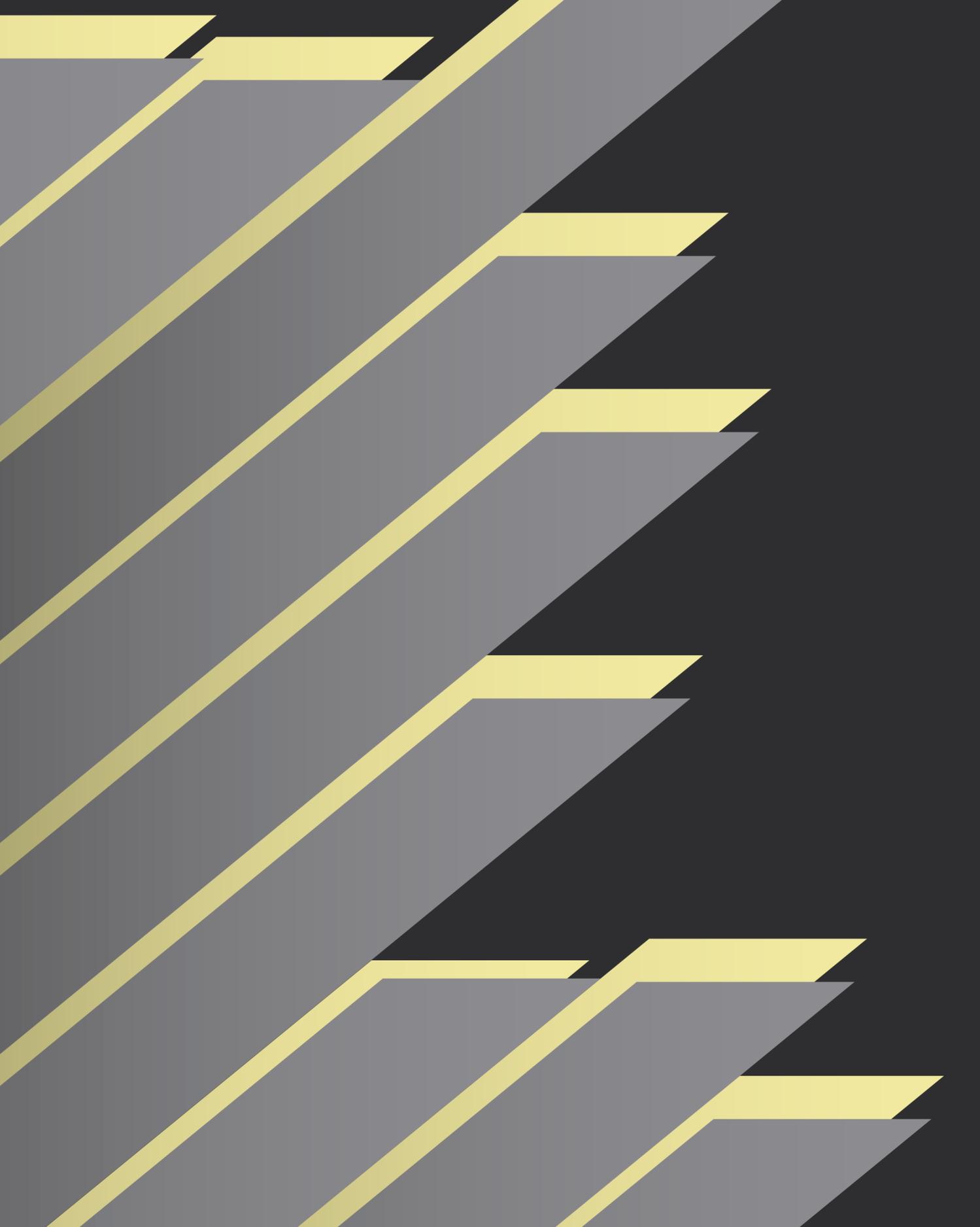


NEXT

CU Boulder



Imagining The Fundamentals of Space Exploration

Prof. Dr. Hanspeter Schaub

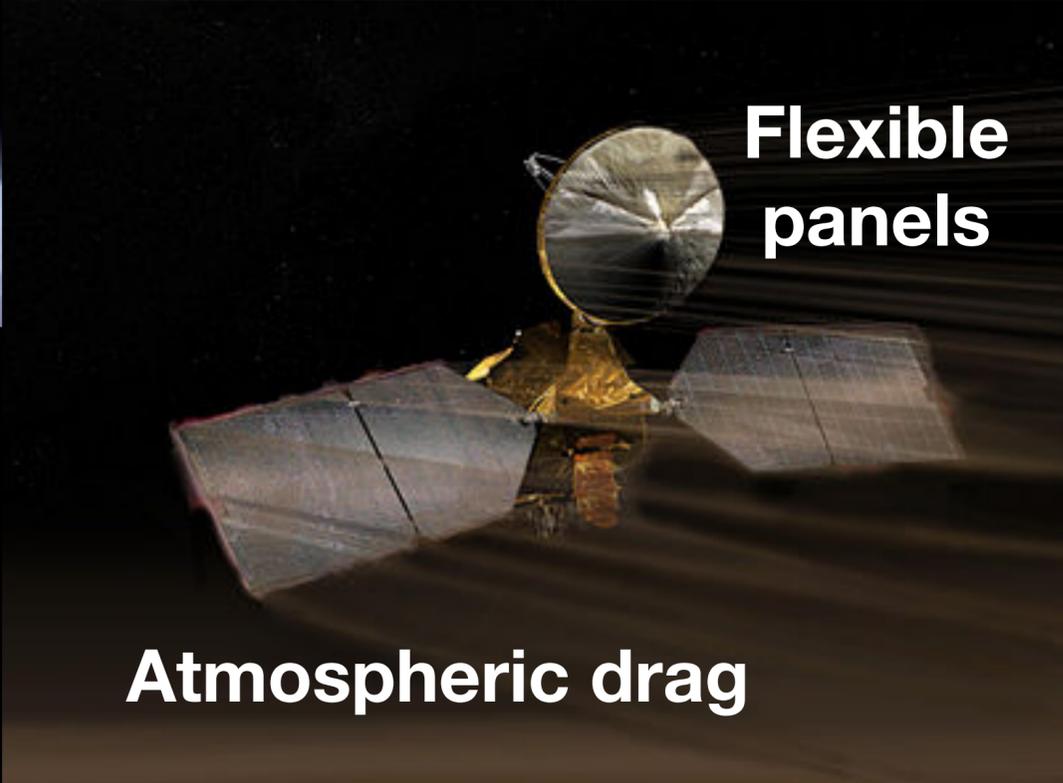
NEXT
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Spacecraft Simulation Challenges

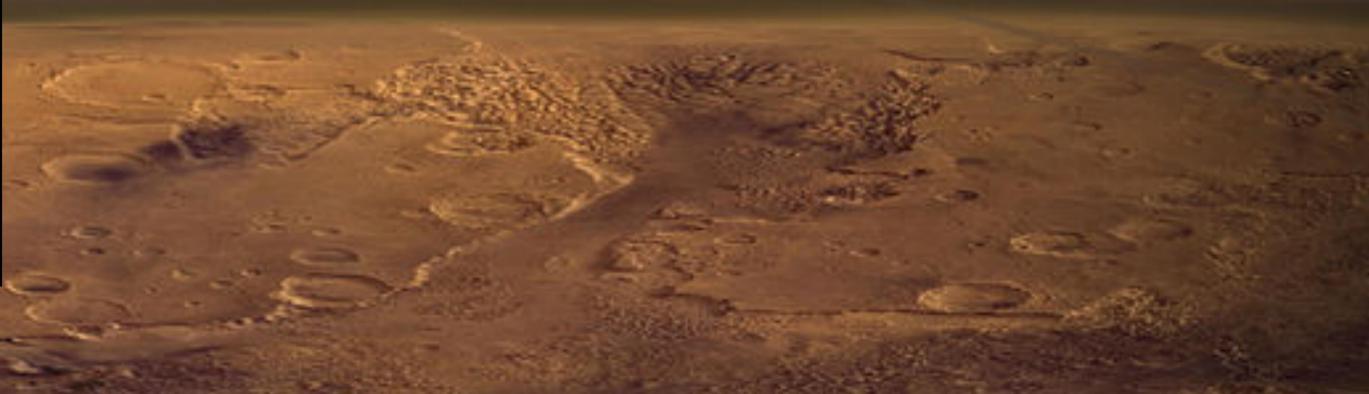
Complex Orbital Dynamics



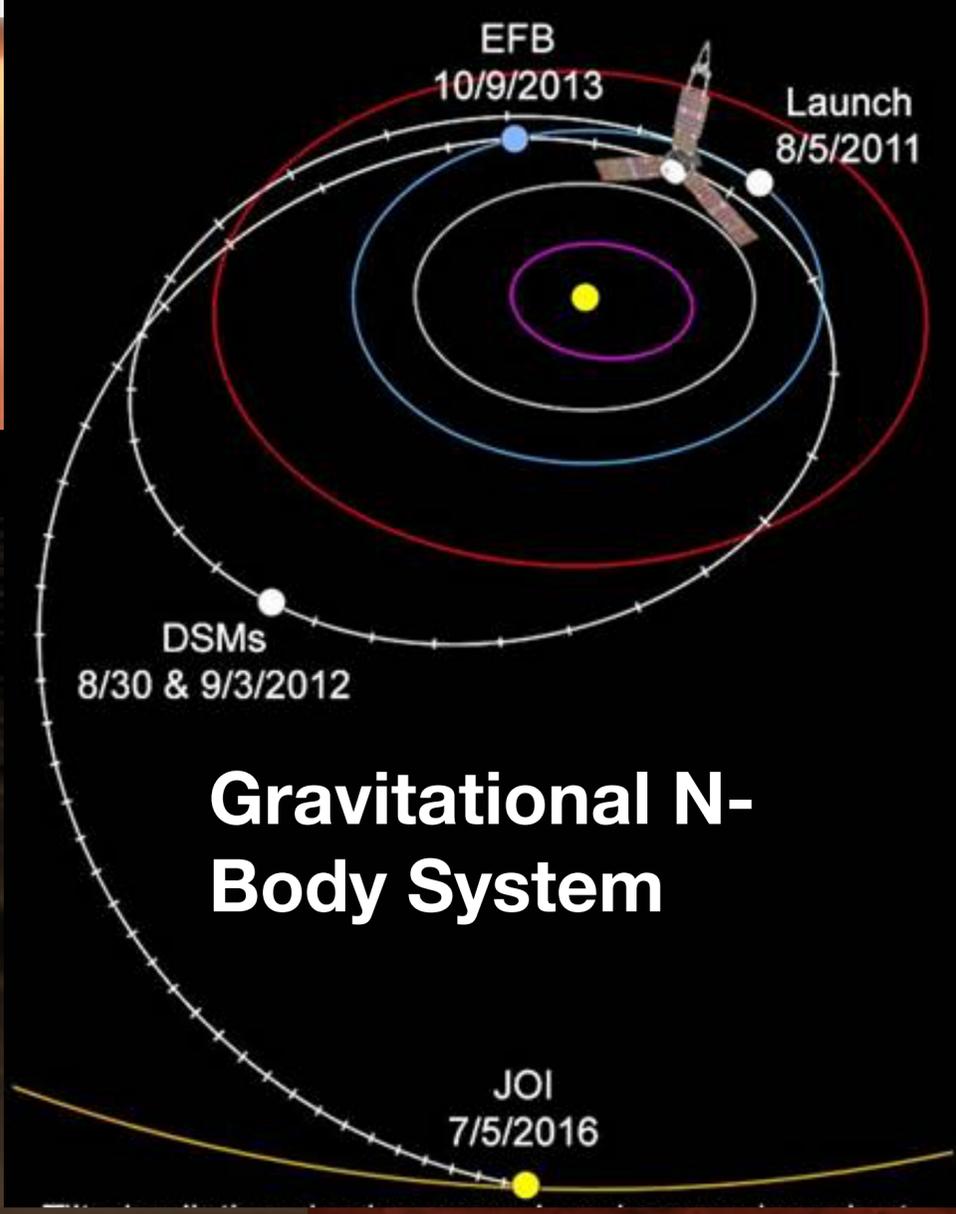
Solar radiation pressure



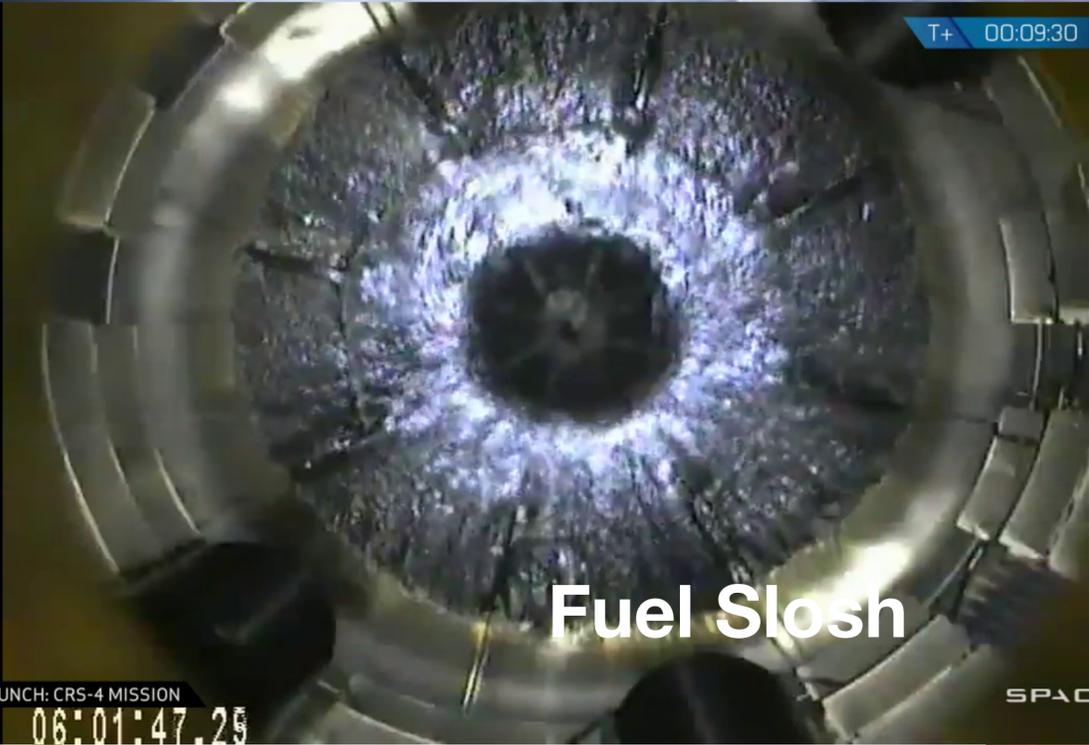
Flexible panels



Atmospheric drag



Gravitational N-Body System



Fuel Slosh

LAUNCH: CRS-4 MISSION
06:01:47.25

SPACEX



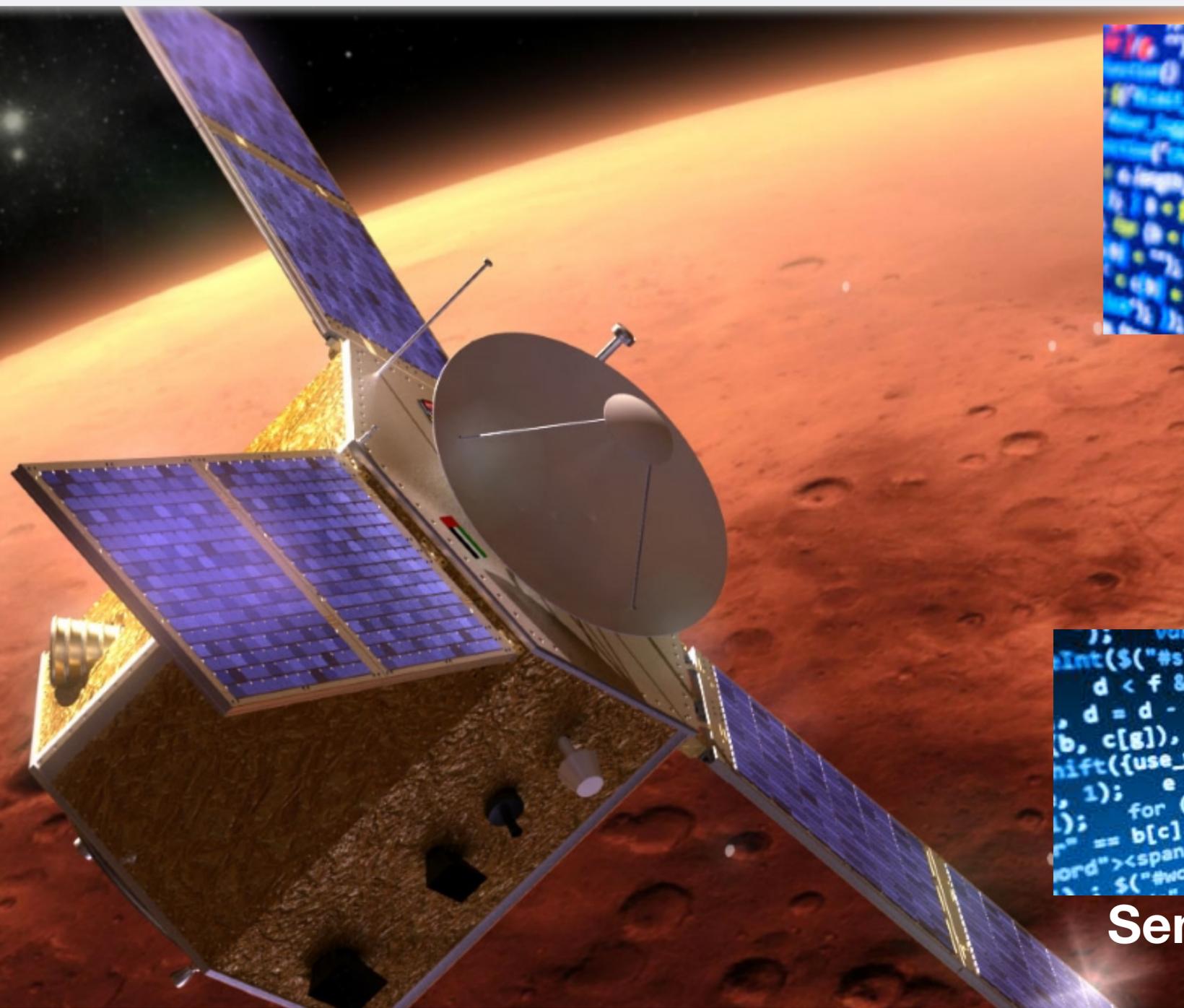
Autonomous Algorithm Simulation



Guidance



Control

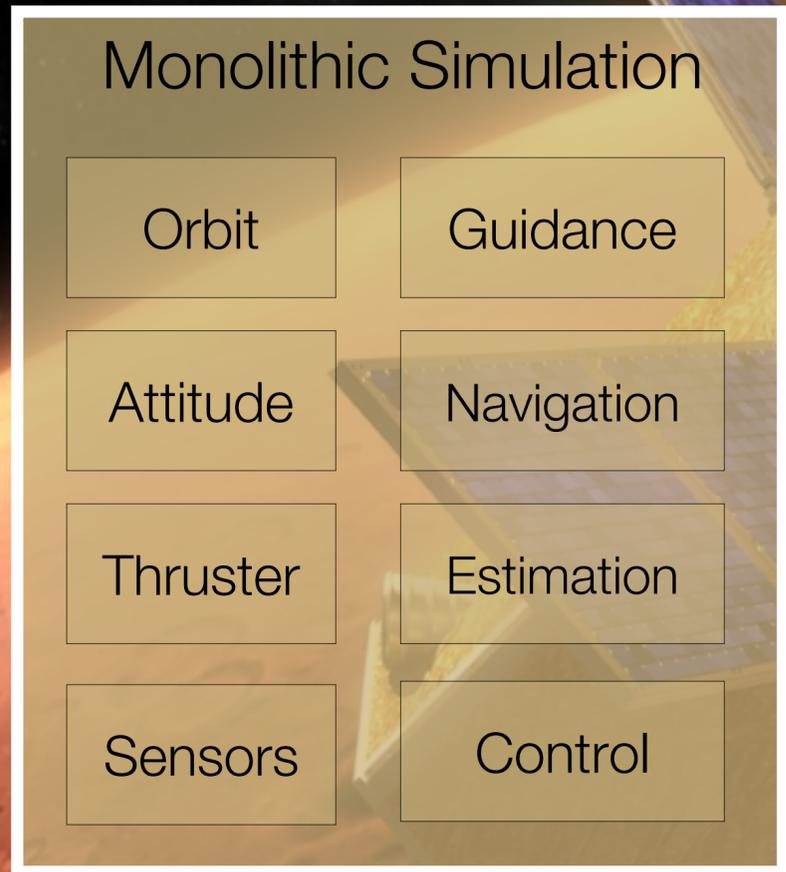


Navigation



Sensor Processing

Software Challenges



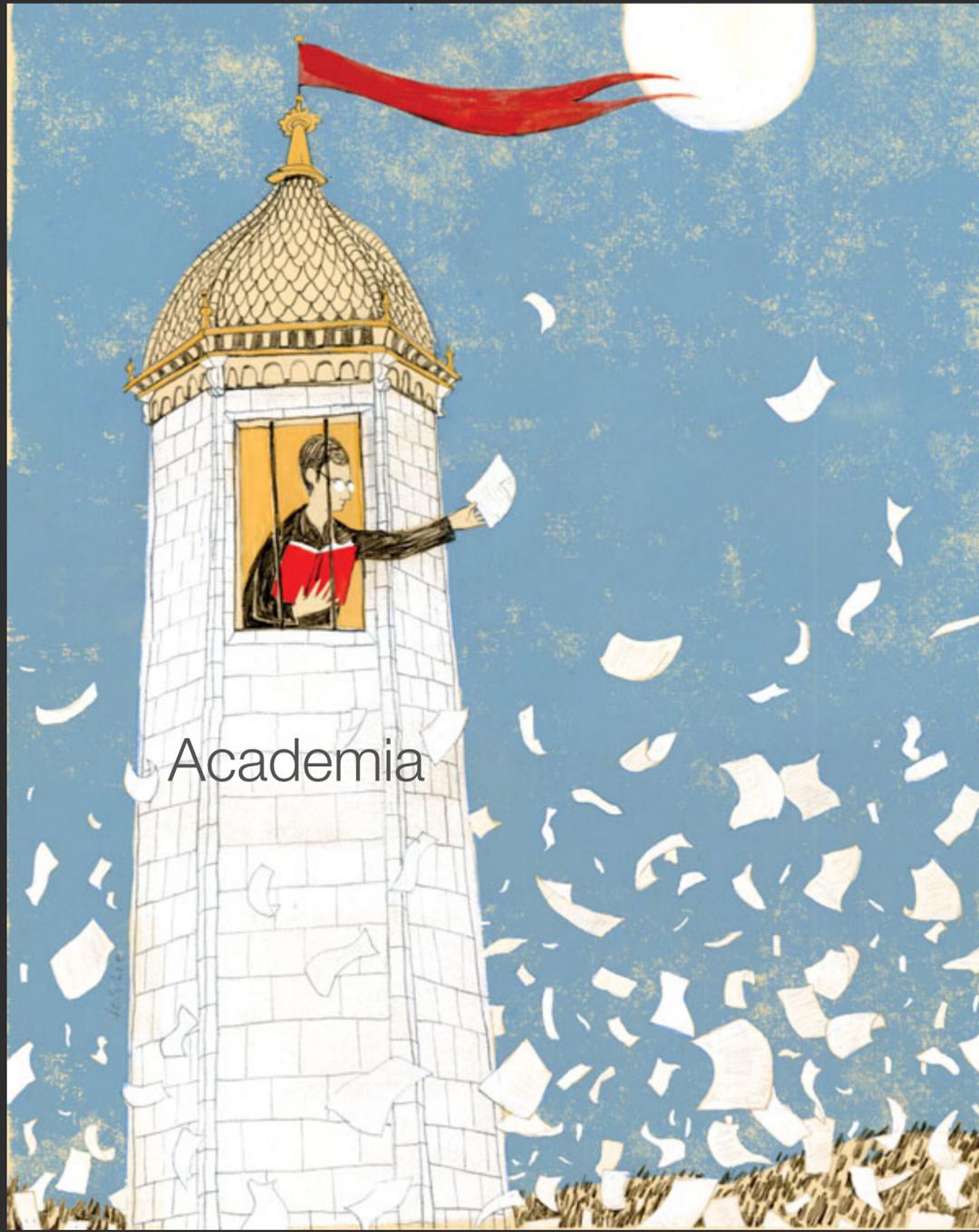
How to verify and validate?

How to reuse code?

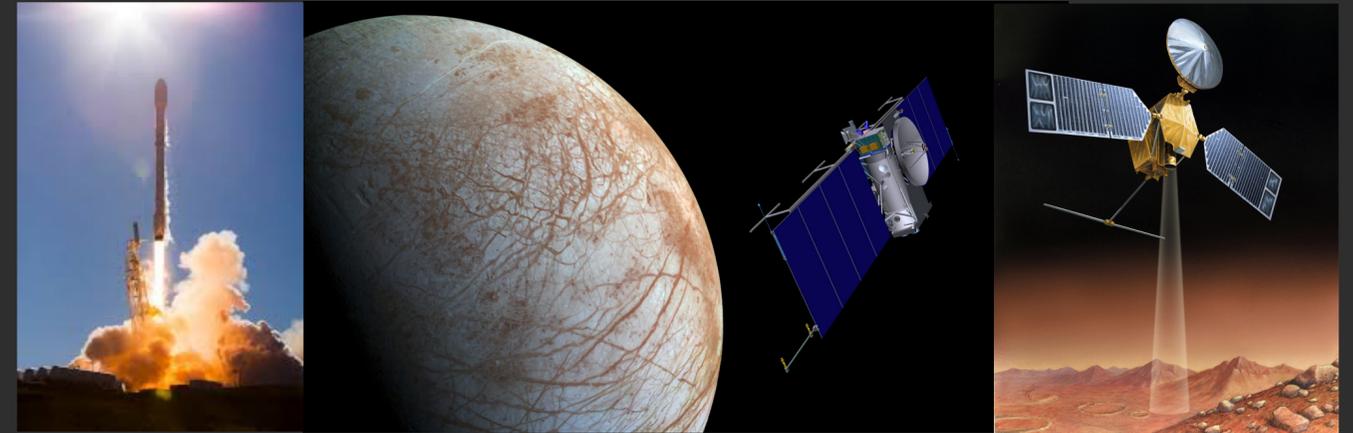
How to reduce development costs?

How to continually improve?

Academic - Industry Challenges



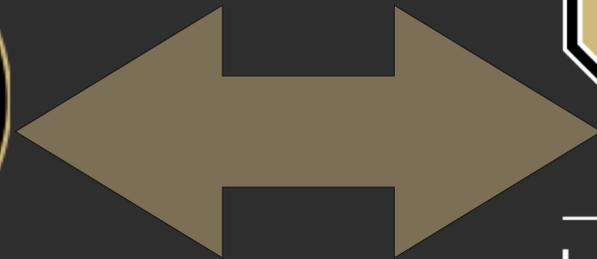
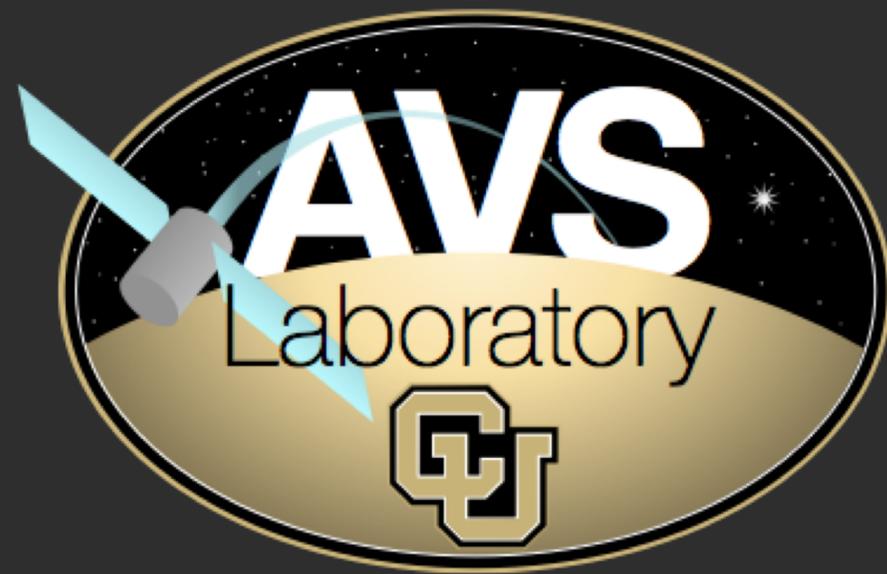
Academia



Space Research Center or Industry



New Integrated Collaborations



LASP

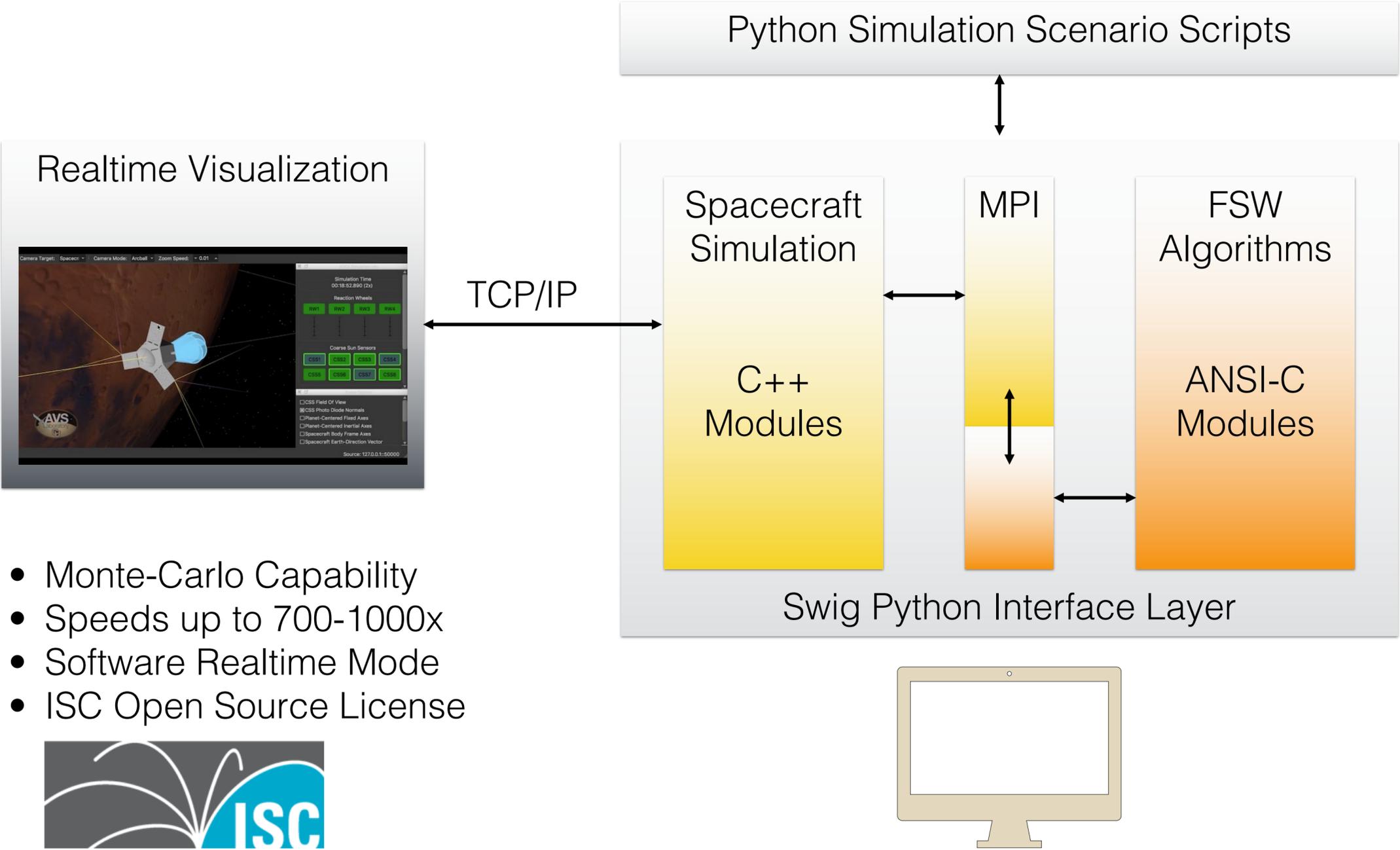
Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**

Developed a close mission analysis and research collaboration that directly engages graduate students in challenging mission.

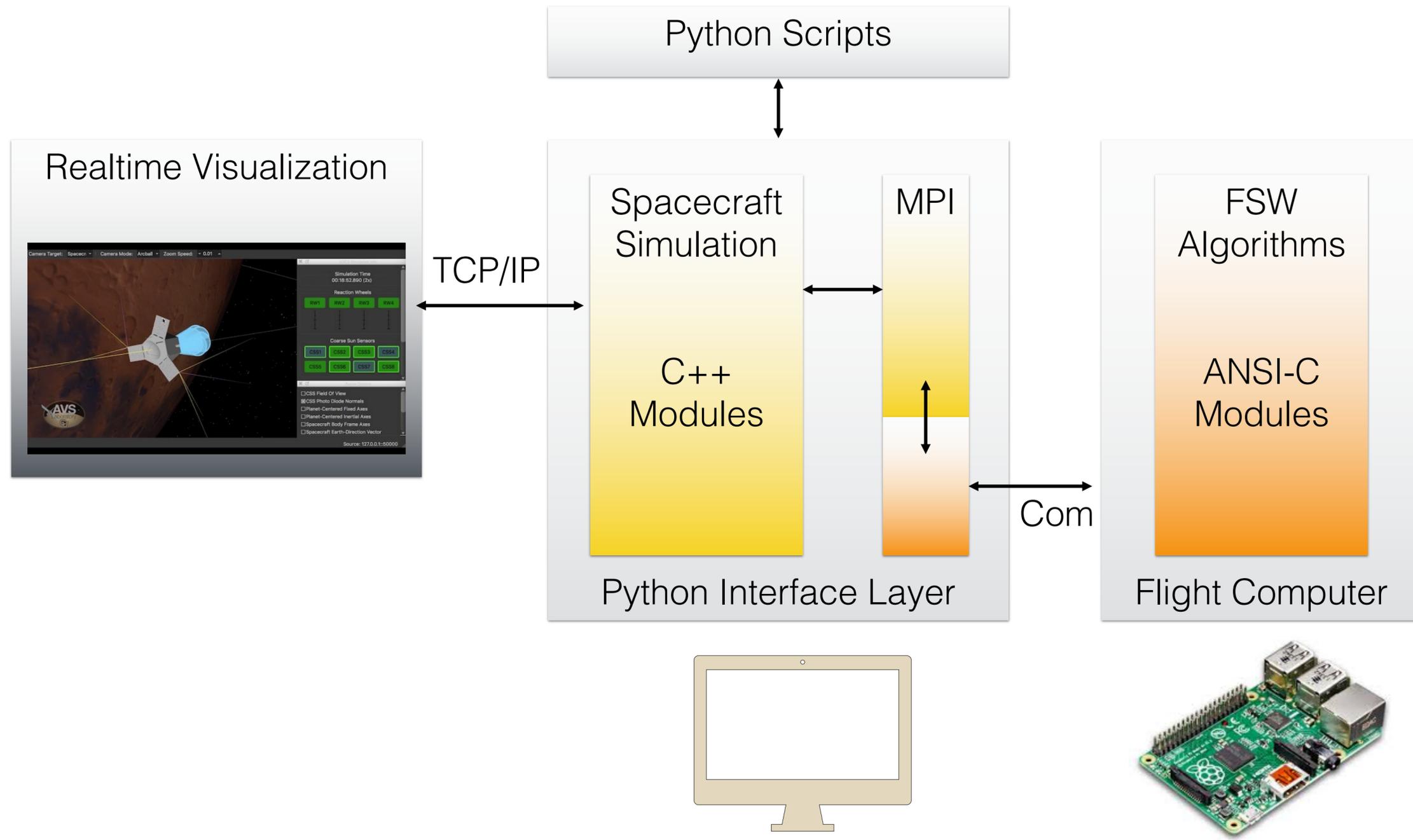


Basilisk Astrodynamics Simulation Framework

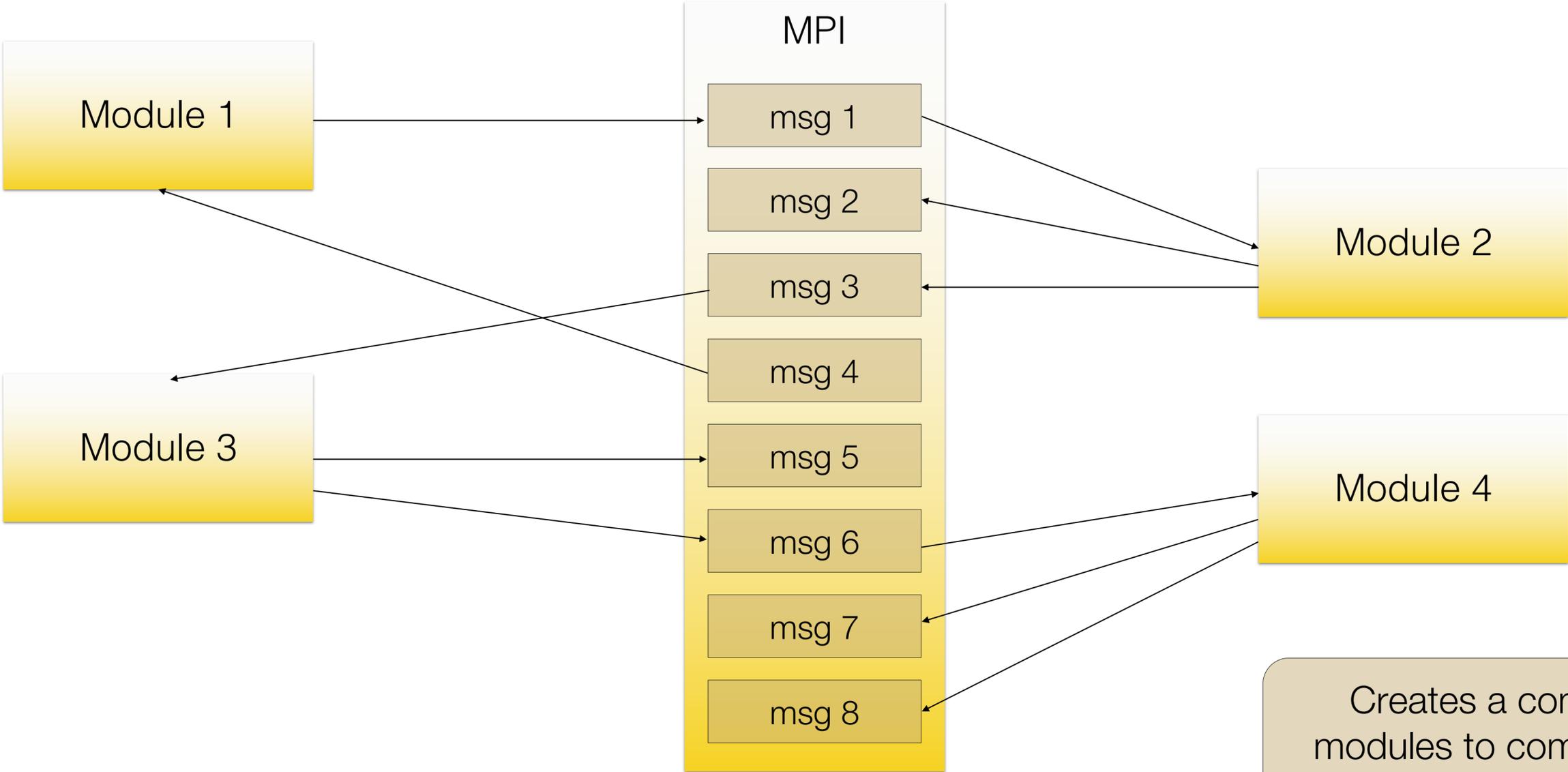
Basilisk Software Architecture (Analysis)



Basilisk Software Architecture (Flatsat)

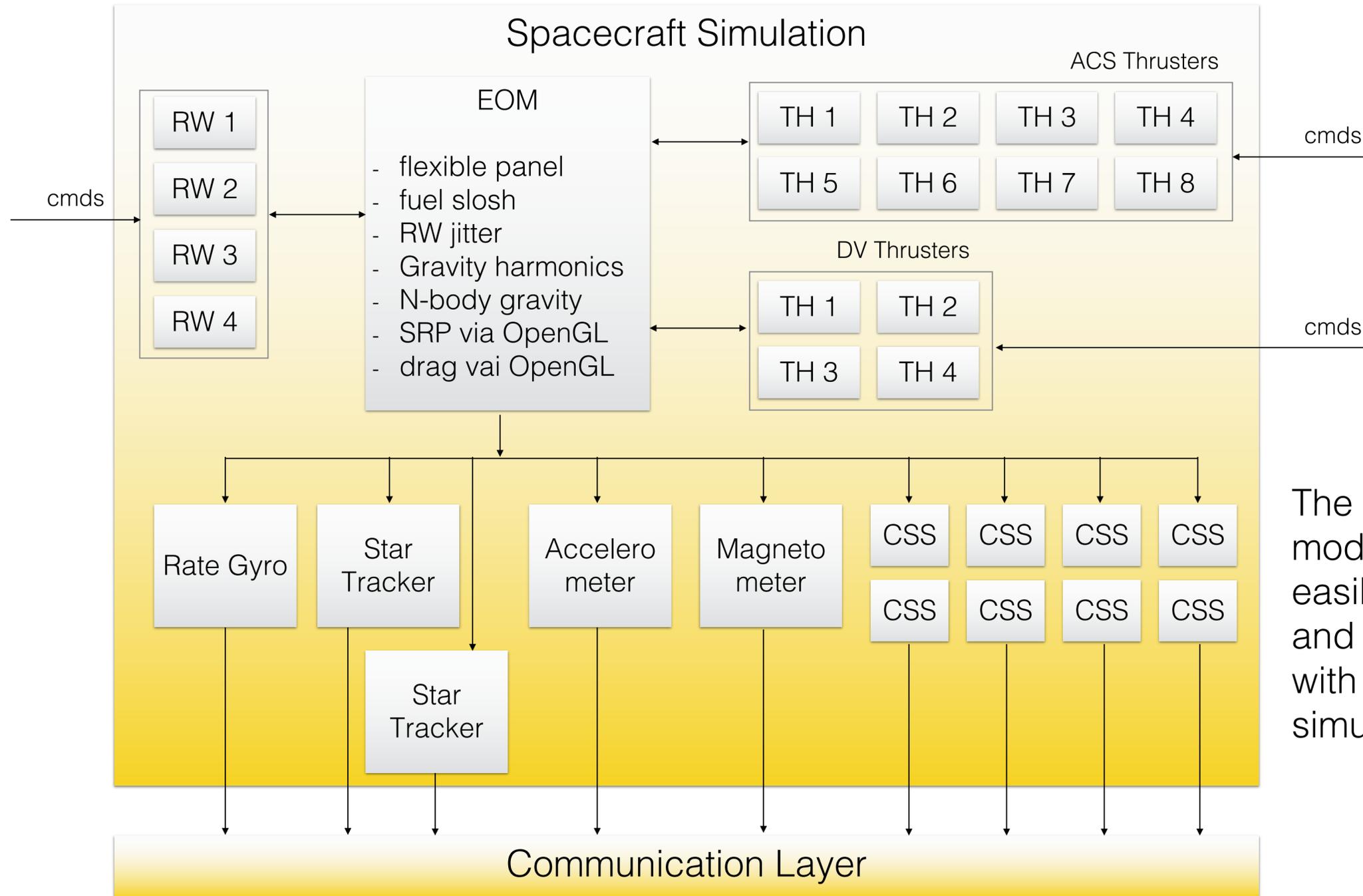
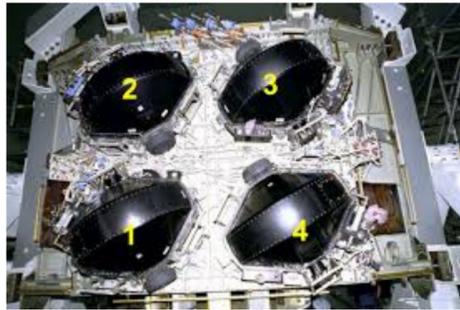


Message Passing Interface for BSK Modules



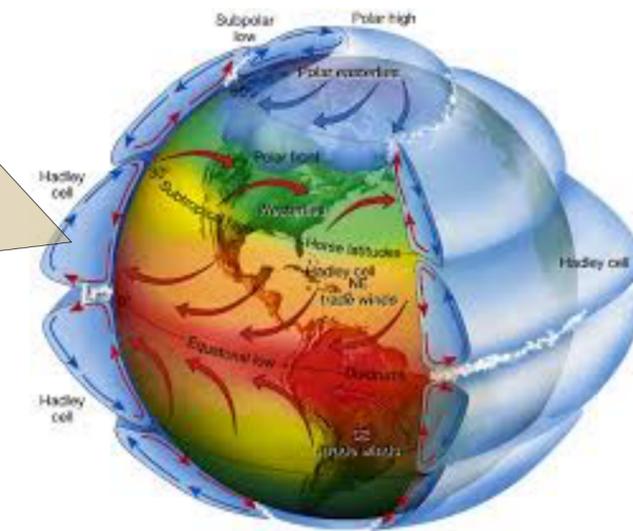
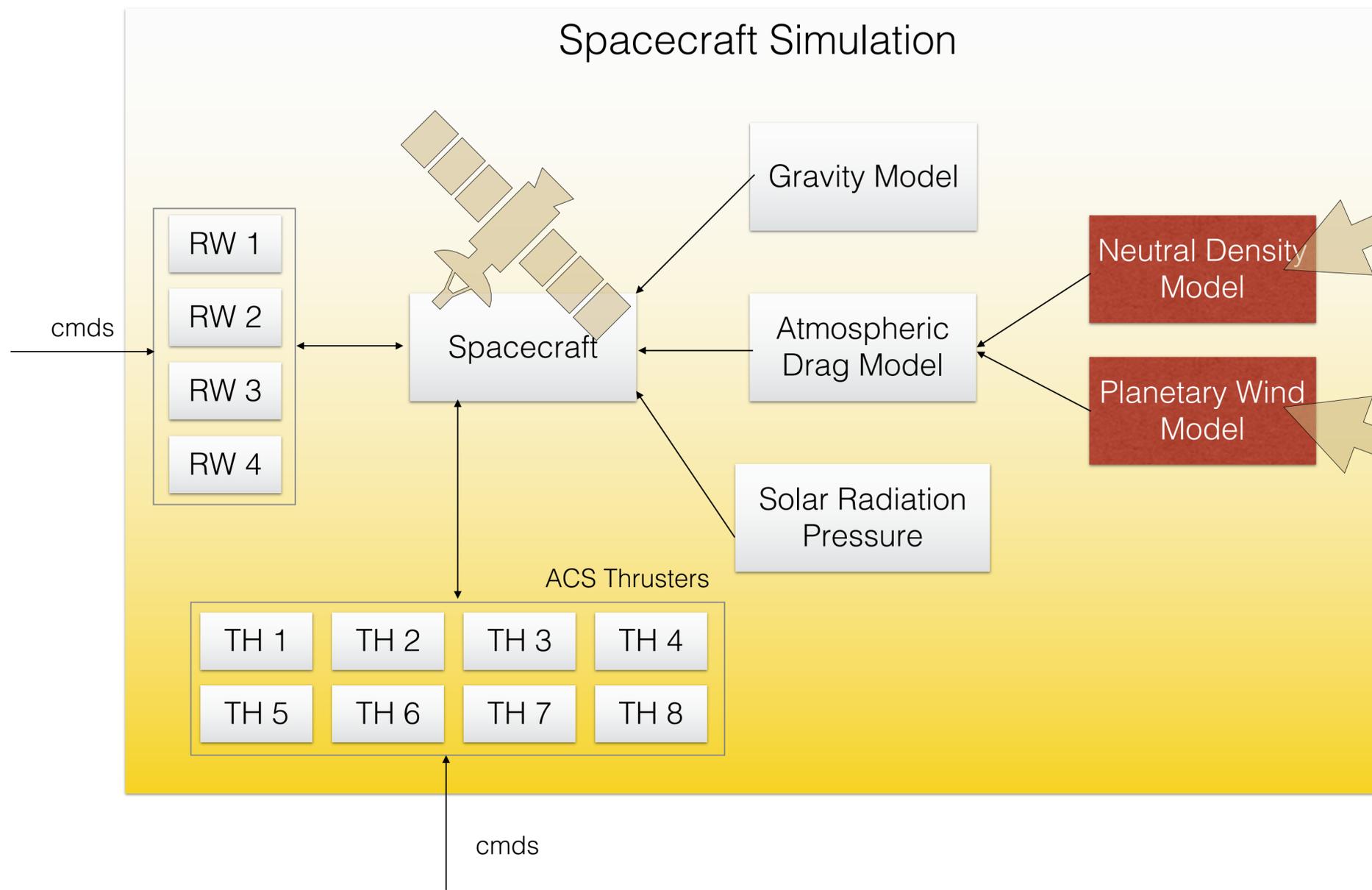
Creates a common API for modules to communicate, thus creating module exchangeability.

Sample Spacecraft Simulation Setup



The C++ device modules can easily be added and connected with the the simulation.

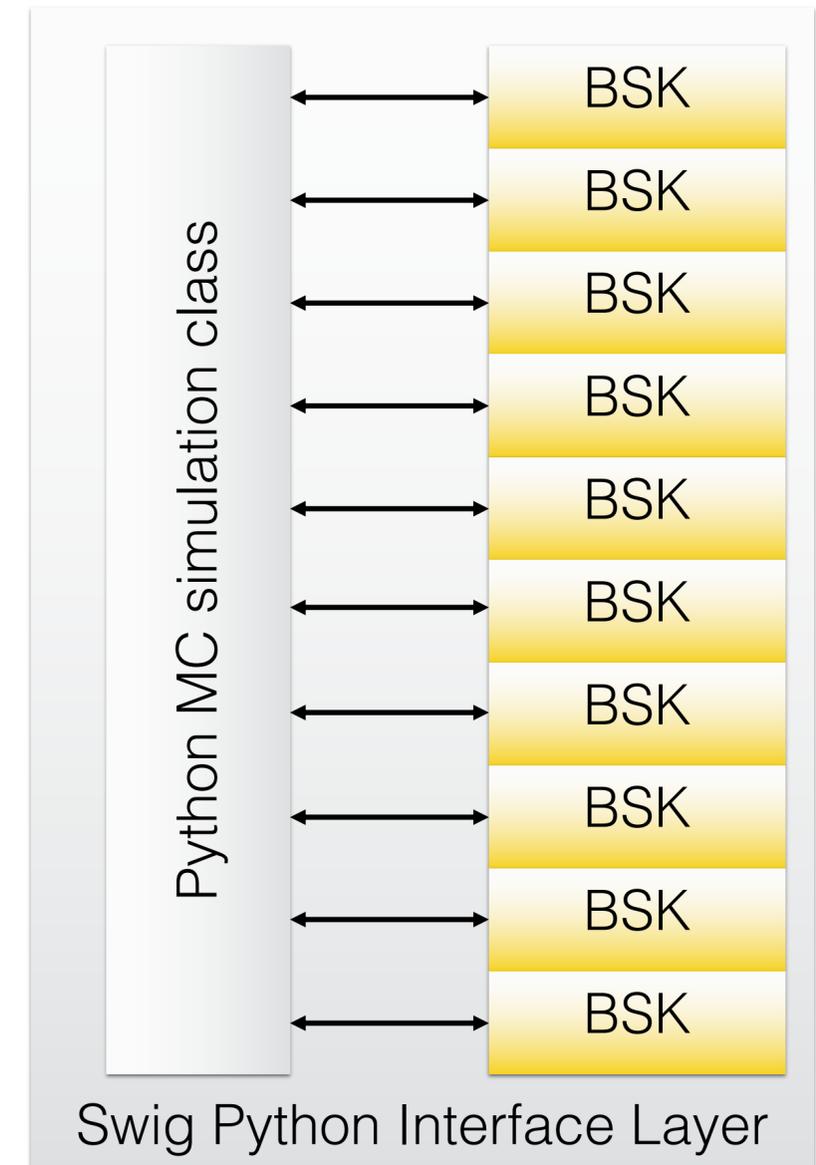
Spacecraft Environment Integration



Monte-Carlo Multi-Processing



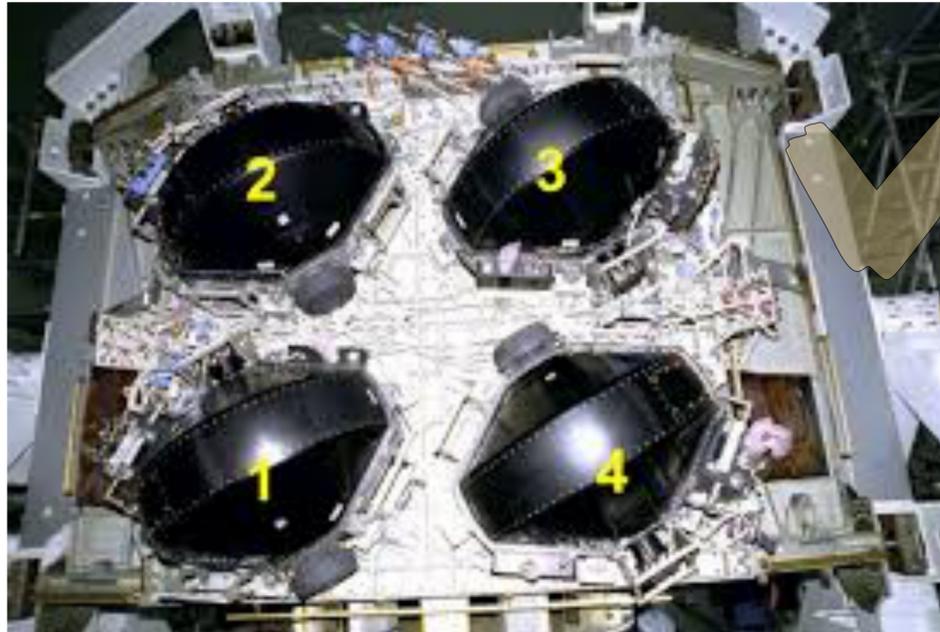
- Ability to run Monte-Carlo simulations with a range of dispersion
- Data is retained between runs
- Takes advantage of multi-core processors and hyper-threading





BSK Simulation Research

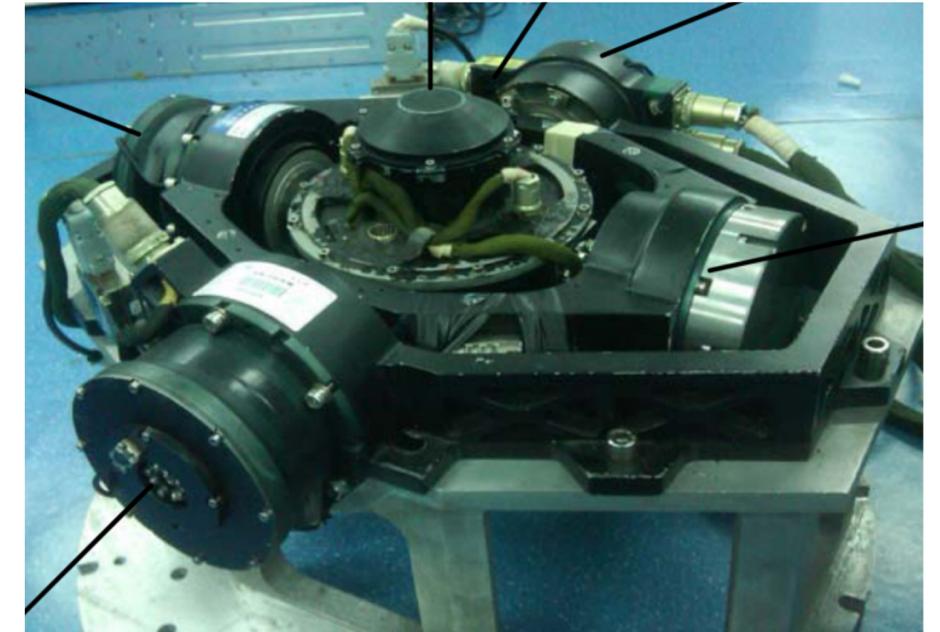
Momentum Exchange Devices



Reaction Wheels



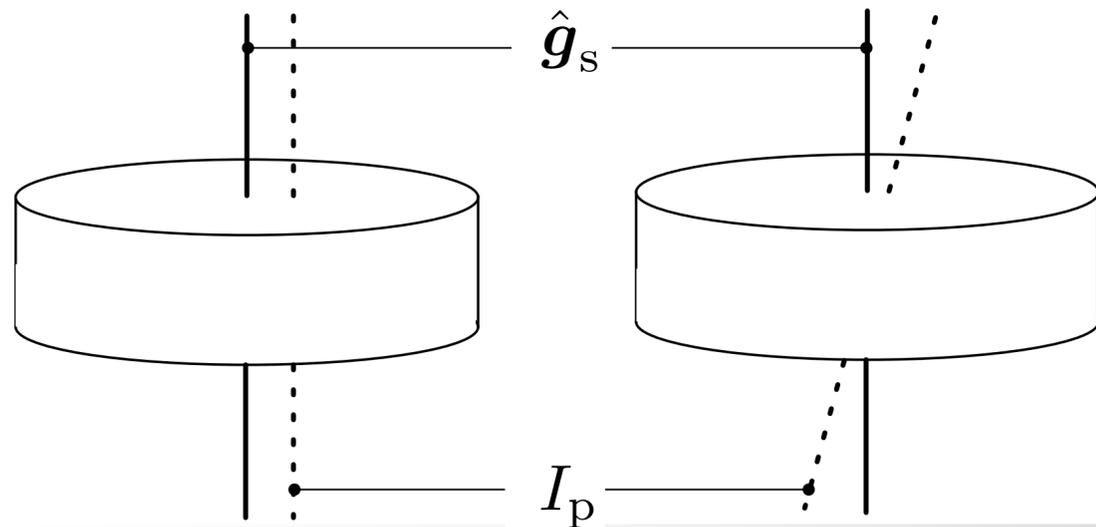
Control Moment Gyros



Double Gimbal Control Moment Gyros

Static Imbalance

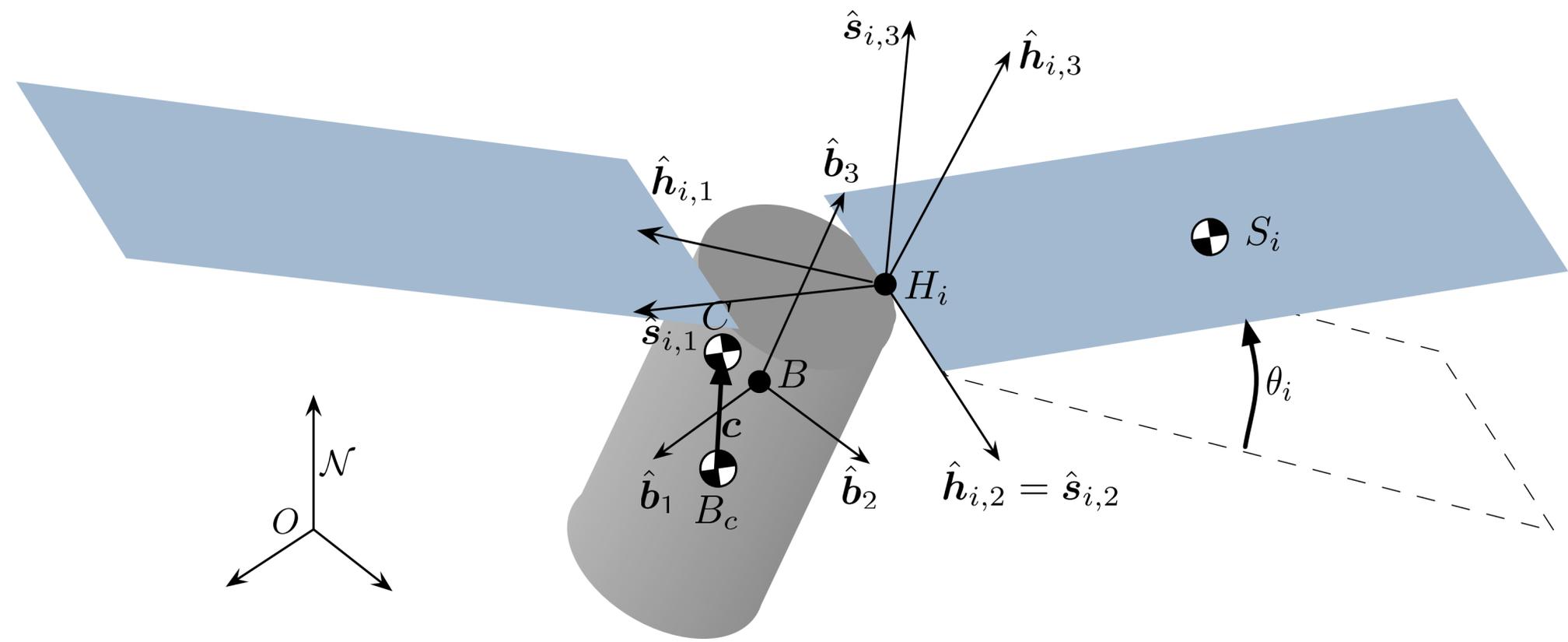
Dynamic Imbalance



Physics Based Imbalance Modeling

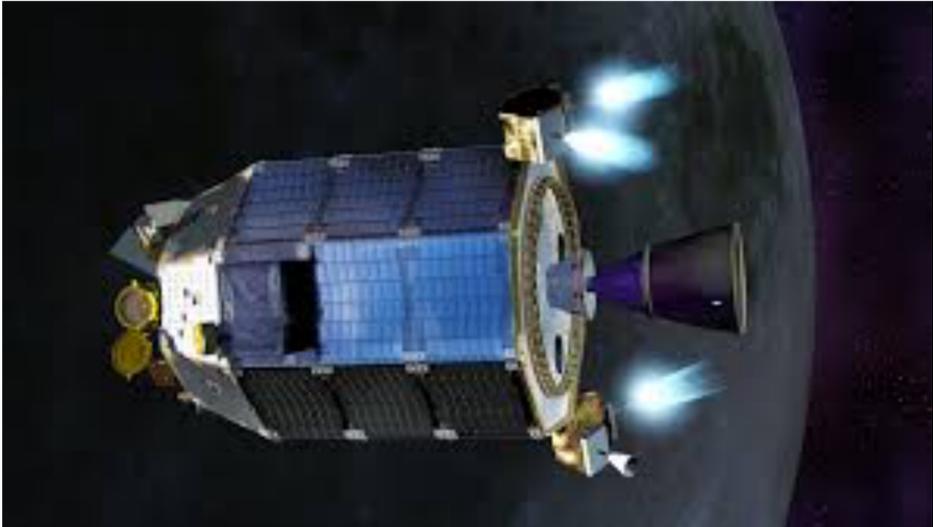
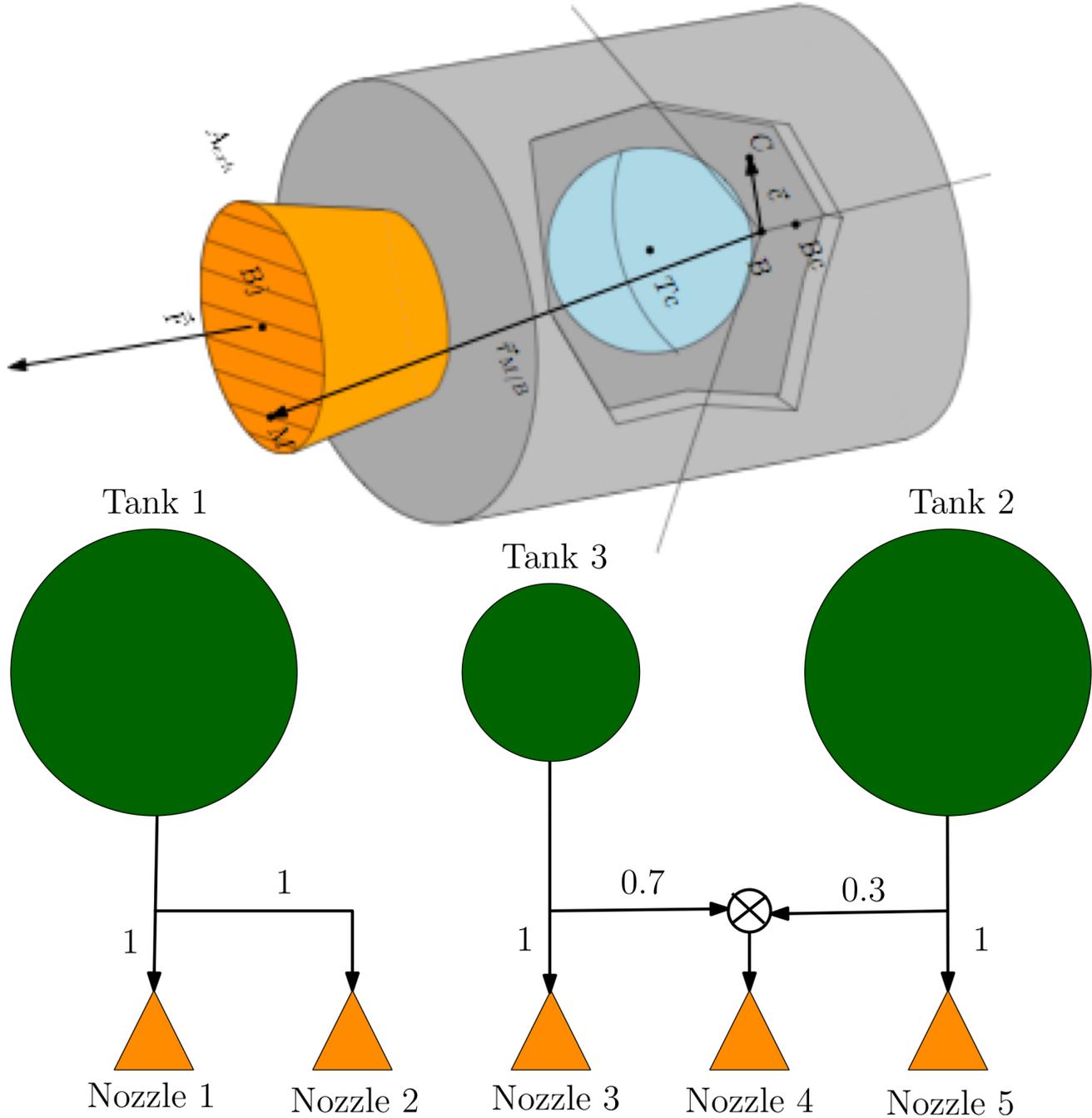
Solved the imbalanced RW spacecraft dynamics in a manner that complies with power rate and angular momentum conservation.

Flexible/Hinged Panel Modeling



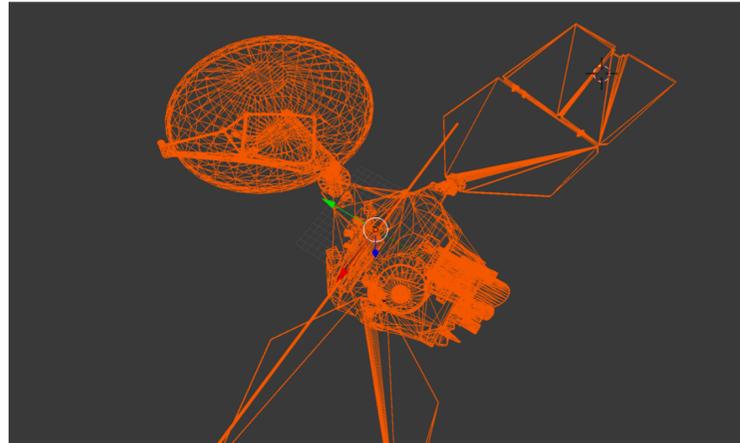
Solved the spacecraft dynamics in a general, closed-form manner for a series of hinged panels.

Depletable Mass and Fuel Tank Modeling

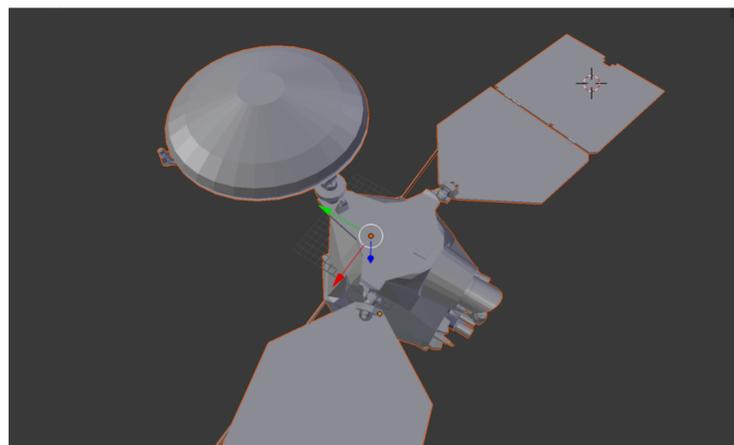
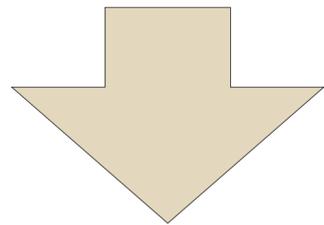


Depletable mass system with general setup of tanks, thrusters and connections

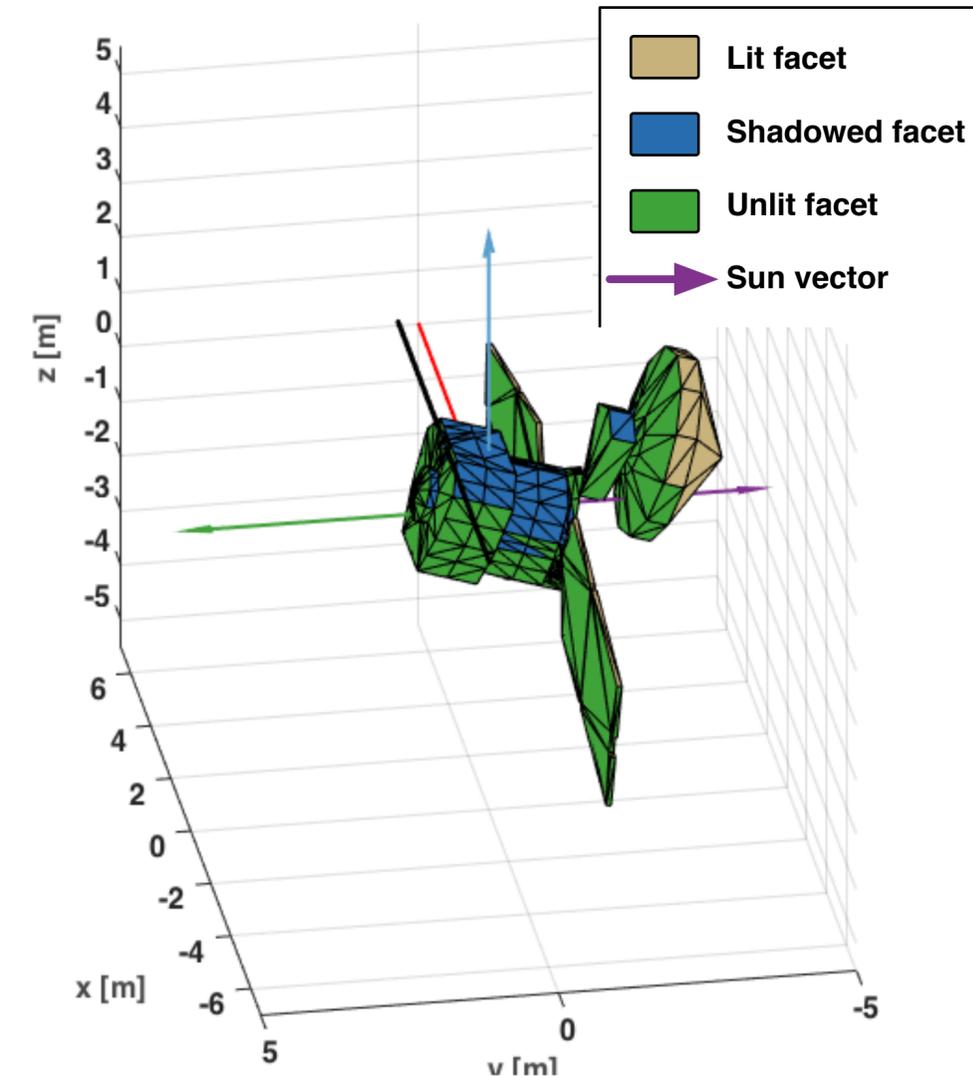
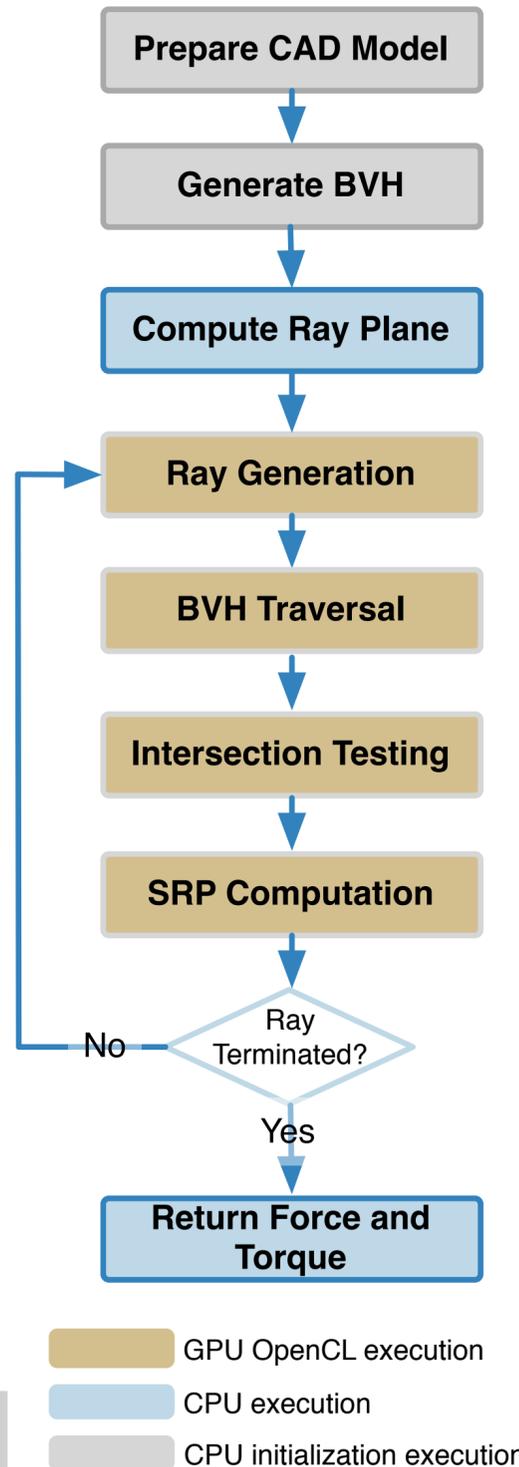
GPU Based Solar and Atmospheric Pressure Drag



CAD model with material properties



Use GPU to evaluate forces and torques using custom vertex shaders



Drag forces can be rapidly computed on complex, time-varying geometries at speeds suitable for even hardware in-the-loop scenarios.



Distributed Basilisk or Black Lion

Heterogeneous Distributed Simulation Capability



Ground Software

mini-Lion

C++

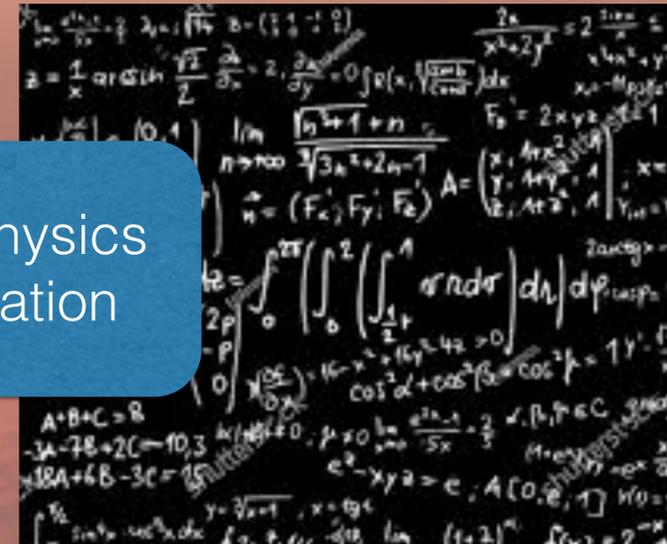
- dynamic discovery of the simulation network topology
- starts and synchronizes the sim
- networks all the message packages

Black Lion

mini-Lion

BSK Physics Simulation

Python



Flight Computer

mini-Lion

C++

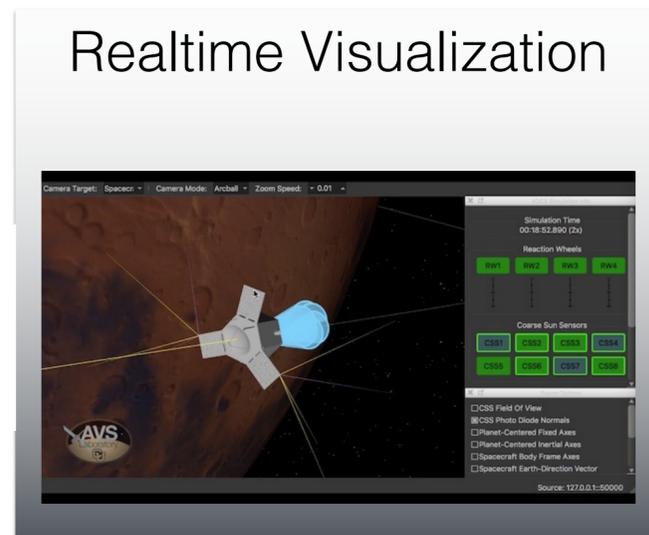
hardware flight board

- receives packages and interfaces with other code
- consistent translation layer across nodes
- can record message stream

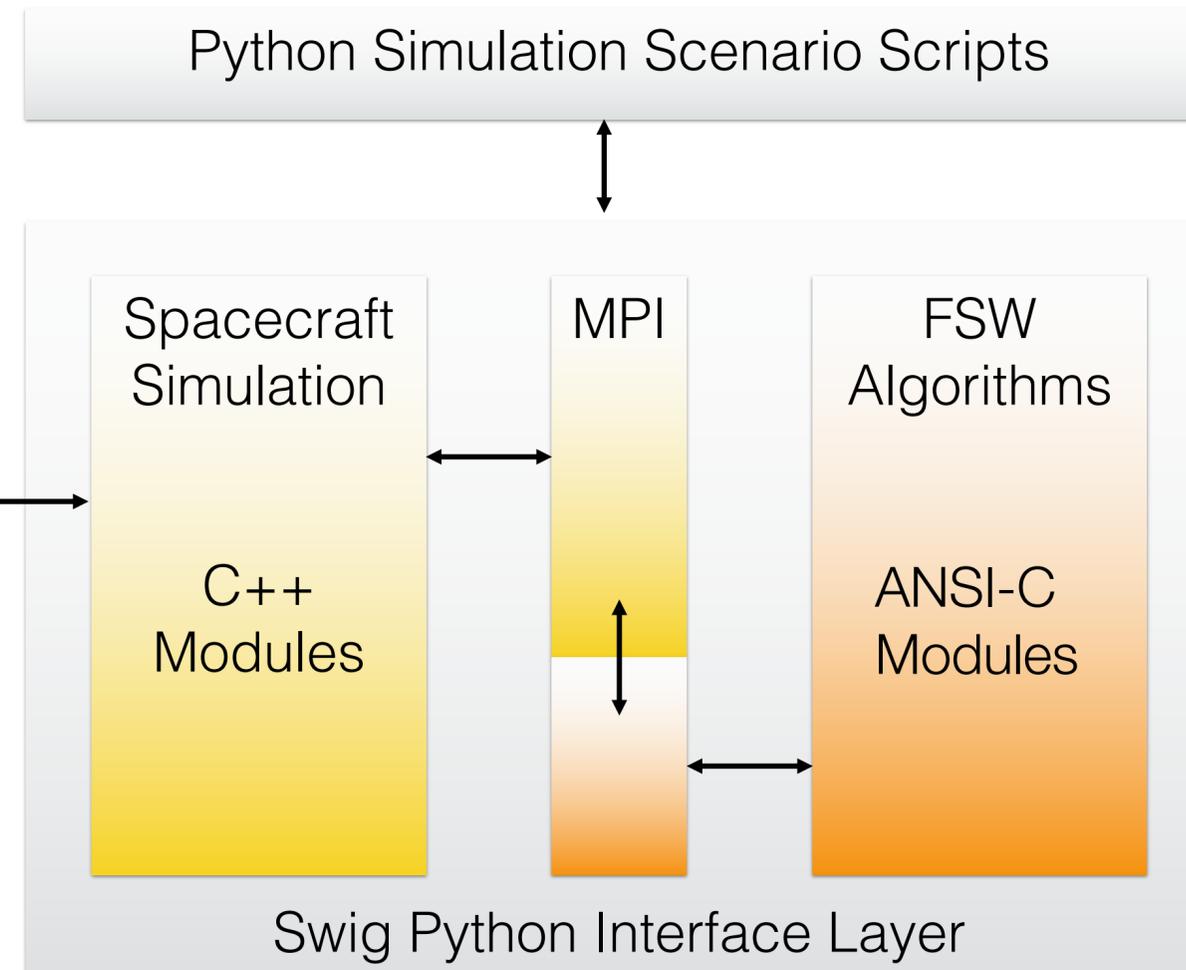


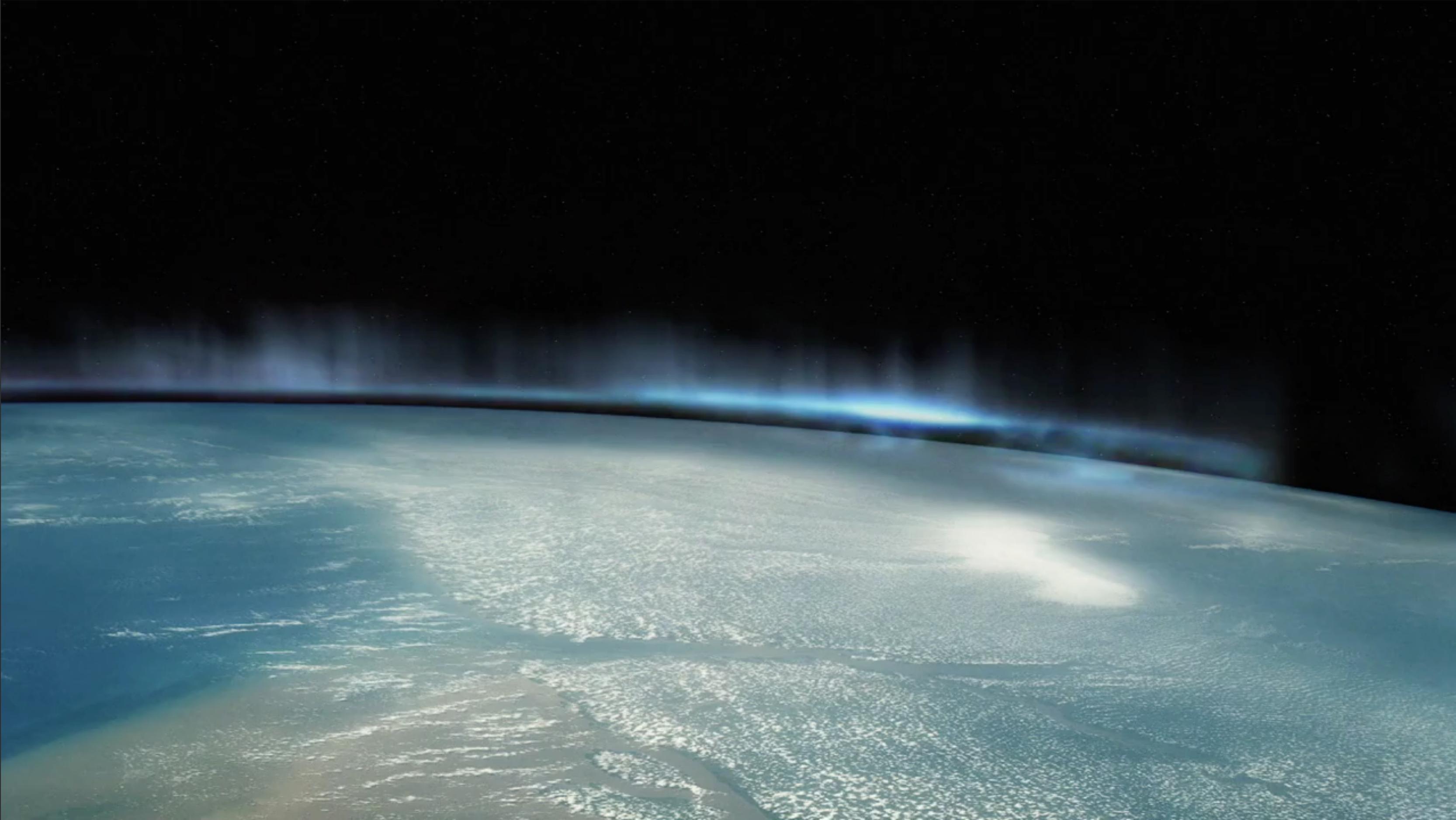
Basilisk Visualization

Basilisk Software Architecture (Analysis)



- Monte-Carlo Capability
- Speeds up to 700-1000x
- Software Realtime Mode
- ISC Open Source License





Questions?



NEXT
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