CLARREO Pathfinder: Mission Overview

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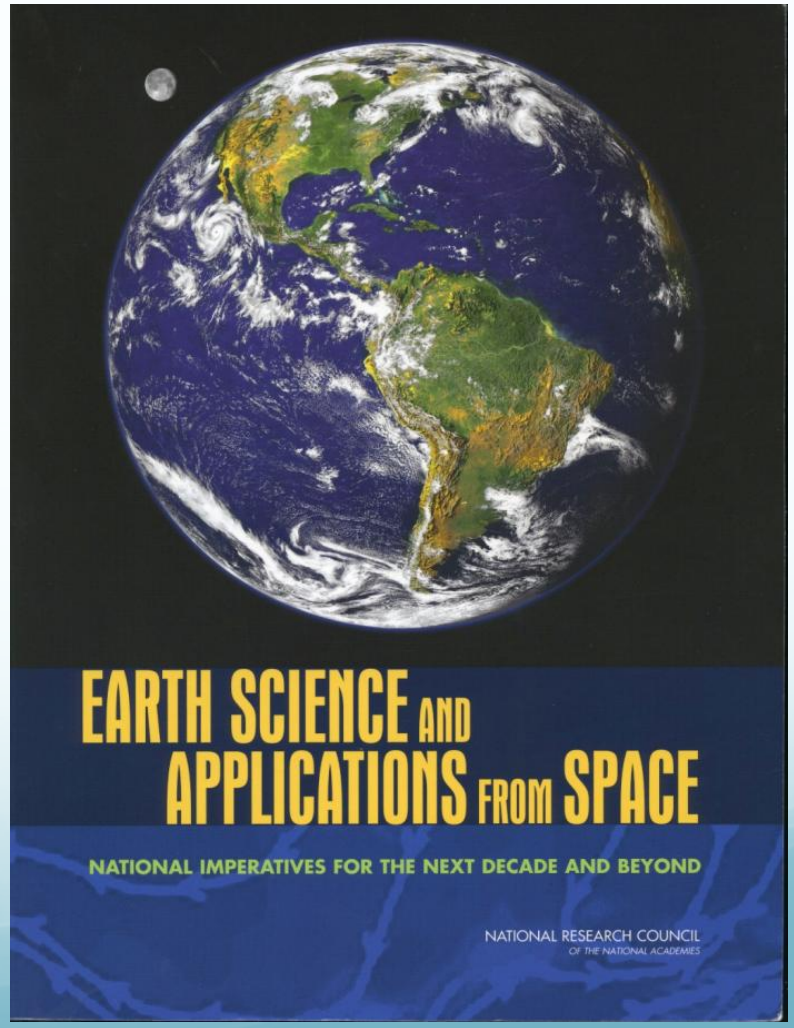
CLARREO: 2007 Decadal Survey Origins

Climate Absolute Radiance and Refractivity Observatory

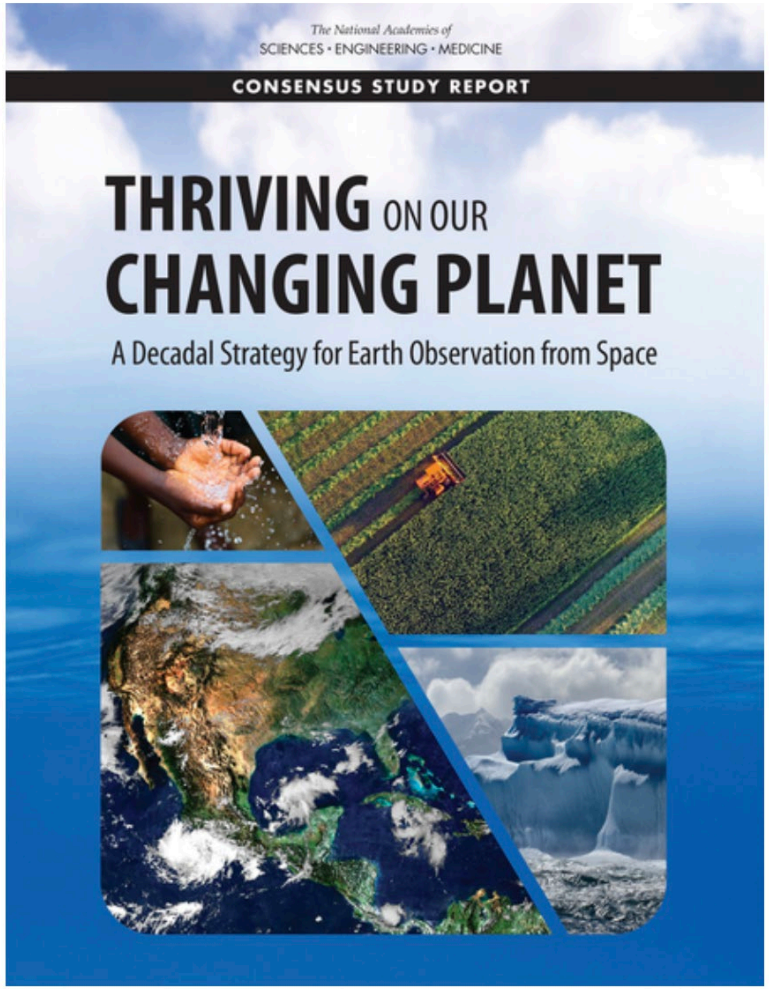
- **CLARREO Mission:** Tier 1 recommended mission in 2007 Decadal Survey
- **Purpose:** To address critical need of…
  1. Sufficient accuracy for climate change observations and improved confidence in observing the small climate change signals over decadal and longer time scales
  2. Sufficient information content for attribution.



CLARREO Pathfinder: 2017 Decadal Survey

Climate Absolute Radiance and Refractivity Observatory

- **2017 Decadal Survey:** Radiance Inter-calibration recommended to address *Most Important* science priority of reducing climate sensitivity uncertainty.
  - Recommended that NASA execute Program of Record – *Including CLARREO Pathfinder*

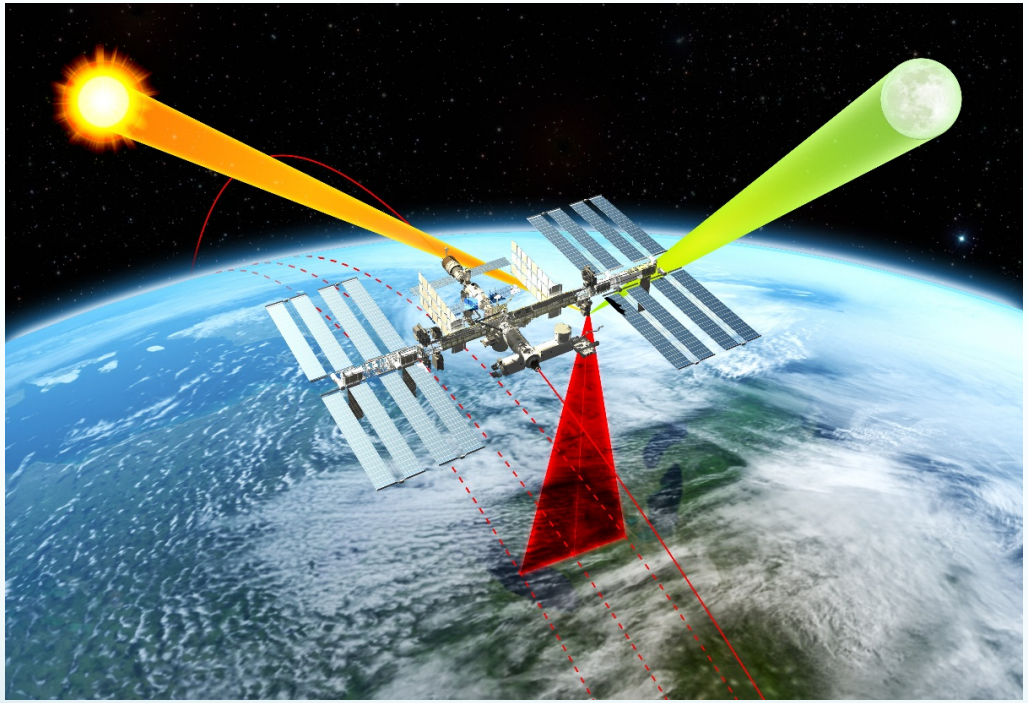


Mission Summary

- LASP-Led Reflected Solar Spectrometer
- Hosted on International Space Station
- Nominal 1-year mission life + 1 year science data analysis
- Launch Readiness: Late 2022

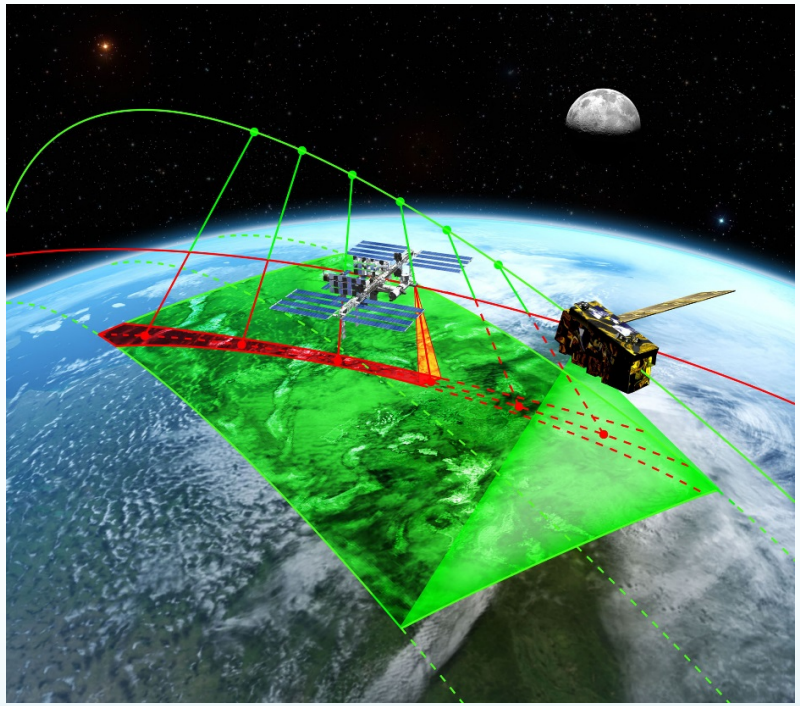
CLARREO Pathfinder: Mission Objectives

Objective #1: Demonstrate High Accuracy SI-Traceable Radiance Measurements



Through on-orbit calibration demonstrate ability to reduce radiance uncertainty by a factor of ***4-8 times*** compared to the best operational sensors on orbit.

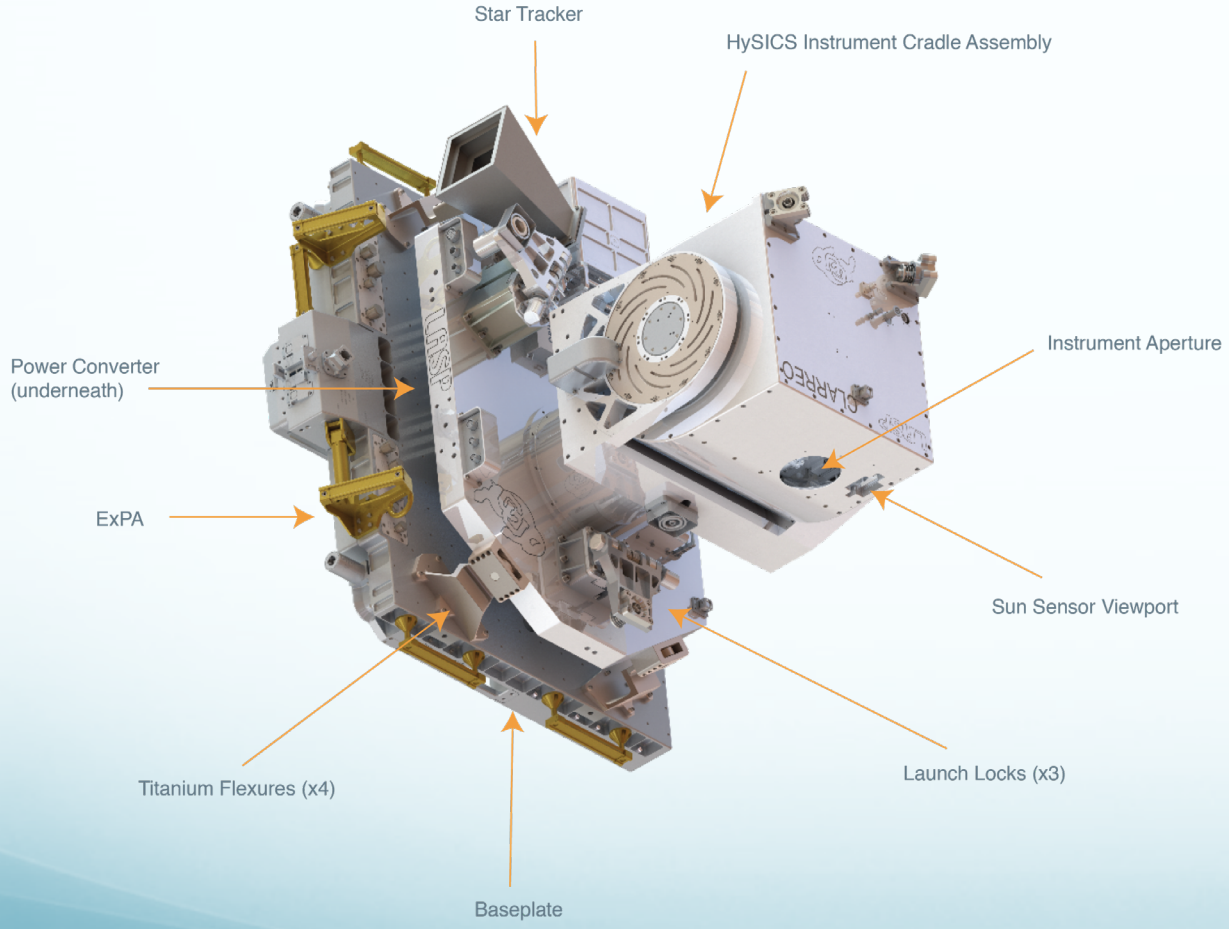
Objective #2: Demonstrate Inter-Calibration Capabilities



Demonstrate ability to transfer calibration other key RS satellite sensors.

CPRS Payload: LASP Leadership

HYSICS: Hyperspectral Imager for Climate Science



Radiometric Uncertainty	0.3% (1-sigma)
Spectral Range	350 nm – 2300 nm
Spectral Resolution	6 nm
Swath Width	10° (70 km nadir)
Spatial Resolution	0.5 km
Sampling Rate	15 Hz

Pushing Accuracy Boundaries

Demonstration Parameter	Measurement Uncertainty
Spectrally-Resolved Earth Reflectance (350 – 2300 nm): Referenced to spectral solar irradiance	≤ 0.3% (k = 1)
Spectrally-Integrated Earth Reflectance (350 – 2300 nm): Broadband reflectance with spectral accuracy weighted using global average Earth spectrally reflected energy	≤ 0.3% (k = 1)
On-Orbit Inter-Calibration: Inter-Calibration with CERES shortwave channel and VIIRS reflectance bands	≤ 0.3% (k = 1)

CPF Advancing Science

Challenge: Reduce Climate Sensitivity Uncertainty

- No significant progress in reduction of climate sensitivity uncertainty since the 1979 Charney Report

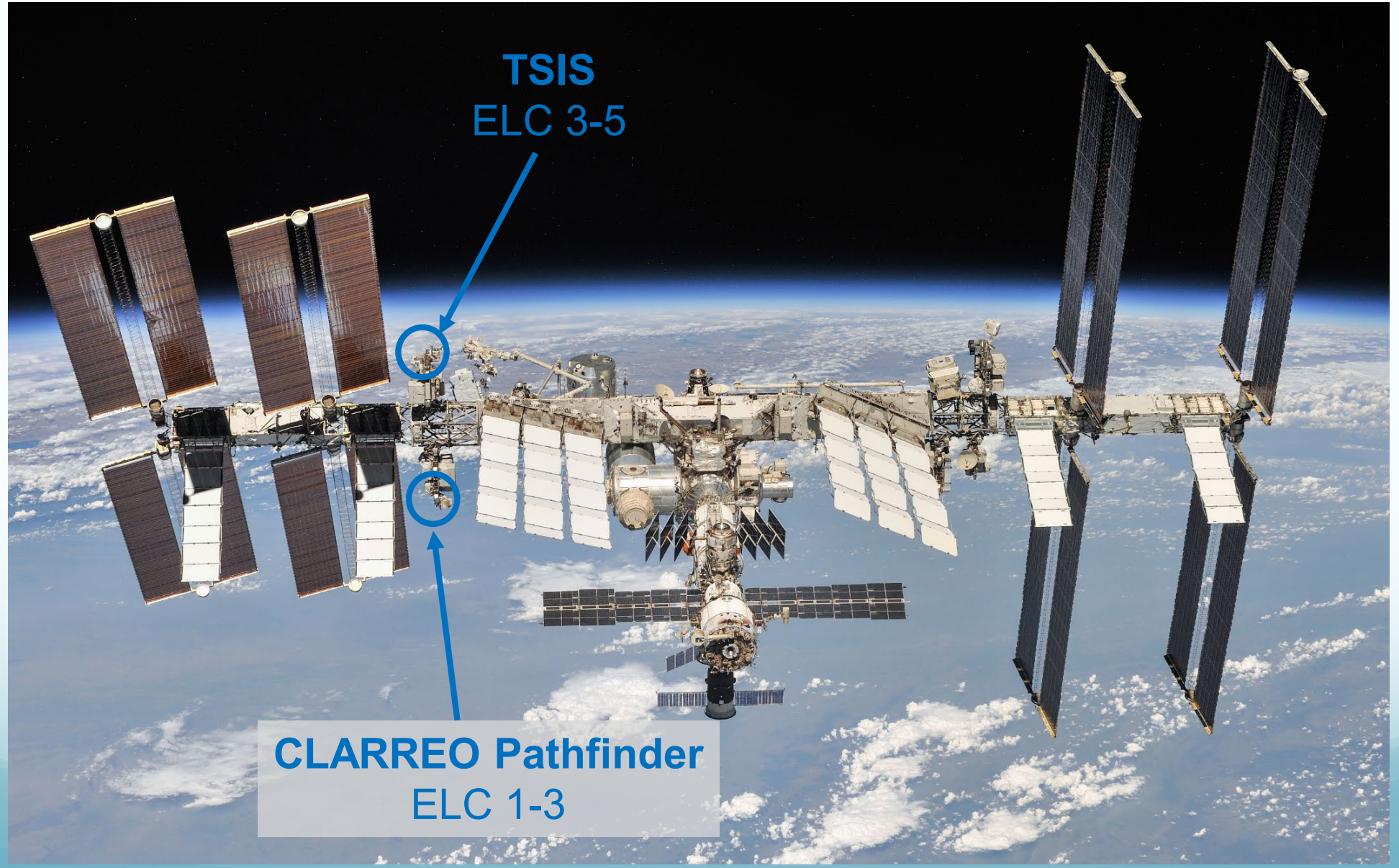
Significant Benefits to Reducing Uncertainty

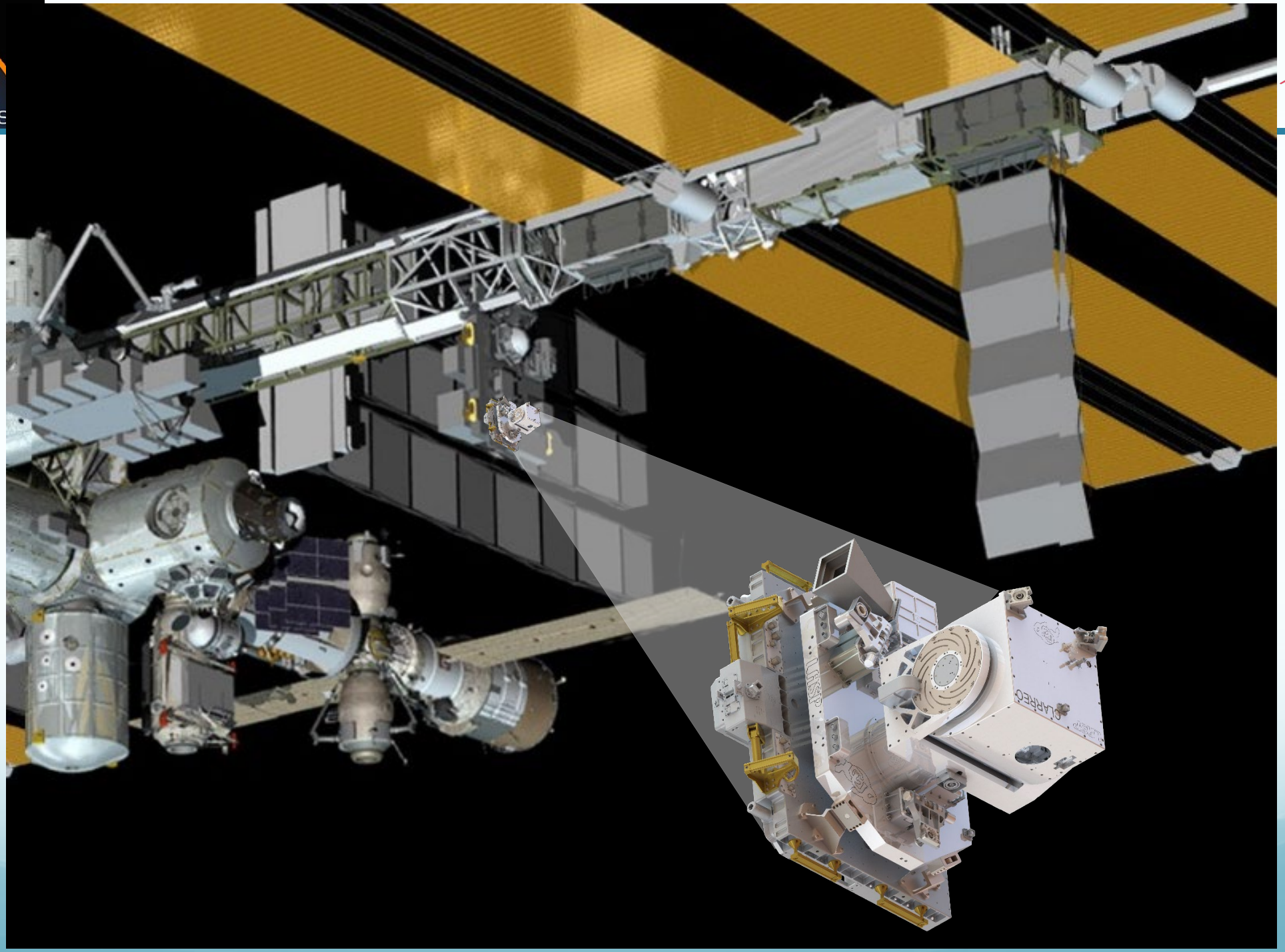
- Enables reduced climate trend detection times resulting in economic, social, and homeland security impacts.
- ***Improved strategic planning*** by government agencies for operations and sustainment of key national assets
- ***Improved risk assessment*** by the reinsurance industry

CLARREO Pathfinder Contributing to the Solution

- ***SI-traceable advanced in-orbit calibration*** enables more accurate Earth climate observations
- CPF will demonstrate taking high accuracy measurements needed to detect small decadal trends earlier than possible with current technology
- CPF will shows how to perform on-orbit ***high accuracy inter-calibration*** to multiple national and international assets: sensors in LEO and GEO, Moon, and land sites

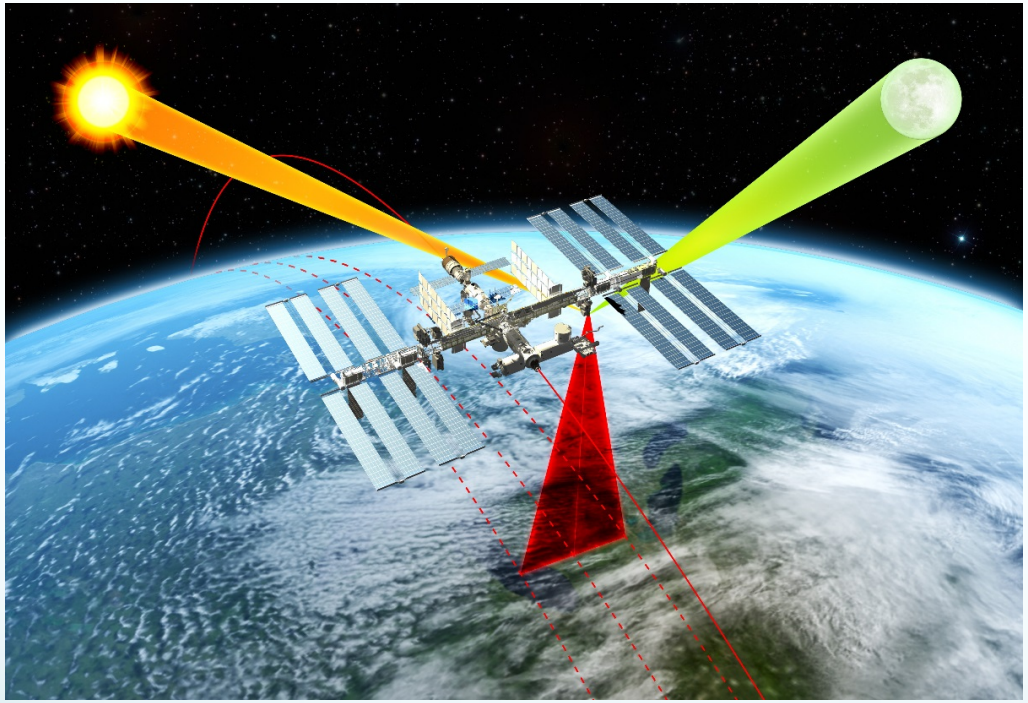
Our Future Home on ISS




LASP
CLARREO

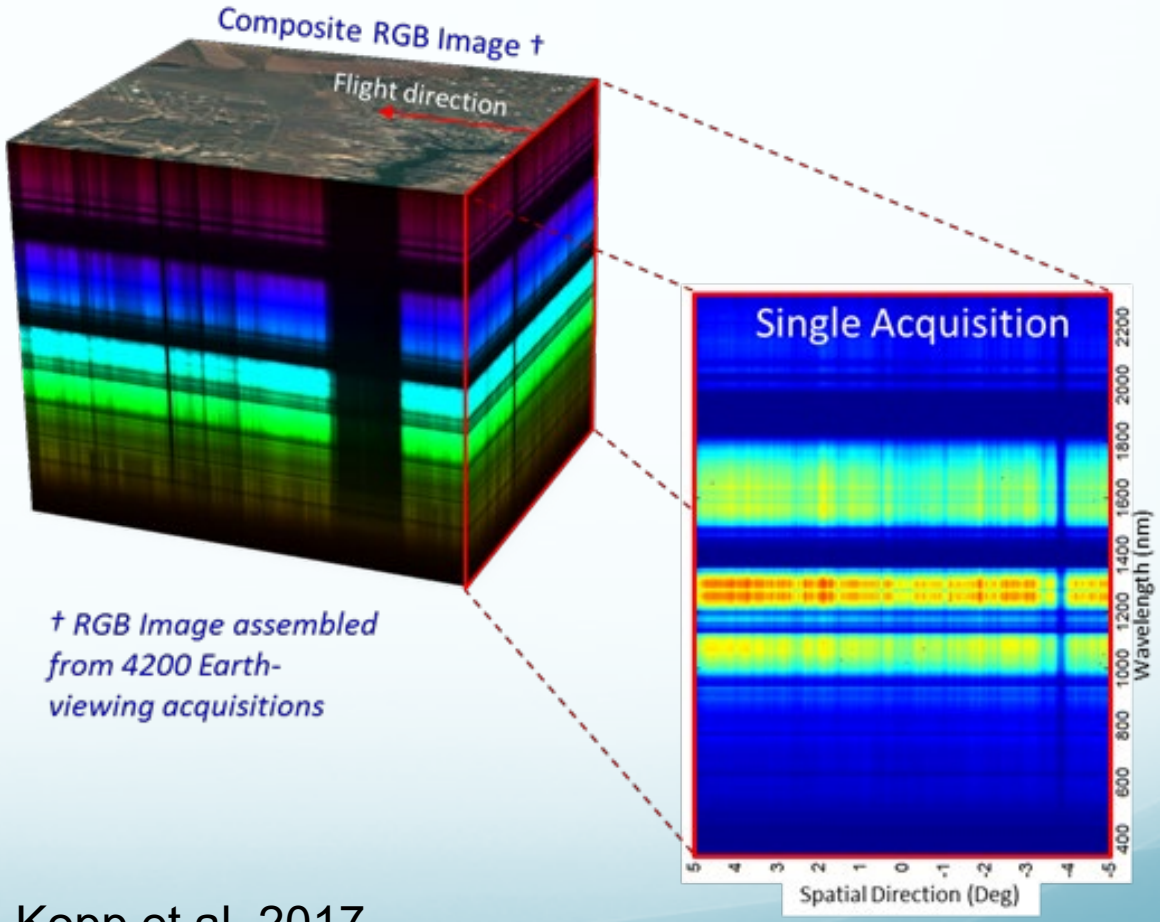
Mission Objective #1: Calibration

Objective #1: Demonstrate High Accuracy SI-Traceable Radiance Measurements



Through on-orbit calibration demonstrate ability to reduce radiance uncertainty by a factor of ***4-8 times*** compared to the best operational sensors on orbit.

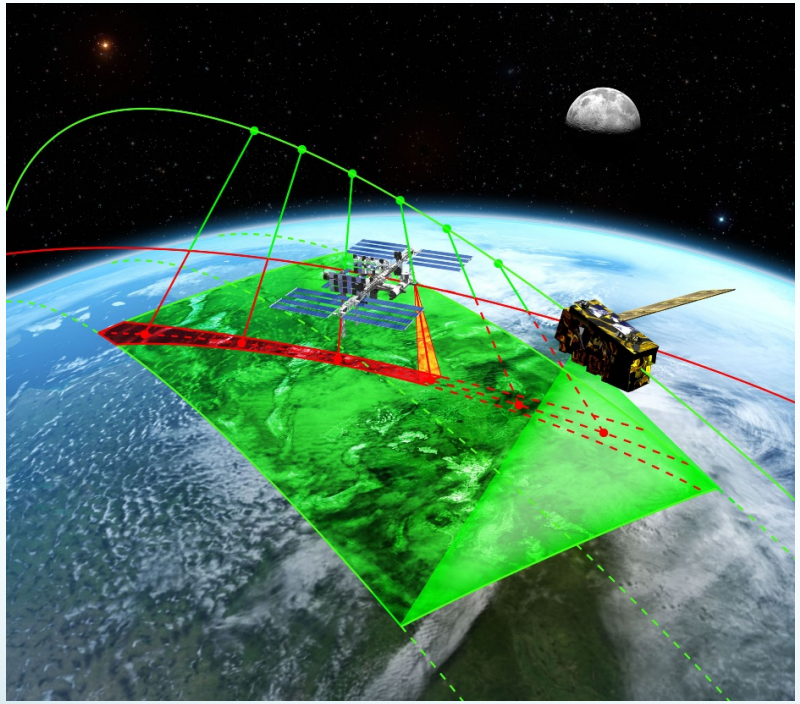
Spectrally-Resolved Earth Reflectance



Kopp et al. 2017

Mission Objective #2: Inter-calibration

Objective #2: Demonstrate Inter-Calibration Capabilities



Demonstrate ability to transfer calibration other key RS satellite sensors.

Demo Inter-calibration of Two On-orbit Assets

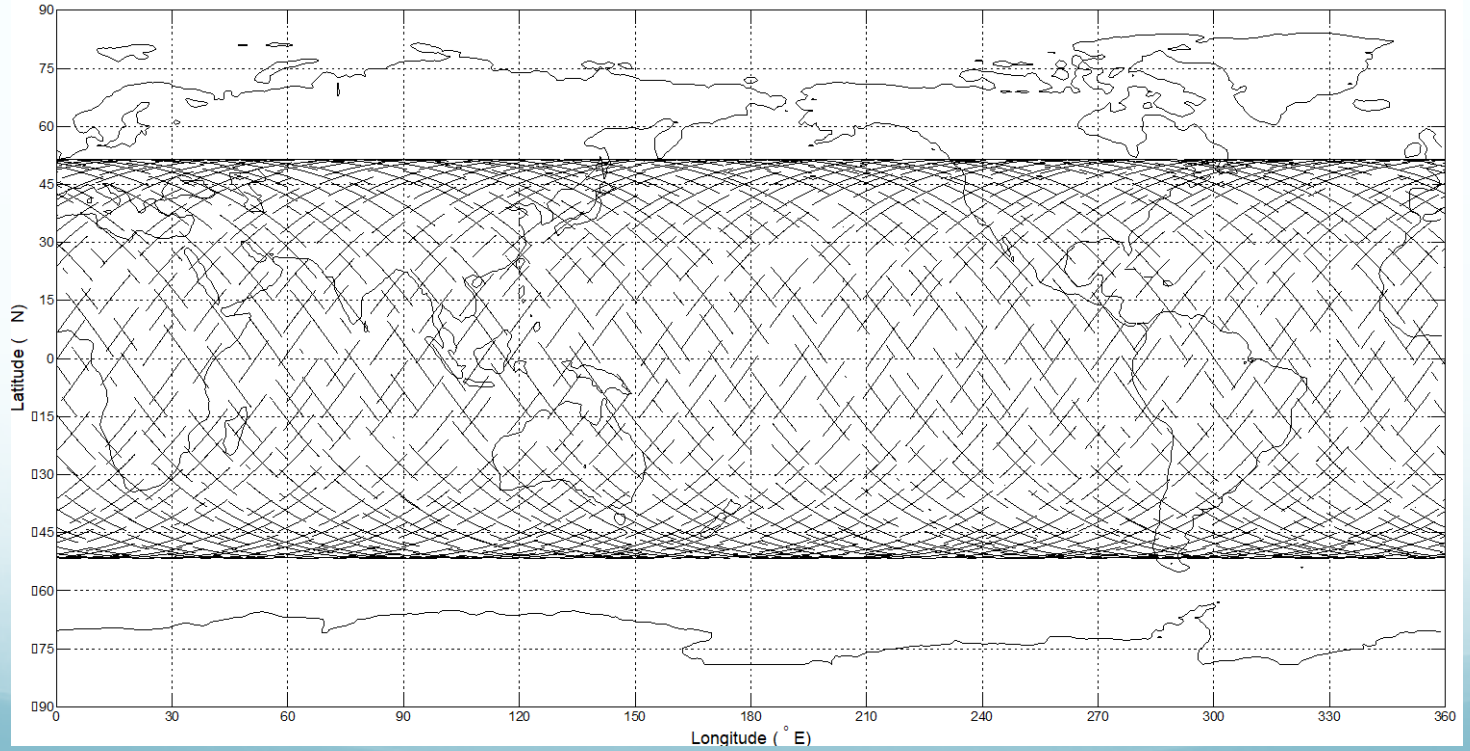
1. CERES: Clouds and the Earth's Radiant Energy System
   - Broadband Radiometer (.2 um – 5 um)
2. VIIRS: Visible Infrared Imaging Radiometer Suite
   - 16 Moderate-resolution reflected solar bands

How Inter-Calibration Uncertainty Requirements are Achieved

- Inter-calibration uncertainty requirements are met (in part) by acquiring and analyzing data from an aggregation of inter-calibration events

- More events improves reduction of data matching noise

Predicted inter-calibration events (~1,300) between CLARREO Pathfinder on ISS and NOAA-20 for 1-year of operations



CLARREO Pathfinder: Science Obs.

Required Mission Operations	
On-orbit Instrument Calibration	Solar & Lunar Views, Other Calibration Modes
Spectrally-resolved Earth Reflectance and Radiance	High accuracy, geolocated nadir measurements
Inter-calibration with CERES and VIIRS	Earth-views matched in time, space, viewing angle, and spectral band

Additional Mission Opportunities	
Inter-Calibration of Geosynchronous Imagers	Examples: ABI on GOES-16, EUMETSAT's GERB
Inter-Calibration of Low Earth Orbit Imagers	Example: Landsat imagers
Improved calibration of vicarious calibration sites	Spectrally-resolved reflectance over instrumented and non-instrumented sites to calibrate operational and future Earth Science sensors
Improved calibration of lunar radiance	Potential ~10x improvement of current lunar standard, enabling the moon to be used as on-orbit calibration source for current / future Earth Science instruments

Distributed Data Products

Data Product	Description
Level 0	Reconstructed, unprocessed instrument and payload data at full resolution, with any communications artifacts removed.
Level 1 A & B	Calibrated and geolocated observations at full resolution, annotated with ancillary information such as radiometric and geometric calibration coefficients and georeferencing parameters
Level 4	Time/angle/space-matched inter-calibration data for reference (CPF) and target sensors (CERES and VIIRS), scene information from target sensors, and parameters for estimated VIIRS polarization sensitivity

Project Status & What's Next?

- Passed PDR & KDP-C in 2019
  - Currently in Phase C - Implementation
- Preparing for CDR (March 2020)
- CLARREO Pathfinder Science Team solicitation planned but date TBD
- Launch Readiness Date: Late 2022

https://clarreo-pathfinder.larc.nasa.gov/