Statement of
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to the
Committee on Commerce, Science, and Transportation
United States Senate
on
Space Missions of Global Importance: Planetary Defense, Space Weather Protection, and Space Situational Awareness
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Mr. Committee Chairman Wicker, Ms. Ranking Member Cantwell, and other members of this committee, thank you for the invitation to appear before you today to share my perspectives regarding salient issues on space safety, security, and sustainability. It is an honor to be seated at this table with these great witnesses. It has been two years since I last testified to this great body's subcommittee on Space, Science, and Competitiveness. My name is Moriba Jah. I'm an astrodynamicist and space environmentalist. My perspectives have been shaped through a 20-year aerospace engineering career in government, industry and academia. I started my career as a member of the technical staff of the NASA Jet Propulsion Laboratory. Whilst there, I contributed to the navigation of a variety of spacecraft to Mars and Asteroid Itokawa, and also developed advanced spacecraft navigation algorithms toward autonomy and improved orbital knowledge, beginning with Mars Global Surveyor and ending with the Mars Reconnaissance Orbiter mission. After JPL, I worked as a Civil Servant in the Air Force Research Laboratory (AFRL), where I led the design, development, and implementation of algorithms that have successfully and autonomously detected, tracked, identified, and characterized human-made objects in space, so called "Resident Space Objects," to include orbital debris. My last position within AFRL was as the Mission Lead for Space Situational Awareness. Amongst my achievements, I was given the highest award that can be earned as an AFRL employee, that of AFRL Fellow. I currently serve on the faculty of the Aerospace Engineering and Engineering Mechanics Department, in the Cockrell School of Engineering at The University of Texas at Austin. At UT Austin, I lead a transdisciplinary research program focused on delivering pragmatic solutions to problems regarding space safety, security, and sustainability. I am a Fellow of several organizations and professional societies and serve as a chair and member of several major space-related national and international technical committees. However, I am here today as an individual citizen and the views I express are mine alone. I'd like to also thank my wife Cassaundra, and children Denali, Ari, and Satyana for lending me to you, today.

Executive Summary

Near Earth Space is (a) geopolitically contested (b) commercially contested and (c) a finite resource in need of environmental protection.

The entire set of space events and processes that occur and can happen, as a whole, is unknowable for a myriad of reasons, not the least of which that we still do not widely share our observations of the space domain. If we wish to know something, we must measure it and if we want to understand something, we must predict it! What do we call this knowledge regarding causal relationships for things in space? We call it Space Situational Awareness.

If we wish to protect ourselves from extraterrestrial hazards in the form of near-Earth asteroids, space environment effects and impacts on satellites and Earth-based infrastructure, as well as space activities and services from loss, disruption, or degradation, we must have timely and actionable Space Situational Awareness. Just a couple of weeks ago, two dead satellites in Low Earth Orbit were predicted to have an alarmingly high probability of collision[1] but these probabilities were quite varied: one entity said 1 in 10, another 1 in 100, another 1 in 1000. The decisions anyone might make given each of those might be extremely different. Is there consensus in the combined Space Situational Awareness? No! Case in point? Recently, there was a predicted conjunction between Aeolus, a European Space Agency satellite and a Starlink satellite belonging to the SpaceX Internet constellation[2]. The European Space Agency attempted to contact SpaceX to coordinate an evasive maneuver but antiquated methods (relying on email) of communication conjured a systemic obstacle in meaningful space debris mitigation. The European Space Agency maneuvered Aeolus to prevent the predicted collision. SpaceX stated in hindsight, obviating the communication snafu, that they would not have maneuvered anyway because their Space Situational Awareness and decision threshold indicated it not sufficiently risky to them. Do we want to be "playing chicken" in our orbital commons? We have no "rules of the road" for space. The world's space debris experts agree that there is a very high rate of non-compliance with space debris mitigation guidelines. It's common practice to operate satellites long past their intended safe and useful lifespan. Last but not least, the global Astronomy community has taken issue with the exponential growth of resident space objects as these "corrupt" their astronomical images and negatively impact the science[3]. Humanity as a whole is left to suffer the consequences of these behaviors.

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[1] https://spacenews.com/potential-satellite-collision-shows-need-for-active-debris-removal/

[2] https://spacenews.com/esa-spacecraft-dodges-potential-collision-with-starlink-satellite/

[3] https://www.forbes.com/sites/startswithabang/2020/01/30/dangers-to-astronomy-intensify-with-spacexs-latest-starlink-launch/#337a38a56a57

A safe, secure, and sustainable space domain requires improved transparency, predictability and for us to develop an *independently corroborated* body of evidence of space activities, events, and actor behaviors that can be used to hold people accountable and can inform meaningful space policies, rules, regulations, and norms of behavior.

U.S. National Space Policy Directive #3, signed by President Trump on June 18th of 2018, laid out very succinct goals to address these issues. Its first goal is to advance Space Situational Awareness and Space Traffic Management Science and Technology. It further states that the United States should continue to engage in and enable Science and Technology research and development to support the practical applications of Space Situational Awareness and Space Traffic Management. These activities include (a) improving fundamental knowledge of the space environment, such as the characterization of Resident Space Objects, (b) advancing the Science and Technology of critical Space Situational Awareness inputs such as an openly accessible and curated set of multi-source observational data, algorithms, and physics-based models necessary to improve Space Situational Awareness capabilities, and (c) developing open-source software to support big-data science and analytics. In summary, we must develop the required science and technology to reliably deter, predict, operate through, recover from, or attribute cause to the loss, disruption, or degradation of any given space service, activity, or capability. This means making space transparent and predictable, and having the evidence to hold entities accountable.

Beyond examples I previously listed, I can personally attest to the fact that we are significantly behind in this endeavor as evidenced by our inability to accurately and precisely infer unique or unambiguous causal relationships between space domain events and observed satellite anomalies. You can read about these in the news frequently these days. Satellites are experiencing malfunctions where the evidence could have more than one explanation: was it the environment? was it caused by another entity? If so, was it intentional? The information collection, curation, analysis, and dissemination requirements for Space Situational Awareness does not end with collision risk assessments or re-entry predictions; they only begin there! The much more difficult and critical requirement is to assemble the evidence of events, processes, and activities in space that would need to be used to assign culpability of negligent behavior, for instance, or assessing compliance or the lack thereof with space policies. Nobody is quantifying these needs. Every domain of human activity has experienced malicious behavior and to think otherwise is naïve at best. In the face of a next “space race” or “gold rush” equivalent, driven by global space commerce, it’s not a matter of if, but when! The space domain is holistically poorly monitored. We are unprepared and ill-equipped to deal with disputes resulting from space activities and events.

The U.S. is home to some of the world’s top-ranked research institutions; these should be brought to bear to, once and for all, bring us out of the dark ages in terms of space domain decision-making knowledge and actualize us in order to meet the great demands of space commerce, exploration, and other activities. A well-funded and dedicated Space Situational Awareness Institute could undertake the Science and Technology research and development we desperately require. Europe and other countries are becoming leaders in these endeavors. Academia, the source of the purported workforce to meet the demands of operating so-called mega-constellations, has been mostly neglected in this area. As a professor at a top-tiered research university, I alone find myself turning away over a dozen qualified U.S. citizens every year, from joining my research program due to an absence of resources and financial support to perform clearly needed research.

The National Science Foundation does not fund Space Situational Awareness research although there are many basic research problems still salient in this mission area. The Air Force Research Laboratory and Air Force Office of Scientific Research have been the only real, and overwhelmingly underfunded, organizations making any semblance of investments in Space Situational Awareness research. I know this because I was the Mission Lead for Space Situational Awareness at the Air Force Research Laboratory for several years. The National Academies has several relevant boards that should be invoked to engage in studies that inform a nationally committed roadmap of Space Situational Awareness Science and Technology Research. Moreover, these research outputs must be committed to being transitioned into operationally relevant environments that could directly support the U.S. Department of Commerce's stewardship of providing Basic Space Situational Awareness and Space Traffic Management services and products to the global community.

What are the next steps required to put this into effect?

- Per National Space Policy Directive #3, provide the Department of Commerce with an adequately funded and resourced mandate to: 1) have a Space Traffic Management Pilot Program to work with USSPACECOM and the community to provide the first instance of a Civil Space Traffic Management system and 2) begin collecting, curating, and exploiting multi-sourced resident space object (e.g. non-Space Surveillance Network tracking) data for orbital safety and sustainability purposes that is open and widely accessible, with multi-tiered access and dissemination (e.g. ASTRIAGraph[4]).
- Create or expand the existing role of NASA to: 1) uniquely focus upon leading the **scientific and technical** requirements for a robust, effective, and meaningful Civil Space Traffic Management System, and 2) to work closely with other government agencies, industry, and academia.
    - Conjunction Analysis concerns itself with predicting so-called "close approaches" between any two Resident Space Objects[5]; it is a growing and changing field, and research into new methods is critical to keep up with the rapidly changing and marginally predictable space environment. NASA already has an effort in this area (the CARA Program at Goddard Space Flight Center) that can be leveraged along with 30+ years of developing and executing this capability for use by civil space operators. It is government's role to retire risk, invest in Science and Technology (S&T) Research and Development (R&D), and share the results with the community to encourage growth.
- Invest in and expand the role of University Affiliated Research Centers (UARCs) as foundational, dedicated, and focused government-academic partnerships to solidify science and technology (S&T) research and development for critical space-related core technical

[4] http://bit.ly/astriagraph

[5] http://astriacss03.tacc.utexas.edu/ui/min.html

competencies and technology risk-retirement needed by the U.S. Space Exploration program and Commercial Space Industry[6].

- Engage and craft mechanisms for Industry to get their investment and participation in a Civil Space Traffic Management System:
    - Satellite manufacturers
    - Satellite launch providers
    - Space Insurance Brokers and Providers
    - Commercial Space Situational Awareness Providers
    - Space Angel Investors and Venture Capitalists
    - Space Service Users

At The University of Texas at Austin, we are taking our own steps in a meaningful direction by (a) becoming the first academic partner to the USSPACECOM in Space Situational Awareness Data Sharing, (b) collaborating with the NASA CARA program, hosting their tools at the Texas Advanced Computing Center (TACC) and leveraging our large scale computing platforms to improve current state-of-practice regarding collision risk assessments, (c) finalizing a fully executed set of Cooperative Research and Development Agreements (CRADAs) with the Department of Commerce's space weather prediction center and NOAA satellite operations facility in Suitland MD, (d) advancing the state-of-the-art in developing the world's first crowdsourced space traffic monitoring system, ASTRIAGraph, initially funded by the Federal Aviation Administration, (e) leading a dedicated transdisciplinary academic programs in space safety, security, and sustainability.

Mr. Chairman, we have some wicked problems to solve in near earth space and we need Congress to act now. Perfect is the enemy of good enough! We know that we won't have a perfect system at the start but let's create a system that is agile and adaptive to meet the growing demands and as a community, we will iteratively refine our tradecraft and collaboration and get better. This committee should provide the required leadership; the opportunity to act is before you.

Narrative

In my vast travels around the globe, speaking to and collaborating with space scientists, engineers, and policymakers, it is evident that "American Exceptionalism" is still invoked and desperately yearned for, by many. America's leadership in the space domain, underscored by taking on and delivering upon what seemed to be an impossible feat, to send humans to another celestial body and return them safely, has inspired not only our great nation, but an entire planet, and seeded some of the world's most creative and innovative ideas.

[6] https://www.arlut.utexas.edu

Exploration is critical to who we are as a species; it drives our growth and evolution. When our minds and bodies are idle, we tend to self-defeating behaviors. What brings out the best in us? Rising to great challenges, and working as a nation to overcome them. What got us to the Moon and back, safely and repeatedly? Government, Industry and Academia working seamlessly, together. No one sector could do it by themselves.

The US Space Command (USSPACECOM) currently has over 26,000 records active in its space situational awareness database, commonly referred to as the Department of Defense "catalog." Of these, well over 18,000 records correspond to well-tracked, well-understood Resident Space Objects in Earth-centric orbit, roughly 3,000 of which are operational satellites; the rest are so-called "space junk." The remaining records in USSPACECOM's active space situational awareness database are not as well-tracked or understood, which creates increased uncertainty when operational satellites are screened against them to identify possible orbital safety hazards, or conjunctions. The number of Resident Space Objects is increasing given an increase in launches, and on-orbit breakup events (i.e. when one Resident Space Object collides with another, a satellite explodes, or breaks on its own due to space aging and material fatigue and stresses). If we could track every detected object, we could wrap a sensible Space Traffic Management system around that and even develop empirically-based policies and regulations. Unfortunately, it is hypothesized that we can only track a few percent of the total number of Resident Space Objects that can cause loss, disruption, or degradation to critical space services, capabilities, and activities. In other words, we have an orbital iceberg equivalent of sorts. The ability to track a Resident Space Object depends on two main factors: our ability to detect the object AND our ability to uniquely identify the object. This is to underscore that <u>an object that is detectable does not imply it is trackable</u>, and this is a critical distinction to make moving forward.

Tracking an object means that we know where it was, a notion of where it is, and have some idea of what it is and where it will be. Think of how we track air traffic, where the aircraft is in the "custody" of someone who monitors its motion and relationship to other aircraft. The following Figure (1) puts into perspective the problem we face in our inability to track more of the objects we can detect. It was generated from real data collected by the U.S. Space Surveillance Telescope, currently in Exmouth, Australia. It is worth mentioning that we have the long-awaited Space Fence on Kwajalein, and I've been told that the initial results are much like with the Space Surveillance Telescope, as seen in Figure 1. When one has an exquisite sensor and it's unique, you'll get very accurate observations during a very small part of the total orbit and you'll be observing things that other sensors will not or cannot. Think of a hula-hoop. An exquisite sensor is having one hand on this hoop. Think about the variety of ways in which the hula-hoop can rotate if you only grab it with one hand. This is like the ambiguity you will have with a unique and exquisite sensor. It will help but you'll have a large number of objects that you can detect but will be unable to track.

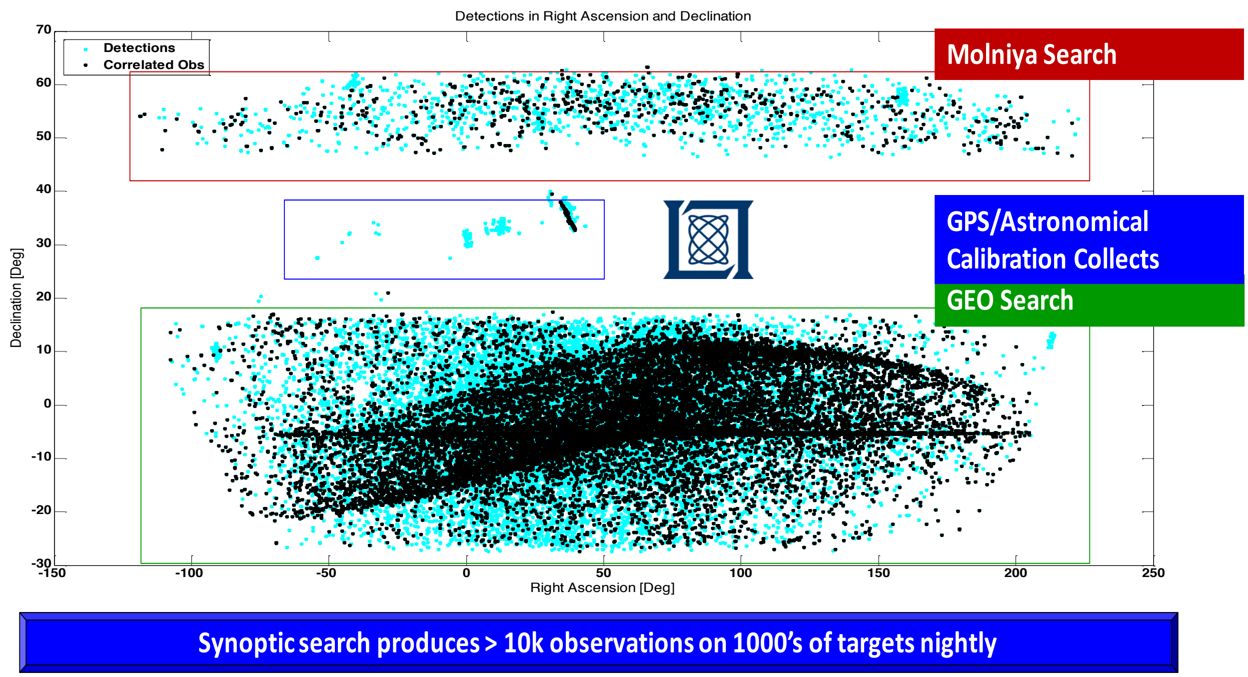

Figure 1. A Single Night's Worth of Resident Space Object (RSO Detections (for various orbital regions) from the U.S. Space Surveillance Telescope (SST) in New Mexico. Detections (dots) that are Black are those believed to be from known (cataloged) RSOs. All else (Cyan) are Detectable but Untrackable RSOs.

So, what prevents us from doing better at tracking objects in space? First, we don't have ubiquitous observations, meaning we don't persistently detect all objects all of the time. In fact, we generally have very sparse observations on any given object in space. Globally, we do not share observational data as a community. This lack of data sharing is perhaps the single biggest problem in us having a more robust space traffic monitoring and management capability. Secondly, every single object in the world's largest space object catalog (that of our DoD) is represented and modeled as a sphere, a cannonball in space! Needless to say, there aren't many human-made cannonball-shaped objects in space. Only those Resident Space Objects whose motion is not significantly different from that of a sphere in between observations, are ones we can "track." Gravity is what I call an equal opportunity accelerator: just tell me where you are and I will tell you your acceleration due to gravity, regardless of your size, shape, material constitution, orientation, etc. However, there are non-gravitational forces experienced by every single Resident Space Object and all of these depend on the object's physical characteristics. Thus, <u>the lack of a rigorous Resident Space Object characterization and classification scheme is a strong contributor to our inability to track more objects in space</u>. When we wish to understand any population of things, we first "tag" individuals in that population and then "track" these individuals through time, space, frequencies, and evaluate their interaction with other individuals and their environment. We formulate hypotheses, test them, and draw conclusions based upon evidence. We do not do this, rigorously and scientifically, for Resident Space Objects, in great part because we cannot physically go to them and tag them. If we wish to someday have Norms of Behavior for Near Earth Space that led to safety, security, and sustainability, we will need to know how many classes or species of Resident Space Objects there are, and how each class or specie moves, behaves, is influenced by the local space environment, etc. Trucks carrying hazardous fuel are regulated differently than Vespa scooters, Oil Tankers on our seas are regulated differently than kayaks and canoes. So, why would we treat all Resident Space Objects as the same thing…cannonballs? The following figure (2) is a cartoon to show the difference between the limitations imposed by assuming space objects to be cannonball-like versus what they actually are like.

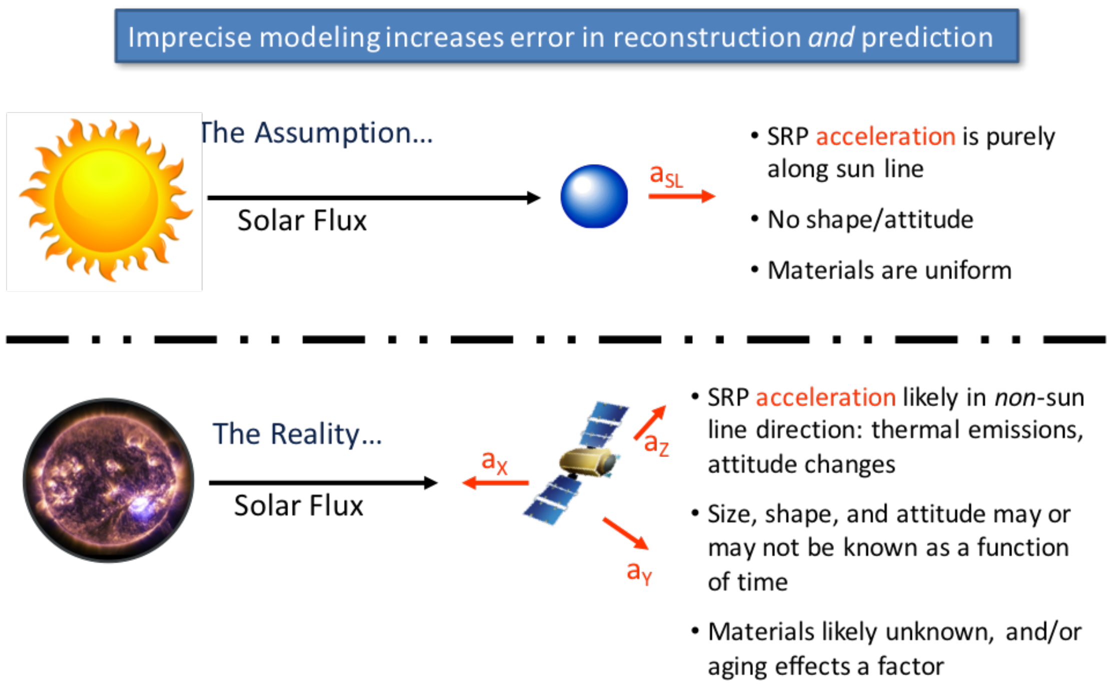

Figure 2. Difference between the motion experienced by a spherical (cannonball-like) space object and a satellite with realistic size, shape, orientation, and material properties. For the sphere, the acceleration due to the sun's effects are unidirectional. In reality, our tracking data informs us that objects experience accelerations due to the Sun's effects in 3-dimensional space (multi-directional).

Lastly, <u>regarding our inability to track more objects in space, are the mathematics and physics we use to process the observed data and infer physical quantities regarding these objects. It really matters…call these our algorithms</u>. Our representation of uncertainty is demonstrably and inarguably oftentimes flawed, unrealistic, and inconsistent amongst our software and tools. The following figure (3) shows a picture our current problem with having multiple detections at multiple times and having to find clever methods of uniquely identifying objects in order to make them go from detectable to trackable. Most Resident Space Objects are defunct and therefore do not self-report their identities.

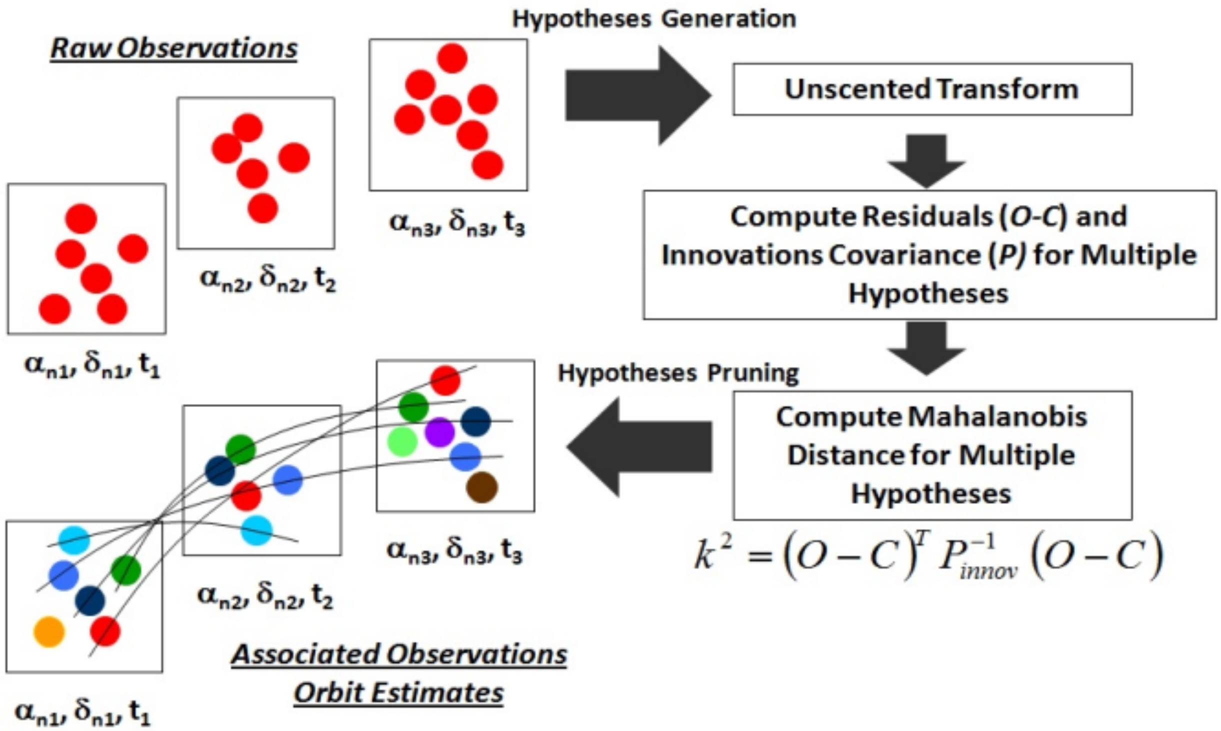

Figure 3. How to Uniquely Identify Space Objects from a Set of Unidentified Detected Objects in Order to Make Detectable Objects, Trackable. The method shown here is one of Multiple Hypothesis Testing as a mechanism to decide which detections should be paired to which objects.

If the Resident Space Object population was held constant, I'd say we'd might have more time on our hands to figure this all out. However, our global space environment is finite, getting increased traffic, and all in the absence of global governance related to safety and sustainability.

We don't even agree on what is on orbit or where it is. I know this because I have developed the world's first crowdsourced space traffic monitoring system, called ASTRIAGraph[7] at The University of Texas at Austin, initially funded by the FAA. Here, we combine multiple independent sources of information and can visualize these all in a common frame of reference.

Figure (4) shows an example of what this combined database of Resident Space Objects looks like.

[7] http://bit.ly/astriagraph

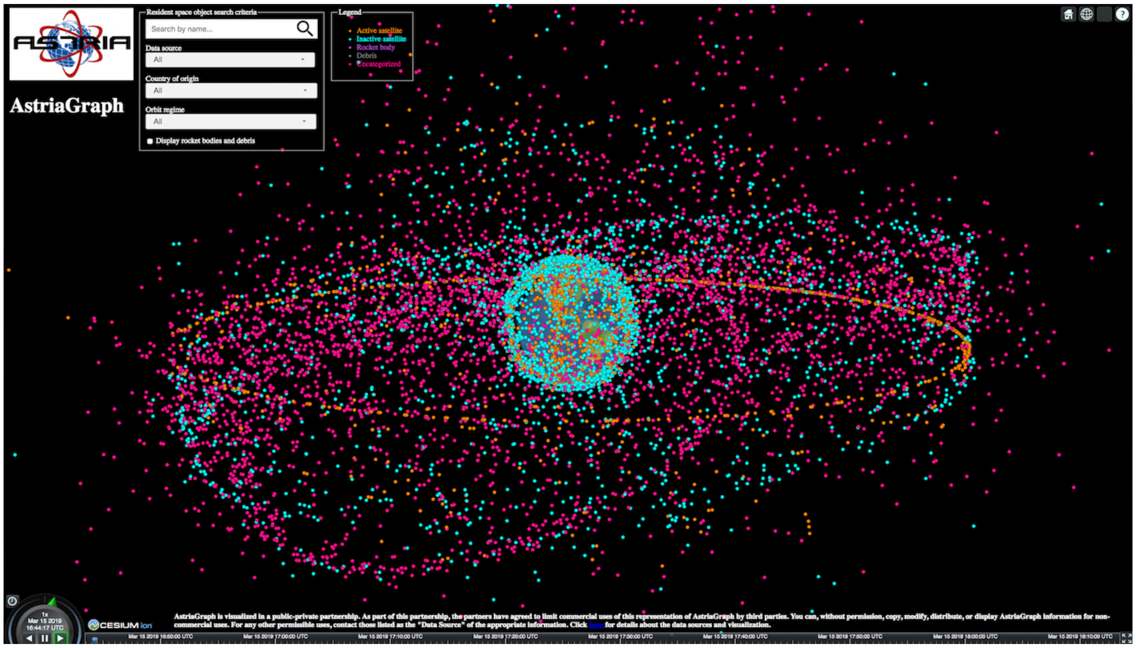

Figure 4. ASTRIAGraph: World's First Crowdsourced Space Traffic Monitoring System.

Our eventual goal is to make this like a "Waze" for space. To wit, we seek to create a so-called participatory sensing capability that openly allows and encourages those with sources of information about anything in space, to make contributions and benefit from the information that can only be inferred from the aggregated big-data science and analytics.

To my earlier point, if one only had the USSPACECOM public catalog, Figure (5) shows you what your space traffic map might look like.

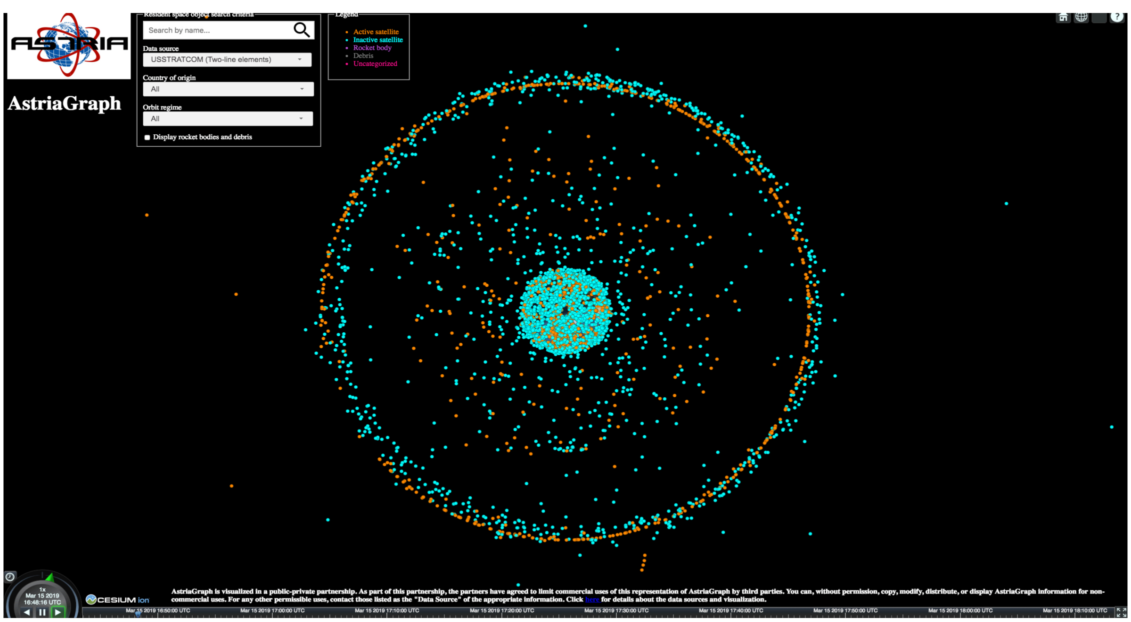

Figure 5. ASTRIAGraph: USSPACECOM Information Only.

Alternatively, if one only had the Russian JSC Vimpel catalog, Figure (6) shows you what your space traffic map might look like.

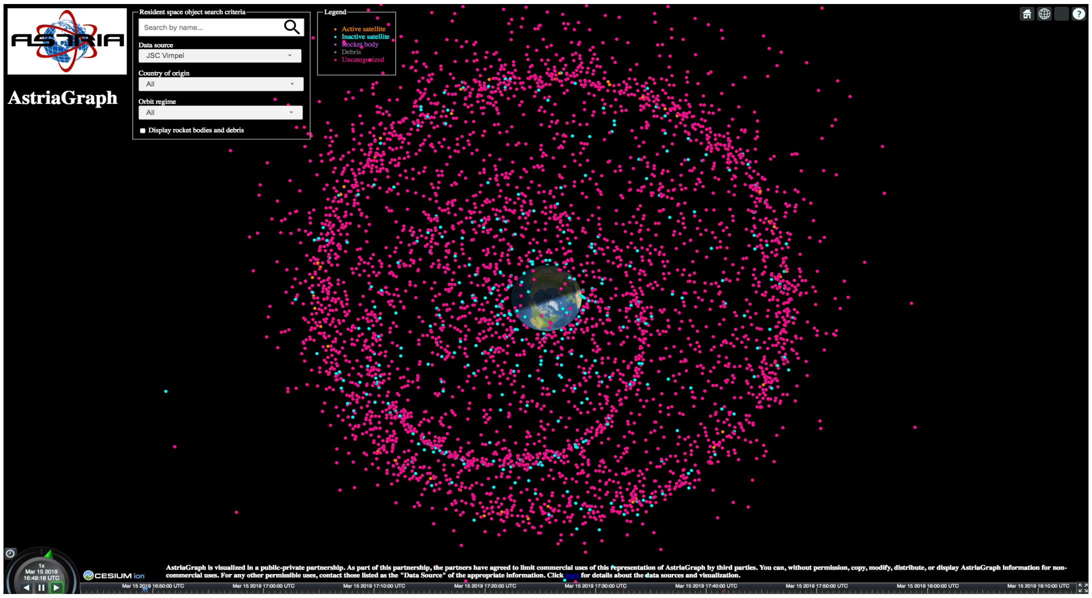

Figure 6. ASTRIAGraph: JSC Vimpel Information Only.

Which source does one believe as accurate? These sets of information reflect a very different space traffic picture. This is a major source of ambiguity. Moreover, the problem gets a bit worse. Figure (7) shows you an example of multiple opinions on a single common Resident Space Object (FLOCK 1C 10 in this case).

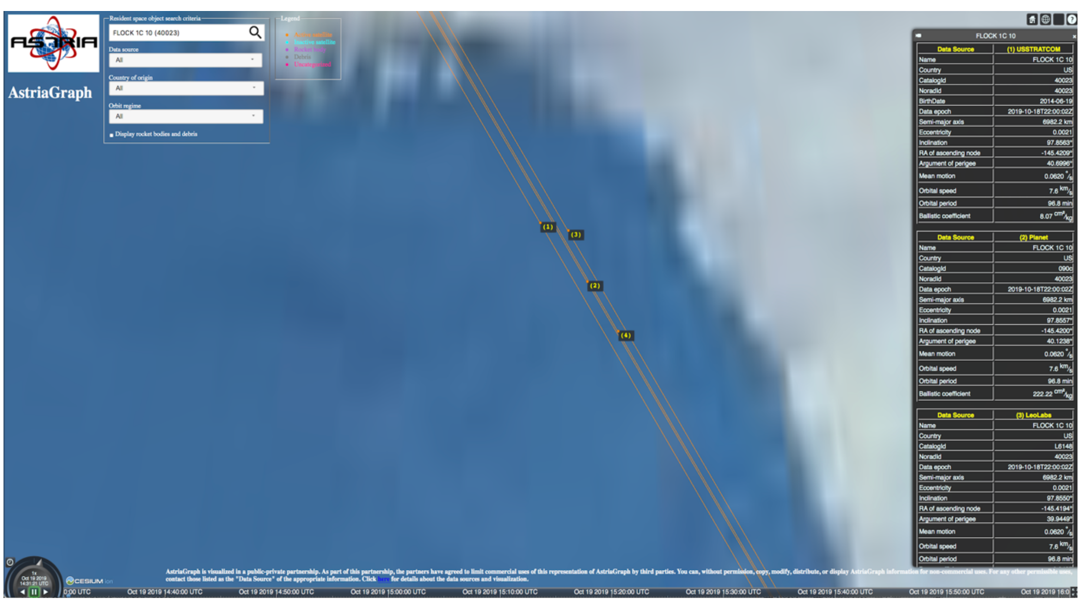

Figure 6. ASTRIAGraph: Multiple Opinions for One Resident Space Object.

The difference in positions between these is on the order of a few hundred meters. However, when it comes to predicting a collision, this variance alone could be the difference between a high or really low collision probability and hence could lead to flawed decisions that could have dire consequences.

As the cost of access to space is decreasing, the number of space actors is increasing. It's like what the Transcontinental Railroad did for helping businesses explode, connecting the East Coast and Western Frontier. In the past 3 years, we saw a record-braking 104 satellites being deployed by India's PSLV space capabilities. Unfortunately, while they did assess potential collisions amongst these 104 satellites, no one performed analyses of potential collisions between those 104 newly deployed satellites and the remainder of the current Resident Space Object population. OneWeb just recently launched their first batch of a few dozen satellites with the aim of deploying over 1000 satellites that will aim to provide global internet. SpaceX is well on its way toward the same goal, having several hundred satellites already on orbit and will surely aim to launch a planned ~4000+ satellites.

As was experienced in the Western Frontier of old, the environmental impact of runaway mining and prospecting was harsh and detrimental in many instances. Examples are mercury poisoning, silt in our water sources, etc. Our space environment is becoming much more commercially driven and populated. Many "New Space" companies or start-ups are getting significant investment from Angel Investors and Venture Capitalists who are focused on getting a Return On Investment (ROI) within a few years, believing Space Traffic and Orbital Safety to be someone else's problem. I have personally found an absence of space operations expertise amongst the workforce driving some of these "New Space" ventures, causing me further concern regarding orbital safety and long-term sustainability of space activities. There is a mentality of "take risks and fail often." While this worked well for software companies in Silicon Valley, we can't afford to have this mentality in space.

We should look to so-called tenets of Traditional Ecological Knowledge (TEK) as a model for achieving space sustainability. Some of our indigenous peoples have learned how to become sustainable over many millennia. One tenet underscores the need to quantify the carrying capacity of the environment before making decisions on how to interact with it. My personal experiences have shown me that "Mother Nature" tends to seek states of equilibrium. Do we know what the carrying capacity is for different orbits? If we launch 60+ satellites every several weeks, to we know what the equilibrium state of the environment will be? We are operating in the space domain well beyond our ability to make sound and sustainable decisions, and this will be to our eventual detriment.

I propose that Congress move to create a Civil Space Traffic Management (CSTM) system led by the Department of Commerce (as directed by national space policy) that will:

- Accelerate the pace and reduce the costs of Civil Space Traffic Management development by modernizing approaches to Space Situational Awareness and Space Traffic Management, with focus on long-term sustainability of space activities, through the creation of new federated data standards, measurement standards, models and ontologies, open source software, and big-data management and analysis techniques that aid in the scientific evaluation of the efficacy and safety of space operations, and attendant policies.
- Act as an entity that could create consortia of industry, academia, and government for collaboration and sharing of databases, computational techniques, and standards.
- Operate a Civil Space Traffic Management system that provides the accuracies and products necessary to safely enable innovative and non-traditional commercial uses of space.

The Civil Space Traffic Management Mission should be to:

- Assure the safety of operations in space.
- Maximize, encourage, and incentivize the use of commercial capabilities and data sources.
- Provide transparency, advocacy of informed guidelines, and safety services as a public good to preserve the space environment.

The Civil Space Traffic Management Primary Functions would be to:

- **Observe and Monitor:** Space Domain and Traffic Observations, Space Situational Awareness (SSA)
- **Track and Catalog:** Identify, Characterize, and Catalog Objects; Relational Statistics, Catalog Updates, Traffic Attribution, Achieve Track "Custody"
- **Analyze and Inform:** Information Dissemination, Safety Products, Conjunction Data Messages

The Tenets of a Civil Space Traffic Management system would be to provide and incentivize:

- **Open observational data** - All collected or acquired data will be made open and available for 3rd party analysis to improve learning and enable high Quality of Service domain analysis.
- **Open catalog of space objects and events** - All derived conclusions from Civil Space Traffic Management data will be made open and available for 3rd party verification and peer-review of results and conclusions.
- **Open Safety Advisory Services** - As these services are intended to be a global public good, they will be made available to the world.

- **Open and objective verification of data and analyses** - As the Civil Space Traffic Management capabilities and processes improve, impartial feedback will be made available to all service providers in the spirit of achieving increasingly effective Quality of Service.
- **Open Market** - It is not the role of the Department of Commerce to define the economics of the data and/or analysis marketplace. The intent of the Civil Space Traffic Management is to empower industry to stay involved in the provision of service to all space domain actors.
- **Open Workforce Development** - It is to the benefit of all for the specialized skills required of effective space traffic managers to proliferate globally. To this end this Civil Space Traffic Management will support mechanisms which result in the education of additional skilled space traffic managers and analysts.

The Benefits of a Civil Space Traffic Management system are that it would:

- Provide standard and benchmark data sets that enable quantifiably consistent comparative analyses between competing tools, techniques, and algorithms.
- Provide the government with a transparent mechanism to guide and exploit Civil Space Traffic Management activities and capabilities AND a sustained/focused investment in STEM education.
- Provide industry with a free foundational Civil Space Traffic Management service and a marketplace of focused, cost-shared and openly available sciences and technologies that it can “pick up” and operationalize/commercialize for its own profit.
- Provide academia with a sustained scientific and technological Civil Space Traffic Management research and educational investment, to ensure that the U.S. is stocked with capable and skilled workforce to handle the scientific and technological problems of tomorrow.

How does industry profit from such an activity, financially? It can easily wrap profit-making services around the foundational “for public good” layer of basic space situational awareness and space traffic management services and products. It lowers the bar for entry for new space initiatives as they don’t need to shoulder the burden of self-providing of these basic space situational awareness and space traffic management services. It’s like the benefit of the U.S. developed, owned, and operated Global Positioning System (GPS)! Think of not only the paradigm-changing science but explosion of commerce that has resulted from this U.S. Government investment and service. Many companies have developed profit-making applications which exploit the layer of foundational service provided by GPS.

I also propose that the U.S Government create the NASA Space Situational Awareness Institute using Cooperative Agreements (like the NASA Astrobiology Institute) as a mechanism under which an academic consortium could be assembled, invested in, and properly leveraged to deliver on goal #1 of Space Policy Directive #3. The funding would need to be appropriated and delivered to NASA with a strategic roadmap on how the S&T is developed and transitioned to both government and industry. Several University Affiliated Research Centers (UARCs) should also be invoked, invested in, and leveraged, to be foundational partners in this NASA Space Situational Awareness Institute. The UARCs could provide foundational capabilities and sciences to NASA and those Space Situational Awareness Institute academic members could then focus uniquely on SSA needs and requirements, working closely with the government and commercial communities.

The motto of my research program at UT Austin is:

Ex Coelestis, Scientia…Nihil Arcanum Est! This loosely translates to, "from the heavens, knowledge…nothing hides!"

As Ever,

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