



*Promoting Cooperative Solutions for Space Sustainability*

# Trends and Developments in Commercial Space Situational Awareness

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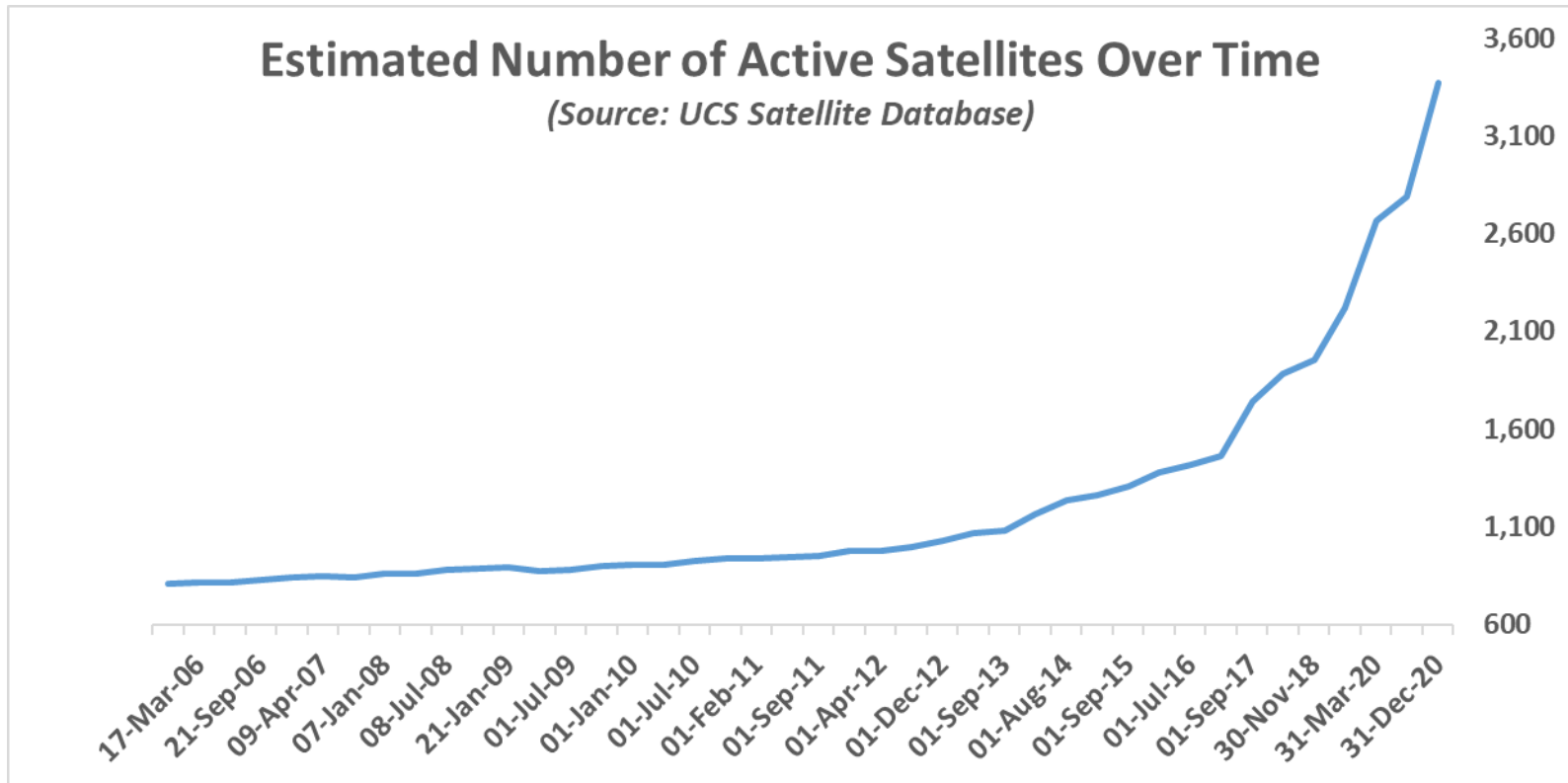


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# I. – TRENDS IN COMMERCIAL SPACE

Increasing needs for SSA and STM

# A Fundamental Change



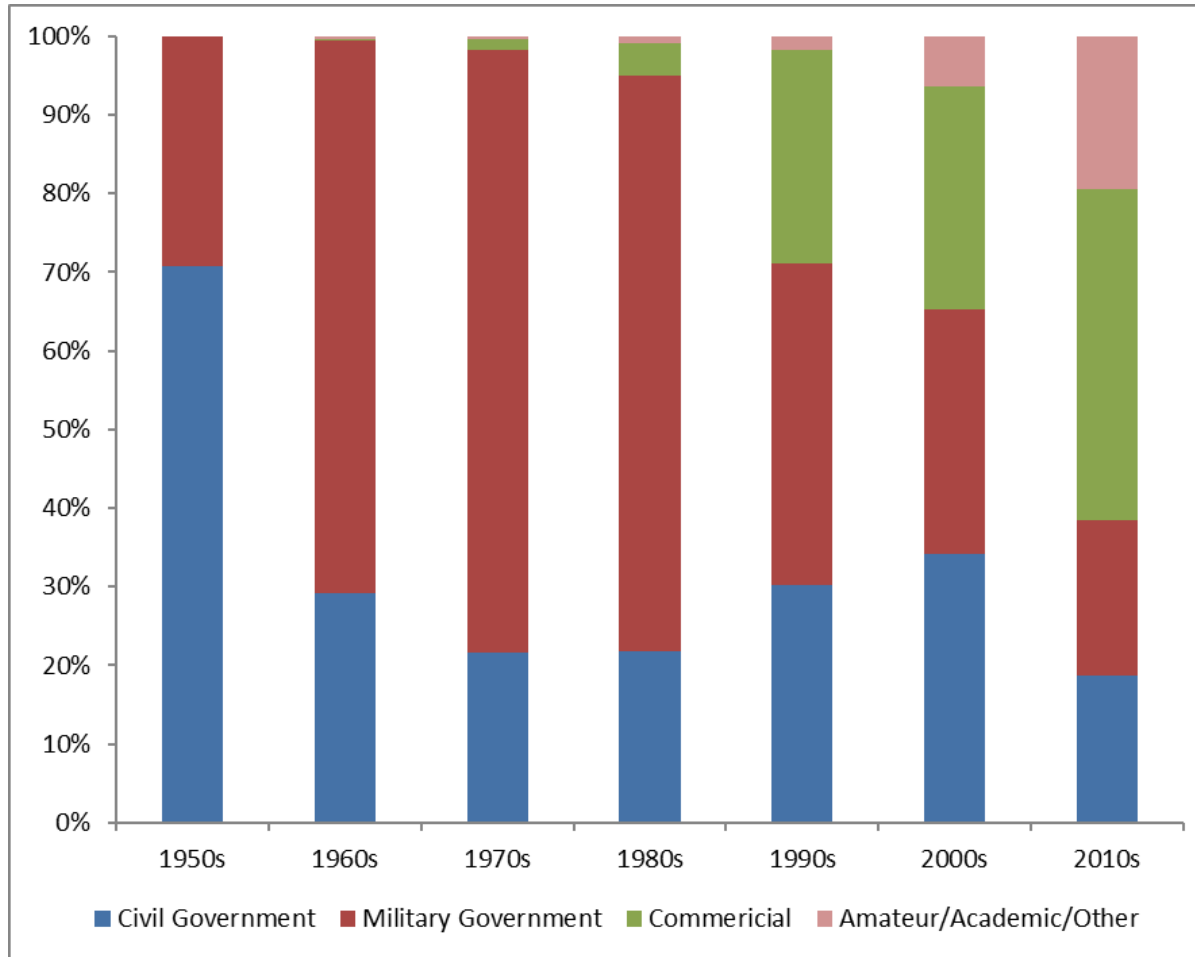
Operating satellites as of Dec. 31, 2020: 3,372

March 1-30, 2021: 349 objects launched over a period of 30 days

Mega-constellations: Tens of thousands of announced satellites

# A Private Sector Driven Domain?

## Share of Satellites Launched per Decade, by Operator Type



Source: McDowell, Jonathan C, 2021—Satellite Statistics <https://www.planet4589.org/space/stats/out/dcateg.out>



➤ ~1,311 satellites in orbit as of March 29, 2021



➤ ~146 satellites in orbit as of March 29, 2021



➤ ~335 satellites in orbit as of March 29, 2021

# Trend: Rideshare Launch

- SSO-A SmallSat Express: Launched Dec 3, 2018 aboard a SpaceX Falcon-9 carrying 64 spacecraft from 34 different organizations
- SpaceX Transporter-1: Launched January, 24, 2021 aboard a SpaceX Falcon-9 carrying 143 spacecraft; including a free-flying CubeSat deployer – which itself deployed 20 CubeSats

2018



Audacity @Audacity · Dec 7

More than ever, real-time connectivity is now necessary. Imagine searching for a tiny CubeSat among this flock of 64 satellites from the #SSOA flight. We have 8 min each time it passes, 4 times a day with our ground station. Our search continues



2021



T.S. Kelso @TSKelso · Mar 26

SOCRATES is showing 456 conjunctions in the coming week with the presumably dead COSMOS 1703 & cubesats from the recent Transporter-1 launch (2021-006): [celestrak.com/SOCRATES/search...](https://celestrak.com/SOCRATES/search...) Yet one more reason not to leave stuff in orbit past end of mission.



**SOCRATES**  
Search Results

Search parameters:

- Name(s): COSMOS 1703
- Order by Minimum Range
- Return first 1000 items

Data current as of 2021 Mar 26 08:06 UTC

Computation Interval: Start = 2021 Mar 26 00:00:00.000, Stop = 2021 Apr 02 00:00:00.000  
Computation Threshold: 5.0 km  
Considering: 6,648 Primaries, 20,431 Secondaries (47,988 Conjunctions)

See notes at bottom of page for data field descriptions  
Re-sort results by Maximum Probability, Time In.

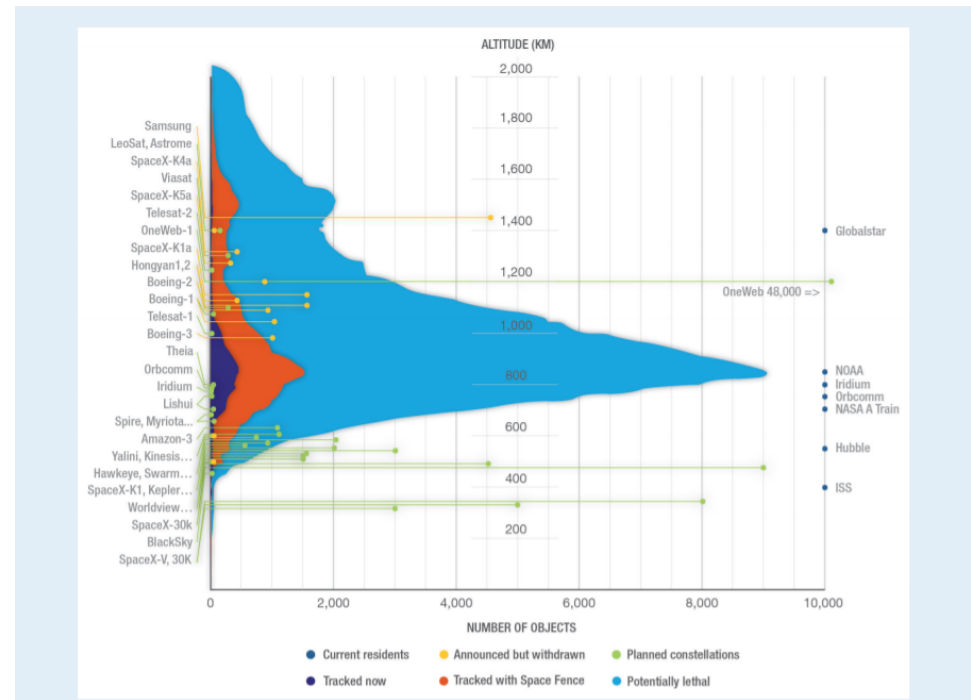
Action	NORAD Catalog Number	Name	Days Since Epoch	Max Probability	Dilution Threshold (km)	Min Range (km)	Relative Velocity (km/sec)
				Start (UTC)	TCA (UTC)	Stop (UTC)	
	16262	COSMOS 1703 [?]	4.269	1.560E-05	0.217	0.307	.....

**Identification of payloads poses challenges to both operators & commercial and governmental SSA systems. Improvements in info-sharing and tracking capabilities required.**

# Trend: Very Large Constellations ("MegaConstellations")

- Satellite reliability and end-of-life passivation commitments
- Adequacy of space debris guidelines
- Spectrum management & coordination
- Information sharing and transparency
- Satellite check-out practices
- Inter-operator coordination practices and data-sharing
- Satellite tracking, orbital position sharing, and maneuver notification/coordination
- Best practices for satellite end of life operations, beyond the de-orbit guidelines

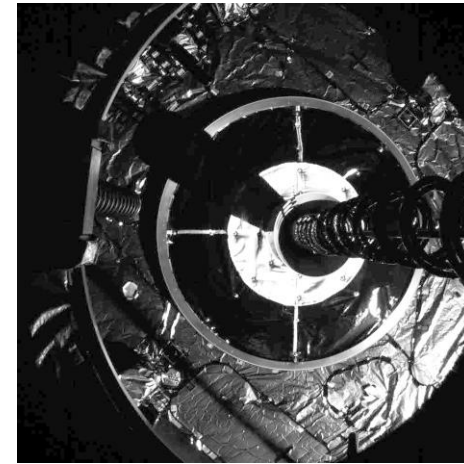
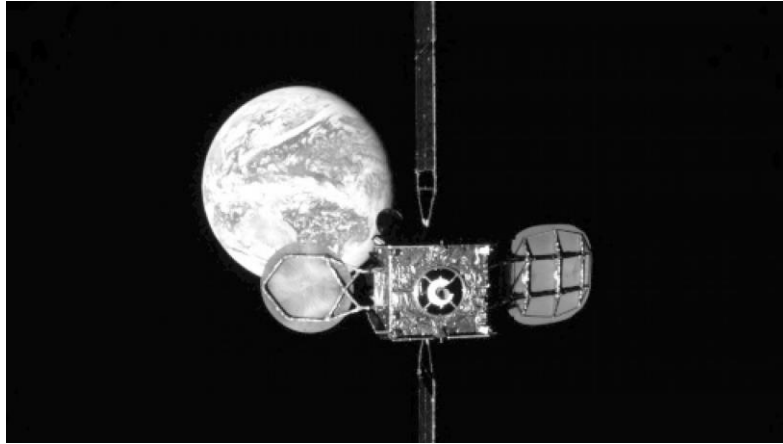
## Announced Megaconstellations Overlaid with Space Objects Environment



Source: Marlon E. Sorge, William H. Ailor, and Ted J. Muelhaupt, "Space Traffic Management: The Challenge Of Large Constellations, Orbital Debris, And The Rapid Changes In Space Operations." The Aerospace Corporation. [https://aerospace.org/sites/default/files/2020-09/Sorge\\_STM\\_20200915.pdf](https://aerospace.org/sites/default/files/2020-09/Sorge_STM_20200915.pdf)

How can operators work with government(s) to ensure safety of operations for all users of the space environment?

# Trend: On-Orbit Servicing (OOS) and Rendezvous and Proximity Operations (RPO)



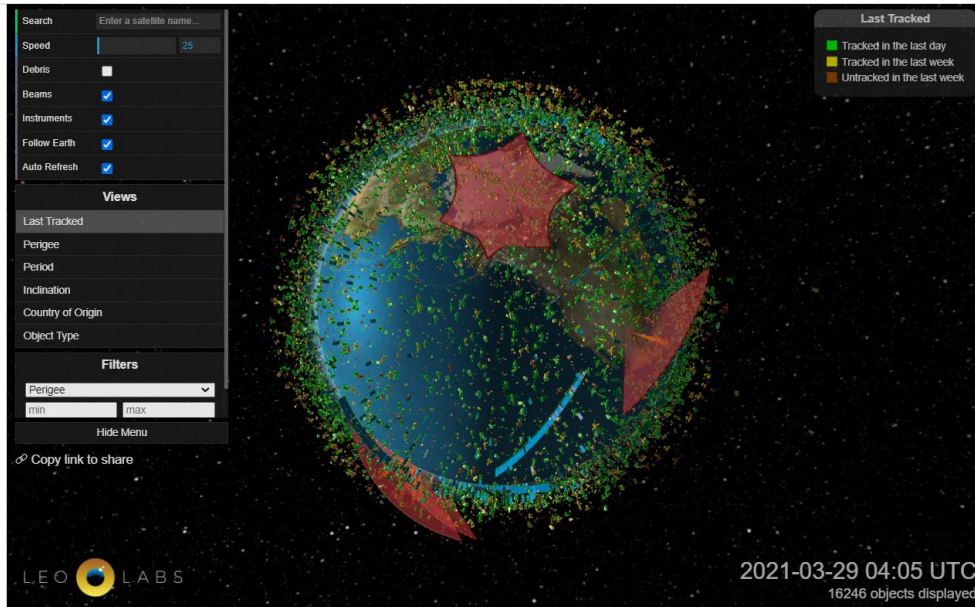
- On-orbit servicing (OOS) and Rendezvous and Proximity Operations (RPO) are key to enabling future of on-orbit activities
- Raises a number of diplomatic, legal, safety, operational, and policy challenges that need to be tackled
- As OOS/RPO activities develop need to think about role of improved space situational awareness (SSA) info and resources as a key enabling factor
- The role of SSA in OOS includes:
  - Key information to inform and enable operations
  - Monitoring OOS operations to ensure safety and transparency
  - Providing confidence in OOS activities and outcomes

## **II. – COMMERCIAL SPACE SITUATIONAL AWARENESS**

Commercial capabilities to contribute to SSA data and services

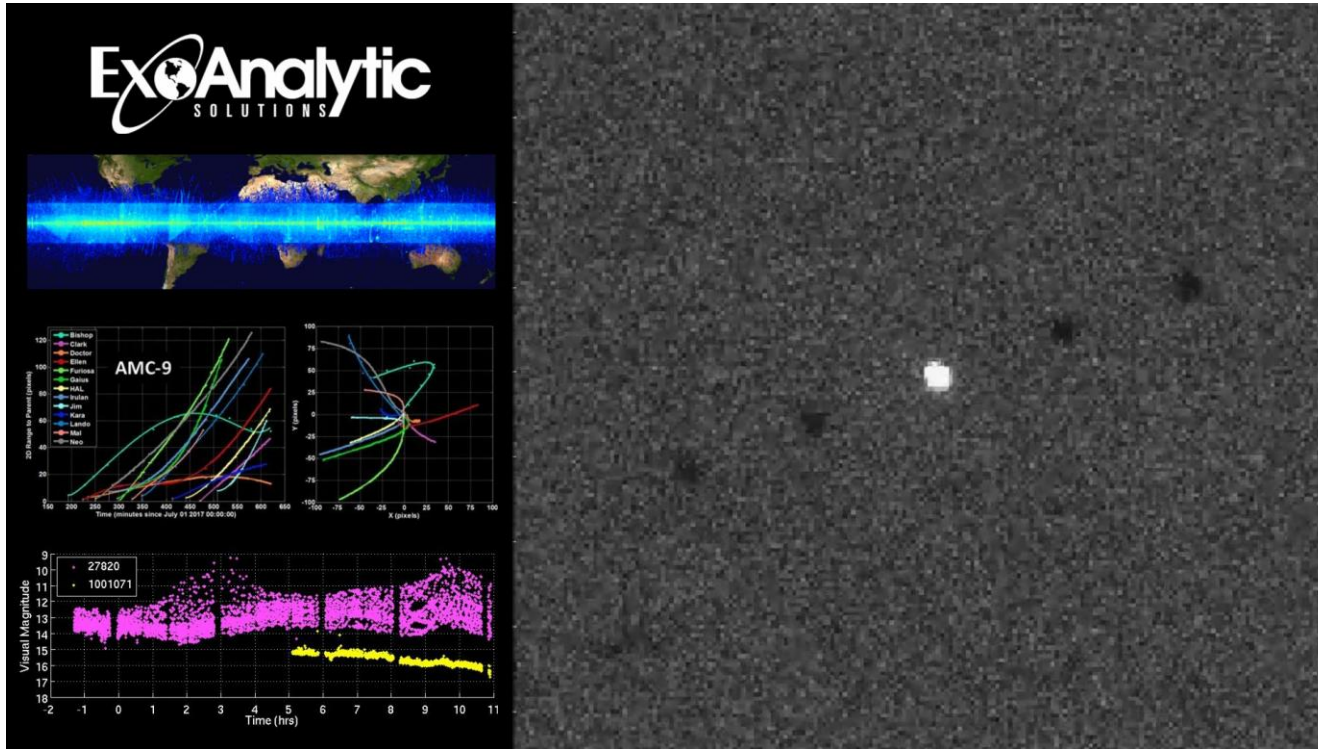


- Private sector is developing capabilities across the full spectrum of SSA operations
  - Raw data (ground and space-based, multi-phenomenology)
  - Data fusion
  - Analytics
  - Decision-making tools
- Currently have as good (or better) GEO catalog as the US military, likely to have as good (or better) LEO catalog within 5 years
- Commercial satellite operators are contracting with commercial SSA providers for operational SSA needs, as supplement to government catalogs



Name	KOMPSAT 5
Catalog Number	L225
NORAD ID	39227
Object Type	Payload
Perigee	551 km
Apogee	555 km
Inclination	98°
Period	96 min
RCS	2.44 m <sup>2</sup>
Operator	
Country of Origin	South Korea
Revisit Rate	4.77 passes/day
Site Visibility	KSR, MSR, PFISR

- Ground-based phased array radars for tracking LEO space objects
- Currently operating radars in Alaska, Texas, and New Zealand, with plans to build additional systems (4<sup>th</sup> announced for Costa Rica)
  - Tracking over 18,000 objects
  - <https://platform.leolabs.space/visualization>
- Variety of data and analytical services for operators & governments



AMC-9 Anomaly

- More than 30 observatories and 300 telescopes deployed worldwide
- Tracking nearly all objects >10 cm in GEO, can also do photometrics and persistence

# Additional Companies



**L3HARRIS™**

- Contracts for operational and sustainment support for U.S. Air Force / Space Force SSA capabilities



- GEO/MEO focused telescope network
- Additional tracking, catalog, and operations services for operators



**ComSpOC®**

- AGI acquired by Ansys in Dec. 2020; COMSPOC spun-out as separate company
- Commercial Space Operations Center (ComSpOC)
- Fuses data from multiple commercial sensors
- CelesTrak public catalog tracks ~22,700 objects (payloads & debris) on orbit
- Planned updates to SDA Data Center will utilize ComSpOC

## **III. – COMMERCIAL SPACE & SSA: COOPERATION AND POLICY QUESTIONS**

How commercial and governmental SSA considerations interact

# Example of Civil / Commercial Cooperation

- January 2021: NASA and SpaceX enter into a [special information sharing agreement](#) to avoid conjunctions between NASA and Starlink spacecraft
- “increased interaction and partnership between NASA and SpaceX is needed to ensure continued safe on-orbit operations and avoidance of conjunctions between agencies satellites and human missions”
- First of its kind agreement; no-cost, under NASA Space Act authority
- NASA agrees to enhance information sharing of ephemeris and maneuvers both through the 18<sup>th</sup> SPCS and direct with SpaceX
- SpaceX agrees to enhance information sharing of ephemeris and maneuvers both through the 18<sup>th</sup> SPCS and direct with NASA
- NASA agrees NOT to maneuver in event of conjunction; SpaceX agrees TO maneuver. *Does this establish right of way for NASA?*
- Various other technical and info sharing collaboration

# Space Data Association (SDA)

- Improving Our Vision (2006-2010)
  - Set of conferences and workshops to discuss SSA and relationship between US military and satellite operators
  - Growing frustration by satellite operators over lack of “customer service” from the US military
- SDA formally created in 2009
  - Intelsat, SES, Inmarsat, and Eutelsat as founding members
  - “Added value” conjunction screenings for members
  - Radio Frequency Interference (RFI) geolocation
- SDA 2.0 announced in 2017
  - Using commercial SSA data to feed their own catalog
  - Moving towards being completely independent from US military data and services

# Commercial Guidelines and Best Practice



## “Best Practices for the Sustainability of Space Operations”

Date: 16 September 2019

1. **Spacecraft owners, operators and stakeholders should exchange information relevant to safety-of-flight and collision avoidance.**
  - a. Such information should include, at a minimum, operator points-of-contact, ephemerides, ability to maneuver, and maneuver plans.
  - b. Typical interfaces include direct operator-to-operator coordination and use of Space Situational Awareness and/or Space Traffic Management entities.
  
5. **Spacecraft operators should adopt space operations concepts that enhance sustainability of the space environment.**
  - a. Operators of spacecraft in orbits with apogee altitude above 400 km should conduct active collision avoidance to reduce the probability of collision per conjunction to less than 0.0001, so long as it remains possible for the spacecraft to do so (i.e., until the spacecraft fails or has been passivated).
  - b. Collision avoidance maneuvers should be coordinated with the other spacecraft operator(s) and implemented as applicable.

- Voluntary guidelines endorsed by 48 non-governmental space actors and companies, calling for improved practices to enhance space sustainability
- Several recommendations related to SSA information sharing

[https://spacesafety.org/wp-content/uploads/2020/12/Endorsement-of-Best-Practices-for-Sustainability\\_v39.pdf](https://spacesafety.org/wp-content/uploads/2020/12/Endorsement-of-Best-Practices-for-Sustainability_v39.pdf)



# Big Policy Questions

- Should the government continue to develop its own SSA capabilities or purchase commercial services?
  - How should commercial SSA data be integrated with government data?
  - Where do we want the commercial innovation to occur?
- How do government and commercial operators interface?
  - What responsibilities do operators have to maintain their own SSA data vs. reliance upon government data?
  - What mechanisms exist for ensuring that the growing number of private sector operators are aware of, and know how to interface, with governmental SSA data sources and services?
  - How do operators share data?
- How to incent continued creation of public goods?
  - Open access to SSA data for scientific research
  - Public access to data for transparency
  - Open algorithms and standards



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# Thank you. Questions?

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