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Executive Summary

Omitron is pleased to submit the following response to the OSC's Request for Information for the TraCSS program. As identified in our responses below, Omitron concurs with all of the included basic services identified by OSC. Omitron further agrees with the majority of the non-included services and we have provided justifications for our two non-concurrence items.

Omitron has a long history of providing the operational support, software systems, and spaceflight safety services identified in this RFI. The ASW software is the trusted and validated standard used by DoD and NASA for operations support and anomaly resolution. Omitron maintains over 15 instances of ASW deployed to various customers, meeting their specialized needs for SSA data processing within a common collection of apps. Our common footprint enables compatibility and interoperability of results across the industry. In addition to the development and sustainment of the ASW application suite, Omitron provides on-premise 24/7 operational support with reach back to our top technical and astrodynamics experts as needed for operational events. This depth of expertise allows Omitron analysts to quickly identify emergent needs and prioritize ASW solution development, allowing our users to stay on the cutting edge of SSA and spaceflight safety techniques and capabilities.

With ASW in current use at operations centers for the DoD, Intelligence Community, and NASA, our software solutions could mitigate much of the potential integration and interoperability issues between TraCSS and these legacy organizations. Omitron is uniquely positioned to enable a path forward for the OSC which significantly reduces deployment schedule risk by implementing our numerically validated ASW and NASA CARA services currently supporting the DoD, NASA, NRO, and commercial customers.

Expediting the deployment of the ASW products and services will allow OSC to rapidly provide TraCSS owner/operators with spaceflight safety products as good as or better than currently available products from the DoD. Additionally, it will allow OSC to focus on policy issues and new vendor integration by inheriting the reliability of today's spaceflight safety product supply chain. In support of bringing on new vendors, Omitron recommends OSC create a robust vendor algorithm validation capability to be independently performed by an FFRDC.

Whichever path OSC chooses to take, Omitron is prepared to participate in the launch of TraCSS as we have done with the mission systems of the DoD, NASA, and NRO. Omitron stands ready to support and is available for further conversations at your request.

Section II
Basic Services and Omitron Response

(1) *Satellite Attributes, Capabilities, Status, and Point of Contact (Included).*

To maintain a database of primary (protected) assets, which contains basic satellite attributes (approximate dimensions, mass), indicates satellite trajectory change capabilities and current status, and includes 24/7/365 contact information to coordinate mitigation actions for conjunctions between active satellites.

Omitron Response

Omitron concurs with maintaining a database of assets which contains metadata and status as a basic service. This type of information is extremely important for as many Resident Space Objects (RSOs) as possible to facilitate coordination and communications. Maximizing participants is important as well as collecting information on non-participating RSOs or debris. This basic service will extend commercial O/O supplied data as well as derived RSO attributes not freely given to participating O/Os to better articulate and understand the flight safety risk of active assets.

Omitron's current operational experience has informed and shaped the design and intent of the current Department of Defense (DoD) capabilities available through the DoD's space-track.org website. Satellite O/Os may report satellite hard body radius (HBR) which is crucial for accurate probability of collision (Pc) calculation. Information for non-participating RSOs or debris will need to be derived by observation and provided to participating O/Os to enable the same Pc accuracy. Omitron currently performs the analysis that allows for HBR estimation of space objects which are not self-reporting. Sharing of other O/O data like mass,

maneuverability status, and conjunction coordination contact information support risk assessment or coordination between spacefarers and the OSC. As an example of community improvement enabled by this data sharing service, Omitron currently formats O/O information where applicable to correspond with Omitron's catalog maintenance and conjunction assessment software to include integrating the O/O maneuver notifications currently provided via the Orbital Parameters Message (OPM).

(2) *Receipt and Sharing of Predictions O/Os Ephemerides (Included).*

To receive predicted ephemerides from O/Os, store them in a manner that makes them available for download by other interested O/Os, and use them as the representation of the primary object for collision assessments (CA) screenings, risk assessment, and (when appropriate) mitigation planning.

Omitron Response

Omitron concurs with the receipt and sharing of propagation of O/Os ephemerides as a basic service. Predictive state information sharing is in current practice today using space-track.org to facilitate community collaboration. The sharing of data by willing O/Os increases the knowledge and understanding of all participating O/Os in regards to conjunction mitigation and risk assessment. This sharing of information enables peer-to-peer analysis, coordination, and conjunction remediation without obliging users to coordinate solely through the TraCSS-provided screenings mentioned in this RFI.

Omitron has integrated such practices into the current DoD data management infrastructure. In support of the OSC goal of collaboration to reduce on orbit risk, the O/Os data should represent past states to support tracking association as well as future predicted states for

sensor queuing and conjunction mitigation practices. Omitron's data management services currently enable this data cataloging without requiring satellite operators to retain previously-predicted information. Some mission partners, such as SpaceX's Starlink constellation, have provided non-predicted past ephemeris further increasing this feedback loop. While some O/Os may elect to not share their accuracy information with competitors, our third-party ephemeris evaluation service facilitates discreet feedback without requiring publicly available quality assessments. Finally, this data is currently exposed as an available augmentation data source for state updates enabling catalog integration with readily shared information.

With the proliferation of satellites in recent years, Omitron has been a driving force for scaling current services to meet the growing demand. However, an improved communications infrastructure is needed to support current and future mission requirements and Omitron is actively pursuing solutions to meet those needs.

(3) *Routine Collision Assessment (CA) Screening and Conjunction Data Message (CDM) Production (Included).*

To screen primary objects against a robust satellite catalog, both routinely and on demand; and to generate CDMs for objects that violate the particular physical volumes used for the screening activity.

Omitron Response

Omitron concurs that routine Collision Assessment (CA) Screening and alerting is a basic safety service as this screening is one of the foundational elements of space flight safety. If not a core OSC service, it would be exposed to unvalidated analytical tools and increase risk of on-orbit collisions. Only the government can provide consistent answers with a well-

validated and maintained tool set to enable accurate Pc calculations and physical proximity results. The key to Traffic Management System for Space (TraCSS) mission assurance and success is reliant upon value-added spaceflight safety products and services. As a core service, CDM generation should not rely on untested/unvalidated commercial products which by statute would have to be competed periodically. This competition and validation cycle would be a significant and persistent issue with O/O confidence in the TraCSS system products as well as causing many integration issues with National Aeronautics and Space Administration (NASA) and the DoD. Consistency, reliability and responsiveness of the TraCSS products and services will ensure the supporting commercial O/Os and flight risk assessment providers find value in TraCSS participation.

The current most accurate and trusted flight safety applications, service and support are provided by Omitron's Astrodynamics Support Workstation (ASW) software suite. The DoD currently creates hundreds of thousands of CDMs every day with ASW, ensuing the accuracy of the DoD catalog is consistently propagated for use in the ever-growing conjunction mission set. These CDMs are based on the numerically-validated ASW where each upgrade goes through a mission assurance process to revalidate and regression test each software version release (SVR). Omitron currently develops as many as three SVRs per year based on user-requested changes and to keep up with mission demands. Omitron has kept ASW up to date to address the greatly changing mission needs. Our ability to adapt to community needs is demonstrated by the initial integration of NASA probability algorithms as well as the current updates allowing for the ability to filter conjunction reporting by risk as well as volumetric assessments.

Items that OSC will have to contend with and mitigate are screening only a partial catalog

from the DoD, the need to augment commercial sensor data to help fill out orbital regimes, and to develop an operations concept with NASA and the DoD for collaboration. Information sharing and alert exchanges will need a robust communication infrastructure to improve data transfer speeds, data availability, and enable full automation of these conjunction assessment functions.

(4) *Special CA Screening and CDM Production (Included).*

To perform an on- demand screening against a robust satellite catalog for a particular submitted ephemeris or set of ephemerides (usually for a confirmatory or speculative screening as part of maneuver planning).

Omitron Response

Omitron concurs that performing on-demand screening service should be part of the basic service for TraCSS with one caveat: Special CA screenings support hypothetical future states for use in risk mitigation and their non-real nature lends them to possibly being overly requested or abused by some O/Os and should thus have limitations or boundaries for the availability as a basic service. Heightened demand for this service will drive costs despite automation. Omitron can assist the OSC in developing policies to limit on-demand screenings based on relevant RSO metrics such as orbit type, constellation size, or anomalous/not fully functional satellite status that can drive significant resource costs. We recommend limiting the number of special screenings per individual satellite per month with additional screenings made available for purchase above and beyond the basic service level to ensure this basic service remains available for the community without limiting the growth of potential industry.

In response to the growing need for this task, Omitron with our DoD partners, has evolved the CA screening process and ASW tools to greatly reduce the time and resources required. Omitron's modifications will further enable full service-level automation of the same validated algorithms which would allow near real-time self-screening for satellite operators. Under the TraCSS effort, the screening services could readily be exposed for real-time public consumption. These services offer seamless integration of catalog and O/O positional data with probability calculations enabled for all datasets containing covariance. This integration reduces the need for multiple screenings and reduces the computation time to produce CDM results. While Omitron's automation capability and optimization greatly reduces workload, computational resources can still be stressed if a tiered system is not put in place to support addition demands by some O/Os. The lack of a complete high accuracy space catalog (HAC) will also diminish the effectiveness of any CA screening without mitigation efforts to include those non-disclosed RSOs.

(5) *Data Quality Evaluation (Included).*

To perform a first-order evaluation of the orbit determination and propagation of the (usually secondary but in principle both) objects' state estimates and co-variances in order to determine whether these inputs are of sufficient quality to serve as a basis for a durable risk assessment calculation

Omitron Response

Omitron concurs that the evaluation of O/O state estimates and covariances in order to determine whether these inputs are of sufficient quality, is also one of the foundational elements of space flight safety. Data quality evaluation is highly recommended to be a core

OSC service as exposing unvalidated analytical state and covariance data to the CA and Pc processes would significantly degrade the reliability of the CA results. Only the government can provide consistent answers with a well-validated and maintained tool set matched to O/O state estimates, so evaluation of third-party O/O data must be enabled to compare results effectively to those generated solely using the TraCSS dataset. These evaluations will maintain a quality standard of TraCSS products in order to ensure accurate and reliable CA and Pc generation.

The ASW applications in use today to maintain the High Accuracy Catalog (HAC) include accuracy assessments for all states generated by the validated ASW suite. We also maintain the quality of the HAC state data by self-evaluation over time of prediction accuracy, producing readily-available metrics for a specific object's prediction accuracy and reliability for use in conjunction assessment. This capability provides an understanding of covariance realism for the HAC and could be extended to support O/O data evaluations in like terms.

Non-catalog data can be evaluated for accuracy in comparison to catalog or other third-party data deemed sufficiently accurate. Validating state accuracy and covariance realism data requires long-term consistency assessments for any given data and propagation source. This verification can also be accomplished to a lesser extent without third-party data when none exists. Current Omitron tools exist to enable manual evaluation of state data and our analytic expertise can perform covariance evaluations, though current government customers have elected not to purchase said services out of concern for the results implying government validation of any given dataset. Without covariance validation, probability calculations should be treated as secondary decision space data points behind positional separation allowing data providers to assume risk for invalidated error volumes.

(6) *Launch Collision Avoidance (COLA) Screenings (Included).*

To perform timely screenings of a set of launch nominals against a robust satellite catalog in order to identify specific launch times during a launch window that would create unacceptably high collision risk and therefore should not be used.

Omitron Response

Omitron concurs that performing timely screenings of a set of launch nominals against the TraCSS space catalog should be part of the basic service for TraCSS with one caveat: As this service is not difficult to accomplish, we have observed in our operational support role that some launch service providers place a lot of demand on screening resources. Omitron recommends implementing limitations for the basic service in order to establish expectations of support and to minimize excess demand for system resources. In order to accommodate the needs of launch service providers who require more than the basic service, Omitron can assist the OSC by establishing a concierge service for excess screenings, thereby limiting the significant increase in cost and use of resources driven by high demand.

Omitron has pioneered the current launch screening process and associated ASW application updates to reduce risk and provide windows to the launch service providers in a timely manner. Timeliness of data availability for launch conjunction assessment screening must be matched against necessary accuracy levels. As such, industry demands for long-term high-accuracy propagation screenings should be tempered by the costs and viability of the results. Recent Omitron studies have highlighted the transient nature of low-Earth orbits and the volatility of space launch safety screening results where data availability and timeliness mitigate some of the uncertainty.

Whether low-fidelity or high-accuracy results are required, Omitron's ASW applications currently produce timely responses for multi-stage and variable-trajectory launches. Probabilistic launch screening results are readily produced for space launch screenings with ASW. These functions are available with full automation and lend themselves to full machine-to-machine interactions. Timeliness of the results rely greatly upon the available computing resources and the complexity of the launch profile. This also requires a high degree of coordination with DoD and other U.S government organizations.

(7) *O/O Ephemeris Generation and Curation with Covariance (Included).*

To use O/O telemetry and on-board global positioning system state information, as well as potentially other commercial tracking information, to generate a reliable predicted O/O ephemeris that includes covariance at each ephemeris point and incorporates planned maneuvers (and maneuver execution error).

Omitron Response

Omitron concurs that ephemeris and covariance generation should be part of the TraCSS basic service. Omitron's experience has found that the reliability and accuracy of the position and covariance data provided by each O/O ephemeris tends to be the most accurate single source, but validity varies greatly from one O/O to the next. The need for accurate and reliable ephemeris is why today we validate the accuracy of the O/O data and request covariance realism evaluations be provided by O/Os to ensure compliance with the standards and accuracy of the ephemerides. Validating the O/O data as in basic service #5 avoids the regulation of how the O/O develops their ephemerides implied by this service. Recommend OSC consider defining a covariance realism evaluation as a concierge service as well as

define a method of standardizing ephemeris and covariance generation to enable various paths to successful participation in spaceflight safety. In either case, the result is more consistent and reliable state and covariance data which further bolsters the value of TraCSS CA screenings.

Adding off-board observations such as the incorporation of commercial data should be a separate concierge service and not part of the basic service. This service should focus solely on taking data available to an O/O's internal processing to enable participation in the basic services without requiring additional data purchases.

This service will be facilitated with adherence to standardized ephemeris formats such as those prescribed by Consultative Committee for Space Data (CCSDS) to avoid confusion and simplify data ingestion.

Through several of our current efforts, Omitron is proficient using O/O data and as mentioned, can validate the O/O data with the ASW application suite.

To facilitate CA screening viability, predicted ephemerides must be furnished frequently, span an appropriate period of predictive time, employ point spacing close enough to enable interpolation, provide a full state (position and velocity) for each ephemeris point, provide a realistic 6 x 6 covariance matrix (with both variance and covariance terms) for each ephemeris point, and be provided in an acceptable data format. Providing a normalized means to generate reliable ephemeris and covariance data will enable the commercial industry to safely participate in space traffic management.

(8) ***Re-entry Management and Assessment (Included).***

To perform and event pacing assistance for primary objects undergoing either natural decays or managed deorbits in order to assist the DoD in orchestrating the overall decay and decataloguing process.

Omitron Response

Omitron concurs that re-entry and management of deorbit forecasting should be included in the basic services since generating reliable and accurate predictions have significant consequences and cost and should be part of the TraCSS basic services.

The current system of record for re-entry management and assessment is the DoD's Space Defense Operations Center (SPADOC), primarily because the associated messaging is resident on that system. However, since an erroneous warning to Australia in 1996, ASW services have been the primary system for prediction of all high interest re-entries, including Phobos-Grunt (2012) where the ASW applications' predictions were within 5 minutes of the confirmed reentry time. For the same event, SPADOC, a newly-developed AFRL re-entry capability, and select commercial SSA systems were much less accurate, producing predictions well outside mission requirements with one application reporting results more than two days off. Because of the severity of the consequences of accurately predicting re-entry position, it is imperative this be in the basic service for TraCSS. Additionally, ASW applications were used for some non-traditional re-entries like the Genesis (2004), Stardust (2006), and Hayabusa (2010) comet and asteroid sample return probes. The ASW application suite was used to provide confirmation to JPL that the reentries were on track. Stardust and Hayabusa required the use of the ASW hyperbolic orbit capability already built into the application.

The ability to propagate high accuracy state vectors is inherent within the ASW functionality, so software changes will be minimal.

Also, current DoD re-entry services can improve with OSC's goals to expand access to and processing of data from sensors beyond the current set of Space Surveillance Network (SSN) sensors. Data from foreign, commercial, and other U.S. government sensors (e.g., optical, radar and RF) will ease the burden on the SSN, but requires catalog data integration of new sources. Given the addition of these world-wide data sources, the space catalog of tomorrow will be vastly more accurate in terms of both quantitative and qualitative measures. All core SSA products (i.e., vectors, element sets, CA screening results, reentry predictions, etc.) will be significantly improved. A key component Omitron brings to this effort is Hyperion, the calibration and monitoring of sensor data, that enables the fusion of various sensors and sensor type into a single solution. Sensor calibration should be an additional basic service given the criticality of accurate integration of new observation sources. Also, important to the re-entry mission is the High Accuracy Satellite Drag Model (HASDM) drag model and the Manual Piece Separation (MPS) application allowing the operator to perform an Orbit Determination (OD) on difficult re-entries. Eventually, the DoD capabilities will be consolidated into Advanced Tracking and Launch Analysis System (ATLAS), with all the messaging and forecasting needed to manage and predict re-entries, but these processes are unlikely to contain the variety of data available to TraCSS.

(9) *Precision Probability of Collision Calculation (Included).*

To include in each generated CDM a Probability of Collision (PC) calculation that uses more advanced approaches for determining the appropriate hard-body radius (HBR) and employs a calculation technique appropriate to the particular dynamics of the encounter.

Omitron Response

Omitron concurs that Probability of Collision (Pc) calculation should be part of the TraCSS basic services. The TraCSS system would set a standard for initial flight risk assessment for O/Os to ensure a commonly-available threshold of spaceflight safety regardless of the risk tolerance for any given O/O. Only the government can provide consistent calculated answers with a well validated and maintained tool set with further accuracy enhancement given O/O-provided satellite details such as hard body radius (HBR).

There are several techniques in the calculation of Pc based on the specific geometries and dynamics of an encounter. To reduce chaos in the flight safety discussion, OSC should provide a repeatable process and techniques that provide insight to the risk of given conjunctions. This TraCSS product would set a quality standard in order to reduce flight safety risk of O/Os whose operational focus may not include this kind of assessment. Addition of the Pc calculation along with the CDM enhances flight safety as it has been determined by the community that miss distances do not adequately account for state uncertainty from ground- and/or space-measurement error, whereas these Pc calculations include both miss distances and state uncertainties. Today's SSA service industry has shown the ability to provide more involved risk assessment and mitigation services, but this basic service should be available to all participating O/Os such that risk is not solely a product of concierge services.

Omitron has extensive experience with NASA in calculating Pc for civil and commercial O/Os and can provide that quality standard necessary for OSC safety of flight goals. Our scientists and engineers are on the cutting edge of determining and developing advanced techniques on the formulation of effectively combined HBR to improve the Pc calculations for the risk assessment by O/Os.

(10) *Collision Consequence and Debris Production Potentials (Included).*

To calculate, using an appropriate model, an estimate of the number of trackable debris fragments that would be generated if a particular conjunction were to result in a collision.

Omitron Response

Omitron concurs that collision consequence and debris production and potential should be part of the basic services provide by TraCSS as the best of these techniques have been developed by the U.S. Government. Correctly predicting the outcome of a conjunction or intentional action has a high degree of uncertainty because of the numerous impact scenarios and the actual impact location of the two RSOs with associated final state vectors. Since it is hard to take effective action on the predictive results, this should be left as a basic function given the availability of GFE tools like the Aerospace Debris Analysis Response Team (DART) created to do predictive risk assessments from debris-creating events and provide a general understanding of the potential event's resulting debris environment. As we have observed from operational experience, the key to any breakup is the quick identification and cataloging of pieces so that CA runs can be done against observed objects to enable actionable information generation.

While space debris producing events require immediate action, long term debris risk

mitigation can also be performed as a concierge service. The debris production potentials being offered as a basic service will enable follow-on mission planning services such as long-term debris risk mitigation. Omitron has developed a model for satellite constellation planning based on long-term debris risk assessment.

(11) *Conjunction Object Solution Improvements with Additional Tracking (Included).*

To obtain additional tracking on the satellites involved in conjunctions of interest (typically the secondary objects), improve these objects' predicted states at the conjunction time of closest approach (TCA), and calculate higher-fidelity risk assessment metrics with this improved information.

Omitron Response

Omitron concurs that additional tracking on either the primary or secondary RSOs involved in a potential conjunction that breaks a set volumetric or Pc threshold should be part of the basic services provide by TraCSS. There should be a volumetric and/or Pc threshold at which the OSC deems the potential conjunction of two RSOs pose a significant flight risk to other spacefarers. For consistency of alerts and published data, only a well-validated tool set and process for solution improvement should be used to avoid confusion among O/Os.

If the OSC threshold is breached, it is incumbent upon the OSC through TraCSS to request additional observation data on the primary and or secondary RSO. Balancing requests for the DoD SSN or commercial providers is an optimization and efficiency question.

Additional observations when provided close to TCA help to reduce the uncertainty at TCA and provide a much-improved Pc calculation, but O/Os require time to plan and mitigate risk

events. These contradictory planning and TCA uncertainty timelines should be balanced to enable efficient mitigation strategies. As stated in other services, use of commercial data may need to be conditioned and calibrated to optimize the resulting states vectors of each RSO. This must be a basic core function of the TraCSS system for standardization of inputs and results.

O/Os wishing to purchase or contribute data for a conjunction event not meeting the OSC threshold should be enabled to do so, but not as part of the basic service. A common utility to integrate data should be considered for consistency of results, but the resource cost for non-critical services should not be owned by TraCSS.

Omitron is the developer of the current optimization tasking tool used by the SSN to minimize covariance error of each RSO in the HAC. Omitron is also modernizing how SSN and commercial sensor calibration is accomplished. All observations used for the development of high accuracy states either from DoD, civil, foreign or commercial sensors must be monitored and maintained to a central governing standard so as these additional measurements do not increase the overall state uncertainty, thus causing a degradation in the computed Pc value.

(12) *Expected Tracking Determination (Included).*

To generate a pass schedule and probabilities of detection for obtaining additional commercial tracking for conjunction-related objects, so that O/Os can infer the potential benefit of additional tracking and be able to schedule mitigation action decision points appropriately.

Omitron Response

Omitron concurs that expected tracking determination should be included in the basic

services. As previously noted, multiple studies have identified that there is a correlation between observation age and uncertainty at TCA. Operational reaction planning thus should include an understanding of potential data availability. This prediction should use the most accurate predicted positional knowledge possible as represented by the integrated TraCSS catalog. This again can be a cost driver based on the frequency of the request, so per-object, per-event limits should be considered for the frequency of this basic service with additional determinations available for purchase.

Pass schedule generation algorithms are generally available and as accurate as the orbital models powering them. Probability of detection, however, requires sensor sensitivity information as well as object size or reflectivity assessments. While these data can be produced, sensor owners may be disinclined to share such sensitive data. Object-specific size or reflectivity assessments require multiple data sources to derive. Omitron currently produces pass schedules for the DoD and NASA using the DoD high accuracy catalog as well as government datasets on object size and reflectivity as well as sensor sensitivity. These sensitive datasets are generated using algorithms developed and maintained by Omitron analysts. Omitron could readily automate these detection capabilities to facilitate data requestors and data providers in a DoC marketplace.

Omitron has defined these tracking assessment products and services for its customers' direct need for a decision point timeline where risk and cost of delaying action must be weighed against the likelihood of future data collection. The assessment for future data's potential to impact a conjunction event is further supported by Omitron's expertise in space state dataset analysis and ongoing support to government efforts to evaluate commercial sensor data.

(13) ***Risk Assessment Time History Plots (Included).***

To produce time-history plots of conjunction risk assessment parameters of interest to allow assessment of conjunction event phasing and stability.

Omitron Response

Omitron concurs that risk assessment time history plots should be a basic service. Like the provision of Pc in item #9 of this RFI, the provision of a time-history of TraCSS data provides a basic level of risk assessment capability. This can then be used by commercial flight safety support providers to augment and articulate the risk to the assets they protect as a non-basic service. These core plots show each physical separation component (Radial, In-track, Cross-track) plotted over time with its corresponding 1-sigma combined uncertainty value. Additional data plots for TraCSS datasets such as time of observation can be provided to represent some level of anticipation for how the event will evolve without further intervention. For missions that provide ephemeris data, this plot functionality should be available for commensurate CA screening results.

Time-history plots can also be used to indicate validity/accuracy of provided data. A sudden change in the nominal miss value and/or Pc value could be an indicator of a primary/secondary maneuver or an indication of a mis-calibrated sensor observation.

Omitron currently produces these time-history plots and assessment for NASA assets and commercial O/O assets.

(14) ***Space Weather Sensitivity (Included).***

To provide warnings about space weather perturbative events and to assess the effects the perturbation-induced atmospheric density uncertainty will have on conjunction risk assessment parameters.

Omitron Response

Omitron concurs on its inclusion as part of the basic service since space weather sensitivity service is essential to maintaining safety of space flight. Omitron developed a number of space weather products over the years to aid the SSA mission. Initial efforts were crude, but effective in maintaining a basic satellite catalog. Techniques developed under the solar procedures were in reaction to a 1989 solar event and incorporated the broadening of observation association criteria in light of temporarily degraded catalog prediction accuracy. While effective for basic SSA, the significant improvement in the LEO orbital regime to orbit accuracy came when we deployed the High Accuracy Satellite Drag Model (HASDM). By applying HASDM, ASW is much better at representing drag at low and high solar cycles. The models adapt automatically to a change in the solar environment and not only assist in maintaining a satellite catalog, but enable precise orbit predictions throughout a solar storm. HASDM II made additional improvements in the orbits subject to high drag to include a storm prediction capability for near-term drag propagation.

Omitron applied this experience to the development of the NASA CARA Space Weather Trade Space (SWTS) application which maps the sensitivity of a conjunction event's Pc values to potential atmospheric changes.

Space weather modeling and representation is best suited for a TraCSS-provided service as there are limited data sources for space weather measurement and various drag models may

interpret this data differently if at all. Providing an understanding of the potential future space environment in a consistent way will enable O/Os to effectively create risk assessment and mitigation plans.

The key outcome of modeling a range of possible atmospheric densities is the ability to identify the effect that this density range may have on a Pc calculation for a given event. Changes in space weather are typically the prime cause of short-notice conjunction events. As such, maintaining awareness and notification of solar events can help in remaining vigilant and ready to respond during such times.

(15) *Fusion of CA Products (Not Included).*

To combine CA products, such as CDMs or predicted ephemerides, from multiple providers into a single, higher-fidelity product that can then be used to enable CA risk assessment

Omitron Response

Omitron concurs that the Fusion of CA products should not be included in the basic services provided by TraCSS. Not all O/Os approach a conjunction risk assessment uniformly, so there is an uneven value proposition in data fusion services across the community. These functions add value, but only to O/Os who deem the current data environment insufficient for accurate conjunction event assessment.

In preparation for our current space landscape, Omitron has pioneered data integration capabilities to include sensor observations, ephemerides, and satellite downlink data. Because not all data imparts equal validity, our ASW software allows for source-specific weighting to create a common space in which data can be seamlessly integrated. In this model, Omitron could merge government catalog and user-provided data into a single modified state for any

space object. The quality of such a state would be difficult to assess unless the covariance of all contributor datasets were well-validated. While our high-accuracy orbital model will impart fidelity onto a combined product, it is beholden to the quality and accuracy of all combined input datasets.

(16) *PC Variability (Not Included).*

By considering bounding scale factors for the "true" size of the primary and secondary objects' covariances, to generate a matrix of possible PC values to allow risk assessors to assign a more conservative "high-water-mark" PC value.

Omitron Response

Omitron concurs that Pc Variability should not be included in the basic services. Covariance realism is a difficult topic not currently solved for existing catalog datasets let alone the envisioned TraCSS integrated catalog. By providing the Pc described in item #9 of this RFI, OSC will effectively enable a basic level of risk assessment and spaceflight safety.

There is an ongoing study into covariance realism and Pc variability with a final implementation which should be funded by NASA or Commerce. Once fully implemented, the resulting data should fully inform OSC as to whether Pc variability should be a concierge or basic service.

Collision probabilities are very sensitive to orbital state uncertainties, typically reported in the form of covariance matrices. Pc calculations require the orbital state vectors of each object propagated forward in time to TCA, along with the propagated covariance matrices. Unfortunately, analysis indicates that such propagated covariances are not always realistic, because they often do not accurately characterize actual trajectory uncertainties.

Omitron has incorporated a more precise method of self-evaluating orbital state accuracies in the ASW SuperCODAC application. Omitron currently has software functions that implement these evaluations to calculate covariance scale factors for propagation times up to one week. When processing a current conjunction, these pre-tabulated scale factor distributions provide an efficient means per-object in the HAC to establish statistical confidence bounds on the "true" sizes of the primary and secondary covariances.

(17) *Additional Concierge Services (Not Included).*

To provide on-call, personalized telephone support at all times by CA subject matter experts to assist O/Os with the interpretation of conjunction screening and risk assessment products.

Omitron Response

Omitron concurs that this should not be included into the basic service. Many O/O operators might not use this service and a few might want it all the time. Providing the products for further risk assessment on the concierge list is a logical way to go.

While these services do not need to be included in TraCSS basic services, such services have been beneficial and, at times, necessary for providing expert recommendations and responses to high-risk events. Expert-in-the-loop support for non-nominal conjunction events can be invaluable for reducing risk of an event by reducing human error. The following are types of concierge services that have been provided by Omitron for conjunction support.

On-call support for:

- Conjunction/close approach analysis

- OD updates (solution reviews)
- Additional tracking opportunities
- HIE briefings
- Maneuver planning services
- Covariance checks
- 1 v 1 screening, 1 v All screening
- Head Count check
- Break-up notifications/impacts to orbit regimes
- Emergency late notice conjunctions
- Emergency debris avoidance maneuver support
- Monte Carlo runs
- Definitive solution after TCA
    - High Interest Event support, launch support, and other special activities may require off-nominal support
    - Providing data for all conjunctions identified in the screening period
    - Monitor tasking levels and (OD) for conjunctions
- Critical event period support including ascent, maneuver campaigns, and decommissioning
- Automated event metrics and reporting
- Close approach data quality evaluation
- Work with Mission to facilitate communication with potentially active secondaries

- Assist with O/O mitigation strategies including avoidance maneuver planning and HIE briefings as needed

(18) ***Anomaly Resolution (Not Included).***

To arrange for the obtaining and interpretation of anomaly resolution SSA products, such as point signatures (radar cross- section and/or photometry), time-series satellite signatures, and radar and optical imaging.

Omitron Response

Omitron concurs that anomaly resolution should not be included in the TraCSS basic services.

In our operational support, Omitron supports many space events and spacecraft anomalies. We have used all available phenomenologies and have been in dialog with many radar and optical experts on the implications of collected signature data. As the developers and analysts supporting the Space Surveillance Performance Assessment Toolkit (SSPAT), our staff continually monitors the performance metrics for sensors that are sending observations into ASW. This has allowed the space C2 customers to inform sensor operators that their system may be broken or drifting out of calibration.

Omitron is "flying" over 80 satellites for our NASA customer, and has a deep bench of satellite operators and mission specialist. Anomalies arise in power management, satellite contacts, and a number of other common on-orbit issues. Most O/Os are prepared for these type of issues. However, with the explosion of new space companies putting up constellations and other complex satellite systems, ad hoc support may be needed, either due to workload or the inexperience as satellite operators.

For a more comprehensive database of the data desired, and the related analytical tools, Omitron recommends working with the National Air and Space Intelligence Center (NASIC). There are potentially a number of products and tools at the unclassified level that would provide signature data on objects. Another future source of unclassified government data will be the Unified Data Library (UDL). Once fully populated, it is to be both an authoritative source and a Market Place to obtain the data requested in the RFI.

(19) *Design-time Assistance for Improved CA (Not Included).*

During the satellite construction and mission design phase, to assist O/Os in the prudent selection of mission orbits, satellite construction decisions to produce favorable light pollution properties, and the proper build-out of effective O/O ephemeris construction and CA software and procedures.

Omitron Response

Omitron concurs that the Design-time Assistance for Improved CA should not be included in the TraCSS basic services. This is a very specialized function and requires experienced space subject matter experts and modeling capability to be leveraged for a specific mission plan. Many of the satellite developers today like to do this engineering in house so to lower the cost of the TraCSS systems, this type of support should be reserved as by-request and paid for by the developers and O/Os. Omitron has supported both space-based and ground-based systems designs to enable the functions of this service.

During design and pre-launch mission periods, satellite O/Os must make many safety related design decisions, as explained in the "NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook". Omitron has provided key support to NASA

and other organizations in developing procedures and software tools to facilitate this design-time decision making process.

The NASA Best Practices Handbook also recommends that O/Os build and fly satellites in such a way as to minimize the creation of astronomical light pollution. Large constellations with satellites consistently brighter than V-band magnitude $M_V \approx 7$ can create unacceptable light pollution. Omitron-developed tools can evaluate light pollution levels for proposed or nascent constellations. The algorithm also predicts approximate brightness levels for individual proposed satellites, based on those observed for currently orbiting satellites.

(20) *Maneuver Trade Space (Not Included).*

To assemble a visual aid that identifies particular maneuver times and intensities (and, for some maneuver types, durations) to achieve the desired level of conjunction risk reduction (for both the main conjunction and any other conjunctions that the particular maneuver might introduce).

Omitron Response

Omitron concurs that maneuver trade space analysis should not be included as a basic TraCSS service. Maneuver Trade Space (MTS) is critical to risk mitigation, but is specific to the satellite being protected and the risk tolerance of the O/O. Many O/Os would not use this service or do not have the ability to maneuver, so to lower the cost of the TraCSS systems, this type of support should be as requested and paid for by the developers and O/Os.

A concierge service can be set up either to advise O/Os on how to develop their own MTS, or to modify and operate a core GFE capability. Omitron has developed an MTS tool used by NASA. The MTS analyses is critical component for mitigative efficacy. While a Pc value is

useful for identifying the risk of a conjunction, it does not alone identify the success or failure of any mitigative action. As such, it is the responsibility of the O/O to provide planned maneuver ephemerides that (1) mitigate the immediate conjunctions of concern and (2) do not introduce any additional high-risk events. For NASA, Omitron provides a maneuver trade-space plot that is constructed to provide a high-level laydown of the propulsive mitigation possibilities.

Commercial applications can certainly provide these services to their customers. However, policy is needed to communicate and coordinate between two or more maneuverable conjuncting satellites, especially where non-cooperative foreign satellite owners are involved. The question is, where does the responsibility for mitigating the risk to the operators and the orbit regimes lie? The coordination / communication responsibility may have to be an inclusion to the basic services Commerce provides. O/Os may not have the means or the wish to coordinate with foreign nationals or competitors.

(21) *Optimized Maneuver Recommendations (Not Included).*

In addition to the parameters in service (20) above, to include satellite contact restrictions, spacecraft maneuverability limitations, and O/O optimality preferences to construct a recommended maneuver plan to mitigate the main conjunction and ensure against the creation of any serious derivative conjunctions.

Omitron Response

Omitron concurs that this should not be included in the basic TraCSS services. This would require specific O/O satellite and ground system technical details. It should be a capability in any MTS capability used by an O/O. This would be particularly important for conjunctions

within constellations and autonomous CA events. This would be a concierge service either to help develop an O/O-specific MTS capability or operate a commercial MTS capability modified for a specific O/O.

(22) *Breakup Detection, Tracking, and Cataloguing (Not Included).*

To commission routine surveillance tracking to detect satellite break-ups; and upon the detection of a break-up, to increase supplementary surveillance tracking to collect break-up uncorrelated tracks (UCT), perform UCT processing, obtain dedicated tracking on new candidate objects, and suggest/perform cataloging actions for stable candidates for which the country of origin can be established.

Omitron Response

Omitron non-concurs and recommends that OSC move breakup detection, tracking, and cataloguing to the basic service as a breakup has severe consequences to active satellites in similar and adjacent orbits. Unlike Included Item 10, this is the actionable information needed to perform safety of flight risk reductions. OSC should possess this core capability and work closely with DOD and NASA to rapidly track and catalog all pieces of a breakup event. Initial orbit determination algorithms can create a low-fidelity state which may enable propagation over short timespans for subsequent tracking. Functional state may be achieved through subsequent data collection, association, and state updates.

Omitron has developed algorithms currently employed by the DoD for UCT generation and refinement as well as sensor scheduling. Our algorithms further identify UCTs which are sufficiently stable to automatically promote into standard objects within the space catalog.

At this point the data become sufficiently reliable to treat as actionable in CA screening and risk assessment.

(23) *Maneuver Detection and Processing (Not Included).*

To commission heightened surveillance tracking on maneuverable objects; execute maneuver detection algorithms against the tracking obtained from such heightened surveillance; and for objects for which maneuvers are detected, perform appropriate maneuver processing to create a durable post-maneuver state estimate.

Omitron Response

Omitron non-concurs and recommends that OSC move Maneuver Detection and Processing to the basic service. Because some O/Os may not be forthcoming in their plans, satellites that have ability to maneuver without notification should be observed more often to ensure a safe operating environment for participating TraCSS O/Os. Given that O/Os do not always share plans or intent, this service is essential for safety of flight. If TraCSS intends to use commercial sensor data and maintain a unique civil space catalog, all space tracking and catalog maintenance functions must be included. Currently, the Omitron-developed ASW software provides highly sensitive maneuver detection algorithms capable of identifying potential maneuvers at the first instance of tracking data post-maneuver. Our system automatically resolves post-maneuver states and, provided sufficient tracking data, can provide state updates using both pre- and post-maneuver tracking information. For self-announced maneuver planning, the ASW software can integrate maneuver times and magnitudes into user displays and state update algorithms. Omitron's software can calculate delta-V estimates for maneuvers and enable future technology implementation, such as

pattern-of-life predictions, for a more realistic future conjunction probability calculation. These technologies are developed for data-sparse environments to ensure tracking need not be constantly applied to achieve maneuver detection capability.

Basic Service and Omitron Response

III. Questions to Inform Development of Basic SSA Safety Services

OSC seeks responses to three categories of questions, and invites any member of the public to provide input:

A. Scope of Proposed Basic Space Situational Awareness (SSA) Safety Services;

B. Impacts of Proposed Basic SSA Safety Services on Commercial SSA Providers;

C. Tenets of Participation and Receipt of Basic SSA Safety Services; and

D. General Feedback.

Respondents are encouraged to explain how the capabilities to be provided by OSC's TraCSS can be structured to enable a competitive and burgeoning U.S. commercial space sector. Responses may also explain how the U.S. Government can work with industry and international partners in the development of open, transparent, and credible international standards, policies, and practices that will aid in the provision of these basic SSA safety services.

A. Scope of Proposed Basic SSA Safety Services

OSC seeks to clearly define and communicate the scope of basic safety SSA services to enable industry innovation of advanced services. OSC seeks responses regarding which SSA services should be included as part of TraCSS. OSC understands that the need to provide certain services through TraCSS may change over time. Similarly, some services may be necessary to include in the TraCSS initial offering only and others should be added in the future. For each of the services discussed above, OSC is seeking public input about whether the service should be included in TraCSS, and if so, whether it should be part of the initial offering or added in the future. Additionally, OSC seeks input on whether the services should be developed by the government or purchased from commercial vendors and redistributed. Furthermore, OSC invites comment on the following questions for each of the services:

- ***Does the proposed basic safety SSA service provide sufficient data to allow ongoing operations of orbital assets at a level equal to or beyond that currently provided by the DoD?***

Omitron Response

As a provider of flight safety services to the DoD, U.S. Civil and commercial spacefarers the proposed services described as basic are an equivalent capability currently provided by the DoD and NASA with some caveats. Restricting results to the current unclassified catalog obviously leaves analyst satellites out of the publicly available catalog. Per a recent DoD report, there are over 21,000 such restricted objects. One mitigation would be a robust communications concept with the DoD to provide alerts when a commercial asset might have to take action based on an object withheld from the OSC catalog. This can be implemented using a similar concept as is

being done currently with NASA where the catalog is screened at a DoD site, then the results are provided to NASA for action. This screening concept can be further enhanced by setting up a classified enclave for OSC with the appropriate guards to provide the unclassified results to the appropriate owner/operators. This enclave could use the SSN data along with commercial data/observations and ephemeris, but be transparent to the end users**.** Omitron has experience and establishing and operating safety of flight capabilities at multi-level secure environments with multiple customers.

Another mitigation action could be to enhance OSC catalog with commercial observation data. This could be acquired at one level to maintain and enhance TraCSS catalog. OSC could add a concierge service that would be augmenting the basic service for accuracy and timeliness with commercial space observation data depending on the risk profile of the O/O. There are orbital regimes such as Geosynchronous Orbit (GEO) where the addition of commercial space sensor data could reduce the error covariance and in turn produce a more certain risk assessment potentially saving satellite life. As commercial data would be an additional cost to the OSC, it could be fully or partially recouped.

- ***What proposed basic safety SSA services are essential to your ongoing operations? If the U.S. Government were to prioritize the delivery of individual services as part of TraCSS, which ones should be provided soonest?***

Omitron Response

Of the basic services, Omitron is dependent upon the following to conduct risk assessment for both civil and commercial operations:

(3) Routine Collision Assessment (CA) Screening and Conjunction Data Message (CDM)

(5) Data Quality Evaluation

(6) Launch Collision Avoidance (COLA) Screenings

(4) Special CA Screening and CDM Production

(7) O/O Ephemeris Generation and Curation with Covariance

(2) Receipt and Sharing of Predictions O/Os Ephemerides

And the not included

(22) Breakup Detection, Tracking, and Cataloguing

Our risk assessment services rely upon large data analyses of conjunction event datasets beyond the standard O/O-reportable volumes. For accurate environmental assessments, this must include the entire RSO environment and be conducted consistently to understand the dynamic risk environment. To sustain this business functionality, Omitron would require access to the space catalog or the ability to request screening data for analytic assessment.

- ***If the U.S. Government were to prioritize the delivery of individual services as part of TraCSS, which ones should be provided soonest?***

Omitron Response

If OSC cannot field these basic capabilities near the same time then we recommend a three-phase deployment

Phase I

- Infrastructure, platform, OSC catalog and communications
- The following basic services

- (3) Routine Collision Assessment (CA) Screening and Conjunction Data Message (CDM)
- (5) Data Quality Evaluation
- (6) Launch Collision Avoidance (COLA) Screenings
- (7) O/O Ephemeris Generation and Curation with Covariance
- (8) Re-entry Management and Assessment
- (11) Conjunction Object Solution Improvements with Additional Tracking

Phase II

- basic services
  - (1) Satellite Attributes, Capabilities, Status, and Point of Contact
  - (2) Receipt and Sharing of Predictions O/Os Ephemerides
  - (4) Special CA Screening and CDM Production
  - (9) Precision Probability of Collision Calculation
  - (13) Risk Assessment Time History Plots
  - (14) Space Weather Sensitivity
- Not included in the basic but recommended for the basic services
  - (22) Breakup Detection, Tracking, and Cataloguing
  - (23) Maneuver Detection and Processing

Phase III

- (10) Collision Consequence and Debris Production Potentials
- (12) Expected Tracking Determination
- The remaining Concierge services

Omitron is ready with capability today to rapidly deploy these basic services using operationally tested and many validated services.

- ***What, if any, additional capabilities beyond those currently provided by the DoD should be included in the TraCSS?***

Omitron Response

Omitron understands that the question refers specifically to DoD provided capability, however, the NASA CARA elements are tightly coupled from a flight safety perspective. Thus, between the capability of the DoD and NASA, the basic and concierge services make a good initial baseline for the TraCSS system.

Specifically, we believe these basic services and capabilities should be considered:

- Maintaining an OSC catalog that extends the DoD unclassified space-track catalog with commercial observations as is done with the Joint Task Force-Space Defense Commercial Operations cell (JCO) and should include a significant amount of debris tracking. An alternative is to release many of the DoD analyst-range debris objects to the unclassified catalog. This catalog must be interoperable with the DoD catalog as we have seen in operations not using common tools imparts unknown levels of uncertainty when using different propagation theories.
- A TraCSS help desk or 911 service for normal inquiries and immediate support help or notice to "Spacefarers". Omitron has directly witnessed much of the labor hours spent in establishing a world-class CA service being primarily dedicated to around the clock customer support.
- A plug-in service for O/Os using a compatible atmosphere model and the associated

solar proxies and Dynamic Calibration Atmosphere (DCA) coefficients.

- ***Are there any additional capabilities not listed that should be included in the basic SSA safety service to provide a baseline level of safety for owners and operators?***

Omitron Response

(See answers to previous questions) Plus

- Orbit Determination (OD) error quantification / Sensor calibration. Sensor calibration and conditioning to assess, normalize, and maintain quality of any space observation data inputs regardless of phenomenology. It is important that this be a basic service to pair with how the OSC catalog is maintained. New space data providers need to go through a data consistency analysis and if satisfactory, then be subject to periodic or real time data calibration. This normalization process allows data from various sensors (optical, radar, Passive RF, space-based) to be fused into a single solution with a reliable covariance. Omitron currently maintains and supports the Calibration application on ASW, but is developing an automated capability, Hyperion. Hyperion is specifically designed to assist in the automatic calibration and data fusion of commercial sensors.
- Vendor algorithm validation service. Noted on some recent high visibility conjunctions, publicly-provided vendor close approach results on inactive RSOs such as dead payloads or large debris have been markedly off in comparison with the DoD catalog. As an officially-released CA notice, this disparity could cause inappropriate risk mitigation actions in situations where one of the objects is an active payload. OSC may have to build a validation suite of hardware, software and test data to validate commercial solutions. If a vendor wishes to enter the marketplace and sell data

products or services based on their algorithms, the validation should be a vendor-paid cost item. This service should be independent of other contractors and be conducted by Federally Funded Research and Development Center (FFRDC) support.

- ***Where applicable, at what level or how often should the service be performed? For example, comments may address how often routine collision assessments should be conducted as part of the basic SSA safety service. DoD currently provides these assessments three times a day. How often should OSC's basic safety SSA service provide these assessments?***

Omitron Response

- Omitron could hazard an answer which would likely be not suitable for all conditions as would be the case for all responders. This should be a topic of multiple studies but that should not hold up the initialization of TraCSS. The initial frequency should be set at or better than current capability. The best answer will be determined per service on a case-by-case or scenario basis. Current operations for NASA, DoD and NOAA can be used as a guideline with an understanding that current support levels were determined based on the needs and capabilities of the responsible agency. Even for services identified as an included basic service, OSC should consider anything beyond the operational pace of service be conducted at extra cost. Again this should not be a single response as there may surely be instances to deviate from the current support levels such as a high Pc conjunction or other critical safety issue that requires out of cycle screening and other support.

B. Impacts of Proposed Basic SSA Safety Services on Commercial SSA Providers

OSC's provision of basic SSA safety services through TraCSS is intended to advance safety, stability, and sustainability in space and help the domestic commercial SSA industry grow. OSC is evaluating the potential impacts that the basic SSA safety services provided through TraCSS may have on the commercial SSA industry. OSC is seeking public input on whether there are any concerns with respect to commercial SSA providers with their own services or other value-added providers that may rely on governmental SSA basic safety services. Furthermore, OSC invites comment on the following questions:

- ***Are any of the basic SSA safety services readily available from the current U.S. SSA industry? If so, is the service affordable to owners and operators of spacecraft?***

Omitron Response

- Omitron has operational support capabilities fielded for all of the basic services except (10) Collision Consequence and Debris Production Potentials (prediction). Omitron believes that service is sufficiently available through FFRDC.
- Omitron has operational support capabilities fielded for all of the not included risk reduction services in some form.
- As with almost every SSA safety service provider, Omitron has contracts with the U.S. Government and also provides support to commercial and foreign spacefarers for risk assessment. U.S. Government programs like JMS from AFSPC/SMC used commercial SSA service providers and funded many improvements to the commercial tools sets that are part of the commercial tools baseline.
- Omitron provides the license-free tool use because the ASW application suite is jointly developed and only charges labor for operations and training on ASW and for risk

assessment services. If a government user requires their own ASW tools, we extend license-free use and only seek the cost of integration on to their environment, their data networks, and for any provided training and operational support.

- Most if not all commercial SSA data product suppliers rely upon the government-provided space catalog at some level. Omitron's model of using government data to provide a consistent starting point for all commercial SSA services benefits the TraCSS establishment of a secondary data and service market. This model places the burden of intense validation on the core catalog and risk assessment products, allowing commercial SSA service providers to focus on adding affordable value to O/Os.

- ***For commercial SSA service providers, does the current SSA capability offered by the DoD have any impacts on your current or future product offerings?***

Omitron Response

SSA services offered by DoD has significant impact to our future plans if not available. Omitron, like all commercial SSA service providers, uses the DoD unclassified services to reduce costs to other U.S. Government organizations and commercial support. Our future strategy is built on this data to maintain cost competitiveness and O/O expenses.

- ***For commercial SSA service providers, do any of the basic SSA safety services identified for inclusion in TraCSS have any impacts or implications on your current or future product offerings? If so, which services proposed to be part of TraCSS would have an impact on your offerings and why?***

Omitron Response

Similar to previous question, Omitron, like all commercial SSA service providers, uses the DoD unclassified services to reduce costs to other U.S. Government organizations and commercial support. Our future strategy is built on this data to maintain cost competitiveness and minimize O/O expenses.

If these basic services were not available there would be significant increase risk to the results of our CA assessment because of the lack of insight into most of the orbits for non-active RSOs. This is particularly important to LEO constellations and systems. The Government provided foundational catalog and basic services greatly enhance the CA process, reducing O/O risks.

- ***For O/Os, are any of the basic SSA safety services identified for inclusion in TraCSS duplicative of what O/Os of spacecraft are already responsible for obtaining or providing?***

Omitron Response

There is no currently enforced consensus on the requirements for an O/O to safely participate in space traffic. As such, there is no uniformly-defined responsibility for an active O/O. With many new companies and universities entering spaceflight operations for the first time, the focus is generally on mission capability and not spaceflight citizenship. To accurately respond, the OSC should define what is required for an O/O to safely operate a vehicle and not be a hazard to others. Services in this RFI such as ephemeris generation may be required for most O/Os, but the quality and stringency may not suffice for spaceflight safety uses.

A number of O/Os already use DoD services and we foresee them moving to OSC once they are sure of the same level of safety of flight and related services. Some O/Os use in-house or commercial services for both CA and Pc risk assessment and as such the OSC TraCSS services

would be redundant to what they are already have. However, the additional steps of OSC validation algorithms and providing a more robust catalog could enhance the current services O/Os receive.

- ***Are there unique advantages to the government purchasing and redistributing certain commercial services rather than leaving these to the commercial marketplace?***

Omitron Response

Yes, depending on the commercial service. Sensor data collection has been proven as a useful commercial service. Commercial SSA data providers have proven the ability to expand the current space catalog and provide timelier response in detecting maneuvers at GEO than the currently releasable Space-Track catalog is able to provide. Procurement of SSA data can thus enhance the catalog an reduce the Pc risk, but this data collection model improves the catalog for all TraCSS participants. With an initial thorough analysis and annual updates, a procurement of some commercial SSA sensor data should be in basic services at the expense of the tax payers to share the cost of common catalog availability. O/Os may find the need to purchase additional sensor data for analysis and conjunction event resolution beyond the data already purchased and provided in the OSC solution. In these scenarios, the benefit is localized and should be at the expense of the data consumer.

Another solution worth purchasing would be the solar indices used in the High Accuracy Drag Model employed by the DoD. Solar Environmental Technologies – SET is the commercial company providing these indices. This would require DoD approval and Omitron to build a

compatible application for the O/Os to incorporate our dynamic drag model into the ephemeris generation tools.

Many O/O are capable of doing risk assessment evaluations but OSC should standardize a minimum TraCSS product level to help avoid confusion amongst the O/Os. The benefits of a commercial SSA marketplace service provider could then be evaluated by O/Os in light of the standard TraCSS services.

C. Tenets of Participation and Receipt of Basic SSA Safety Services

OSC is seeking public input regarding what should be required to receive "free of fee" basic SSA safety services through TraCSS. OSC recognizes that certain basic SSA safety services should be made publicly available. For example, space objects from a current DoD catalog that are not sensitive to national security are currently made accessible to the public through the *Space-Track.org* website. OSC also recognizes that other basic SSA safety services should be available to all owners and operators. In response to previous RFIs, some comments suggested that OSC require owners and operators to provide operational information or act in good faith in response to the basic SSA safety services in order to participate in TraCSS. OSC also invites comment on the following questions:

- ***Which basic SSA safety services identified for inclusion in TraCSS should be made publicly available?***

Omitron Response

To address this question let's define O/Os as organizations that currently operate in the near-earth space medium (100km to the moon), SSA safety service providers as developers who support O/O and the public which might have interest but no economic or safety considerations. Others such as universities, nonprofits, reporters, and foreign organizations and government can fall in any of the above or create a new category of users for the discussion of access. A special group that would require access would be insurance providers who will have unique requirements but may not and should not need full access. For insurers, potential reports and metrics might be the right level of access. The only service that should be open to the general public should be the OSC catalog. All other basic or concierge services

could reveal proprietary data that is unnecessarily released for purposes other than safety of space flight.

- ***What, if any, information should owners and operators of spacecraft be required to provide to OSC to participate in TraCSS?***

Omitron Response

O/O should be required to supply 72 hours of predicted positional information for their active satellites to be shared with other TraCSS participating O/Os. Ephemeris should be formatted in accordance with the Consultative Committee for Space Data Systems (CCSDS) Orbital Ephemeris Message (OEM) standard. Participants should also be required to provide 72-hour maneuver planning information to allow for effective and timely conjunction mitigation planning. Maneuver planning information should be provided in accordance with CCSDS Orbital Parameters Message (OPM) as is currently coordinated on the space-track.org website. Additional satellite-specific information should be required as well to include O/O contact information, satellite size and mass, and satellite maneuverability status. These items all contribute to the risk assessment functions which should be accessible to a secondary O/O in case of a shared conjunction event.

Further, O/Os should be required to provide additional non-sharable information with TraCSS which may aid in enabling secondary tracking services such as on-board telemetry capabilities, anomaly history, corner-cube reflector availability, or RF transmission capabilities. Protections should be in place for the non-sharable O/O data to provide some comfort that the minimal amount of their business plan is revealed. Items, data, and plans, that impact flight safety, such as satellite characteristics that effect flight, orbital plans, and repositioning

maneuvers, should be shared with other O/Os in situations where these plans have fight safety impacts. Similarly, TraCSS data that indicate health of orbiting assets should be limited in distribution unless the data have flight safety impacts. In these flight safety scenarios, data sharing should be limited to those O/Os involved.

- ***What, if any, actions should owners and operators agree to take to participate in TraCSS as part of the tenets of participation?***

Omitron Response

For participation in TraCSS, O/Os should be required to abide by a set of mitigation and remediation standards. Anomaly notification to the OSC should be obligatory with a special emphasis on potential debris-causing anomalies such as thermal, battery, or propellant related failures. O/Os should also be required to provide contact information for any active satellite which has the ability to change trajectory to avoid critical situations. Finally, there should be agreed-upon standards when two active satellites are predicted to approach which one shall change trajectory. This standard of conduct will impart a direct fairness in terms of resource expenditure expectations among various O/Os. These rulesets will also enable further autonomous operations. Participants should finally agree to some form of orbital debris mitigation with phase-in opportunities to allow existing satellites to comply while requiring newly-launched satellites to implement OSC-defined standards. The debris environment increases risks and mitigation costs for the community, so active participants should have some obligations to maintain the shared environmental space.

Key tenets or doctrine for OSC interaction with O/Os and SSA safety service providers are:

- Information and technology will be protected

- Only information will be shared and limited to data for purpose of safeguarding space-based assets
- Information required for efficient management and safety of space-based assets but not required by another O/O will be protected.

Actions for O/Os for participation in TraCSS

- All launches, transiting vehicles and eventual deployments in the near-earth space medium from U.S. governed territory to include littoral launches will participate in the TraCSS services and required to provide a data to manage the safety of space-based assets.
- (OSC and TraCSS supporting contractors Protected info) Vehicle characteristics while under development and update 6 months prior to launch:
    - Vehicle mass
    - Hard Body Radius
    - Redundant Systems e.g. control processing, thrust or other control, power
    - Safe modes and safety features
    - Deployment and disposal plans
    - FAA, FCC, ITU and other licensing/approvals
        - Frequency or wave length of emitters
    - Operational orbits
    - Operational satellite control concept, POCs and TT&C ground entry locations
- Operational information
    - Launch profile, launch complex separation, deployments and expected debris and

debris mitigation-not shared

  - Ephemerides shared with only potential conjuncting assets O/O
  - Accurate/actual spacecraft's drag coefficient and frontal area – not shared

- On-orbit event plans
  - High level early orbit plan- not shared
  - Station keeping concept/plan- not shared
  - Maneuver planning ephemeris
    - Will there be autonomous control what are the override concepts
  - Deployment and separations during any part of orbit injection or final orbit plan- not shared
  - Redeployment plan shared with only potential conjuncting assets O/O
- SSA safety of flight procedures and tools
  - Concept of safety of flight for O/O assets and other spacefarers- not shared
  - Tools in use and subject to validation by OSC (e.g. FFRDC)- not shared

- ***What should happen when owners or operators fail to provide the relevant information to OSC or fail to take actions consistent with the tenets of participation?***

Omitron Response

The consequences for failure to comply should be the denial of O/Os or service providers to operate from U.S. territories or if by treaty, denial of operations from all members of the treaty. This could include control nodes and ground entry points if serious safety violations and

concerns are at play. If an O/O is removed from the TraCSS participant list, they should be treated like other non-cooperative space assets and debris for flight safety purposes.

The requirement for mandatory participation should be codified in law and treaty by working with Congress and International partners. There are corollaries in both air and sea, US and International agreements allow a wide range of consequences for inappropriate or non-cooperative behavior that put fellow air and seafarers at risk. Once laws, treaties and agreements are in place the consequences of non-compliance by degree of infraction should be clear to O/O and Launch service providers.

Similar to air and sea traffic management, recommend investigation into two issues that could improve space flight safety:

- Requiring transponders on satellites
- Establishing “rules of the road” for autonomous maneuvering satellites.

D. General Feedback

OSC welcomes feedback about any other related topics. For example, are there any matters not discussed above that OSC should or must consider before it provides basic SSA safety services through TraCSS?

Omitron Response

There are acquisition, legal, policy and eventually treaty details for the OSC to work out and Omitron is certain that many items are being worked. In our responses to the basic services, we hope we have been clear that we are able to provide immediately almost all basic services as soon as a cyber secure processing environment is established an appropriate network connectivity is in place with personnel to support. We highly recommend that the OSC's approach to the basic services be interoperable with the DoD and NASA operations and that workflows are established to simplify communications and reduce uncertainty and confusion amongst the U.S. Government spacefaring departments. DoD investments and development can greatly reduce OSC costs while minimizing any additional legal exposure as the foundations of the OSC TraCSS systems will be derived from DoD and NASA's validated functions.
We recommend OSC consider an acquisition approach that contains two parts: the system integrator and SSA product or service providers.

- The system integrator would have the responsibility for the infrastructure, application platform, and onboarding process. This approach allows the contractor to focus on the security, reliability, and availability of the critical processing and services while providing a clear path to onboard applications.
    - The system integrator can establish a "Marketplace" where the integrator provides a virtual storefront environment where O/Os can requests service

above the basic services. To make this work it needs to be simple and straight forward with understandable pricing for service.

    - Additional fee for service could be
        - Addition of Commercial Space Data
        - Risk Assessment per satellite or constellation
        - Maneuver planning support

- Two options for SSA product or service providers:
    - First is for OSC to establish an IDIQ contract to provide the basic TraCSS services or concierge services. This approach ensures product and service providers can be contractually accessed by an O/O which will enable participation of smaller O/Os.
    - Second can be accessed through the system integrator to shorten the contracting time. The integrator can act as the contracting arm to procure additional applications and be a contract entry point for additional services requested by O/Os.
- Recommend Contracting type be flexible for the initial establishment
    - Cost Plus Award Fee/Incentive fee would seem to be the most flexible and responsive contract type with the exception of the additional services that can be FFP.
    - Contract type can be revisited once the TraCSS is establish and under a more sustainment update footing.

Liability is minimized using current validated tools.