JPL's Starshade Technology Activities
Recent Progress, Needs and Opportunities

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Mechanical Architecture and Key Requirements

(26-m total dia. and 26% bandpass at 37 Mm separation gives 72 mas IWA)

Petal Subsystem (Qty. 26, 8-m long)
Stiff lattice structure with low CTE lateral members, pop-up ribs for out of plane stiffness, and optical edges to limit solar scatter.

Inner Disk Subsystem (IDS. 10-m dia.)
Stiff perimeter truss with bicycle-like spokes, central hub and co-deployed opaque optical shield.

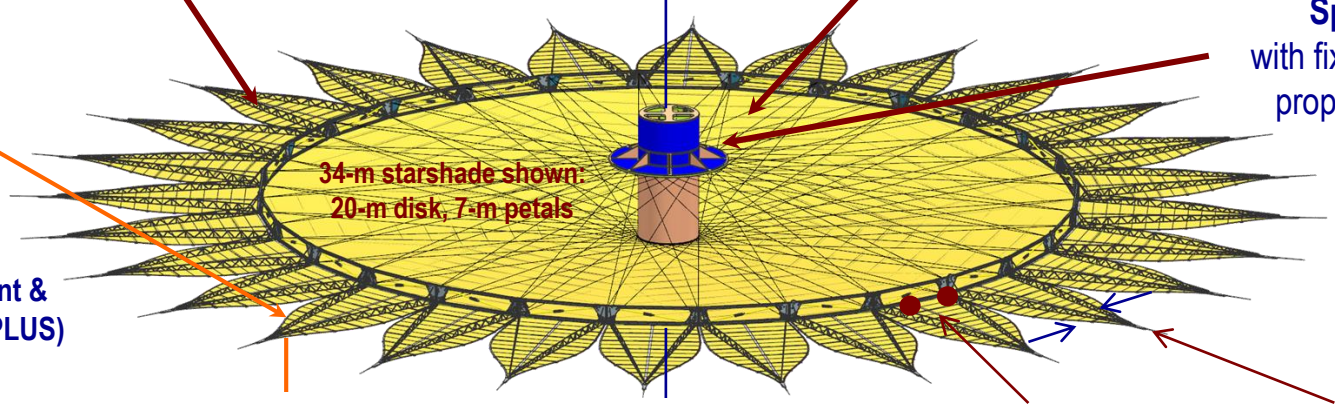
Spacecraft Bus
with fixed solar array and prop tanks inside hub

Target Star

Sun

54° - 83°

WFIRST Field of regard



Petal Launch Restraint & Unfurler Subsystem (PLUS)
(not shown)

No edge contact during launch and unfurling

Control solar edge scatter to ≤ 10 µm-%
(edge radius x reflectivity)

to telescope

Control starshade position to ≤ ± 1 m lateral ≤ ± 250 km axial

Control petal positions to ≤ ± 0.5 mm in-plane ≤ ± 1 cm out of plane

Control petal shape to ≤ ± 200 µm envelope

Sense axial position ≤ ± 1 km

Sense lateral position ≤ ± 24 cm

Coarse Acquisition

Starshade Acquisition Camera (SAC)

RF Transponder with 2-way ranging

WFIRST Spacecraft

Fine Sensing ≤ ± 1/10 pupil dia.

Intermediate Acquisition

LOWFS*

Imager

Tertiary Assy

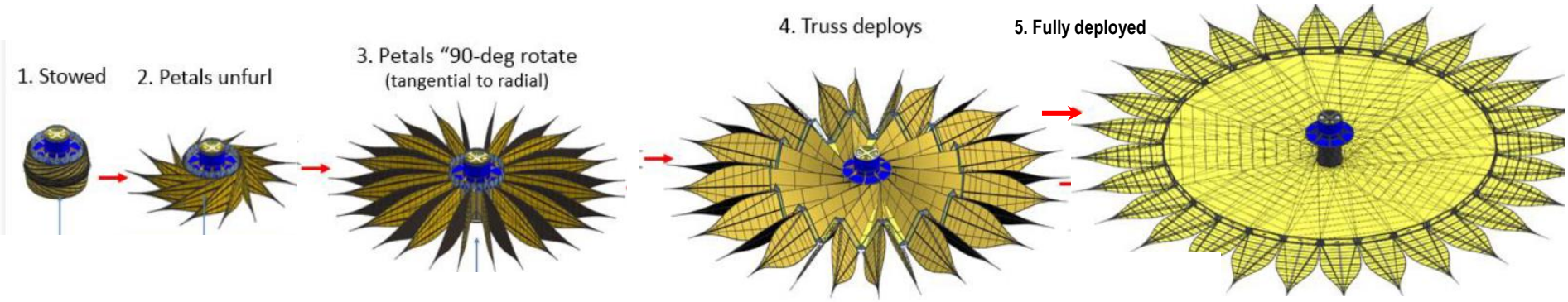
Spectro-meter

Coronagraph

*LOWFS = Low Order Wavefront Sensor

Deployment Scheme

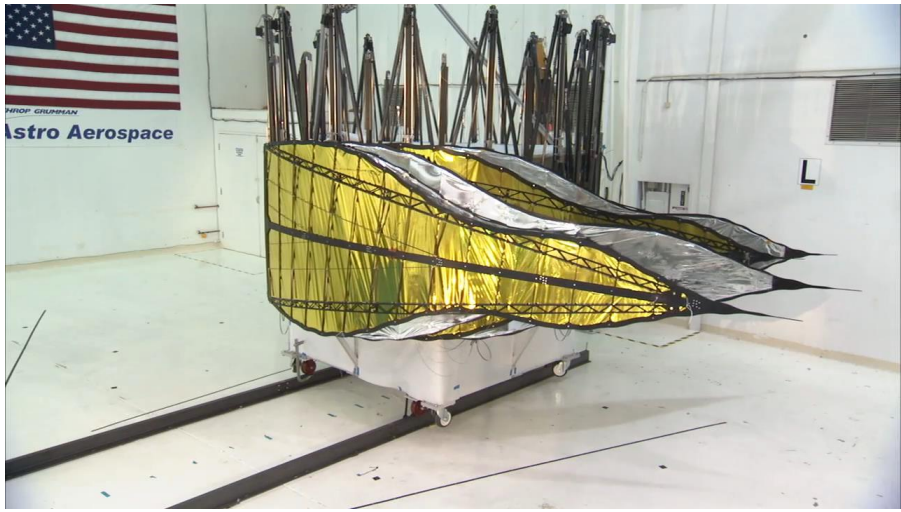
2-stage deployment



Petals & IDS are stiff by themselves and can be performance tested early.

System Animation + Prototype disk deploy video

Petal Unfurl video



Key Architecture Features

- **Stiff deployed system gives repeatability/accuracy and enables ground testing with gravity compensation fixtures of manageable complexity**
- **Stiff deployed subsystems (petal and inner disk) give early performance confidence**
- **26% Bandpass to match CGI capability and reduce starshade size**
- **Proportionally long petals (61% of total dia.) gives 72 mas IWA with 26-m starshade to match the 34-m Exo-S performance with 41% petal proportion and 34% bandpass**
- **Guide on out of band starlight and a starshade laser beacon**

General Technology Development Need

Establish technology readiness (TRL-5) critical to: garner a Decadal mission recommendation, pass KDP-A and enter Phase A with limited risk, on a path to WFIRST rendezvous

TRL-5 Working Definition

Verify critical performance in relevant environments of high-fidelity full-scale* subsystem prototypes by test or analysis with validated models and demonstrate an understanding of all critical interfaces.**

* *No scaling activity saves schedule and reduces risk. TRL-6 system activity is accelerated by integrating TRL-5 subsystem prototypes.*

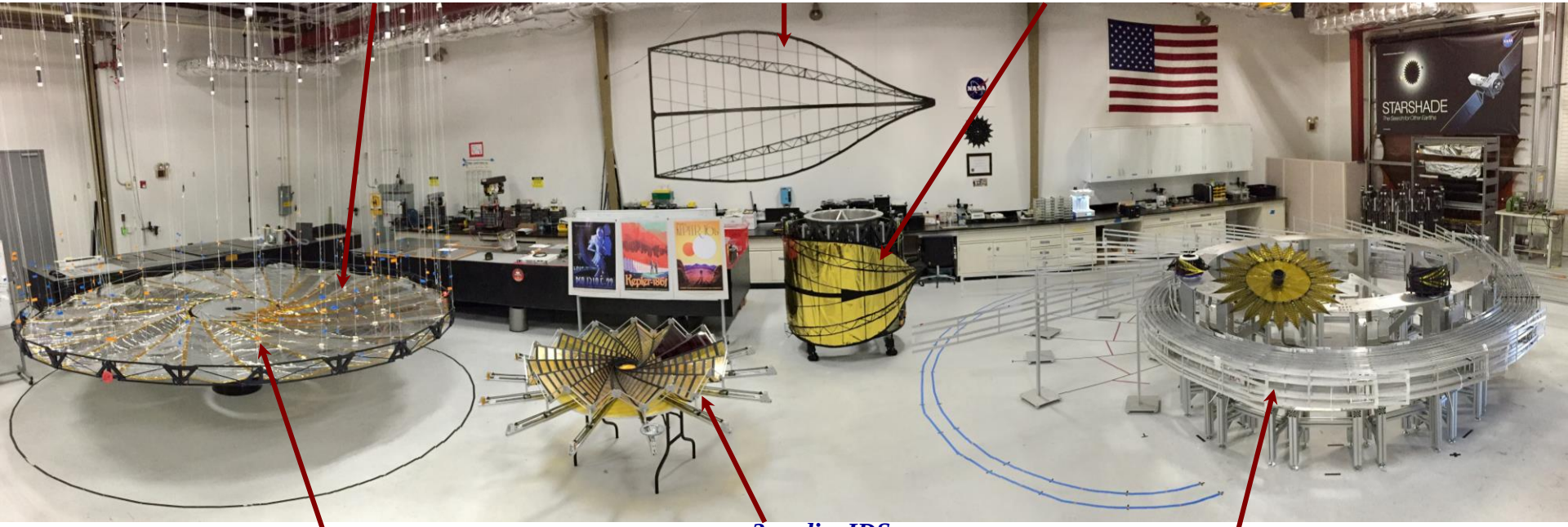
** *Mechanical subsystem prototypes include PLUS.*

Recent Technical Progress - Mechanical

Thin-film solar cell demo for SEP

Petal shape prototype

10-m dia. IDS prototype



2-m dia. IDS optical shield testbed

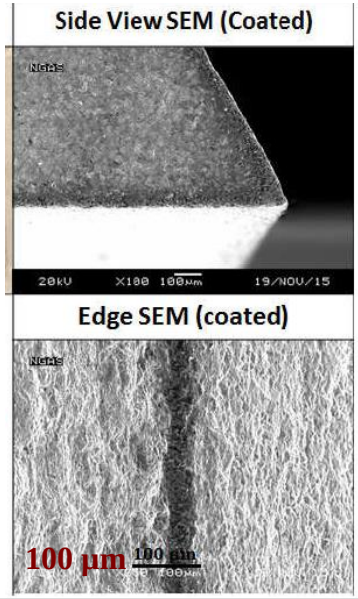
Established 5-m dia. IDS optical shield testbed to: Develop truss closeouts, incorporate carbon rods at all OS hinge lines, demo thin-film solar cells.

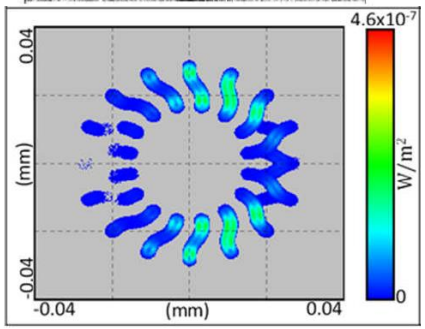
Established Petal Unfurler Testbed to: Develop PLUS proof of concept

Recent Technical Progress – Solar Glint
(Limit to below exo-Zodiacal Light)

- **NGAS & JPL have explored two separate approaches (shown below) and an effort is now underway to revisit the full spectrum of options. Other progress: durability, dust sensitivity, mech. integration, metrology facility etc.**

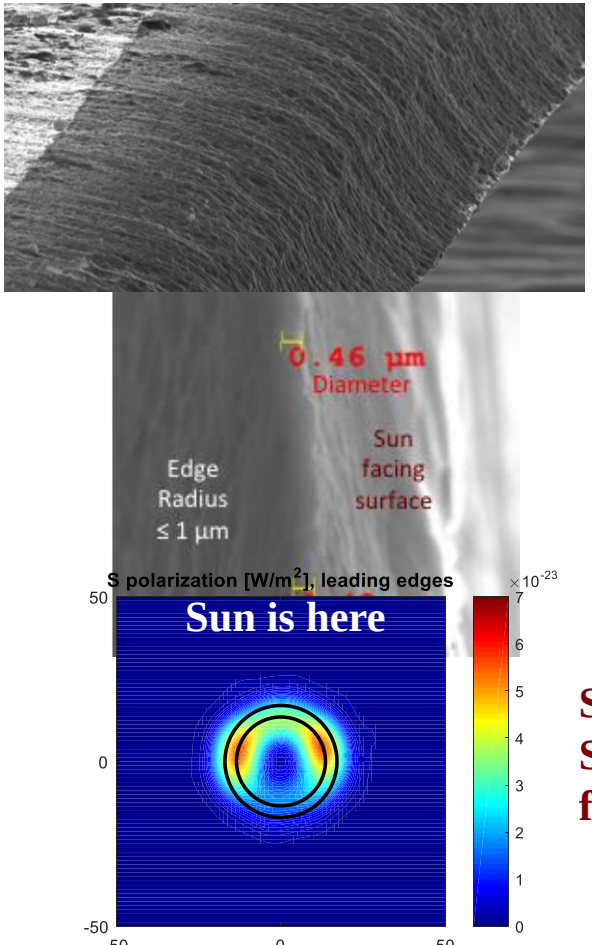
Dark & Diffuse(NGAS), e.g.:
Enbio CoBlast Solar Black on Ti





Sun is here

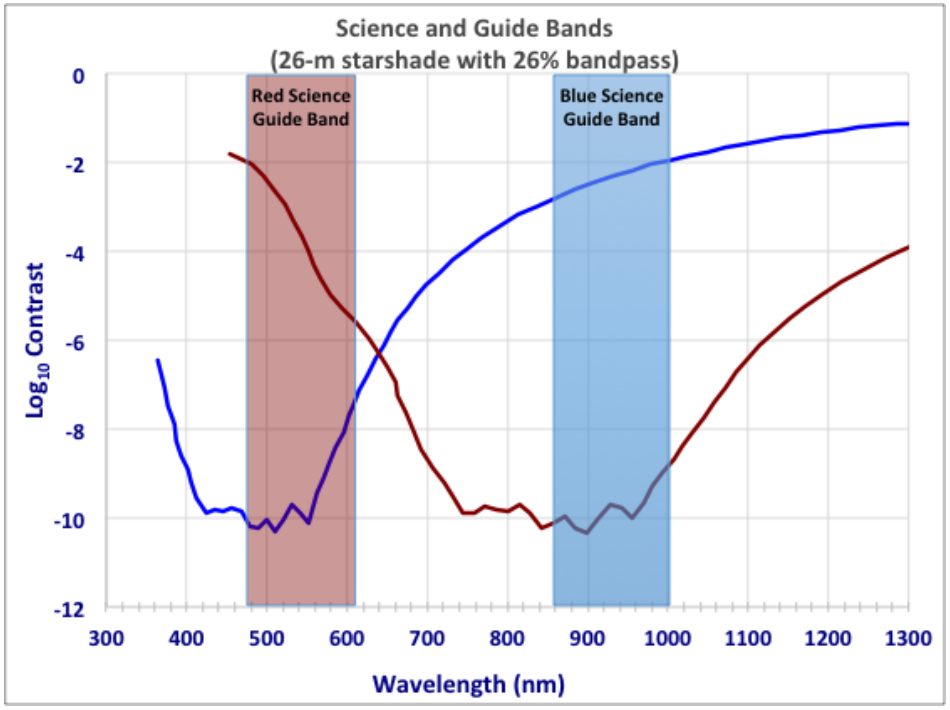
Sharp & Specular (JPL), e.g.:
Chemically etched amorphous metal

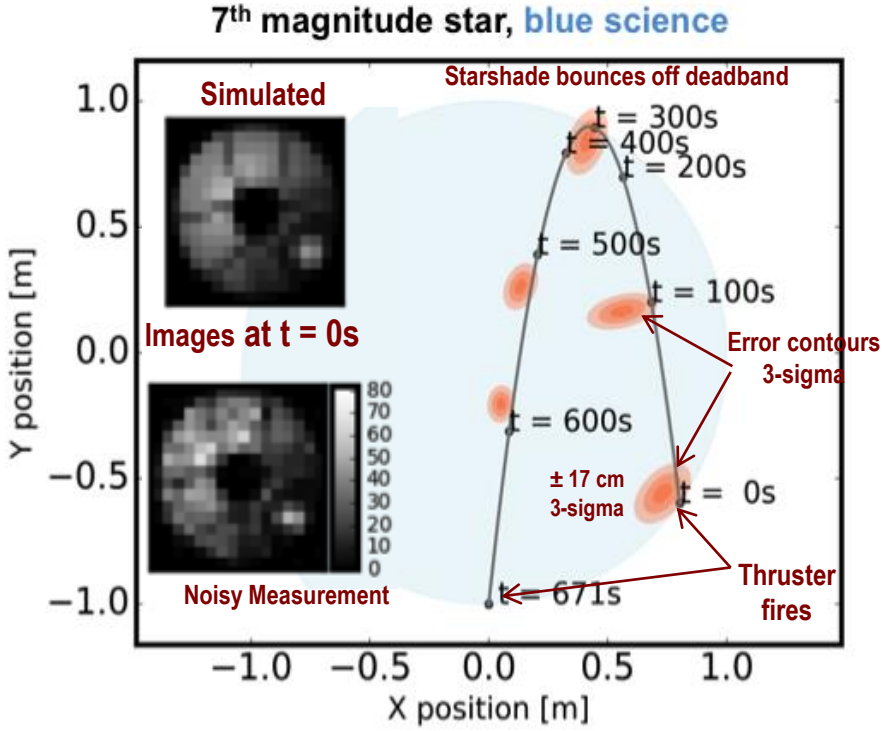


Select stealth edge Segments reduce flux by 10X

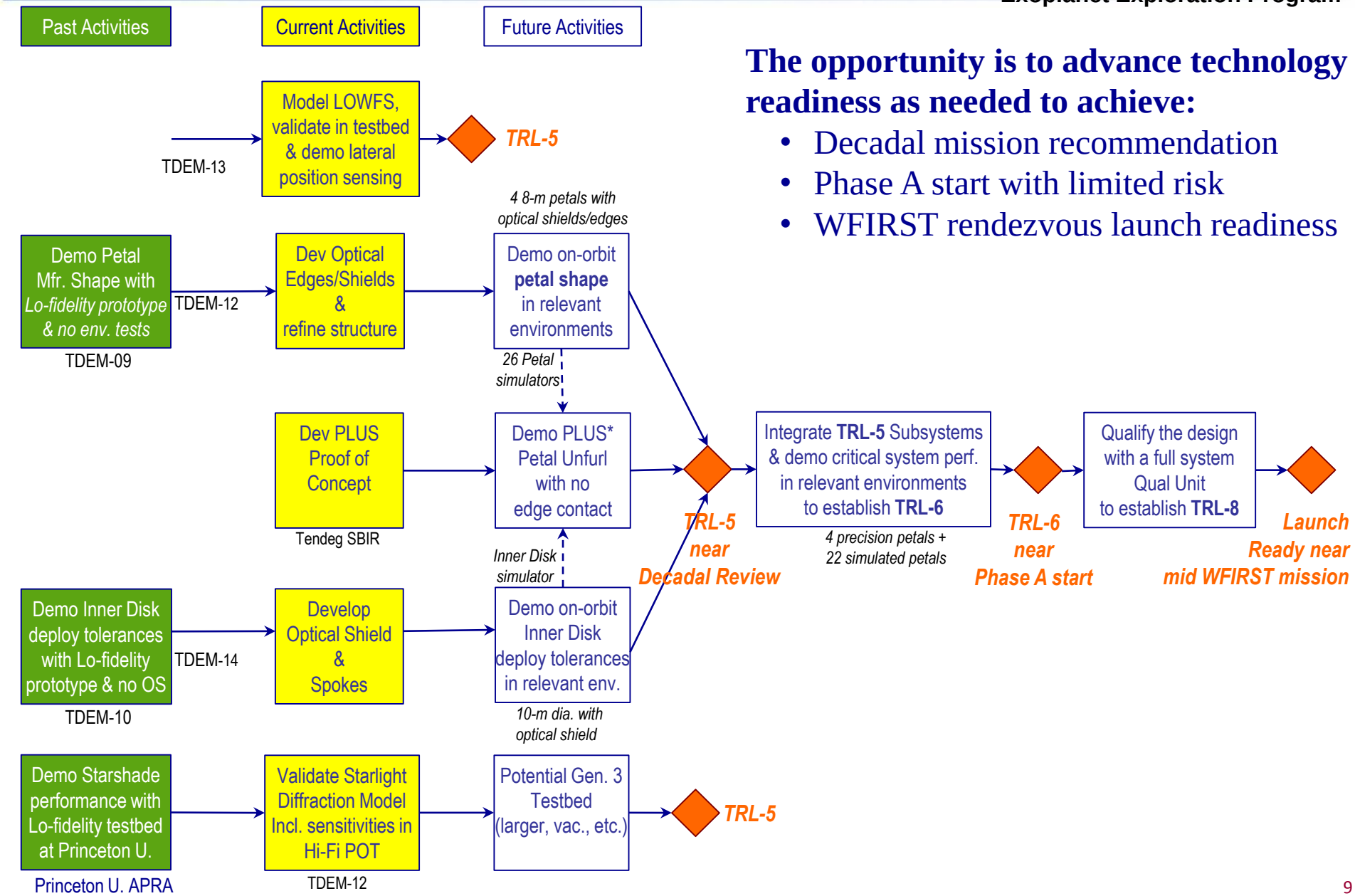
Recent Technical Progress – Lateral position sensing

- CGI-LOWFS senses lateral position with out of band starlight at relatively high flux
- Accuracy of ± 24 cm 3-sigma corresponds to a shear of ± 1/10th pupil diameter
- Optical modeling is straight forward and leverages the WFIRST pupil model
  - Measurements are match filtered against a catalogue of images
- Model validation at flight Fresnel numbers is underway in a low contrast testbed
- Will also feed sensor simulations into acquisition and control algorithms





Opportunity



The opportunity is to advance technology readiness as needed to achieve:

- Decadal mission recommendation
- Phase A start with limited risk
- WFIRST rendezvous launch readiness