# Future Models of Space Traffic Management

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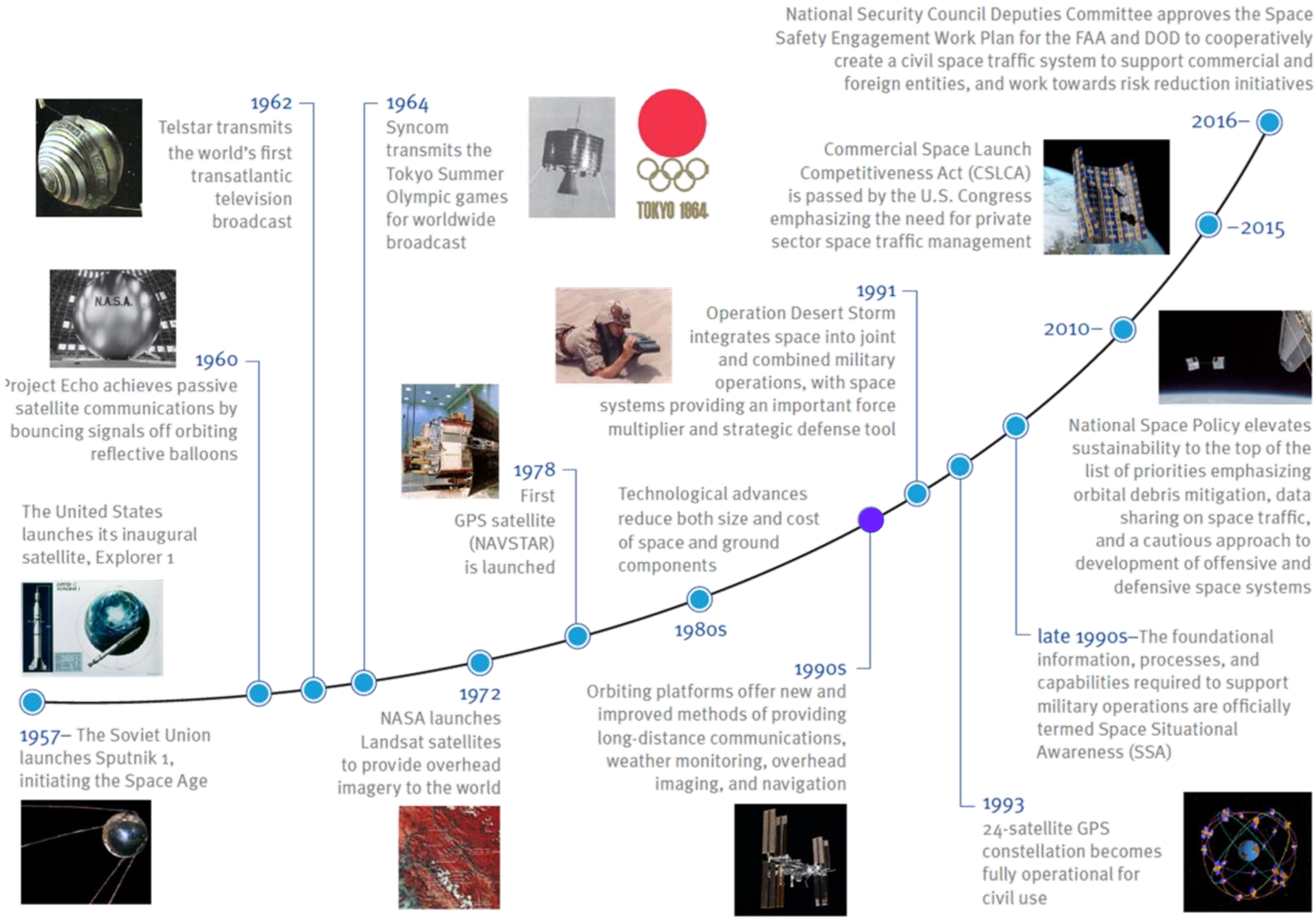
# *What is Space Situational Awareness and Space Traffic Management*

- Different definitions for SSA sometimes cause for confusion
  - *DoD Joint Publication 3-14*
    - Space Situational Awareness is foundational to conducting space operations.
    - SSA is the requisite foundational, current, and predictive knowledge and characterization of space objects.
  - *European Space Agency*
    - Space Situational Awareness is about detecting hazards.
    - SSA aims to detect, predict and assess the risk to life and property due to man-made space debris objects, reentries, in-orbit explosions, in-orbit collisions, disruption of missions and satellite-based service capabilities, potential impacts of Near-Earth Objects (NEOs), and the effects of space weather phenomena on space- and ground-based infrastructure.
- Regardless of definition, common goal is to provide mission assurance.

***SSA is foundational. It enables safe operations and provides mission assurance.***

# *Space Situational Awareness Timeline*




***The Aerospace Corporation 2017 – Space Situational Awareness in an Evolving World***

# The Space Traffic Management Pyramid

STM has no agreed upon definition


- COSMIC Study – 2006: First widely recognized definition – International Academy of Astronautics (IAA)
  – *Space Traffic Management means the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference.*
- U.S. Space Policy Directive – 2018
  – *Space Traffic Management shall mean the planning, coordination, and on-orbit synchronization of activities to enhance the safety, stability, and sustainability of operations in the space environment.*

- Common themes in the definition
  – *Safety, stability and sustainability of outer space*
- Difference in approach
  – *Regulatory provision vs.*
  – *Coordination and synchronization*

***STM goals are operate responsibly and predictably in space.***

# *Traffic Management: A Historical Analogy*

1906

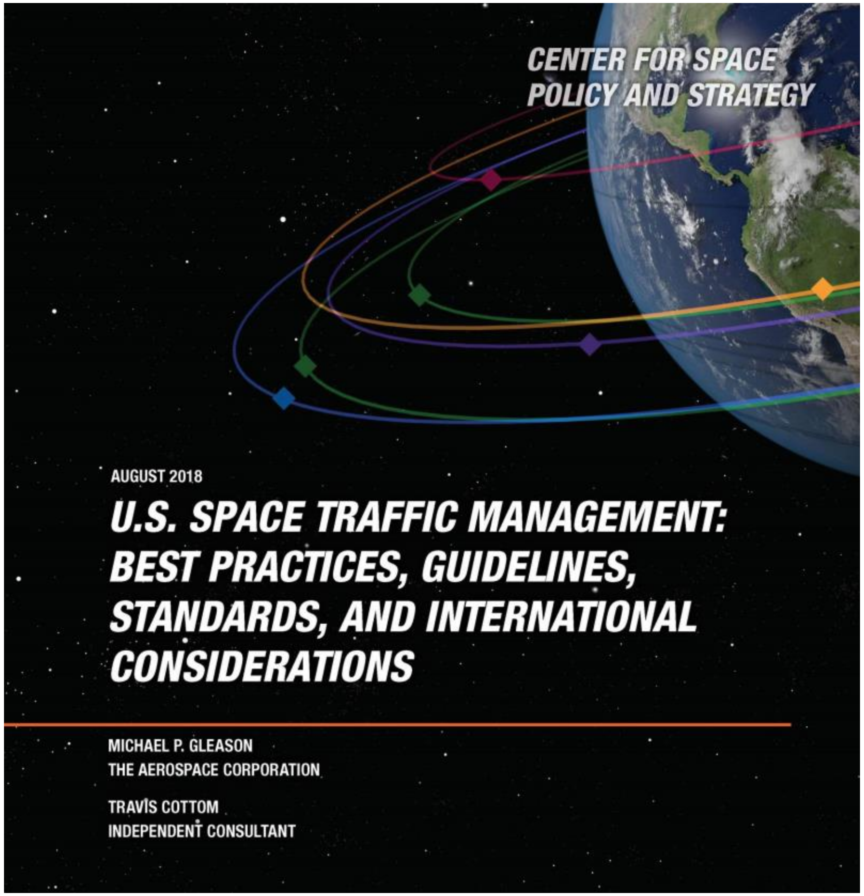
today

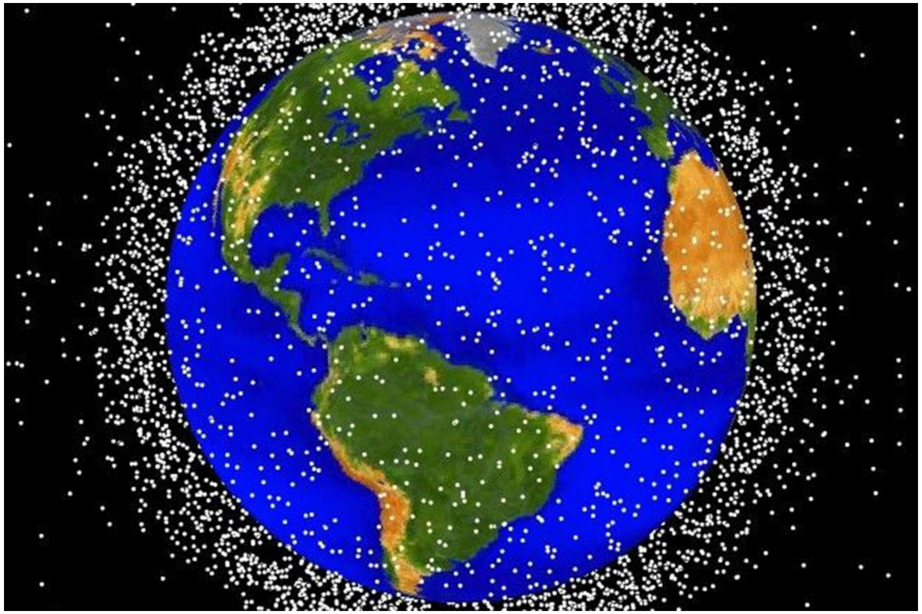
https://www.youtube.com/watch?v=8YRbMMqj0qw

***Traffic norms and rules move vehicles faster from A to B with less interference.***

# Space Traffic Management: today

## STM today is monitoring with some coordination



*Courtesy: NASA*

***Space traffic could double and triple in the near future.***

# *Why Space Traffic Management*

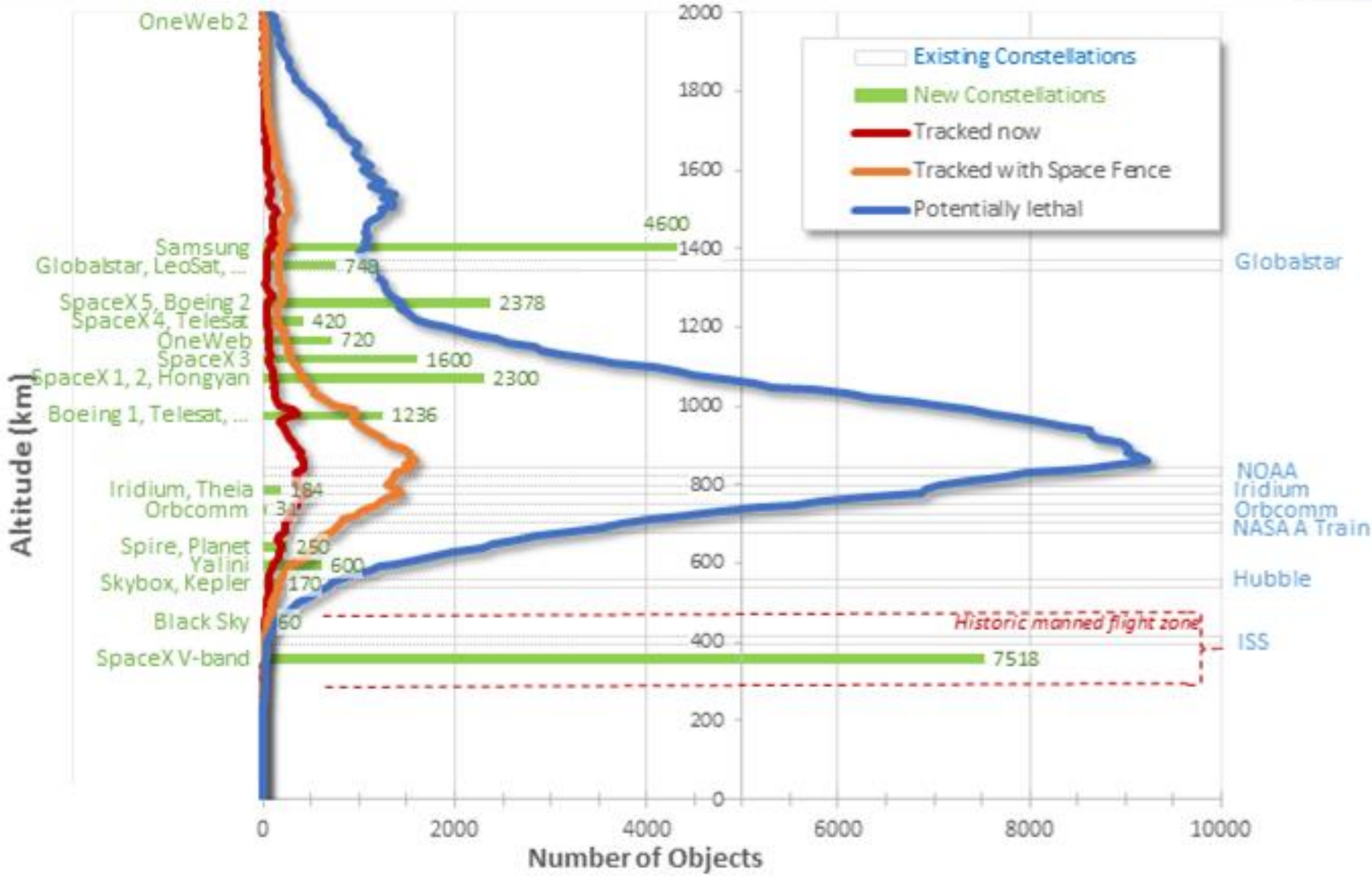
- Currently, U.S. DoD is tracking over 20,000 objects
- Estimated nearly 500k additional un-trackable objects
- Active Satellites (taken from space-track.org on 1/11/2019)

| Country (top 3) | Payloads | Total |
|---|---|---|
| USA | 1640, 33% | 6379 |
| Russia | 1521, 31% | 6606 |
| China | 333, 7% | 4041 |
| **TOTAL (all nations)** | **4910** | **19432** |

- <u>Proposed</u> large constellations (not all may get to full implementation):

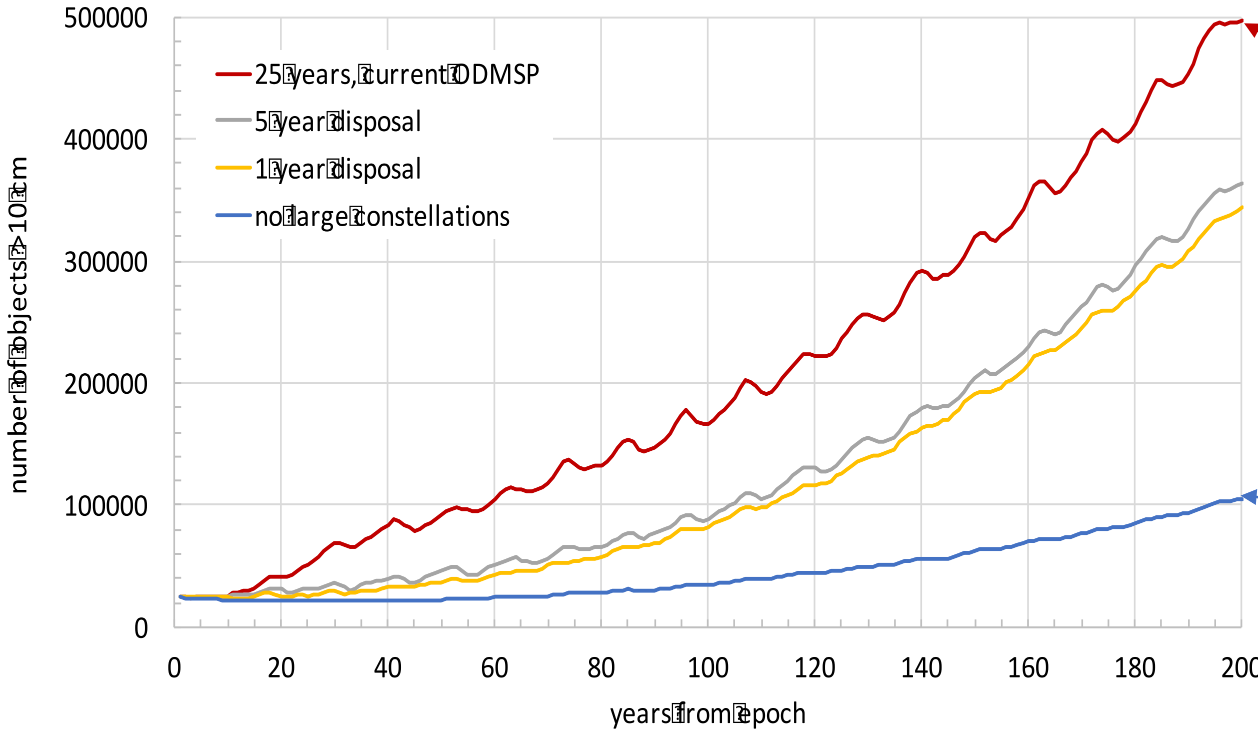
| Constellation | Total Satellites | Orbit Altitude (km) |
|---|---|---|
| SpaceX K-band | 4425 | 1100-1300 |
| OneWeb | 720 | 1200 |
| LeoSat | 120 | 1400 |
| Theia | 112 | 800 |
| Telestar | 117 | 1000-1200 |
| Boeing | 2956 | 900-1000 |
| SpaceX V-band | 7518 | 340 |
| **TOTAL** | **15968** | |

# *Combined Impact to Current Missions*



# *Growth in LEO debris environment due to collisions*

- Plots show the growth in LEO debris relative to current population for various large constellations disposal scenarios (25-year current ODMSP, 5-year, 1-year)
- Current rules/infrastructure will not be sufficient for New Space activity
- Simulation results are worst-case scenarios assuming no collision avoidance maneuvers




At 200 years, expect ~25x current number of tracked objects with large constellations if ODMSP 25-year rule followed at 90% disposal success rate

At 200 years, expect ~5x current number of tracked objects if no large constellations are present (i.e., business-as-usual)

*Values averaged over 100 Monte Carlo runs*

# *General Approaches to Space Traffic Management*

Guidelines, Standards, Rules

- Bottom-Up Approach
  - *Operator developed standards that are broadly followed, implemented as government regulation, and promulgated internationally*
  - *Examples:*
    - Orbital Debris Mitigation Guidelines
      - *Evolution from NASA standard to U.S. Governmental Standard, U.S. Regulation, IADC, UN*
    - CONFERS (Consortium for Execution of Rendezvous and Servicing Operations)
      - *Developing standards for on-orbit satellite servicing based on industry consensus*

- Top-Down Approach
  - *Developed guidelines, rules, regulation at a high-level and apply them in a regulatory framework*
  - *Examples:*
    - UN COPUOS Long-Term Sustainability of Outer Space Activities (2018)
    - IAA Cosmic Study on STM (2006, 2017)
    - Draft International Code of Conduct for Outer Space Activities (2013)
    - UN Group of Government Experts on Space Transparency and Confidence Building Measures (2013)

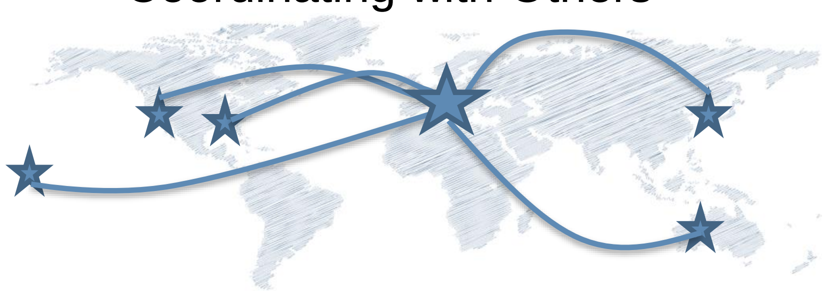
***Both approaches have benefits and risks.***

# *Notional Concepts of coordinating and centralized SSA and STM centers*

One Center

One U.S. Center Coordinating with Others

One International Center Coordinating with Others



A Web of Cooperating National Centers

***Each concept comes with a set of different problems and advantages.***

# Potential STM Functional Capabilities

## *Military, Civil, Commercial, International, Regional*

- Space Catalog Maintenance
  - *Maintain the database of resident space object positional information is foundational to SSA and STM functions*
- Space Launch Deconfliction
  - *The Process of screening for potential collisions between a launch vehicle and known, tracked on-orbit objects from liftoff through the end of the launch phase*
- On-Orbit Conjunction Assessment (CA)
  - *Predict close approaches*
- On-Orbit Collision Avoidance
  - *Maneuver planning*
- Deorbit/Reentry Support
  - *The process of predicting the point of atmospheric reentry and the terrestrial impact*
- Disposal/End-of-Life Support
  - *Advise on disposal orbits, CA support to maneuvers*
- Satellite Anomaly Resolution
  - *Detect, track and identify health/status, electromagnetic interference deconfliction support*
- Integration of Air and Space
  - *Support suborbital reusable vehicles*
- Regulatory authority
- Space Law and Policy
- Insurance and Indemnification
- Operation of a Web-Based Customer Portal
  - *Unclassified database for space users (e.g., Space-Track)*

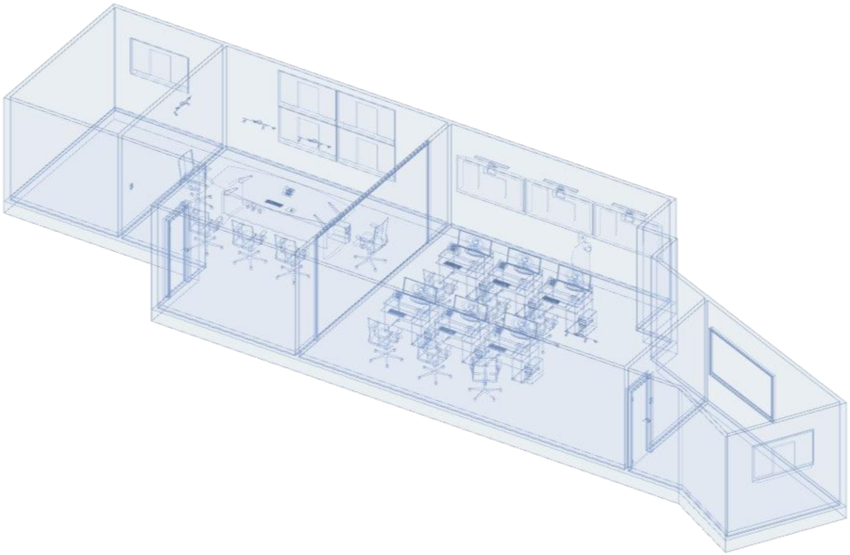
***Some functions are easier in a centralized system, some need national frameworks.***

# *The Aerospace Corporation's Space Analysis and Collaboration Center (SACC)*

- Aerospace developed a unique exploratory environment to collaborate, innovate and experiment with new Space Situational Awareness tools, processes and data sources in an operational setting.

- The Space Analysis and Collaboration Center (SACC) enables government, industry, and international partners to solve complex problems and to develop new capabilities.

- Aerospace can support the testing, validation and verification of sensors, algorithms and models in a sandbox environment.



# Thank you