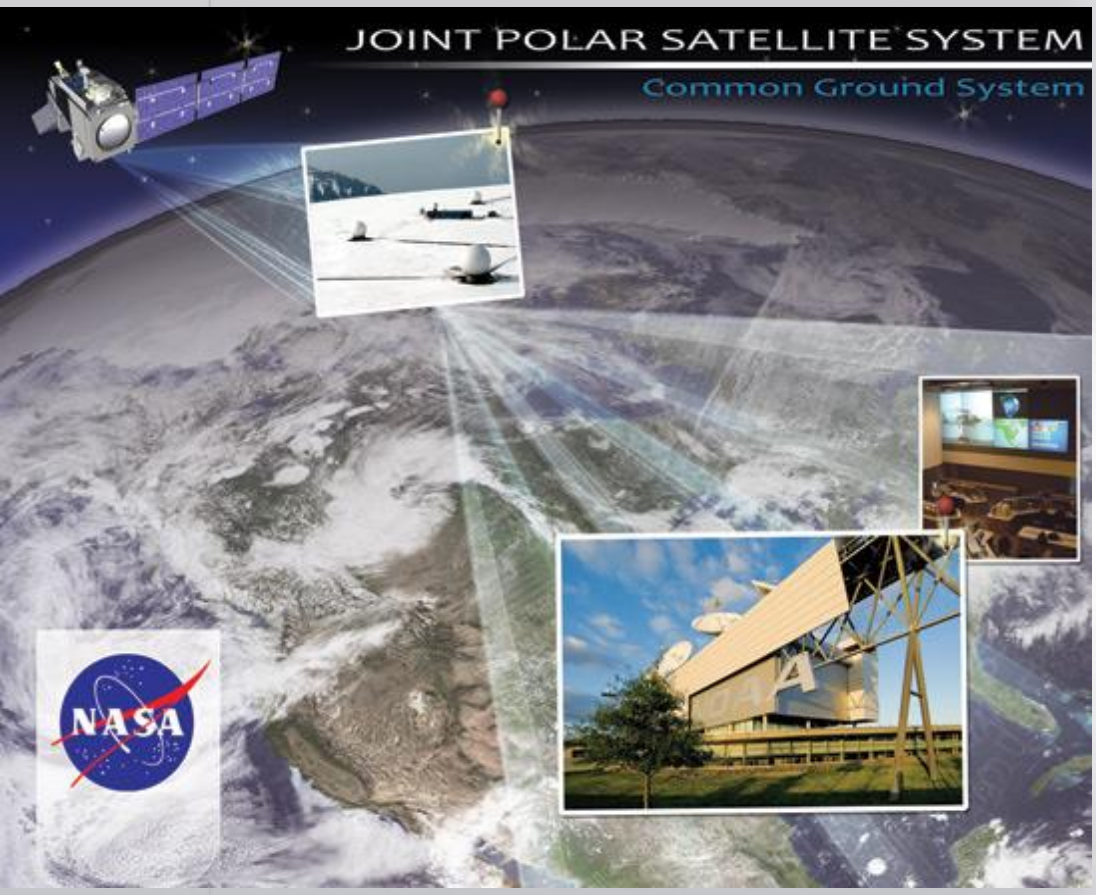

Utilization of AGI STK© and S-NPP Operational Data to Generate JPSS-1 Proxy Test Data

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Outline

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JPSS-1 Proxy Test Data Requirements and Challenges

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- Two data streams are needed to support JPSS multi-mission (S-NPP and JPSS-1) system test requirements.
  - S-NPP: Operational data stream "live data" during the test event timeframe
  - JPSS-1: S-NPP operational data-based "canned; not live" as proxy test data
  - CCSDS packets are routed through the two JPSS ground stations (GSs)
    - S-NPP downloaded to the Svalbard, Norway "North Pole" GS.
    - JPSS-1 downloaded to both the Svalbard and McMurdo, Antarctica "South Pole" GSs.
- Challenges
  - Synchronization of the JPSS-1 proxy "time-shifted" data stream with the S-NPP operational "live" data stream at the test event.
  - Generate JPSS-1 proxy "time-shifted" data that produces Sensor Data Records (SDRs) and Environmental Data Records (EDRs) with "minimal to no fill"

For a test event, generated JPSS-1 proxy test data needs to be synchronized w/ the S-NPP live data stream and capable of producing "minimal to no fill" SDRs and EDRs.

JPSS-1 Spacecraft (S/C) Attitude and Ephemeris (A&E) Proxy Test Data Generation (1/2)

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- Generate JPSS-1 S/C A&E proxy data to:
  - Meet sensor payload (ATMS, CrIS, OMPS and VIIRS) geolocation needs.
    - Ensure the completion of the more-complicated sensor chain product generation with proper functional quality “minimal to no fill” products.
  - Synchronize the JPSS-1 proxy test data with the S-NPP live stream data set for the particular test event.
- Leverage the technique for the upcoming JPSS missions and satellite test data needs (e.g., JPSS-2).
- Previous Technique:
  - Utilized 17-days (242 orbits) of S-NPP-based operational data (Apr 2014) containing both S/C A&E and sensor packets
    - Renamed S-NPP packets to JPSS-1, as the basis for JPSS-1 proxy test data.
    - Result: Quality of generated products is highly dependent on date of test execution (e.g., alignment of ground tracks, season conditions, etc.)

Pervious technique resulted in mostly fill products being generated due to bad-quality of generated geolocation products.

JPSS-1 Spacecraft (S/C) Attitude and Ephemeris (A&E) Proxy Test Data Generation (2/2)

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- New Technique:
  - For the same 17-days (242 orbits) of S-NPP-based operational data (Apr 2014), CCSDS sensor packets:
    - Utilizes S-NPP operational TLE set as an input to AGI STK© propagator (e.g., SGP4) to A&E data for JPSS-1 S/C corresponding to the target test date.
    - Swaps out the existing JPSS-1 proxy A&E CCSDS packets in the 17-day dataset, with the AGI STK© created A&E (i.e., replaces the S-NPP based A&E packets).
    - Uses these generated "JPSS-1" S/C A&E packets along with the S-NPP-based sensor CAL/SCI/ENG proxy packets to drive the generation of various JPSS-1 sensor products, e.g., SDRs (calibrated science data; Level-1B) and EDRs (Clouds, Aerosols, Land, Ocean, Cryosphere, etc. products; Level-1C).
  - Result: Generation of good-quality geolocation products for the sensor suite.
  - The geolocation products are the main factor driving the completion of the sensor chain resulting in proper functional quality "no fill" products.
  - Percent of sensor mostly-fill products is reduced from ~70% to ~1%.

New technique resulted in ≤ 1% fill products being generated due to good-quality of generated geolocation products.

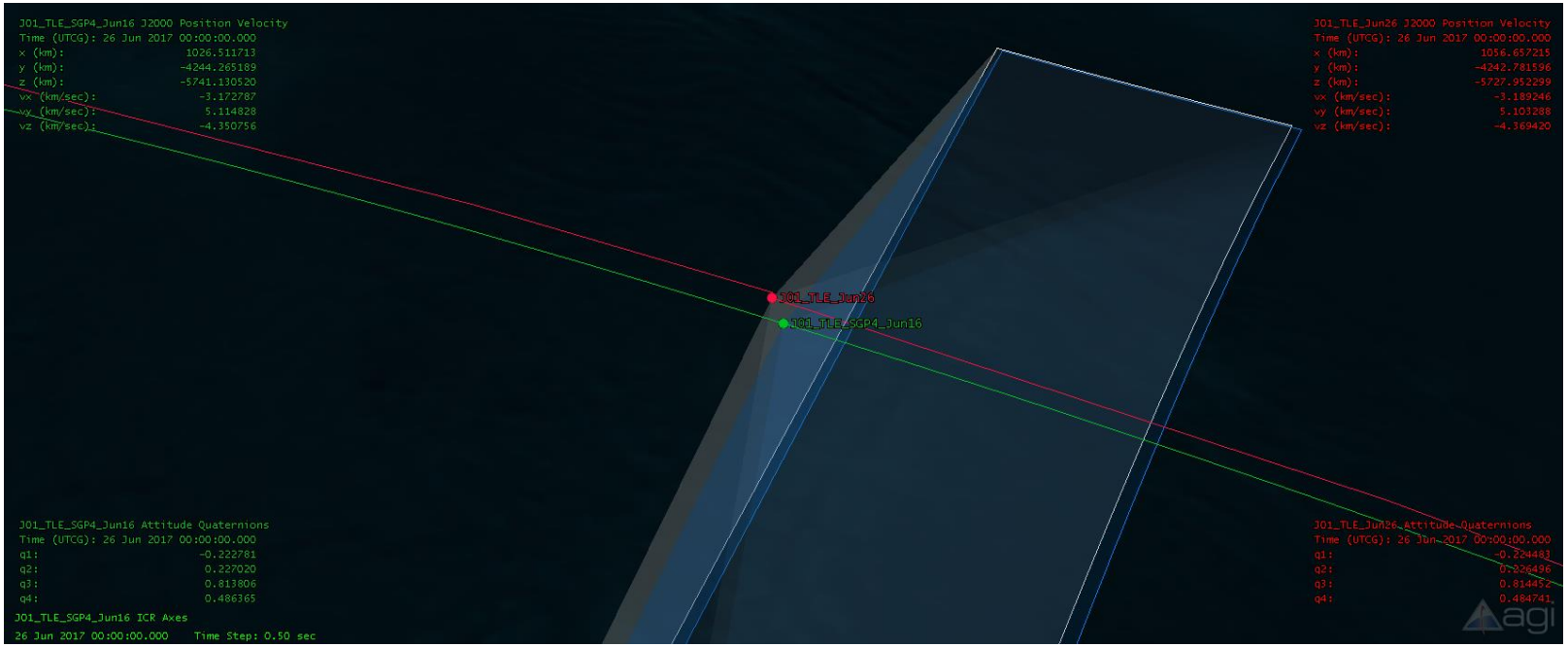
New Technique Details

1. Use an S-NPP TLE set that is closest to the desired JPSS-1 proxy test data creation date.
2. Load S-NPP TLE into STK© scenario.
3. Generate daily reports (00:00z to 23:59:59) from STK© that contain 1-sec output frequency of following information:
   - Time (UTC)
   - Position (m)
   - Velocity (m/s)
   - Quaternions
4. Use S-NPP 16-day repeating orbit track to line up test data date to orbit track of test event timeframe.
5. Replace existing test data A&E data with newly generated STK© A&E output.

Simulated A&E Stability

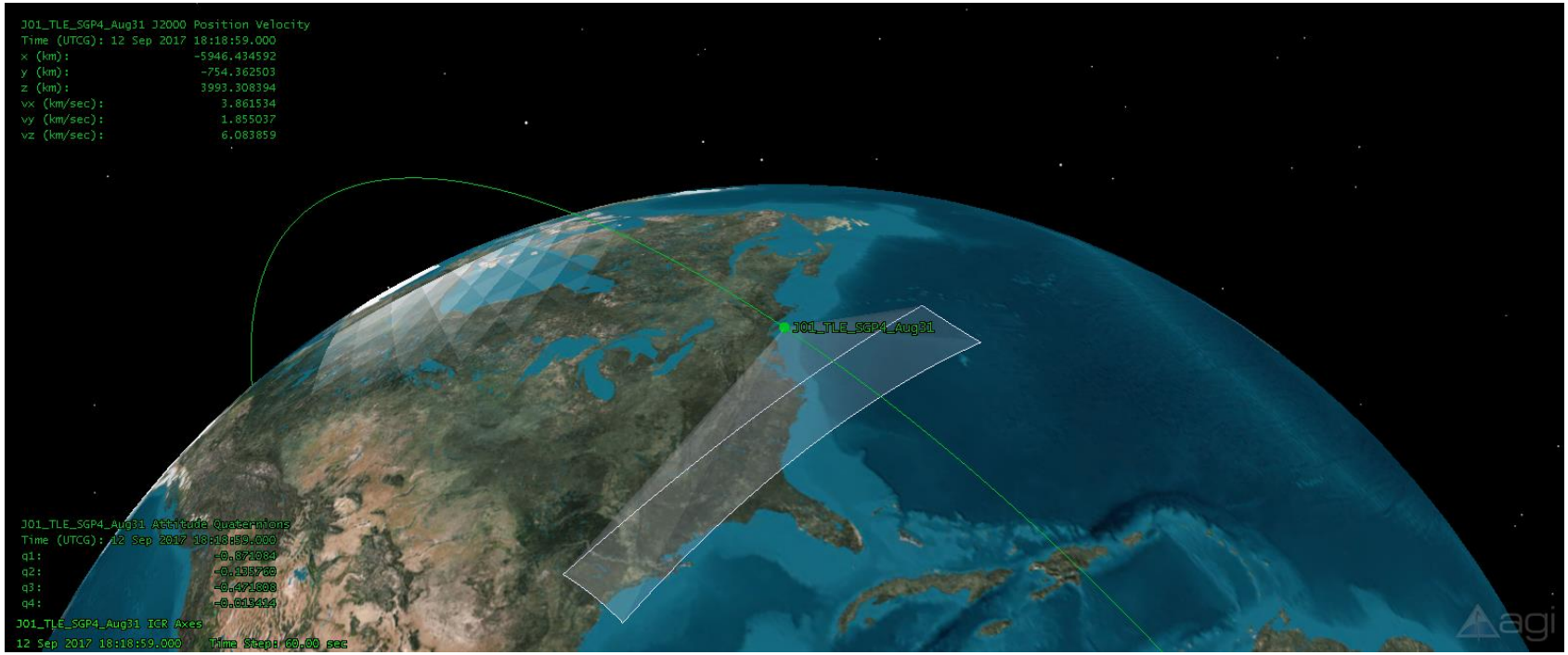
- Technique is highly stable
  - Simulated A&E is < 0.3% off after 10 days

Simulation Results after 10 days		
Errors	Abs Diff SGP4 vs Day 10 TLE	
Position (m)	[666, 30146, 13228]	0.3%
Velocity (m/s)	[12, 17, 19]	0.2%
Quaternion	[0.0017, 0.0005, 0.0006, 0.0016]	0.2%



STK© Scenario

- Basic scenario with a single S/C
  - S/C uses SGP4 propagation for orbit determination
    - Uses TLE as initial starting point
  - Attitude is fixed to be nadir-pointing and velocity constrained to in-track
    - Ensures sensors always record on-earth data
  - Add VIIRS basic sensor footprint to allow for visualization of S/C pointing



Propagation Error (1/2)

- Movie on following slide shows 3 days of propagation
- Blue S/C is current propagation method (i.e., SGP4) with 10-day old TLE
- Green S/C is current propagation method (i.e., SGP4) with 0-day old TLE
- Red S/C is old J4 propagation method (i.e., first propagation method attempted) with 10-day old TLE

Propagation Error (2/2)

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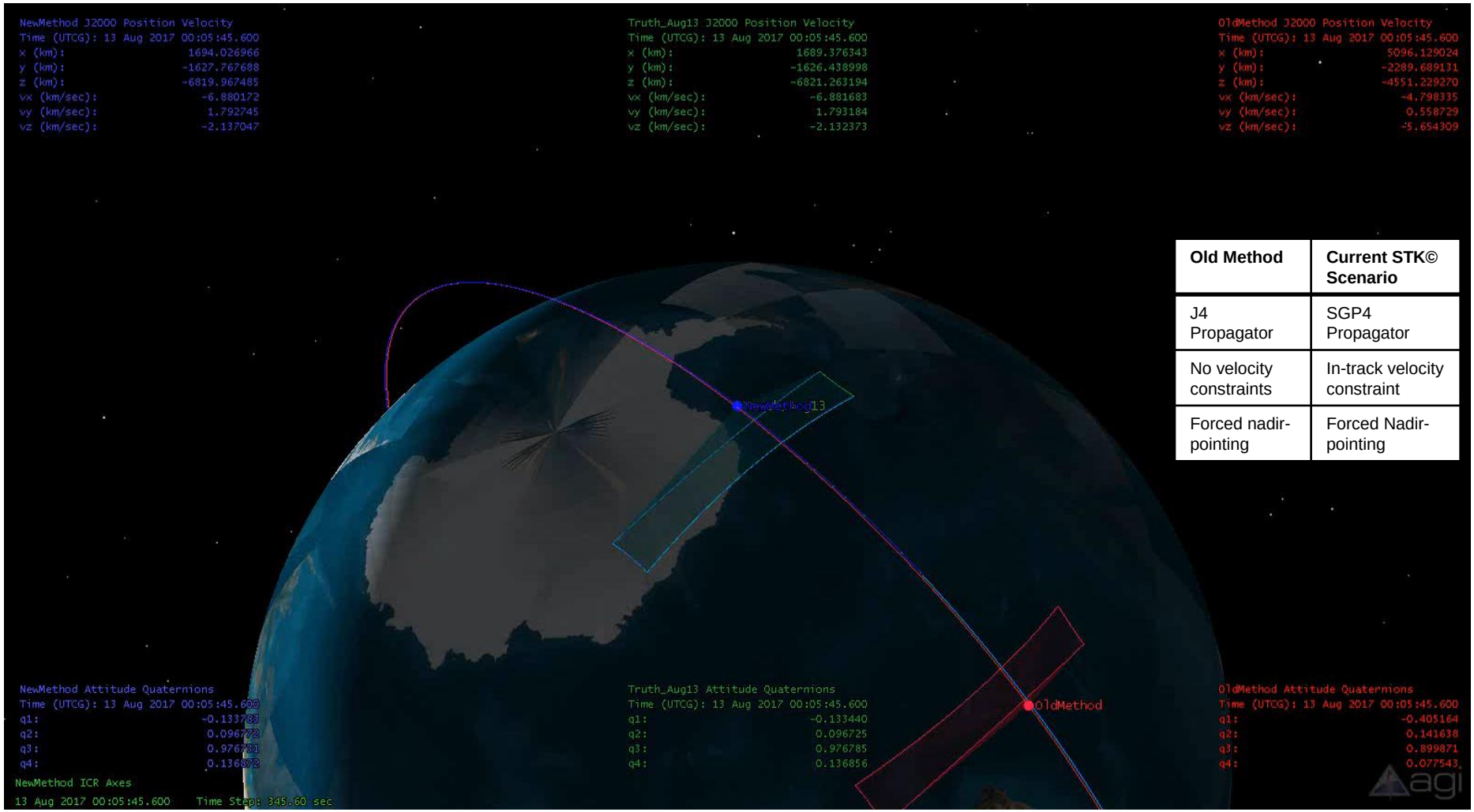


Old Method	Current STK© Scenario
J4 Propagator	SGP4 Propagator
No velocity constraints	In-track velocity constraint
Forced nadir-pointing	Forced Nadir-pointing

Summary

- New technique developed to provide simulated JPSS-1 S/C A&E data with higher fidelity
  - Leverages existing 17-day S-NPP-based proxy dataset
  - Replaces existing proxy dataset A&E data with STK© generated values
  - Aligns test data with current test timeframe using the 16-day repeat track
  - Provides high fidelity simulated A&E results for at least 10 days
- Enables completion of the sensor chain product generation with higher functional-quality “fill ≤ ~1%” products.

New developed technique provides high fidelity simulated S/C A&E data and can be leveraged for upcoming JPSS missions (e.g., JPSS-2).

Backup

STK© Report

- Custom STK© report shows
  - Time (UTC), Position (m), Velocity (m/s), Quaternions
  - Generated with a 1-sec frequency for a 24-hour period

Satellite-J01_TLE_SGP4_Aug31

Time (UTCG)	x (m)	y (m)	z (m)	vx (m/sec)
12 Sep 2017 00:00:00.000	328681.6005	1296517.3896	7071991.7847	7027.2239091702
12 Sep 2017 00:00:01.000	335708.8369	1299072.8815	7071194.5318	7027.2449577943
12 Sep 2017 00:00:02.000	342736.0906	1301625.9734	7070389.7367	7027.2582173108
12 Sep 2017 00:00:03.000	349763.3536	1304176.6626	7069577.4002	7027.2636872989
12 Sep 2017 00:00:04.000	356790.6182	1306724.9463	7068757.5233	7027.2613673463
12 Sep 2017 00:00:05.000	363817.8765	1309270.8218	7067930.1066	7027.2512570495

vy (m/sec)	vz (m/sec)	q1	q2	q3	q4
2556.6912077307	-793.4816365961	0.9902763005772	0.1028751401126	-0.046349803687	0.0813710621782
2554.2925225534	-801.0242814301	0.9902521924272	0.1028332643362	-0.046861633714	0.0814242127657
2551.8911300852	-808.5660766984	0.9902278197594	0.1027913610774	-0.047373451105	0.0814773415909
2549.4870339915	-816.1070144070	0.9902031825803	0.1027494303474	-0.047885255722	0.0815304486396
2547.0802379392	-823.6470865675	0.9901782808969	0.1027074721571	-0.048397047428	0.0815835338975
2544.6707455988	-831.1862851892	0.9901531147160	0.1026654865176	-0.048908826086	0.0816365973505

16-day Repeat Track

- Purpose is to align 1st ascending node in the April 2014 Dataset with similar ascending node for test data
  - Align the Longitude
  - Results in ~36 sec of offsets over the 16-day repeating period
  - April 2014 S-NPP orbital period vs test timeframe orbital period
    - 101.500 minutes in 2014 vs 101.498 minutes today
  - S-NPP repeating track currently is 16.0000098 days

From Initial IDPS Test Data (April 2014)

Epoch	Rev	Long.
2014/04/04 00:46:57.809	12608	190.584

*1st analysis

For Initial checkout of this method May 2017

Epoch (1st Node after TLE Epoch)	Rev	Long.
2017/05/14 00:42:05.237	28725	190.728

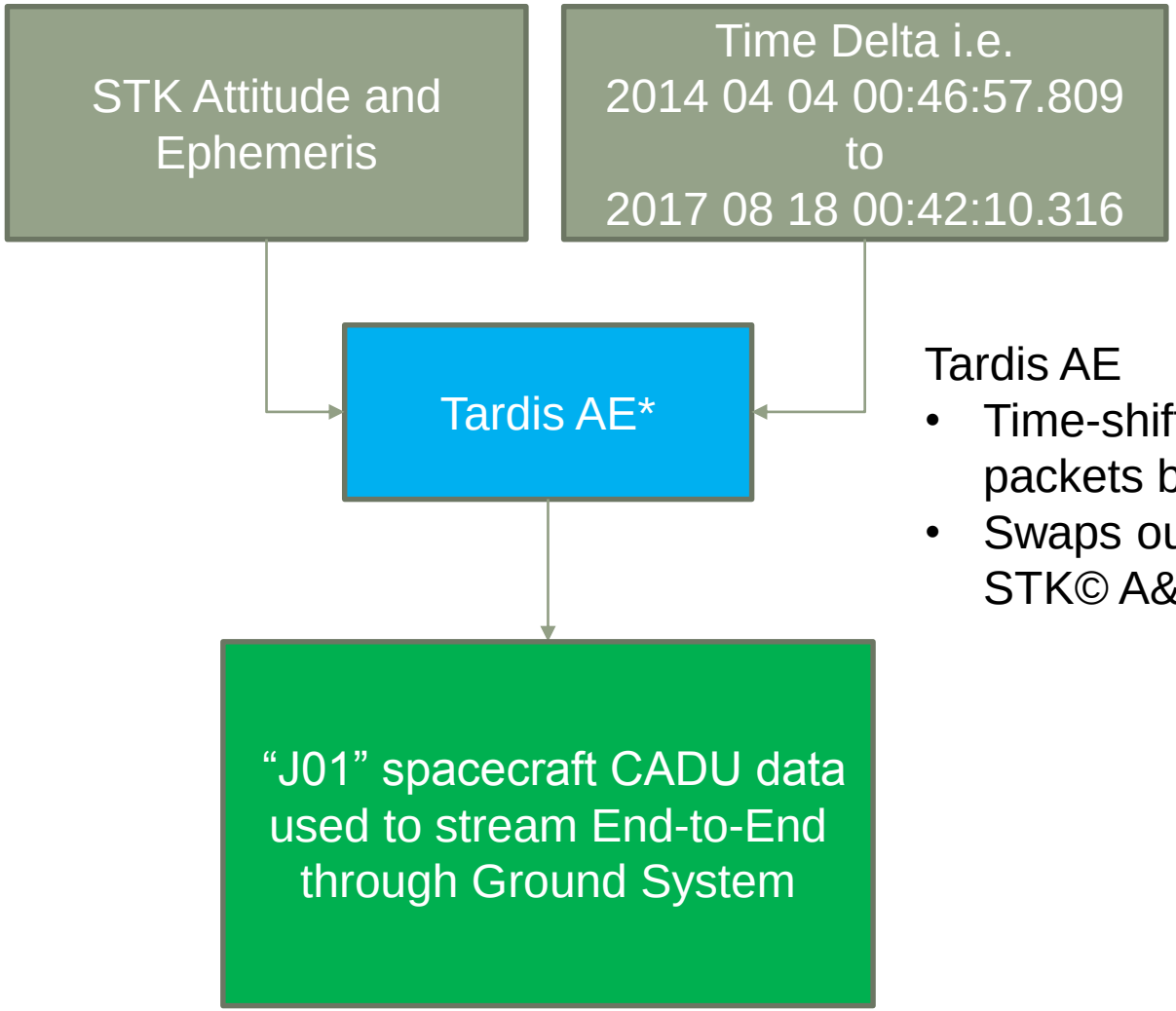
For 1st 8 day run August 2017

Epoch
2017/08/02 00:42:09.469

For 2nd 8 day run August 2017

Epoch
2017/08/18 00:42:10.316

Time-shifting & Replacing APID 11

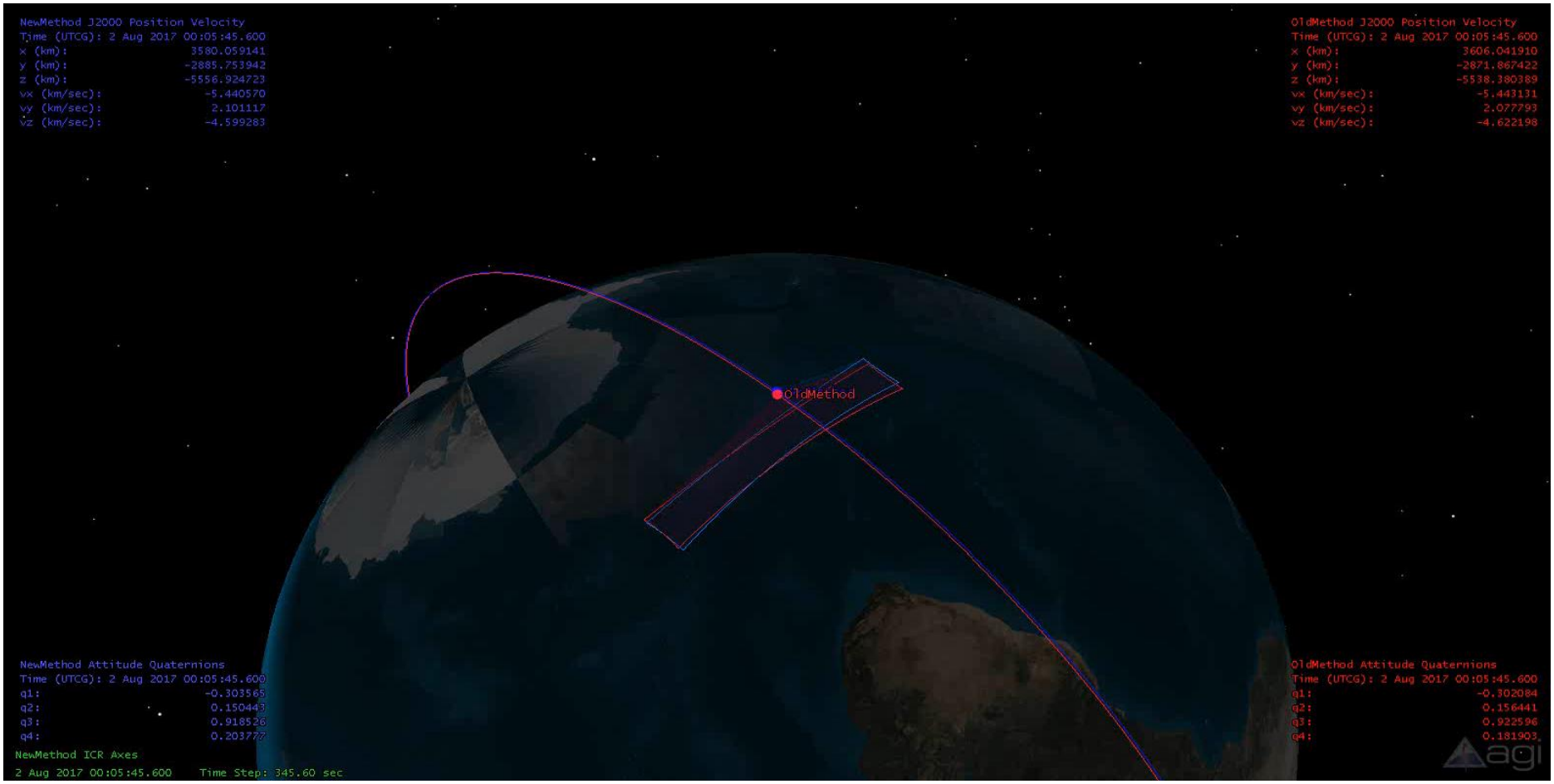


Tardis AE

- Time-shift of April 2014 data packets based on the time delta
- Swaps out APID 11 data with STK© A&E (nearest 1 sec)

* Tool Upgraded by CGS Scott Leszczynski

Iterations to produce STK© scenario



Old STK scenario	Current STK Scenario
J4 Propagator	SGP4 Propagator
No velocity constraints	In-track velocity constraint
Forced nadir-pointing	Forced nadir-pointing

3-Days Out: Old STK© vs Current

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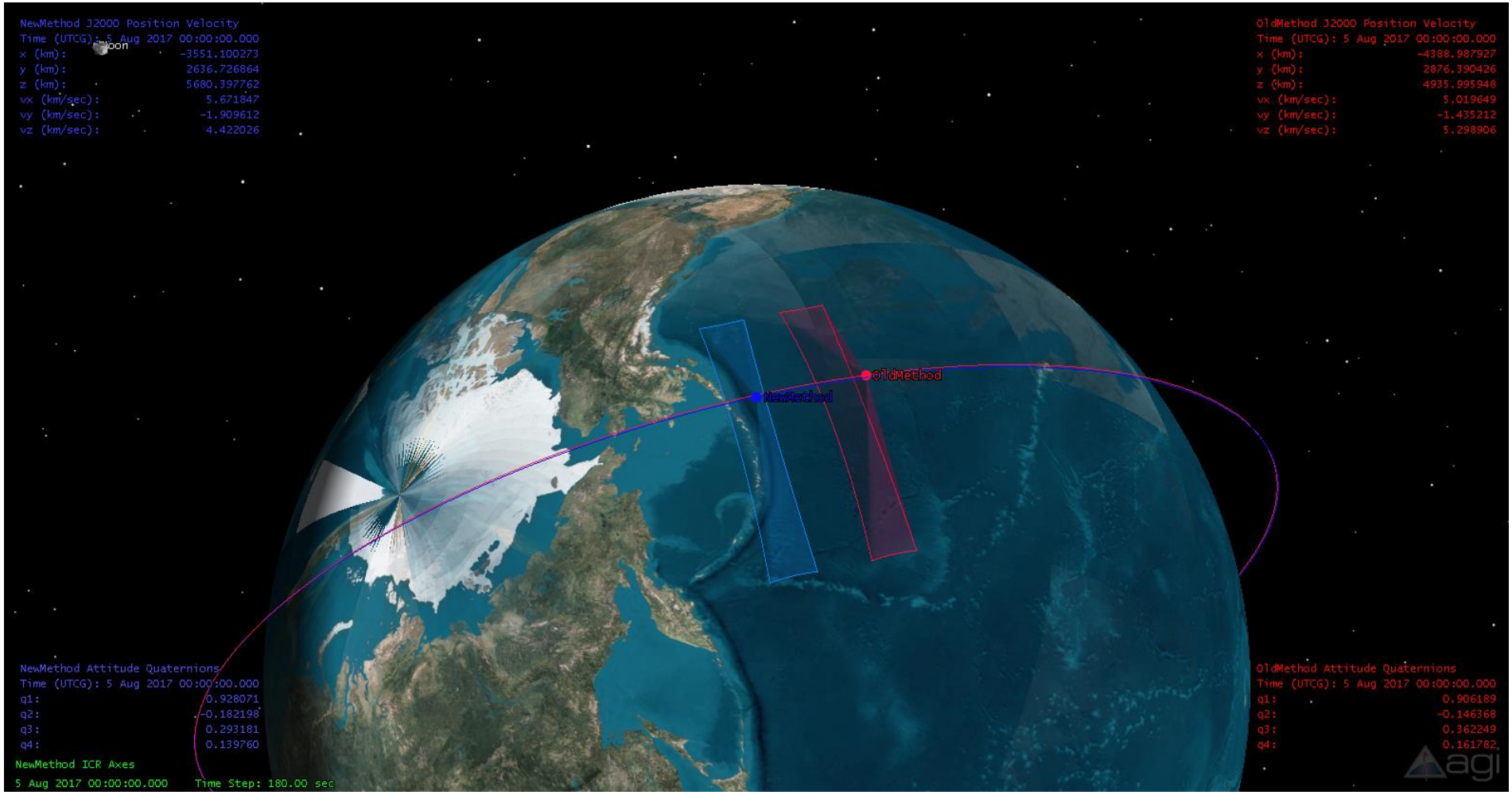

5-Days Out: Old STK© vs Current

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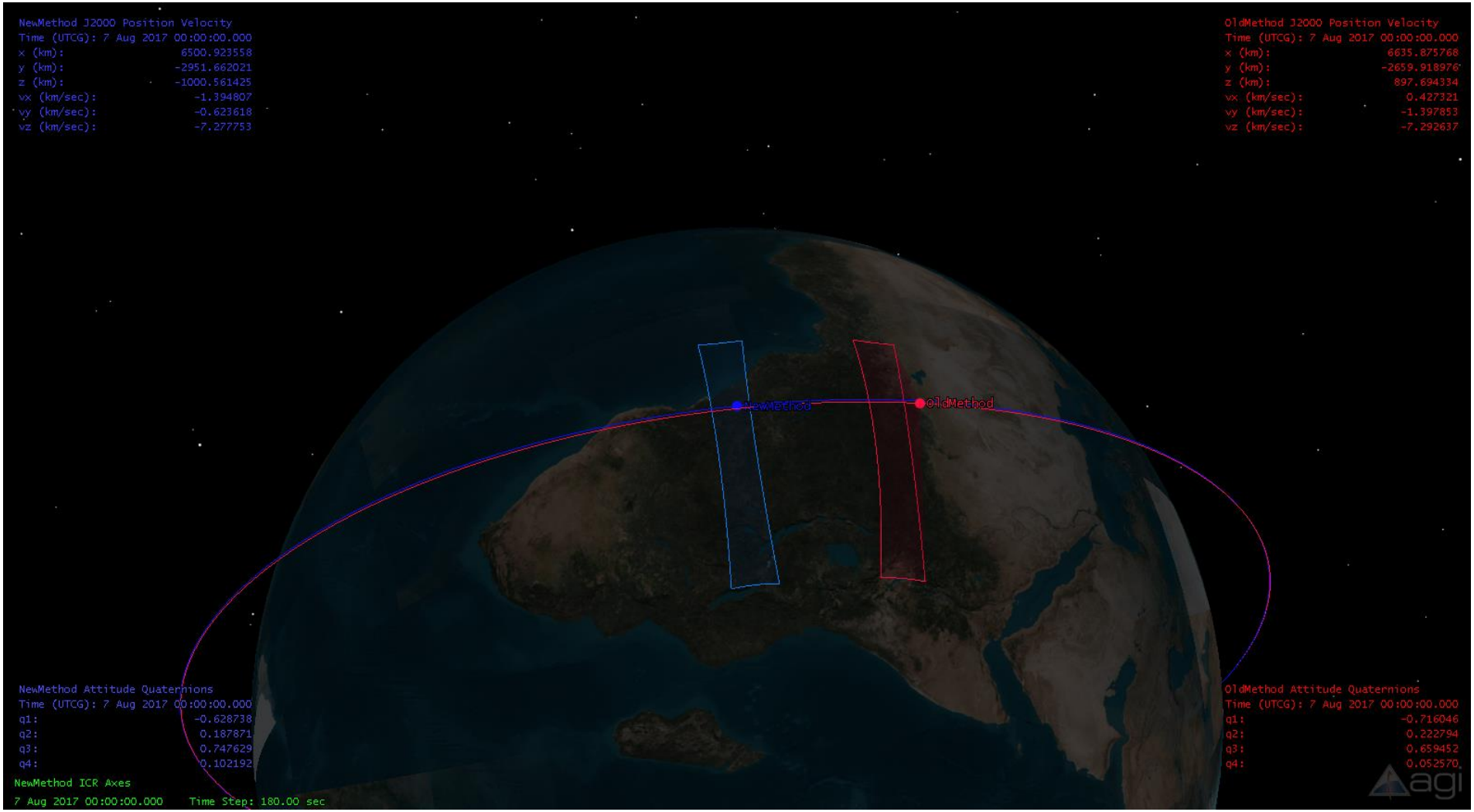

New Method 10-day Propagation vs TLE (truth)

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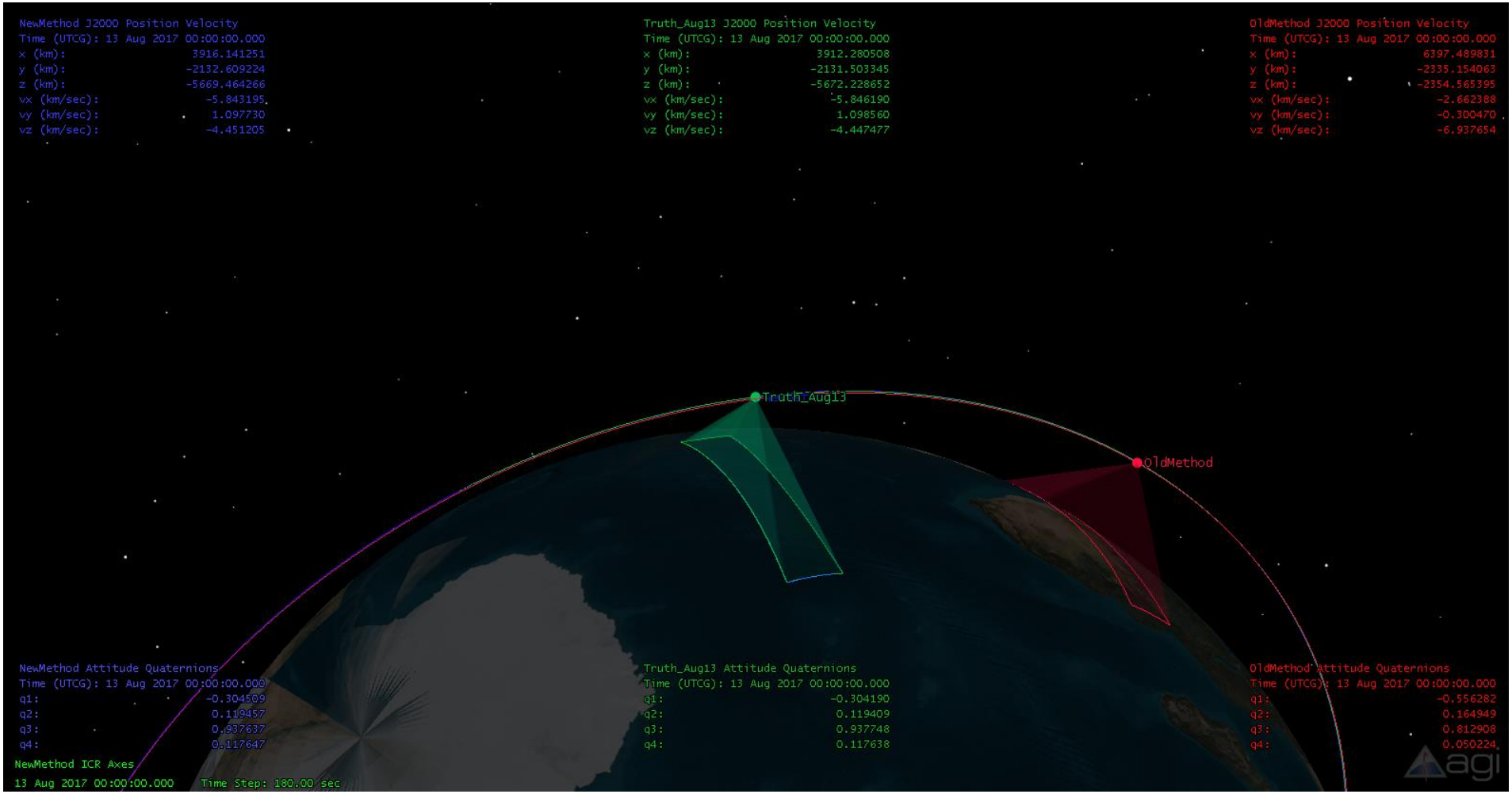

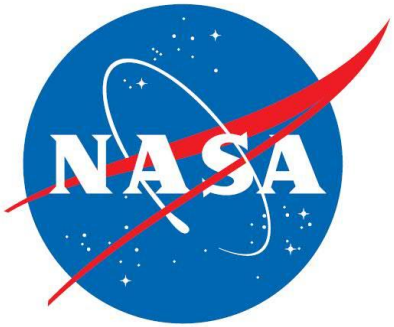

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