Standards considerations for a space domain where humans will travel to, live in, and work

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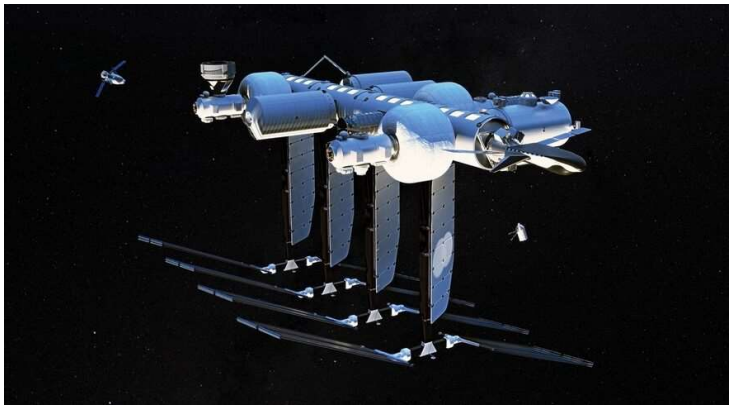
Human spaceflight transitioning from State Actor-led to commercial

- Once exclusively government-led… Now open to commercial/private operators.
- Many commercial companies developing human suborbital and space station systems
  - SpaceX – Operational to ISS (2021)
  - Blue Origin – Suborbital operations (2021)
  - Virgin Galactic – Suborbital operations (2021)
  - Axiom Space – ISS module (2024), then standalone station
  - Nanoracks/Lockheed/Voyager/Boeing/Redwire – Starlab (by 2028)
  - Blue Origin/Sierra Space/MHI – Orbital reef (beginning 2027)
  - Orion Span – Aurora Station planned
  - Northrop Grumman – By 2029
  - Space Transportation Beijing – Suborbital (2025), Hypersonic transport (~2030)*

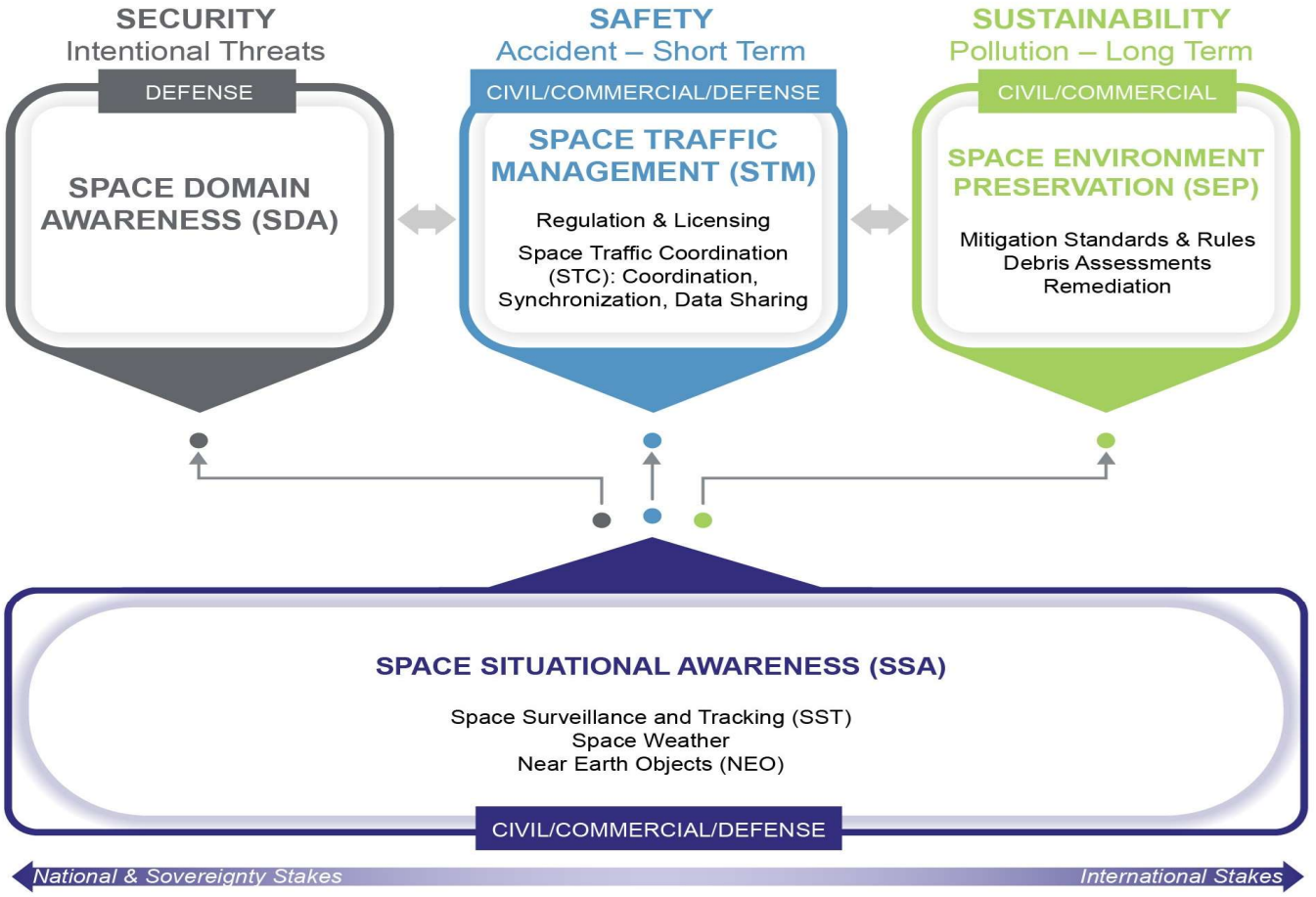


Orbital Reef (SpaceNews)

- Happening coincident with deployment of large constellations!

http://www.parabolicarc.com/2022/07/13/suborbital-spaceflight-numbers/
https://spacenews.com/nasa-companies-reject-concerns-over-commercial-space-station-development-schedules/

Human spaceflight must transcend terminology “boundaries”



Types of standards

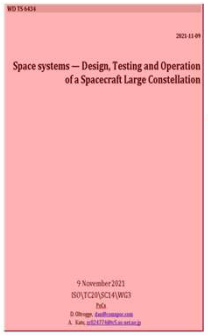
Best Practices

Space data exchange

Normative

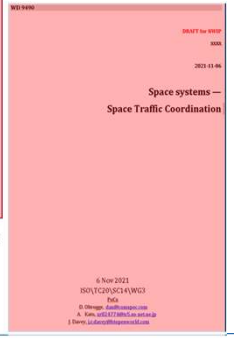
UNITED NATIONS
Committee on the Peaceful Uses of Outer Space

ISO



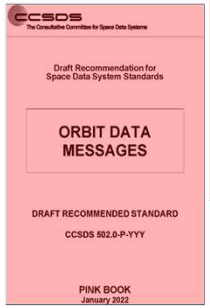
Large Constellations

Space Traffic Coord.



Consultative Committee for Space Data Systems

ODM: standardized way to share orbits



CDM: standardized way to share transits

ADM: standardized way to share attitude

Aspirational

SSC SPACE SAFETY COALITION

CONFERS

SIA SATELLITE INDUSTRY ASSOCIATION
The Voice of the Satellite Industry

COMMERCIAL SPACEFLIGHT FEDERATION

AIA AEROSPACE INDUSTRIES ASSOCIATION

SECURE WORLD FOUNDATION

AIAA
SHAPING THE FUTURE OF AEROSPACE

SPACE DATA ASSOCIATION

CELESTRAK SINCE 1985

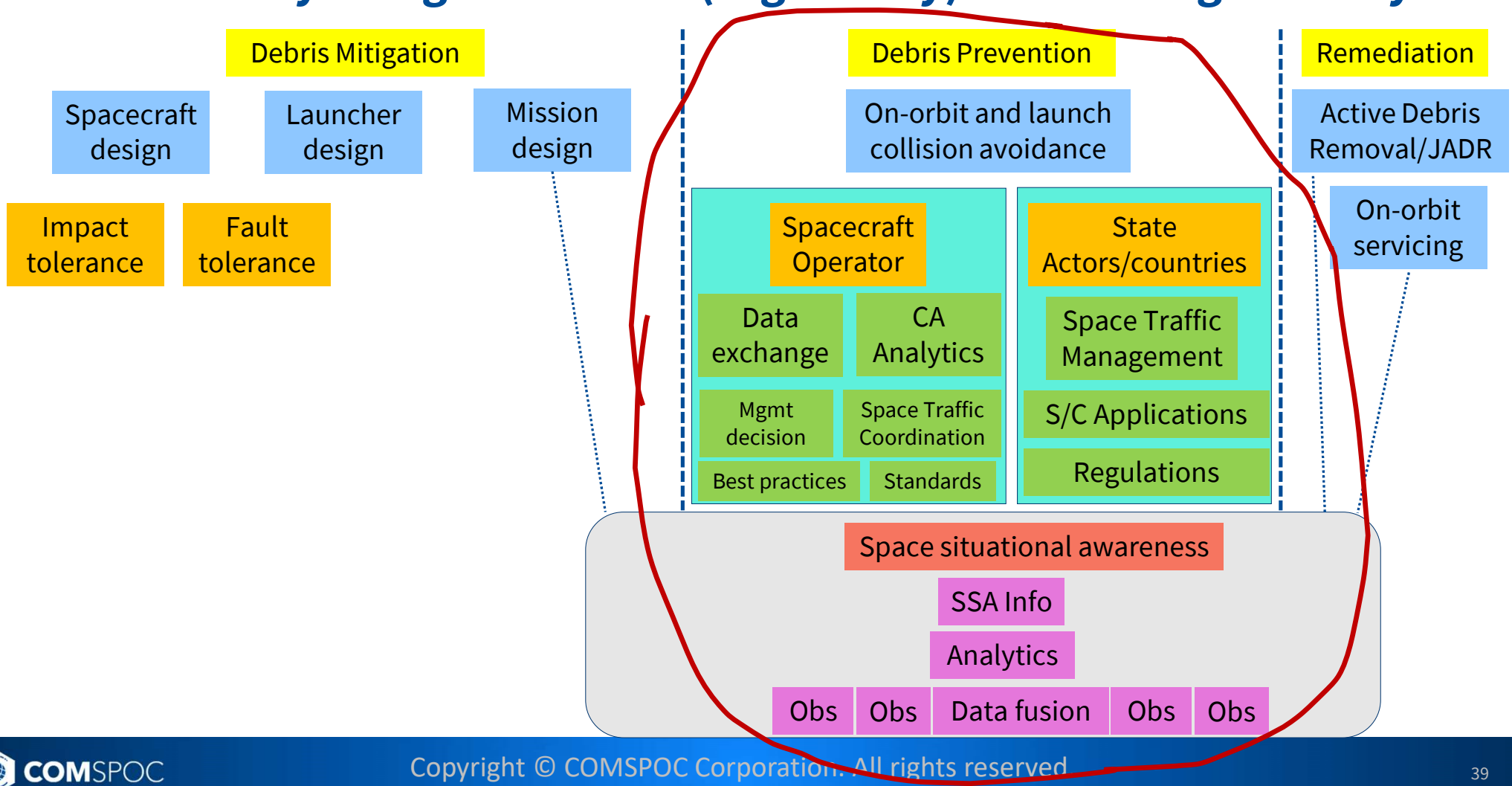
CSSI

U.S. regs for commercial human spaceflight

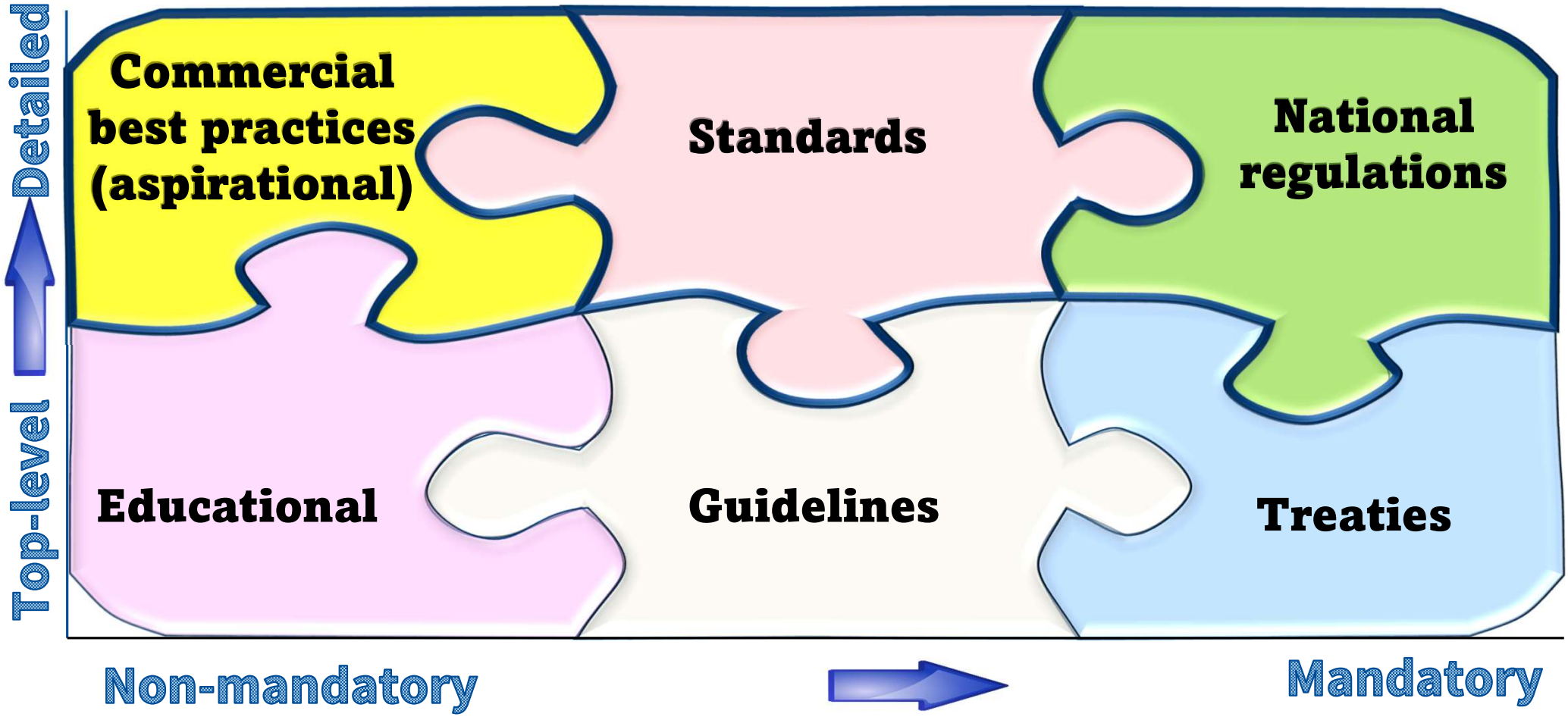
- *Space Tourism: Risks and Solutions* Workshop Feb 2013
  - Lloyd's Building of London
  - Commercial human spaceflight insurance seen as cost-prohibitive
- Regulatory as of 17 May 2022*:
  - ***FAA does not certify launch or reentry vehicles as safe for carrying humans***; only that they perform as intended.
  - ***Federal law requires informed consent framework***, so flight crew and spaceflight participants are fully aware of human spaceflight launch and reentry operations risks and hazards.
  - FAA largely prohibited from regulating health and safety of commercial human spaceflight occupants.
  - Legislative "moratorium", established in 2004 and extended three times by Congress, expires Oct 2023.

* https://www.faa.gov/space/human_spaceflight

Mix of industry and government (regulatory) address flight safety:



Key space governance mechanisms for human spaceflight



Data exchange standards

ISO air and space standards developed in TC20

- ISO has 245 technical committees
  - 100 000+ subject matter experts
  - 22 000 international standards
    - Languages: English, French, Russian
- ISO/TC 20 develops and maintains standards for aircraft and space vehicles, including:
  - materials, components and equipment for construction and operation of aircraft and space vehicles
  - equipment used in the servicing and maintenance of these vehicles
  - Over 600 published standards
  - Over 200 in development

ISO TC 20/SC 1 Aerospace electrical requirements
ISO TC 20/SC 4 Aerospace fastener systems
ISO TC 20/SC 6 Standard atmosphere
ISO TC 20/SC 8 Aerospace terminology
ISO TC 20/SC 9 Air cargo and ground equipment
ISO TC 20/SC 10 Aerospace fluid systems and components
ISO TC 20/SC 13 Space data and information transfer systems
ISO TC 20/SC 14 Space systems and operations
ISO TC 20/SC 15 Airframe bearings
ISO TC 20/SC 16 Unmanned Aircraft Systems
ISO TC 20/SC 17 Airport Infrastructure

SC13 develops international space data standards

- SC13 is operated by the Consultative Committee for Space Data Systems (CCSDS)
  - Comprised of 11 space agencies
  - Standards available through ISO and also at: https://public.ccsds.org/default.aspx
- CCSDS navigation data exchange messages:
  - Orbit Data Message (ODM)
  - Conjunction Data Message (CDM)
  - Tracking Data Message (TDM)
  - Attitude Data Message (ADM)
  - Events Data Message (EDM)
  - Reentry Data Message (RDM)

The ODM is the most popular Navigation WG standard today

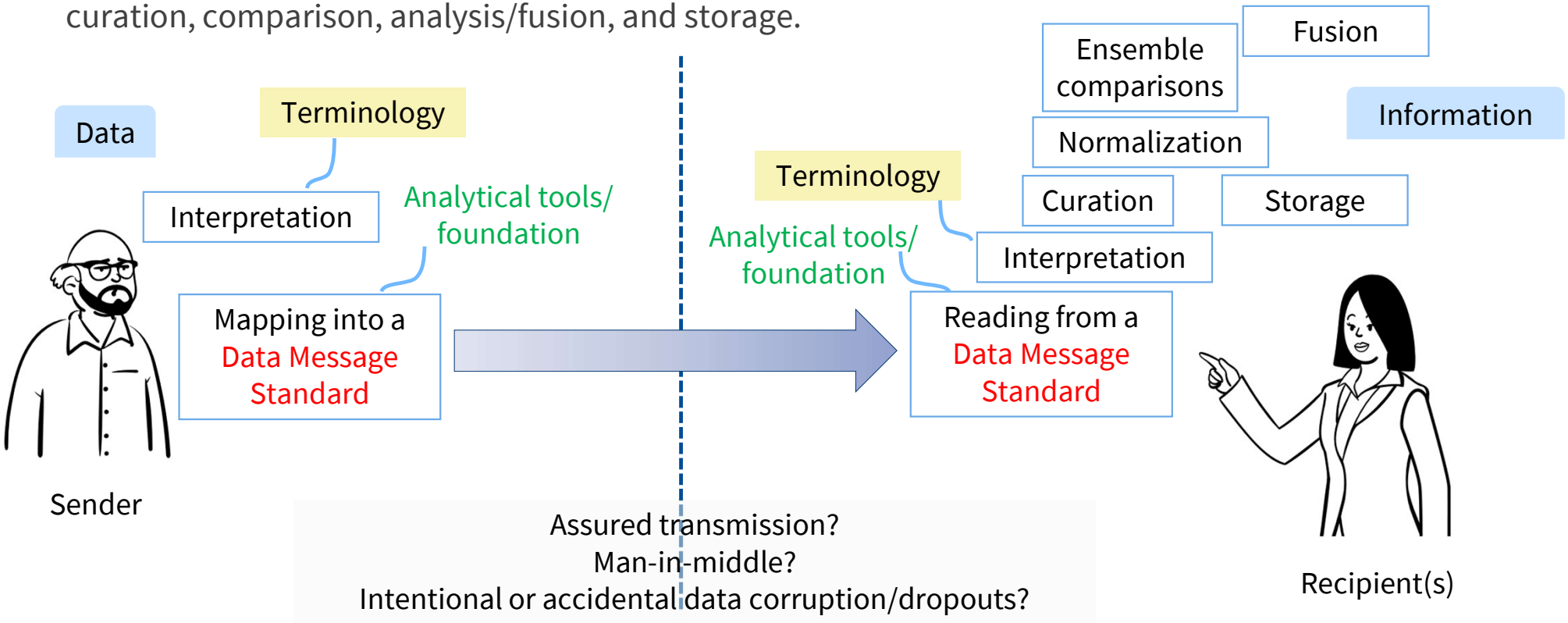
CCSDS standards relevant to space data sharing and STCM

Table 1 STC-relevant data conveyance needs and standards

	Existing CCSDS messages and related standards										
	Attitude Data Message	Conjunction Data Message	Digital Motion Imagery	Events Message*	Orbit Data Message	Pointing Request Message	Radio Freq & Mod. Systems	Re-entry Data Message	Space Data Link Security Stds	Time Code Formats	Tracking Data Message
Attitude	•				•	•				•	
Conjunctions	•	•			•					•	
Maneuvers					•					•	
Orbit & errors					•					•	
"Phonebook"					•						
Reentry								•			
RF, RFI, Geoloc							•				
RPO/OOS			•		•		•		•		•
Space catalog					•	•				•	•
Space events	•	•		•	•			•		•	•
S/C chars, SoH					•					•	
Sensor trk, obs						•				•	•
STC system									•		

CCSDS standards for data integrity (data security + data quality)

- Ensuring data integrity <u>between and within</u> space systems includes:
  - Data creation, data interpretation, exportation, transmittal, ingestion, interpretation, normalization, curation, comparison, analysis/fusion, and storage.



Best practice standards

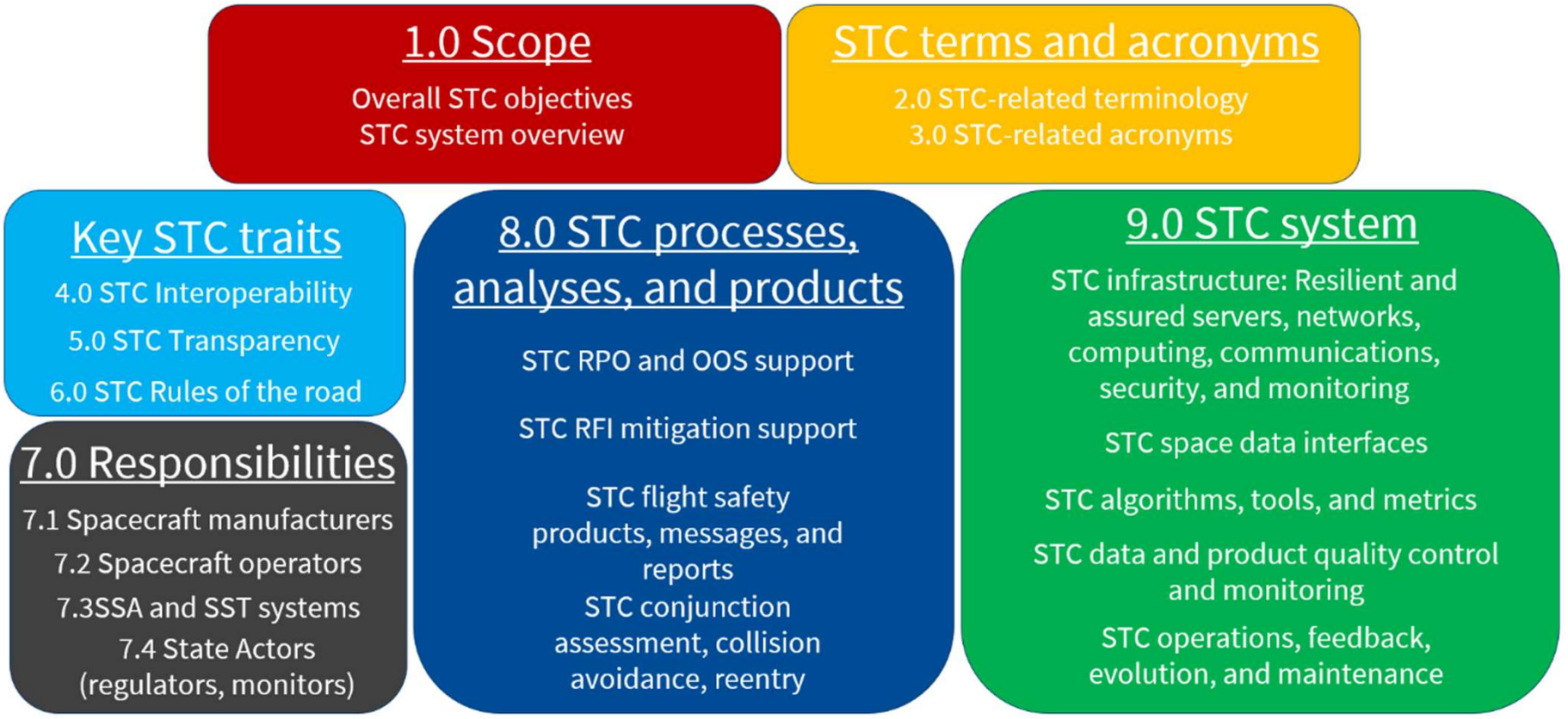
SC14 develops standards for space systems and operations

- Subcommittee 14 of TC20: ***Space Systems & Operations***

Working Group		Convener
WG 1	Design, engineering and production	Japan
WG 2	Interfaces, integration and test	United States
WG 3	Operations and ground support	Germany
WG 4	Space environment (natural and artificial)	Russia
WG 5	Space system programme management and quality	France
WG 6	Materials and processes	Japan
WG 7	Orbital debris	United Kingdom
WG 8	Downstream Space Services and Space-Based Applic.	France
WG 9 (?)	Human Flight Safety (?)	<Russian proposal>

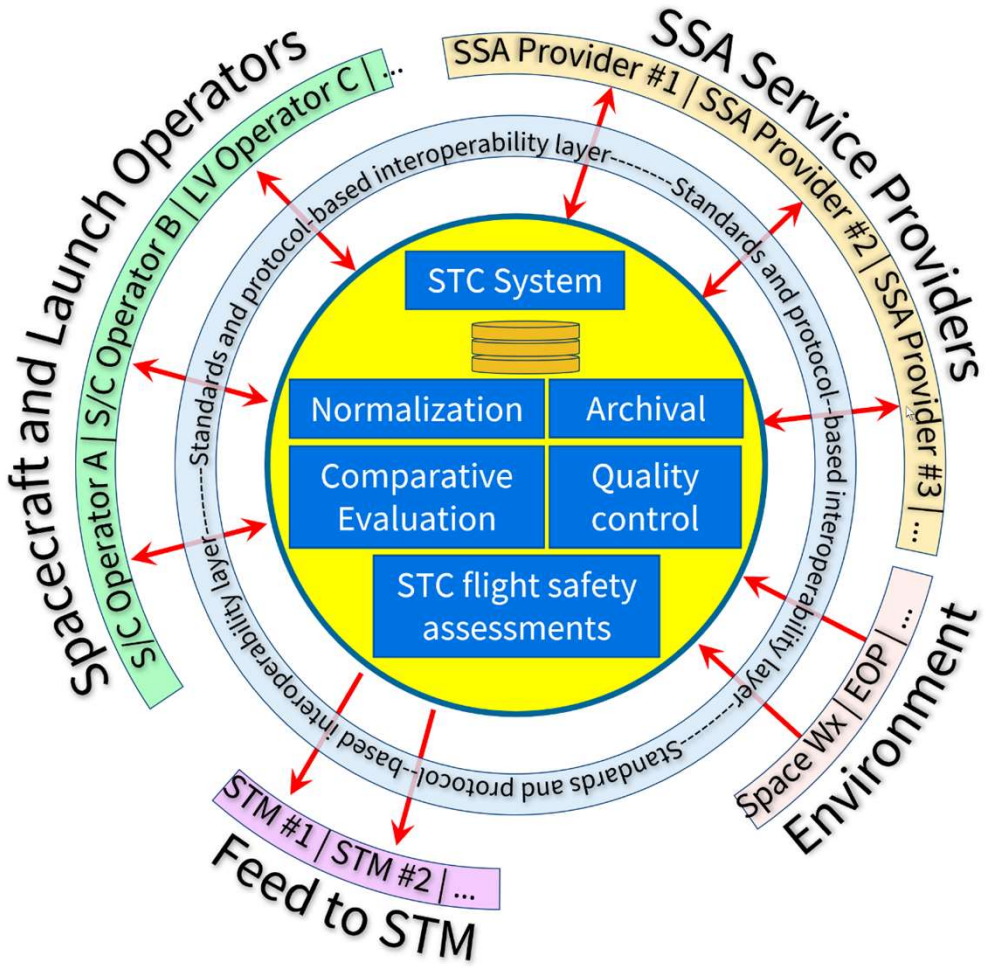
Space Traffic Coordination standard relevant to human flight too!

ACTIVE WORK ITEM



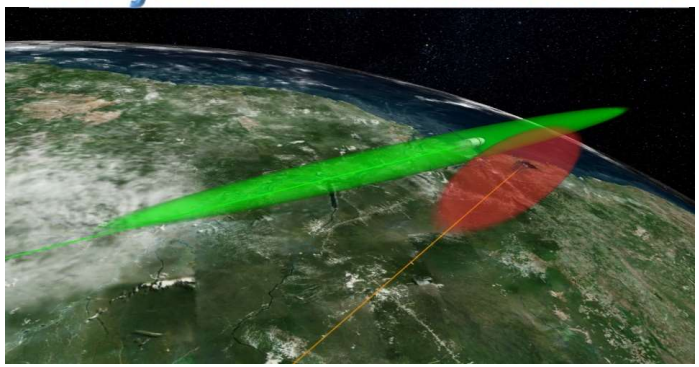
ACTIVE WORK ITEM

Basic framework for Space Traffic Coordination and Management



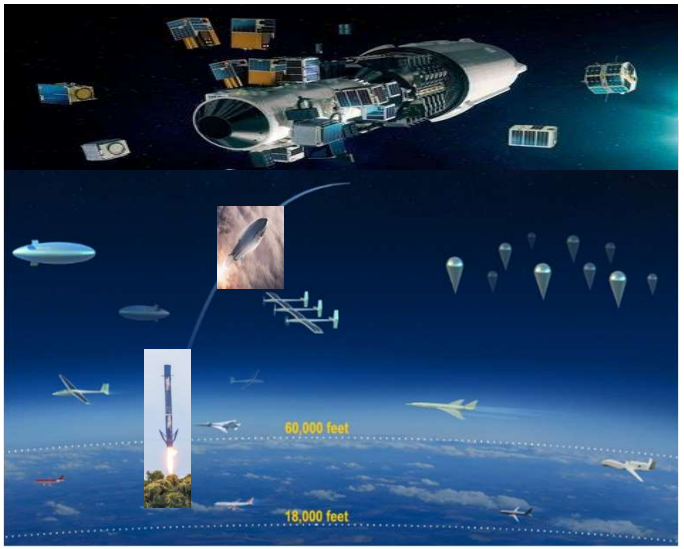
Human spaceflight analysis components - - - - - - spanning all domains

Conjunction assessment

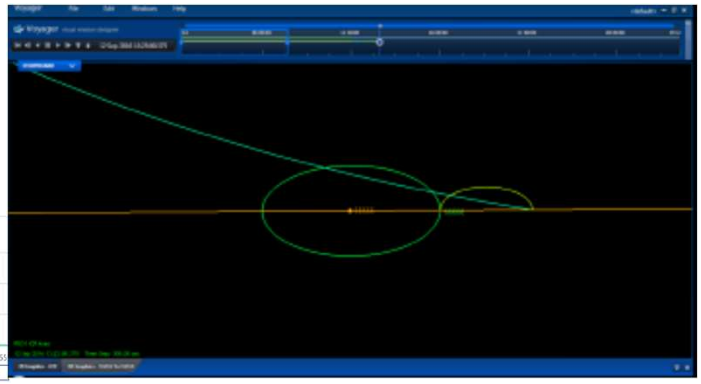


Orbit and Maneuver Determination

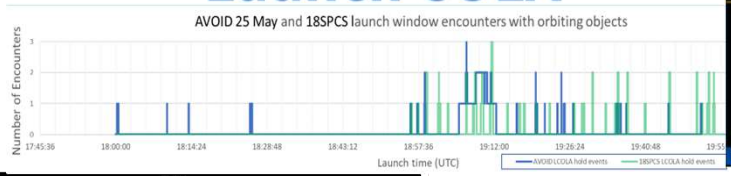
Automatically characterizes non-cooperative maneuvers and allows analysts to examine and fix observation association problems.

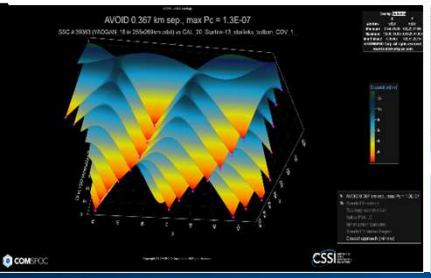


RPO/OOS Planner



Launch COLA





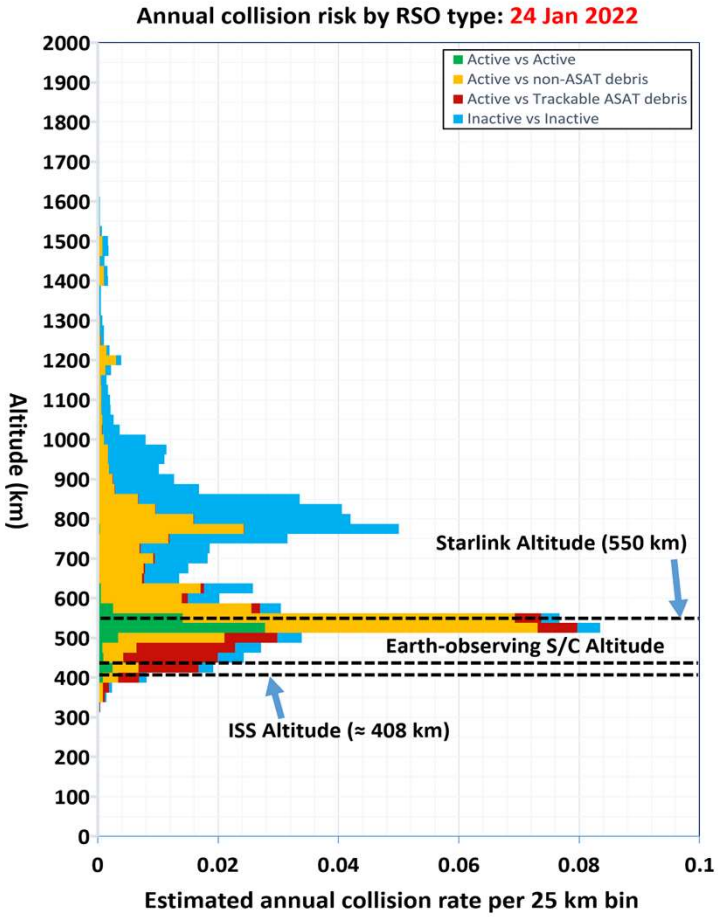
Space Event Generator

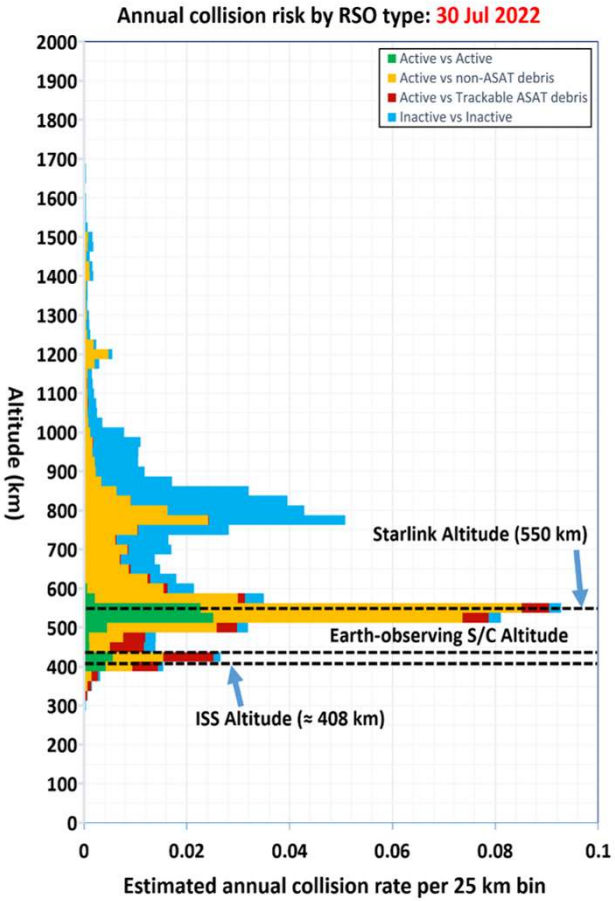
Rapid and accurate simulated space events for Test, Training, and Exercise (TTX) support.

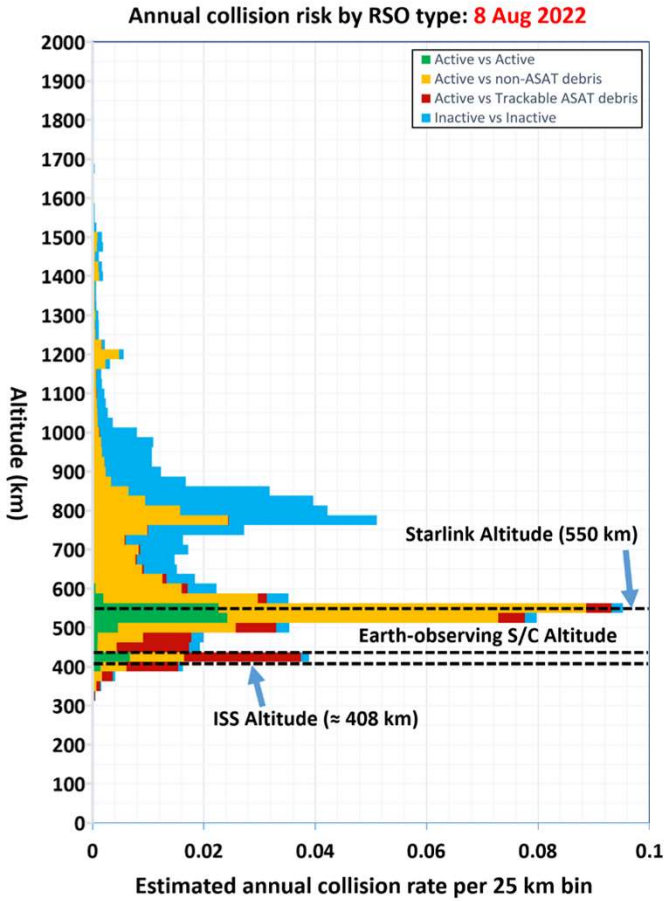
Space Object Threat Assessment

Decreases risk to satellite missions and increases survivability against threats by assessing a space object's vulnerability to another object's actions or events

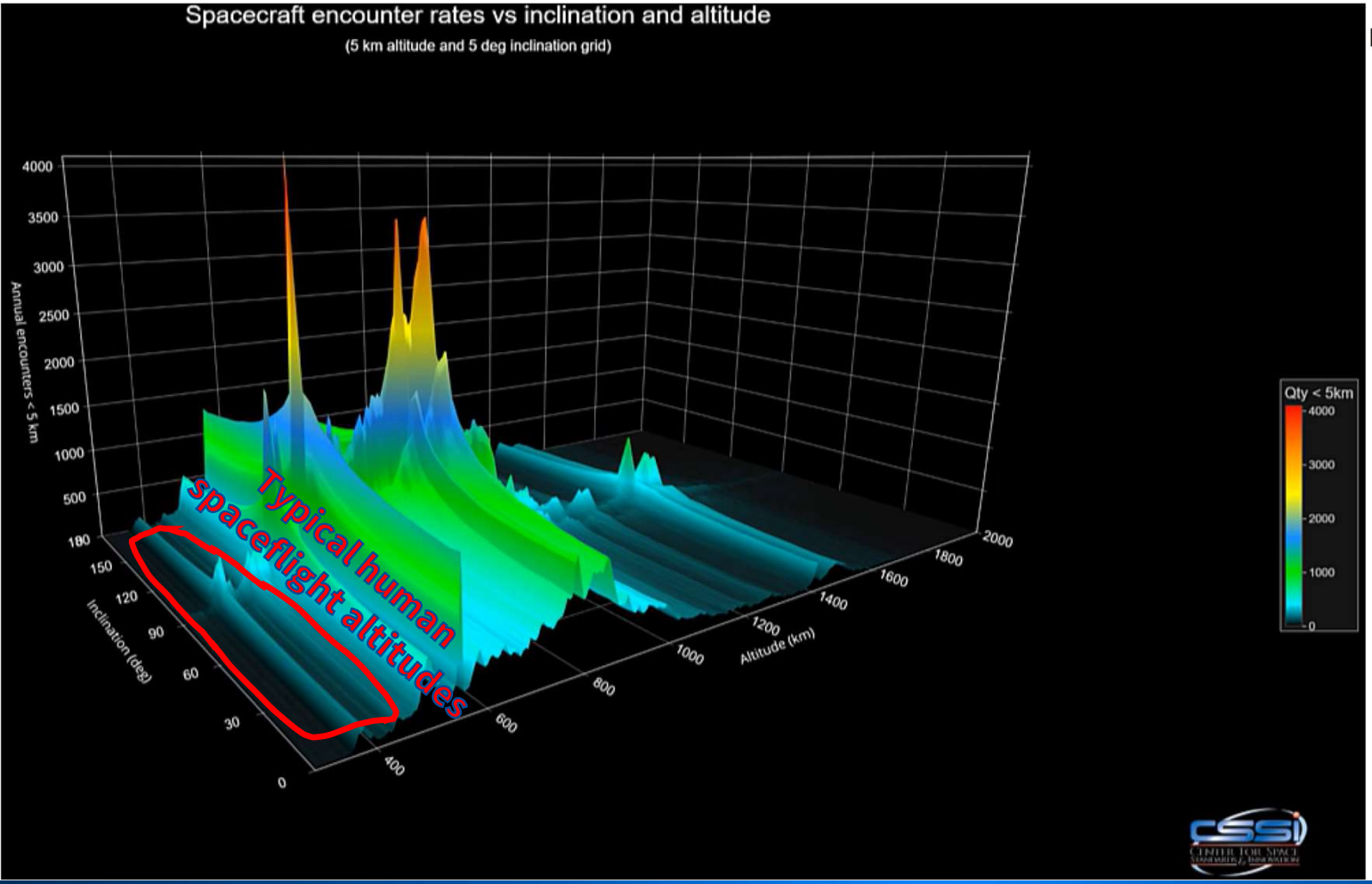
Safe commercial spaceflight depends on addressing bad actors (e.g., direct ascent kinetic energy ASAT testing)







Commercial human spaceflight must coexist with existing debris



Number of Encounters Assessment Tool

The Number of Encounters Assessment Tool (NEAT) assesses collision risk by adjusting key parameters including constellation size, orbit altitude, and inclination. Users can also customize their threshold for warnings, maneuvers, and hard-body collisions.

Average encounters per day:

Warnings: 1.46

Maneuvers: 0.162

Collisions: 0

Encounter Period:	Days
	1
Number of Satellites:	64
Warning Threshold (m):	3000
Maneuver Threshold (m):	1000
Collision Threshold (m):	5
Inclination (deg):	3
Altitude w.r.t. Earth equatorial radius (km):	330
Space population	19697

- "NEAT" estimates encounter rates: http://www.comspoc.com/neat

Thanks for your attention!

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