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Sandia National Laboratories

Valhalla – Satellite Computing Tools
2022 Tri-Lab ASC S3 Conference

PRESENTED BY

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MONITORING SYSTEMS AND TECHNOLOGY
Videre Est Credere

- ❖ Bravely do what others are not
- ❖ Hold ourselves accountable to achieve excellence
- ❖ Communicate honestly and in a timely manner
- ❖ Be truthful and respectful
- ❖ Serve and sacrifice

U.S. DEPARTMENT OF ENERGY NNSA

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Talk Outline

- Remote Sensing Overview
- Valhalla Architecture At Glance
- Demonstrations
- Future Development
- Questions and Answers

Remote Sensing Overview

- Remote sensing is the acquisition of information about the state and condition of an object through sensors that do not touch it (Cheveico – 2016).
- A well-defined remote sensing scenario should have the following essential components:
  - Target to be observed
  - Sensor to observe the target
  - Host vehicle of the sensor
  - Data acquisition systems (DAS)
  - Communication between sensor/host vehicle and DAS
- To model and simulate a space-based remote sensing scenario, we need tools to model/simulate:
  - Object and its attributes to be observed
  - Sensor and its observabilities
  - Space vehicle and its orbit/constellation
  - Ground segment

E. Cheveico, Fundamentals of Satellite Remote Sensing: An Environment Approach, Boca Raton, FL: CRC Press, Taylor & Francis Group, 2016.

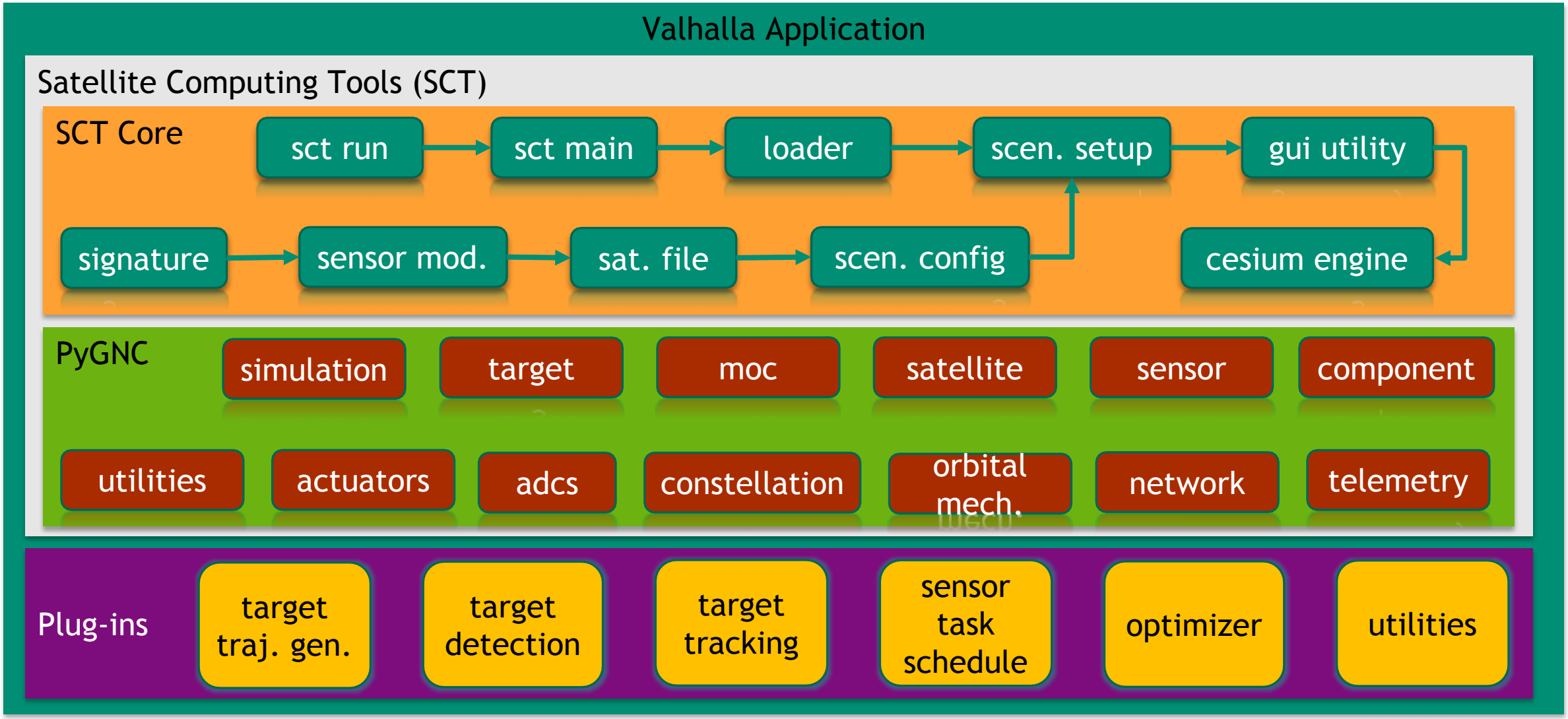
Modeling and Simulation Software for Remote Sensing

Software	Type	Code Language(s)	Availability	Developer
RemoteView	Remote sensing app, GIS	C++	Licensed	Textron Systems
OpenEV	GIS	Python	Open-source	Atlantis Scientific
Opticks	Remote sensing application	C++, Python	Licensed	Ball Aerospace
STK	Systems analysis	C++, Script (Python, MATLAB)	Licensed	ANSYS (AGI)
AFSIM	Mission analysis	C++, Script (Python, MATLAB)	Licensed	AFRL
ASCENT	Mission analysis	C++, Python	Only to SNL	SNL

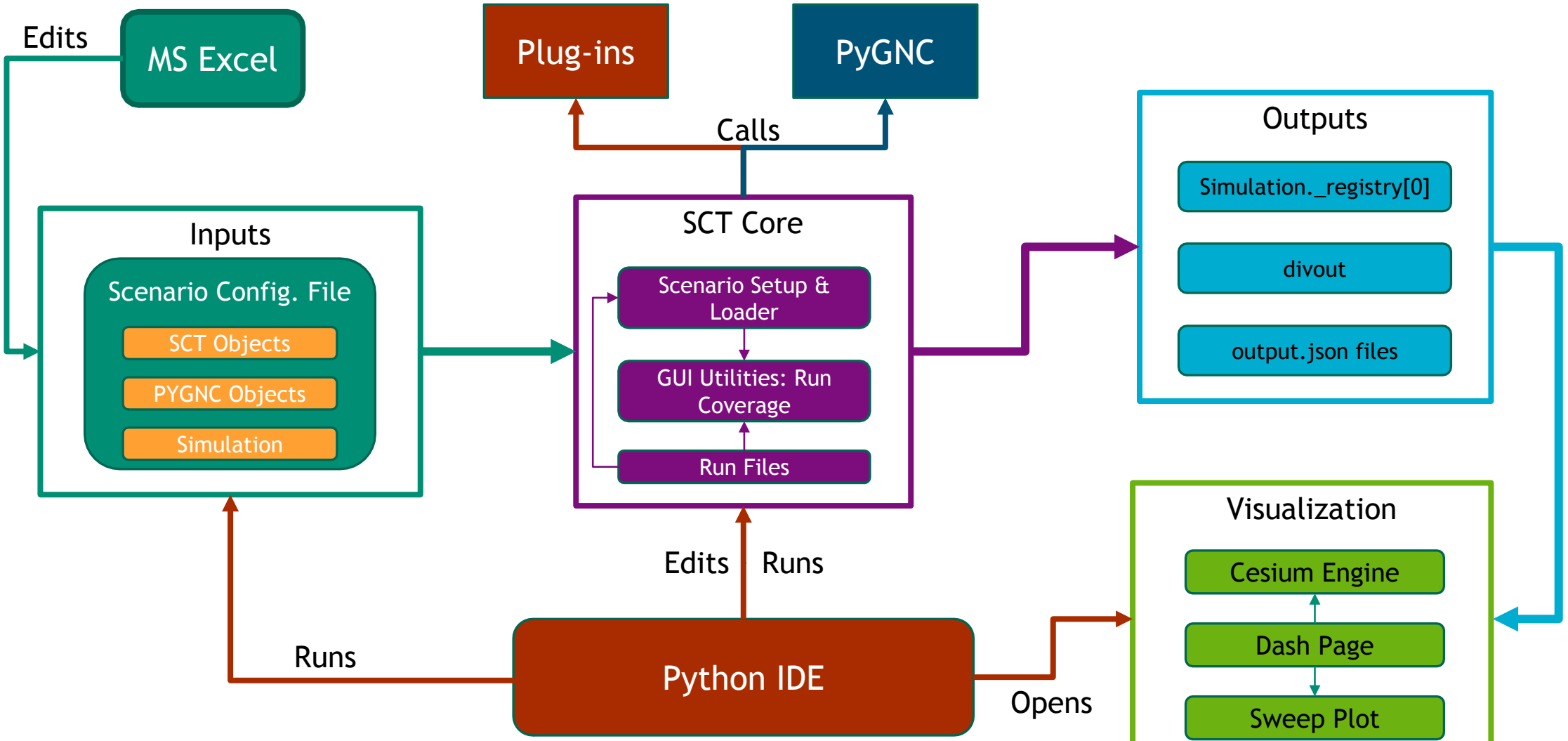
Why Valhalla?

- Satellite analysis combines with remote sensing applications
- Developed entirely in Python – easy to install and use
- Simple structure – easy to modify, expand, debug

Valhalla Architecture Overview



Valhalla Tool Operation Scheme



California Wildfire Detection and Monitor Scenario

❖The target is an active wildland fire in northern California (Earth Data 2022)
- Located at (latitude, longitude) = (39.886 degrees, -121.387 degrees)
- Started from 18:40 on July 14, 2021 until 19:04 on July 26, 2021.

❖The constellation includes
- One satellite on a polar orbit plane (Science on a Sphere 2022).
- The orbit is described by the following Keplerian elements (MODIS 2022):
  - Altitude: 705 km
  - Eccentricity: 0
  - Inclination: 85 degrees
  - Descending node: 10:30 a.m.
  - Ascending node: 1:30 p.m.
  - Sun-synchronous, near polar

❖The satellite carries an infrared imaging telescope as the observation instrument.

❖The ground station is the NOAA Satellite Operations Facility located in Suitland, Maryland. Its latitude and longitude are 38.8523 degrees and -76.9328 degrees, respectively.

E. Data, "Earth Data Opens Access For Open Science - 2021 Satellite Detections of Fire," NASA, [Online]. Available: https://earthdata.nasa.gov/learn/toolkits/wildfires. [Accessed 28 3 2022].

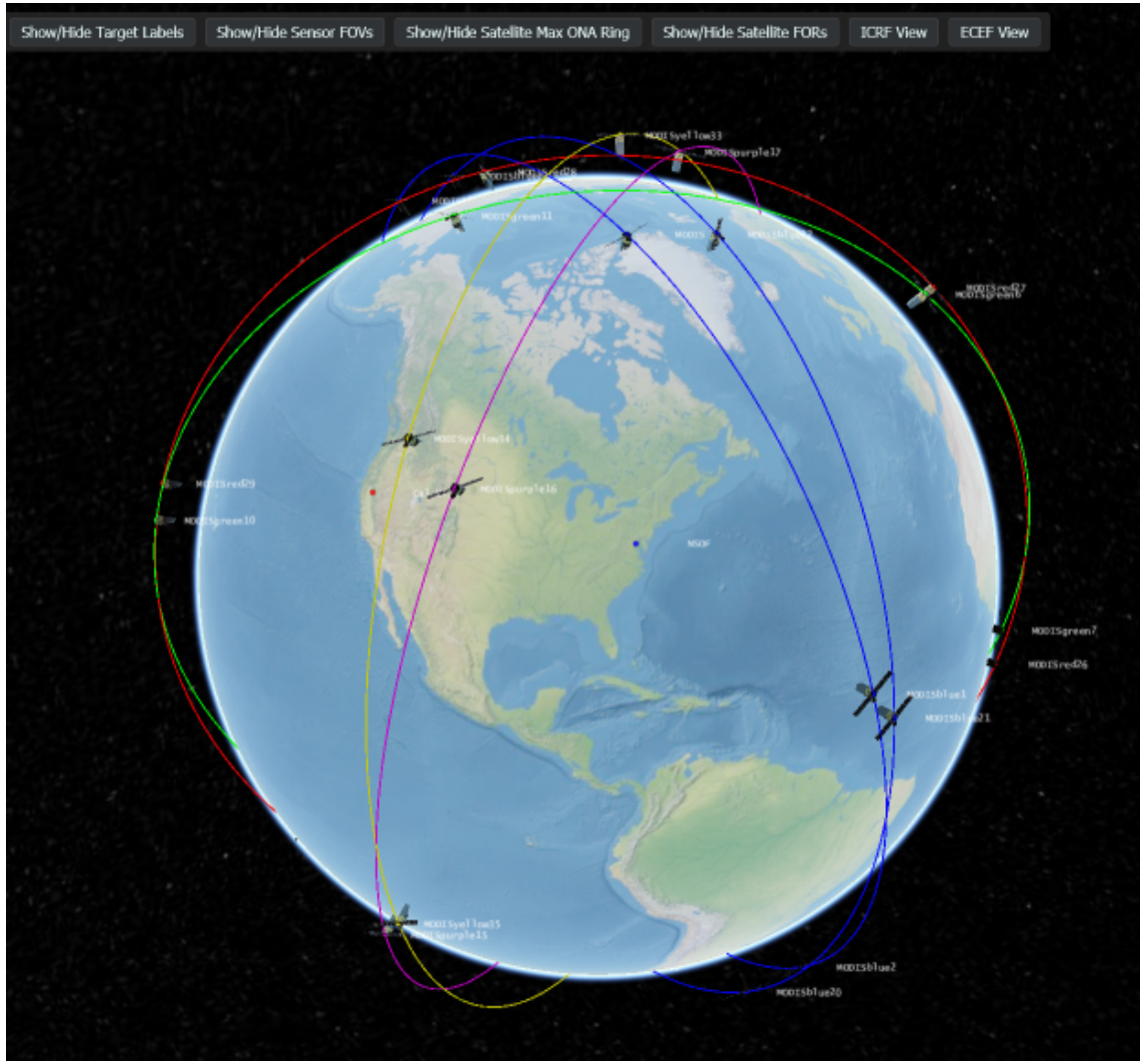
S. O. a. Sphere, "Polar Orbiting: Aqua Satellite and MODIS Swath," NOAA, [Online]. Available: https://sos.noaa.gov/catalog/datasets/polar-orbiting-aqua-satellite-and-modis-swath/. [Accessed 29 3 2022].

MODIS, "Moderate Resolution Imaging Spectroradiometer," NASA, [Online]. Available: https://modis.gsfc.nasa.gov/about/specifications.php. [Accessed 28 3 2022].

Target Coverage vs. Number Satellites and Orbital Planes

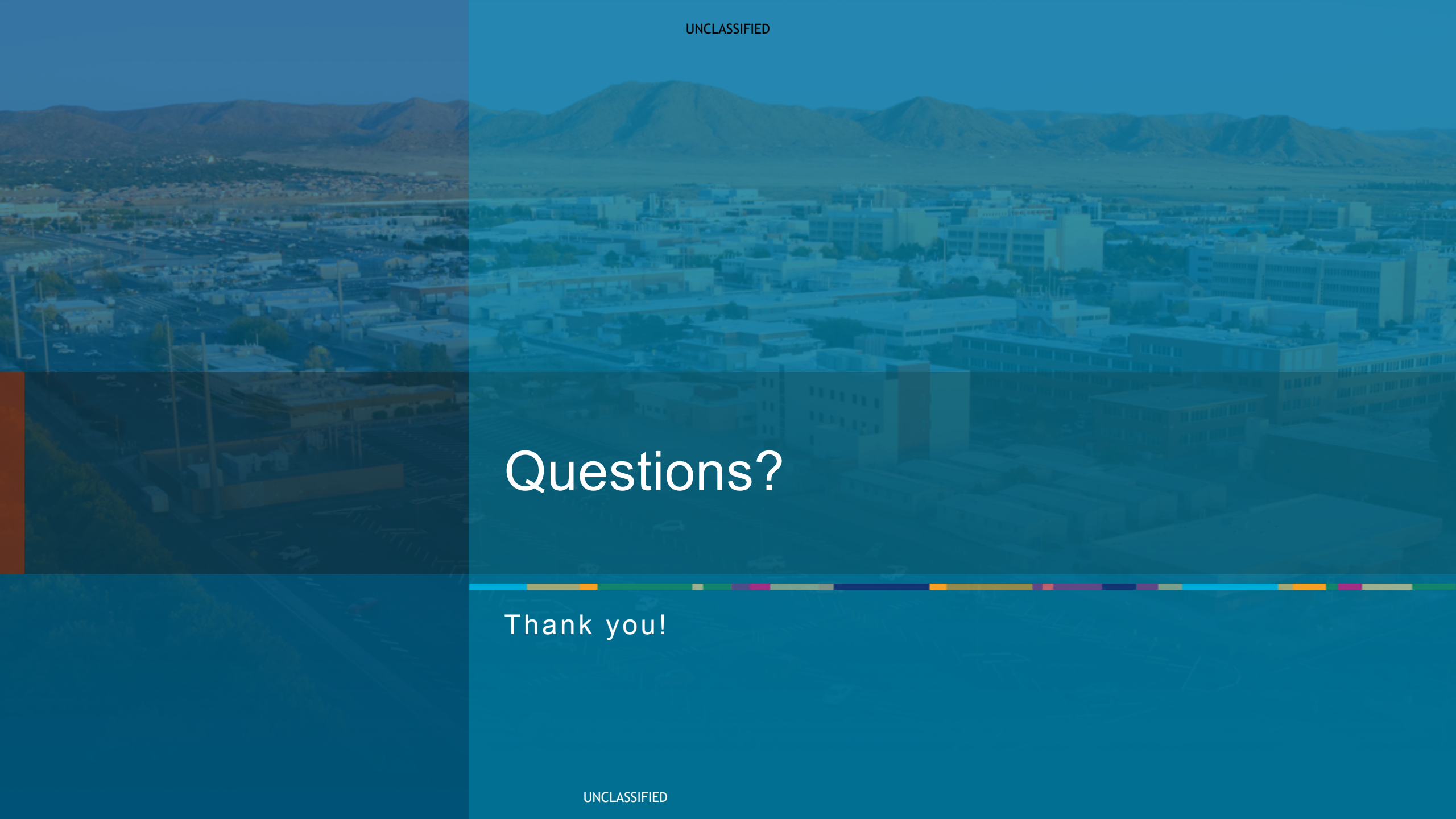
Planes	Sat./Plane	Balls	Coverage %	
1	1	1	0.833	
1	2	1	2.083	
1	6	1	6.944	
2	2	1	4.514	
2	6	2	1.736	12.718
6	6	2	7.639	36.736

- The target coverage increases as the number of planes and the number of satellite per plane increase.
- When there are more than one plane, the relative space between the satellites on the same plane needs to be paid attention on.



Future Developments

- Atmospheric effects on detection capabilities
- Adding air target (currently have ground, sea, and space targets)
- Orbit maneuvers
- Others



Questions?

Thank you!