Improving Orbital Debris/Space Situational Awareness Knowledge

Overview:

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Goals of the proposed concept:

- Dedicated LEO observatory for surveying and improving the current orbital debris knowledge base in LEO or GEO
- Obtained information must be sanitized for use by the "open" community
- Secondary goal would be the use of asset for other astronomy missions: NEO surveys,

Identified Stakeholders:

- NASA, DoD, Service Academies, NRO, US Commercial Satellite Industry, Sat Insurance Industry
- ESA, CNES, DLR, JAXA, ISON, UN, Space Data Associates, Int'l Sat Insurance Companies

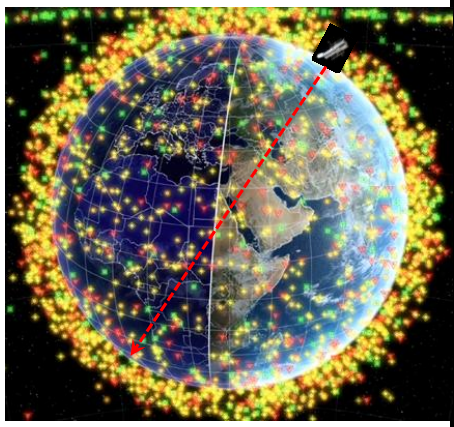
Collaborative Team Members (as of Jan 4, 2013): USAF Academy

Potential Team Members (draft):

- DoD: JSpOC, USAF Sp Com, USAF RL (Kirtland AFB),US Dept of State
- Int'l : ESA, CNES, JAXA, ISON,

Ops Concept & Graphic:

Graphic shows orbital track of notional space telescope and tracked orbital debris 800 km circular orbit at a high inclination ~83 deg) (red dashed line)
Telescope viewing direction is in spacecraft velocity direction
Telescope will be able to detect large spent rocket bodies 100's of km in distance,
For a tracked OD object, the object should appear in the telescope FOV at a precise location and time based upon the SSN catalog. Deltas from the predicted location and times will be processed and utilized by JSpOC and others to enhance orbital debris understanding



Description:

- Develop a space based visual and near infra-red observatory to continuously improve/enhance the world's knowledge of the orbital debris environment
- Estimated mass for observatory, instruments, & spacecraft is: ~4000 kg +/- 200 kg
- TRL components are used for Spacecraft bus
- Estimated DDT&E costs for observatory, instruments , and spacecraft are estimated to be in the range of : $160-$240 Mil
- Launch costs are estimated to be: $80-$150 Mil
- Operational costs are estimated at ~$15M per year; these costs may be borne by another partner – requires further study
- Launch single telescope to a 800 km circular orbit
- Binocular optics will be added to NRO optics to enhance tracking capability of a single large telescope
- Launched to 800 km circular orbit via a multitude of available LVs, No need for upper stage
  -- Least expensive US LV is Falcon 9,
  -- But a foreign partner may desire to launch from foreign site
- International participation and cost sharing may be possible to support common goals associated with understanding the orbital debris environment better

Values to NASA, the Nation & the World:

- **Supports direction given to NASA in the Nat'l Space Policy (June 28, 2010):**
  - Pursue research and development of technologies and techniques, through the Administrator of the National Aeronautics and Space Administration (NASA) and the Secretary of Defense, to mitigate and remove on-orbit debris, reduce hazards, and increase understanding of the current and future debris environment;

- **Enhances today's US Space Surveillance Network (SSN) database of tracked debris**
  - Improves tracking capability of today's cataloged debris by reducing uncertainties associated with each debris objects trajectories
  - Can be used to detect & develop trajectories for today's untracked orbital debris

- **Enhances spacecraft lifetimes and collision risk:**
  - Reduces unplanned spacecraft maneuvers as collision warnings issued by JSpOC to satellite owners will be greatly reduced since warnings will be based on higher fidelity data than is currently available with today's SSN

Improving Orbital Debris/Space Situational Awareness Knowledge Through Use of NRO 2.4 m Space Telescope Optics

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Qualifying Statement:

I have been working in the subject of Orbital Debris (OD) and Space Situational Awareness over the past 3 years at MSFC's ACO and many respective OD subject matter experts (USA & Int'l) have determined that Active Debris Removal (ADR) is a required necessity in the not too distant future. Other experts feel that improving the collective knowledge base of the trajectories of the currently tracked OD objects by reducing each objects trajectory uncertainty will provide immediate benefits and should be done before major amounts of resources are spent on ADR. If each OD objects associated trajectory uncertainty were reduced by a factor of 10, then the US Joint Space Operational Center (JSpOC) would issue far less possible spacecraft conjunction warnings on a daily basis, and the satellite owners would also move these identified spacecraft (S/C) less, thereby saving the spacecrafts fuel reserves and lengthening the lifetimes of such S/C. As the USA continues to refine its capability to identify and track OD through planned major improvements to the Space Fence ($6+ Billion as of Nov 27, 2012) and other space fairing nations (ESA & CIS primarily) are also improving their OD detection capabilities via ground based radar and ground based telescopes, a dedicated telescope in LEO would provide additional capabilities that would make the job of detecting and cataloging OD much more efficient. Therefore, I am proposing a concept develops a Space Based LEO telescope for OD investigations from one of the two NRO assets to help provide capabilities to understand the problem and threat of OD better.

Primary Concept Goal Category: Human Spaceflight & Space Technology

1.0 Concept: The concept described herein is to use one of the two sets of space qualified telescope hardware that was given to NASA from the NRO to be utilized as a space telescope dedicated to the furthering of humankinds knowledge of Earth's orbital debris environment. Each set of hardware is comprised of a 2.4 meter f/1.2, lightweight ULE primary mirror configured in an f/8 system with < 20% Obstructed Aperture. More information on these telescope optics can be found at: http://science.nasa.gov/salso/. It is envisioned that this orbital debris space telescope will be launched to a Low Earth Orbit (LEO) altitude where there is both present: 1) A high OD flux level, and 2) A high number of operational spacecraft. A tentative obit is at 800 km circular at an inclination of 83 degrees as it meets the constraints given.

The telescope could be used to:

1) Develop a better understanding of the OD environment and the threat that OD poses now and in the future.
    a. Detect and track known cataloged OD (>10 cm in size) and provide the data necessary to improve the exact trajectory of each tracked object (reduce the trajectory uncertainty associated with discrete cataloged debris objects)
    b. Witness actual satellite conjunctions to verify the conjunction assessment warnings,

c. Provide data on currently untracked OD objects (<10 cm in size) so that these smaller objects can be cataloged as well. By cataloging these items S/C operators can move their S/C when collisions may be eminent.

2) Provide detailed supportive visual data for various S/C anomalous events
   a. Examine commercial and government satellites as warranted or requested
3) Survey regions of space for Near Earth Objects (NEOs) when conditions are not favorable for OD investigations,
4) Material Science investigations
   a. To be used in understanding long term environmental effects on S/C materials and construction techniques by witnessing the long term visual degradation of many materials over time.

2.0 Mission: To be built and launched from a multitude of worldwide launch sites to an 800 km circular orbit (tentative). The telescope would be viewing objects in the ram direction and larger items such as derelict stages would be seen for 100s of km in the distance. (Note every 100 km of distance is 6 seconds of viewing time.). It is conceivable that this mission could be ready for flight in 2018/2019 given immediate Authority to Proceed (ATP).

3.0 Return to NASA/Nation: MSFC's development of this telescope builds upon MSFC's past & current space telescope work (HST, Chandra, & the JWST) and would enable a LEO capability that does not exist today. By providing the necessary data to improve the trajectories of OD objects, daily conjunction warnings would be greatly reduced to satellite owners. In addition the detection of smaller OD objects on a collision course for a $500M satellite in a timely manner would enable the operational satellite to move out of harms way, thereby saving $ now and eliminating the creation of 100's of thousands of smaller pieces resulting from a collision. An asset, so developed, would provide the necessary needed data to the worldwide space-faring community related to OD investigations similar to the way the HST provides data to the astronomer community.

4.0 Hardware Configuration: The telescope, associated sensing equipment, and integrated spacecraft is expected to have a mass of ~4000 kg and this is with a 30% mass growth margin. This estimate was derived from two recent ACO space telescope studies and includes mass for the necessary de-orbit propulsive burn. The goal is to use the optics as they are with no modifications. The S/C subsystems would be derived from Off the Shelve (TRL 9) components. The telescope would require a hinged aperture to protect systems during launch and during solar & lunar occultation, as well as safe mode.

5.0 Operations Concept: Once the telescope was operational on orbit, its control authority may be directed by a special ground flight center similar to the HST or Chandra, but its data that was collected most likely would have to be cleared by the NRO or JSpOC or other gov't entity before being disseminated to the world for OD scientific investigations. The yearly cost of operations is very hard to ascertain at this point in time but in the past two recent ACO studies values of ~$15 Mil per year was the annual operations cost used.

6.0 Estimated Costs: Estimated costs are broken down into three specific areas: 1) Telescope and sensors, 2) Integrated Spacecraft Bus, and 3) Launch Costs. The telescope and sensors needed are expected to cost in the range of $70M to $100M. (Note, the recently developed Canadian Sapphire Satellite was delivered for ~$67M and was optics, sensors & S/C bus and the WISE S/C cost estimate was ~$300M including ~$100 M for launch costs.) The S/C bus is expected to range in cost from $90M to $140M. And the launch costs are expected to range in cost from $60M to $150M. Note depending upon the potential international collaboration the costs of launching this telescope may be an in kind contribution from ESA, CNES, JAXA or the CIS.

7.0 Advantages for This Concept: This concept will provide an asset which will provide high fidelity data to reduce the OD threat to operational satellites as well as help US JSpOC to reduce the number of Conjunction Warnings between Satellites and OD. Iridium Satellite Corporation announced a $2.9 Billion contract to procure 81 operational Iridium Next Satellites and these will be launched into a 781 km orbit beginning in 2015. The 66 new Iridium Next satellites will join the original 66 Iridium satellites in a 781 km orbit that has one of the highest OD fluxes known. The number of possible conjunctions/collisions between these satellites and OD will increase as more and more S/C and derelict rocket bodies are added to this orbital shell. Having an eye in space focused on increasing the knowledge of the trajectories of OD objects may become a necessity. And this concept may be able to be developed and flown for a total cost of $220M to $390 M in total before 2020.

8.0 Strategic Alignment with NASA Goals: This effort aligns with both human spaceflight and space technology within NASAs strategic alignment, but also directly supports the directives given to NASA in President Obama's National Space Policy; as dated June 28, 2010. The Nat'l Space Policy directs the following related to OD:

> "*Pursue research and development of technologies and techniques, through the Administrator of the National Aeronautics and Space Administration (NASA) and the Secretary of Defense, to mitigate and remove on-orbit debris, reduce hazards, and increase understanding of the current and future debris environment*".

The development of an OD LEO operational Space Telescope would provide the much needed data for many utilize as the world tackles the Earth's Orbital Debris Problem.

As of January 4th, 2013; the USAF Academy SSA/OD experts (Drs. Chun and Dearborn) have expressed an interest with partnering with MSFC on this proposal. In addition, OD SMEs from Aerospace Corp, USAF RL, key US universities, Iridium satellite Corporation, as well as, international participation (ESA, JAXA, CNES, etc.) are being queried for interest in teaming and most queries will take until late January to work. The author and his small team will be working with the entities listed above over the next few weeks to develop an overall consensus on teaming together to advocate the use of one of the NRO assets for OD investigations. The author realizes that many scientists will perceive astronomy or heliophysics research as more important than OD research. But our 21st century relies upon satellites for communications, business, and warfare – And what are the economic benefits of protecting these assets by better OD monitoring and warning? In closing, how does the economic benefit of saving a key satellite compare to astronomy research?