Dragster

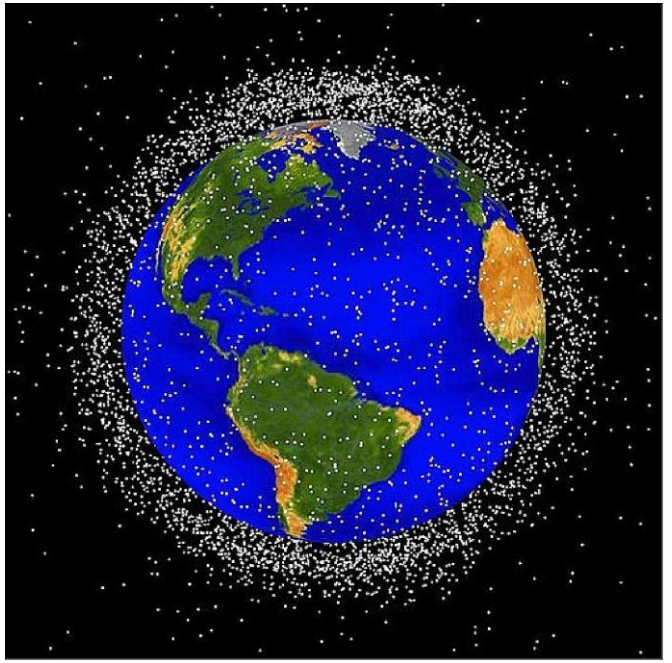
A Neutral Density Tool for Today's Space Traffic Management Challenge

orion SPACE SOLUTIONS

Geoff Crowley and Junk Wilson
SWPC Space Weather Exercise
25-27 Oct 2023

Dragster: The Need

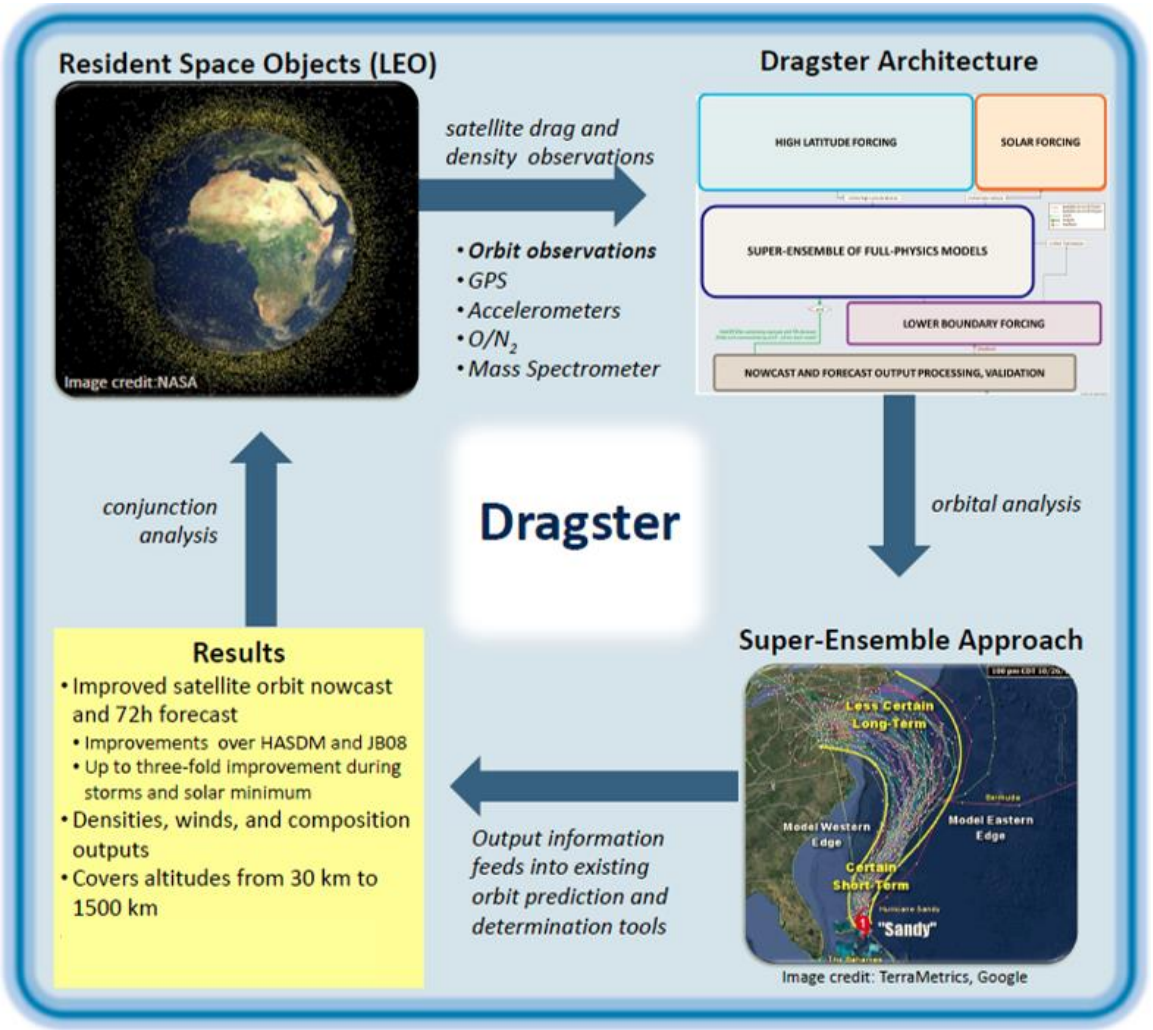
- Space traffic growing exponentially, with no sign of slowing down
- Satellite orbits are affected by space weather via changes in atmospheric drag
- Need improved orbital predictions for:
  - collision avoidance for manned and unmanned space flight
  - accurate catalog maintenance
  - satellite lifetime & reentry prediction
  - defining on-board fuel requirements
  - satellite attitude dynamics
- Satellite operators are under stress from too many false alarms
- The largest source of error in Collision Avoidance, Maneuver Planning, and maintaining custody SDA missions is the neutral density



- THE NEED: neutral density, with fully quantified uncertainty, to specify and predict satellite drag

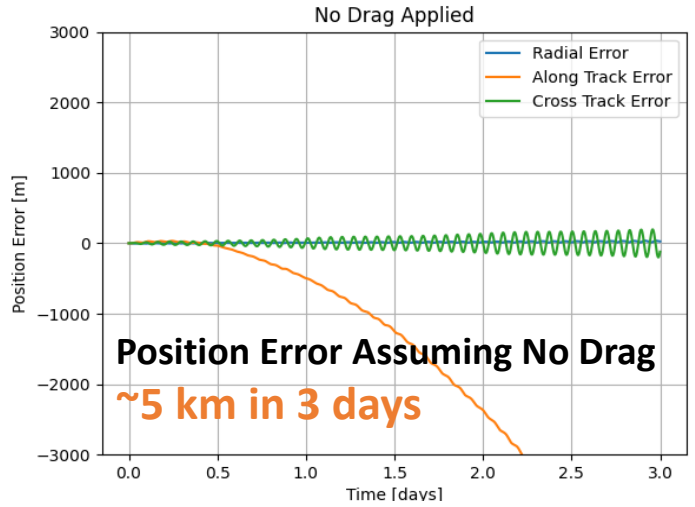
Dragster: High-Level Overview

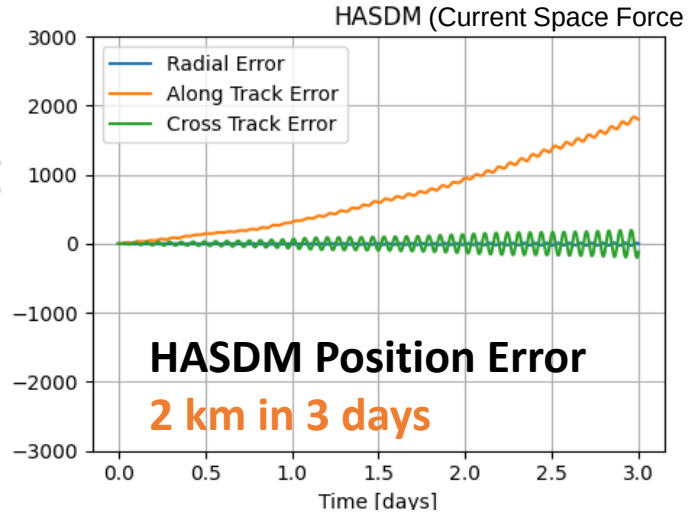
- Ensemble of world-class well-validated, full-physics atmospheric models
  - Uses modern ensemble assimilation techniques to ingest multiple data types
  - Improves drag specification between 120-1500 km
  - Can be used as a Testbed for new models/data
- The resulting Dragster modeling architecture:
  - Demonstrates major improvements over leading models currently used to predict orbital drag
  - Enhances orbit specification and drag forecast fidelity
  - Reduces errors in the current operational model by a factor of 30% or more
  - Provides continuously updating 72-hour forecasts for enhanced conjunction/collision analysis.
  - Reduces number of false positive conjunction & collision predictions

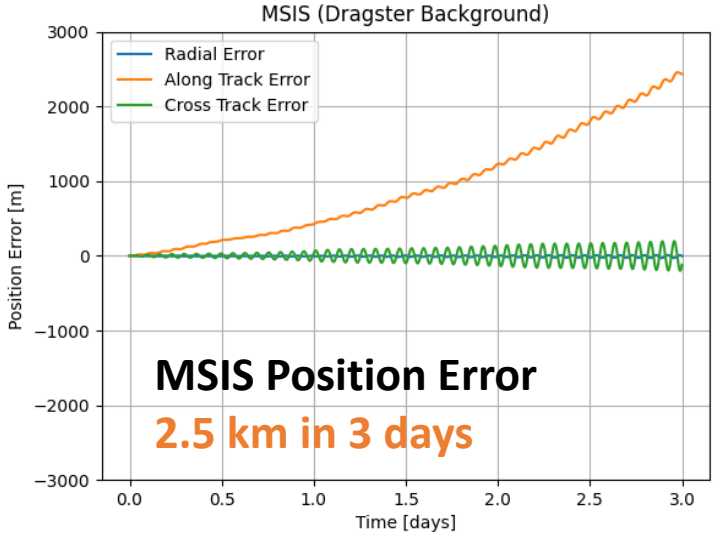


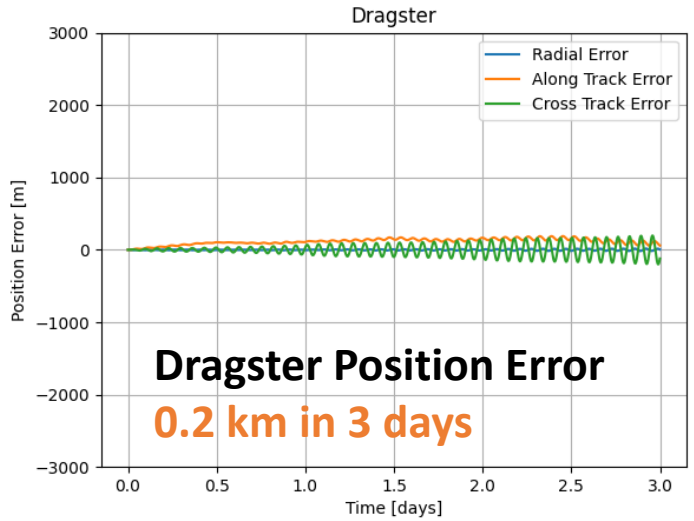
Dragster Validation versus HASDM & MSIS Models

Accuracy of Position Prediction for Actual Satellite (Swarm-A)









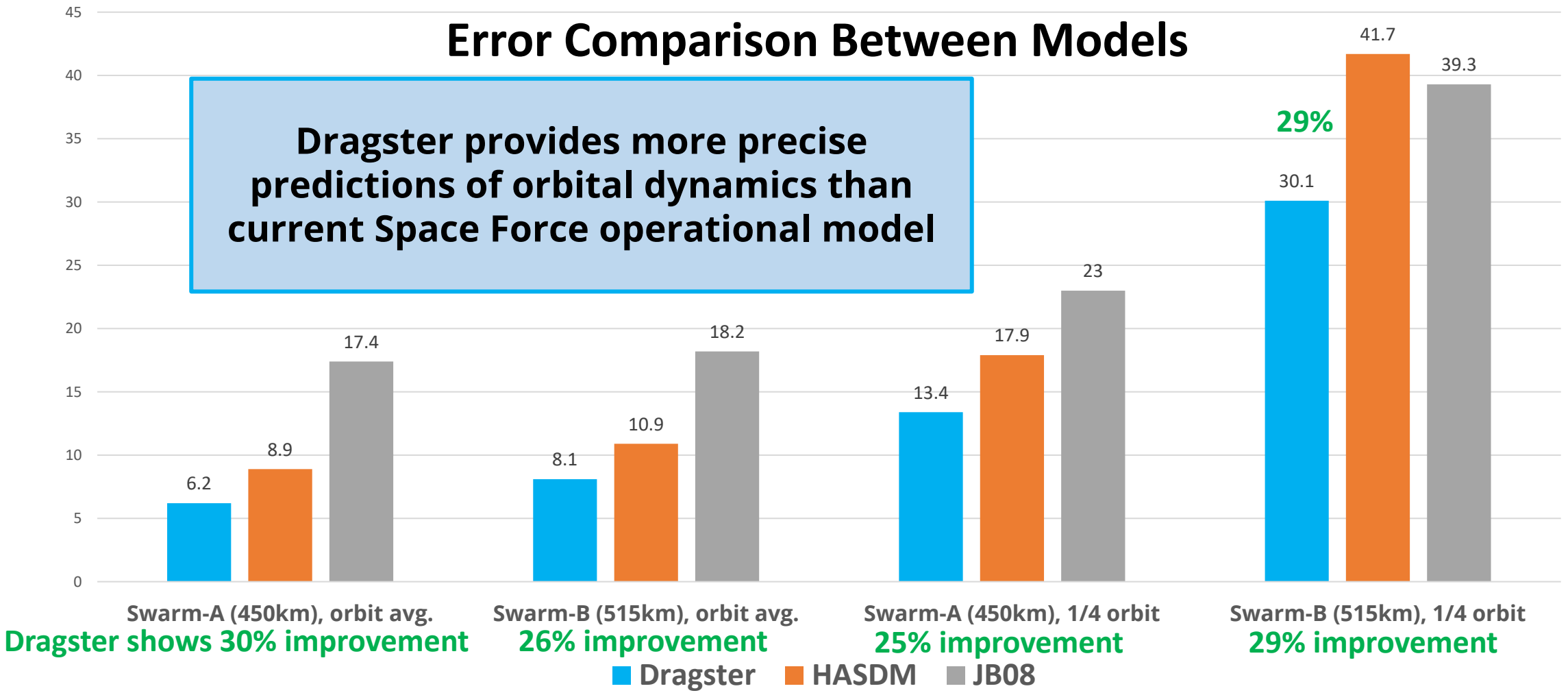
Validation Satellite: Swarm-A (450 km)

Dragster provides more precise predictions of orbital dynamics than HASDM or MSIS

The smaller error derived from using the Dragster model would reduce collision uncertainties and the number of false alarms that are causing satellite operators unnecessary work.

Dragster Validation versus HASDM & MSIS Models

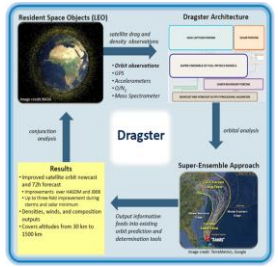
Accuracy of Position Prediction for Actual Satellites (Swarm-A & B)



Dragster development timeline:

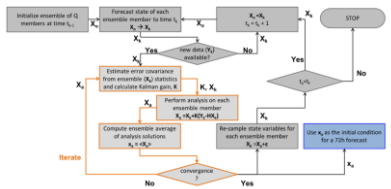
2019 2020 2021 2022 2023 2024+

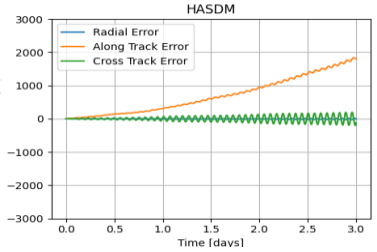
TRL 2



Dragster AFRL SBIR Phase 1

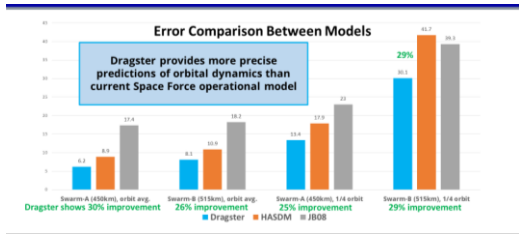
Dragster SBIR AFRL Phase 2





V&V #1

TRL 5



Dragster NASA SBIR Phase 1

TRL 6

Assimilate Starlink data

V&V #2 by LASP*

*Presented at SWW

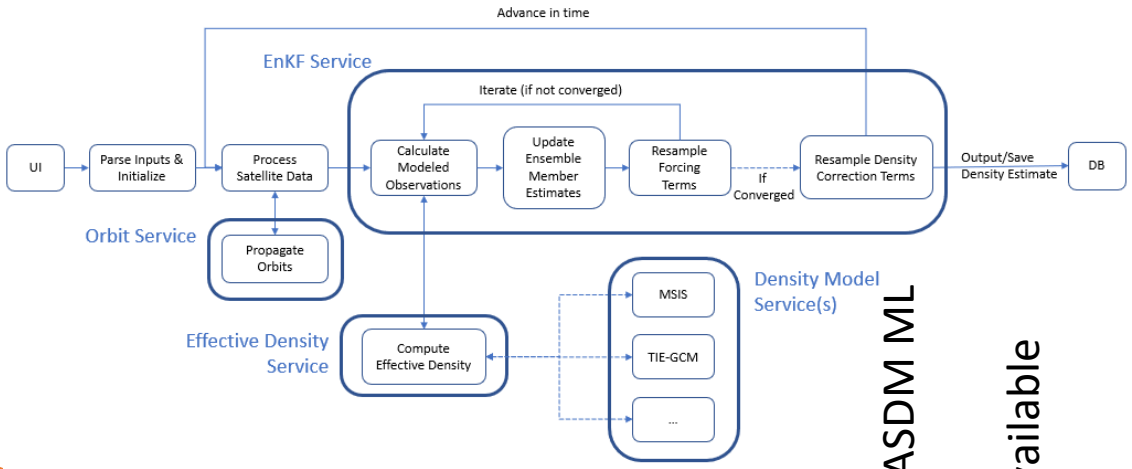
NASA SBIR Phase 2

Refactored code

New Architecture

Super Ensemble

Running in AWS



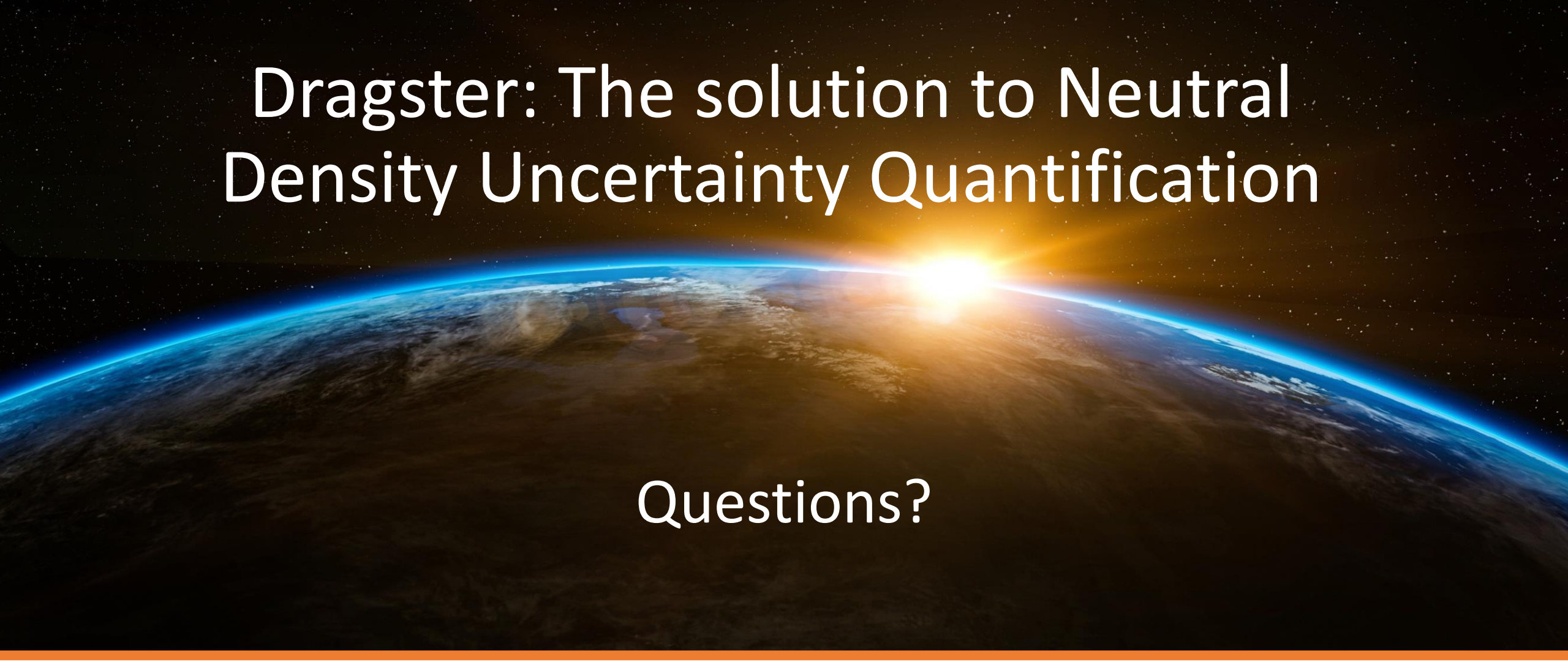
Version 2.0

V&V #3

Comparison HASDM ML

Commercially available

Dragster: The solution to Neutral Density Uncertainty Quantification



Questions?

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Dragster: The Solution

- With Air Force and NASA funding, Orion Space Solutions (OSS), has created a better drag-forecasting modeling architecture and framework.
- Dragster is an *ensemble assimilation modeling framework* that runs multiple models and then fuses and analyzes data from multiple sources to yield better prediction of drag effects on satellite and RSO orbits.
- Generates a sophisticated 3-D picture of the space environment (ionosphere & thermosphere).
- Dragster reduces errors in the current operational model by a factor of 30% or more
- In addition to Satellite Drag, Dragster also outputs drag uncertainties and neutral winds
- Uses modern software methods
- Orion is funded to move Dragster toward operational status (TRL: 8 by Q1'24)
- Orion would like to hear more about Government and Industry product preferences and needs.

Dragster Characteristics

Most LEO satellites are between 500-1500km

Dragster Area of Coverage:

3-D, 120km - 1500km, with global coverage (all latitudes and longitudes)
Includes neutral density, composition, winds and ionospheric electron density.
Dragster has improved accuracy in Oxygen-Helium transition above 500km

Opportunity for Model Improvements

Dragster is Scalable:

Dragster provides a framework, or architecture
Modular, Expandable (can also be used as a Testbed for new models and data types)
Takes advantage of world-class General Circulation Models (TIE-GCM, TIME-GCM)
gaining better fidelity on atmospheric dynamics versus empirical models

Space Safety is dependent on tracking all Objects

Dragster Object Types:

Captures drag on non-spherical and rotational objects.
Supports space debris and new commercial satellite constellations

Processing Power

Dragster CPU Requirements:

Dragster includes sophisticated GCM models and yet continues to maintain
real-time / nowcast results on relatively low-end workstations