Passive RF in Support of Closely Spaced Objects Scenarios

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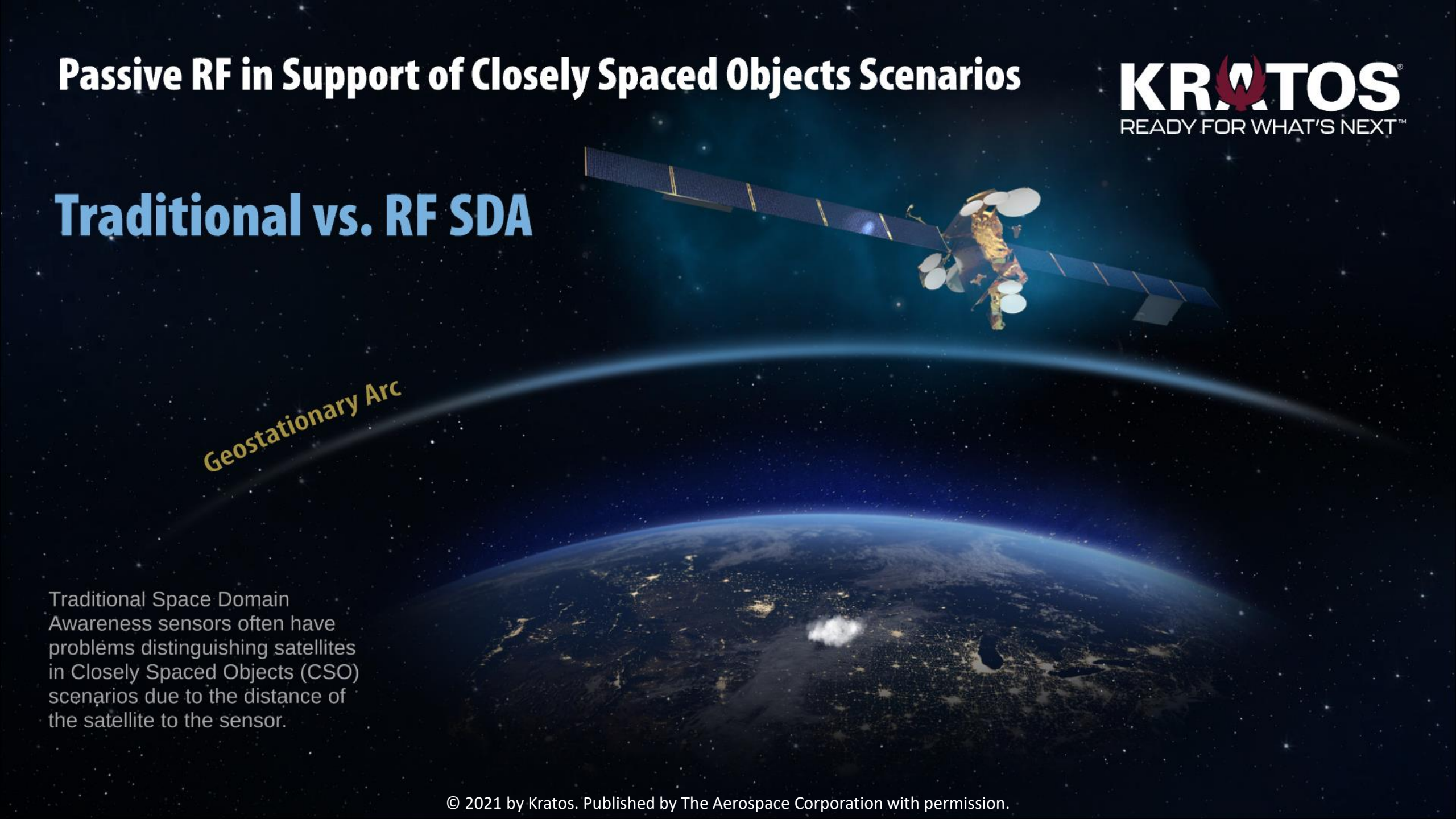
Traditional vs. RF SDA



Traditional Space Domain Awareness sensors often have problems distinguishing satellites in Closely Spaced Objects (CSO) scenarios due to the distance of the satellite to the sensor.

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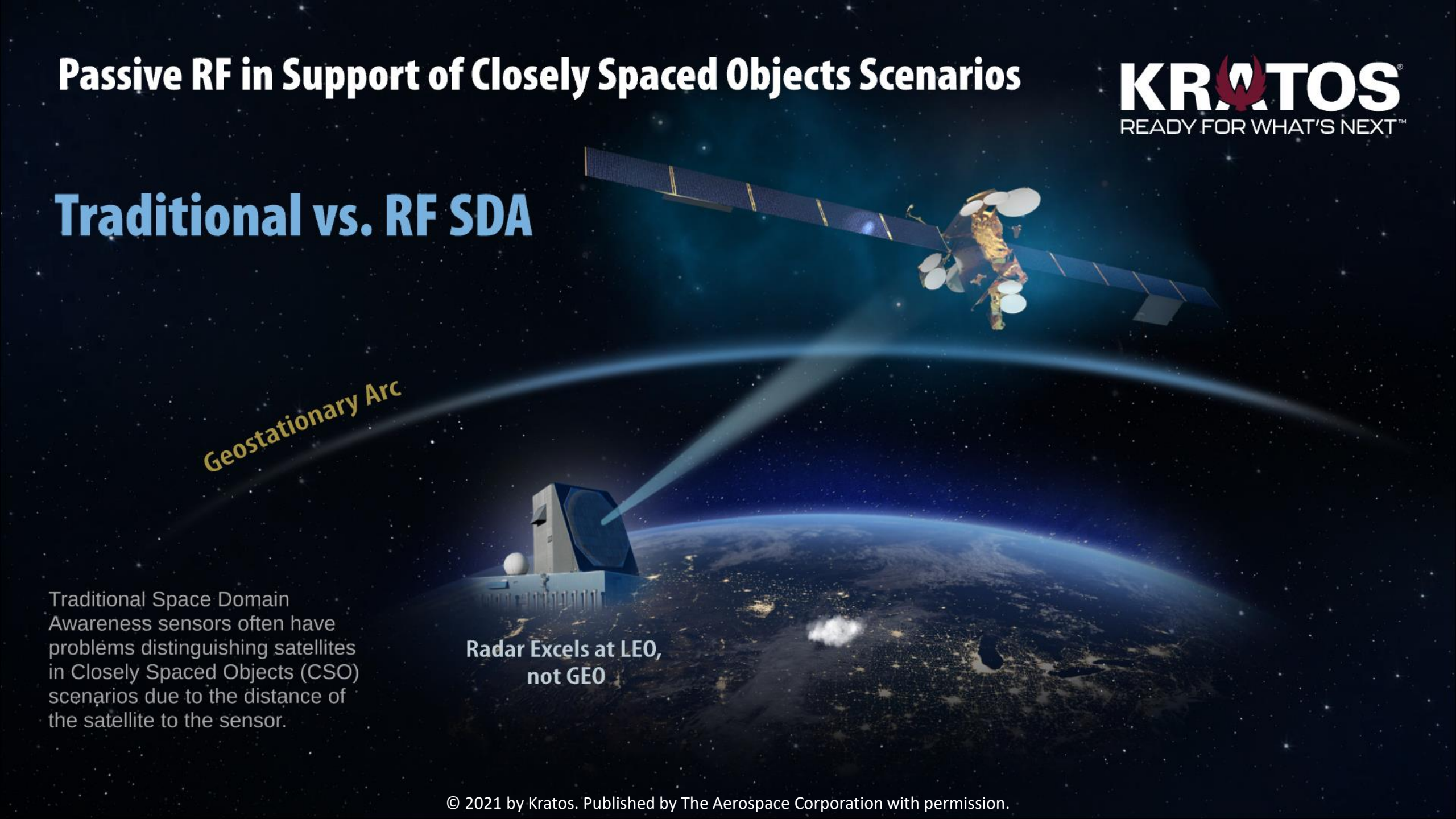

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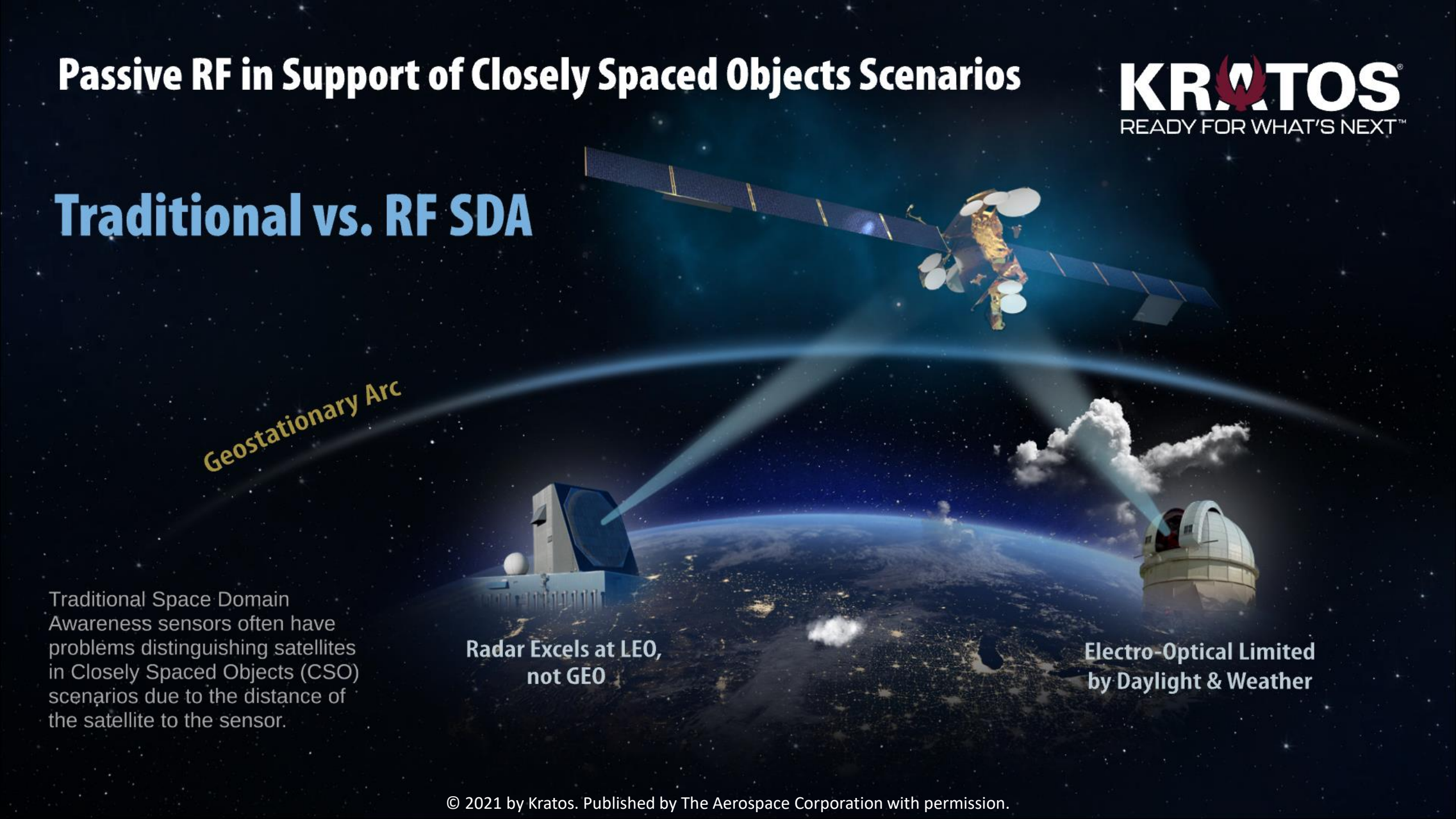

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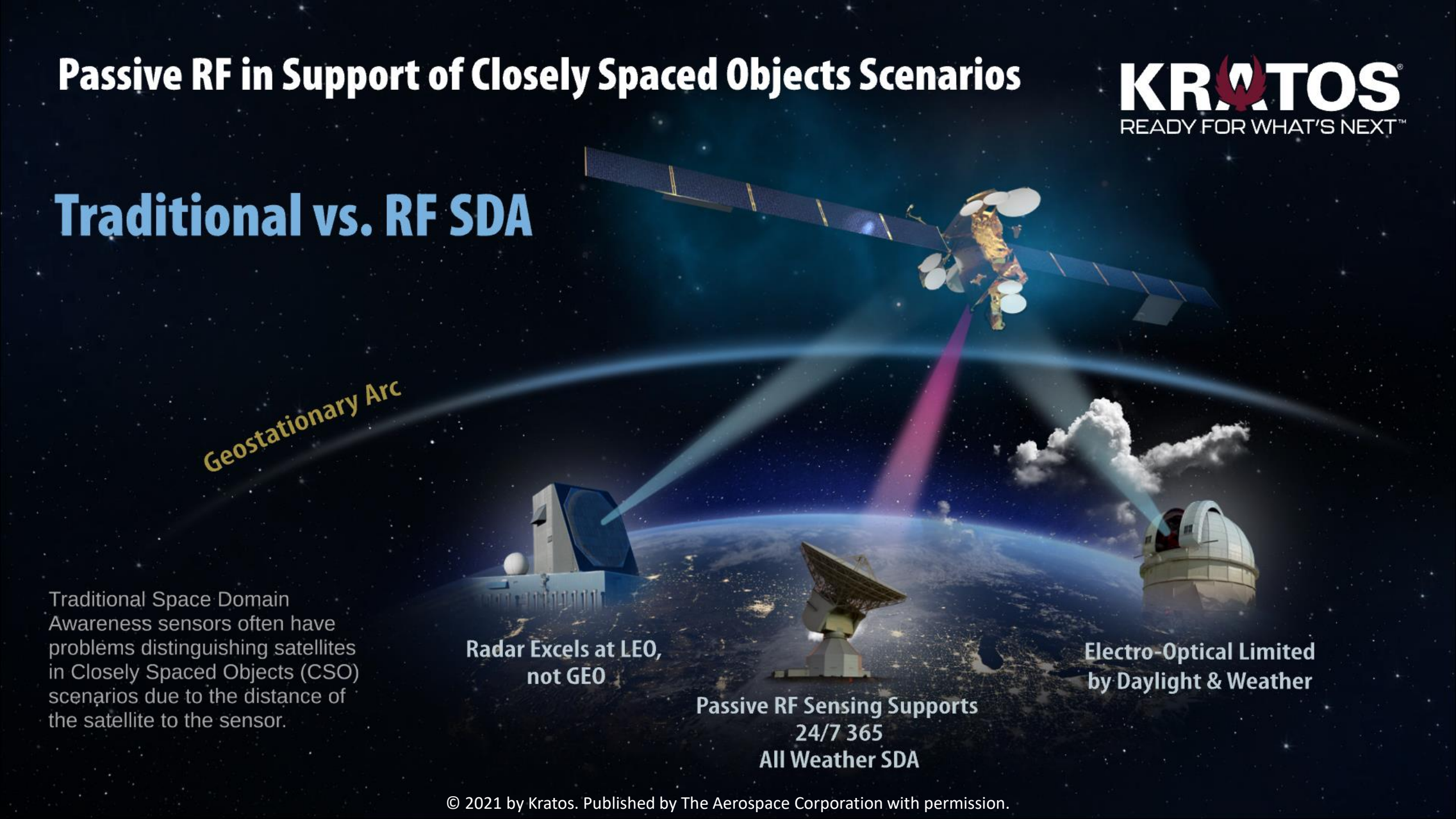

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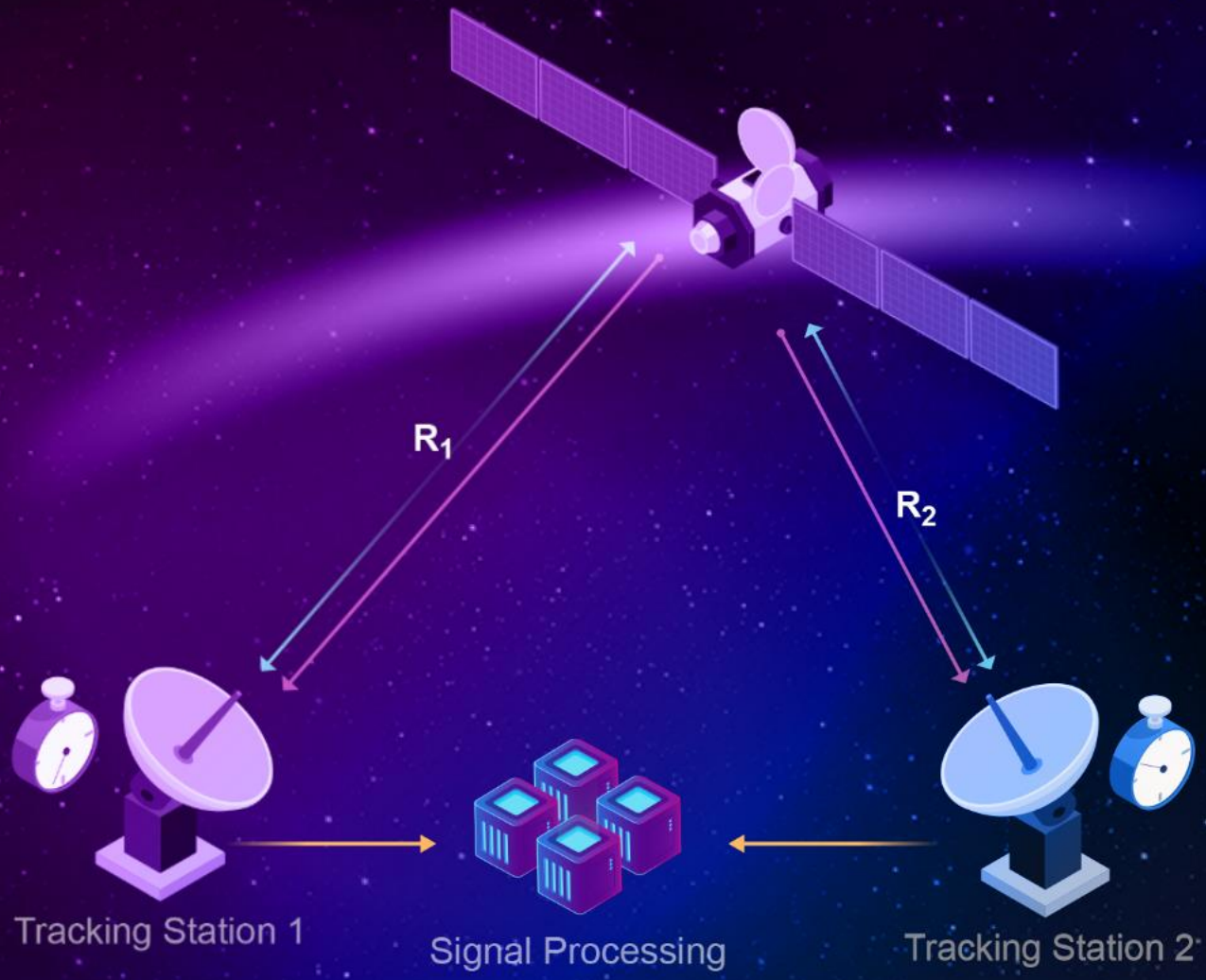
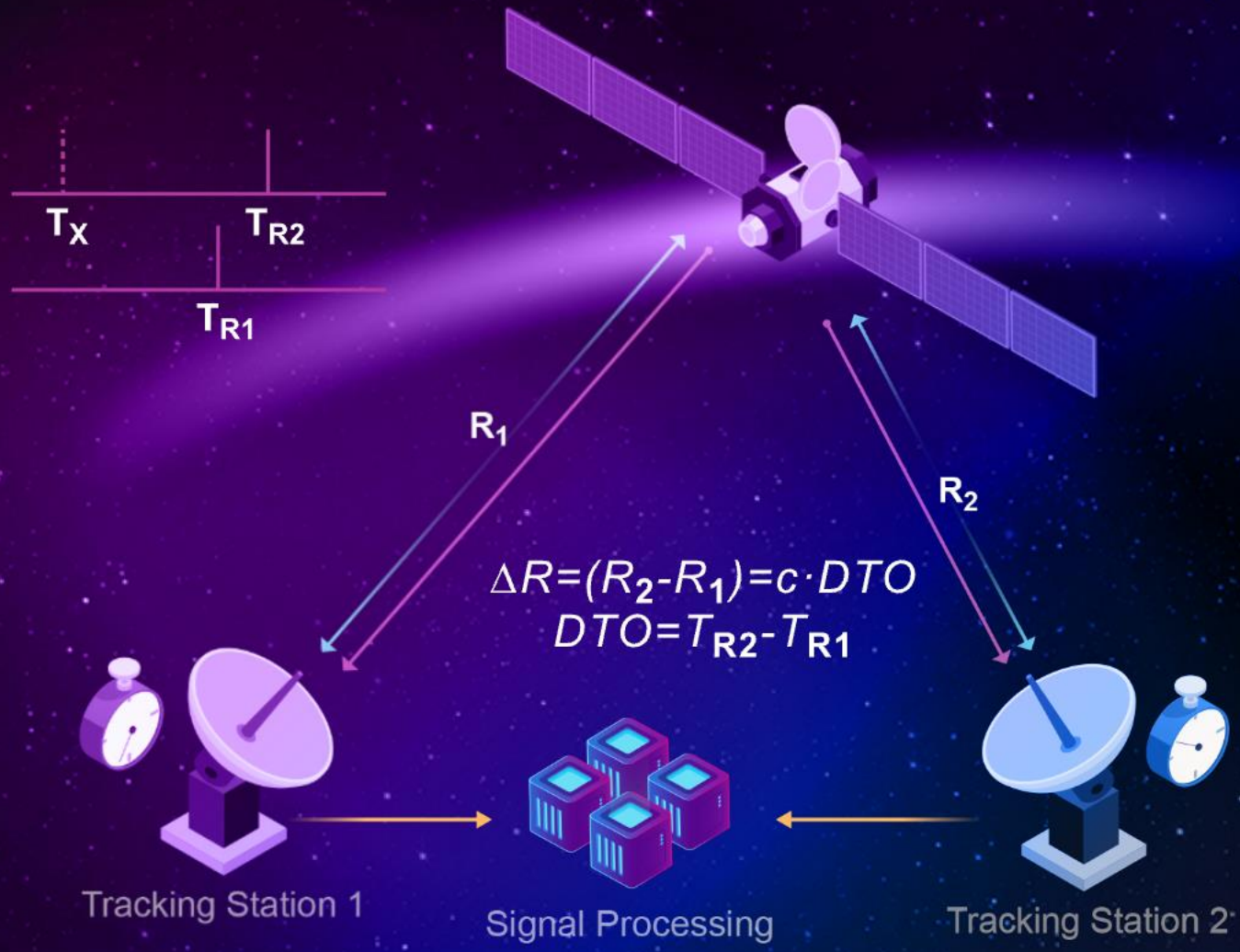
Passive Ranging Overview



- Passive ranging leverages the satellites transmitted RF signal for locating the satellite

Passive Ranging Overview



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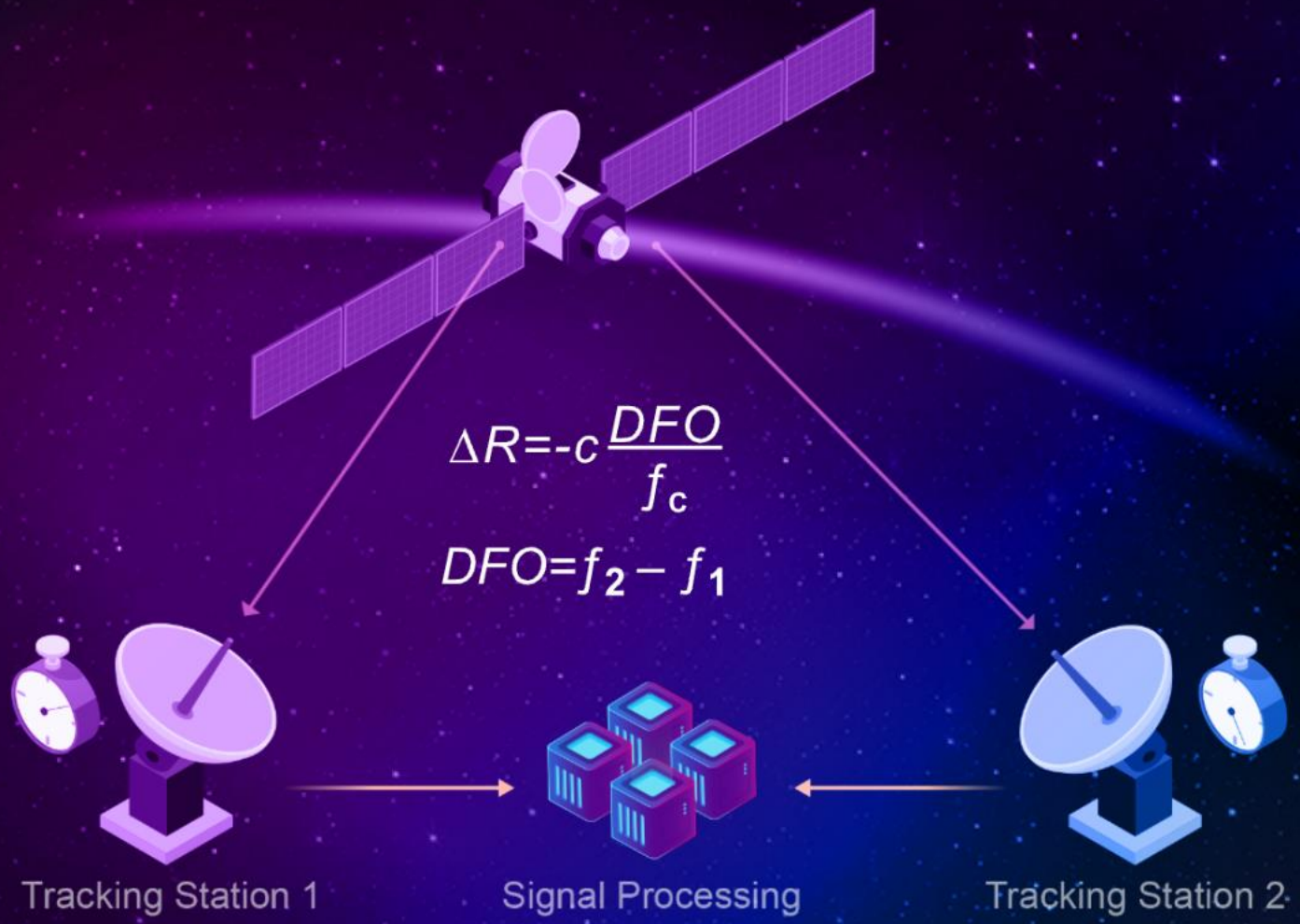

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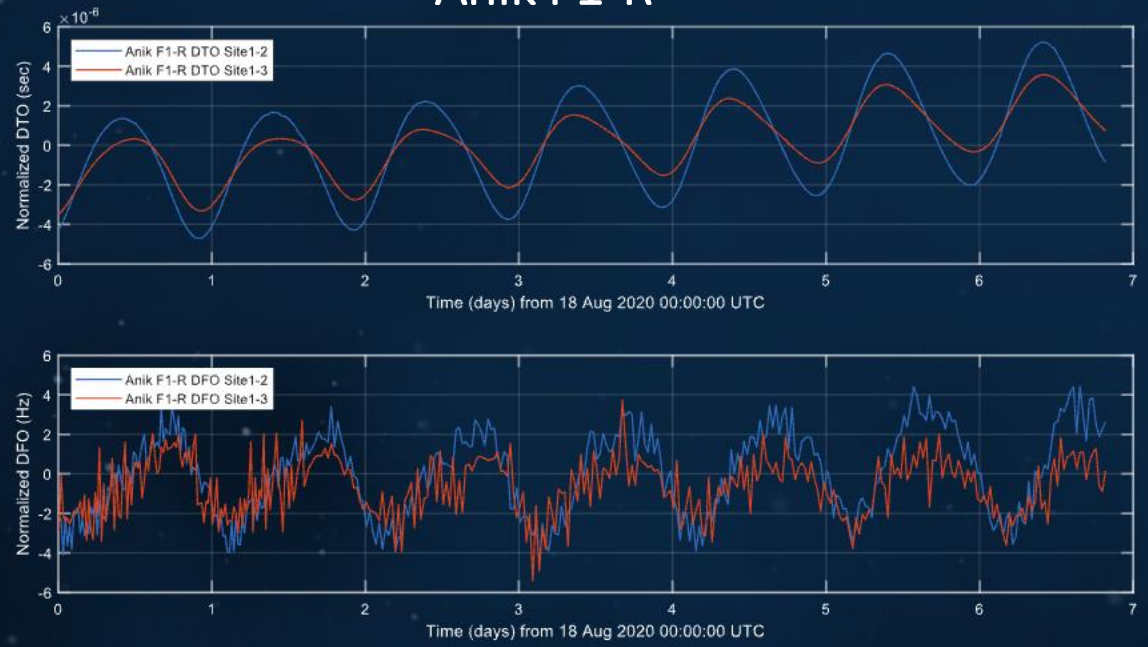
Passive Ranging Overview

Anik F1-R



- Anik geosynchronous cluster located at 107.3deg W
- DTO and DFO collected on
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Passive Ranging Overview

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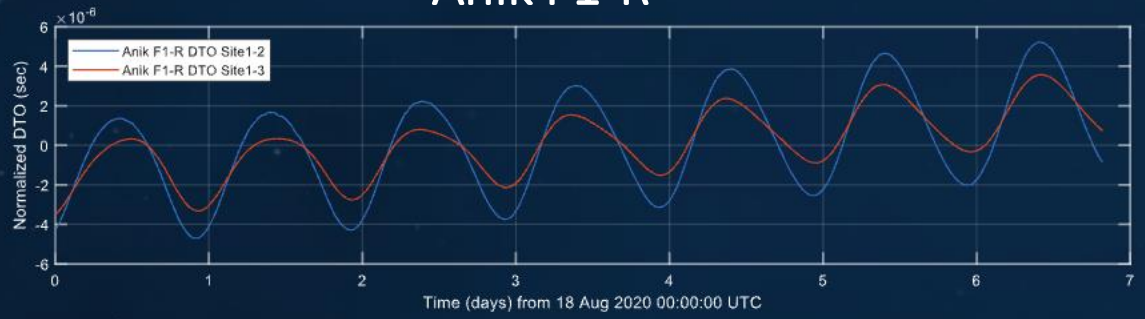
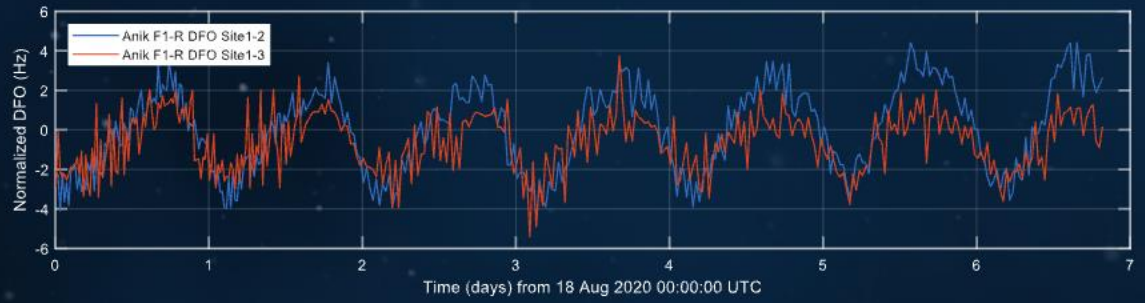
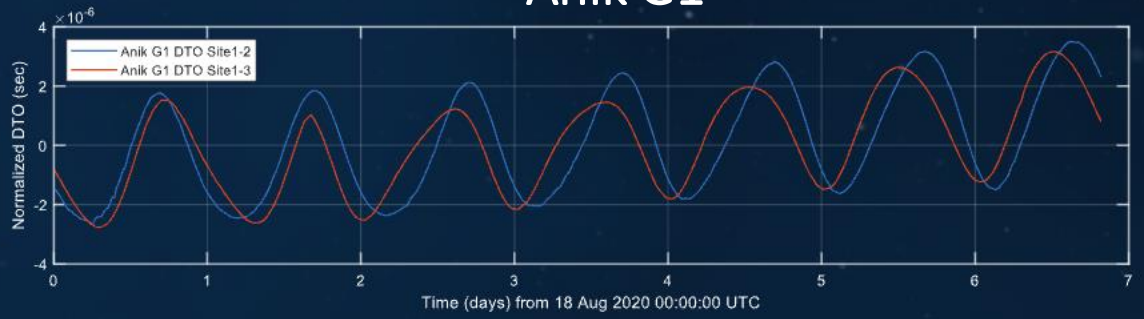
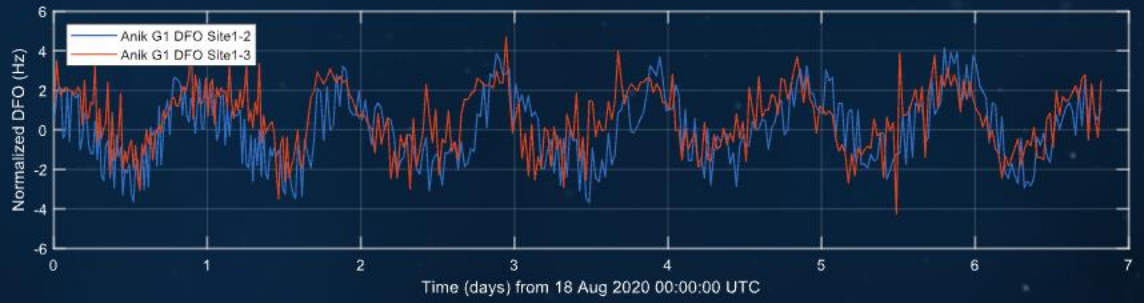
Anik F1-R





Anik G1





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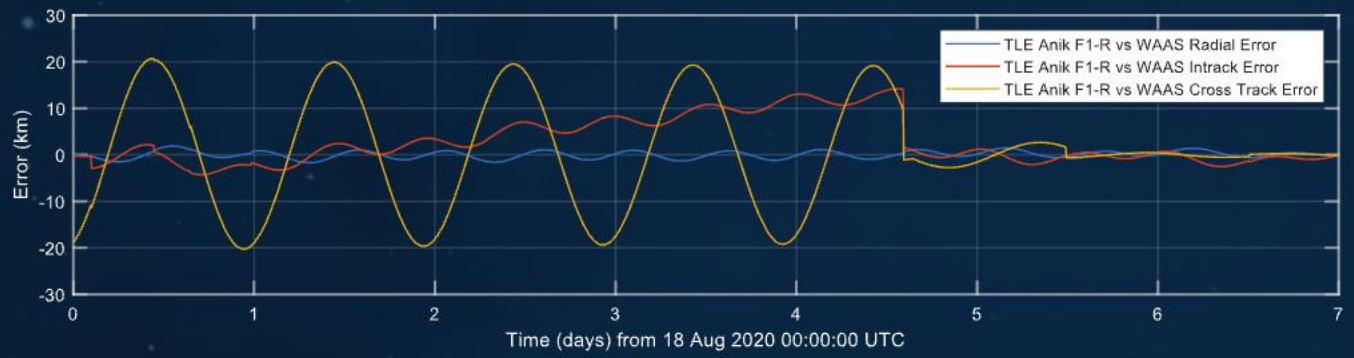
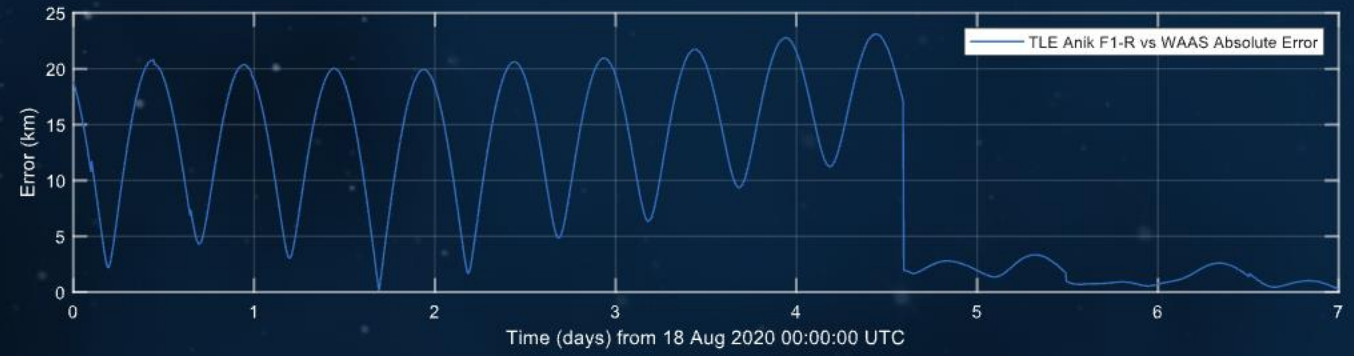
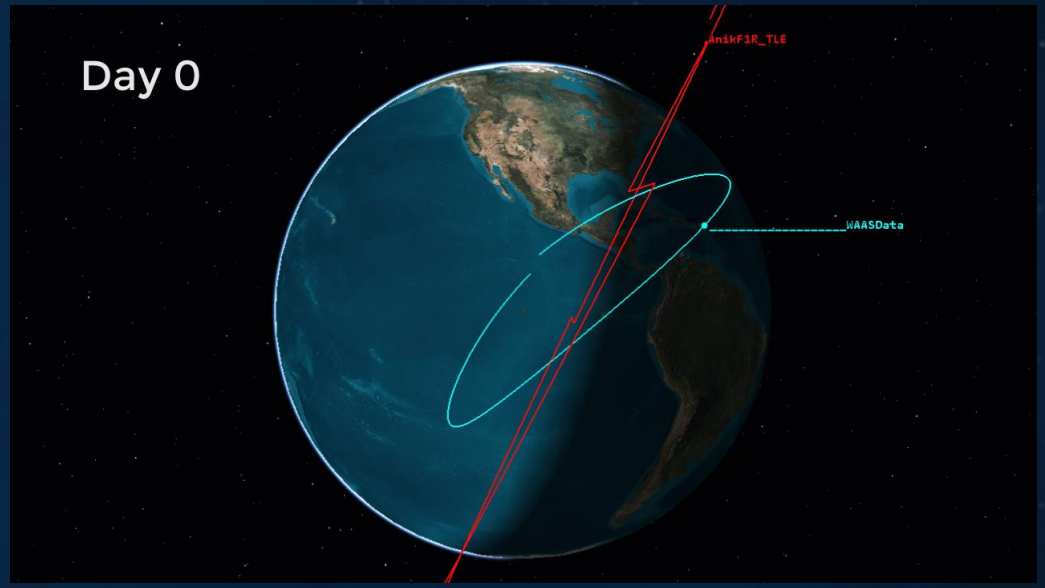
Anik F1-R TLE Solution Compared to WAAS Data





- Anik F1-R hosts a Wide Area Augmentation System (WAAS) payload
- Anik F1-R location from WAAS data used as system calibrator



Anik-F1R WAAS

red orbit = TLE Data
light blue = WAAS Data

- Satellite had no maneuvers during the 7-day time span
- Multiple discontinuities seen in TLE data
  - Assumed to be from cross tagged measurements used in orbit determination process
  - Average Absolute Error of **10.0424 km**

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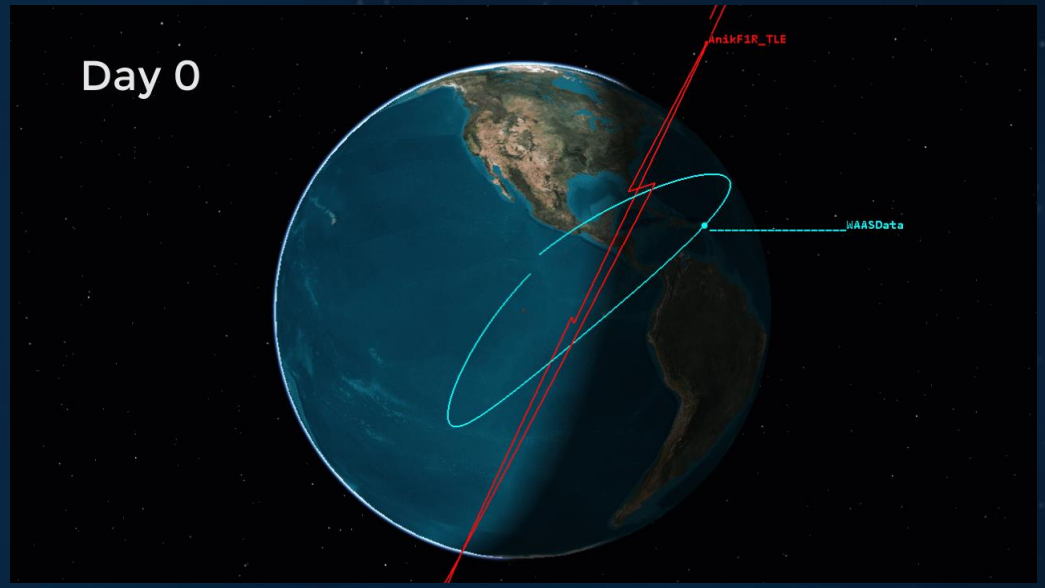

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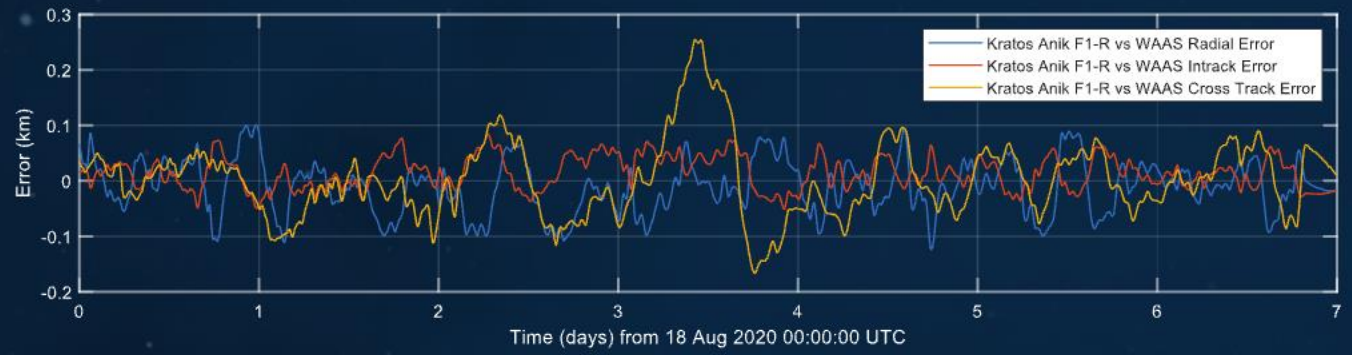
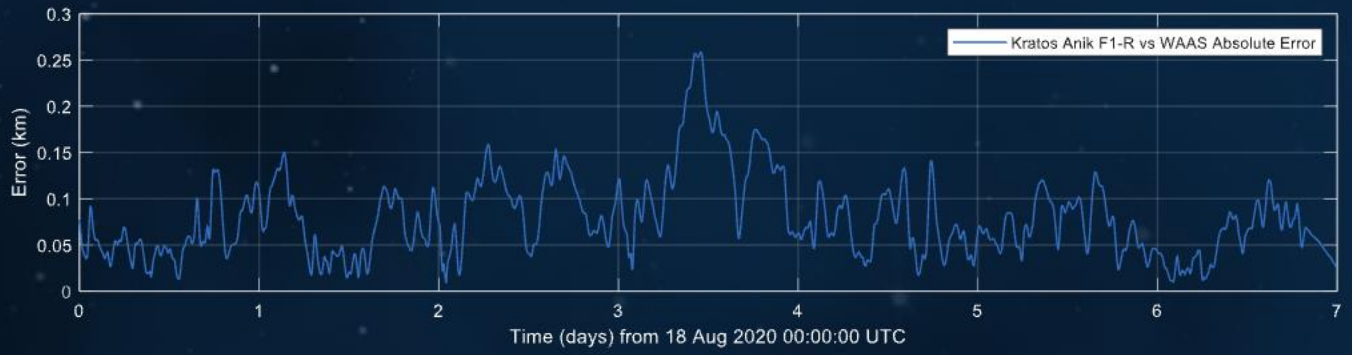
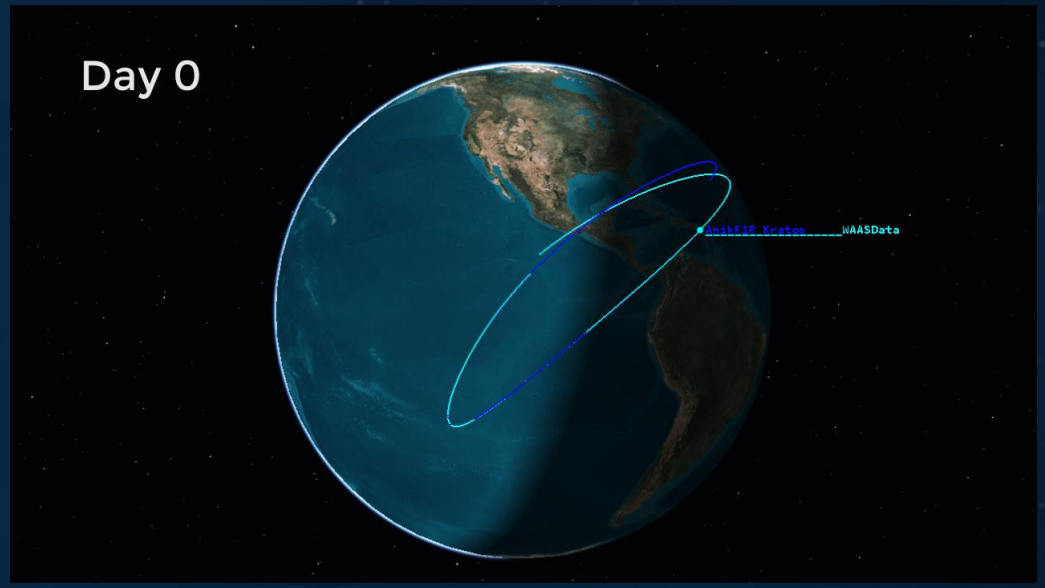




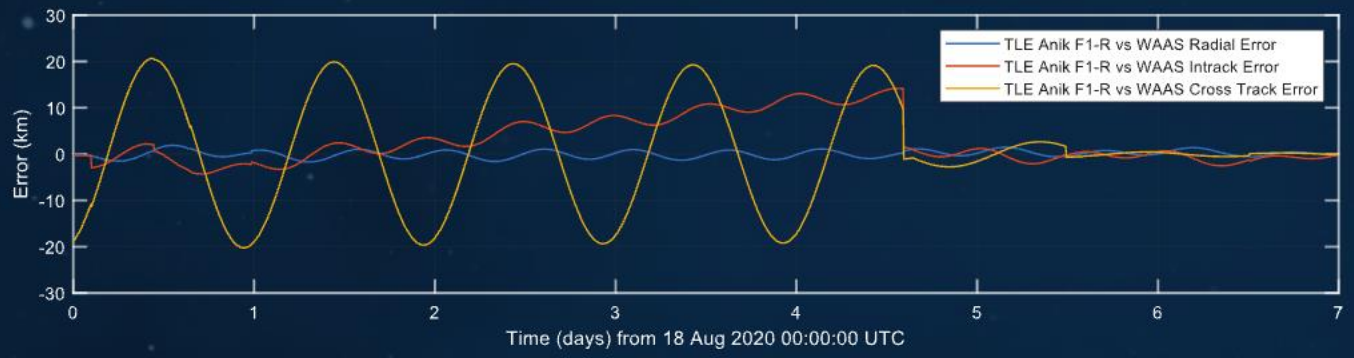


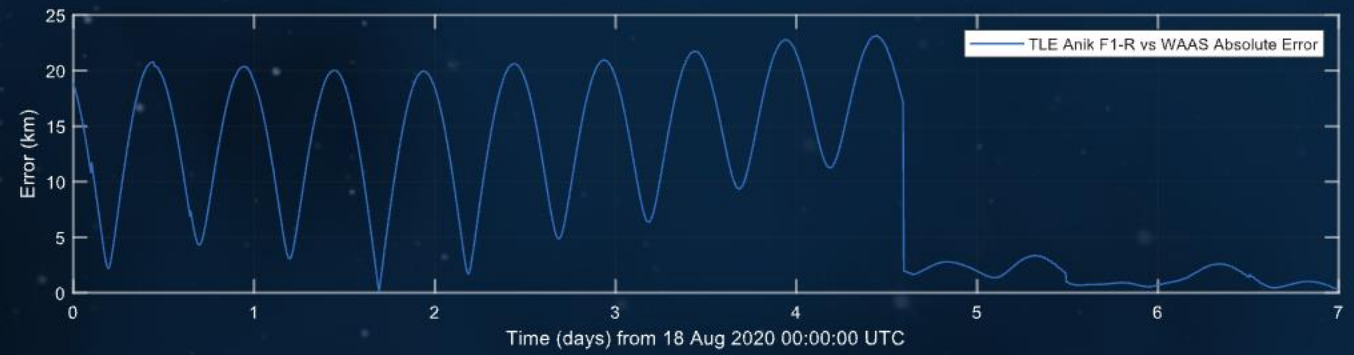
Anik-F1R WAAS

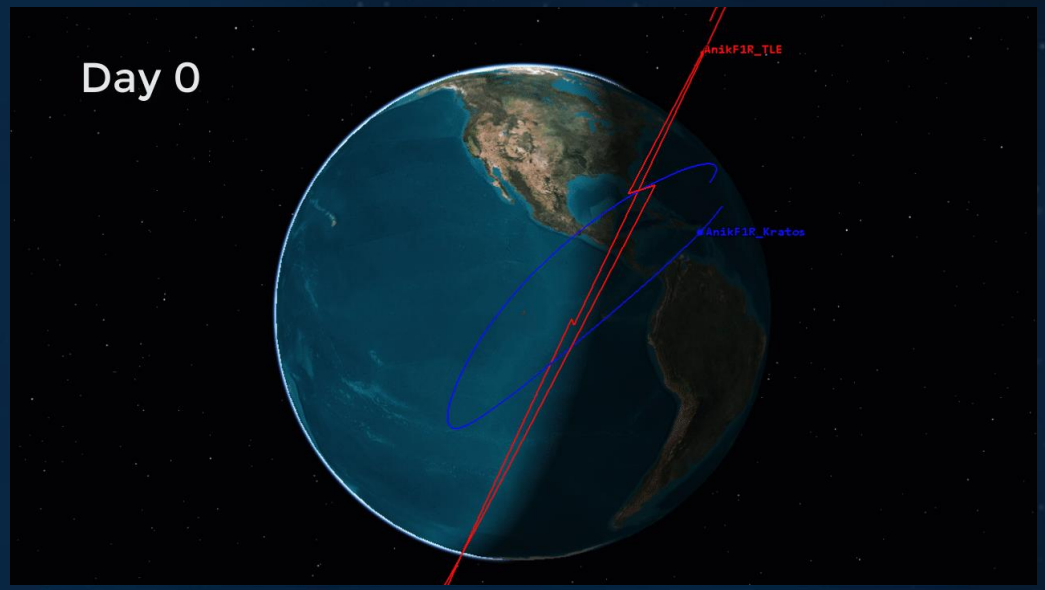
dark blue orbit = Kratos Solution
light blue = WAAS Data

- Satellite had no maneuvers during the 7-day time span
- No discontinuities seen in the passive ranging data
- Average Absolute Error of **0.0785 km**

Anik F1-R Kratos Passive Ranging Solution Compared to TLE Data





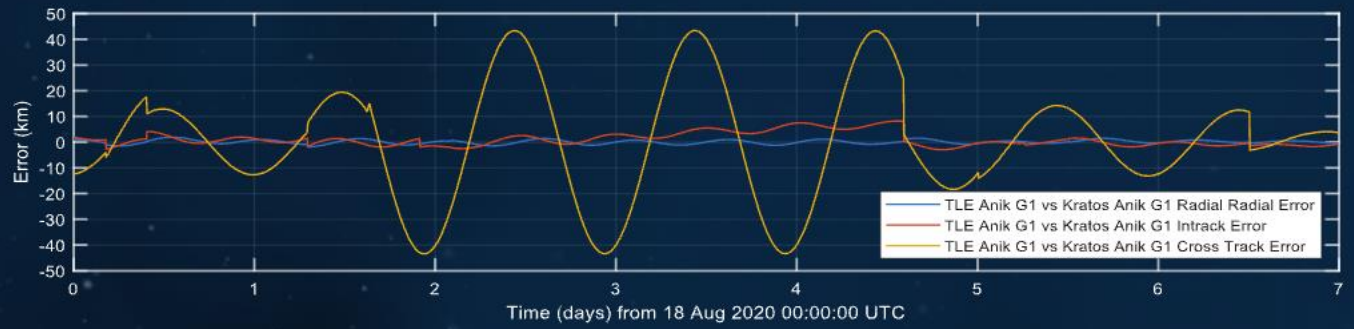


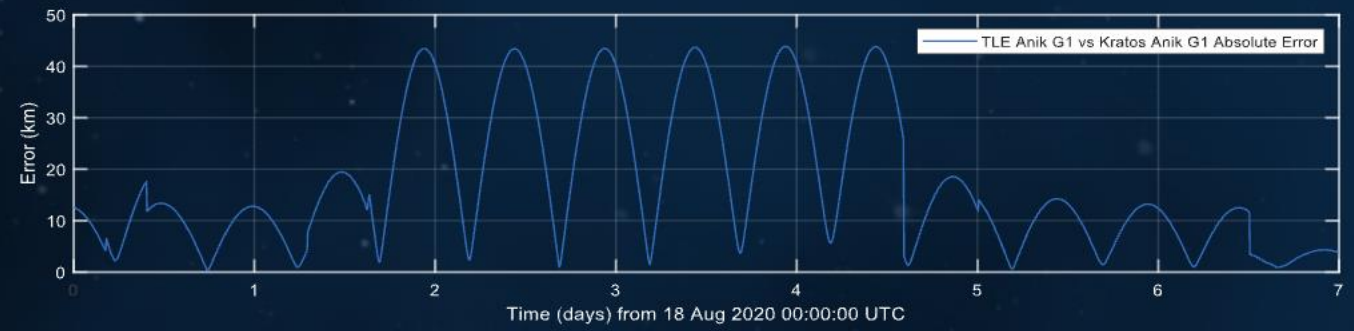
Anik-F1R

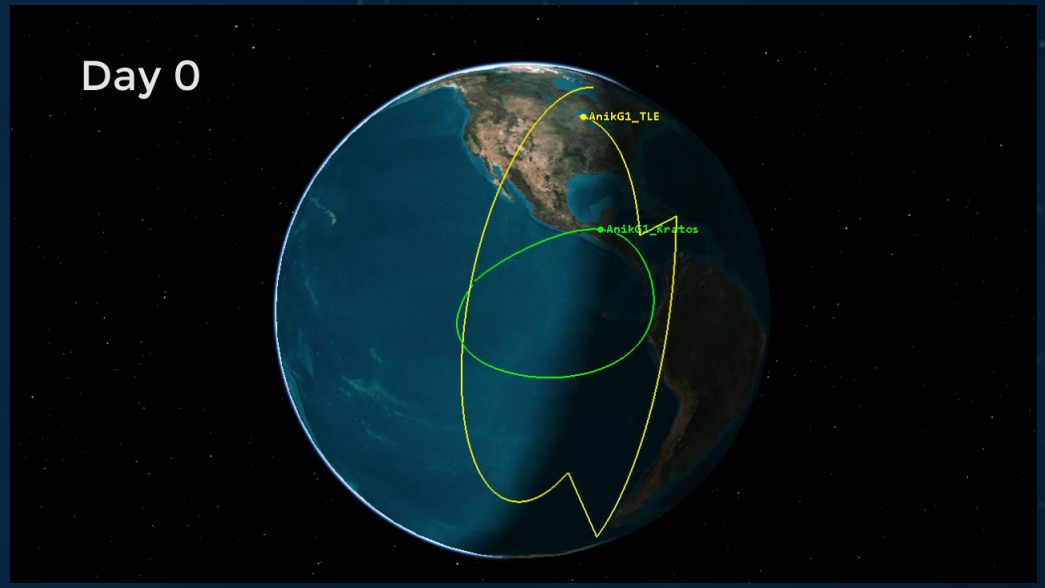
dark blue orbit = Kratos Solution
red orbit = TLE Data

- Satellite had no maneuvers during the 7-day time span
- Multiple discontinuities seen in comparison
  - Assumed to be from cross tagged measurements used in orbit determination process
  - Kratos solution is so close to the WAAS data that the discontinuities are identical
  - **131.6x improvement in accuracy**

Anik G1 Kratos Passive Ranging Solution Compared to TLE Data





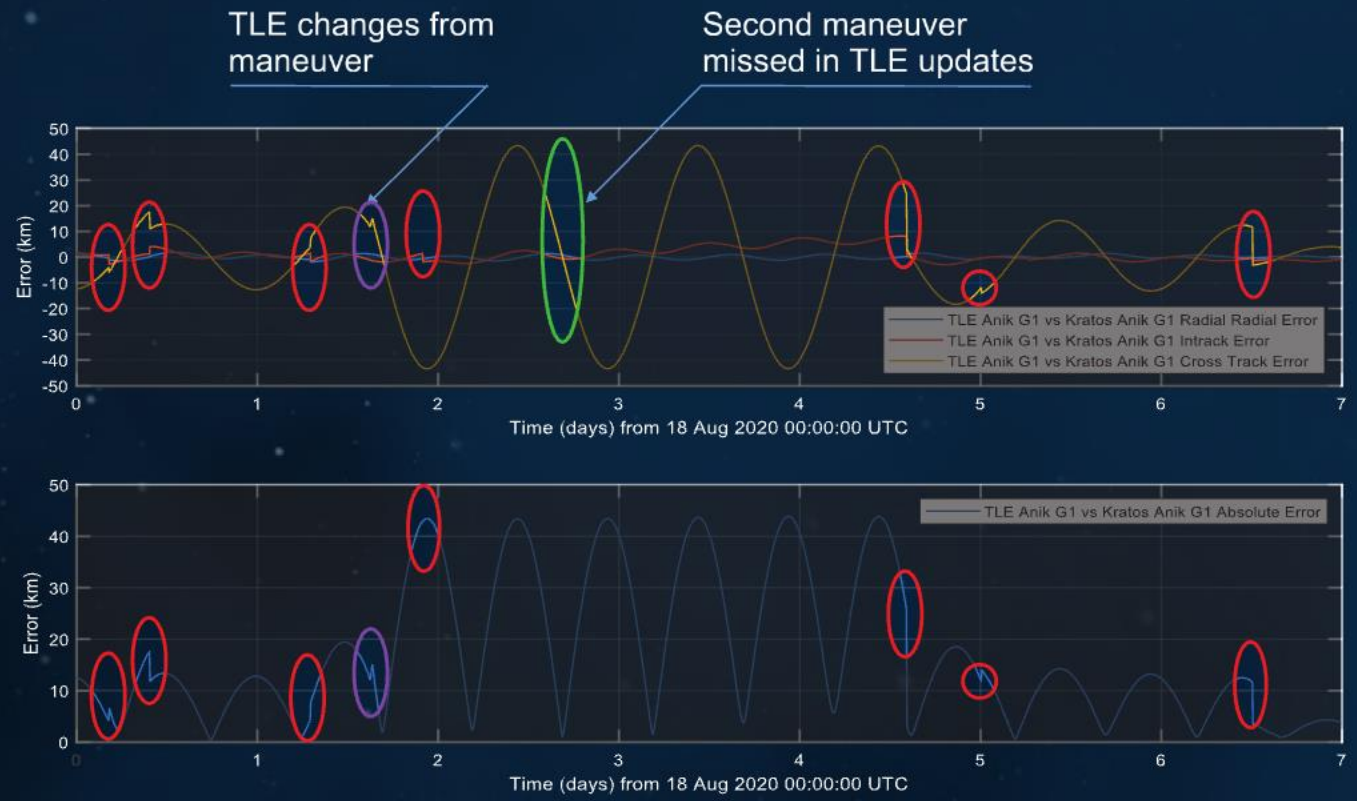


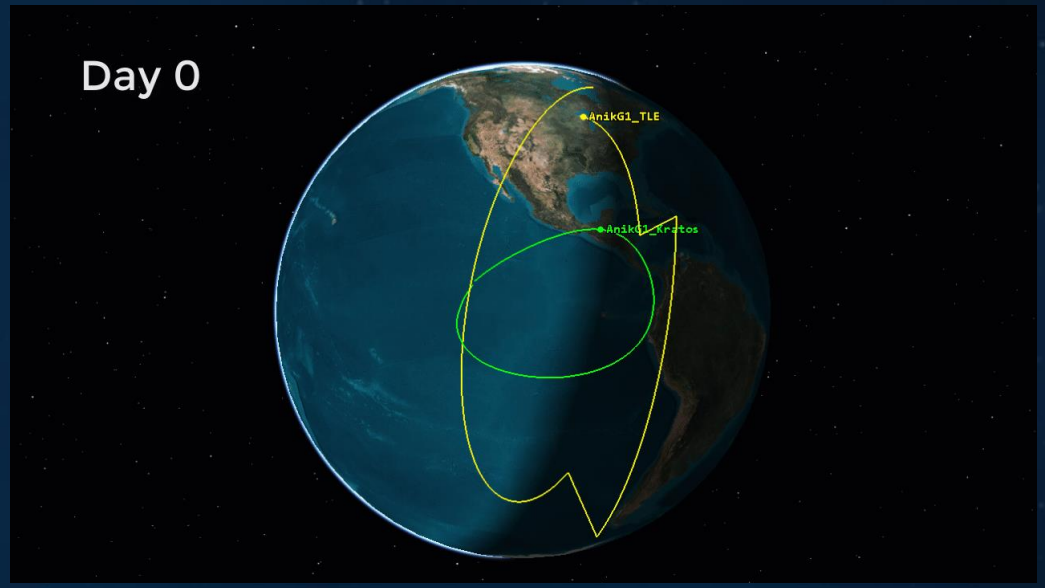
Anik G1

green orbit = Kratos Solution
yellow orbit = TLE Data

- Satellite had two maneuvers during the 7-day time span
  - Approximate times were:
    - 19 August 2020 15:00:00 UTC
    - 20 August 2020 18:30:00 UTC

Anik G1 Kratos Passive Ranging Solution Compared to TLE Data





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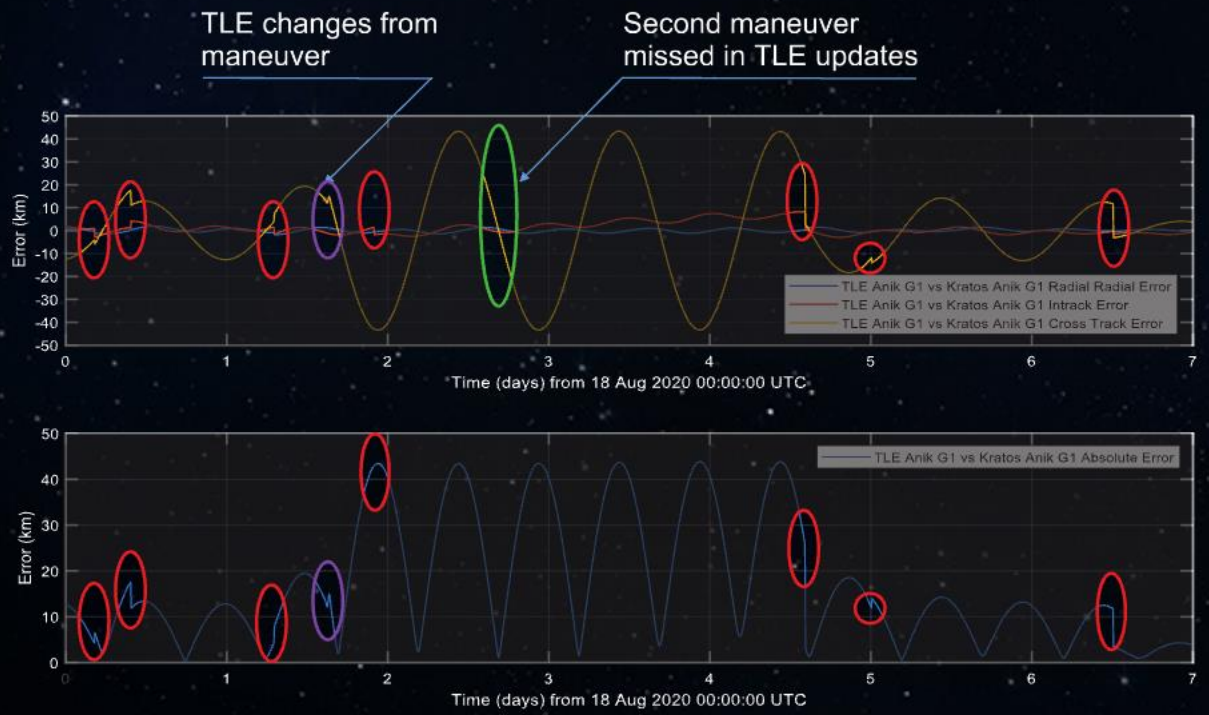
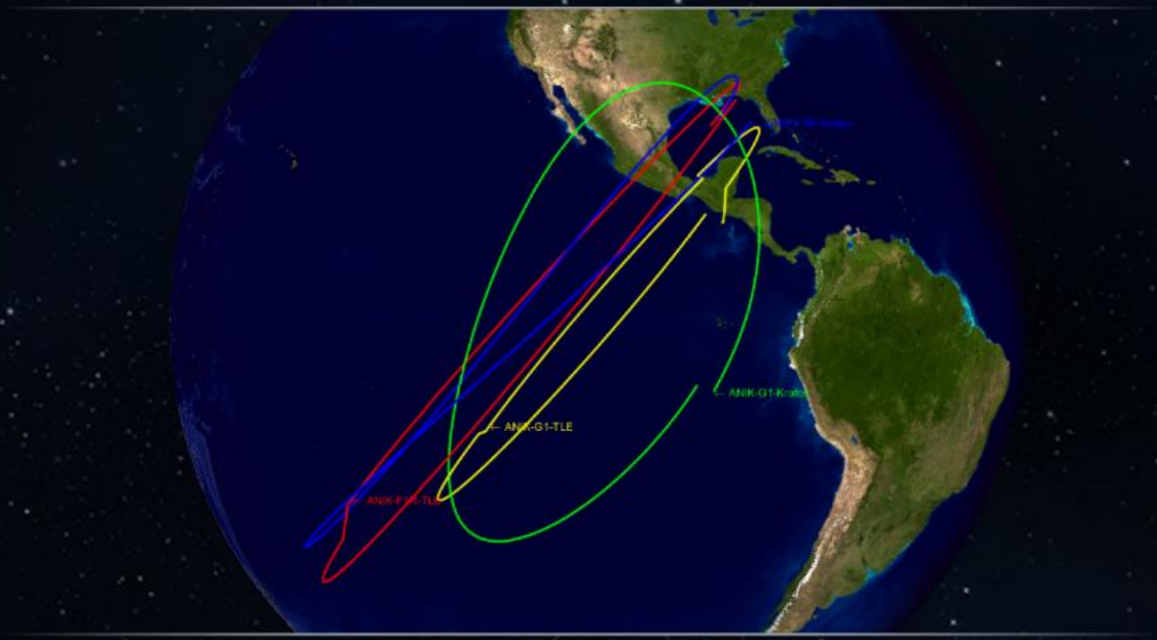




Day 6 image

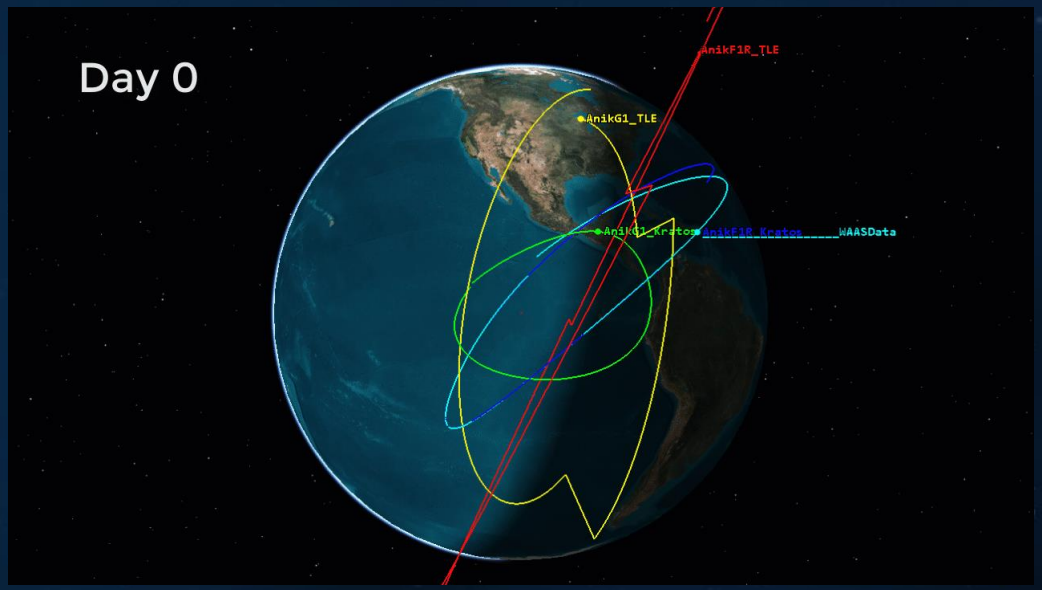
- Multiple discontinuities seen in TLE data
  - One is from the maneuvers
  - Rest are assumed to be from cross tagged measurements used in orbit determination process
  - Day 6 shows orbit aligning with Anik F1-R instead of Anik G1
- Average Absolute Error of **17.0658 km**

Kratos Passive Ranging Summary

- Passive ranging is a great augmentation to traditional SDA because:
  - DTO/DFO data is very accurate
  - Results in high accuracy ephemeris
  - Ability to detect and characterize maneuvers
  - Provides the ability to track satellites 24x7 in all weather conditions
  - Ability to uniquely identify each individual satellite in Closely Spaced Object Scenarios eliminating cross tagging

- Passive ranging would best be used when fused with other phenomenologies such as existing radar and optical data
  - Only requires two sites for fusion with other phenomenologies
  - Requires three or more sites for independent orbit determination

- Passive ranging requires satellite to have active signal
  - Not able to passively range debris



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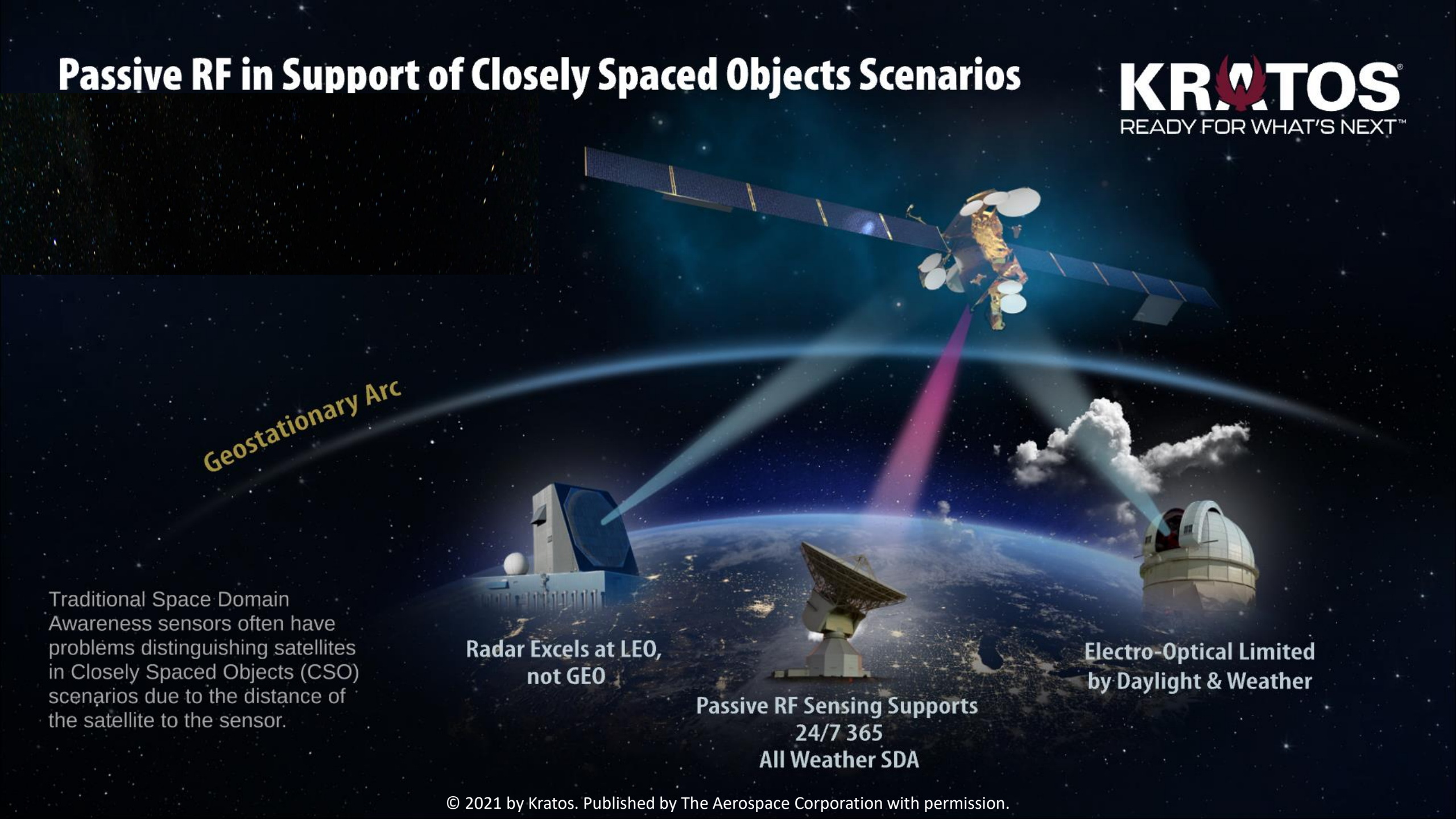

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Thank You

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