

STM lessons learned and suggested solutions

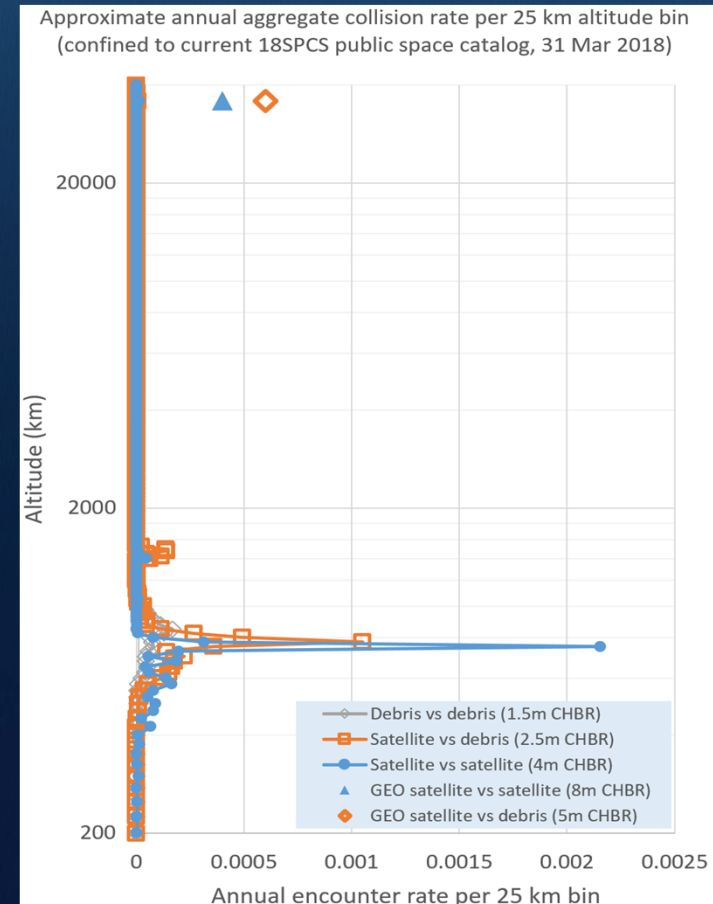
Spring 2018 Meeting Of The
Aeronautics And Space Engineering Board
Focus Session on Orbital Debris

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1 May 2018

Why SSA is challenging and disagreements abound

- Operators and analysts often differ on actionability and risk in orbit regimes
 - Not all orbit regimes are created equal !
 - Positional accuracy is highly altitude-dependent
 - Space weather poses challenge below 700 km
 - High-eccentricity LEO-crossing satellites and debris difficult
 - GEO accuracy challenging, particularly for active satellites
 - Estimated collision risk and encounter rates are highly regime- & category-specific
 - Active-on-active satellites
 - Active-on-debris
 - Debris-on-debris
- Errors in the many “moving parts” of an SSA system can invalidate SSA:
 - **SSA system**
 - **Sensors**
 - **Data pooling and fusion**
 - **SSA analytics**
 - **Space object meta-data**
 - **Orbit determination, propagation**
 - **RFI flyby and mitigation**



What makes SSA challenging? Answer: Everything must work!

Space object metadata

- Debris sizes and/or RCS or Vmag
- Accurate space object dimensions
- Complete LEO-crossing catalog > 2cm
- Complete GEO-crossing catalog > 20 cm
- Operator satellite attitude/ flight orientation

Orbit determination, propagation

- Accurate orbit determination & propagation
- Well-suited techniques & algorithms
- Covariance realism w/o scale factors
- Non-cooperative maneuver recovery
- Appropriately tailored force models
- Models prior & planned maneuvers
- Low-thrust modeling of maneuvers
- Accurate space weather predictions
- Proper tagging and obs association
- Accurate interpolation and digits
- Accurate atmosphere models
- Correct Earth orientation
- Calibrates maneuvers

RFI flyby and mitigation

- Incorporates operator's authoritative RF chars
- Advanced tools for RF interference mitigation
- Aids with geolocation of RFI source

Missed
Iridium
Maneuver

Sensors

- GEO and LEO all-weather sensors
- Responsive sensor scheduling
- Diverse sensor locations
- Well-calibrated sensors
- Sufficient observations
- Large sensor network
- Diverse sensor types
- Prioritized to meet all customer needs
- High SLA for timely, accurate CA & RFI
- Well-integrated into regulatory fabric
- Meets cyber security standards
- Inclusive to all space operators
- Transparent processes & results
- Stably funded and dependable
- Autonomous processing
- Quality control process
- Free to operators

SSA system

Data pooling & fusion

- Legal protection of IP
- Compatible timing systems
- Uses international data standards
- Proper normalization of diverse data
- Flexible, user-configurable M2M and UI

SSA analytics

- Non-linear encounter Pc
- Accurate conjunction assessments
- Timely processing and notification
- Pc for non-spherical shaped objects
- Decision-quality collision avoidance metrics
- GEO positional accuracies support Pc of 1.e-4
- LEO positional accuracies support Pc of 1.e-4
- Applies consensus risk mitigation best practices

STM

Policing

Monitoring

Observing

Space Situational Awareness

Regulatory

Intl Standards

UN Guidelines

Centralized STM Challenges (Oltrogge, 2002)



- Who funds the threat monitoring?
- Mission conflict: STM entity must have Safety of Flight (SoF) as its top priority
- Disparate tracking and operator orbit determination systems
 - Unmodelled (or mis-modeled) maneuvers is perhaps the single biggest challenge!
 - Need to create, adopt internationally-standardized data messages
 - Shared understandings of coordinate frames, timing systems, units
 - Biases in tracking and operator data must be identified and removed
- Insufficient model fidelity and data consistency
- Latency of debris and operator positional knowledge
 - Must continually update tracking data for non-cooperative or debris objects
 - Need to increase ops cadence of tracking, OD and data sharing
 - Need servers to receive and automatically process owner/operator data
- Protection of company or country-proprietary data
 - Data recipients and analysis generation systems must maintain sanctity and privacy of pooled data
 - Legal and cyber protections for proprietary data

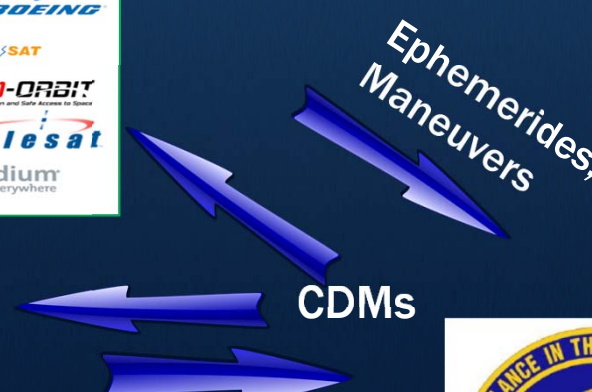
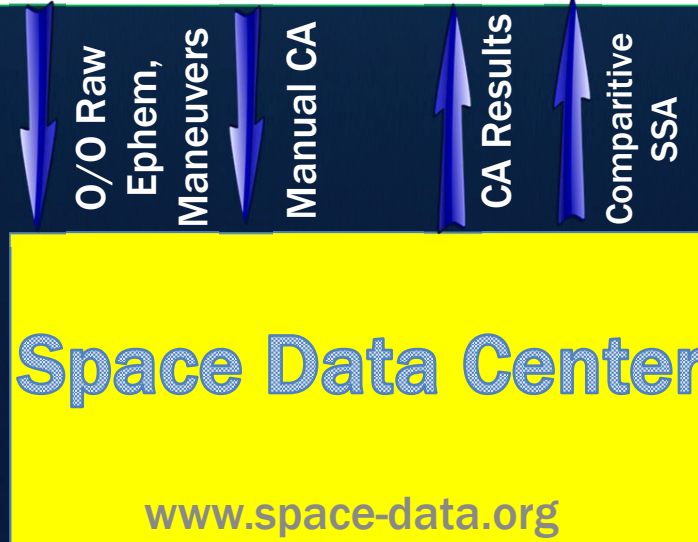
To effectively avoid collisions, must evolve to:

- Highly accurate, precise, complete and timely results
- To get there requires:
 - STM framework leveraging **collaboration & input data pooling**
 - Increased tracking sensors, sensor sites and sensor sensitivity
 - Advanced sensor data processing techniques
 - Data fusion of multiple sensor phenomenologies
 - Meaningful Common Operating Pictures and SSA displays
 - Advanced OD, CA and SSA algorithms
 - OD thru non-cooperative maneuvers, aspherical and non-linear Pc, ...

The SDA: Providing operational STM since 2010.



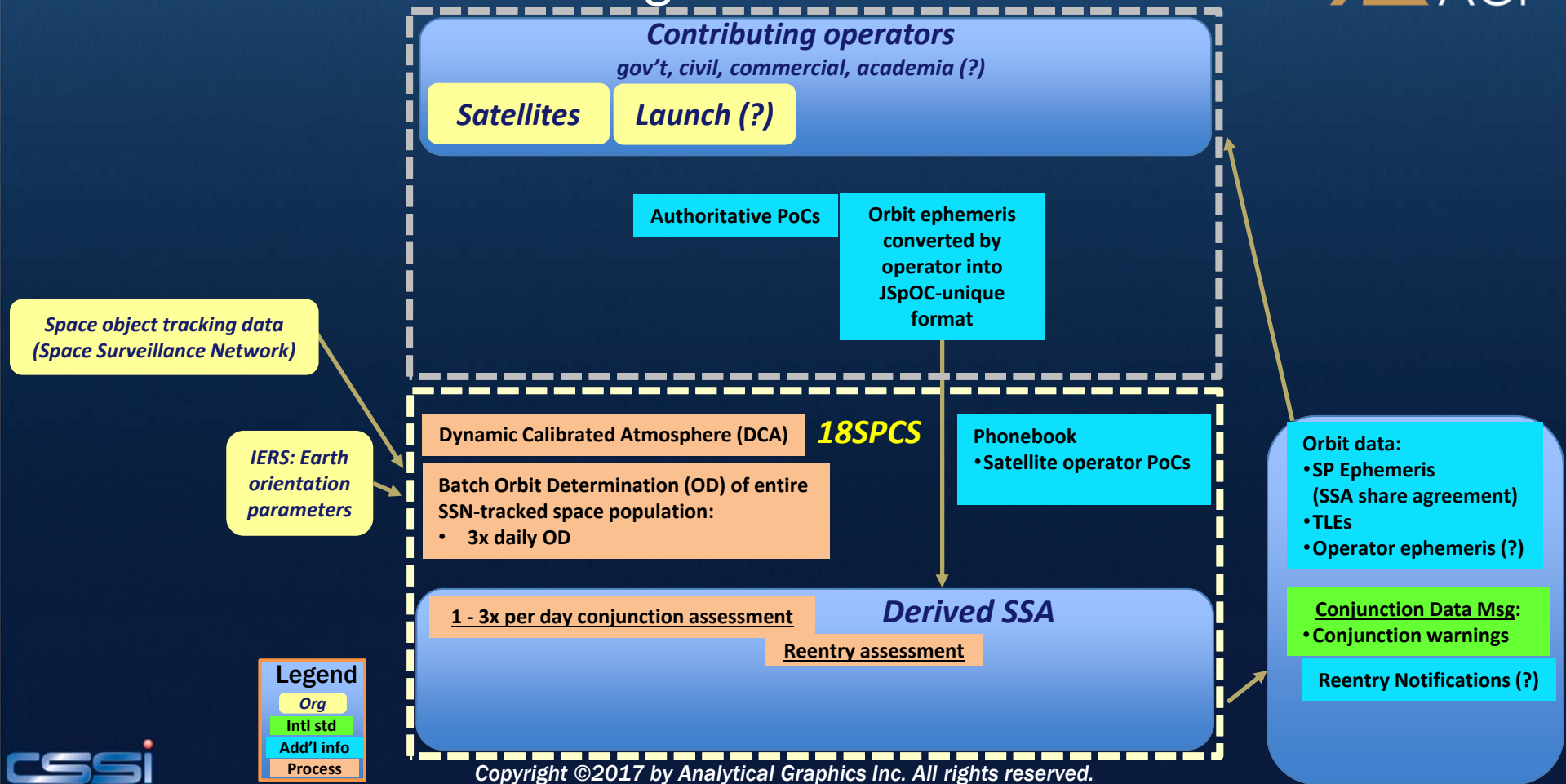
- Self-organized in 2008 to promote safe and efficient use of space
 - Safety-of-flight
 - RFI mitigation
- SDC is largest single contributor of owner/operator ephemerides
 - Voluntary; part of we are committed to “always do the right thing”
 - Quality assurance and consistency checks are imperative
 - JSpOC (18th) has been very receptive to this assistance
- SDC frequently alerts JSpOC to any issues with JSpOC SSA products



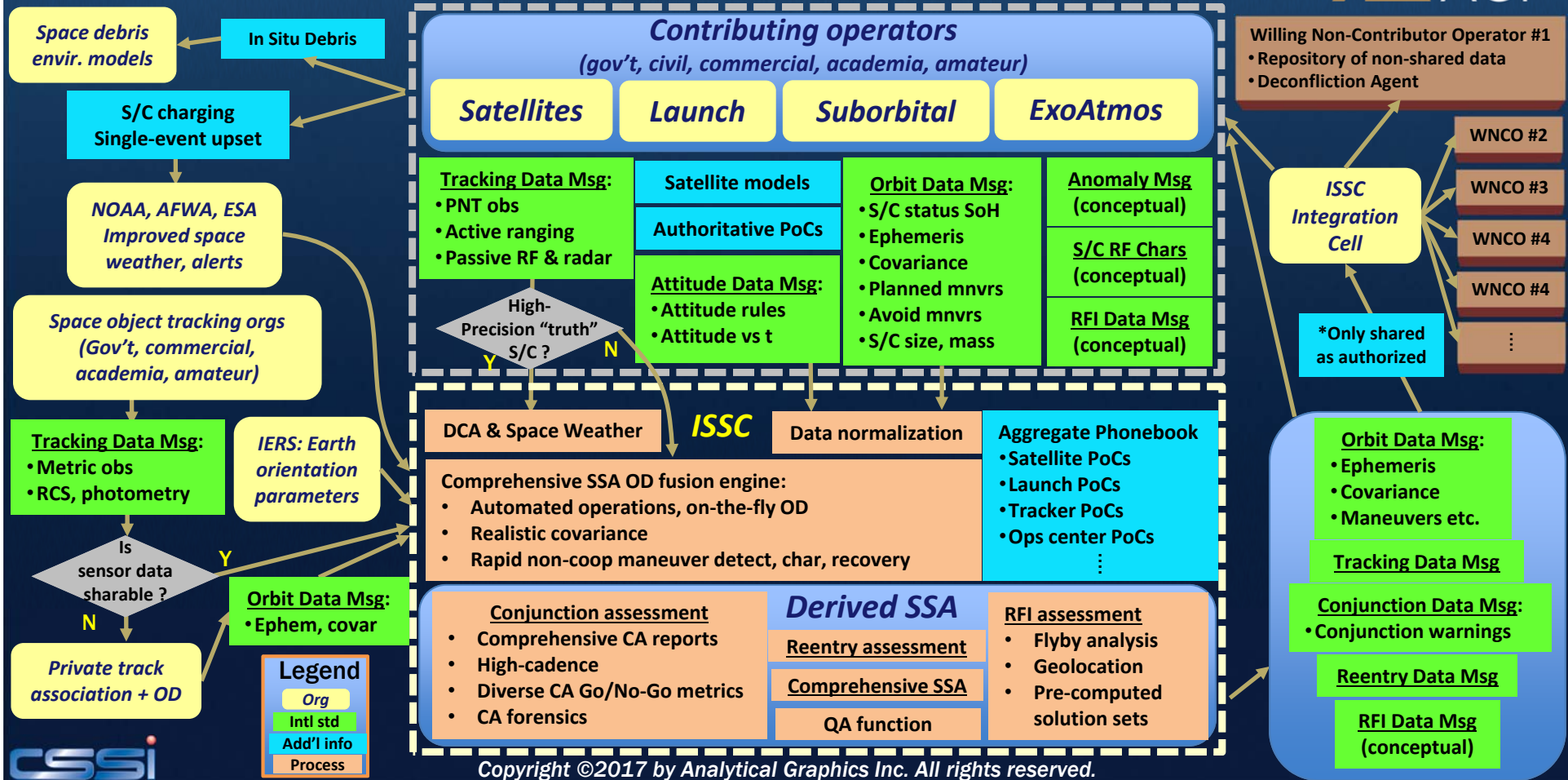
• Notify JSpOC of significant JSpOC issues/errors



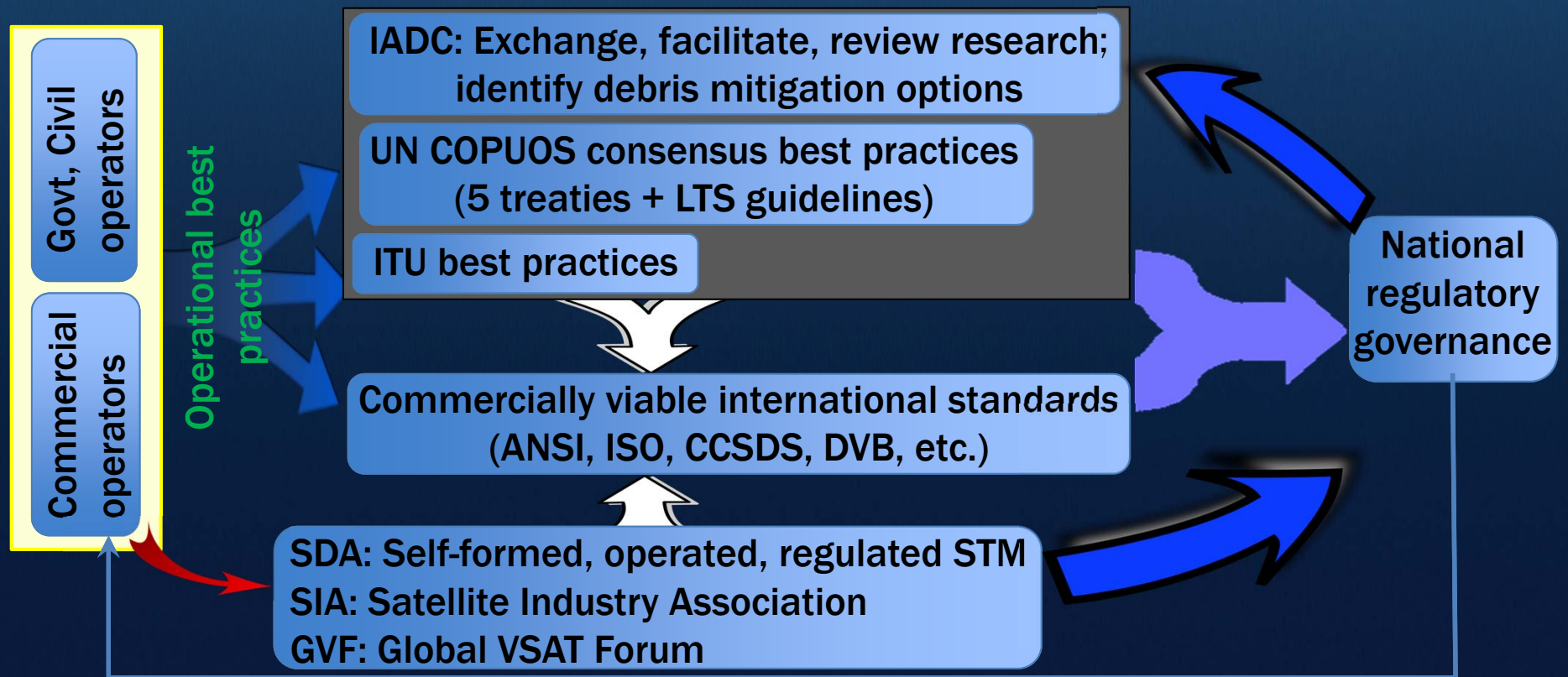
Current U.S. STM Paradigm



Suggested STM Paradigm: Int'l Satellite Safety Center



Confluence of all things: A holistic STM perspective AGI



Conclusions

- Collision risk in both LEO and GEO is real but is manageable
- SSA and STM:
 - The “terminology battle” continues...
 - Differing views (or understanding) on current SSA performance
 - Differing views (or understanding) on current STM performance
- A single “weak link” breaks the entire SSA analysis chain
 - No partial credit given for having SSA “mostly correct”
 - Some of SSA’s weak links can be addressed by holistically and inclusively “crowd-sourcing” data from proven, trusted sources
- A “crowd-sourcing” approach to STM (similar to SDA or the International Space Safety Center concept) is required

Thank you! Questions?

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