initial operations and provide continuous feedback. The vendor's capability value and performance in the JCO will determine provisioning via follow-on contracts. The JCO government team provides each JCO vendor monthly feedback on their capability and performance to ensure continuous improvement. Once vendors are on contract with the JCO, they may develop additional capabilities for the JCO and present those through the appropriate step in the onboarding process.

15. WAY FORWARD – NEW MISSION AREAS

The JCO is rapidly expanding into new mission areas beyond the protect and defend mission. The most recent mission area to integrate into JCO, is Positioning, Navigation and Timing – Situational Awareness (PNT-SA) which leverages the use of commercial satellites' onboard PNT telemetry to detect, characterize and geolocate interference to PNT services. Additional Electromagnetic Spectrum Operations (EMSO) prototypes are in development in SATCOM and TT&C bands, with SATCOM-SA as the most mature and likely to onboard into the JCO in the near-term.

The USSF Chief of Space Operations (CSO)-directed Tactical Surveillance, Reconnaissance and Tracking (TacSRT) pilot program has matured and is ready to integrate into JCO operations. Standardized procedures and a training program are in development with TacSRT at this time, and the TacSRT capability is on track to onboard into JCO-Americas operations during day-staff operations Monday through Friday by the start of FY25.

The JCO has also been collaborating with the 19th Space Defense Squadron (19 SDS) and commercial vendors to experiment with capabilities and processes for maintaining situational awareness of satellite activity in the extra-GEO and Cislunar orbit regimes. With the recent success of PNT-SA activation and additional prototype operations in work, the JCO is rapidly becoming the go-to operational cell for integrating commercial capabilities supporting any space mission area.

16. ELECTROMAGNETIC SPECTRUM OPERATIONS (EMSO)

According to Space Doctrine Publication (SPD) 3-0, Operations, "Space Domain Awareness (SDA) is the timely, relevant, and actionable understanding of the operational environment" that includes "situational awareness of operations and threats in the electromagnetic spectrum." The JCO's "Protect and Defend" mission includes monitoring and characterizing the electromagnetic operational environment for threats. The JCO conducts this through Electromagnetic Spectrum Operations (EMSO) which includes PNT-SA and will be extended to SATCOM and eventually TT&C situational awareness in the coming year.

17. DATA EXPLOITATION AND ENHANCED PROCESSING FOR PNT (DEEP-PNT)

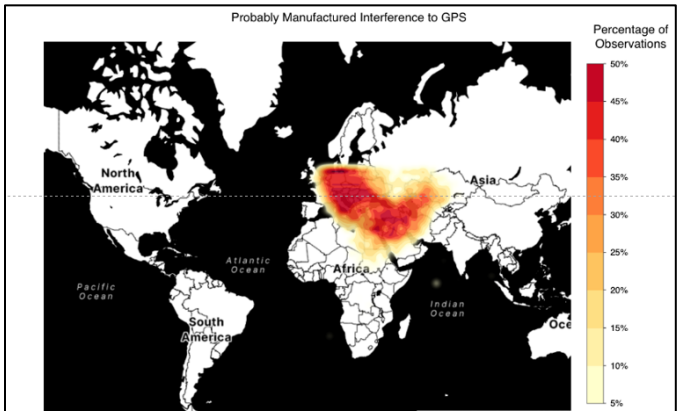

Figure 9: DEEP-PNT Heat Map showing location of GPS interference

On 1 July 2024, JCO initialized the EMSO PNT-SA mission area into the JCO-Americas cell operations. DEEP-PNT processes unclassified commercial telemetry to provide actionable insights for manufactured or naturally occurring threats that can disrupt, degrade, or deny PNT services from Global Navigation Satellite Systems (GNSS). JCO EMSO is expanding to provide monitoring and characterization of the electromagnetic operational environment across SATCOM, Command and Control (C2) and TT&C, and other services that utilize the electromagnetic spectrum to operate in, from, and through the space domain. This includes detection and characterization of intentional or

unintentional electromagnetic interference (EMI), spectrum utilization, spectrum maneuver, or other electromagnetic spectrum characteristics that provide actionable SDA insights. Characterizations can include, but is not limited to, geolocation or localization, PoL, or RF signatures of signals of interest (SOI). The JCO provides summaries of SOI in response to user community Spectrum Area Searches (SAS) and Satellite Spectrum Updates (SSU) taskings coming from JCO chat and email requests, with reporting via NOTSOs. Over 100 operational products have been delivered to combatant commands for military forces to understand where PNT signals may be degraded and to plan for optimal employment of PNT-aided capabilities. The PNT-SA mission uses a variety of tools including:

HAERTS: A tool developed by Slingshot Aerospace to process GNSS Observation Data into an H3-formatted heatmap and provides PNT-SA visualization and analysis.

GLOBAL POSITIONING SYSTEM (GPS) OPERATIONS ANALYST TOOL (GOAT): An external tool that ingests and displays both PNT-SA H3 heatmap data and geolocation data. Credentials and access are managed by an external agency.

DATA EXPLOITATION AND ENHANCED PROCESSING (DEEP) MISSION ASSURANCE TOOLKIT (MATK): Provides Electromagnetic Operational Environment 1) data curation, 2) mission assurance as an alternate assessment tool for PNT-SA, and 3) a quick-reaction exploitation and enhanced processing for emergent and urgent operational needs.

PNT-SA DASHBOARD: A tool developed by DRAGON Army used to display all PNT-SA data to include 1) H3 Heatmaps 2) Space Weather affecting PNT 3) Approved PNT testing events that may impact PNT users.

18. DEEP RADIO FREQUENCY (RF)

DEEP-RF is expanding the DEEP-PNT concept further across the electromagnetic spectrum to provide satellite communications (SATCOM) situational awareness and close coverage gaps. DEEP-RF is focused on detection and characterization of electromagnetic interference (EMI) in SATCOM frequencies, but also general spectrum awareness towards a similar goal of protecting internationally shared spectrum. DEEP-RF operational products would also include characterization of the interfering SOI and summaries of geolocation of possible sources.

19. TACTICAL SURVEILLANCE, RECONNAISSANCE AND TRACKING (TACSRT)

Early in 2023, USSF's Chief of Space Operations (CSO) charged SSC/SN to initiate a pilot program to provide disadvantaged combatant commands with annotated commercial surveillance, reconnaissance, and tracking (SRT) products, referred to as "Operational Planning Products (OPPs)". The CSO's goal was for the team to focus on near-term, event-driven activities and provide products that were easily sharable with Allied and partner nations, especially in under-served combatant commands with limited access to TS/SCI connectivity across security cooperation partners. The SSC/SN team initially worked with the JCO as a model for their pilot program. Their first steps were to conduct research on the commercial market, understand the vendors' capabilities and limitations, and their various business models. In parallel, the team worked with the Global Data Marketplace to onboard the most viable vendors for ease of contracting. The team leveraged commercial electro-optical (EO), synthetic aperture radar (SAR), multi-spectral and infrared (IR) imagery to support Exercise Resolute Sentinel 2023 while outlining their workflows and procedures. The Tactical SRT (TacSRT) team took several key measures to ensure they were complementary to and collaborative with the intelligence community regarding products and processes. To ensure no duplication, the TacSRT team queries the NGA commercial imagery database as the first source for basic space-based products before considering contracting with commercial vendors. The OPPs are space-based analytics, sourced from commercially available vendors and delivered to combatant commands and partner nations for use in military planning, not for intelligence purposes, to support emergent U.S. national interests. Each OPP contains the following disclaimer: "Space-based Commercially Available Information (CAI) OPPs are unevaluated information not for intelligence purposes and should not be used for targeting."

The TacSRT operational cycle consists of four steps. The cycle begins with Step 1, where a US Space Force Component Command, such as SPACEFOR-EURAF, submits an SRT Query form outlining any details pertinent to the request via UDL Chat Channels to the TacSRT team. In Step 2, the TacSRT team will review the request, check the NGA imagery database and if no products are available to meet the need, the team will translate the operational need into requirements documented in a Performance Work Statement (PWS). This PWS is attached to an order

submitted through the Global Data Marketplace where all commercial space-based sensing / analytic vendors have the opportunity to bid on the order by submitting a proposal with an associated purchase price. The TacSRT cell will review the vendor proposals and award the contract appropriately. The Global Data Marketplace allows for immediate processing and payment to vendors who are awarded the order. The vendor then satisfies the order with space-based sensing products and analytics posted to the UDL. In Step 3, the TacSRT cell curates vendors' information and commercial products into an OPP format. To complete the cycle, in Step 4, the TacSRT cell delivers the unclassified and fully releasable OPP to the end-user.

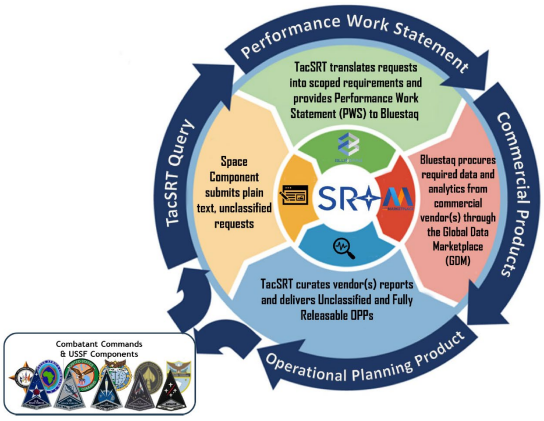

Figure 10: TacSRT Operational Cycle

TacSRT pilot program has proven to be a value-added capability for combatant commands executing Discrete TacSRT (e.g., tactical event-based) in response to specific combatant commands. As the mission set matures beyond the pilot stage, they are transitioning into JCO as a new mission area. The JCO will adopt the current processes created from the pilot program. A mission onboarding team is working to ensure the concept of operations, workflows, procedures are in place and is developing a training program for integrating the TacSRT into daily operations. Initial TacSRT mission sets for global combatant commands will include Humanitarian Assistance / Disaster Relief (HADR) support and illegal resource extraction (e.g., illegal fishing), and JCO will onboard additional use cases as the TacSRT cell completes their prototyping.

Notably, the TacSRT mission set will be one of the first JCO missions primarily for combatant commands other than USSPACECOM, with special emphasis on under-served combatant commands like USSOUTHCOM and USAFRICOM. This mission is provisioned via the JCO operations floor under S4S to other USSF components (e.g., SPACEFOR-SOUTH) in order enable USSPACECOM to maintain awareness of all activities operating in and through its space Joint Operational Area (JOA). CJFSC/S4S and USSPACECOM are "on-the-loop" but not necessarily "in-the-loop" as JCO provisions TacSRT support across the USSF components and combatant commands, to understand if and when capacity limits for space services are breached and must be globally reprioritized until resources can be restabilized.

20. ORBITS BEYOND GEO (XGEO) AND CISLUNAR OPERATIONS

Cislunar space has recently become prominent in the space community and warrants attention, as reflected in the recent Memorandum of Understanding (MOU) between the National Aeronautics and Space Administration and the United States Space Force states: "When established in December 2019, USSF was tasked with defending and protecting U.S. interests in space. Until now, the limits of that mission have been in near Earth, out to approximately geostationary range (22,236 miles). With new U.S. public and private sector operations extending into cislunar space, the reach of USSF's sphere of interest will extend to 272,000 miles and beyond - more than a tenfold increase in range and 1,000-fold expansion in service volume. USSF now has an even greater surveillance task for space domain awareness (SDA) in that region, but its current capabilities and architecture are limited by technologies and an architecture designed for a legacy mission. As NASA's human presence extends beyond ISS to the lunar surface, cislunar, and interplanetary destinations, and as USSF organizes, trains, and equips to provide the resources necessary to protect and defend vital U.S. interests in and beyond Earth-orbit, new collaborations will be key to operating safely and securely on these distant frontiers." [7]

The 19 SDS provides space domain awareness products and services in support of various missions under U.S. Space Command, which include expanding cislunar and extra-geosynchronous (XGEO) awareness via current SSN and commercial capabilities and contributions to the space-based environmental monitoring missions. Starting in early 2024, 19 SDS partnered with the JCO for a series of experiments to better understand commercial SDA vendors' capabilities to track and maintain orbits on space objects in cislunar and XGEO. Following the lessons learned through experimentation, the JCO is working to onboard XGEO and Cislunar as a new mission area in direct support of 19 SDS and expect it to be normalized throughout the regional cells by early 2025.

The first of these experiments was to track the Intuitive Machines -1 (IM-1) Nova-C class lunar lander, named Odysseus, which was launched on a Space-X Falcon 9 rocket from NASA Kennedy Space Center on 15 February 2024. The JCO contracted with a variety of commercial vendors to include electro-optical, passive RF, PAIR, launch nominal generation services and data fusion analytic services. The JCO operations team and the commercial vendors worked collaboratively with 19 SDS to process this event. Commercial SDA sensor capabilities were able to track the payload and rocketbody and submit their raw observation data to the UDL. Then commercial data fusion capabilities were able to perform orbit determination using models specifically designed for the cislunar orbit trajectories and submit state vectors to the UDL. This event helped 19 SDS understand how commercial capabilities could augment the SSN as well as 19 SDS mission processing systems and confirmed the need to update USSF legacy processing systems to maximize use of commercial observations.

The second experiment provided an opportunity to process a non-cooperative event, the Chinese Queqiao-2, which was launched via an LM-8 from Wenchang launch facility on 20 March 2024. The Queqiao-2 is a Chinese satellite serving as a communications relay for future Chinese lunar far side or lunar south pole missions that cannot communicate directly with the Earth. In addition, the Tiandu-1 and Tiandu-2 communication technology test satellites were included on the launch manifest. The Tiandu satellites were the first part of the Chinese Deep Space Exploration Laboratory. According to public sources, "The double stars will fly in formation in the lunar orbit to carry out verification of new technologies such as space reference heterogeneous calibration of the navigation systems, high-reliability transmission and routing forwarding of the communication system, and integrated modulation of communication ranging." JCO commercial vendors were able to generate launch nominals and provide hypothesis trajectories based on publicly available information to enable sensor vendors to track the Quequiao-2 payload and rocket body, as well as the Tiandu-1 and Tiandu-2 satellites. The electro-optical vendors provided raw observations, photometry and in some cases their own state vectors in the UDL. The passive RF vendor provided time and frequency difference of arrival data into the UDL. The data fusion provider was able to ingest all sensor data and provide accurate assessment of orbital parameters.

Finally, the JCO and 19 SDS worked together on the third and fourth experiments to collect on the non-cooperative Chinese Chang'e 6 lunar launch in its initial two weeks after launch (3 – 16 May 2024) as well as a tracking and analysis campaign several months later (29 July – 2 August 2024). The Chang'e 6 consisted of four modules to include a service module, a lunar lander, an ascent vehicle, and a reentry capsule. These events were not as successful for a variety of reasons. The launch took place during a time of solar exclusion, so the JCO chose not to contract with electro-optical sensor vendors due to low likelihood of success and therefore relied primarily on a single passive RF vendor. Based on public information about the Chang'e 6 transmission frequencies, the passive RF also had low likelihood of success, but the JCO decided to proceed with the mission to stretch its operational capabilities. The passive RF vendor was unable to collect in the frequency range for the Chang'e 6. During the tracking and analysis campaign (29 July – 2 August 2024), 19 SDS's primary focus was to work through ingestion of commercial passive RF time and frequency difference of arrival data into their mission processing system. The Chang'e was near the Sun-Earth L2 LaGrange Point and believed to be an approximate 20 visual magnitude which proved to be beyond all the commercial vendors' capability to collect. The JCO used a passive RF vendor with collection capability in the Chang'e 6's transmission frequency bands, however, the distances were believed to be too far for successful collection. The JCO analytic team is still examining the commercial electro-optical raw data to determine if advanced post processing techniques can indicate detection of the Chang'e 6.

Procedures for XGEO operations have been stabilized within the JCO, and low-to-high coordination procedures have been established with 19 SDS. The only delay for normalized operations is a dearth of funding, as the commercial XGEO support is still funded via "unfunded requirement" requests.

21. HIGH VALUE ASSET (HVA) SUPPORT AND HIGHER CLASSIFICATION INTEGRATION

At the heart of the protect and defend mission is the need to alert U.S., allied and partner nation high value assets (HVAs) operations centers so they have situational awareness of and can prepare response options to threatening on-orbit activity. Therefore, the JCO has reached out to U.S. Space Force Deltas and squadrons, partner military and commercial owners of HVAs to train them on how to use the JCO NOTSOs and other tools powered by JCO's commercial data as early indications of threating activity. U.S. Space Force Deltas are equipping their operational crews with the Saber Astro-developed Space Cockpit Battle Management System as a common operating picture (COP). Space Cockpit provides a space domain awareness capability that includes a 3D visualization platform, GEO Summary, Launch Nominals, Real Time Observations, orbit determination (OD) and a variety of other tools. In addition to these SDA capabilities, operators at Delta 8 are now using JCO commercial data to power Space Cockpit to monitor global events and analyze potential threats to their assets. Delta 8 uses customized dashboards, and constellation monitors to independently track and monitor their space-based assets and the activity within their respective orbital regimes. This provides them a tailored approach to domain awareness and allows them to set specific alert parameters to bring their attention quickly to an asset that may be at risk. The Delta 8 operators can also set these alerts up to monitor maneuvers that, if not countered, will create a future threat - for example, an adversary spacecraft initiates a maneuver that, while not presenting an immediate threat, may result in a RPO or close approach over the course of the next several days. This provides the operators advanced warning of potential risks/threats to their specific constellation.

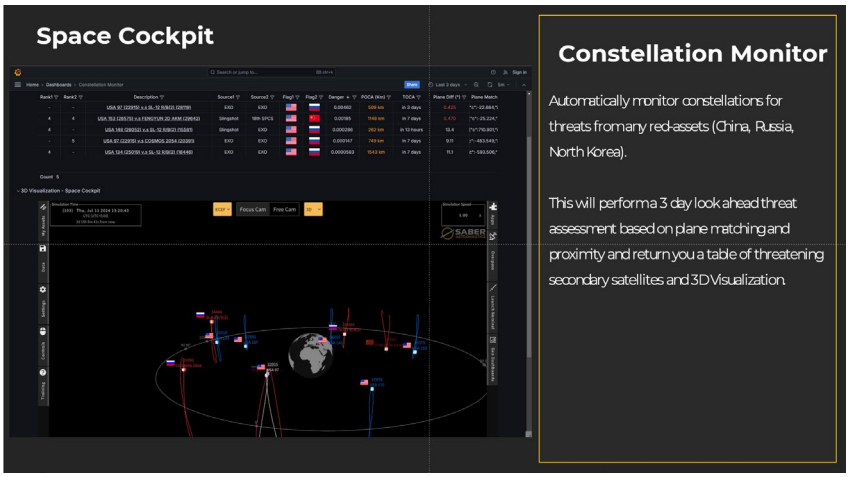

Figure 11: Delta 8 Space Cockpit Common Operating Picture

In addition, the Delta 8 Space Cockpit tool suite is also able to ingest JCO "Event Ledgers." These are machine-readable descriptions and data inputs for the events described within the JCO NOTSOs which are available within the UDL across all enclaves. This feature allows the HVA units to immediately upload and display the NOTSO results calculated by the JCO with a single click, rendering the post-processed situation on high-side visualization tools that can then be used to calculate HVA responses.

The Space Cockpit Battle Management System also provides modeling and simulation capabilities to develop courses of action, maneuver plans, and strategies to minimize risk to their assets. Delta 8 operators will be joining in JCO Live exercises, with realistic threat scenario simulation that will allow SOPS operators to use JCO NOTSOs and their COP to become proficient in recognizing threat activity and then "tell the story" of what's happening in orbit so they can make informed decisions and rapidly execute their strategies to preserve freedom of action in space.

The 4th Space Operations Squadron (4 SOPS) has initiated an architectural modification to enable use of commercial data within their Command and Control Systems-Consolidated (CCS-C) mission processing system. 4 SOPS is connecting the CCS-C to the Secret-level UDL to leverage commercial state vectors to monitor their Wideband Global System (WGS) constellation during non-critical portions of their orbit management plan to reduce the loading on the Satellite Control Network (SCN) by 78%. JCO's commercial data is automatically transferred within the unclassified UDL to higher classification UDLs for use by the NSDC and other partners for protect and defend applications. U.S. Space Force is modernizing its legacy SDA architecture to take advantage of the UDL's common repository for all of USSF data as well as contributions from commercial SDA providers.

The JCO recently began a training campaign with the Combined Forces Space Component Command's (CFSCC) Commercial Integration Cell (CIC), the Combined Space Operations Center (CSpOC), the NSDC, United Kingdom's Space Operations Center (UKSpOC) and UK's commercial SKYNET constellation, Australia's SpOC (AUSSpOC) and their commercial HVAs, New Zealand's space operations personnel and Japan's JSAT Corporation to provide an understanding of how JCO NOTSOs and products can be used in conjunction with operations at higher classifications to detect, characterize and respond to on-orbit threat activity. USSF is developing the Allied Exchange Environment (AxE) as a releasable component of the UDL to enable machine-to-machine sharing of releasable classified data with partner nations. Once approved and provisioned for use, allied and partner nations will also be able to leverage commercial data within their classified SDA architectures to fuse a broader picture of activity in the space domain, built on top of the shareable understanding from the JCO.

22. SUMMARY

The JCO is a highly successful, innovative operation effectively integrating international partners and leveraging commercial capabilities. The commercial space industry allows for agile modernization, innovation, and technological advances to deliver entirely not-classified information that enables transparency and data sharing with partner nations around the globe. General Whiting emphasized the need to not only modernize capabilities and expand partnerships, but also to increase mutual trust through information sharing, "Together, we will ensure that all of us, as a team, win in competition and conflict," he said. "We will work with a Coalition of peace-loving nations to ensure space remains, safe, sustainable and secure for future generations." [5]

REFERENCES

[1] C. Sebastianelli, "US Space Command - RS24 Enhances Global Space Domain Awareness with Partner Nations," 10 June 2024. [Online]. Available: https://www.spacecom.mil/Newsroom/News?Article-Display/Article/3801812/rs24-enhances-global-space-domain-awareness-with-partner-nations/.

[2] J. Pike, "Pacific Air Forces - Largest Pitch Black Exercise Opens for US and 19 Nations," 15 July 2024. [Online]. Available: https://www.pacaf.af.mil/News/Article-Display/Article/3838189/largest-pitch-black-exercise-opens-for-us-and-19-nations/.

[3] S. Zeegers, "Australian Government Defence - Space Command Shines on the Top End," 5 August 2024. [Online]. Available: https://www.defence.gov.au/news-events/news/2024-08-05/space-command-shines-top-end.

[4] C. Saltzman, "U.S. Space Force Commercial Space Strategy," 8 April 2024. [Online]. Available: https://www.spaceforce.mil/Portals/2/Documents/Space%20Policy/USSF_Commercial_Space_Strategy.pdf.

[5] S. Whiting, "US Space Command - Whiting Underscores Growing Partnerships, Capabilities Required for Competition, Conflict at Space Symposium 39," 9 April 2024. [Online]. Available: https://www.spacecom.mil/newsroom/news/Article-Display/Article/3735945/whiting-underscores-growing-partnerships-capabilities-required-for-competition/.

[6] B. Golf, "JCO Concept of Operations," Joint Commercial Operations, Colorado Springs, 2024.

[7] "Memorandum of Understanding between the National Aeronautics and Space Administration and the United States Space Force," 21 September 2020. [Online]. Available: https://www.nasa.gov/sites/default/files/atoms/files/nasa_ussf_mou_21_sep_20.pdf.

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A toast to JCO and DRAGON Army and all who join us at the edge of the known:

“Here Be Dragons”

~Barb Golf