The Importance of Space Situational Awareness (SSA) For ADR and OOS

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What is SSA?

- Space situational awareness (SSA) is information about the space environment and activities in space that can be used to:
  - Operate safely and efficiently
  - Avoid physical and electromagnetic interference
  - Detect, characterize and protect against threats
  - Understand the evolution of the space environment
  - Provide awareness and transparency of space operations
SSA in the context of ADR and OOS

- Entities performing ADR or OOS activities will need a high degree of SSA to be successful
  - Determining which debris objects to remove and precise tracking to enable interaction (docking, lasing, etc)
  - Finding and locating servicing clients, rendezvous operations
- However, SSA requirements go beyond that needed for actual operations
  - How do you convince other space actors that your ADR/OOS activities are being conducted safely?
  - How do you convince other space actors that your ADR/OOS activities are not hostile or malicious?

- Can current SSA capabilities deliver these needs?
SSA NOW
Elements of SSA

- **Metric Data (Catalog)**
  - Locations of objects in space and the ability to predict where objects were in the past and will be in the future

- **Space Weather**
  - Measurement, warning, and forecasting of the effects of Solar activity on objects in orbit

- **Object Status**
  - Health, telemetry, planned maneuvers (usually provided by owner/operator)

- **Intelligence**
  - Information about objects in orbit (images, signals, capabilities, behavior) collected on objects in orbit

**“Civilian”**

**“Military”**
Historical context for SSA

• “Space Surveillance” was born during the Cold War as part of protecting the US and USSR from nuclear attacks
  – Nuclear threat progressed from airplanes to ballistic missiles (and satellites)
  – Space used for strategic warning, intelligence, & treaty verification
  – Two super powers controlled virtually all aspects of space

• SSA capabilities reflected these priorities
  – Emphasis on survivability and reliability
    • Everything revolved around possibility of nuclear war
    • Only take data from sources we can absolutely trust
  – Focus on military and national security customers
  – Data “silos” within certain government organizations
Current context for SSA

• Today’s world is vastly different from 50 years ago
  – 12 countries have demonstrated indigenous space launch capability (Iran, North Korea, and South Korea are the newest)
  – Over 70 entities operate about 1,060 active satellites
  – 15,000+ pieces of tracked space debris (>10cm), 500,000 pieces untracked (1cm to 10 cm)
  – Private sector now makes up significant portion of space activity

• SSA mindset and capabilities have not kept up
  – Still done primarily for military/national security purposes by the military
  – Bureaucracy/security needs have hampered upgrades and modernization, particularly for computer hardware/software and algorithms
• United States military has the best set of SSA capabilities, although not ideal
  – Operates global network of 30+ ground based radars and optical telescopes, plus a satellite in orbit
  – Maintains the most complete satellite catalog of 16,000+ space objects
  – Data fed to Joint Space Operations Center (JSpOC) in California
  – Provides a range of data and services for US government, satellite operators, and public

• Limitations
  – Primary customer is US military
  – Antiquated hardware and software
  – No real coverage in Southern Hemisphere
Current capabilities - Russia

- Russian military has the second best set of SSA capabilities
  - Operates network of ground based radars and optical telescopes across much of former Soviet Union (FSU)
  - Maintains a good catalog of low Earth orbit (LEO) space objects and geosynchronous Earth objects (GEO) space objects over Asia
  - Data largely not made available to those outside the Russian military
  - Roscosmos also has some specialized analysis capabilities to protect human spaceflight

- Limitations
  - Russian military rarely shares data with anyone else
  - Very antiquated hardware and software
  - Limited funds for upgrades
  - No coverage outside of FSU territory
Russian Space Surveillance System

Missile Warning Radar Coverage (Podvig, 2012)
Current capabilities - Europe

• Europe doesn’t currently have an SSA system, but several countries have their own limited capabilities
  – France, Germany, UK, Italy, Switzerland each have a few ground-based radars or optical telescopes
  – Some bilateral data sharing agreements between European countries and/or the US and Russia
  – Maintain catalog that is a combination the public US catalog with other sources

• Limitations
  – Coverage only over Europe and limited sensor throughput
  – Face significant policy challenges in increasing data sharing
  – Limited funding at the European level
Current capabilities – non-state

• Space Data Association (SDA)
  – Not-for-profit entity created by major commercial satellite operators
  – Purpose: “facilitate the controlled, reliable, and efficient sharing of SSA data to improve the safety of satellite operations”
  – Provides members services to support conjunction analysis (CA), collision avoidance (COLA) & radio frequency interference (RFI) detection

• International Scientific Optical Network (ISON)
  – Collection of international scientific telescopes to provide data for scientific analysis, coordinated by the Russian Academy of Sciences
  – 30 telescopes, 20 observatories, 10 countries
  – Excellent deep space catalog

• “Amateur” Observers
Not so “amateur”

X-37B
(OTV-2)
May 21 2011

Thierry Legault
Emmanuel Rietsch
THE FUTURE OF SSA
SSA is inherently international

• “Good” SSA requires a **geographically distributed** network of both radar and optical sensors and **combining sensor observations with owner-operator data**

• Theoretically, building the sensor network can be done unilaterally
  – Large economic cost
  – Need “friends in the right places”, basing agreements
  – Long logistical tails

• Every space actor needs a certain level of SSA for safe and efficient space activities, but few have the resources to build a complete network
  – Many actors can make partial contributions
A potential goldmine of SSA sensors
Conclusions

• It is impractical for a single actor to achieve “good” SSA by themselves

• Fundamentally, SSA requires data sharing and cooperation between different actors
  – Networks of telescopes and radars distributed around the globe to track debris
  – Satellite owner/operators with telemetry, health, and planned maneuvers

• Multiple independent sources of SSA data are good
  – Greater accuracy and redundancy
  – Independent monitoring and validation
The Future of SSA

• Core set of SSA services to support all users
  – Maintain catalog of space objects
  – Conjunction assessment warnings

• Specialized capabilities to support national security
  – Threat assessment
  – Determining object capabilities

• Sharing on multiple levels
  – Sharing between allies
  – Sharing between gov’ts and commercial
  – Sharing publicly

National Security SSA
- Imaging
- Characterization
- Capabilities
- Limitations
- Intent

Civil SSA
- Metric data
- Maneuver plans
- Point of Contact
- Space Weather

Shared SSA
Space sustainability realized

Debris Mitigation

Reduce the creation of new debris

Active Debris Removal

“Space Traffic Management”

Reduce the growth in the debris population

Minimize the impact of debris on operations

Norms and TCBMs

Space Situational Awareness (SSA)
Thank You
Questions?

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