National Aeronautics and
Space Administration

Space Technology Mission Directorate

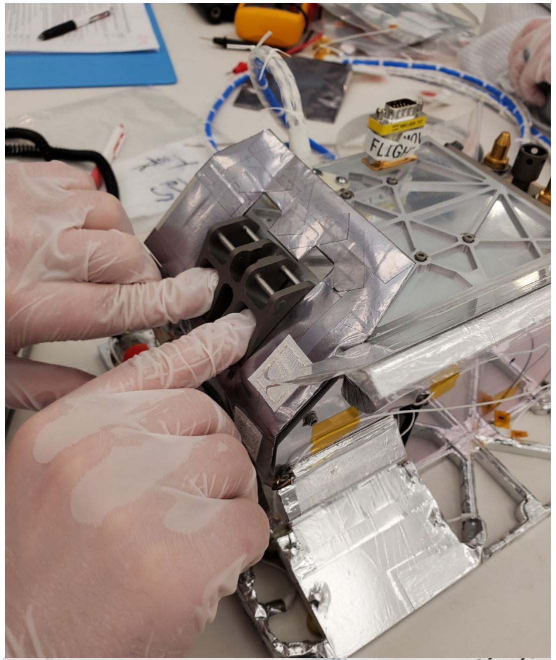
Game Changing Development Program

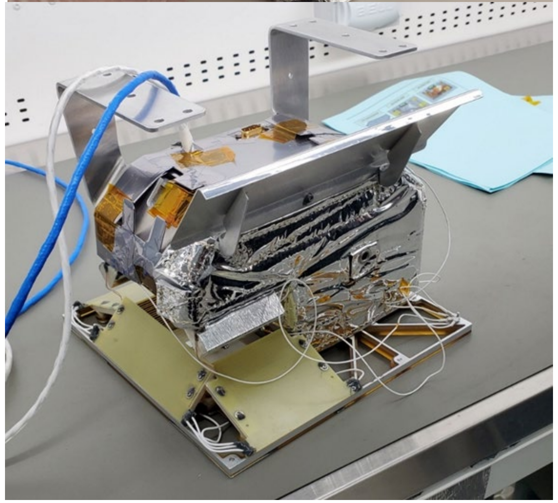
Alexis Hongamen | Dr. Charles Buhler | Rick Walker | Electrodynamic Dust Shield | Annual Program Review | September 10-12, 2024

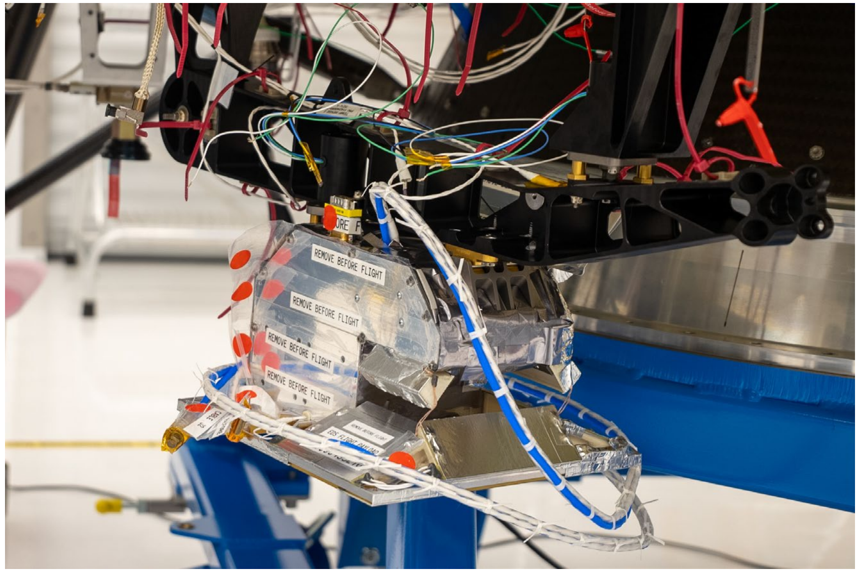
Electrodynamic Dust Shield Overview

Timer

- NASA’s Commercial Lunar Payload System of Commercial Lunar Payload Services (CLPS) will fly an Electrodynamic Dust Shield (EDS) Payload as a technology demonstration to show the removal of dust from a glass panel as well as a thermal radiator surface.
- The EDS Payload will fly on Firefly Aerospace’s *Blue Ghost* Lander NET fourth quarter CY24 to Mare Crisium.
- The EDS hardware being developed for this payload is based on EDS payloads flown on the International Space Station (MISSE 11 and 15).
- The EDS payload consisting of the camera and EDS panels for the lens, the thermal radiator, and the glass EDS will be deposited on the ground by a deployable structure on the lander shortly after landing.
- Mission operations will start shortly after deployment and will take precedence over those of the other payloads.
- The camera will record dust deposition and removal on the Thermal Radiator EDS and the Glass EDS.
- Data handling will be done with a Data Storage Unit (DSU) which is being developed by NASA Langley Research Center. The DSU has flight heritage at JPL.







Electrodynamic Dust Shield Overview

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[redacted]		
GCD	Raise the TRL of the existing EDS dust mitigation solution through payload testing on near term Commercial Lunar Payload Services (CLPS) missions.	Active Dust Solutions Gaps 1047, 521

[redacted]	
Goal #1	Deliver a payload for the Commercial Lunar Payload Services (CLPS) Program task order 19D to demonstrate the Electrodynamic Dust Shield (EDS) technology on the moon in 2025.
Goal #2	Provide data demonstrating performance of the EDS technology to lunar landing missions.

[redacted]	
Objective #1	To design, build, and test EDS payload for CLPS Task Order 19D.
Objective #2	To demonstrate the performance of the EDS on the lunar surface.

Electrodynamic Dust Shield Overview

Timer

EDS PROGRAM ELEMENT MANAGER

Richard A. Walker

EDS CLPS Management

Senior Project Manager
Alexis Hongamen

Deputy Project Manager
Jennifer Wilson

CLPS PROGRAM ELEMENT MANAGER

Mark Dillard

Principal Investigator – Dr. Charles Buhler

System Engineer – Jeffrey Dyas / Troy Toon

Chief Engineer – Marty Grashik

Software Lead
James Phillips

Ground Software
Jonathan Hsu

Software
Chris Forney

Mechanical Lead
Dr. Joseph Toth

Thermal Lead
Melissa Young

Mission Ops Lead
Dr. Krystal Acosta

Electrical Lead
Lex Mazerski

Mission Ops
Dr. Aaron Olson

AI&T Lead
Jerry Wang

Electrodynamic Dust Shield
Blue Ghost Lander Interface

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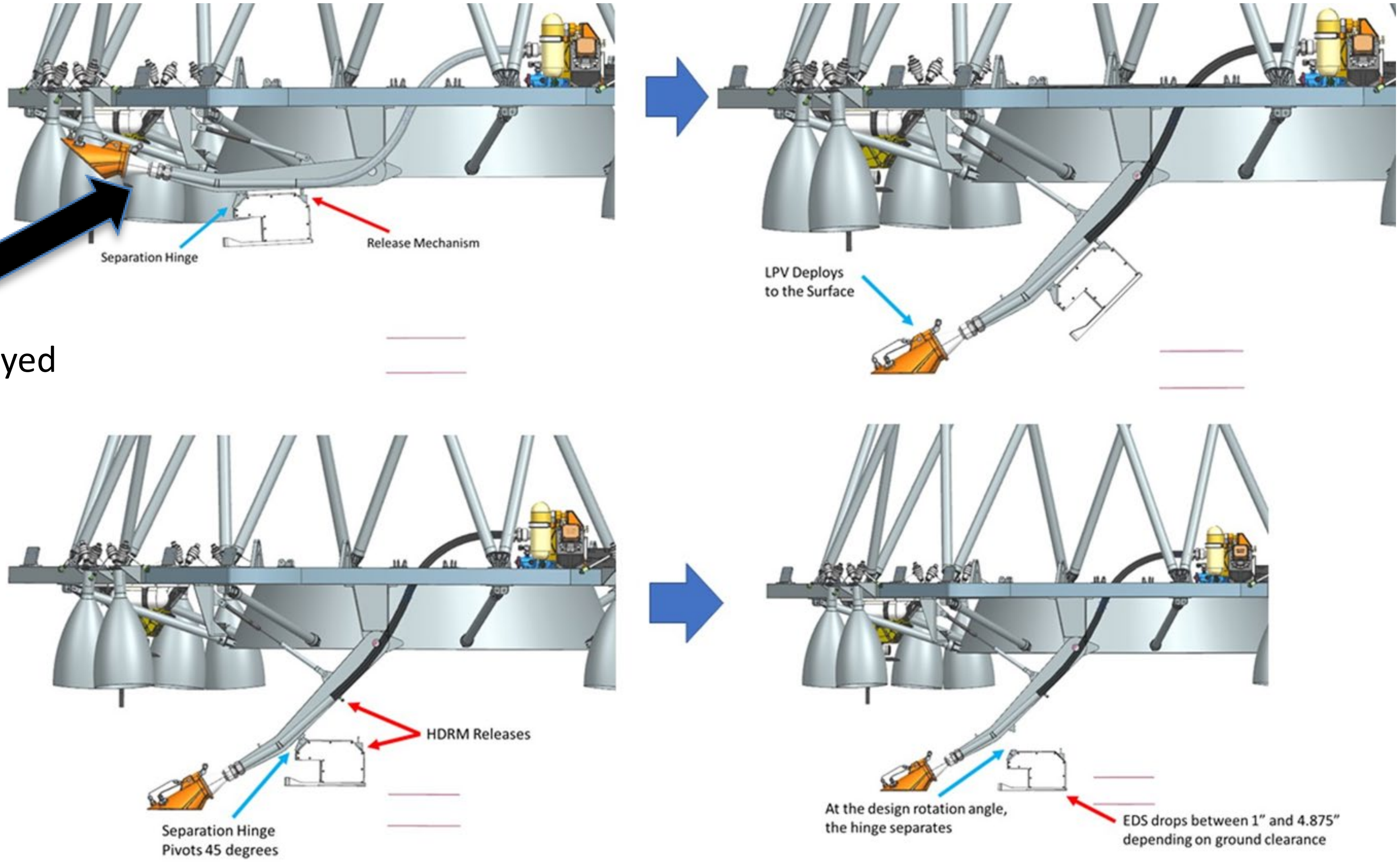

A 5th leg will be deployed shortly after landing

Electrodynamic Dust Shield
Closer Look at the EDS

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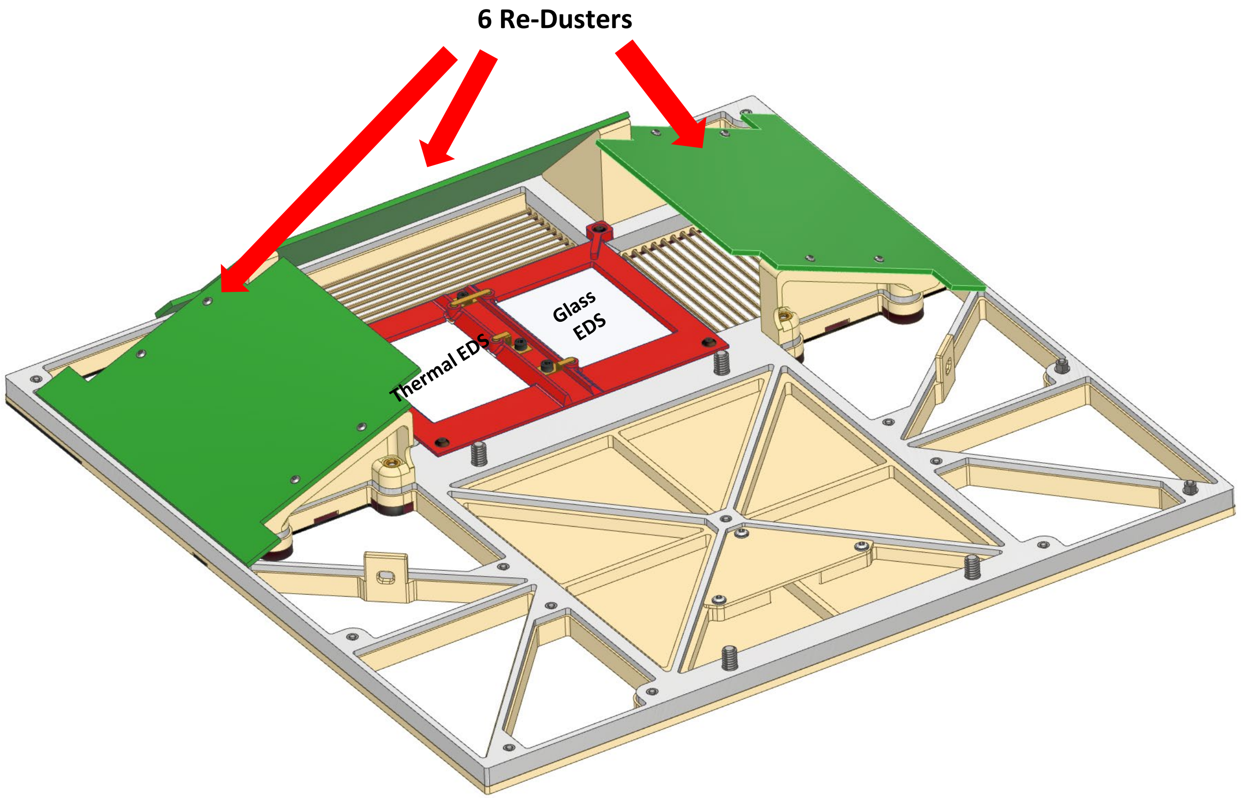

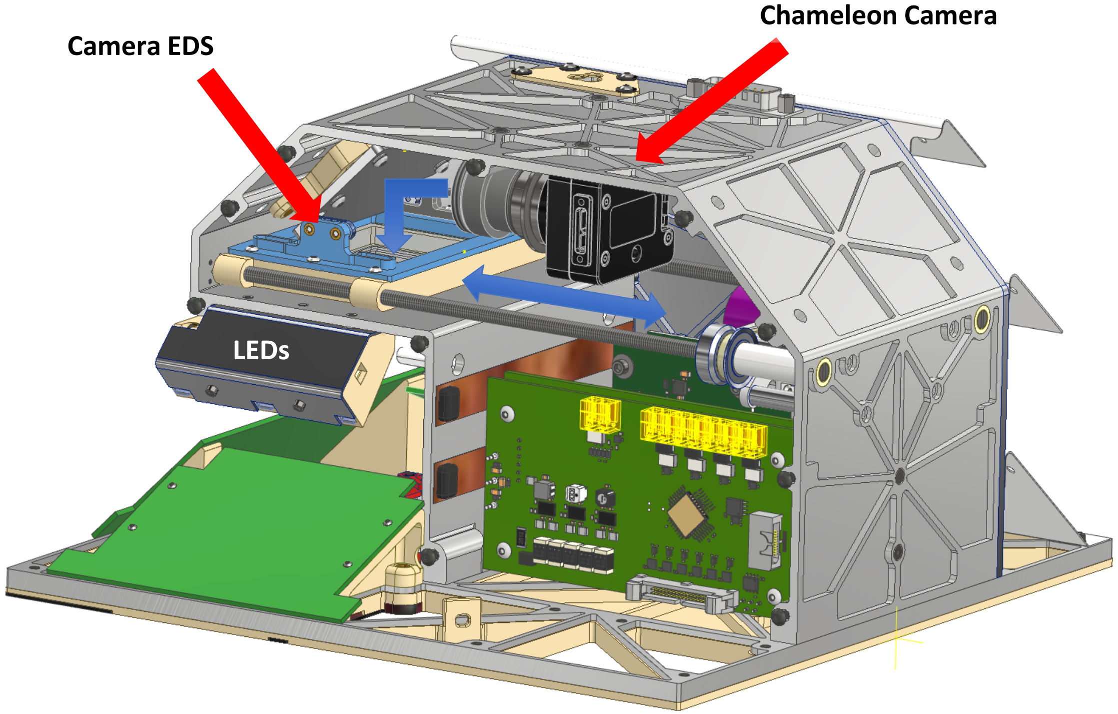

Electrodynamic Dust Shield
EDS Testing

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CLPS 19D EDS payload view
Vacuum test: 1E-5 Torr
JSC-1A unsieved
Video sped up 16x

Electrodynamic Dust Shield
EDS Testing

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2 Phase Glass EDS
Vacuum 1E-6
10 μm – 50 μm JSC-1A
Video sped up 15x

Polarization Steps needed
In high vacuum

Electrodynamic Dust Shield
2D and 3D EDS

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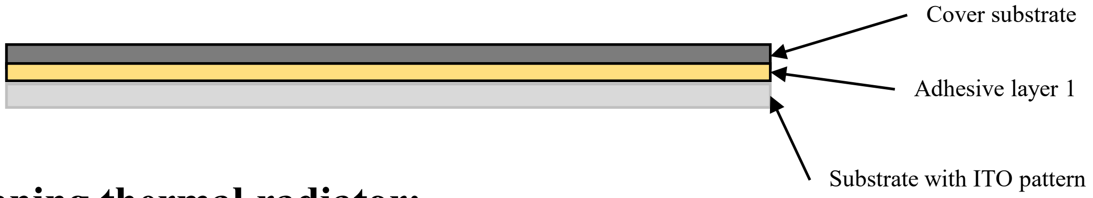
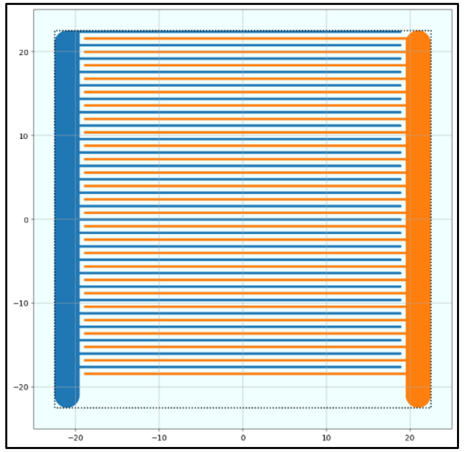
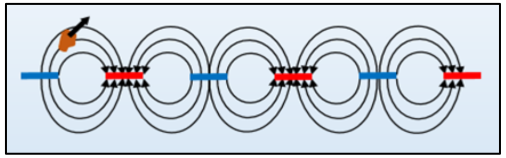
- **2-D Self cleaning glass:**
  - For transparent applications, i.e. viewports, solar panels, camera lenses.
  - Interdigitated pattern.
  - Requires only one substrate with conductive layer and a cover substrate.
  - Uses transparent indium tin oxide (ITO) as electrodes.

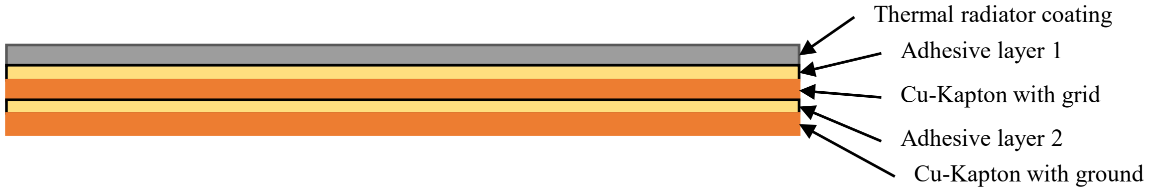


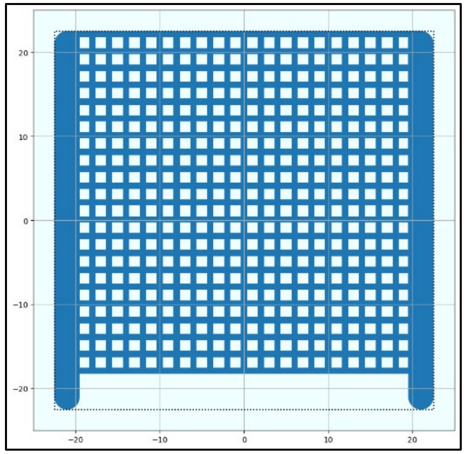


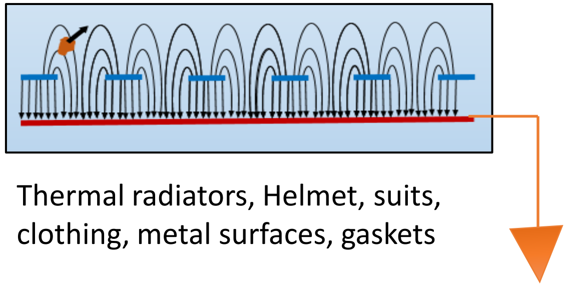


Glass EDS, Optics, Lenses, Windows, Solar Panels, floor mats, Re-Duster

- **3-D Self cleaning thermal radiator:**
  - Placed underneath the thermal radiator coating.
  - Checkerboard grid.
  - Requires a ground substrate at the bottom.
  - Uses copper kapton films as the electrode substrates.







Thermal radiators, Helmet, suits, clothing, metal surfaces, gaskets

Electrodynamic Dust Shield Technology Overview

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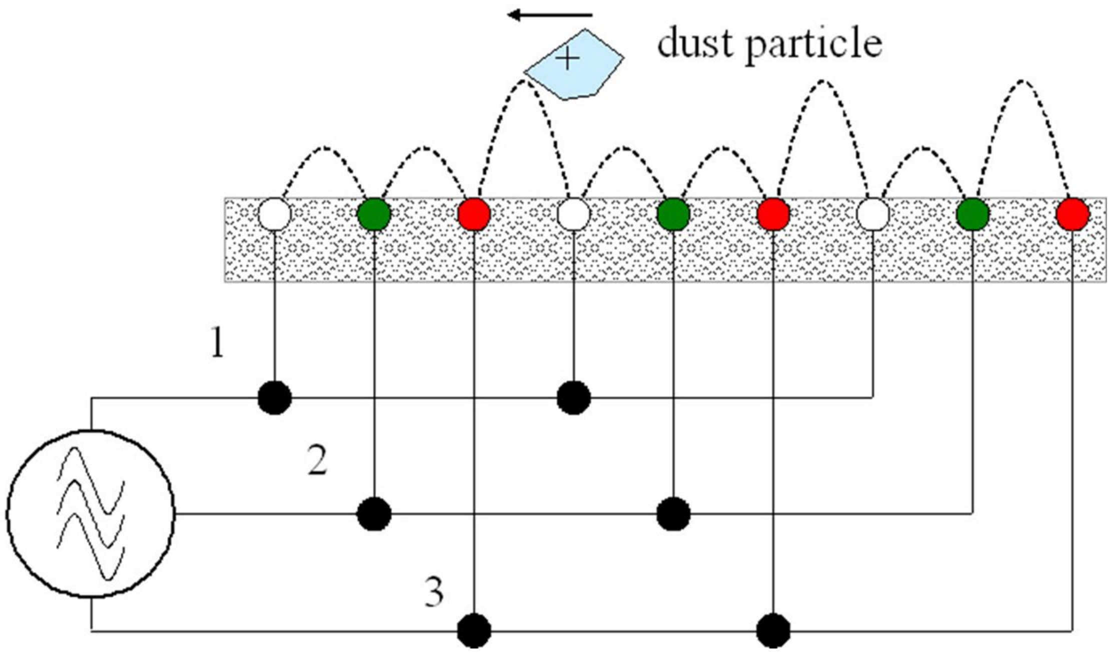
- The technology makes use of electrostatic and dielectrophoretic forces to move charged dust particles off surfaces
- A series of parallel electrodes connected to a multi-phase AC source generates a travelling wave that carries dust particles along.
- Polarization of the soil samples will help infer the electrostatic properties such as volume resistivity and dielectric properties of the lunar dust during EDS operations.



Electrodynamic Dust Shield
Lifecycle Milestone/Maturity Schedule

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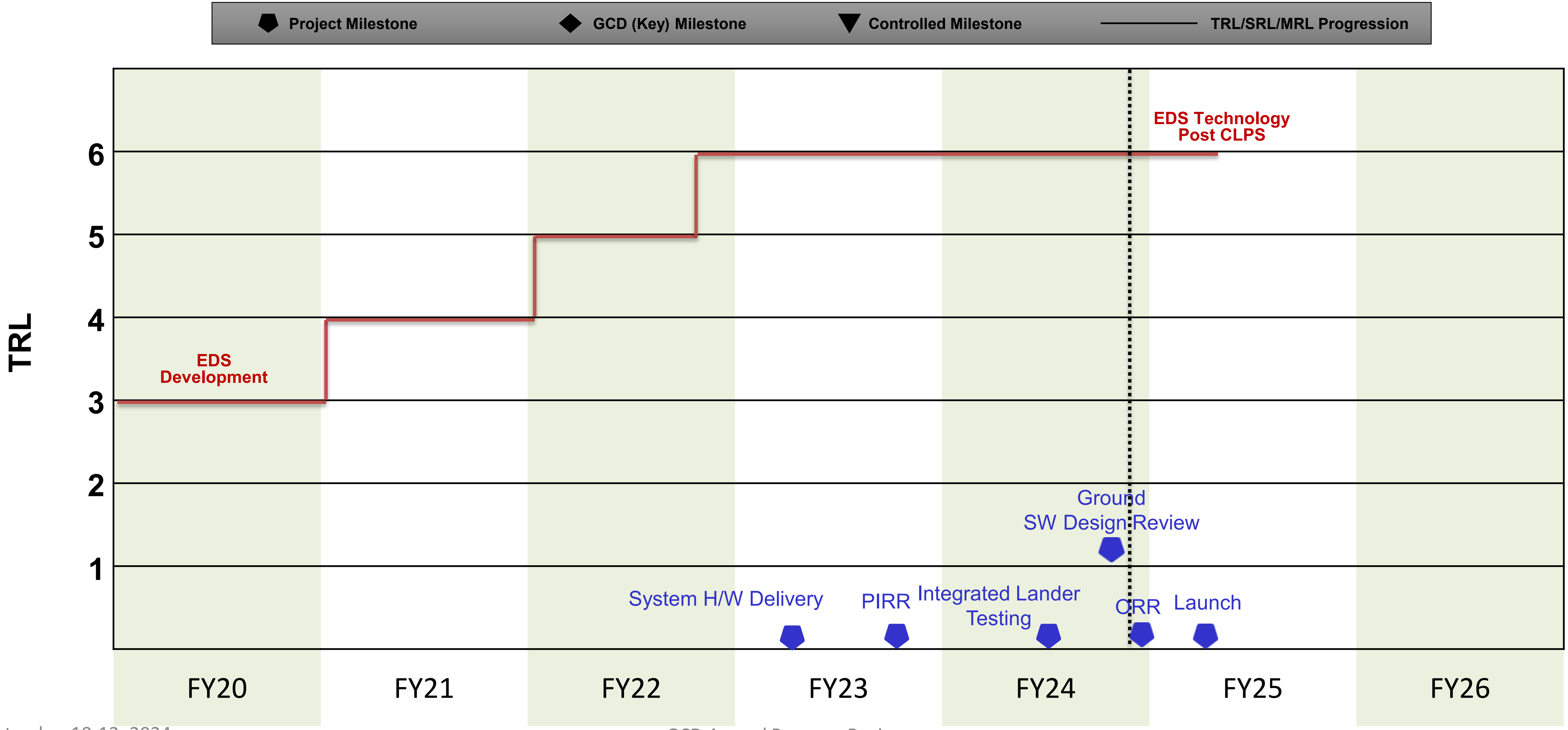

Electrodynamic Dust Shield Technical Progress and Results

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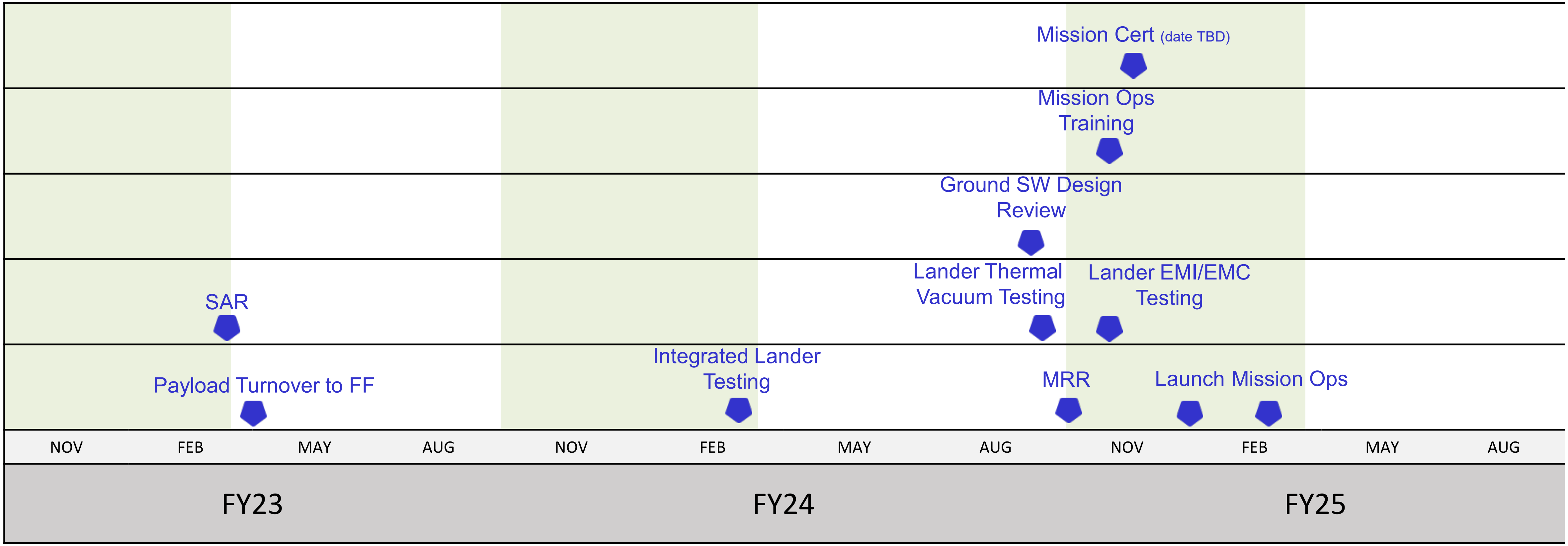

Electrodynamic Dust Shield Technical Progress and Results

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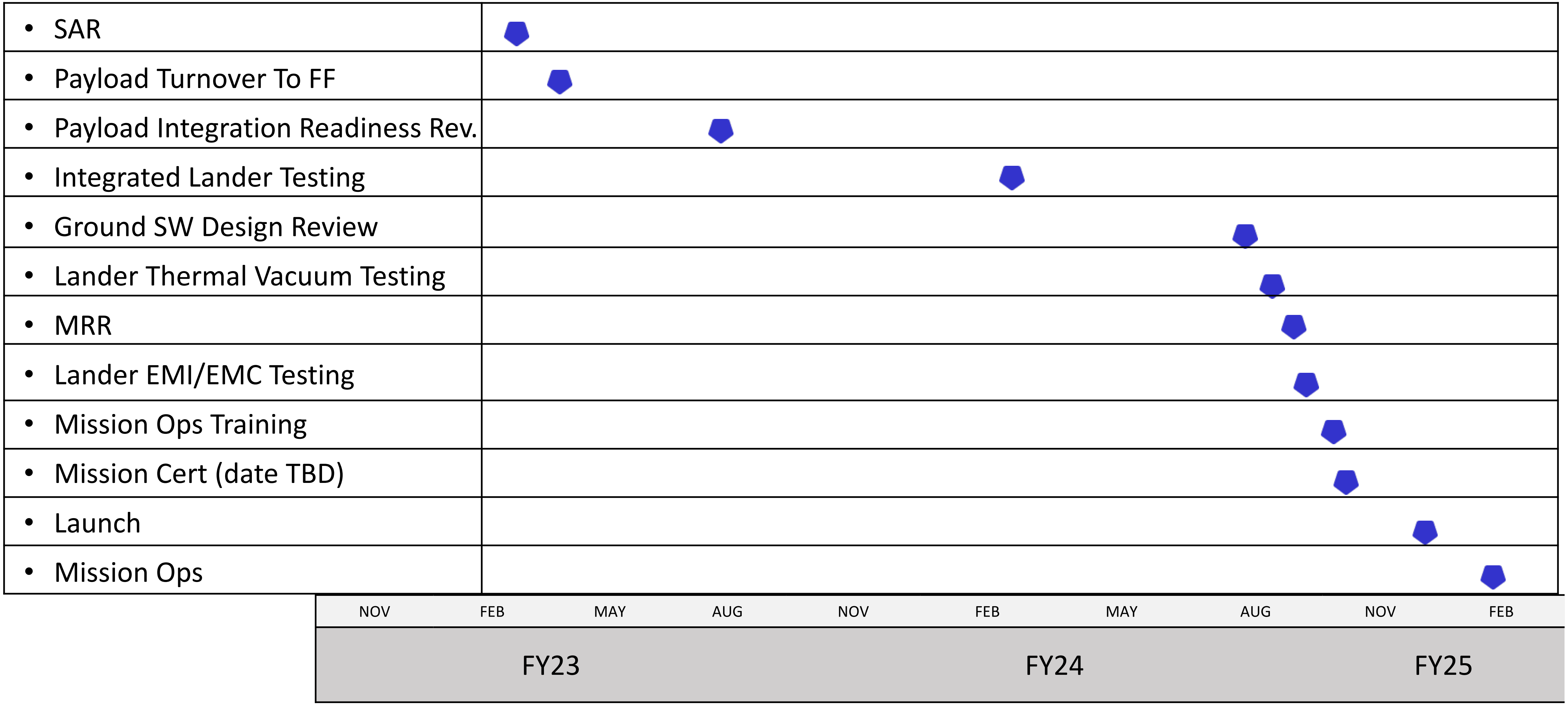

Electrodynamic Dust Shield Transition/Infusion Status

Timer

- Concept was originally called the Electric Curtain by F.B Tatom (ref NASA Technical Report TR-792-7-207A, 1967).
- Further developed by Senechi Masuda at the University of Tokyo in the 1970's.
- Partnered with the University of Arkansas at Little Rock (UALR) in the early to late 2000's as part of the ROSS PIDDP (Planetary Instrumental Developmental Program) and the MRF (Mars Fundamental Research) Program.
- EDS comprised of Indium tin oxide (ITO) coated polyethylene terephthalate (PET) have been made to cover commercial solar photovoltaic panels.

Electrodynamic Dust Shield Transition/Infusion Status

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- The Electrodynamic Dust Shield (EDS) for CLPS has been an internal approach of infusion to raise the TRL to enable use in future landers, rovers, and equipment:
  - EDS flown on the Materials International Space Station Experiment-15 (MISSE 15) on board the ISS with nearly one year exposure to space.
    - Post flight testing confirmed EDS was able to remove dust from glass and thermal radiator materials.
- Integrated EDS on two of five camera lenses for the EagleCAM Payload.
- Developing large EDS floor mats and flex EDS circuits under an SBIR Phase II with HedgeFOG.

Electrodynamic Dust Shield Transition/Infusion Status

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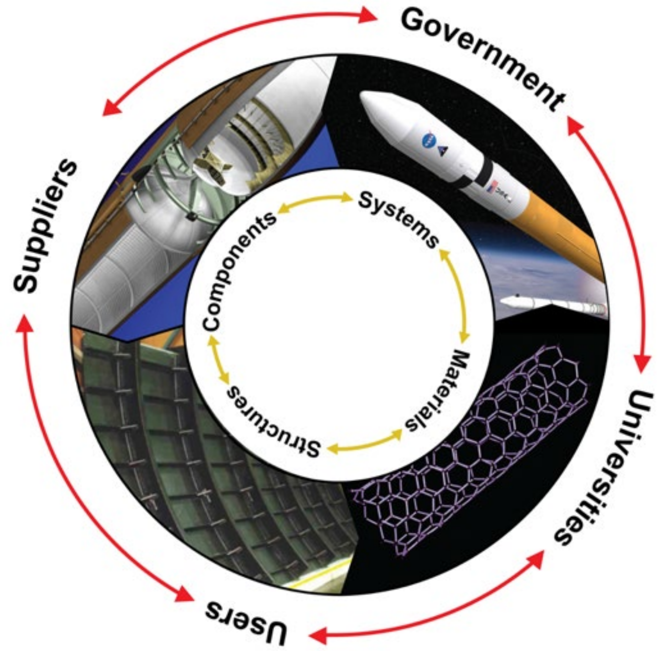
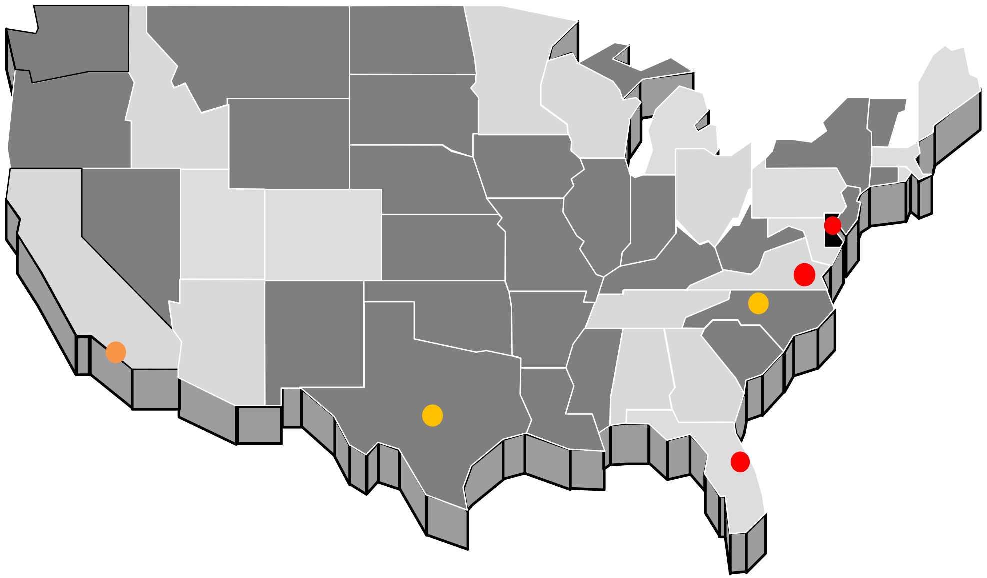
NASA Centers
- KSC
- LaRC
- Goddard

Public/Private Partnerships
- Appalachian State University
- Firefly Aerospace

SBIR/STTR
- HedgeFOG

NSTRI





Collaborative multidisciplinary partnerships to leverage fiscal resources, ideas, knowledge & expertise.

Electrodynamic Dust Shield Assessment Summary

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Project Name	Performance				Comments
	C	S	T	P	
Annual					Technical –- Ground Software acceptance to be completed during mission simulation. Cost – Currently within budget. Schedule – No concerns at the moment. Programmatic – Launch slips have placed pressure on project resources

	Oct	Nov	Dec	Jan	Feb	MYR	Apr	May	Jun	Jul	Aug	APR
C												
S												
T												
P												

- Early in FY24, EDS overcame scheduling delays in integrating with the Firefly Lander.
- In April 2024, EDS had some software challenges completing end-to-end testing with the Firefly Lander. Firefly made some modifications to their hardware and the problem was remedied.
- During August 2024, questions on the footpad release were answered through analysis of Firefly tests in zero-g.
- Ongoing Programmatic concerns related to launch slips have placed pressure on EDS resources to meet obligations without additional support.