



# **CCSDS 502.0-B-2/ISO 26900 Orbit Data Message**

Center for Space Standards and Innovation

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# Status

- Orbit Data Message (OEM, OPM, OMM) overview:
  - SC14/WG3 and CCSDS are partners in this; ODM = ISO 26900
  - Published Nov 2009
  - Now up for 5-year periodic review
- ODMs gaining acceptance across space ops community
  - OPMs used for state vectors and  $\Delta V$ s = quick acceptance
  - OEMs on cusp of mass adoption
    - Want to enhance OEMs to be stand-alone & self-contained
  - OMMs not popular and may not be needed
- Observing sensor organizations, data fusion and analysis centers and satellite operators have new rqmts

# ODM CUSTOMERS & USE CASES

# Current and Anticipated ODM Uses

- Satellite operator data exchange
  - Space Data Association (SDA)
    - Conjunction assessment and collision avoidance
    - Planned: RF interference prediction, geolocation systems and RF interference mitigation
  - Space object tracking networks (e.g. ComSpOC, JSpOC)
    - Standardizes output product format, content
    - Internal sensor queuing
    - Enables multi-source orbit data fusion (seek most authoritative)
- Multi-participant mass deployment missions (eg QB50)

# What is the Space Data Association?

The Space Data Association (SDA) is a not-for-profit association formed by satellite operators to provide reliable and efficient data-sharing critical to the safety of the space environment and the RF spectrum

SDA Executive Members:



SDA Member Directors:



Chief Technology Adviser / SDC Operator:



# The Space Data Association (SDA)

*Multi-national, open to all space operators, in all orbital regimes*

- 24 contributing operators
- 3 civil satellite operators



# SDA Missions

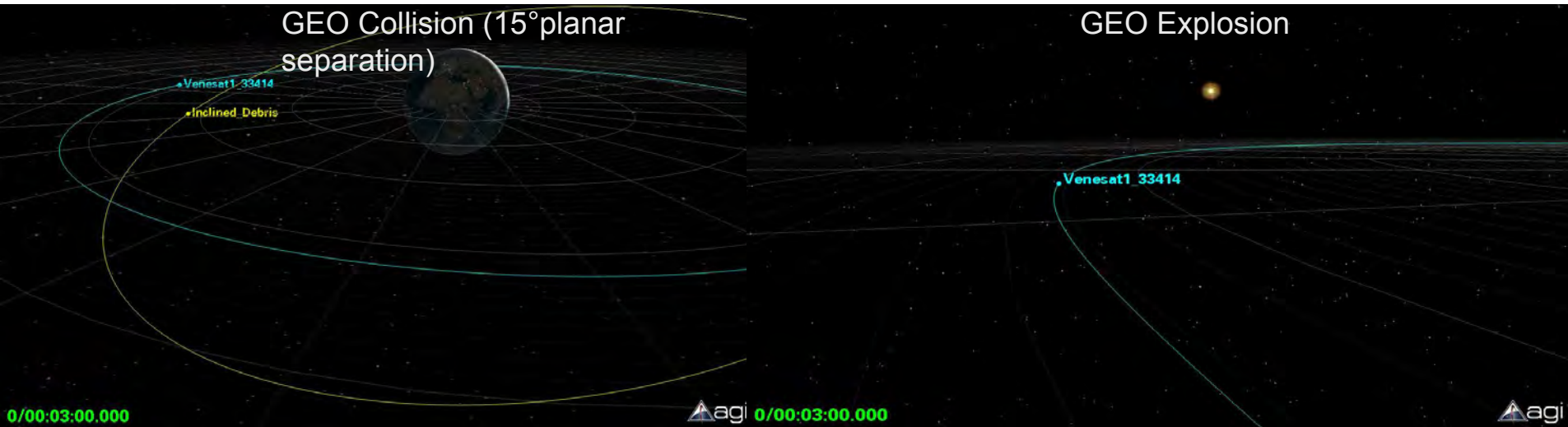
- Increase safety of flight – *functions already operational*
  - Automatic Conjunction Assessment (CA), using operator’s ephemeris
  - Reduce false alarms, missed events
  - Minimize time and resources devoted to CA
  - Include planned maneuvers (unique capability)
- Deal with the growing problem of RFI – *under development*
  - RFI Alerts to focused distribution
  - RFI historical event search: data support
  - Generation of geolocation data sets
  - Library of Reference Emitters
  - Carrier ID database
- Reliable contacts for satellite operators – *functions operational*
- Encourage and promote operational best practices

***SDA Enhances its Members’ Satellite Operations***

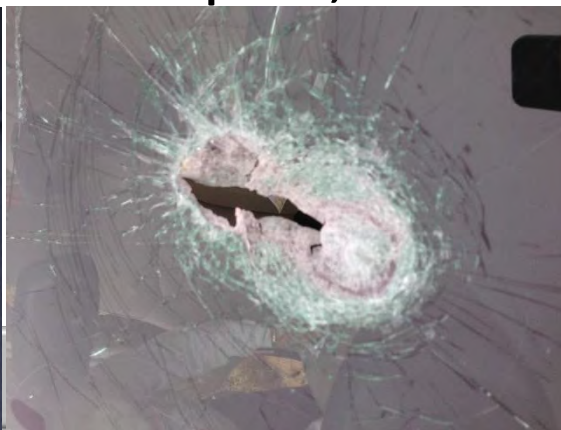


# SDA Working to Prevent Debris in Space ...

- ODM data sharing helps prevent fragmentation events



- Collisions often catastrophic, but don't have to be:





# What is the Commercial Space Operations Center (ComSpOC™)?

- A commercial facility that fuses and processes measurements from a commercial network of telescopes, radars and RF antennas
- Provides analysis and space object characterization on all tracked RSOs
- Produces and serves a summary of all known information on objects > 5cm\* to SpaceBook™
- Target markets:
  - Commercial satellite owner/operators
  - Government space operation centers



# OPERATIONAL REALITIES OF TODAY'S SPACE DEBRIS POPULATION

# Space debris population driven by 2 events:

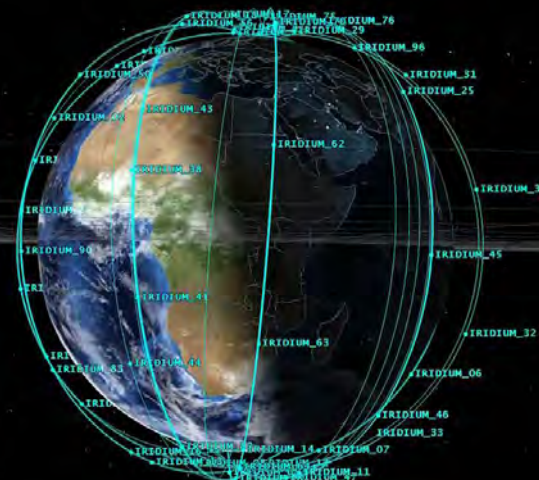
FengYun 1C intercept on 11 Jan 2007

Iridium 33/Cosmos 2251 10 Feb 2009



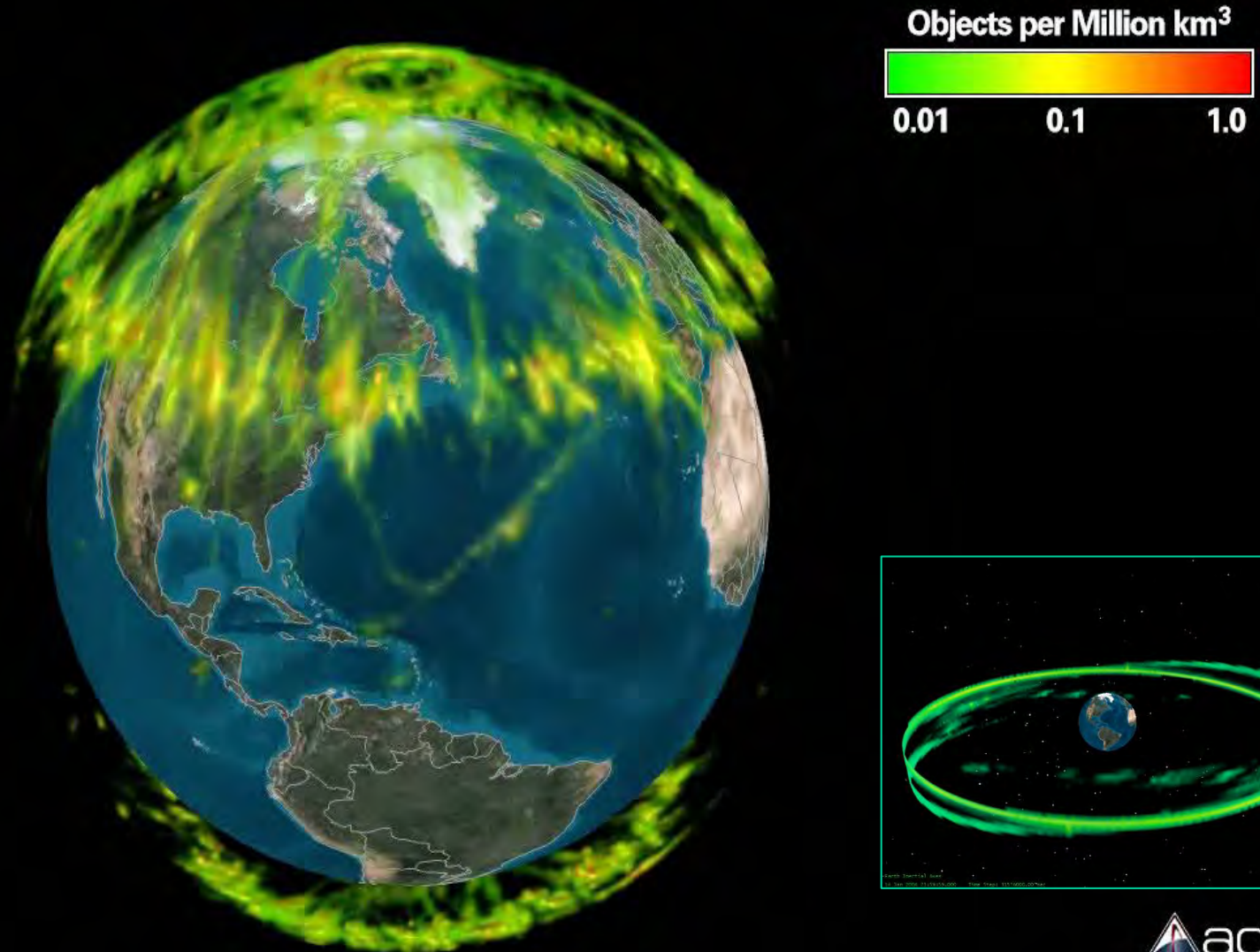
**ASAT TEST**  
**Xichang Space Center, China**  
**January 11, 2007**

Visualization using the data tracks  
 available on January 29, 2007



- Median debris track introduction date is 2002
  - As many debris objects since 2001 as all of 1950s thru 2001 !!
- As ISS depiction in ASAT video shows, debris-generating events impinge on all other space operators

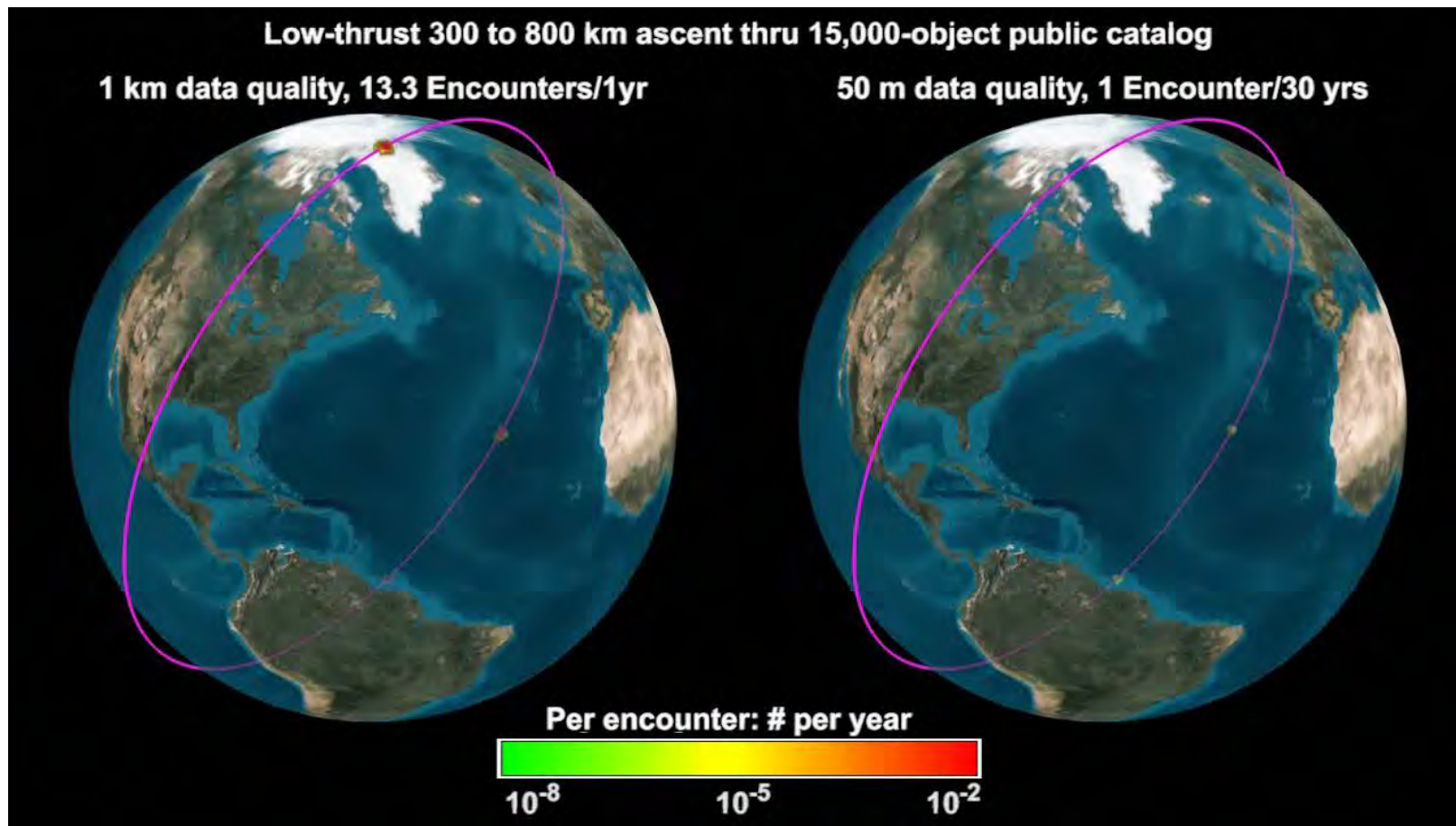
# Space debris volumetric evolution (2005-2014)





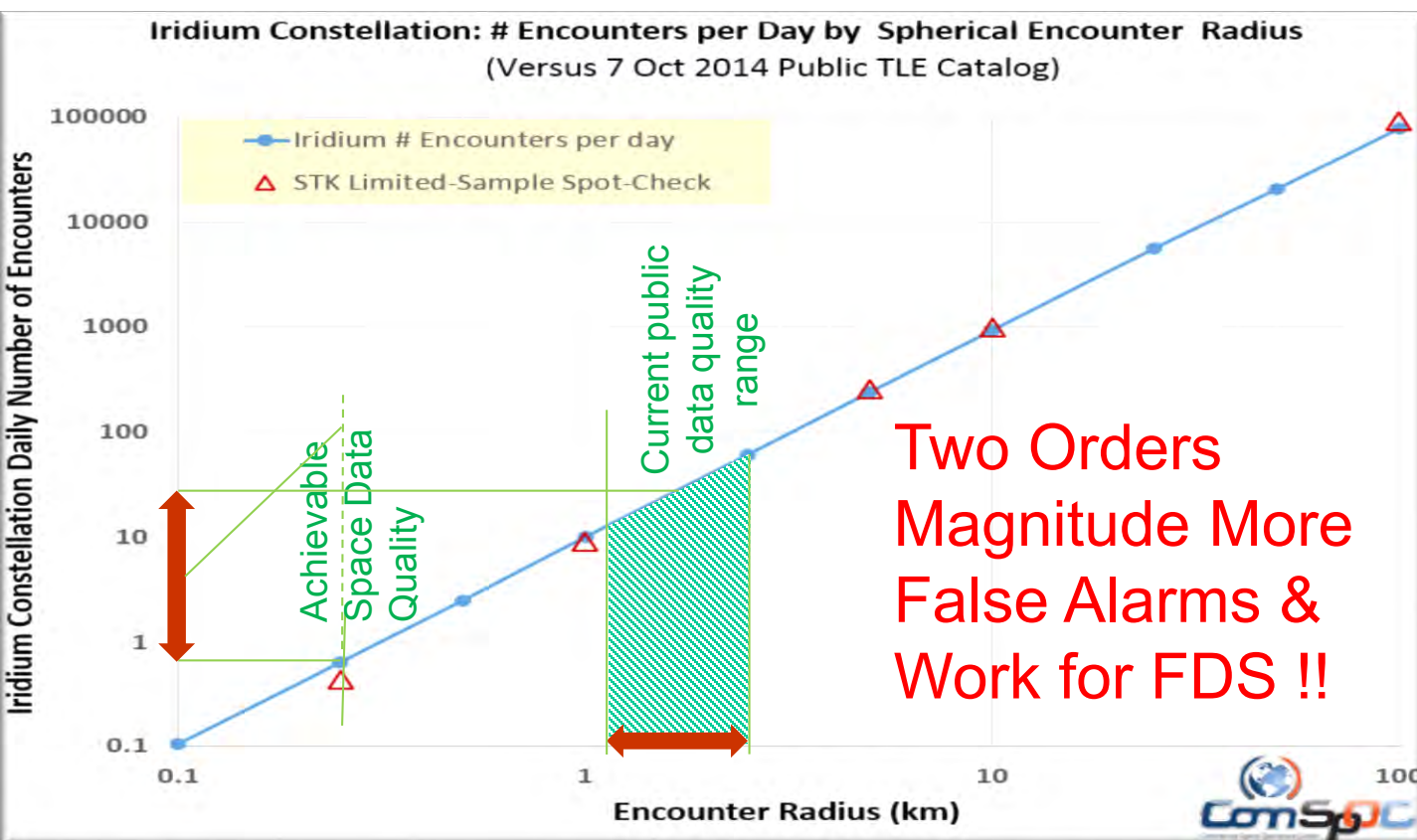
## New low thrust ascent requires better SSA

- Can launch two GEO satellites for price of one!
  - But requires 1-2 mo and transits ALL orbit regimes



# Sample: Iridium Encounter Rates

- New long-term encounter rate algorithm
  - MANY Iridium encounters (conjunctions) identified!



Satellite Flight  
Dynamics Staff Gets  
Overwhelmed ...



Flight  
Dynamicist



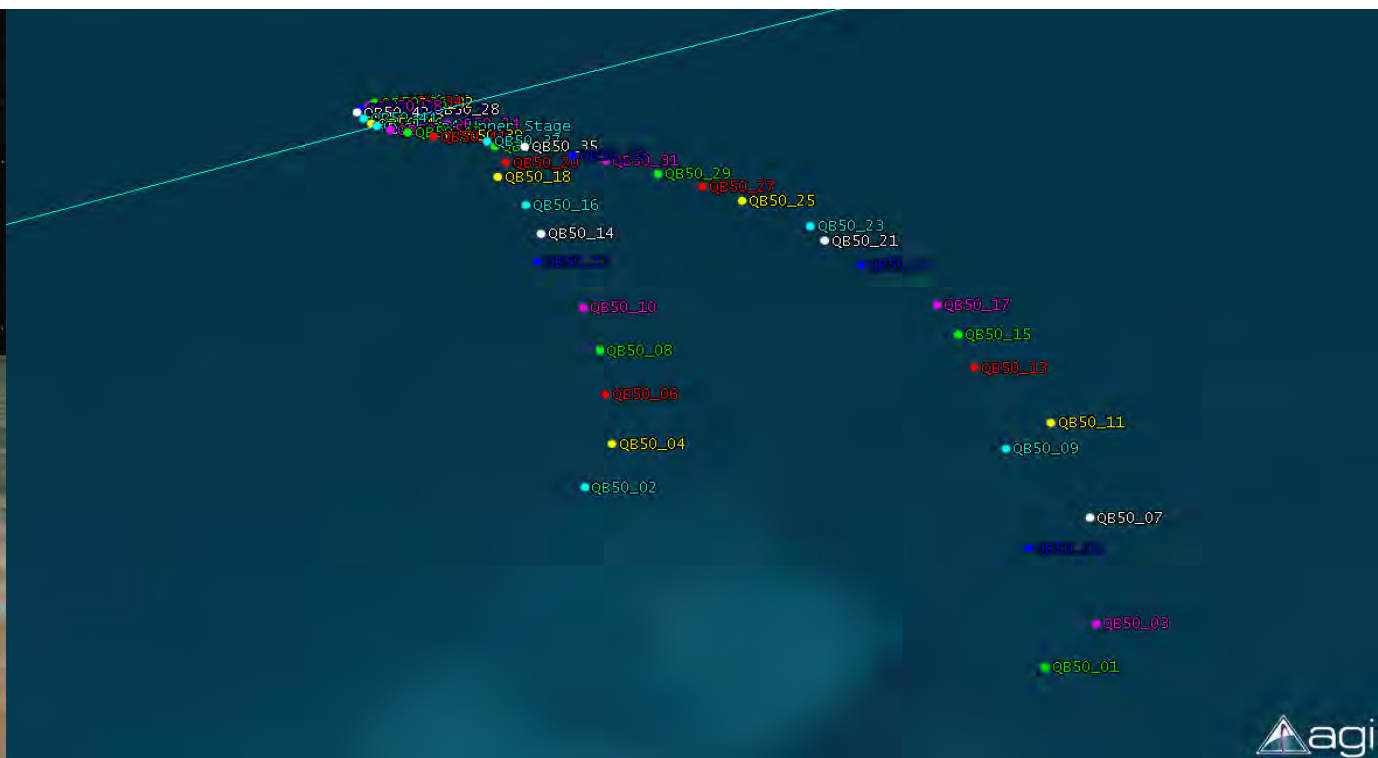
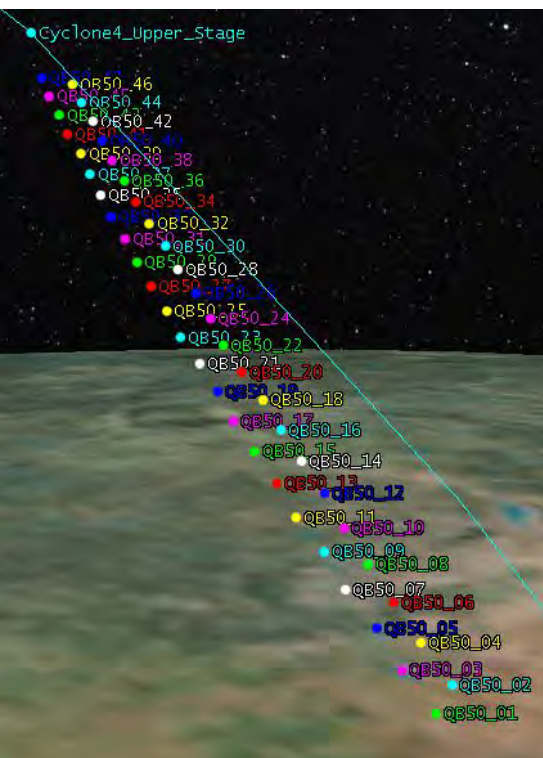
Desirement: Would like ODMs to convey en masse deployments (e.g. QB50, Planet Labs)

- Imperative to easily convey large deployment
- Bad deployment schemes more easily identified/fixed



# Likely QB50 Deployment STK Scenario

- Cyclone-4 along-velocity thrusting scenario created
  - Contains all 50 QB50 satellites plus the Cyclone-4 Upper Stage
  - AGI providing authoritative STK scenario to all QB50 participants and relevant tracking entities



## Likely QB50 Deployment STK Scenario

- Deployment scenario still evolving... but likely to be:



# ODM Enhancements Sought

- ISO WG3 & User Community Seek ODM Enhancements
  - Additional maneuver information for OPMs and OEMs
  - Make orbit-relative frame options more visible for users
  - Re-add Julian Date to OPMs, OEMs for ease of use and file size considerations
  - Generalize OPM Keplerian Elements to be any 6-element set
  - Define parent/child  $\Delta V$ s for en masse deployment scenarios
  - Specify epoch of leap second introduction (if/when)
  - Allow covariances to be provided as positional (only) as 3x3s
  - Include recognition that covariances also derive from MCs
    - Launch traj can even have 7 x 7 matrices, with time the 7<sup>th</sup> param

# OEM Enhancements Sought

- Modify OEM to encapsulate all relevant data to be exchanged
  - Add  $\Delta V$ -based (impulsive and w/duration) and finite burn (thrust, Isp)
- Re-add Julian Date for ease of use, efficiency and file size
  - 3+ definitions of Modified Julian Date, e.g. 2000/01/01 00:00:00z is ESA MJD = 18262.0, classic definition = 51544.0, Telesat MJD = 11544.0
  - But we can either adopt uncontroversial JD or simply define MJD
- Specify epoch of leap second introduction (if/when)
- Origin of COMMENT fields vs “non-obligatory” ? Latter better.
- Allow covariances to be provided as positional (only) as 3x3s
- Modify descriptive language to “emulate propagation results” too

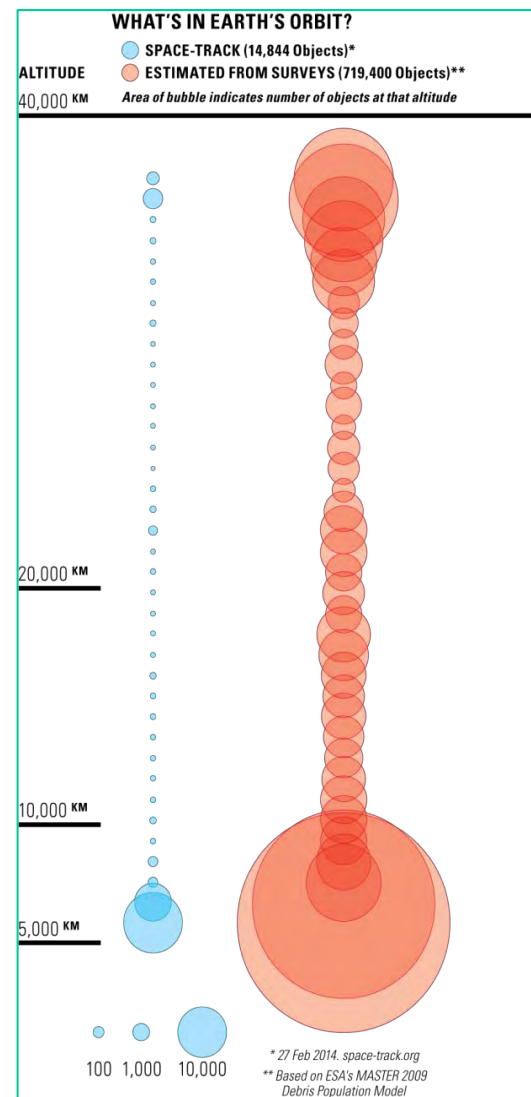


# The OEM Bandwidth Problem

- Operators already sharing fleet two-week ephemerides every two hours
  - Current & new operators have 100s of S/C
    - Iridium, Intelsat, Planet Labs & proposed constel.
  - Need > 90 points per orbit; LEO 15 revs/day
- Space debris presents a problem:
  - Only tracking 1/35<sup>th</sup> of objects > 1cm !
- Improved tracking and large LEO constellations strain bandwidth, CPU

720K	14 days	15 e	pts	line	1 bytes	1Kb
RSOs>1cm	Ephem	1 day	1 rev	pt	line	1024 bytes

304 GB !!





# Bandwidth problem

- Networks pushed to limit now
  - Transmittal of ephemerides, covariances, maneuvers
    - Inter-operator, between operators and fusion centers
  - High-availability systems require geographic diversity and DB synchronization
  - Encryption slows things down
  - Layer 7 threat screening slows things down
  - Data storage is cheap, but backups (more data = more time)
  - Amount of data drives need for archival

## OPM Enhancements Sought

- Add finite burn maneuver specification (thrust, Isp)
- Generalize current Keplerian osculating element set to contain any specified 6-element set plus an optional control param (retro vs prograde)
- Parent/child  $\Delta V$ s for en masse deployment scenarios
- Re-add Julian Date for ease of use
- Allow covariances to be provided as positional (only) as 3x3s
- New solar & geomag indices - - how best to accommodate?

# OMM Enhancements Sought

- Unsure of utility of current OMM message
  - Doesn't include maneuvers; if OMM retained, should add maneuvers and covariances (incl. 3 x 3 positional)
  - Many definitions of mean elements; this addresses only TLEs
  - TLE already in super-compact format with very little size/bandwidth waste
  - Mean element formulations based on other elements too
    - If OMM retained, should generalize to other mean element sets and formulations
  - In my opinion, OPM could readily be generalized to OMMs
    - OPM already contains maneuvers and is being adopted

## Conclusions

- ODMs becoming popular in space operator community
- On cusp of huge demand for ODMs
  - Anticipate substantially growing catalog
  - Operator data sharing for CA & RFI mitigation ever-increasing
- Want to enhance ODMs to meet valid operator needs
- Can assist in defining and implementing such enhancements as efficiently as possible