SPACE DATA
ASSOCIATION

www.space-data.org

SDA Users Meeting: General Forum

18 March 2013

Early Afternoon Agenda: SDA General Forum (13:30-16:00)

- **Introduction and SDA Overview**
- **SDC and the SDC Plugin**
- **How Can You Benefit?**
  - Conjunction assessment
  - Launch and Early Orbit Phase
  - Automated CSSI data source comparisons
  - Cases of interest: DA14 and BLITS
  - EMI/RFI mitigation support (Smith/Rawlins)
- **SDA Future Plans**
- **General Q & A**

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SDA Users Meeting: SDA General Forum

INTRODUCTION AND SDA OVERVIEW

RON BUSCH

What is the Space Data Association?

- The Space Data Association (SDA) is a not-for-profit association formed by and for satellite operators to provide reliable and efficient data-sharing critical to the safety and integrity of the space environment and the RF spectrum.
- The SDA was founded by **Inmarsat**, **Intelsat** and **SES** — three of the leading global satellite communications companies. These three companies, plus **Eutelsat**, now form the Executive Board of the SDA.

"Safety of Flight"

Definition: The condition where satellites are positioned and operated in a manner that preserves their long-term operational viability and the preservation of the orbital regime(s) involved

SDA Charter

- Seek and facilitate improvements in the safety and integrity of satellite operations through wider and improved coordination between satellite operators

- Seek and facilitate improved management of the shared resources of the Space Environment and the RF Spectrum

Why was the SDA created?

- **Enhance "Safety of flight"**
  - Maintain the long-term viability of satellites and their orbit regimes
- **To improve the accuracy of collision avoidance predictions**
  - Expand satellite operator participation
  - Adopt best practices across industry
  - Provide necessary framework for full operations (legal, technical)
  - Address ops. issues with current cross-industry conjunction coord.
    - Reduce false alarms, missed events
    - Minimize member time and resources devoted to CA
- **To take advantage of opportunities for other data sharing**
  - RFI mitigation, including data for RFI geolocation
  - Company contacts
  - General operations data sharing

Conclusion: SDA Enhances its Members' Satellite Operations

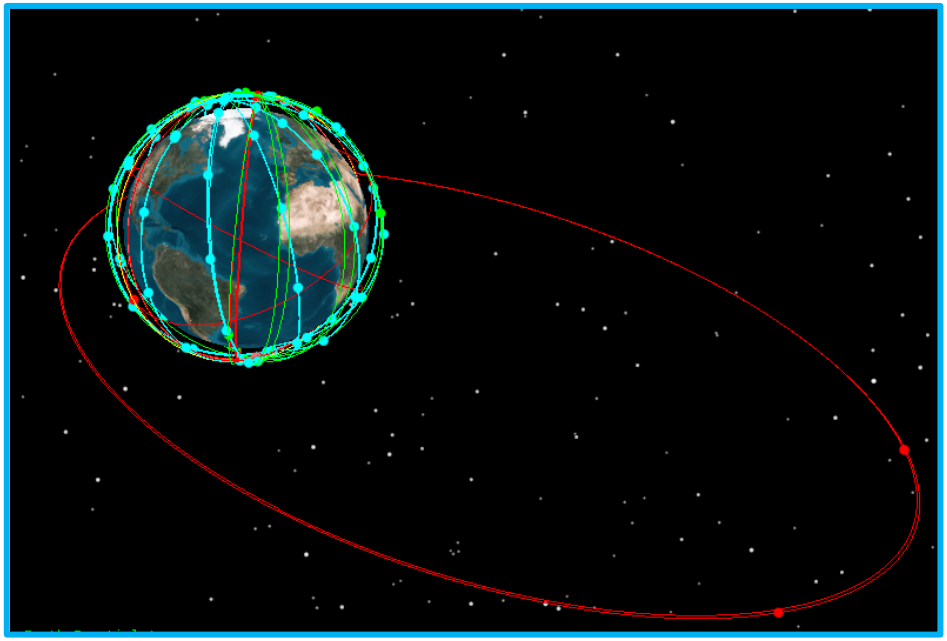
SDA Status

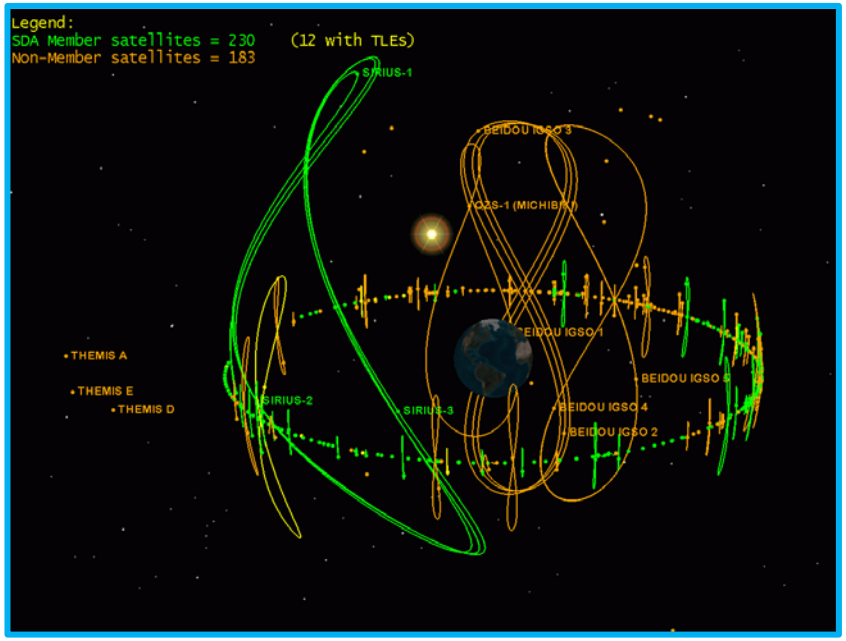
- **SDA established as a legal entity in the Isle of Man**
  - Provides necessary legal framework for data protection and sharing
- **Space Data Center (SDC) system built by Analytical Graphics, Inc. (AGI)**
  - System has now achieved Full Operations Capability, providing Conjunction Assessment service to its members
- **Growing membership**
  - Currently fifteen satellite operators from Geosynchronous and five from LEO orbital regimes
  - As of March 2013, CA processing of 227 GEO satellites (more than 57% of all GEO satellites) and 92 LEO/other orbit satellites

Multi-national, open to all space operators

Space Data Center
Current Participation

- 3 civil satellite operators
- 21 contributing operators
- 92 LEO satellites from 5 operators
- 227 GEO satellites from 15 operators





SDA Participating Operators

GE
Satellite

SDA Missions

- **Increases safety of flight**
  - Automatic Conjunction Assessment (CA)
  - Reduces false alarms, missed events
  - Minimize time and resources devoted to CA
  - Includes planned maneuvers (unique capability)
- **Deals with the growing problem of RFI**
  - RFI Alerts to focused distribution
  - RFI historical event search
  - Generation of geolocation data sets
  - Library of Reference Emitters
- **Enables more efficient operations for all**
  - Reliable contacts database for satellite operators – technical and operations personnel

Conclusion: SDA Enhances its Members' Satellite Operations

SDA Supports Collaborative Improvements in Satellite Operations

- **Dissemination of 'best practices'**
  - SDA legal agreements enforce appropriate behaviour
  - Validation of participant's data and processes
- **Enhanced Conjunction Analysis (CA)**
  - Merging/processing SDA owner-operator data and other sources
- **Enhanced EMI/RFI mitigation data sharing**
  - Participant provided data immediately available
- **Support RFI initiative of other industry bodies (sIRG, EUI)**

Data Use Control / Legal

- **How does SDA obtain & protect member data?**
  - Legal agreements between subscribers and SDA
    - Permitted Uses for SDC data/products
    - Prohibited Uses for SDC data/products
    - Retransmission to third parties prohibited
    - Obligations for member data contribution
    - Legal liability issues are addressed by enforceable contract
      - Isle of Man law allows the members to enforce the terms of the agreement directly against other members
  - Multiple technical / security controls within SDC

Permitted & Prohibited Uses

- **SDC - Permitted Uses:**
  - Operational support, including Safety of Flight
  - EMI/RFI resolution of actual harmful interference, including at ITU
  - Support for insurance underwriting
  - As legally required by national regulatory authorities
- **SDC - Prohibited Uses:**
  - Any commercial purposes (sales, planning, marketing, etc.)
  - Securing orbital-spectrum rights
  - Transmittal to 3rd parties (except for Safety of Flight)
  - **Any other use that is not a Permitted Use**

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SDA Users Meeting: SDA General Forum

OVERVIEW OF SDC AND THE SDC PLUGIN

DAN OLTROGGE

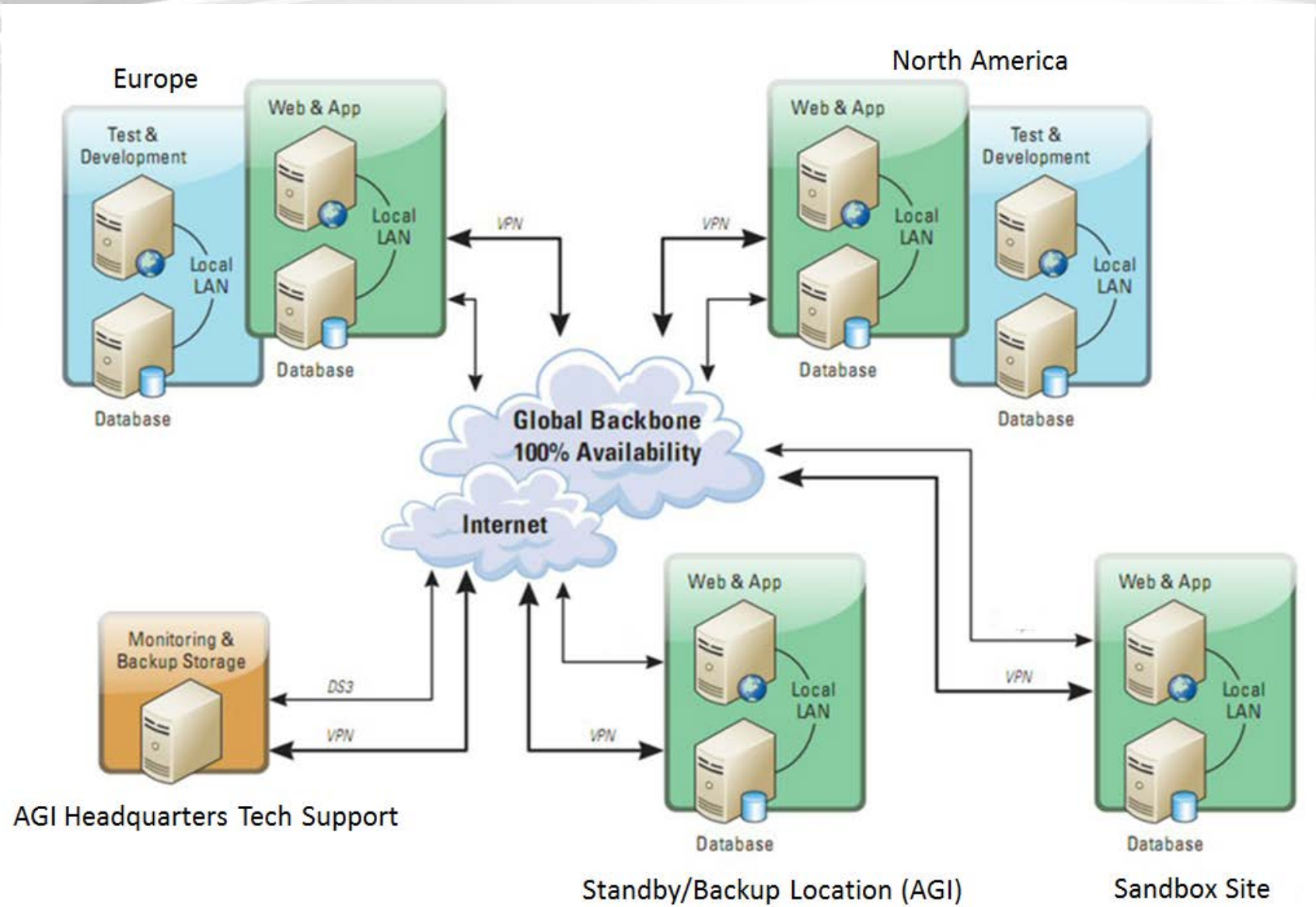
Space Data Center (SDC)

- **The SDC is the processing system of the SDA**

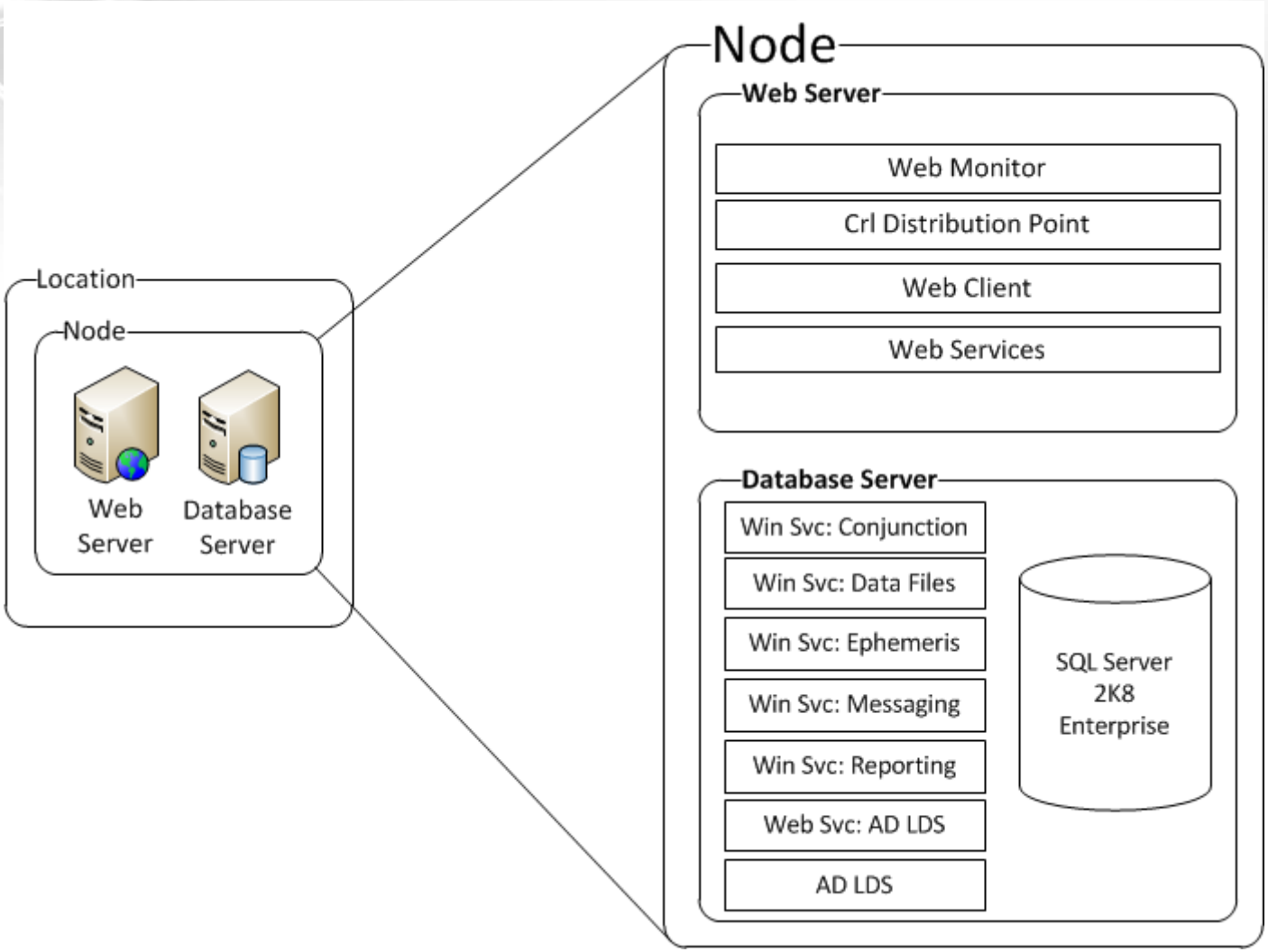
- **SDC – Three Key Mission Areas:**
  - Collision avoidance monitoring (Conjunction Assessment)/ Manuever Planning Validation / Flight Safety
  - Radio Frequency Interference mitigation / Geolocation support
  - Contact information (operations center) for SDA Member objects

- **SDC reliable and secure operation:**
  - Tertiary, geographically separated redundancy
  - High level data security and encryption
  - Best practice Information Assurance (IA) based on standards for high level computing systems

Current SDC Network Architecture



SDC Node Composition



SDC Demo: Home Page…

SDC Demo: Conjunction Reports

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Welcome Jim Wilson | Sign Out Home | Administration | About | Help | Phone Book

Ephemeris Data | Maneuver Reporting | Conjunction Reports | RFI Events

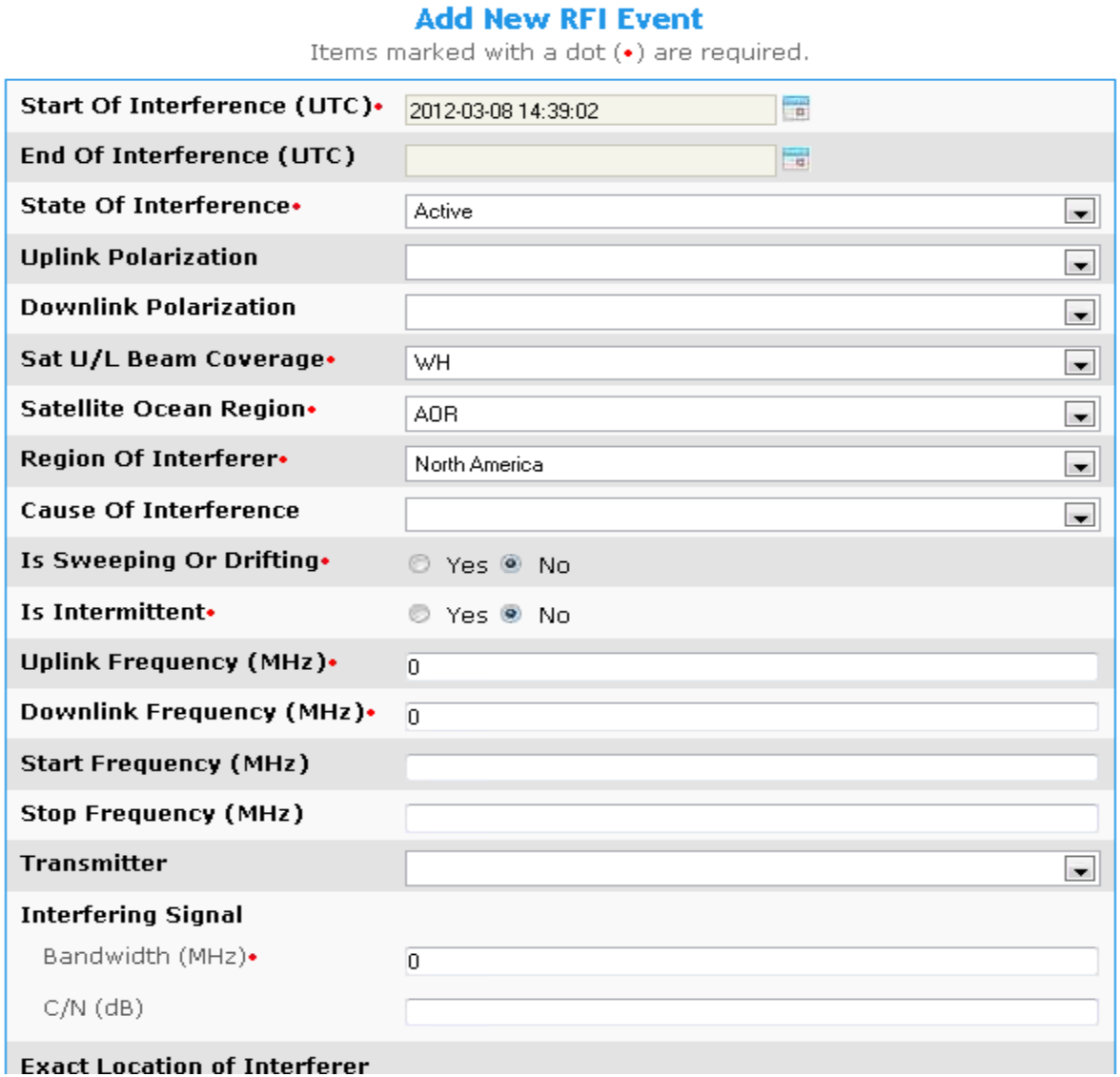
conjunction report » details

Conjunction Report Filter : -- NO FILTER (all items displayed) --

Conjunction Report 11802

ID	Satellites	Radial (km)	In-Track (km)	Cross-Track (km)	Meridian (km)
289492	SL-12 R/B(2) (28139 | 2003-060D)	0.1479	-0.0225	-0.0152	0.1487
	BLOCK DM-SL R/B (28138 | 2004-001B)	-0.1479	0.0225	0.0152	0.1487
	Start Date (UTC) : 2012-03-08 14:00:00		Max Probability : 0.000585520691405325		
	Time of Closest Approach (UTC) : 2012-03-09 17:55:58		Duration (sec) : 604800		
	End Date (UTC) : 2012-03-15 14:00:00		Minimum Range (km) : 0.1504		
289532	SL-12 R/B(2) (28139 | 2003-060D)	-2.3287	-6.2592	-3.0637	3.8482
	INTELSAT 10 (26766 | 2001-019A)	2.3275	6.2586	3.0657	3.8492
	Start Date (UTC) : 2012-03-08 14:00:00		Max Probability : 2.45313792148987E-07		
	Time of Closest Approach (UTC) : 2012-03-08 18:39:13		Duration (sec) : 604800		
	End Date (UTC) : 2012-03-15 14:00:00		Minimum Range (km) : 7.3476		
289542	BLOCK DM-SL R/B (28138 | 2004-001B)	-2.3841	-6.5505	-2.8461	3.7128
	INTELSAT 10 (26766 | 2001-019A)	2.3829	6.5499	2.8486	3.7138
	Start Date (UTC) : 2012-03-08 14:00:00		Max Probability : 2.33600546324756E-07		

SDC Demo: RFI Alerts



SDC Demo: Satellite “Phone Book”

phone book » satellite contact

Satellite Contact Information

Official Name	SL-12 R/B(2)
SSC	28139
Int'l Designator	2003-060D
ID	108132
Owner	SDACOM

Control Center Contacts

Name	E-mail	Phone
Jim Wilson	jwilson@agi.com	

Conjunction Contacts

Name	E-mail	Phone
Jim Wilson	jwilson@agi.com	

RFI Contacts

Name	E-mail	Phone
Jim Wilson	jwilson@agi.com	

Space Data Center Operations Statistics

SDC FOC Statistics To Date

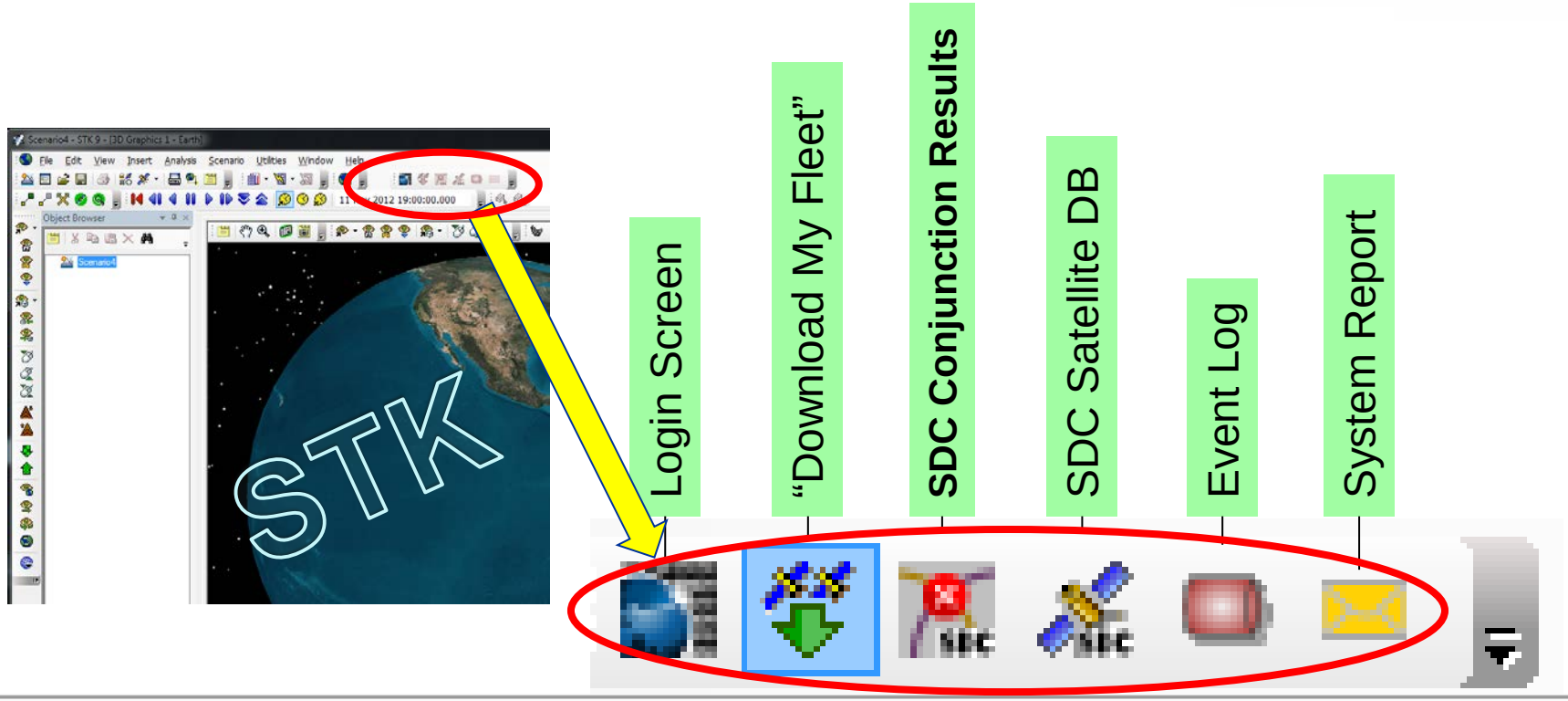
- **Ephemeris files uploaded:**
  - 248,827 operational
  - 2012 training
  - 26 maneuver
- **CA runs executed: 6993**
- **CA satellite pairs processed: 18,132,248,388 (*18 billion!*)**
- **Conjunctions detected: 4,286,915**
- **TLEs in database: 24,906,602**
- **Satellites in database: 16,382 of which 325 are SDA participants and remainder are non-SDA active or debris**

SDC fuses multi-source data multiple ways

- **Each operator's data enables SSA for the others**
- **SDC created to facilitate fusion of most-authoritative operator & tracking data available**
  - On-the-fly data conversion and normalization
  - Automated (Web Services) or manual (UI) up/download
  - Most SDA operators upload data to SDC in fully automated manner via web services
  - **SDC Plugin for STK** to permit operators to easily fuse authorized data in single, customizable scenario

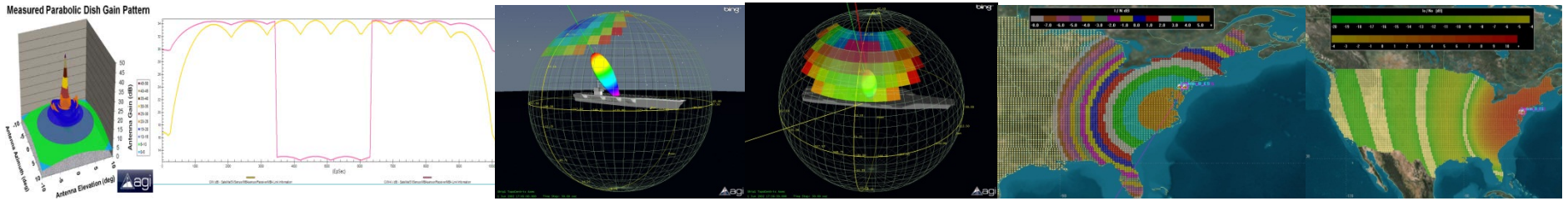
Introducing the New SDC Plugin…

- AGI=creator of SDC and Systems Tool Kit (STK)
- SDC Plugin easily populates STK w/SDC data
- Under the hood: Full SDC security, web services
- Clean interface for straightforward operations



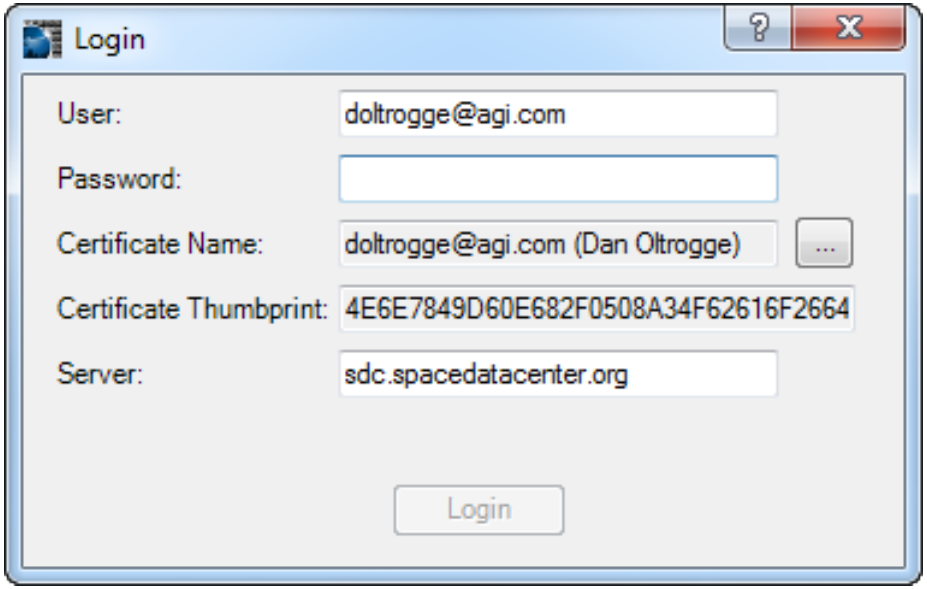
SDC Analysis Via The SDC Plugin

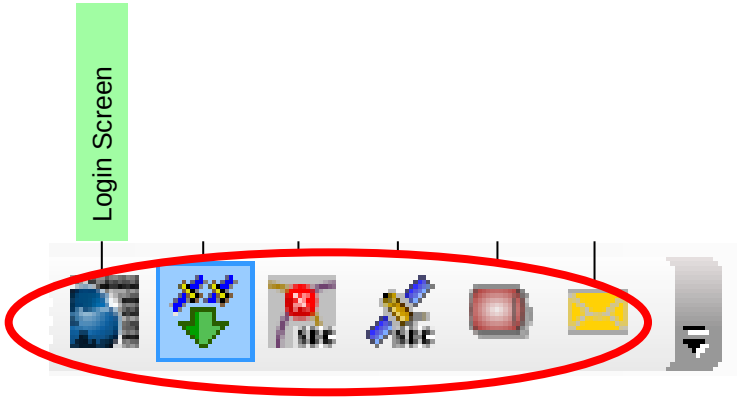
- **The SDC AND new SDC Plugin for STK enable SDA Flight Dynamists, RFI Analysts and support organizations to easily perform:**
  - ☑ Reactive analyses
    - Flight Dynamics Staff (FDS): Post-collision breakup modeling, CA trending
    - RFI: CID, TDOA/FDOA geolocation, Rx Pwr Spectral Density geolocation)
  - ☑ Proactive/preemptive analyses
    - FDS: Collision avoidance, maneuver planning, satellite transits (fly-by!)
    - RFI: fly-bys, intelligent screening, pre-computed geolocation solution sets, coverage, transits)



SDC Login Access

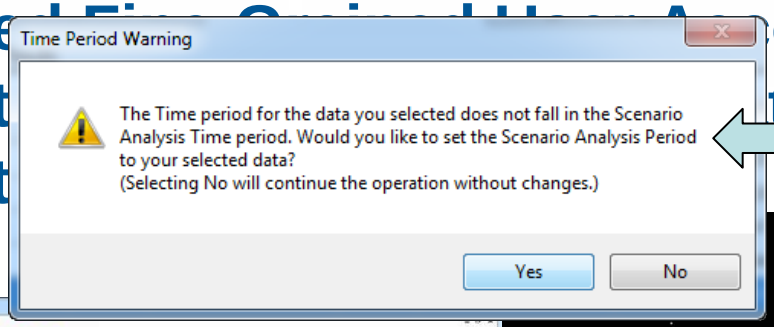
- SDC employs full 3-tier verification using a variety of credentials and secure access features to ensure users “belong”
- SDC Plugin negotiates handshake w/SDC



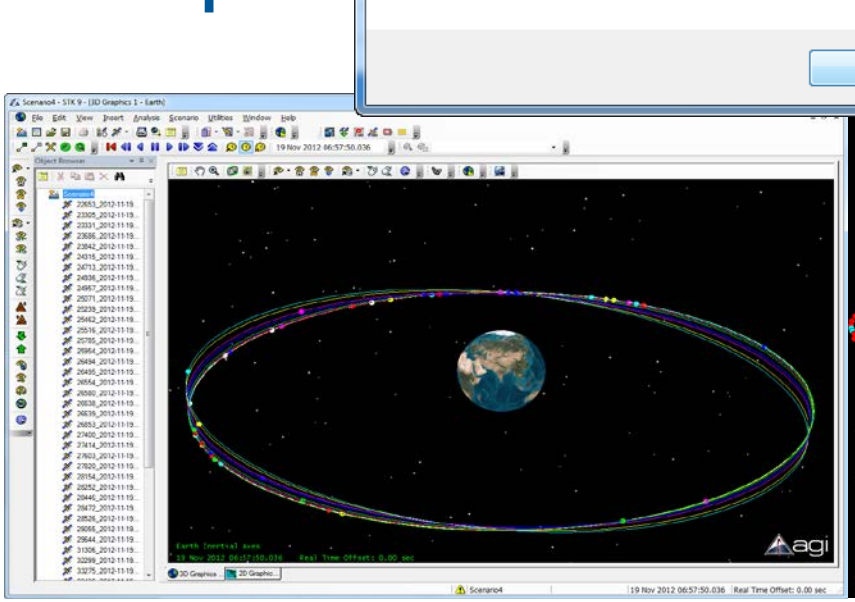


“Download My Fleet” Function

- **Provides immediate capability to populate STK with all of your latest ephemerides (and eventually, RF parameters and antenna pointing)**
- **Planned Fine-Grained User Access feature will permit [illegible] complex, multi-operat[illegible]**

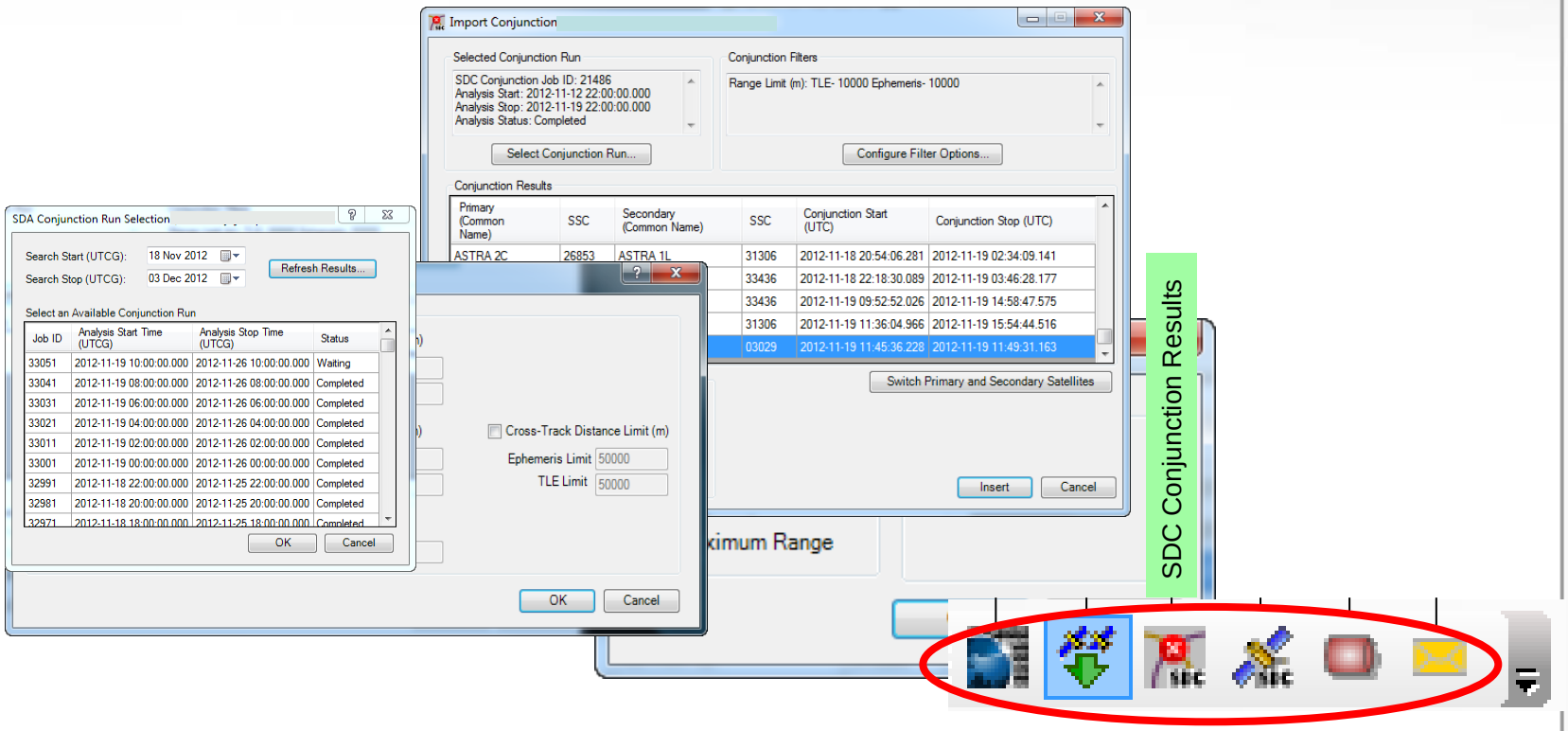


Scenario time interval automatically adjusted to match SDC data



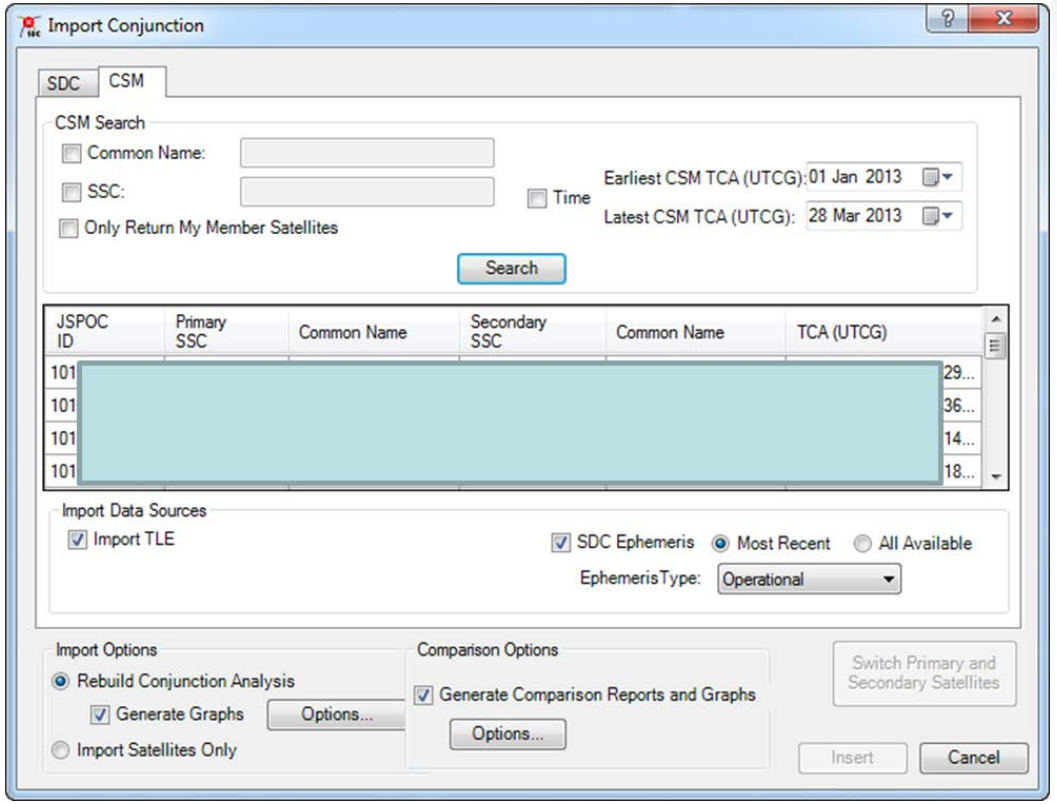
Conjunction Assessment

- **Full support to conjunction analysis**
  - Detection of collision risk
  - Avoidance maneuver planning and optimization



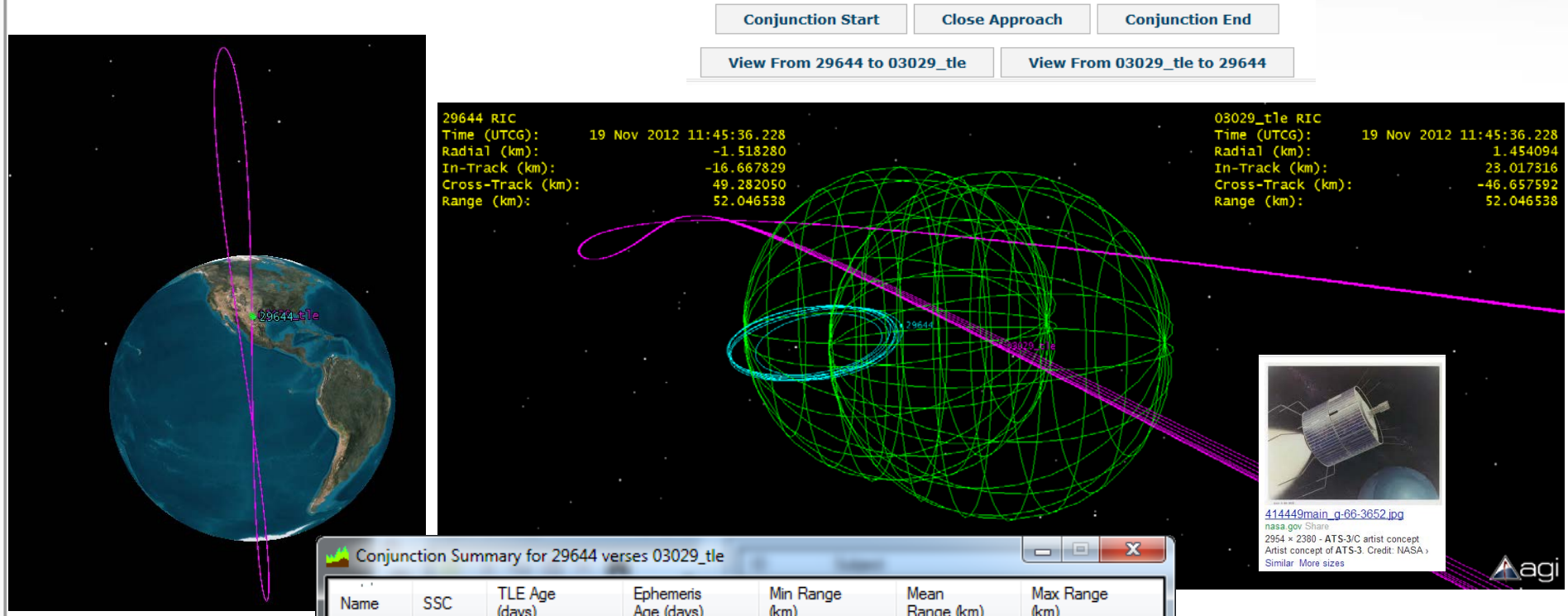
Comparison W/External CA Sources

- **SDC Plugin rapidly compares/contrasts multi-source data**
  - Conjunction predictions (SDC and JSpOC CSM)
  - Satellite positions:
    - Operator ephemerides
    - CSM vectors
    - TLE



Conjunction Assessment Visualization

- **Close approaches can be viewed and animated**
  - Green spheres are 10km radii for relative scaling
  - Facilitates understanding for repeated conjunctions

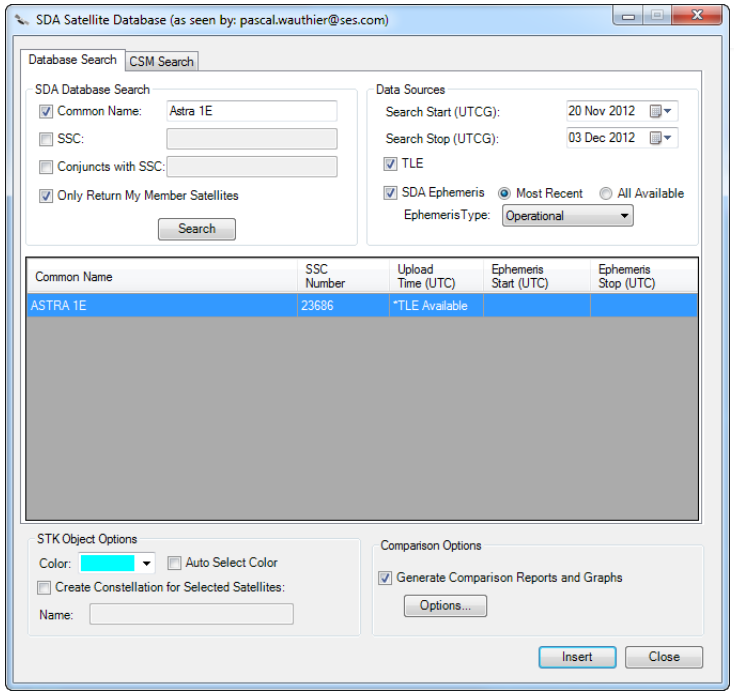


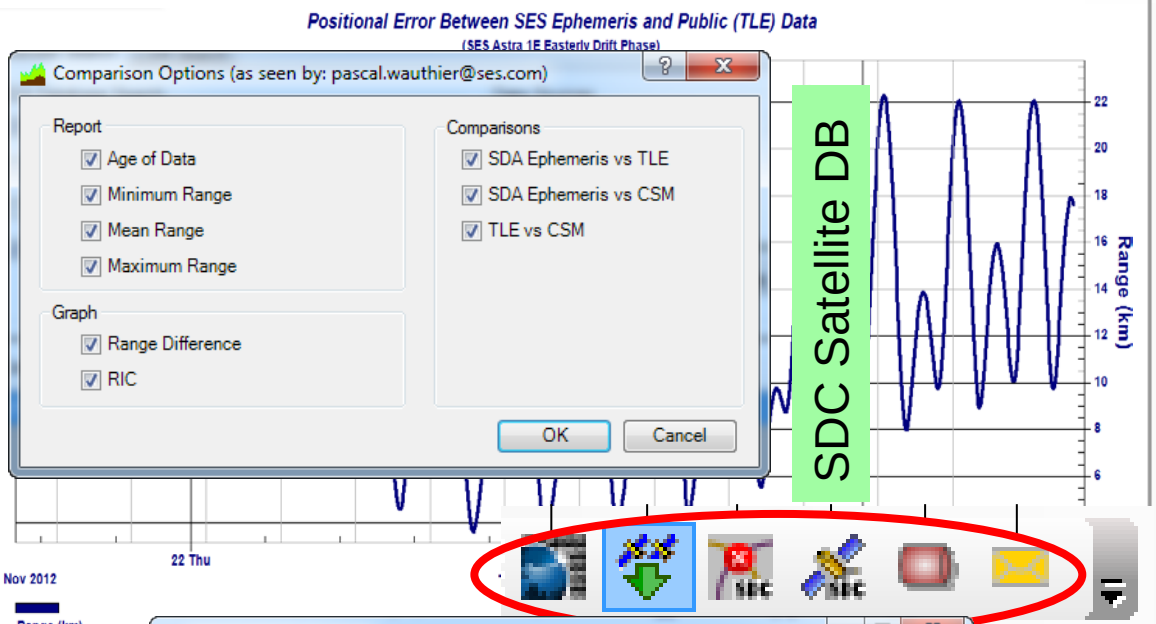
Conjunction Summary for 29644 verses 03029_tle

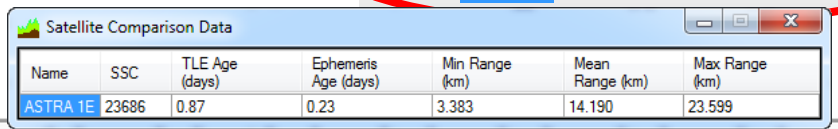
Name	SSC	TLE Age (days)	Ephemeris Age (days)	Min Range (km)	Mean Range (km)	Max Range (km)
AMC-18	29644		6.47	19.890	3567.172	5585.068
ATS 3	03029	6.47		19.890	3567.172	5585.068

SDC Plugin Satellite Database

- SDC Plugin's "Satellite DB" filters & selects any/all satellite objects users are authorized to access
- Also performs powerful comparisons of operator ephemerides with public or other data







Approved

SDC System Messages

- **User can search all SDC system messages affiliated with their account**
  - Filter based upon system time, job status & message

ID	Subject	Creation Date (UTC)
144561	Conjunction Report	20 Nov 2012 00:31:40.000
144551	Conjunction Report	20 Nov 2012 00:31:39.000
144541	Conjunction Report	20 Nov 2012 00:31:39.000
144531	Conjunction Report	20 Nov 2012 00:31:39.000
144521	Conjunction Report	20 Nov 2012 00:31:38.000
144511	Conjunction Report	20 Nov 2012 00:31:38.000
144501	Conjunction Report	20 Nov 2012 00:31:36.000
144491	Conjunction Report	20 Nov 2012 00:31:36.000
144471	Conjunction Report	20 Nov 2012 00:31:35.000
144461	Conjunction Report	20 Nov 2012 00:31:34.000
144451	Conjunction Report	20 Nov 2012 00:31:33.000
144441	Conjunction Report	20 Nov 2012 00:31:33.000
144431	Conjunction Report	20 Nov 2012 00:31:26.000
144421	Conjunction Report	20 Nov 2012 00:30:58.000
144411	Conjunction Report	20 Nov 2012 00:30:57.000
144401	Conjunction Report	20 Nov 2012 00:30:34.000
144381	Conjunction Report	20 Nov 2012 00:30:18.000
144371	Conjunction Report	19 Nov 2012 22:37:40.000
144361	Ephemeris Processing Successful	19 Nov 2012 22:29:03.000
144351	Conjunction Report	19 Nov 2012 22:08:48.000
144341	Ephemeris Processing Successful	19 Nov 2012 22:04:29.000
144291	Conjunction Report	19 Nov 2012 19:27:04.000

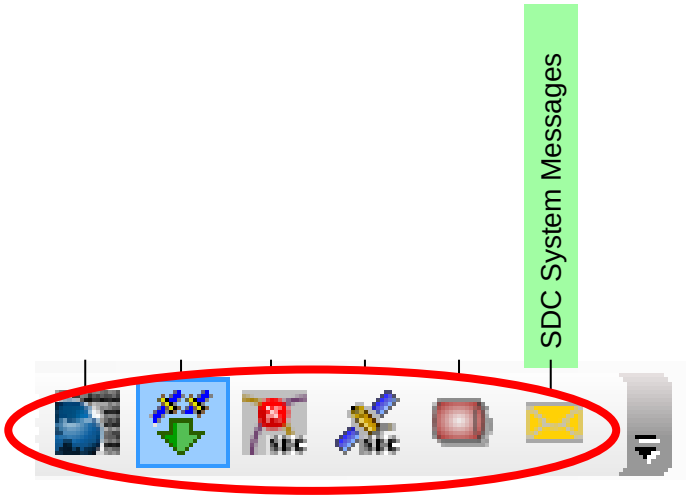
Filtering

From Thursday , November 15, 2012 To Monday , November 19, 2012

Job Status Completed

Message Type

Apply Filter



SDC Plugin: Easy to Build an STK Scenario

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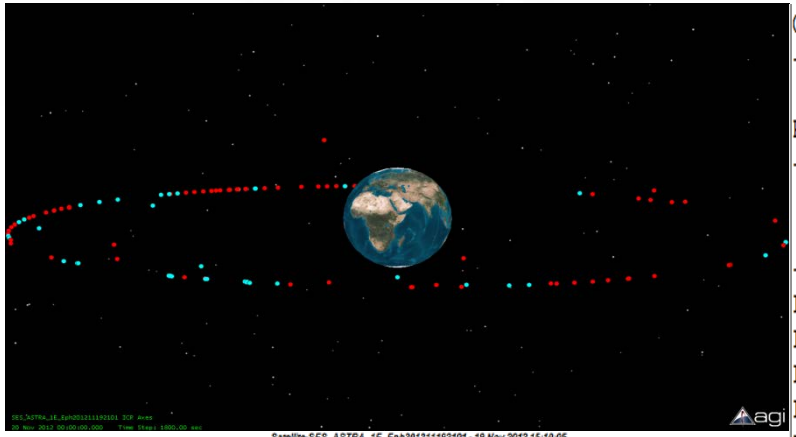
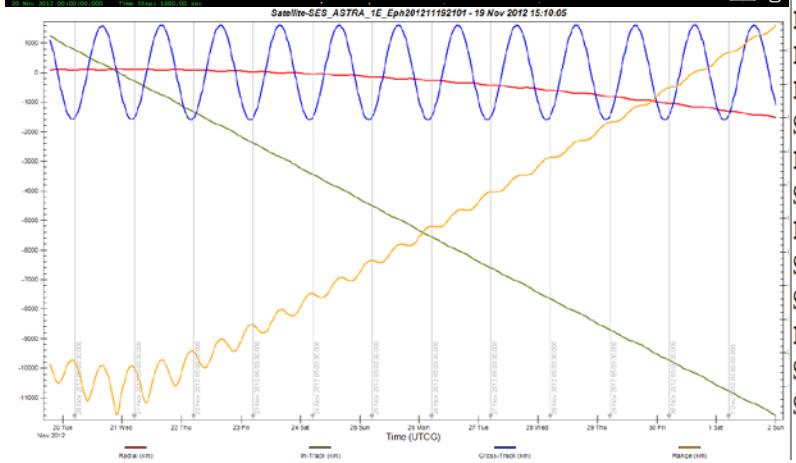
- **Can quickly assess; reveals Astra 1E currently drifting!**

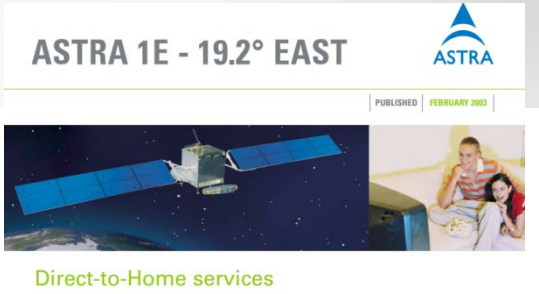




Close Approach Report by Time In

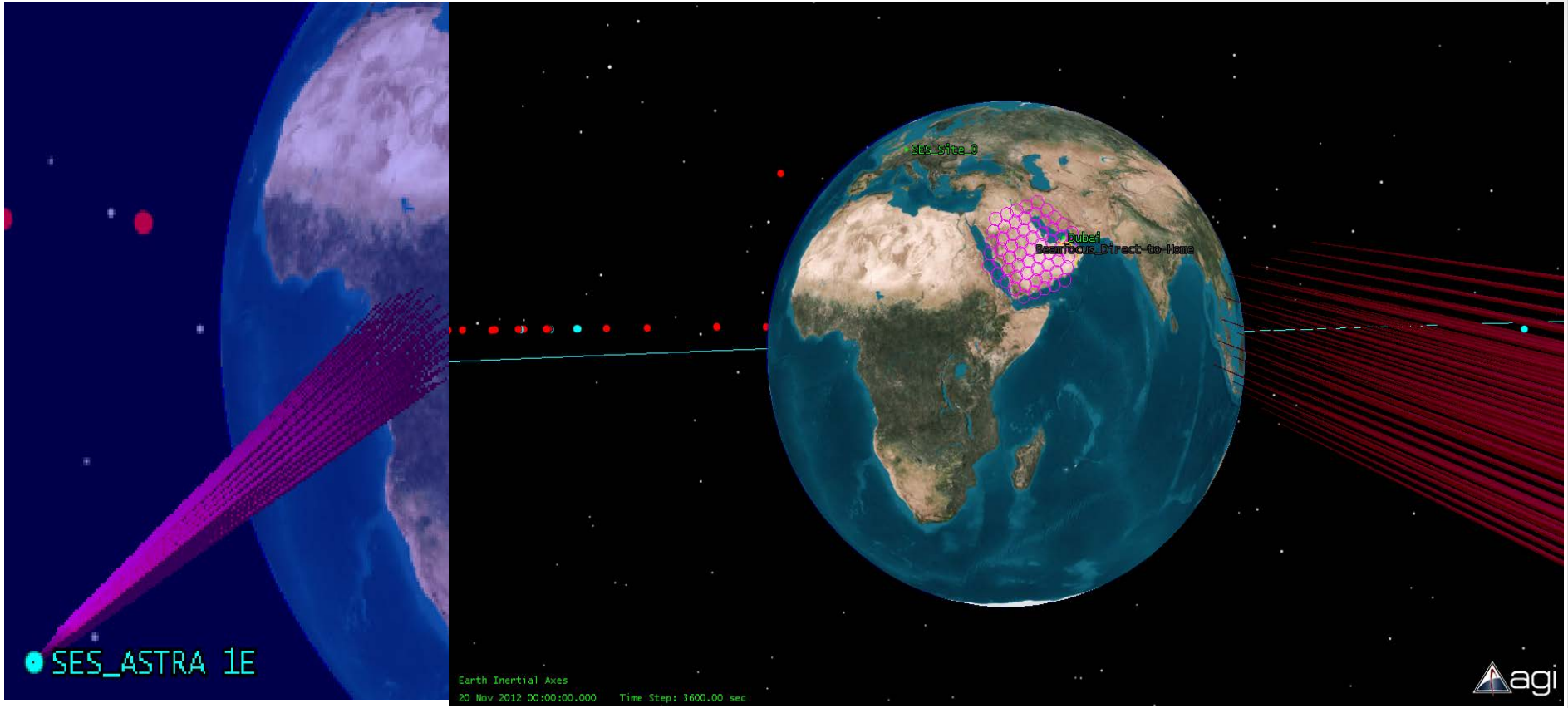
Primary Vehicle: SES_ASTRA_1E_Eph201211192101.sa

Object Name	Time In (UTCG)	Time Out (UTCG)	Min Separation (km)	Min Range (km)
Intelsat_INTELSAT_12__IS-12__Eph201211182034.sa	20 Nov 2012 20:43:47.594	20 Nov 2012 23:05:24.200	121.805812	121.805812
Intelsat_GALAXY_27_G-27__Eph201211182033.sa	20 Nov 2012 20:46:28.598	20 Nov 2012 23:04:51.529	156.142570	156.142570
Intelsat_GALAXY_27_G-27__Eph201211182033.sa	21 Nov 2012 09:13:10.489	21 Nov 2012 10:14:00.736	453.181541	453.181541
Intelsat_INTELSAT_709_IS-709__Eph201211182031.sa	22 Nov 2012 08:27:22.271	22 Nov 2012 10:54:34.261	313.465799	313.465799
Intelsat_INTELSAT_709_IS-709__Eph201211182031.sa	22 Nov 2012 20:00:54.308	22 Nov 2012 22:46:01.409	246.116122	246.116122
Intelsat_INTELSAT_26_IS-26__Eph201211182039.sa	24 Nov 2012 07:22:25.421	24 Nov 2012 09:07:28.887	309.490618	309.490618
Intelsat_GALAXY_26_G-26__Eph201211182033.sa	24 Nov 2012 08:10:25.154	24 Nov 2012 10:30:16.068	115.940016	115.940016
SES_NSS-5_Eph201211192100.sa	24 Nov 2012 08:38:43.272	24 Nov 2012 10:06:47.356	436.302256	436.302256
Intelsat_INTELSAT_26_IS-26__Eph201211182039.sa	24 Nov 2012 19:05:59.114	24 Nov 2012 21:03:24.445	241.542742	241.542742
SES_NSS-5_Eph201211192100.sa	24 Nov 2012 19:39:23.924	24 Nov 2012 22:34:09.330	150.394731	150.394731
Intelsat_GALAXY_26_G-26__Eph201211182033.sa	24 Nov 2012 20:55:33.859	24 Nov 2012 21:23:10.693	490.420534	490.420534
SES_ASTRA_1F_Eph201211192101.sa	27 Nov 2012 08:40:03.286	27 Nov 2012 09:20:20.165	480.017139	480.017139
SES_ASTRA_1F_Eph201211192101.sa	27 Nov 2012 19:38:02.721	27 Nov 2012 21:59:50.903	120.187579	120.187579
Intelsat_INTELSAT_10__IS-10__Eph201211182039.sa	28 Nov 2012 19:24:58.374	28 Nov 2012 21:51:11.120	140.052346	140.052346
SES_NSS-12_Eph201211192101.sa	28 Nov 2012 20:16:22.765	28 Nov 2012 21:09:03.060	465.454699	465.454699
SES_NSS-12_Eph201211192101.sa	29 Nov 2012 07:21:04.520	29 Nov 2012 09:40:35.724	145.280244	145.280244



RF Parameters Fully Populated…

- **When SDC RF parameters fully populated, extensive proactive/preemptive analyses will be possible.**



SDC Plugin Summary

- **SDC Plugin provides easy access to user-friendly, tailored analysis of SDA member data**
  - Augments SDC rich repository of SOAP and REST web services for automated machine-to-machine interface
  - Allows SDC users to obtain any/all SDC data they are authorized to access
    - SDC ephemerides and maneuvers populated by operators
    - SDC RF parameters and RFI alerts to be populated as well.
- **SDC Plugin released January 2013**
  - ***Free*** to SDA members; requires compatible STK licenses
  - Made available on SDA Shared Code Repository
- **SDC Plugin v1.1 targeted for 29 March to comply w/new Space-Track.org CSM format**

Dull but Terribly Important

Terribly Dull and Terribly Unimportant

Terribly Interesting and Terribly Important

"Degrees-of-Terrible" Meter

SDA Users Meeting: SDA General Forum

HOW YOU CAN BENEFIT: CONJUNCTION ASSESSMENT

DAN OLTROGGE

What Are Key SDC CA Benefits?

- **Conjunction assessment (CA) is branch of Space Situational Awareness (SSA) discipline**
- **Key differentiators of SDC SSA analyses are:**
  1) Data normalization of operator data
  2) Data fusion of authoritative data
  3) Ongoing research into CA actionability
  4) Ongoing SDC performance & data quality assessment
     - TLE and CSM automated comparisons
     - Ephemeris precision analyses
- **We now examine each of these aspects**

SDC Data Normalization

- **Accepting operator satellite data in their formats & frames is a key SDC attribute**
  - Operator doesn't have to procure new software or produce new data format/content
- **SDC ingests operator's current data**
  - Any format or content acceptable
  - Centralized implementation of converters facilitates consistent conversion practices and approaches.
  - CSSI experienced in nuances and complexities of reference frames and timing systems

SDC Data Normalization (cont)

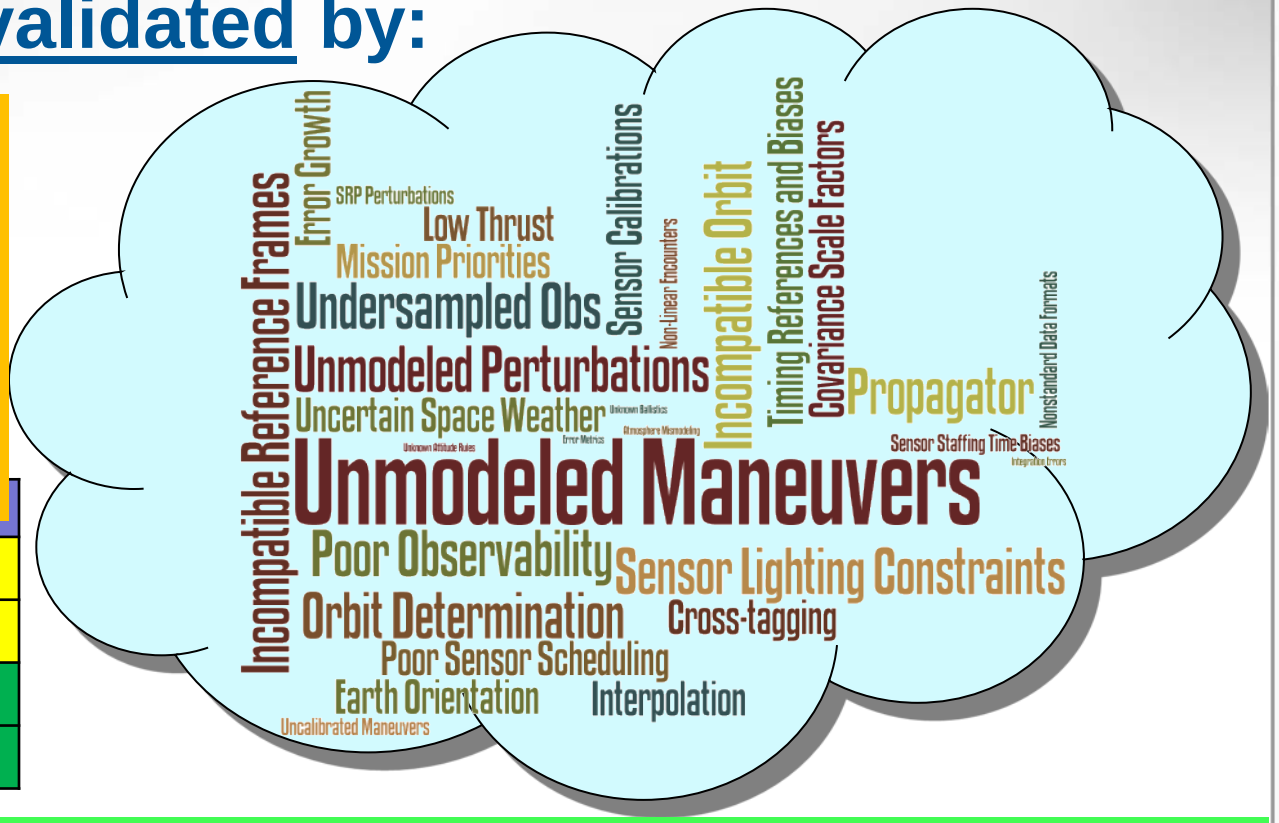
- **Too many potential pitfalls to risk NOT doing due diligence in conversion of external data**
  - SDC/operator dialog to convert data properly
  - Many astrodynamics terms “overloaded”
    - Reference frame names, ballistic coeff., element sets
- **CSSI works to ensure data worthy of SDC use**
- **SDA and CSSI also actively developing and promoting international astrodynamics and data exchange standards for space operations**

Why the Focus on Data Fusion?

- **Space Situational Awareness (SSA) degraded/invalidated by:**

- Don't need a license to become a parent
- Don't need to prove suitability of SSA data or analysis to generate conjunction assessment or RFI mitigation results

Radar		
Optical		
RF Interferometry		
Operator Ranging		



SDC circumvents many of these issues by:
- Careful, methodical fusion of "authoritative" operator & tracking data (as available)
- Automated, continuous performance assessment & comparison w/external sources

Must Consider CA "Actionability"

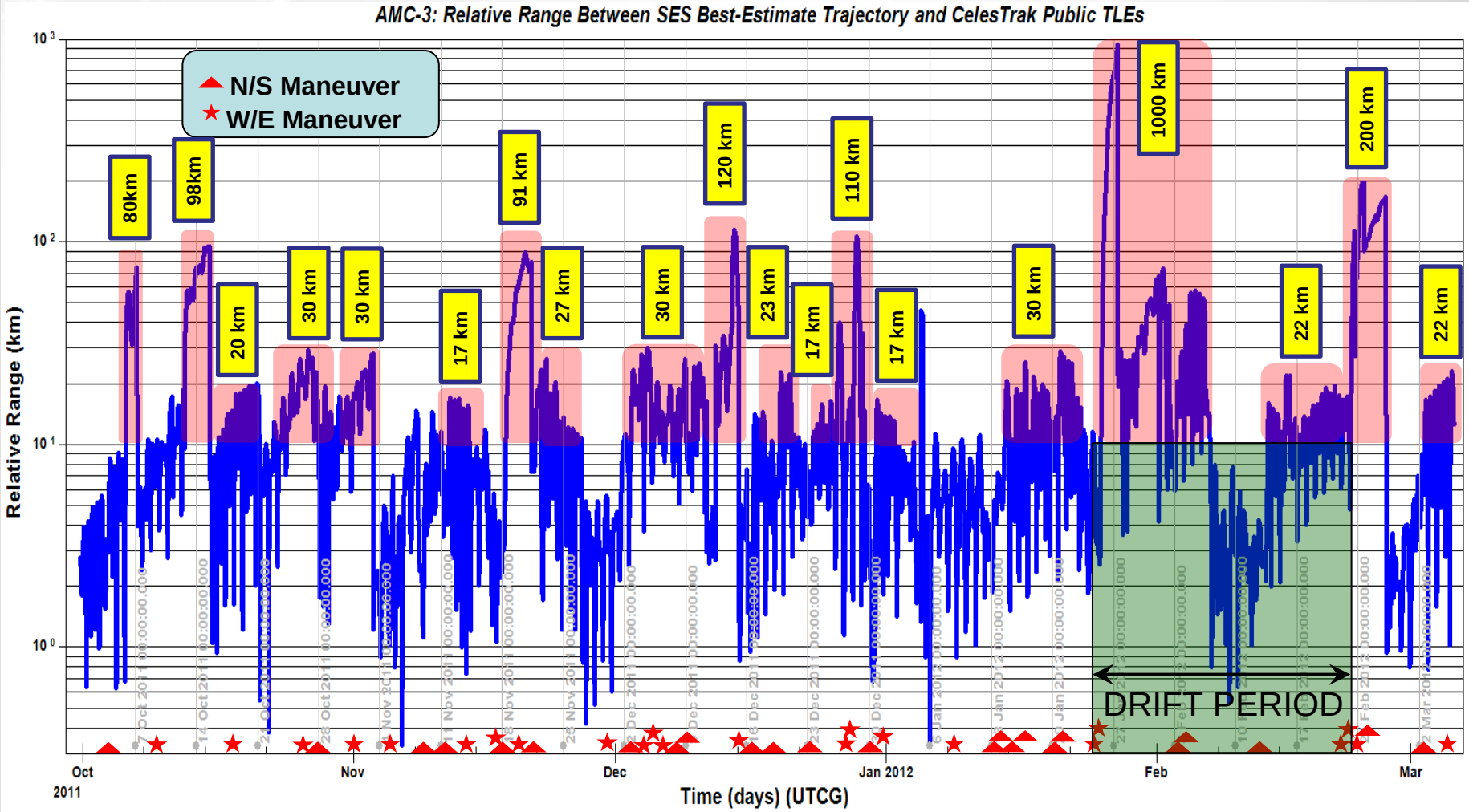
- **Conjunction Assessment (CA) actionability and data quality directly linked**
- **CSSI's CA research characterizes actionable data quality requirements**
- **Orbit solutions corrupted by unknown maneuvers**
  - (i.e. 1×10^{-300} risk!)

GEO Case	Maximum Probability
Operator data	$1/150$
Radar/Optical vs Operator	$1/800$
Radar/Optical	$1/2000$
Radar/Optical TLEs vs Operator	$1/5000$
Radar/Optical TLEs	$1/12000$
Radar/Optical orbit fit thru maneuver unknowingly	1×10^{-300}

*Representative Results from 2011 "Improving Our Vision" SSA Conference Study

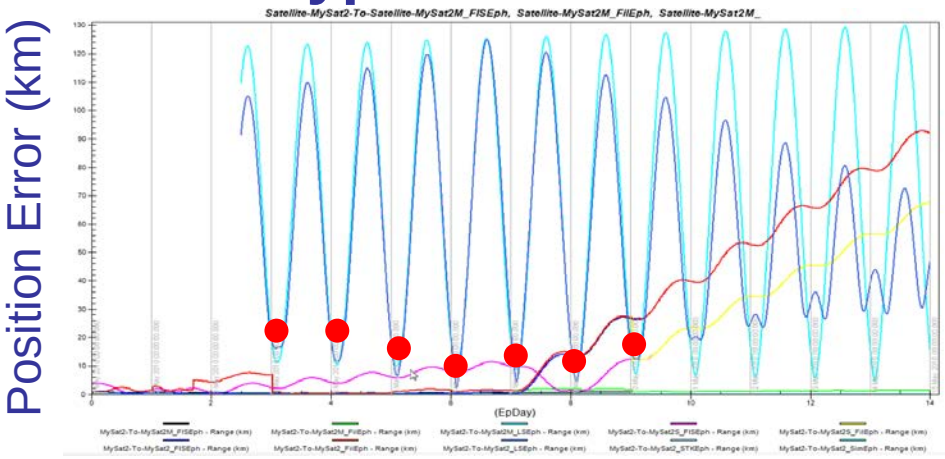
Impact of Maneuvers on SSA

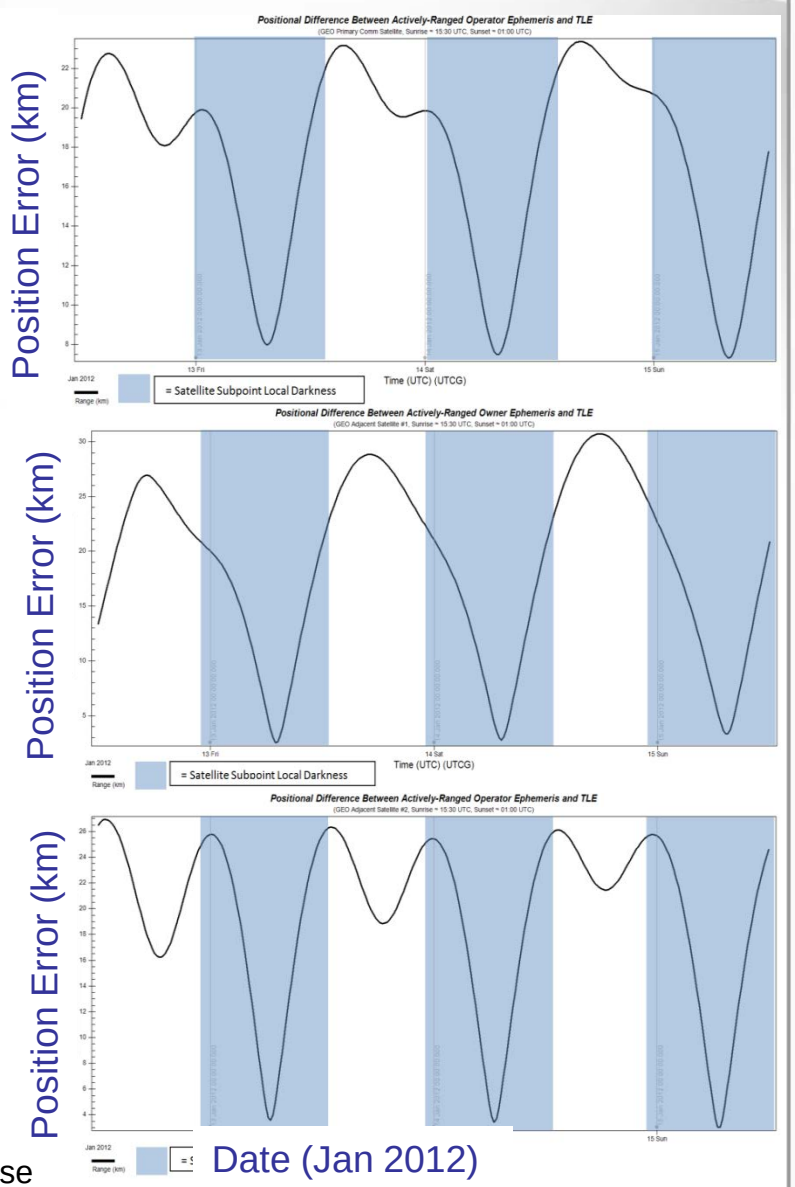
- **AMC-3 6-mo In-Family Maneuver Sequence:**



Impact of Optical Lighting on SSA

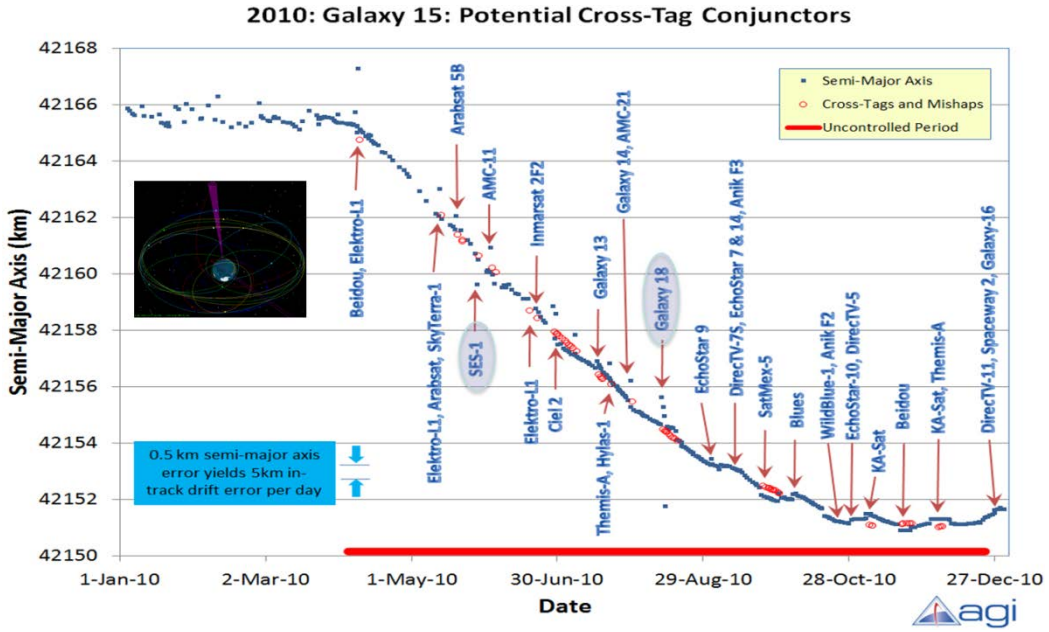
- **Analysis of 3 randomly-selected satellites reveal distinct TLE night-favoring accuracy trend**
  - Night performance ≈3 km; day=35 km
  - Operator data confirmed to be better
  - Optical obs systemic undersampling
- **Solution: data fusion w/other sensor types**





Impact of Radar/Optical Cross-Tags

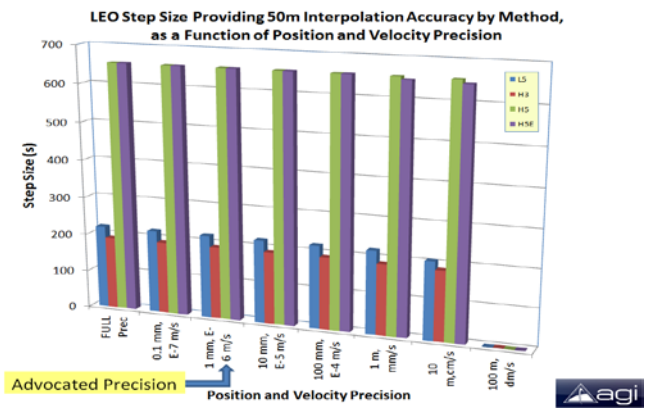
- **Evaluation of GEO orbits reveals as much as 18% of a satellite's TLEs likely corrupted by cross-tagging and track mis-association**
  - Orbit-dependent; median (typically) more like 3%
  - But if in lucky 18th-percentile… ≈1 of 5 TLEs bad

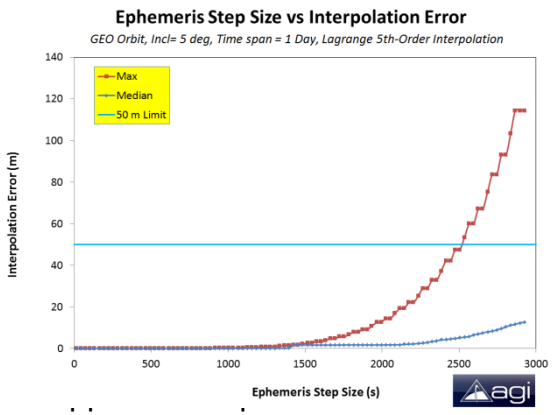


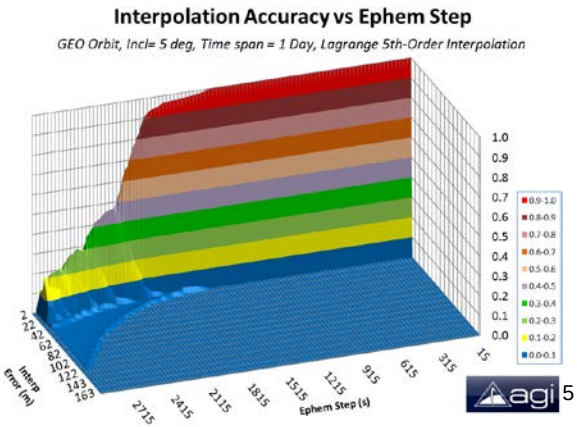
Data Fusion Research at AGI: The Science of External Data Rqmts:

- **SDC external data requirements**
  - Encouraging operator best practices and Int'l Stds
    - Orbit Determination, EOP, Space Wx, ephemeris data exchange
  - Ephem step size, digits-of-precision, interp. schemes
  - Ephem length and upload frequency

$$Eph_{Dura} = Timespan_{SDC} + P_{Upload} + Delay_{Upload} + 2day\_Pad$$







SDA Users Meeting: SDA General Forum

HOW YOU CAN BENEFIT:
LAUNCH AND EARLY ORBIT PHASE (LEOP)

DAN OLTROGGE

SDC Now Processes LEOP

- **New capability to store and perform CA for space objects not yet in JSpOC catalog**
- **SDC defines temporary "*Analyst Satellite*" during LEOP that transitions to actual SSC**
- **Steps (in SDC LEOP Ops Procedure):**
  - Member requests LEOP via SDC-Support@agi.com
  - SDC Support coordinates SDC Team
  - SDC Operations dialogues with SDA member
    - Obtain sample ephemeris format/file
    - Select existing or prototype new data converter
    - SDC Development assigns or implements converter

LEOP Temporary ID Assignments

- **SSC Temporary IDs assigned by number**

SSC Range	***Operator***
77810-77819	AMOS
77820-77829	Arabsat
77790-77799	Avanti
77740-77749	EchoStar
77870-77879	Eumetsat
77720-77729	Eutelsat
77800-77809	GE
77750-77759	GeoEye
77880-77789	GISTDA
77710-77719	Inmarsat
77780-77789	Intelsat
77860-77869	NASA
77830-77839	NOAA
77850-77859	Optus
77730-77739	Paradigm
77700-77709	SES
77770-77779	Space Systems/Loral
77760-77769	StarOne
77840-77849	Telesat

LEOP Missions Supported To Date

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Satellite	SSC	Operator
Amazonas 3 launch	77773	Space Systems/Loral
Astra 2E launch	77701	SES
Astra 2F Launch	77700	SES
Echostar 16 launch	77740	Space Systems/Loral
Echostar 17 launch	77778	Space Systems/Loral
Eutelsat 21B Launch	77720	Eutelsat
Eutelsat 70B launch	77721	Eutelsat
Intelsat 20 Launch	77780	Intelsat
Intelsat 21 Launch	77781	Intelsat
Intelsat 23 Launch	77783	Intelsat
Intelsat 27 Launch	77782	Intelsat
SES-5 launch	77777	Space Systems/Loral
SES-6 launch	77702	SES
Skynet 5D Launch	77703	Paradigm Services Ltd
Star One C3 Launch	77760	StarOne
SatMex 8 Launch	77771	SES
Anik G1	77772	SES

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SDA Users Meeting: SDA General Forum

AUTOMATED DATA ANALYSIS: TLE COMPARISONS

TS KELSO

Process

- **Performed as part of up-front validation**
- **Repeated weekly**
  - Automatically analyzes differences between ephemerides & TLEs
    - RIC range (2D and 3D)
    - Latitude vs. longitude (GEO only)
    - Longitude & inclination history (GEO only)
    - In-track & cross-track acceleration (GEO) or jerk (LEO)
  - Report results via e-mail with web access

Reports

- **Echoes operational & ephemeris status (Table 1)**
- **Summarizes age of data & differences (Table 2)**
- **Shows individual results**
  - Ensure good match when no issues
    - Maneuvers, cross-tags
  - Assesses impacts of SSN performance
    - Delays to resolve maneuvers
- **Report issues to operator and/or JSpOC**

SPACE DATA ASSOCIATION

Ephemeris-TLE Comparisons

Dr. T.S. Kelso

SDC Operations Manager

Process

- **Performed as part of up-front validation**
- **Repeated weekly**
  - Automatically analyzes differences between ephemerides & TLEs
    - RIC range (2D and 3D)
    - Latitude vs. longitude (GEO only)
    - Longitude & inclination history (GEO only)
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Reports

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  - Assesses impacts of SSN performance
    - Delays to resolve maneuvers
- **Report issues to operator and/or JSpOC**

Satellites to be Validated

Table 1. Satellites to be Validated

Official Name	NORAD Catalog Number	Ephemeris Upload (UTC)	Ephemeris Start (UTC)	Ephemeris Stop (UTC)	Ops Status
ECHOSTAR 3	25004	2013 Mar 08 01:30:17	2013 Mar 04 23:30:27	2013 Mar 25 23:30:27	+
ECHOSTAR 7	27378	2013 Mar 08 01:30:18	2013 Mar 04 21:30:30	2013 Mar 25 21:30:30	+
ECHOSTAR 12 (RAINBOW 1)	27852	2013 Mar 08 01:30:22	2013 Mar 05 16:31:16	2013 Mar 26 16:31:16	+
ECHOSTAR 10	28935	2013 Mar 08 01:30:19	2013 Mar 04 14:30:33	2013 Mar 25 14:30:33	+
ICO G1	32763	2013 Mar 08 01:30:25	2013 Mar 02 17:41:14	2013 Mar 23 17:41:14	+
ECHOSTAR 11	33207	2013 Mar 08 01:30:21	2013 Mar 05 14:30:45	2013 Mar 26 14:30:45	+
ECHOSTAR 14	36499	2013 Mar 08 01:30:26	2013 Mar 07 15:19:55	2013 Mar 28 15:19:55	+
ECHOSTAR 15	36792	2013 Mar 08 01:30:23	2013 Mar 05 15:30:56	2013 Mar 26 15:30:56	+
ECHOSTAR 16	39008	2013 Mar 08 01:30:27	2013 Mar 06 11:29:00	2013 Mar 27 11:29:00	+
Number of satellites screened = 9 Number of satellites with ephemeris = 9 (all current)					

Summary of Results

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Table 2. Summary of Results

Name	SSC	TLE Age (days)	Ephemeris Age (days)	Min Range (km)	Mean Range (km)	Max Range (km)
ECHOSTAR 3	25004	1.88	3.15	2.863	13.816	25.006
ECHOSTAR 7	27378	1.73	3.23	3.717	9.846	14.339
ECHOSTAR 12 (RAINBOW 1)	27852	1.88	2.44	2.609	5.634	7.918
ECHOSTAR 10	28935	1.69	3.52	1.864	6.746	9.798
ICO G1	32763	0.88	5.39	0.012	2.369	5.236
ECHOSTAR 11	33207	1.88	2.52	5.499	9.728	12.771
ECHOSTAR 14	36499	1.56	0.49	2.832	8.278	14.432
ECHOSTAR 15	36792	1.01	2.48	2.311	7.400	11.157
ECHOSTAR 16	39008	3.73	1.65	22.501	28.405	34.524

Comma-delimited File of Summary Results

Range statistics: Min = 0.012 km, Mean = 10.247 km, Max = 34.524 km, Standard Deviation = 7.075 km

PASSED with 0 violation(s) of your range threshold(s) (0.00%).

Individual Results

```
ECHOSTAR 11
1 33207U 08035A   13065.24694652 -.00000081  00000-0  10000-3 0   281
2 33207   0.0444 291.4486 0002927  73.7256 137.8394  1.00271871 17014
```

TLE Age = 1.88 days, Ephemeris Age = 2.52

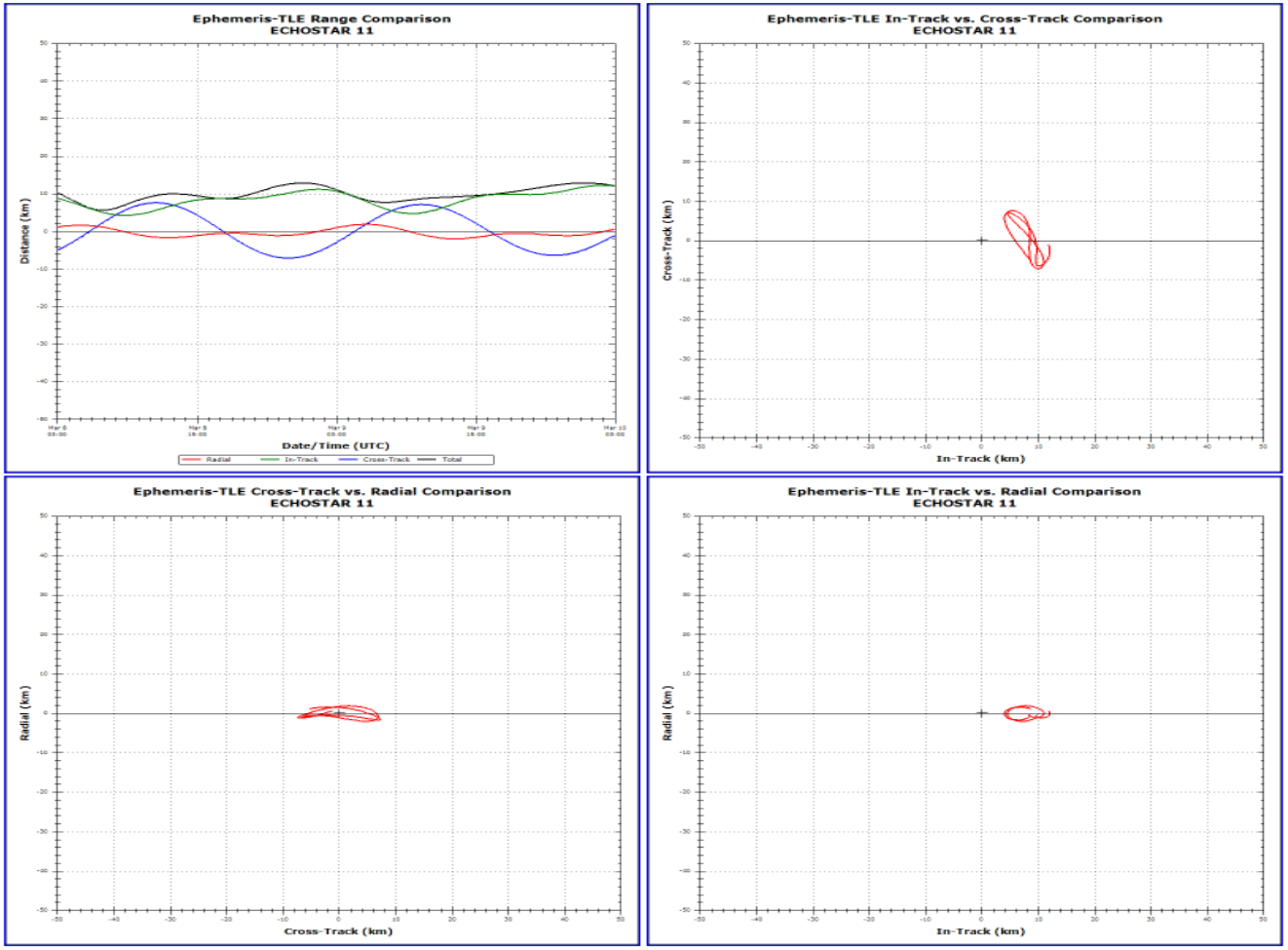


Figure 6a: ECHOSTAR 11 Ephemeris-TLE Range Difference
Min range = 5.499 km, Mean range = 9.728 km, Max range = 12.771 km

Individual Results

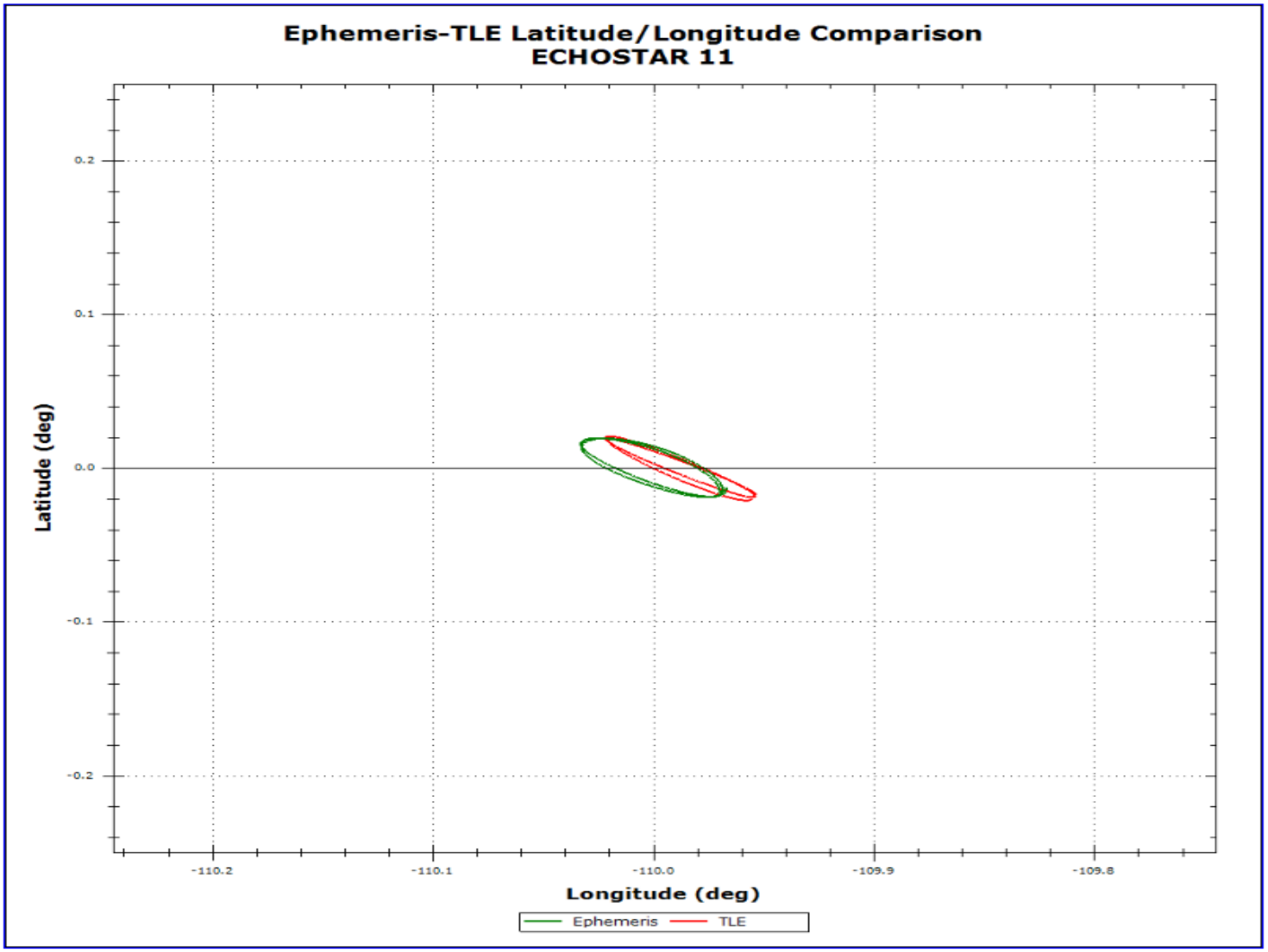


Figure 6b: ECHOSTAR 11 Ephemeris-TLE Latitude vs. Longitude

Individual Results

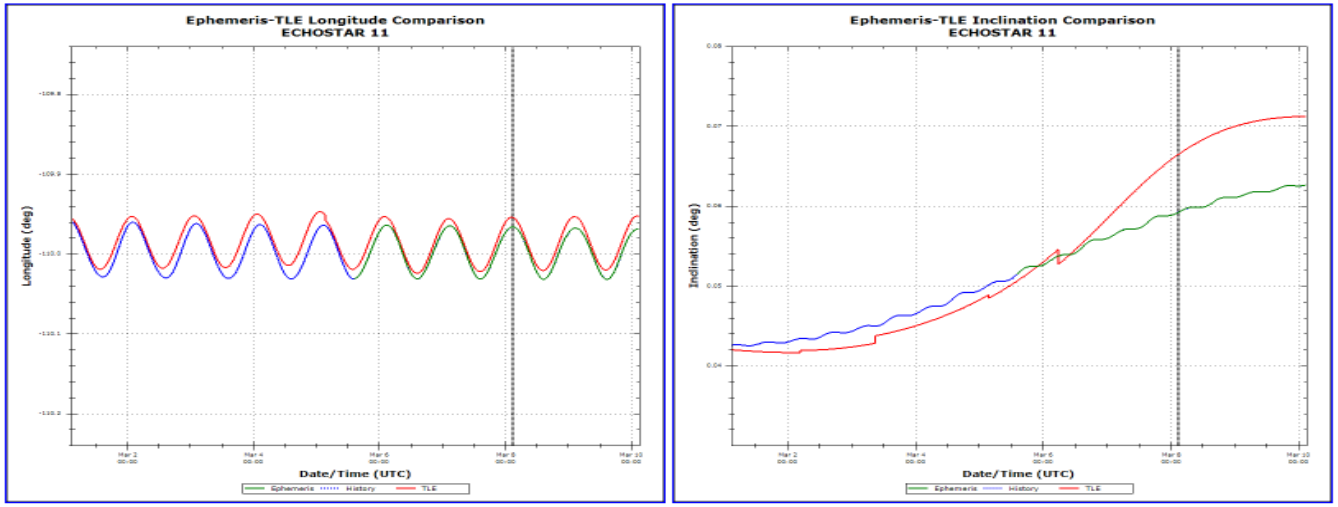


Figure 6c: ECHOSTAR 11 7-day Longitude & Inclination Histories

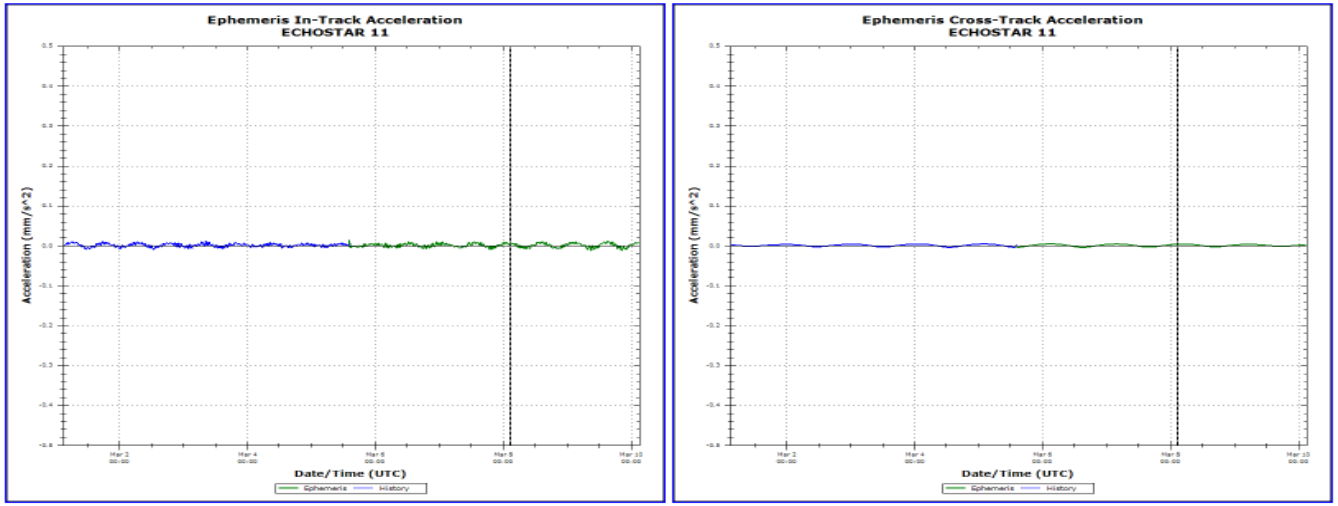
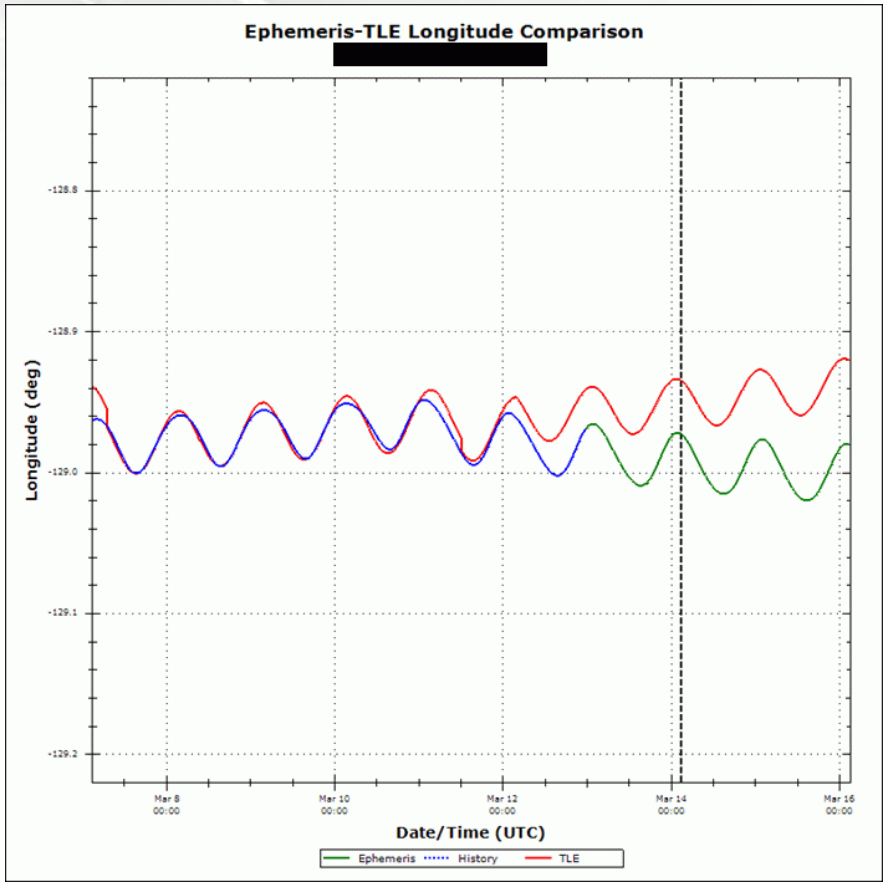
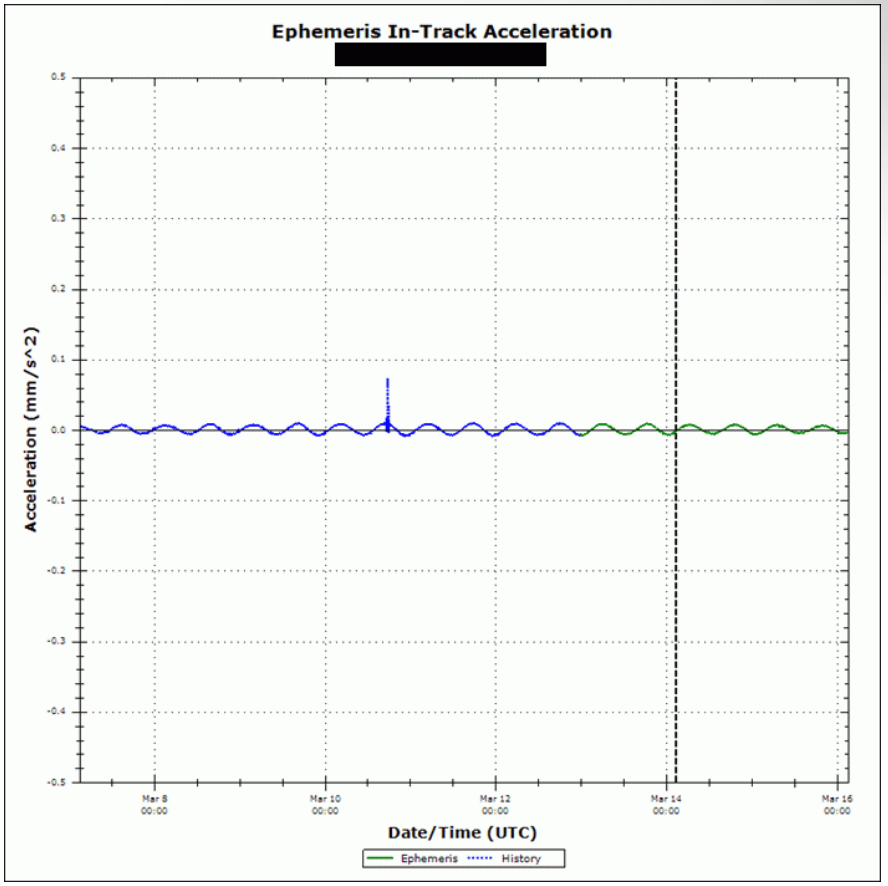


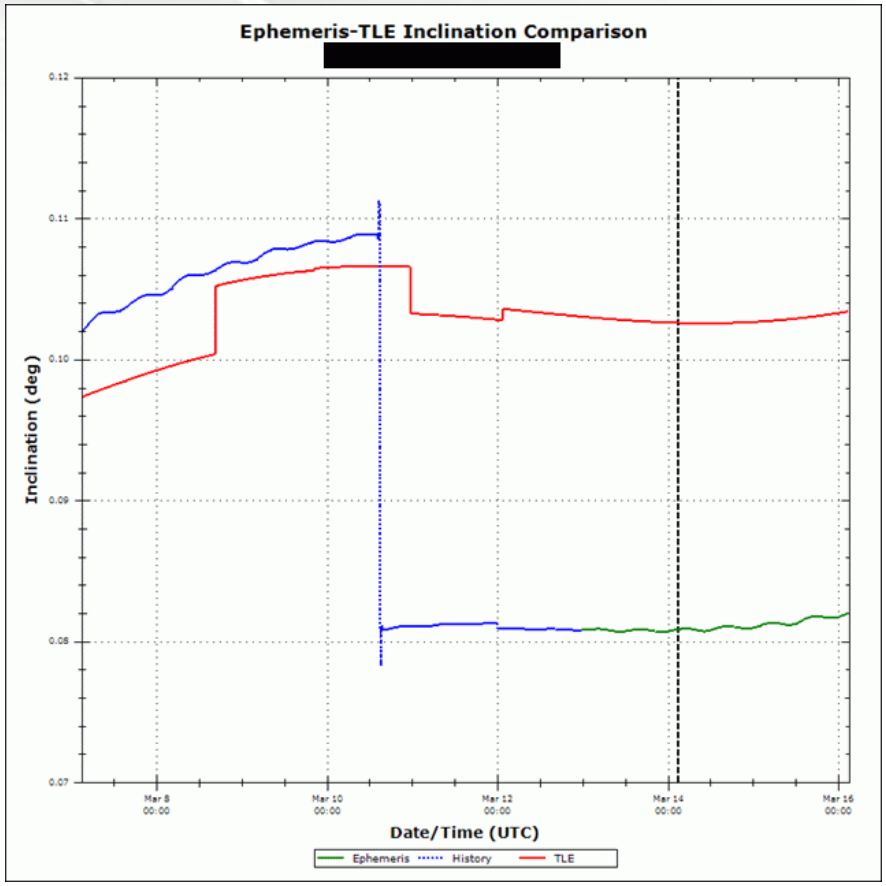
Figure 6d: ECHOSTAR 11 7-day In-Track & Cross-Track Acceleration Histories

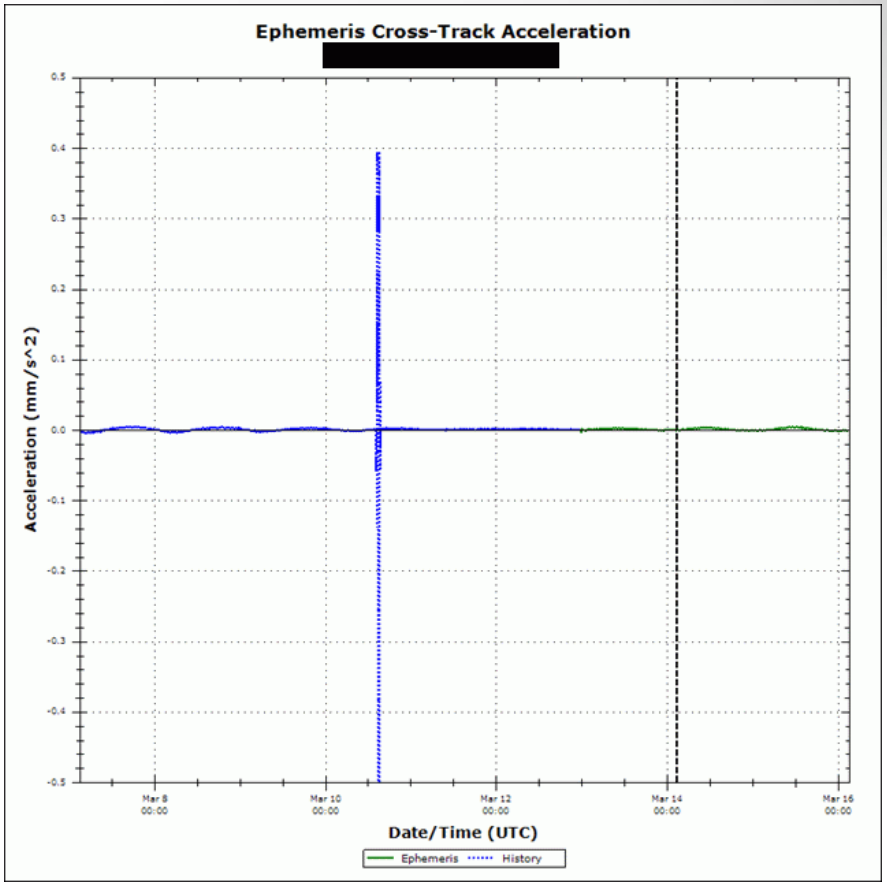
E-W Stationkeeping



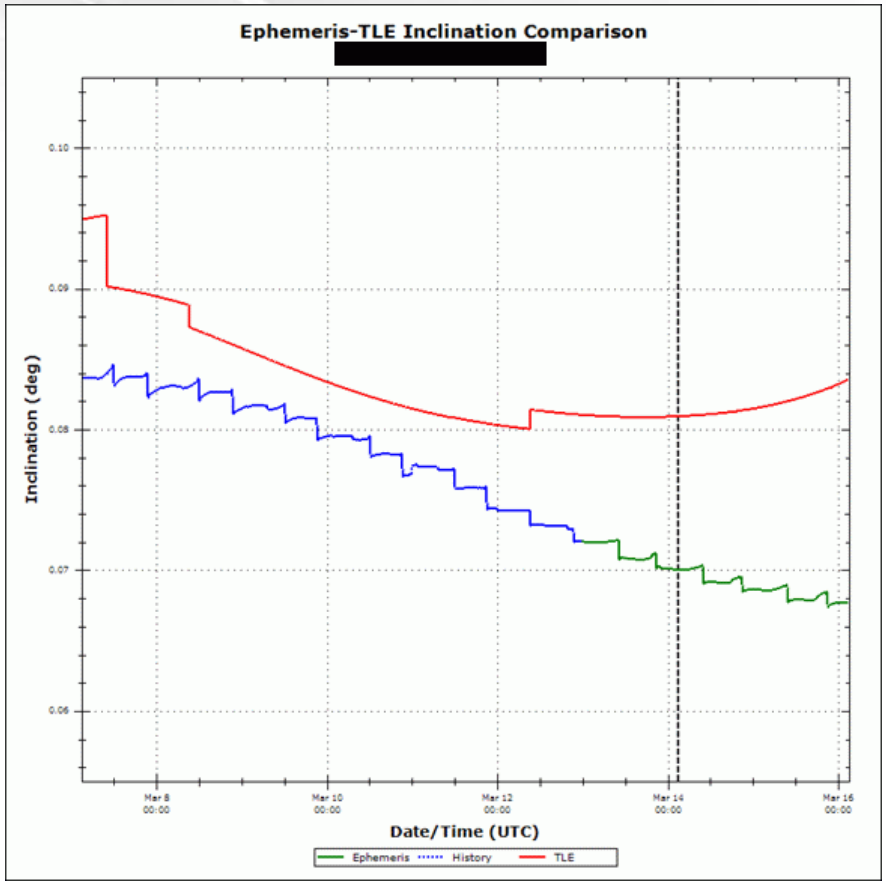


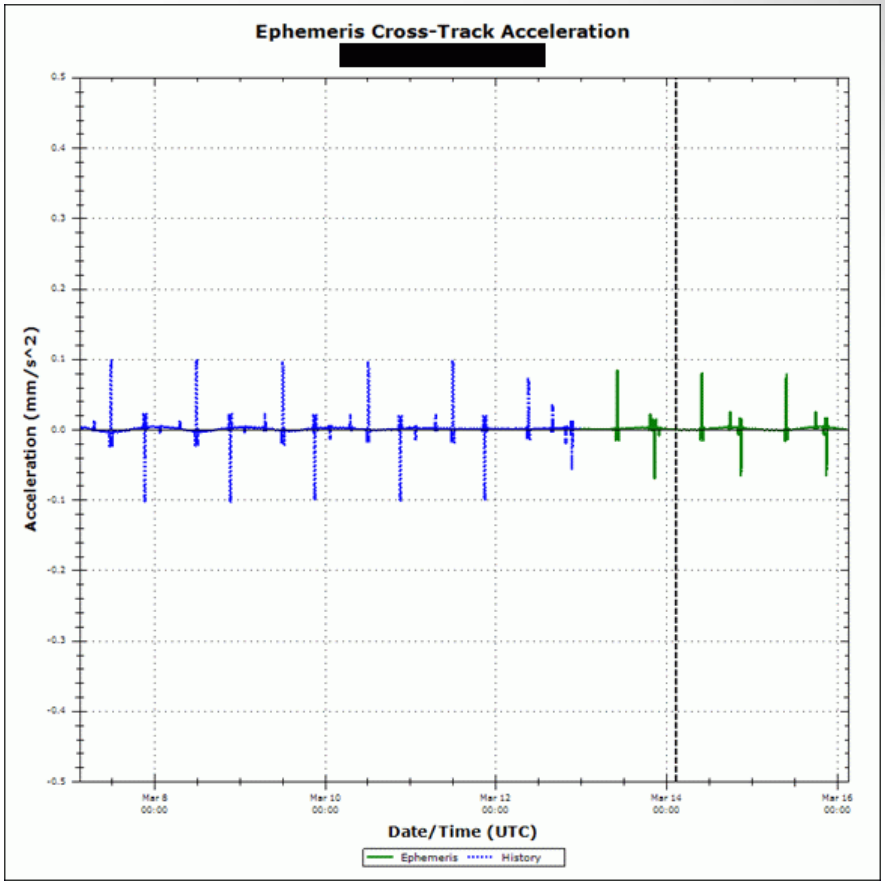
N-S Stationkeeping



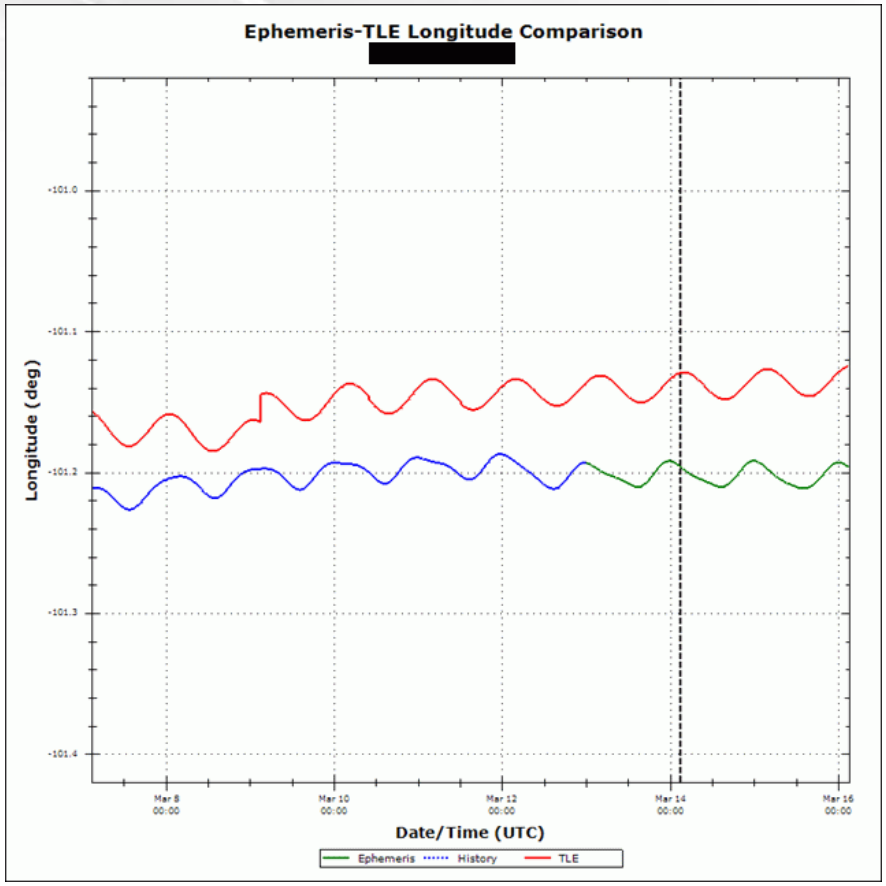


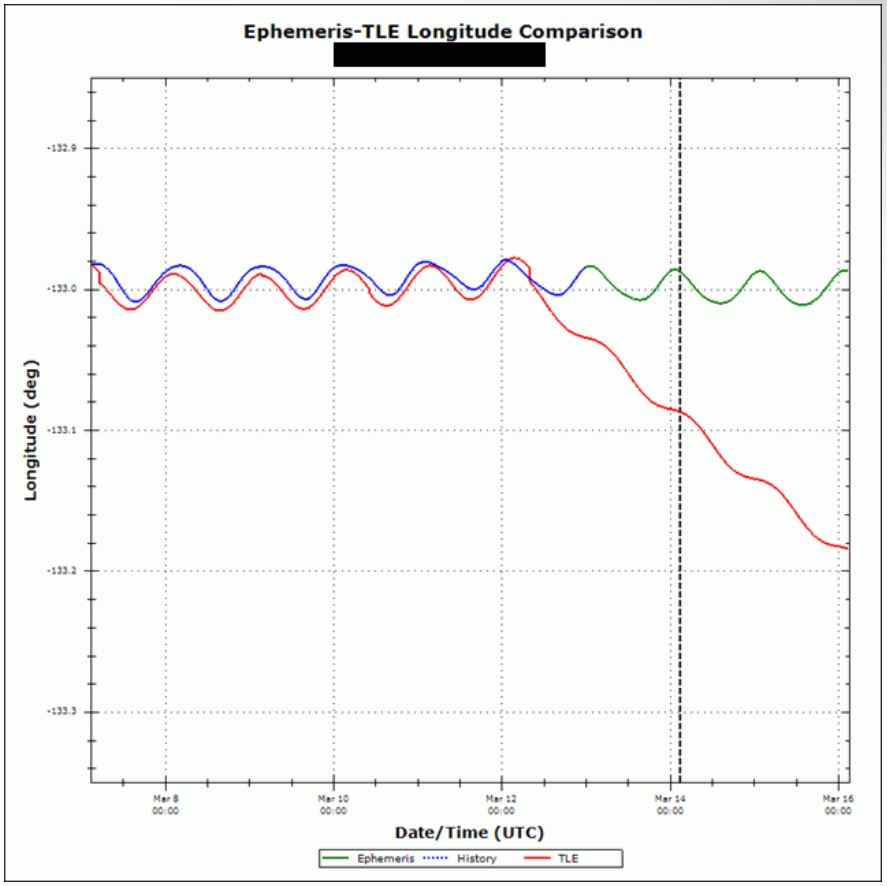
Frequent Maneuvers



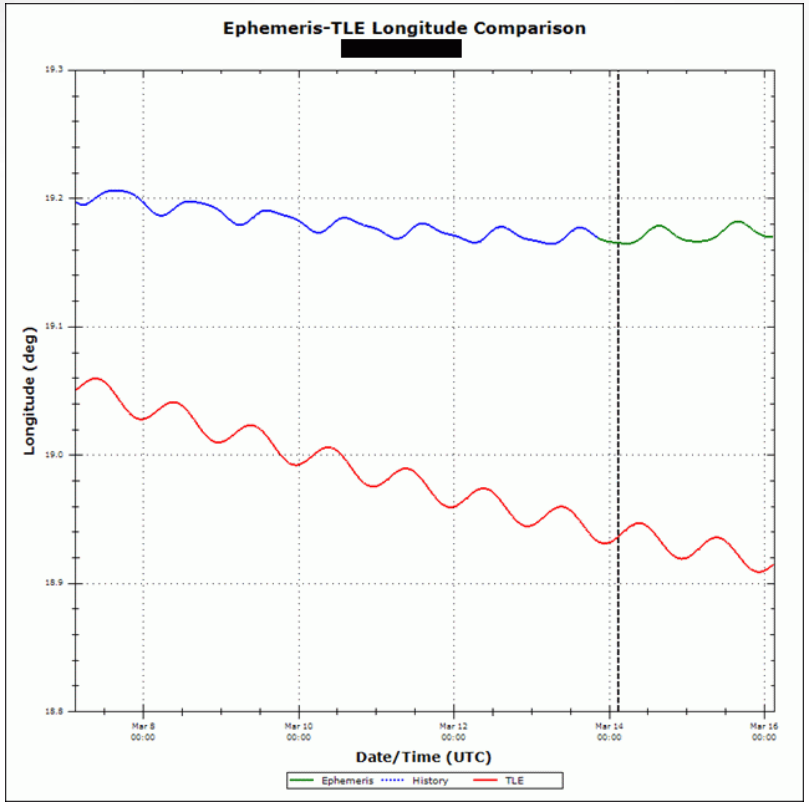


Cross-Tags


Ephemeris-TLE Longitude Comparison
[redacted]
Longitude (deg)
-101.0
-101.1
-101.2
-101.3
-101.4
Mar 8 00:00
Mar 10 00:00
Mar 12 00:00
Mar 14 00:00
Mar 16 00:00
Date/Time (UTC)
Ephemeris
History
TLE


Ephemeris-TLE Longitude Comparison
[redacted]
Longitude (deg)
-132.9
-133.0
-133.1
-133.2
-133.3
Mar 8 00:00
Mar 10 00:00
Mar 12 00:00
Mar 14 00:00
Mar 16 00:00
Date/Time (UTC)
Ephemeris
History
TLE

Lost Satellite



SPACE DATA ASSOCIATION

SDA Users Meeting: SDA General Forum

AUTOMATED DATA ANALYSIS: CSM COMPARISONS

TS KELSO

Process

- **CSSI checks hourly for new Space-Track CSMs**
  - For each operator we receive CSMs for, we:
    - Generate individual summaries comparing different data sets
      - Ephemeris vs. CSM & TLE data
      - Conjunction results for primary vs. secondary based on:
        - » CSM vs. CSM
        - » Ephemeris vs. CSM
        - » Ephemeris vs. TLE
        - » Ephemeris vs. Ephemeris (if available)
    - Send an e-mail containing all summaries
- **Case studies highlight the value of reviewing all data available**

Sample Cases

- **Single Ephemeris Case**
  - Primary Comparison
  - AGI Viewer File (3D View)
- **Dual Ephemeris Case**
  - Primary/Secondary Comparisons
  - Conjunction Comparisons
  - AGI Viewer File (3D View)
- **Unnecessary Maneuver Case**
- **Missed Maneuver Requirement**

Single Ephemeris Case

JSpOC Unique ID 201206240401

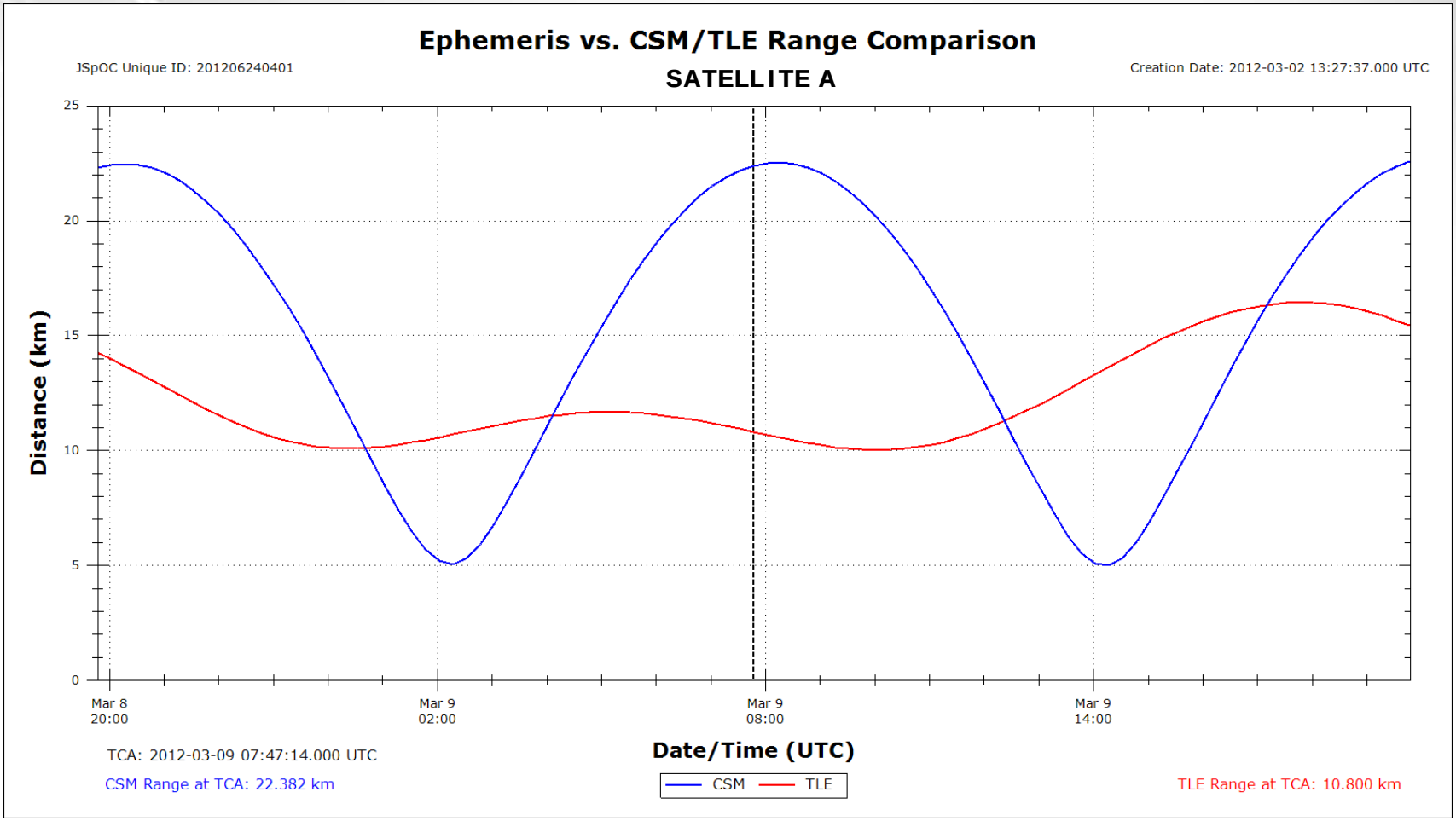
Creation Date: 2012-03-02 13:27:37 UTC (5.3 hours ago)

Upload Time: 2012-03-02 18:13:45 UTC (0.5 hours ago)

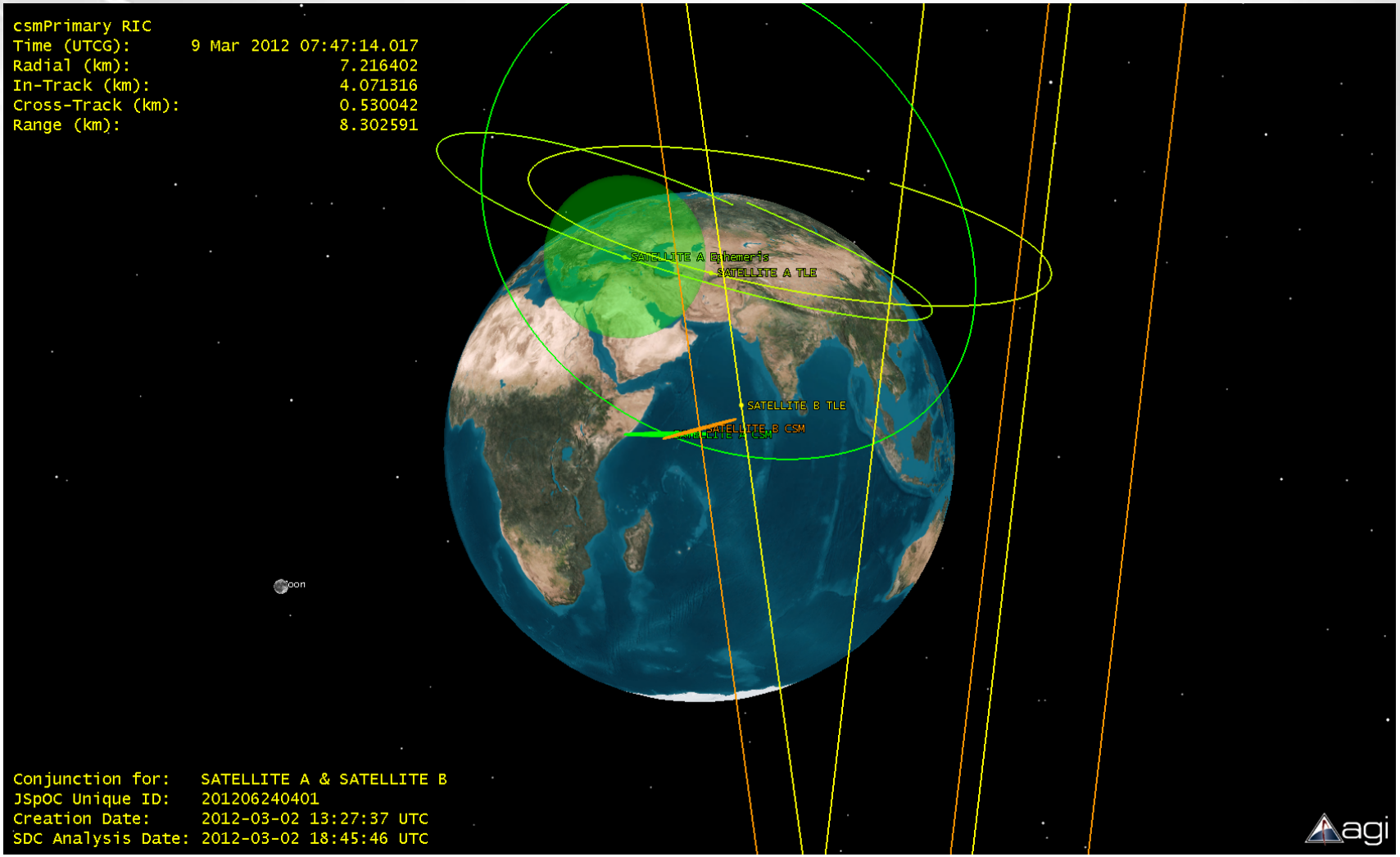
Conjunction for 12345/SATELLITE A [+] and 23456/SATELLITE B [?]		
CSM min range at TCA (2012-03-09 07:47:14.017 UTC) = 8.302 km		
Ephemeris vs. CSM/TLE Comparison		
Primary	CSM Range at TCA: 22.382 km	TLE Range at TCA: 10.800 km
Primary ephemeris epoch: 2012-03-01 00:00:00.000 UTC (1.78 days old)		

CSM Conjunction Comparisons	
CSM vs. CSM	TCA: 2012-03-09 07:47:14.017 UTC, 8.303 km
Ephemeris vs. CSM	TCA: 2012-03-09 07:47:42.716 UTC, 9.541 km
Ephemeris vs. TLE	TCA: 2012-03-09 07:47:40.094 UTC, 15.927 km
Ephemeris vs. Ephemeris	N/A
Latest SDC Search Results for 12345 and 23456	
Complete AGI Viewer Scenario	

Primary Comparison



AGI Viewer File



Dual Ephemeris Case

JSpOC Unique ID 201206240386

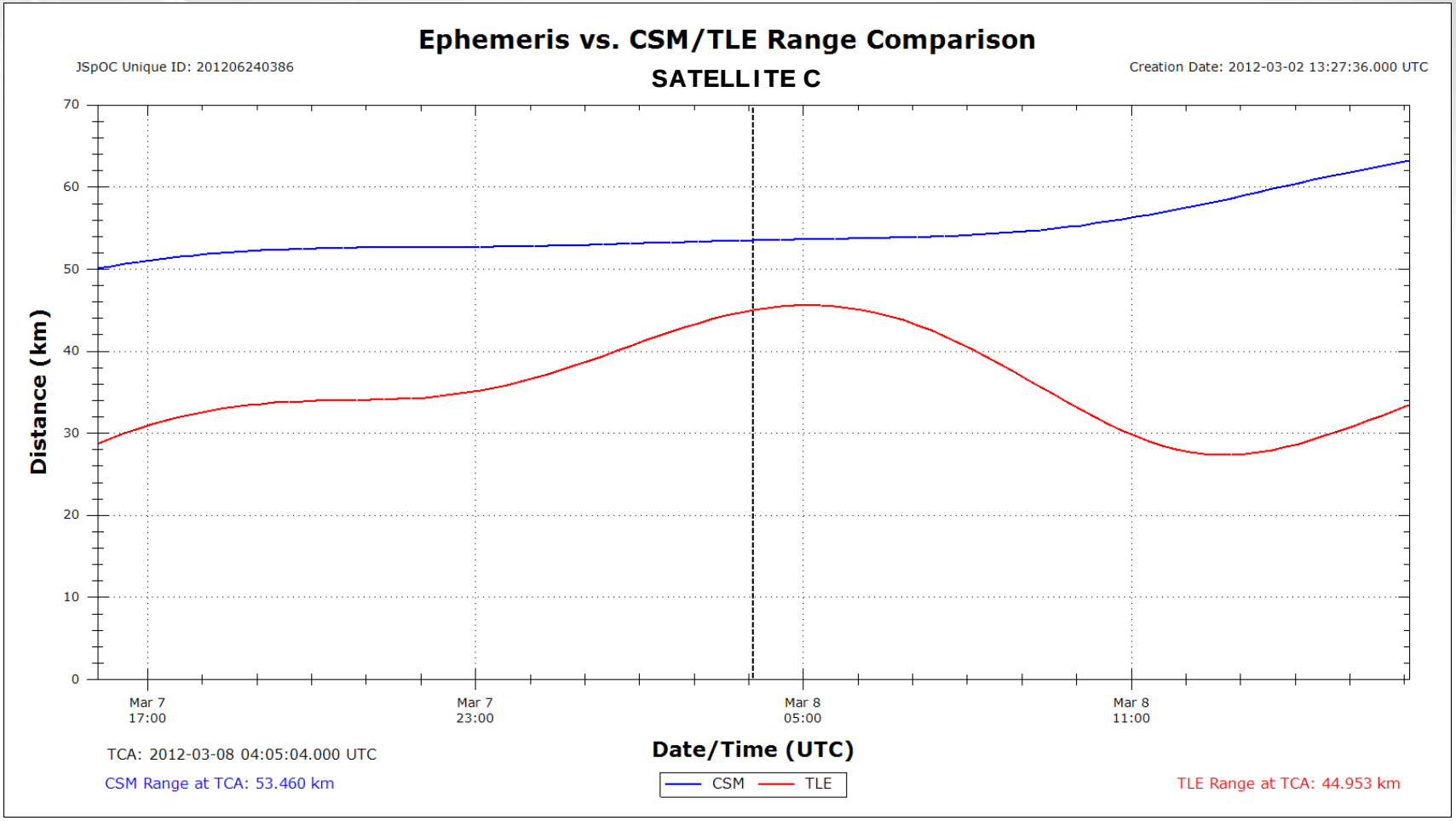
Creation Date: 2012-03-02 13:27:36 UTC (5.3 hours ago)

Upload Time: 2012-03-02 18:13:45 UTC (0.5 hours ago)

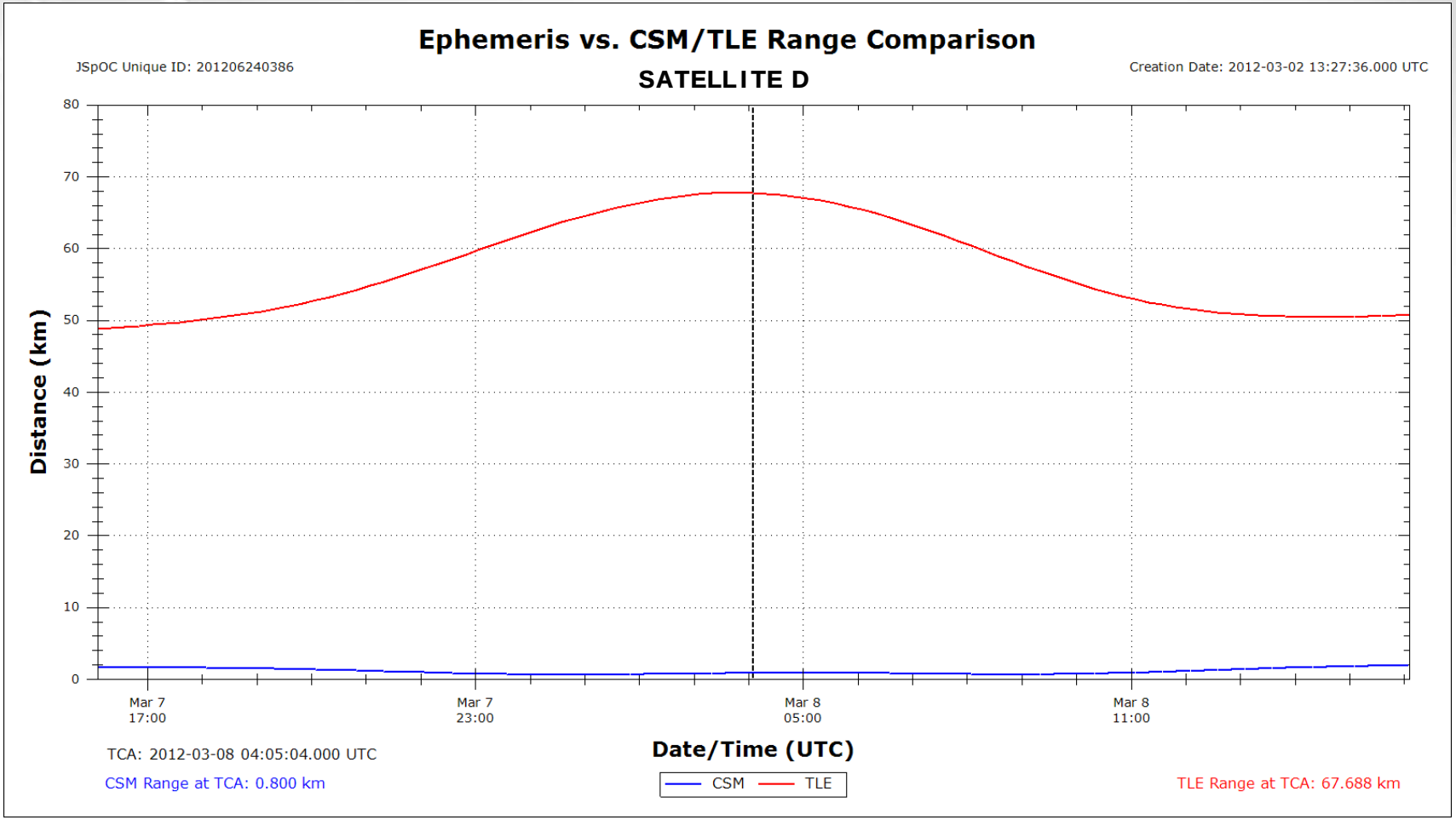
Conjunction for 02468/SATELLITE C [+] and 13579/SATELLITE D [+]		
CSM min range at TCA (2012-03-08 04:05:04.691 UTC) = 3.779 km		
Ephemeris vs. CSM/TLE Comparison		
Primary	CSM Range at TCA: 53.460 km	TLE Range at TCA: 44.953 km
Primary ephemeris epoch: 2012-03-02 10:30:00.000 UTC (0.34 days old)		
Secondary	CSM Range at TCA: 0.800 km	TLE Range at TCA: 67.688 km
Secondary ephemeris epoch: 2012-03-02 10:30:00.000 UTC (0.34 days old)		

CSM Conjunction Comparisons	
CSM vs. CSM	TCA: 2012-03-08 04:05:04.693 UTC, 3.779 km
Ephemeris vs. CSM	TCA: 2012-03-08 03:50:03.926 UTC, 55.594 km
Ephemeris vs. TLE	TCA: 2012-03-08 00:31:43.519 UTC, 122.506 km
Ephemeris vs. Ephemeris	TCA: 2012-03-08 03:42:54.626 UTC, 56.339 km
Latest SDC Search Results for 02468 and 13579	
Complete AGI Viewer Scenario	

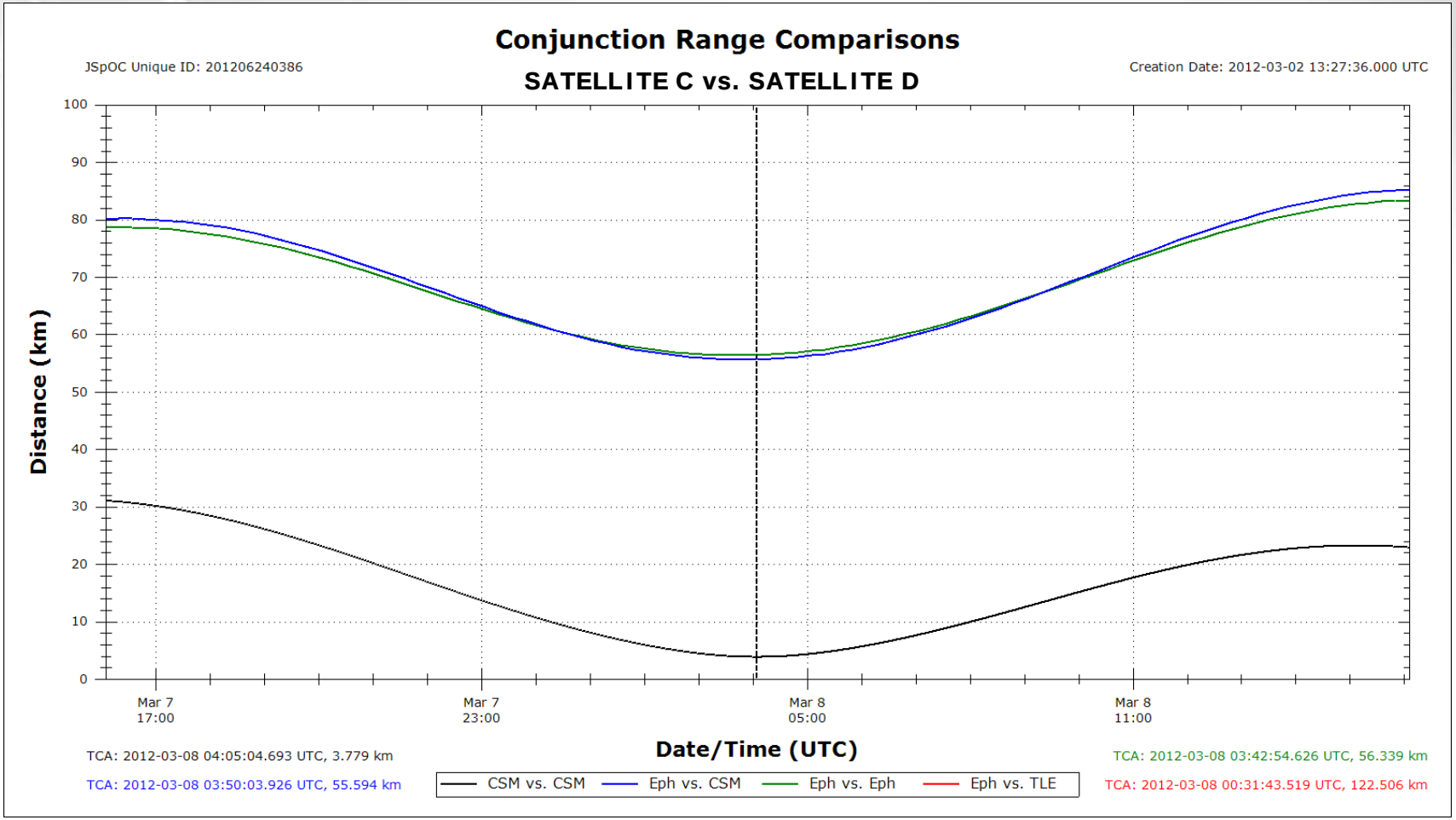
Primary Comparison



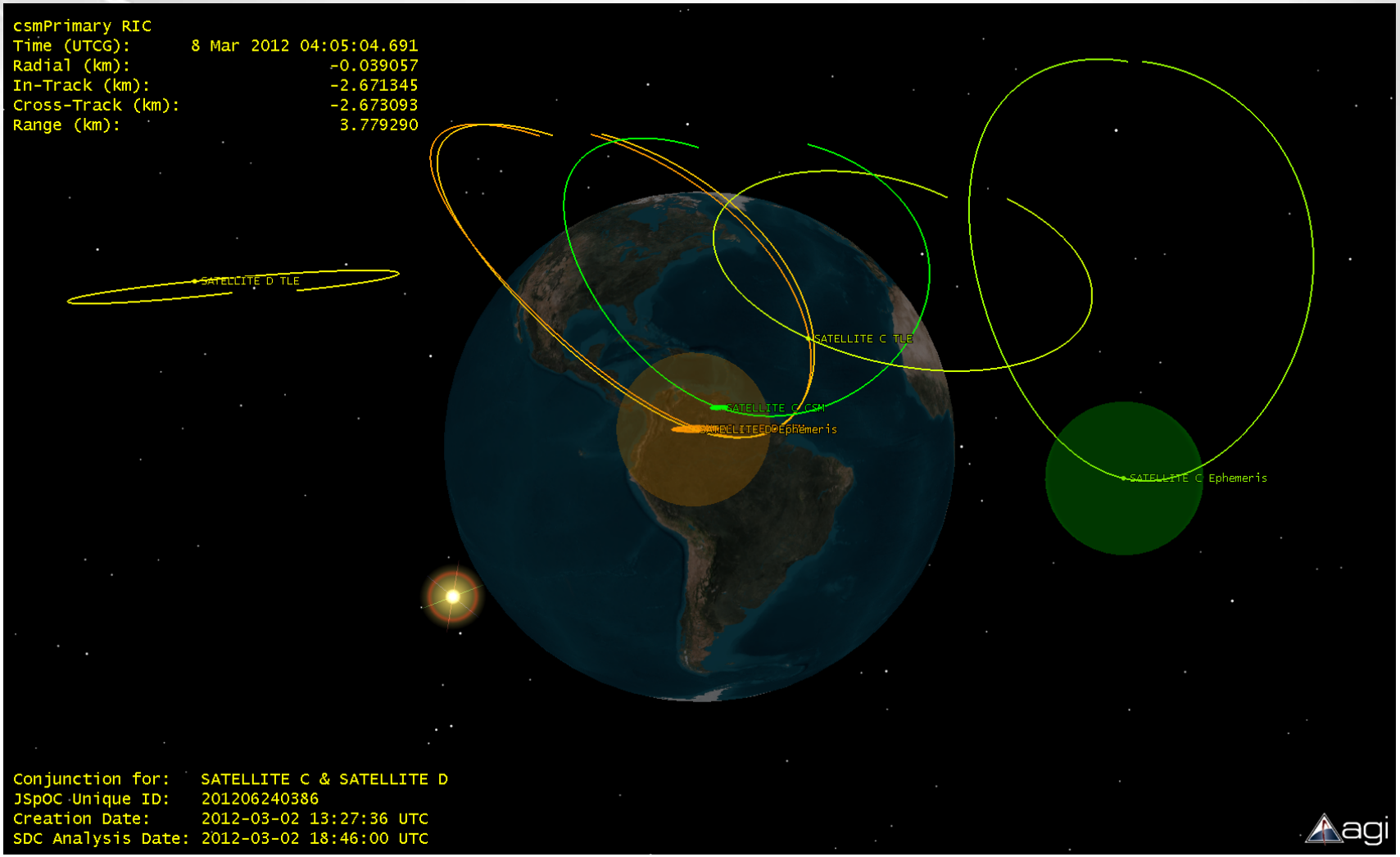
Secondary Comparison



Conjunction Comparison



AGI Viewer File



Unnecessary Maneuver Case

JSpOC Unique ID 201200635887

Creation Date: 2012-01-06 19:08:31 UTC (4.3 hours ago)

Upload Time: 2012-01-06 21:07:39 UTC (2.3 hours ago)

Conjunction for 11111 / SATELLITE E [+] and 22222 / SATELLITE F [+]		
CSM min range at TCA (2012-01-09 20:42:59.242 UTC) = 1.600 km		
Ephemeris vs. CSM / TLE Comparison		
Primary	CSM Range at TCA: 1.295 km	TLE Range at TCA: 25.003 km
Primary ephemeris epoch: 2012-01-05 00:00:00.000 UTC (1.98 days old)		
Secondary	N/A	N/A
N/A		

CSM Conjunction Comparisons	
CSM vs. CSM	TCA: 2012-01-09 20:42:59.242 UTC, 1.600 km
Ephemeris vs. CSM	TCA: 2012-01-09 20:41:23.432 UTC, 1.061 km
Ephemeris vs. TLE	TCA: 2012-01-09 15:40:23.187 UTC, 57.896 km
Ephemeris vs. Ephemeris	N/A
Latest SDC Search Results for 11111 and 22222	
Complete AGI Viewer Scenario	

Unnecessary Maneuver Case

JSpOC Unique ID 201200635887

Creation Date: 2012-01-06 19:08:31 UTC (4.3 hours ago)

Upload Time: 2012-01-06 21:07:39 UTC (2.3 hours ago)

Conjunction for 11111 / SATELLITE E [+] and 22222 / SATELLITE F [+]		
CSM min range at TCA (2012-01-09 20:42:59.242 UTC) = 1.600 km		
Ephemeris vs. CSM / TLE Comparison		
Primary	CSM Range at TCA: 1.295 km	TLE Range at TCA: 25.003 km
Primary ephemeris epoch: 2012-01-05 00:00:00.000 UTC (1.98 days old)		
Secondary	CSM Range at TCA: 70.722 km	TLE Range at TCA: 7.771 km
Secondary ephemeris epoch: 2012-01-03 19:15:44.000 UTC (3.18 days old)		

CSM Conjunction Comparisons	
CSM vs. CSM	TCA: 2012-01-09 20:42:59.242 UTC, 1.600 km
Ephemeris vs. CSM	TCA: 2012-01-09 20:41:23.432 UTC, 1.061 km
Ephemeris vs. TLE	TCA: 2012-01-09 15:40:23.187 UTC, 57.896 km
Ephemeris vs. Ephemeris	TCA: 2012-01-09 15:58:46.889 UTC, 65.415 km
Latest SDC Search Results for 11111 and 22222	
Complete AGI Viewer Scenario	

Missed Maneuver Requirement

JSpOC Unique ID 201203438032

Creation Date: 2012-02-03 08:24:19 UTC (5.4 hours ago)

Upload Time: 2012-02-03 13:31:49 UTC (0.2 hours ago)

Conjunction for 33333/SATELLITE G [+] and 44444/SATELLITE H [+]		
CSM min range at TCA (2012-02-08 11:02:18.612 UTC) = 8.415 km		
Ephemeris vs. CSM/TLE Comparison		
Primary	CSM Range at TCA: 46.511 km	TLE Range at TCA: 27.146 km
Primary ephemeris epoch: 2012-02-01 00:00:00.000 UTC (2.57 days old)		
Secondary	N/A	N/A
N/A		

CSM Conjunction Comparisons	
CSM vs. CSM	TCA: 2012-02-08 11:02:18.600 UTC, 8.416 km
Ephemeris vs. CSM	TCA: 2012-02-08 17:16:11.014 UTC, 27.044 km
Ephemeris vs. TLE	TCA: 2012-02-08 11:35:19.577 UTC, 49.272 km
Ephemeris vs. Ephemeris	N/A
Latest SDC Search Results for 33333 and 44444	
Complete AGI Viewer Scenario	

Missed Maneuver Requirement

JSpOC Unique ID 201203438032

Creation Date: 2012-02-03 08:24:19 UTC (5.4 hours ago)

Upload Time: 2012-02-03 13:31:49 UTC (0.2 hours ago)

Conjunction for 33333/SATELLITE G [+] and 44444/SATELLITE H [+]		
CSM min range at TCA (2012-02-08 11:02:18.612 UTC) = 8.415 km		
Ephemeris vs. CSM/TLE Comparison		
Primary	CSM Range at TCA: 46.511 km	TLE Range at TCA: 27.146 km
Primary ephemeris epoch: 2012-02-01 00:00:00.000 UTC (2.57 days old)		
Secondary	CSM Range at TCA: 36.666 km	TLE Range at TCA: 45.759 km
Secondary ephemeris epoch: 2012-02-01 00:00:00.000 UTC (2.57 days old)		

CSM Conjunction Comparisons	
CSM vs. CSM	TCA: 2012-02-08 11:02:18.600 UTC, 8.416 km
Ephemeris vs. CSM	TCA: 2012-02-08 17:16:11.014 UTC, 27.044 km
Ephemeris vs. TLE	TCA: 2012-02-08 11:35:19.577 UTC, 49.272 km
Ephemeris vs. Ephemeris	TCA: 2012-02-08 15:47:23.111 UTC, 4.676 km
Latest SDC Search Results for 33333 and 44444	
Complete AGI Viewer Scenario	

SPACE DATA ASSOCIATION

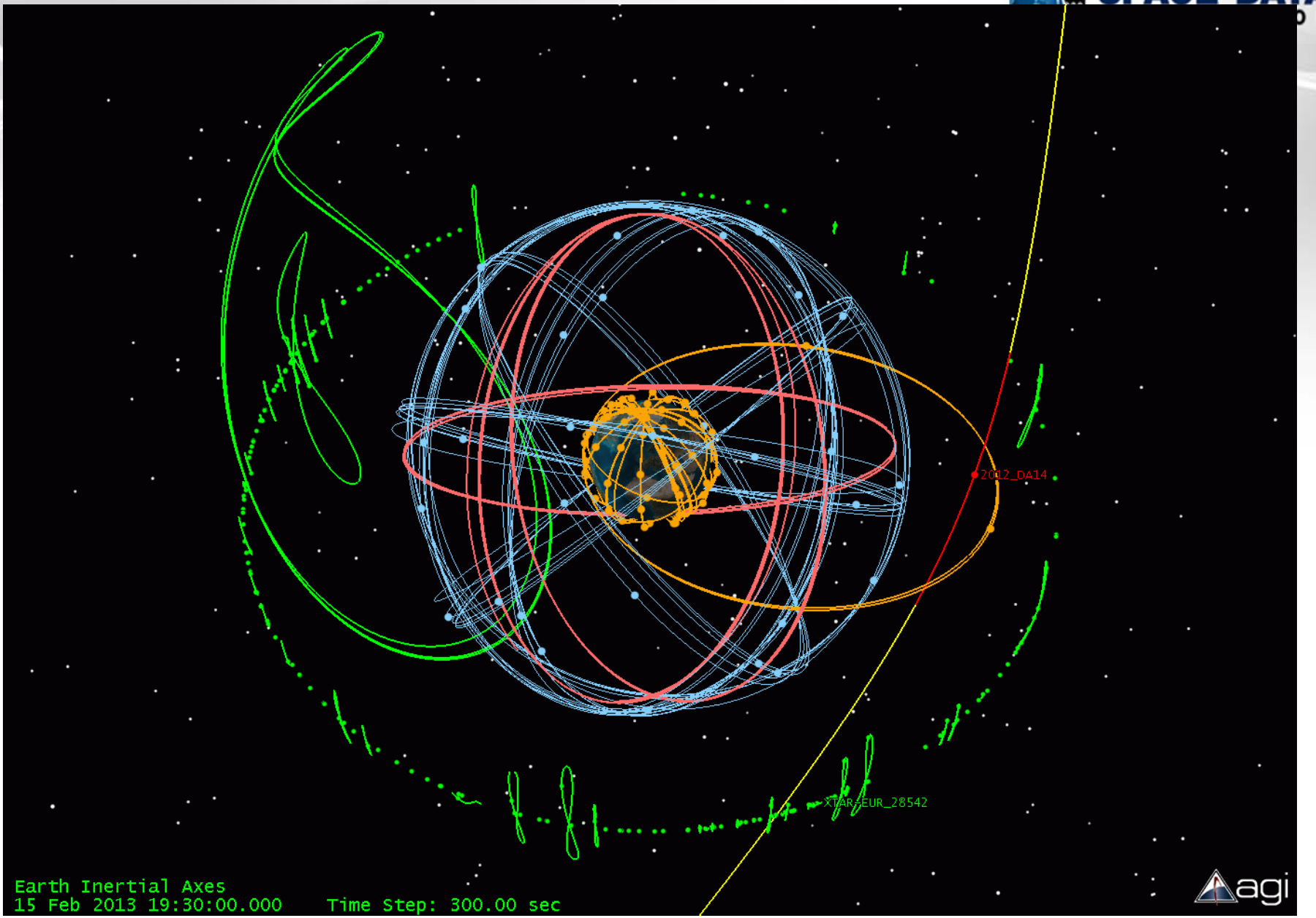
SDA Users Meeting: SDA General Forum

CASES OF INTEREST: DA14 ASTEROID

T.S. KELSO

2012 DA14 Asteroid

- **Predicted close approach on 2013 Feb 15**
  - Altitude at TCA (19:25 UTC): 27,680 km
- **Concern about passage through satellite regime**
  - Used ephemeris from Minor Planet Center
    - Loaded heliocentric data into STK
  - Used STK's Advanced Conjunction Analysis Tool
    - Screened to 1,000 km: No conjunctions with public catalog
      - Just over 15,000 objects
  - Reviewed all SDA satellites + GPS & GLONASS
    - Closest satellite: RBSP B @ 5,630 km
    - Closest GEO: NSS-6 @ 7,970 km


2012_DA14
XTAR_EUR_28542
Earth Inertial Axes
15 Feb 2013 19:30:00.000
Time Step: 300.00 sec
agi

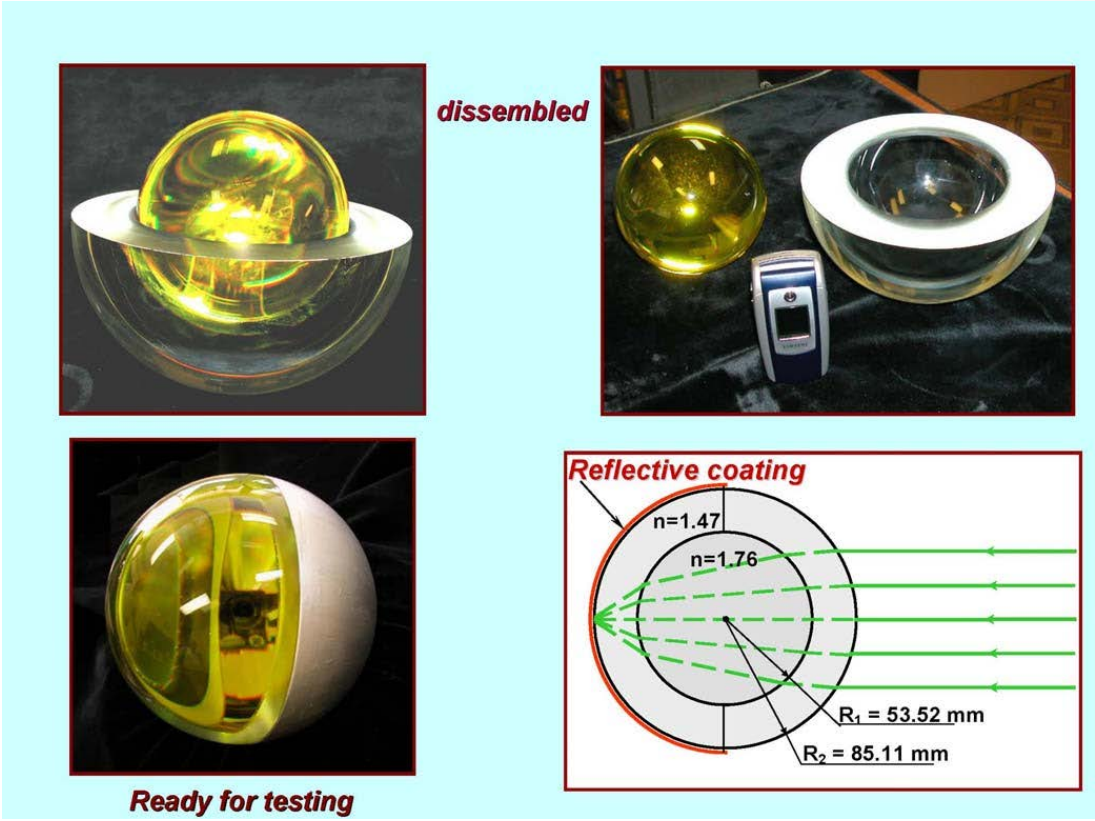
SDA Users Meeting: SDA General Forum

CASES OF INTEREST: BLITS EVENT

T.S. KELSO

BLITS Event

- **Ball Lens In The Space (BLITS)**
  - Russian laser retroreflector operated by IPIE



BLITS Event

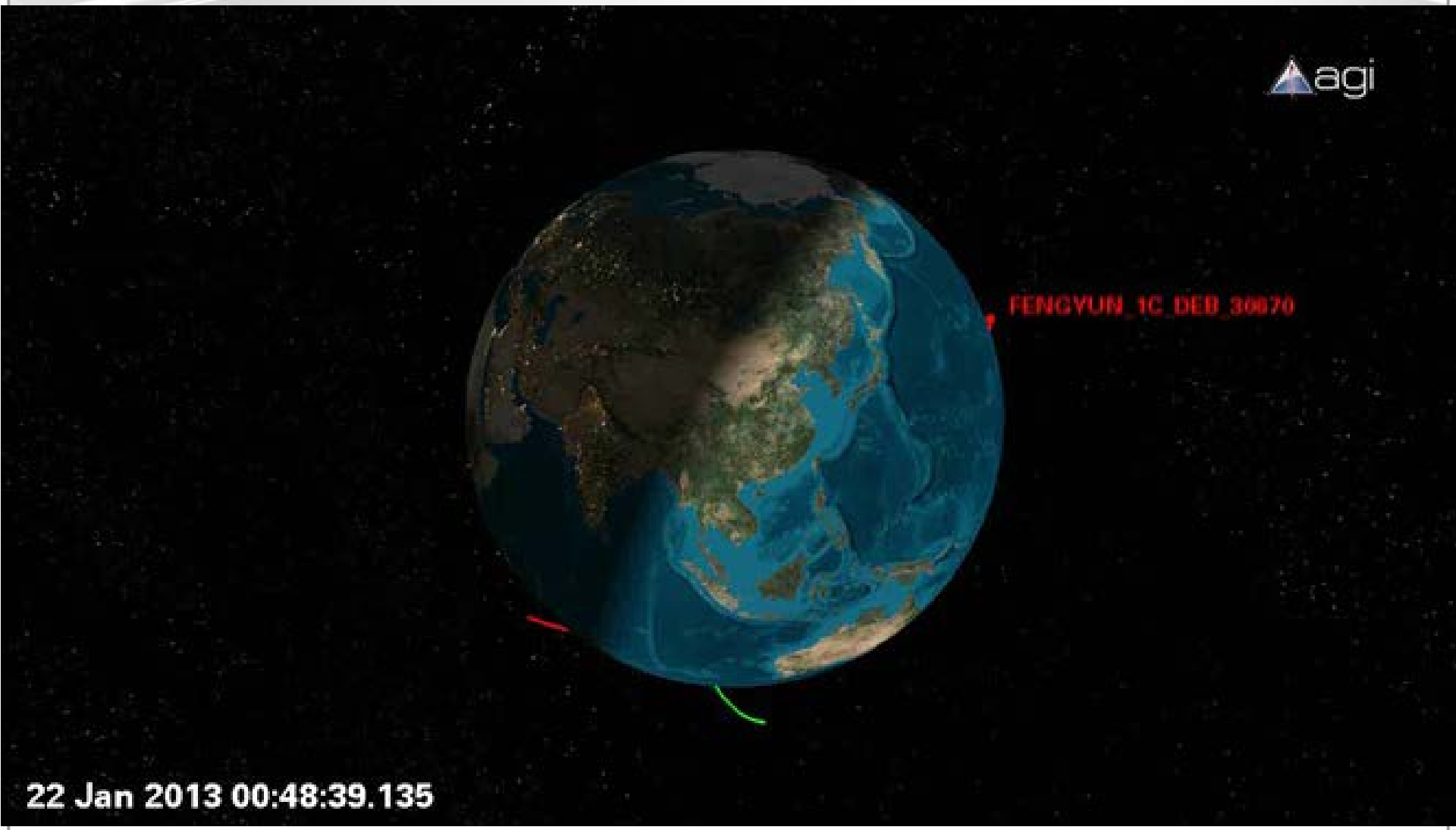
- **Unable to laser range after 2013 Jan 22 @ 01:45:16 UTC**
- **Analysts collected optical and photometric observations**
  - Determined 120-m decrease in semi-major axis
  - Determined spin period change from 5.6 sec to 2.1 sec
  - Unable to determine new spin axis
  - Determined change in state occurred 2013 Jan 22 @ 07:57 UTC
  - Sought information on possible collision

BLITS Event

- **Review of SOCRATES archives**
  - Close approach with SCC 30670 (FY1C debris)
    - 3.109 km on 2013 Jan 22 @ 07:56:51 UTC (within 10 sec)
  - Nothing predicted within 5 km between
    - 3.485 km on 2013 Jan 21 @ 02:12:14 UTC with SCC 31090
    - 4.510 km on 2013 Jan 22 @ 1:37:34 UTC with SCC 33772
  - Proximity to predicted event time made collision likely
- **Without external input, BLITS could not maneuver or change attitude**

BLITS Event

- **Alternative hypotheses under examination**
  - Collision with SCC 30670 (or another object)
  - Satellite breakup due to thermal stresses
- **Evidence to date**
  - No change in 30670 orbit seems to discount it, despite proximity at proposed event time
  - Increased spin rate seems to refute breakup
  - BLITS debris seems too small (~3 cm) for breakup
  - Change in orbit could be caused by very small debris
    - Elastic collision sets lower bound of 0.075 g for 30670


agi
FENGYUN_1C_DEB_30870
22 Jan 2013 00:48:39.135

SPACE DATA ASSOCIATION

SDA Users Meeting: General Forum

RFI FUNCTIONS FOR SDC
STEVE SMITH and MARK RAWLINS

SDC/RFI – Introduction

- **SDC Function Development**
  - Interactive Functions
    - Collision Analysis – Operational
    - RF Data for Interference localisation – In definition phase
  - Reference Functions
    - Contacts Database – Operational
    - RF Interference Alerts – In definition phase
    - RF Interference case study database – In definition phase
    - Carrier ID reference database – Under Evaluation

SDC/RFI – Introduction

- **Why share data or automate RFI functions?**
  - RF interference is the major operational problem affecting customer services on geostationary satellites
  - ~85-90% of customer issues are due to RFI
  - RFI only affects a small amount of capacity (1-2%?) but has a cost and service impact if not resolved
  - Investigation often needs data on other satellites
  - Investigating RFI is time consuming – we are always seeking methods and processes to improve response

SDC/RFI – Current RFI Ops Issues

- **Overview of the current RFI process**
  - Operators need contact details for other operators
    - No existing industry-wide database with reliable contact info
  - Operators need help and information
    - RFI Alert function, to seek assistance – exists today with sIRG email distribution – but need enhanced functions
    - To get information on other operator's payload, have to know who to contact
  - In-house knowledge, not documented
    - Tremendous experience, but not captured, not shared internally, let alone with other operators
  - Cooperation with other satellite operators
    - Geolocalisation using other operator satellites information exchanged "manually".

SDC/RFI – Geolocation Support

- **What is this?**
  - Geolocation of interfering signals requires precise satellite ephemeris data, for ‘affected’ and adjacent satellites
  - Geolocation needs RF payload data for ‘affected’ and potential adjacent satellites
- **Why the SDC?**
  - It already contains the precise ephemeris data
  - It already has a means of securely holding and exchanging data with the users
  - It already has a legal framework to protect users own data
  - The satellite payload information needs adding to complement the information already there

SDC/RFI – Geolocation Support

- **RF Data and Geolocation**
  - Members provide current RF payload (transponder) frequencies, polarizations, connectivity, satellite antenna patterns, reference carriers (data needs to be updated regularly to ensure accuracy)
  - SDC will use payload data to find best ‘pairing’ of primary and adjacent satellites to match geolocation requests from members
  - SDC will provide a ‘dataset’ of the required parameters to feed into the member’s geolocation system
  - **Benefit:** SDC computes optimum pairing of satellites for selection by the member; provides data formatted for the geolocation system; data immediately available for geolocation
- **Drifting satellites and LEOP (Fly-by)**
  - CA predicts fly-bys; TT&C frequencies predict RFI
  - **Benefit:** Analysis and Automatic alerts for potential fly-by RFI

SDC/RFI – Geolocation Support

- **What are Operational benefits?**
  - Centralisation of data in SDC makes it available 24/7 to users
  - Reduces the time to solution
  - Automation of the process reduces mistakes
  - Data is currently shared, but only in an informal unprotected manner, on a best effort basis, normally during office hours. SDC has a better, more secure/format data sharing paradigm.

SDC/RFI – Reference Functions

- **Contacts (Phonebook)**
  - SDC has a phonebook database. Members can enter their own contacts (e.g. 24x7 center, technical managers, support staff, etc.)
  - **Benefit:** Member-maintained, single reliable contacts database
- **RFI Alert (seeking information and assistance)**
  - Structured Alert message can be issued to selectable distribution
  - Data and messages can be saved and searched
  - Feedback provided to the distribution when event is solved
  - **Benefit:** Focused distribution; message tracking; feedback
- **RFI Database (historical information, case studies)**
  - Stores RFI Alerts, case studies, white papers, etc.
  - Assign tags, keywords, to aid searching
  - **Benefit:** Members can search RFI events, find useful information

SDC/RFI – Other Features

- **Access to RF Payload Data**
  - Fine grain user control features will allow a member to control access to their data for geolocation scenario analysis on a satellite/user basis
  - Authorized members will be able to use SDC to perform geolocation scenario analysis using other operators' payload data
  - **Benefit:** Immediate access to data for investigating RFI issues
- **Third party services**
  - Third party service providers could be SDA associate members
  - Members easily contact providers via SDC to request services
  - Members can deliver data for geolocation directly to providers
  - **Benefit:** Quick and simple to request and initiate third party geolocation or monitoring services

SDC/RFI – Data From Members

- **RF Payload Data:** Data describing transponders and connectivity (not customer carrier data):
  Frequencies, polarizations, connectivity, beam antenna pattern data, reference carrier freq/pol/location/bw
- **Drift and LEOP:** TT&C data for satellites:
  Beacon, command and telemetry frequencies, cmd eirp
- **Contacts:** For RF Payload teams:
  Name, email, phone, role (24x7, mgmt, ops center, etc.)
- **RFI Alert:** Information describing an event, or information you need:
  Affected s/c, transponder, connectivity, freq, RFI characteristics, attach plots as needed, comments
- **RFI Database:** Similar data as for 'RFI Alert", for historical reference:
  Info describing an event, investigation performed, resolution, techniques, test equip, poor vendor equip list
- **Carrier ID:** CID code, name of associated operator, optional data identifying the uplinker – name/location/contact info

SPACE DATA ASSOCIATION

SDA Users Meeting: SDA Members-Only Discussion

CARRIER ID
STEVE SMITH and MARK RAWLINS

SDC/RFI – Carrier ID

- New industry development in 2013 – Carrier ID (CID) spec issued for DVB. Equipment now being designed
- Users will start transmitting CID and satellite operators can decode it to identify any interfering DVB carrier
- If the carrier is not one of the decoding-operator's carriers, a database is needed to search for the carrier and find the associated operator
- SDA will host a global database to contain CID codes and their associated satellite operator. ***Accessible by all satellite operators (not only SDA Members)***. The relevant operator can then be contacted to investigate the cause of the RFI
- Additional data can optionally be entered – name, contact, location, etc.

SPACE DATA ASSOCIATION

SDA Users Meeting: SDA General Forum

SDA FUTURE PLANS

RON BUSCH

Space Data Association Objectives for 2013

- **SDA**
  - Grow Membership
  - Develop Government and Industry Relationships
  - Develop Space Insurance Relationships
  - Secure Access to Additional Data Sources

- **SDC**
  - Reduce Operating Costs and Improve Service
  - Implement Data Sharing for RFI Mitigation
  - Carrier ID Database

SDA Future Consideration

- **Space Weather**
  - Improved data distribution & alerts
  - Controlled sharing of proprietary data
  - Improved modelling with feedback
- **Carrier ID Database**
  - Supports RFI initiative of other industry bodies (sIRG, EUI)
- **Space insurance**
  - Secure preferred terms for SDA members based on better management of risk

SDA Future Challenges

- **Data Sources**
  - SDA/SDC built on user data, including ‘future knowledge’
  - Full catalogue requires additional data:
    - Increase participation >>> 100% of satellite operators
    - Access other data sources to fill gaps and verify existing
  - Increasing tracking capabilities/data is key
- **Funding**
  - SDA is funded solely by participants
  - Funding levels limit future developments
  - External funding could affect independence
  - Fee-paying ‘added value’ service models considered

Summary Comments

- SDA has shown that a user owned/managed operational solution is viable and can encourage membership precisely because of its independence.
- The legal framework protection of proprietary data has been critical in encouraging participation.
- SDA has already solved Conjunction Assessment and general processes – the wheel doesn't need to be reinvented – public money is better spent on additional tracking/data sources.
- Physical space and the RF spectrum need better operational management – the SDA is the best means of achieving this.

SDA Users Meeting: SDA General Forum

GENERAL Q & A

BUSCH

Contacts – For Presentation Follow Up

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