

# Introducing Earthfence, a Deep Space Radar

By Brendan (Ben) Quine, CTO

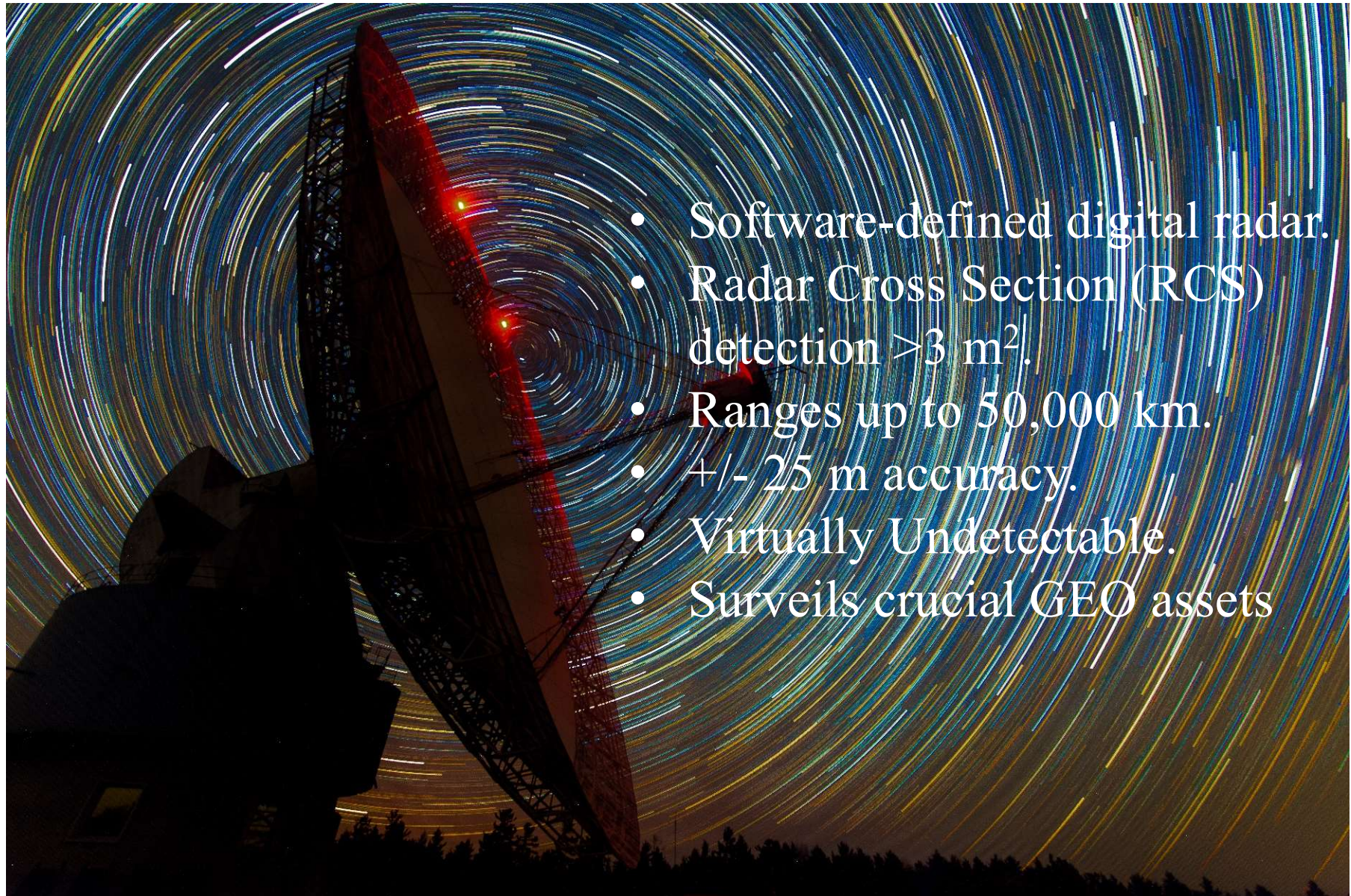
**THOTH** TECHNOLOGY

Services and products for space applications

SINTRA PROPOSERS' DAY

Wednesday, August 10, 2022

# Thoth's SSA Capability: Earthfence

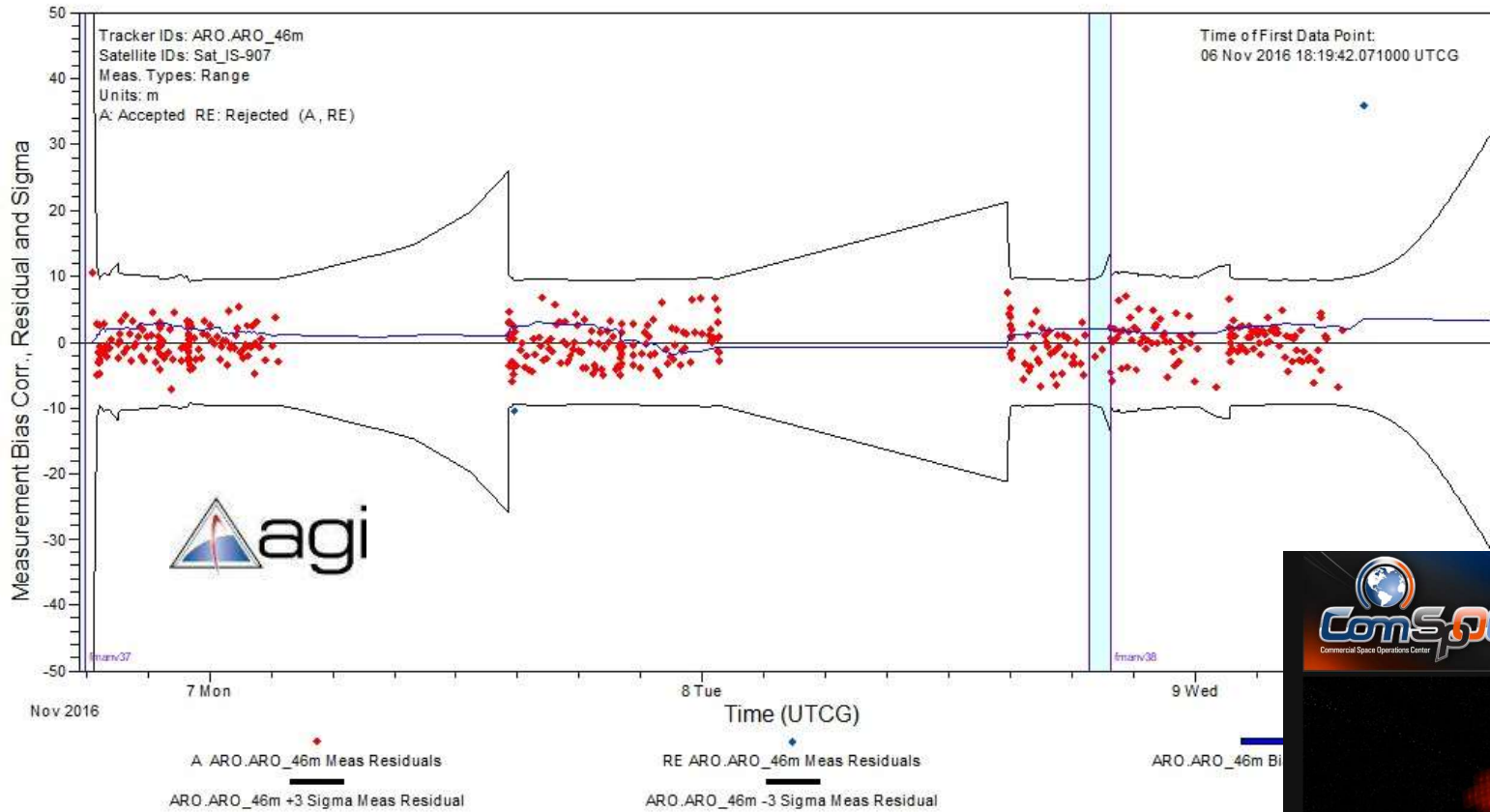


- Software-defined digital radar.
- Radar Cross Section (RCS) detection  $>3 \text{ m}^2$ .
- Ranges up to 50,000 km.
- $\pm 25 \text{ m}$  accuracy.
- Virtually Undetectable.
- Surveils crucial GEO assets



# Earthfence Sensor Calibration

Measurement Bias Corr., Residual and Sigma



Earthfence residuals, Image Credits AGI.

# Analysts Interface: Luch 5B

UTC time

20210408 23:00:33.64



- Radar Online
- Matching
- Thresholding
- Pulses OK
- Pulse Center OK
- Pulse Power OK
- Plotting
- Pointing OK
- Target Observed
- Command Center

Analysis Case Log String  
20210408T225959.722Z AZ=106.564 EL=15.461 AZELOSS=-0.030,-0.030

Client Logging      Unified Data Library

Velocity Match    Target Identification    Client Formats    Range Settings

Raw Data I/O    Raw Data    Raw Pulses    Pulse Detection    RFI Detection

Start Interval Index Array	Extrapolated Pulse Center Index Array	Searched Pulse Center Index Array	Single Pulse Analysis Only
0	5007695	5007695	<input type="checkbox"/> OFF
13000000	18007695	18007695	Extrapolate First Pulse
26000000	31007695	31007695	
39000000	44007695	44007695	
0	0	0	

Acceptable Pulse Power

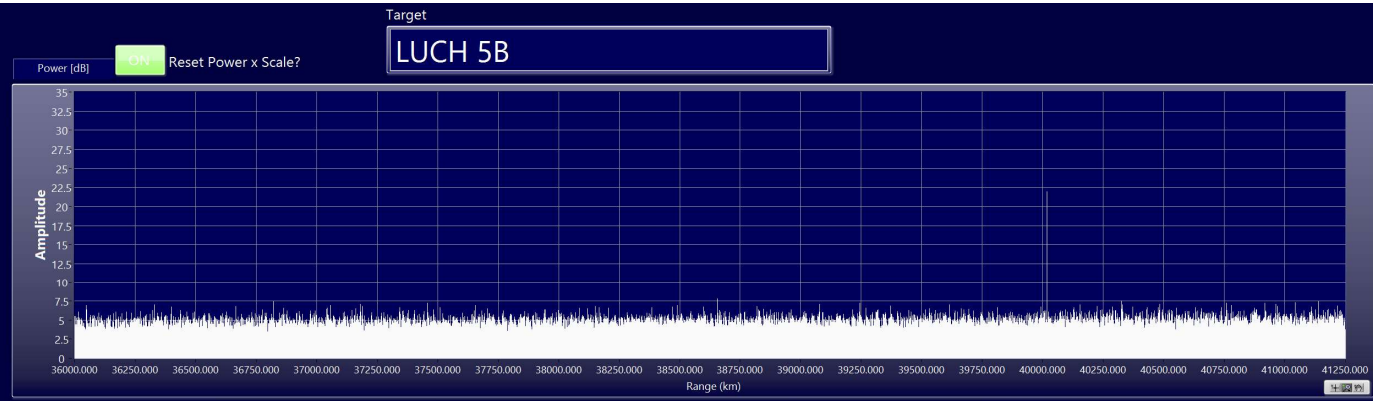
Pulse Power

First Pulse Center

First Pulse center [ms]

Pulse Width [s]

Pulse Interval Delay [s]



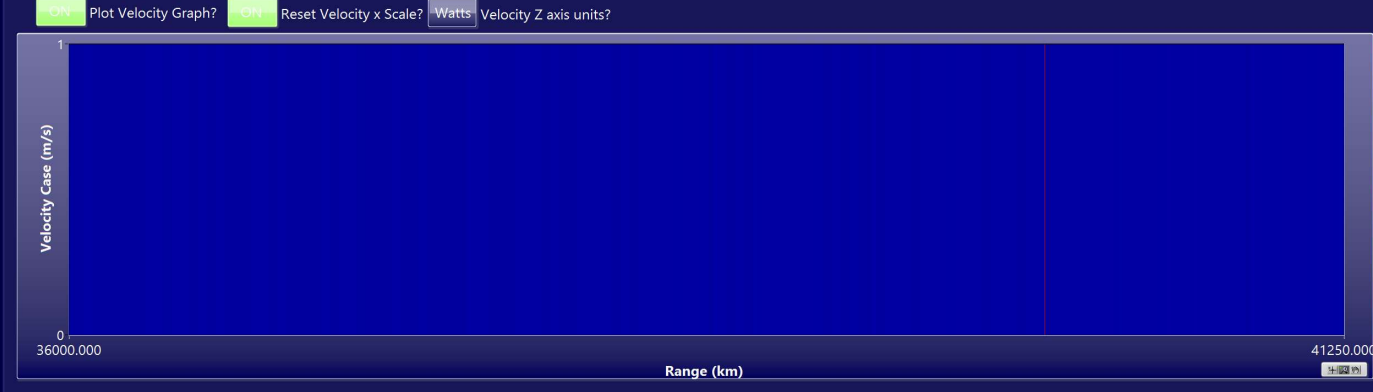
UCT Hits

Total Target Hits

Consecutive Target Hits

Max Consecutive Hits

Velocity Case vs. Sample Index    Prestacked Pulse vs Sample Index    Probability Detection Sigma    Remote Control    Diagnostics    Target Zoom



Record To Database?  ON

SORT RESULTS TABLE  Sort ON

BY

Reverse sort files?  OFF

Identification Results

Range [km]	Power [dB]	Extended	Velocity [m/s]	RCS [m^2]	Delta Range [km]	Delta Range Rate [m/s]	Delta AZ [deg]	Delta EL [deg]	TLE ID	Name
36821.063	7.424	0	0.000	1.569	0.000	0.000	0.000	0.000		
37180.760	7.072	0	0.000	1.504	0.000	0.000	0.000	0.000		
37458.032	7.212	0	0.000	1.600	0.000	0.000	0.000	0.000		
38656.057	7.809	0	0.000	2.082	0.000	0.000	0.000	0.000		
40017.079	11.043	2	0.000	5.036	0.000	0.000	0.000	0.000		
41139.178	7.460	0	0.000	2.465	0.000	0.000	0.000	0.000		
40017.124	21.905	9	0.000	61.423	-0.841	-9.214	-0.035	-0.040	38977	0 LUCH 5B

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# UDL Latency < 1 Minute (SACT 20\_01)

## Last Seen Monitor

Time Since Last Seen	Satellite ..	Common Name	Last seen	
1 minutes	27854	GALAXY 23 (TELSTAR 13)	4/23/2020 15:28:27	
	36358	RADUGA 1M-2	4/23/2020 15:27:01	
2 minutes	39233	EUTE 25B	4/23/2020 15:27:01	
	43700	ES'HAIL 2	4/23/2020 15:27:06	
	26581	ASTRA 3B	4/23/2020 15:26:48	
		1B	4/23/2020 15:26:39	
		SAT (I-4A F4)	4/23/2020 15:26:55	
		1-R	4/23/2020 15:30:13	



## Last Updated

4/23/2020 3:30:28 PM

## Source

- EOSSS
- EXO
- KRTL
- LeoLabs
- MITRE
- Numerica
- PDS
- Rincon
- Thothx
- Zodiac

## Observation Time

Last 8 hours

UTC time  
20200423 14:29:52.26

Log String  
20200423T142927.114Z AZ=217.890 EL=29.743 AZELOFF= 0.050,-0.060

Match Filter: Target Identification, Client Formats, Graph Settings  
Raw Data I/O: Raw Data, Raw Pulses, Pulse Detection, RFI Detection  
Client Logging: SACT

SACT DataMode: Real  
SACT OutGoing Directory Path: \outgoing\_essent

SACT Classification: U//PR THOTH OBS

ON Write SACT Format

Radars Online:

Matching:

Pointing OK:

Thresholding:

Pulses OK:

Pulse Center OK:

Pulse Power OK:

Plotting:

Target Observed:

Command Center:

Target: ANIK F1-R

Power (dB):  Reset Power x Scale?

Velocity Case vs. Sample Index    Prestacked Pulse vs Sample Index    Probability Detection Sigma    Diagnostics    Target Zoom

Plot Prestacked Pulses?     Reset Pulse x Scale?

Total Hits:

Consecutive Hits:

Max Consecutive Hits:

REMOTE CONTROL

Command Computer: localhost

Send which counter? Total Counter

Log Message  
20200423 14:29:20, Azimuth: 217.940, Elevation: 29.803, On target with 28868, Number of hits: 13

Record To Database?  ON

IDENTIFICATION RESULTS

Range (km)	Power (dB)	Extended	Velocity (m/s)	RCS (m <sup>2</sup> )	Delta Range (km)	Target ID	Name
38628.185	11.060	3	0.000	4.389	-1.386	26624	0 ANIK F1
38618.415	11.060	4	0.000	10.393	-0.366	26628	0 ANIK F1-R
39611.941	12.365	3	0.000	5.918	-1.633	39327	0 ANIK G1
37000.995	7.579	0	0.000	1.662	0.000	6174444	
40235.144	8.516	1	0.000	2.877	0.000	6711173	
41141.330	7.534	0	0.000	7.509	0.000	6561642	

STOP PROGRAM

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# SACT: Confirmed G17 Safe Operation

## M008 : Possible G17 Simulated Breakup



**Overview:** Looking for a possible telescope breakup at Latitude 32.903889, Longitude 105.528472

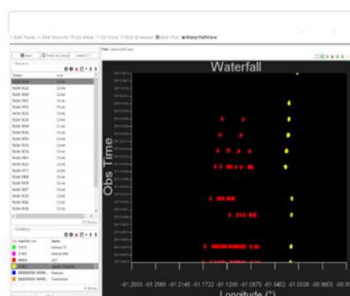
**How Initiated / Found:** Sherlock detection

Automated head-count

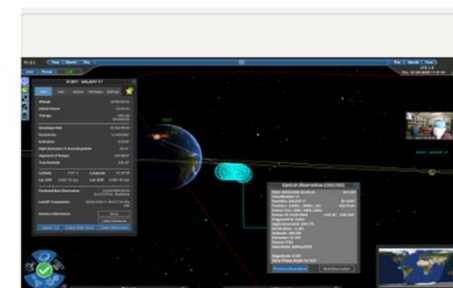
**Time of Start:** 1016Z

**Time of Conclusion:** 14:00Z

### Primary Graphics



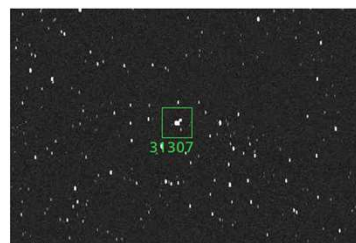
sdccs waterfall confirming breakup on 31307



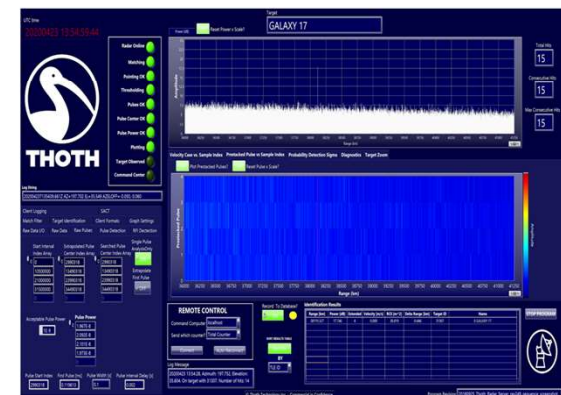
Latest observations on GALAXY-17 from Numerica and EXO

**Technical Details of Interest:** Multiple fragments detected nearby by Stottlet, breakup later confirmed on 31307 by Lockheed/SDCCS. Seradata found evidence possibly linking breakup to Spacebus 3000.

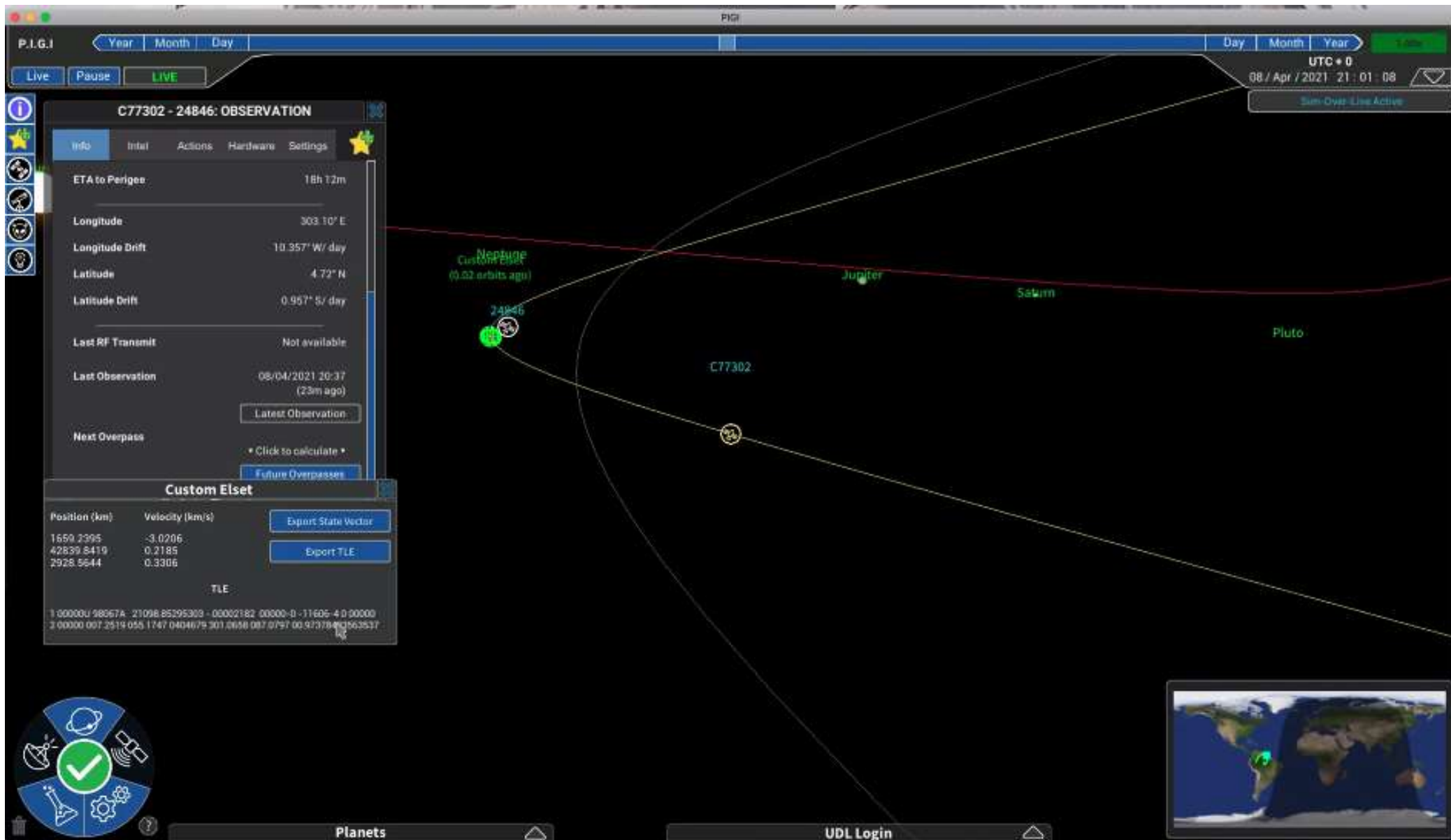
**What Providers Contributed:** Stottlet, SaberAstro, SDCCS, Lockheed Martin, Seradata



Spacecraft Name	Event Date (t)	Event Date (E)	Capability
1. ANIC-9	17/06/2017 Actual	mechanisms/Structures/Thermal anomaly, II, II	3
2. ANIC-9	18/06/2017 Actual	Retired: Due to Mechanisms/Structures/Thermal	0
3. ARABSAT 2A	30/06/2003 Est. to yea	Attitude control - Thruster/Fuel system anomaly, II	0
4. ARABSAT 2A	30/06/2003 Actual	Attitude control - Thruster/Fuel system anomaly, II	0
5. ARABSAT 2A	31/01/2003 Actual	Attitude control - Thruster/Fuel system anomaly, II	0.25
6. ARABSAT 2B	30/06/2003 Est. to yea	Attitude control - Thruster/Fuel system anomaly, II	0
7. ARABSAT 2A (BADR 3)	30/06/2003 Est. to yea	Attitude control - Thruster/Fuel system anomaly, II	0.13



# Saber Visualisation ThothX DSR Data



# Thank You



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