Libera

Understanding Earth's Energy Budget

LASP • JPL • LBL • UA • CSU • UM • NIST • NOAA • Ball • SDL

Libera Mission Status Update

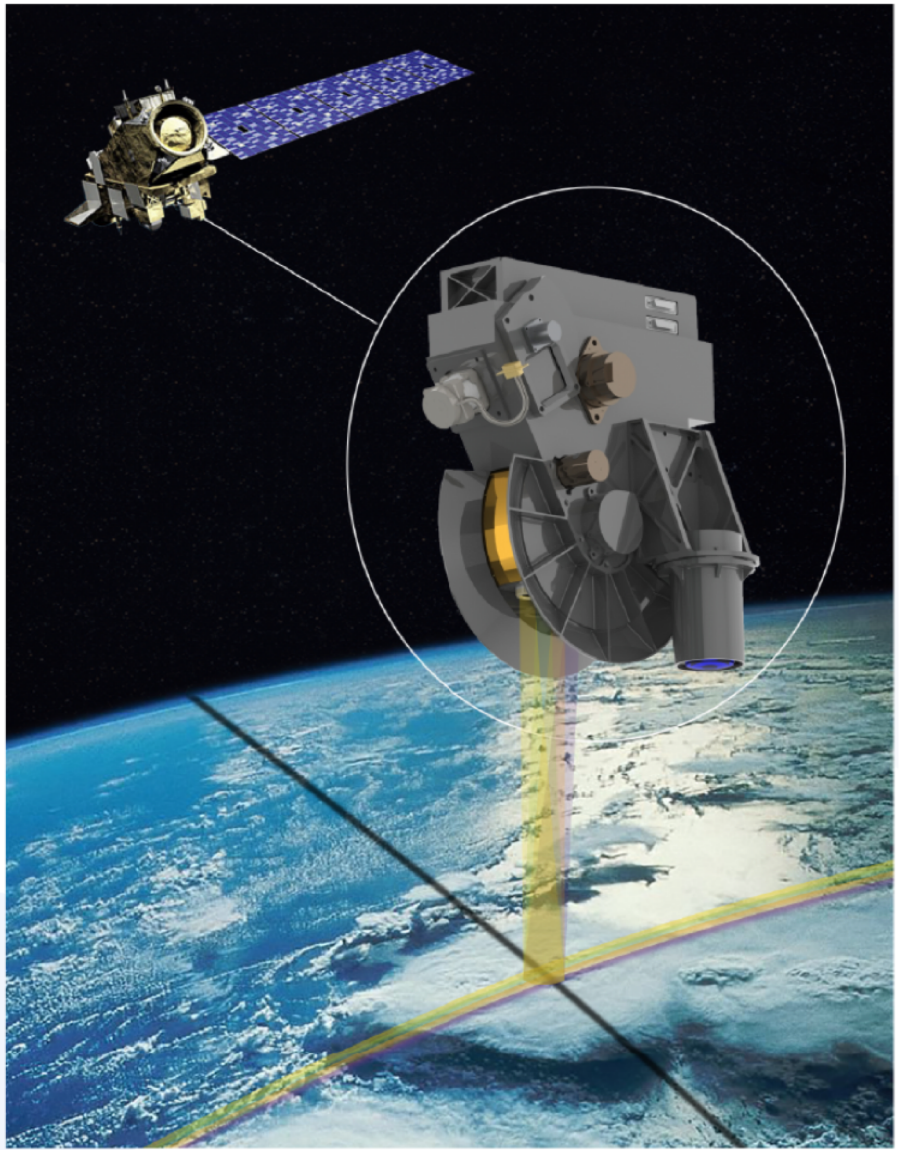
P. Pilewskie & Libera Team

Outline

- *Libera* background
- Updated schedule
- Detector development update
- Managing the handoff from CERES to *Libera*

Libera, First NASA EVC-1 Mission

'Li-be-ra, named for the daughter of Ceres in ancient Roman mythology



Provides continuity of the Clouds and the Earth's Radiant Energy System (CERES) Earth radiation budget (ERB)

- Measures integrated shortwave (0.3–5 µm), longwave (5–50 µm), total (0.3–>100 µm) and ***(new) split-shortwave (0.7–5 µm)*** radiance over 24 km nadir footprint at ***~ 0.2% uncertainty***.
- Includes a ***wide FOV camera*** for scene ID and simple ADM generation to pave way for future free-flyer ERB observing system

Innovative technology improves accuracy:

- ***Electrical Substitution Radiometers (ESRs) using Vertically Aligned Carbon Nanotube (VACNT) detectors***

Primary operational modes:

- Cross-track, azimuthal, along-track scanning; on-board calibrators; solar and lunar viewing.

Flight:

- JPSS-3, 2028 launch; 5-year mission

Partners:

- Technical: LASP, Ball Aerospace, NIST Boulder, Space Dynamics Lab; CU, JPL, CSU, UA, UM, LBL
- Science: CU, JPL, CSU, UA, UM, LBL, ETH, U. Reading, UK. Met Office, Imperial College London

Libera Major Reviews and Key Milestones

Milestone	Acronym	Date	Convening Authority
Authorization to Proceed	ATP	6 Jul 20	-
System Requirements Review	SRR	22 Feb 21	SRB
Key Decision Point - B	KDP-B	30 Apr 21	SMD PMC
Preliminary Design Review	PDR	8-10 Feb 22	SRB
Key Decision Point - C	KDP-C	Apr 22	SMD PMC
Critical Design Review	CDR	Feb 23	SRB
Instrument Integration Review	IIR	Jun 24	SRB
Pre-Environmental Review	PER	Oct 24	SRB
Pre-Ship Review	PSR	Mar 25	SRB
Delivery to Spacecraft		May 25	-
Key Decision Point D	KDP-D	Jun 25	SMD PMC
Launch		2028	-
Key Decision Point E	KDP-E	2028	SMD PMC
Post Launch Assessment Review	PLAR	L+90d	SRB
Operational Transition Review	OTR	PLAR + 9mo	TBD

COVID-19 Impacts

- NIST facility closure and restart at limited occupancy delayed prototype detector work schedule for Phase A.
  - Status: Despite early delays, prototype manufacturing schedule now being met
- Limited occupancy at LASP since the start of the pandemic. .
- LASP engineering staff ramp up impacted by Covid-related schedule delays on other programs.
  - Status: All identified engineers are on Libera. Now watching post-CDR staffing for similar issues

Detector Development:
Collaborations with the NIST Boulder *Sources and Detectors Group*

The NIST-LASP detector development process is iterative

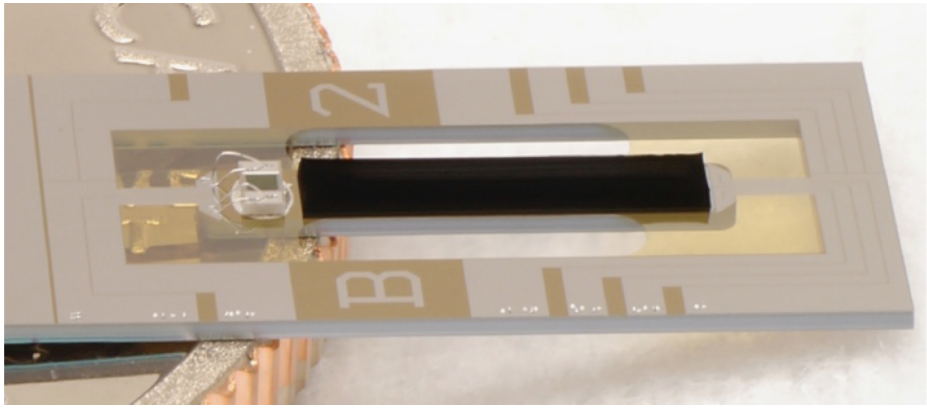
- Fabricate initial detector, test, repeat …
- Accelerated by fabrication of multiple detectors per wafer

From advanced components to instruments to missions …

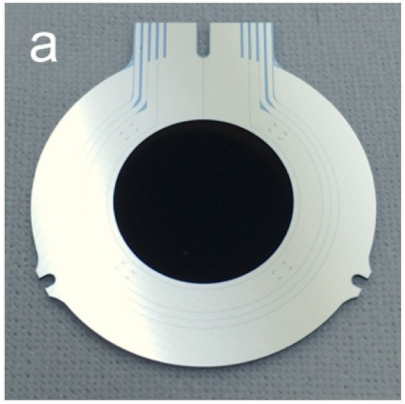
- Carbon Absolute Electrical Substitution Radiometer (CAESR)
- Compact Spectral Irradiance Monitor (CSIM)
- Compact Total Irradiance Monitor (CTIM)
- Black Array of Broadband Absolute Radiometers (BABAR)
- Black Array of Broadband Absolute Radiometers for Imaging Earth Radiation (BABAR-ERI)
- *Libera*

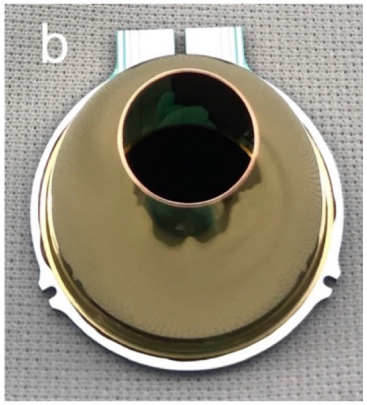
VACNT ESRs for Climate Studies

Compact Spectral Irradiance Monitor (CSIM)

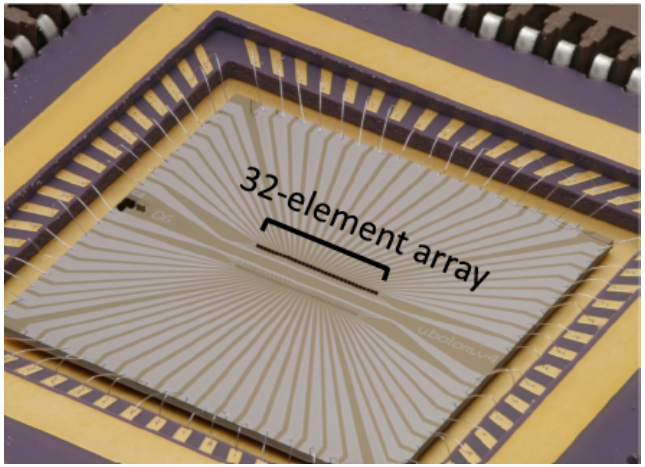


Compact Total Irradiance Monitor (CTIM)

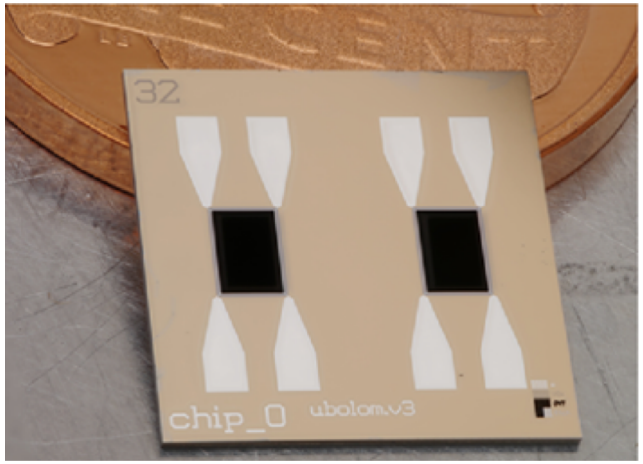




Black Array of Broadband Absolute Radiometers (BABAR)

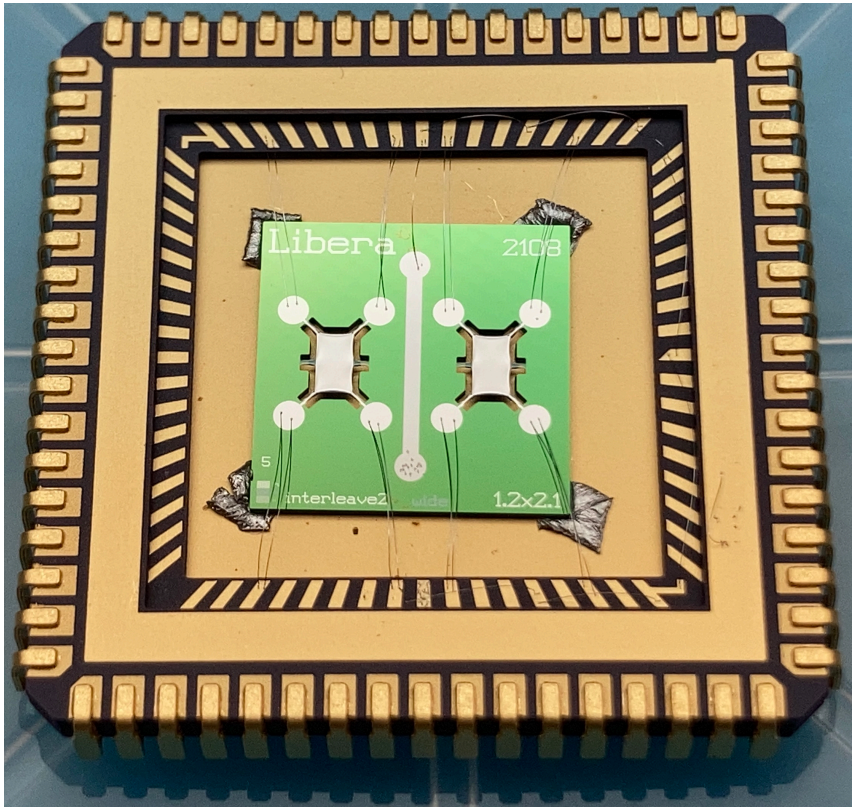


Libera Prototype 0



Libera Detector Development

Prototype 4



Detector Requirement Status

Requirement	Baseline Value	Prototype 3 Performance
Spectral Ranges	0.3 μm - 5 μm 0.7 μm - 5 μm 5 μm - 50 μm 0.3 μm - >100 μm	Confirmed from reflectivity measurements
Channel Accuracies (k=1)	SW: 0.17% Split SW: 0.17% LW: 0.24% Total: 0.22%	Supported by analysis
Channel Precision	0.11 $W/m^2/sr$	In test
Dynamic Range	0 - 500 $W/m^2/sr$	0 - 500 $W/m^2/sr$
Linearity	0.1%	In test
Response Time	Match CERES	Confirmed
Survival Temperature Range	-20˚C to +50˚C	Verified

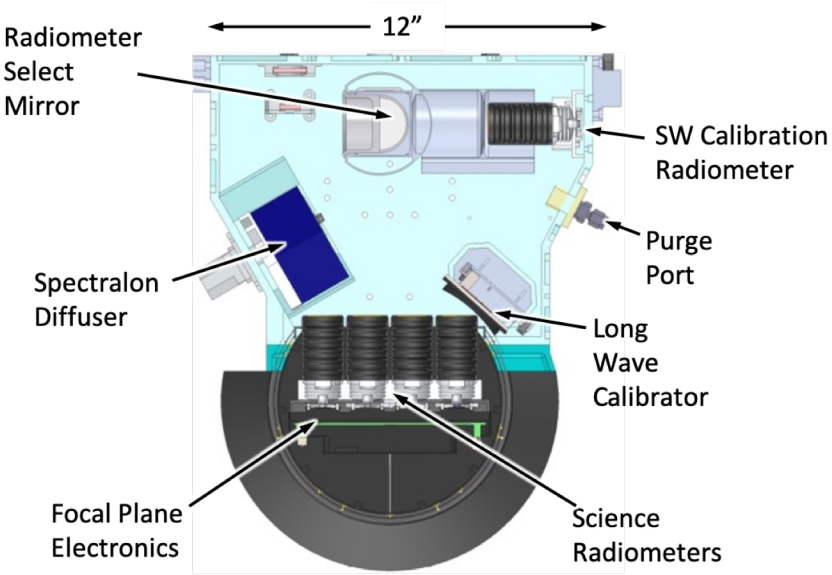
Radiometer Pre-flight Calibration

- Component-level
  - Component-level testing of flight components
    - Update values in the filtered radiance measurement equation
    - Spectral response functions generated from spectral measurements of components
- Detector-level
  - Electrical calibrations
    - Populate filtered radiance measurement equation
  - End-to-End testing of the detectors
    - Test time response, non-equivalence
- Radiometer-level
  - Validate and adjust filtered radiance measurement equation
  - Validate and adjust the spectral response functions
- Validation
  - *Independent check* performed at SDL to validate the filtered radiance measurement equation and spectral response functions

On-Orbit Calibration and Validation

A *belt-and-suspender* approach:

- Onboard calibration targets (daily)
  - Shortwave calibrator using LED sources (375, 405, 469, 660, 810, 1550 nm) and engineered diffuser; stability tracked via a SW calibration radiometer
  - Longwave calibrator: flat-plate blackbody (310-330K) with CNT coating, Si-traceable PRTs to NIST standards.



- Solar calibrations (bi-monthly)
  - Three Spectralon diffusive panels viewed bi-monthly/monthly/semi-annually for degradation tracking
- Lunar calibrations (~ monthly)
  - Obtained during JPSS SC roll maneuvers for VIIRS lunar calibration

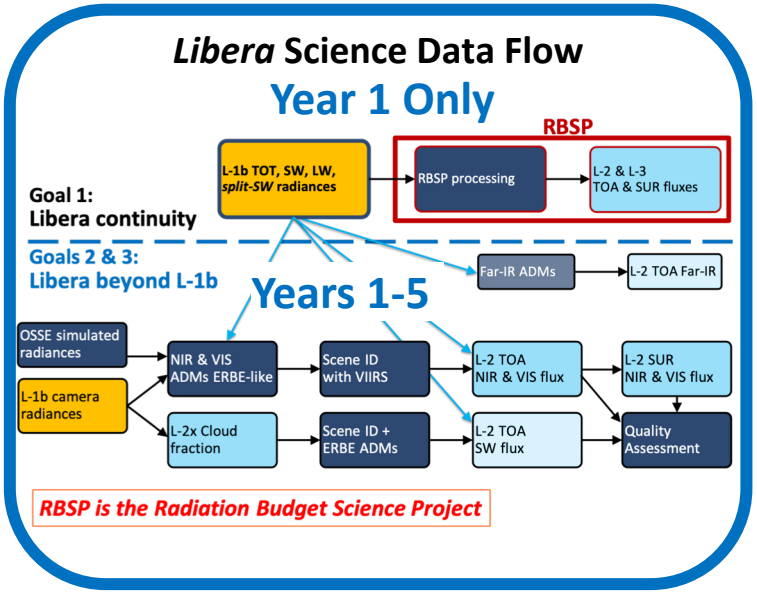
Libera Science Goals

Meet EVC-1 specific objectives on Earth Radiation Budget (ERB) continuity, innovation, and affordability

1. Provide seamless continuity of the Clouds and the Earth's Radiant Energy System (CERES) ERB Climate data record (CDR).
   - Measurement of TOT, SW and LW with same characteristics as CERES to prevent gap in ERB CDR vital for studying global climate change.
2. Advance the development of a self-contained, innovative & affordable observing system.
   - Wide field-of-view camera for Scene ID and split-SW ADM development.
3. Provide new and enhanced capabilities that support extending ERB science goals.
   - Additional split-SW channel to quantify shortwave near-IR and visible irradiance.

Transfer of Mission Operations to the RBSP

- *Libera* is responsible for the first year of Phase E mission operations.
  - During this time Libera produces L-1b radiance products for the RBSP to ingest and produce higher level ERB data products.
- After one year, operations are transferred to the RBSP.
  - RBSP also takes over production of L-1b data.
- *Libera* science team activities continue in years 2-5:
  - science data processing of split channel radiance
  - production of camera radiances and derived products
  - addressing Libera science objectives related to all three goals



Coordination Between *Libera* and RBSP

- Weekly meetings between LASP and RBSP
- Calibration and Validation working group oversees ground and on-orbit calibration activities. Interface between LASP, technical partners at Ball, NIST and SDL and the RBSP.
- The *Libera*/RBSP/ASDC Data Management Working Group oversees the production and distribution to the RBSP and ASDC of Libera level 1-b data and metadata.
- The *Libera*/RBSP Operations Working Group will manage the Libera concept of operations before and during the year-1 Phase E operations effort.

All part of the *Libera Earth Radiation Budget Continuity Plan*

Thanks!