Jet Propulsion Laboratory
California Institute of Technology

Starshade Science and Industry Partnership Forum #2 – Welcome and Introduction

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Jet Propulsion Laboratory, California Institute of Technology

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Boulder, Colorado

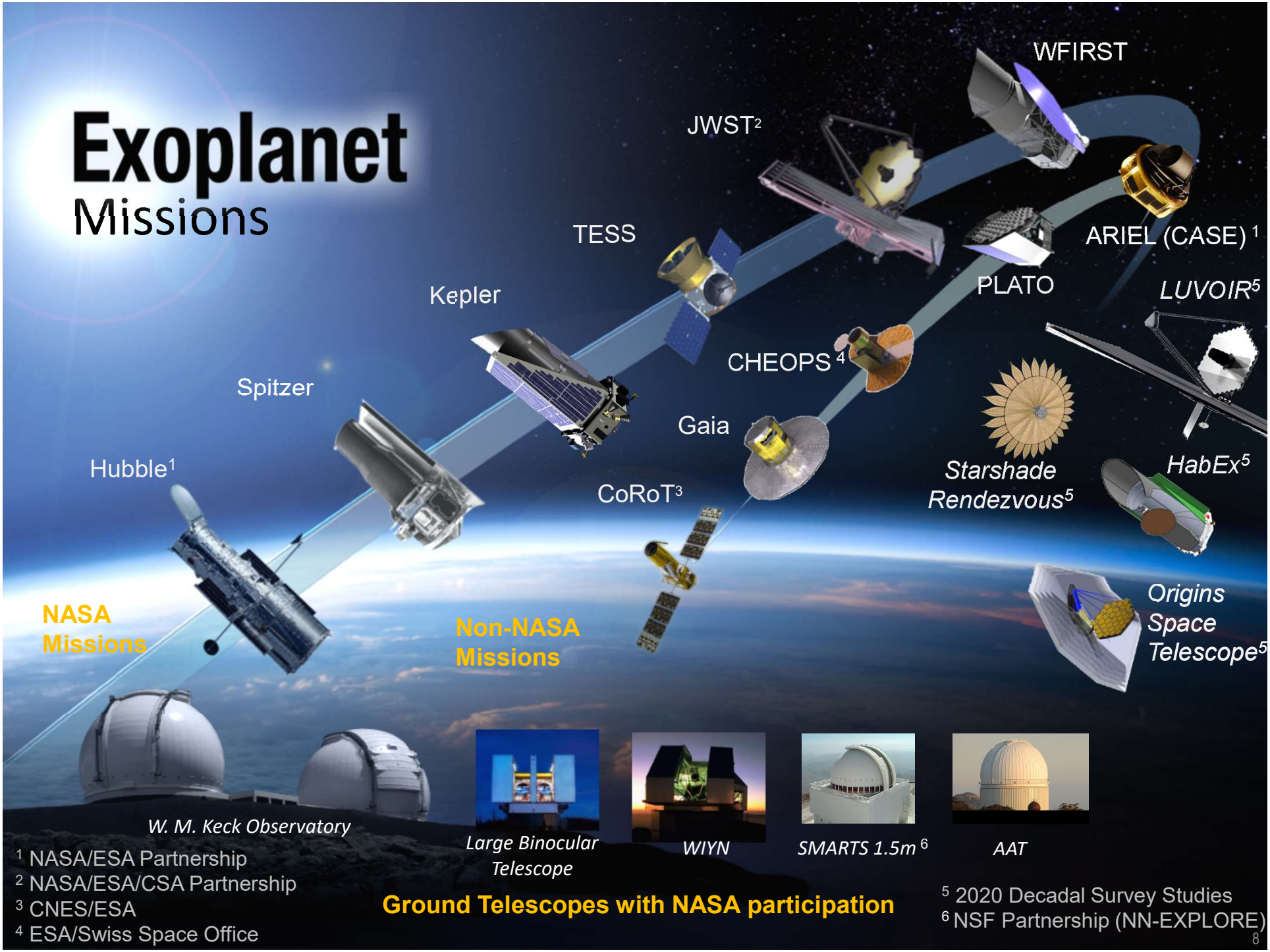
CL # 19-1960

Motivation for Starshade Science and Industry Partnership

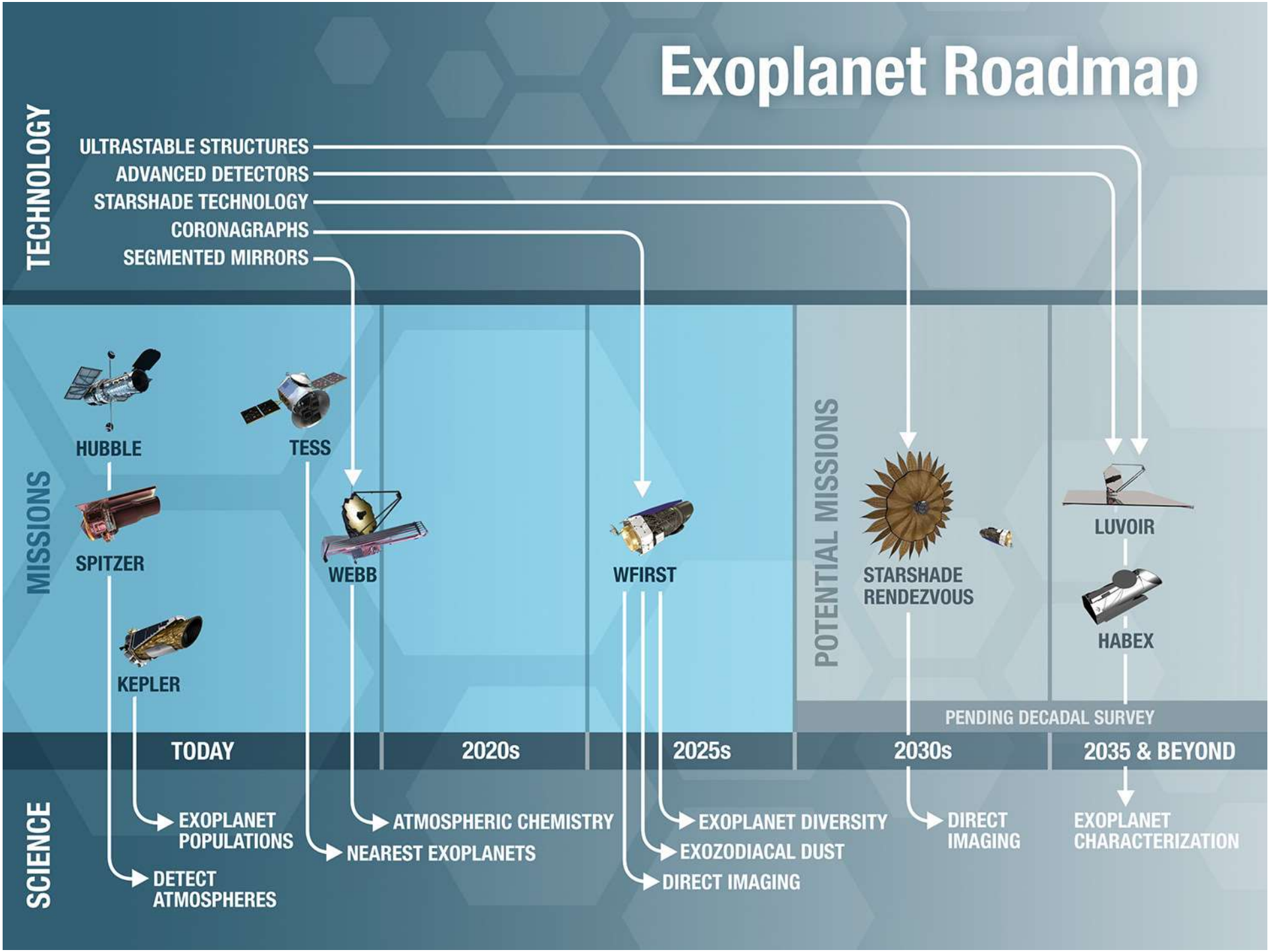
The purpose of the Starshade SIP

is to maximize the

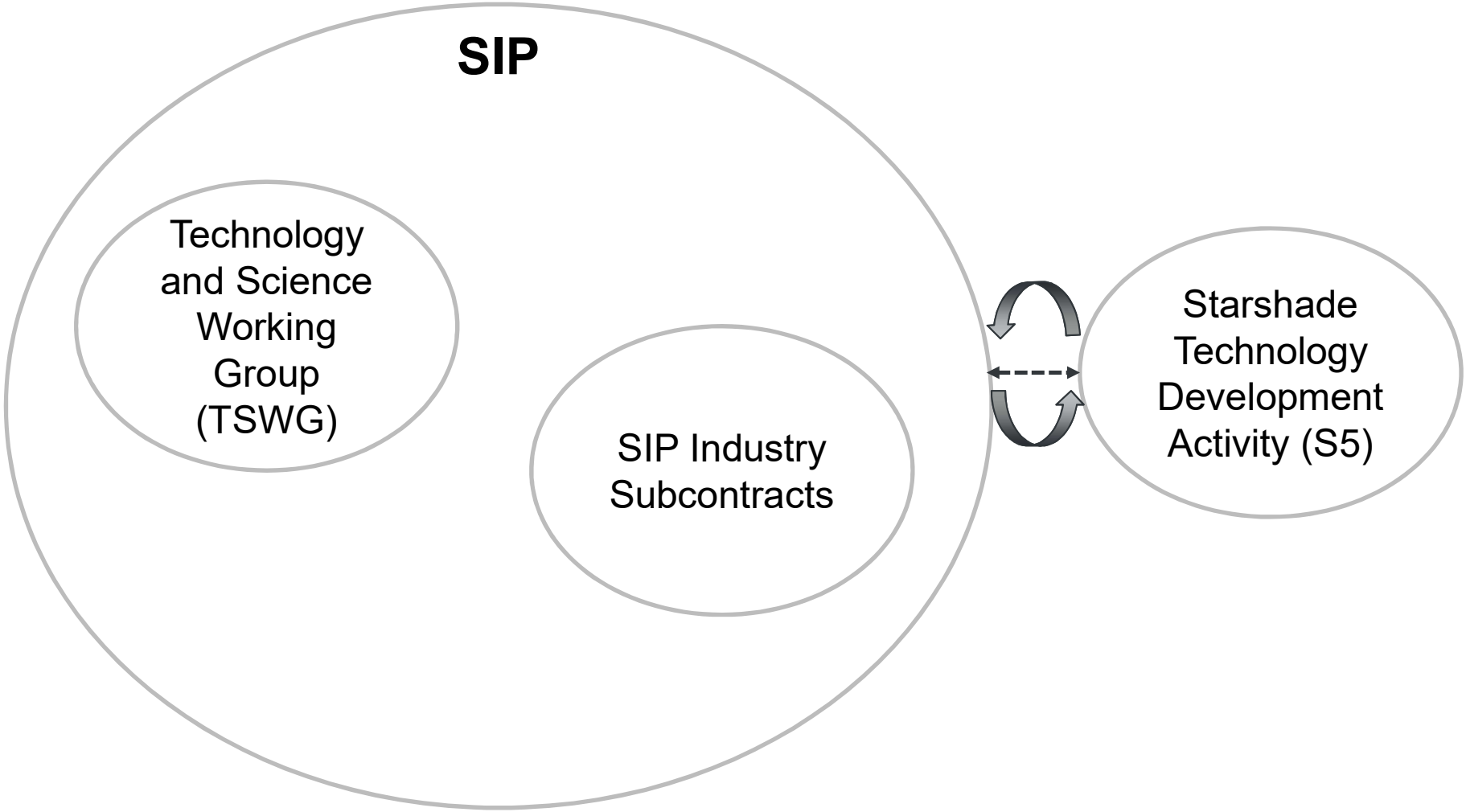
technology readiness level of starshades to enable potential future exoplanet science missions.


Exoplanet Missions
WFIRST
JWST[2]
TESS
ARIEL (CASE) [1]
Kepler
PLATO
LUVOIR[5]
CHEOPS [4]
Spitzer
Gaia
Hubble[1]
CoRoT[3]
Starshade Rendezvous[5]
HabEx[5]
Origins Space Telescope[5]
NASA Missions
Non-NASA Missions
W. M. Keck Observatory
Large Binocular Telescope
WIYN
SMARTS 1.5m [6]
AAT
Ground Telescopes with NASA participation
[1] NASA/ESA Partnership
[2] NASA/ESA/CSA Partnership
[3] CNES/ESA
[4] ESA/Swiss Space Office
[5] 2020 Decadal Survey Studies
[6] NSF Partnership (NN-EXPLORE)

Exoplanet Roadmap



Starshade Science and Industry Partnership



Starshade SIP – Terms of Reference

https://exoplanets.nasa.gov/exep/technology/starshade/

Starshade Science and Industry Partnership – Terms of Reference
5/30/2019

A. Background

Starshades (or External Occulters) are one of the starlight suppression technologies for high contrast imaging of exoplanets and are baselined for large- and probe-class mission concept studies[1] funded by the NASA Astrophysics Division for submission to the Astro2020 Decadal Survey. Recently the Astrophysics Division authorized the Exoplanet Exploration Program (ExEP) to execute a directed technology development activity to advance starshades to Technology Readiness Level (TRL) 5 to enable potential future exoplanet science missions. The Starshade Technology Development Activity to TRL5, or S5, follows an approved Technology Development Plan[2] with technology milestones that respond to documented mission performance requirements. The ExEP recognizes that robust and impactful technology maturation requires ongoing consideration of new technology approaches and new mission concept drivers. Therefore the ExEP charters the Starshade Science and Industry Partnership (SIP). The purpose of the Starshade SIP is to maximize the technology readiness level of starshades to enable potential future exoplanet science missions.

B. Expected Outcomes

Expected outcomes of the Starshade SIP are to:

1. Identify solutions to challenges and risks faced by the S5 development activity;
2. Propose new approaches, techniques, and research beyond planned S5 activities that can maximize starshade technology readiness;
3. Document new mission concept drivers for starshade technology performance requirements;
4. Maintain alignment between S5 technology development activities and future mission needs;
5. Facilitate groups of investigators to communicate research, new technology, and new mission concepts across disciplinary, organizational, and geographic boundaries;
6. Enable continued participation of the community in NASA's starshade technology development activities.

C. Participation

The Starshade SIP is open to all participants from NASA, industry, academia, and any organization or individual with research, technology, or science capabilities and contributions in starshade-related technology. *Ex officio* participants in the SIP include S5 project staff, ExEP Chief Technologists and Chief Scientists, and the Exoplanet Technical Assessment Committee (ExoTAC)[3] chaired by Dr. Alan Boss. Non-US participation is welcome. Export-controlled topics, if any, will be covered in a separate forum.

The Starshade SIP will be managed by the ExEP Manager (Dr. Gary Blackwood) and supported by the ExEP Scientist for Starshade Technology (Dr. Renyu Hu).

To maximize participation of small businesses and academia in the Starshade SIP within limited program funds the following opportunities are planned:

1. Up to three set aside contracts for small business to be announced on FedBizOps by the Jet Propulsion Laboratory.
2. A Technology and Science Working Group (TSWG) of approximately 8 members solicited through a NASA *Dear Colleague* letter. Travel expenses will be reimbursed to TSWG members.
3. Up to four graduate students and/or post-docs will be selected by the TSWG to attend and present at Starshade SIP events. Travel expenses will be reimbursed for these students.

D. Work Structure and Timeframe:

The Starshade SIP will convene periodically by telecon (approximately bimonthly) and biannually in face-to-face Starshade SIP forums facilitated for remote participation. Small-business awardees and TSWG members, when selected, are expected to participate in the Starshade SIP telecons and forums. Agendas for telecons and Forums will include status from the S5 Project and presentations from Starshade SIP participants recommended by the TSWG.

Timeline:

- Dec 2018: SIP informational telecon
- Jan 2019: Request for Proposal for cost-sharing contracts
- Feb 2019: *Dear Colleague* letter for the Technology and Science and Working Group
- Jun 2019: Award of small business contracts; announce TSWG membership
- Aug 2019: Starshade SIP forum #1
- Feb 2019: Starshade SIP forum #2
- July 2020: Starshade SIP forum #3
- Nov 2020: Starshade SIP forum #4

The Starshade SIP, TSWG, and contracts will conclude in December 2020 and may be renewed pending the outcome of the Astro2020 Decadal Survey.

E. Reporting

The Starshade SIP Manager, The ExEP Scientist for Starshade Technology, and the TSWG will prepare a report summarizing each forum. Annually the SIP Chair and TSWG will provide a briefing to the NASA Astrophysics Division.

[1] https://science.nasa.gov/astrophysics/2020-decadal-survey-planning
[2] https://exoplanets.nasa.gov/exep/technology/starshade/

Expected Outcomes of the Starshade SIP

1. Identify **solutions to challenges** faced by the S5 development activity;
2. Propose **new approaches, techniques, and research** beyond planned S5 activities that can maximize starshade technology readiness;
3. Document **new mission concept drivers** for starshade technology performance requirements;
4. **Maintain alignment** between S5 technology development activities and future mission needs;
5. **Facilitate** groups of investigators to communicate research, new technology, and new mission concepts across disciplinary, organizational, and geographic boundaries;
6. Enable **continued participation** of the community in NASA's starshade technology development activities.

Technology and Science Working Group

Congratulations and Welcome!

Last Name	First Name	Institution	Title	Email
Seager	Sara	Massachusetts Institute of Technology	Professor	seager@mit.edu
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d'Amico **	Simone	Stanford University	Assistant Professor	damicos@stanford.edu
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Romero-Wolf	Andrew	NASA Jet Propulsion Laboratory	Technologist	Andrew.Romero-Wolf@jpl.nasa.gov
Witkowski	Allen	Katabasis Engineering	Owner	al.witkowski@katabasisengineering.com
Stahl	Phil	NASA Marshall Space Flight Center	Senior Engineer	h.philip.stahl@nasa.gov
Jensen-Clem	Becky	UC Berkeley	Post Doc	rjensenclem@berkeley.edu

** Chair

Technology and Science Working Group

- Context:
  - TSWG is a steering group for the SIP
  - The SIP will help S5 achieve its milestones, and, help NASA understand if S5 has the right milestones
- TSWG members will:
  1. Identify solutions to challenges faced by the S5 development activity
  2. Propose new approaches, techniques, and research beyond planned S5 activities that can maximize starshade technology readiness
  3. Document new mission concept drivers for starshade technology performance requirements
  4. Maintain alignment between S5 technology development activities and future mission needs
  5. Document findings in annual Starshade SIP reports to NASA APD
- The TSWG will select up to four graduate students and postdocs to attend and present at each SIP forum (travel expenses reimbursed), starting with forum #2

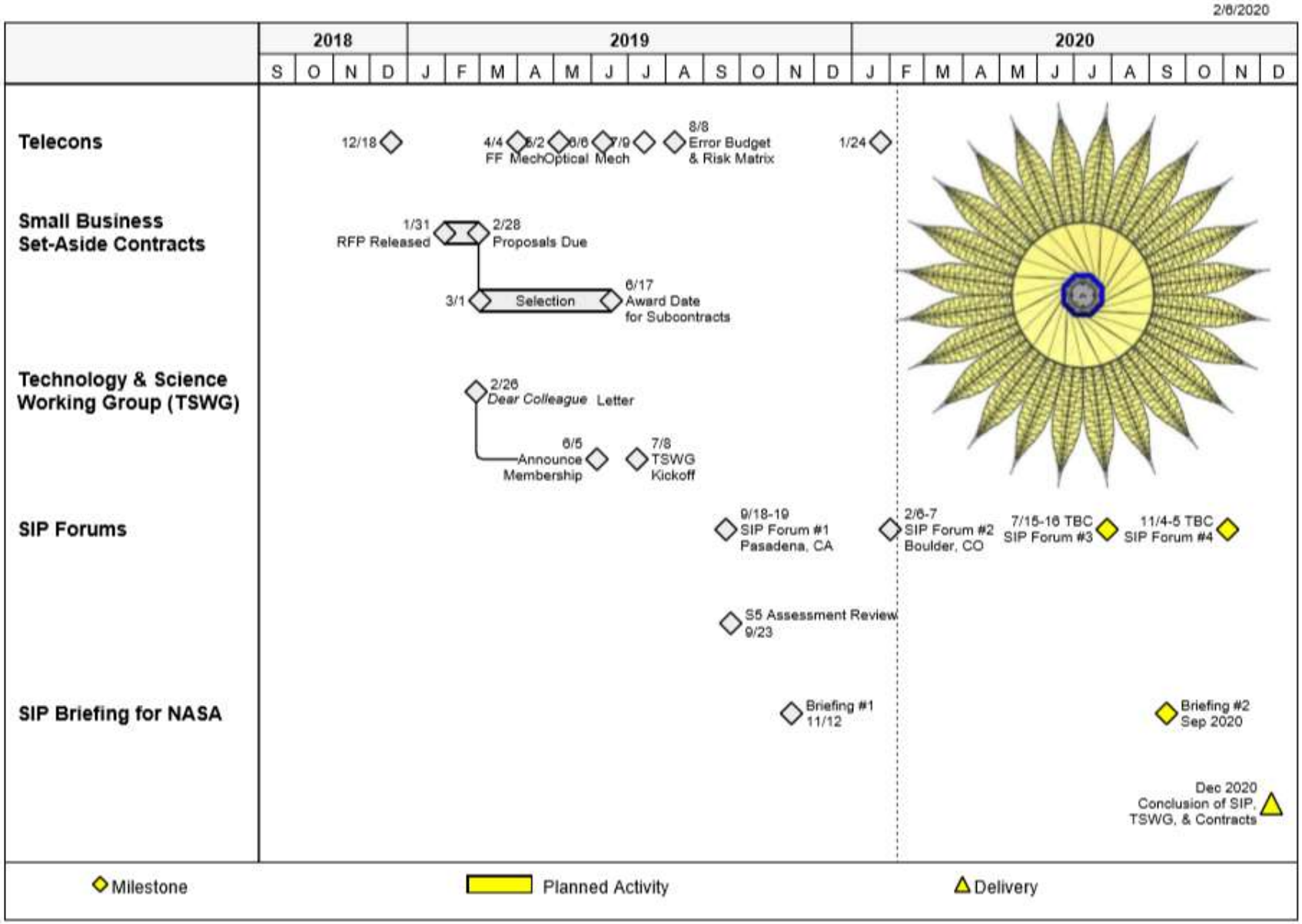
Small Business Subcontracts

- **Zecoat Corporation**, Torrance CA. Zecoat will evaluate, optimize, and test performance of a specular black coating on the starshade edges to minimize solar glint.
- **Opterus Research and Development Inc**., Fort Collins CO. Opterus will evaluate creep behavior of composite material resins through test and analysis.
- **Tendeg, LLC**, Louisville CO. Tendeg will perform analysis and test of petal and PLUS deployments and petal deformations under stowage loads.
- **ATA Engineering, Inc**., San Diego CA. ATA will evaluate multiple structural analysis methodologies and software and assess the benefits of the approaches using petal deployment and position error as case studies.

Highlights Since our Last Meeting

- Starshade Technology Project (aka S5) met several milestones
- Briefings to NASA Astrophysics Division: the SIP recommendations, and Remote Occulter
- Mission concepts completed (HabEx, Rendezvous Probe)
- WFIRST – starshade accommodation, held DPMC, next: APMC
- Starshade briefings to the National Academies
- Starshade briefings at the AAS splinter session on technology and at the ExoPAG (mDOT, mission yields)
- Small business teams active – presentations, tours at this meeting
- TSWG active – four student/post docs selected to present today
  - Mario Damiano (JPL)
  - Mengya Hu (Princeton)
  - Adam Koenig (Stanford)
  - Gabriel Soto (Cornell)

Starshade Science and Industry Partnership



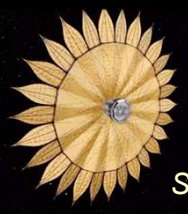
NASA Exoplanet Exploration Program

Space Missions and Concept Studies

Kepler K2

Large- and Probe-Scale Mission Concepts

Coronagraph



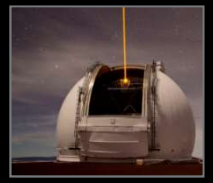
Starshade

Exoplanet Communications

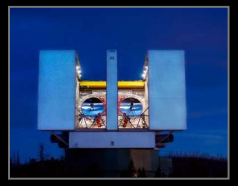
Supporting Research & Technology

Key Sustaining Research

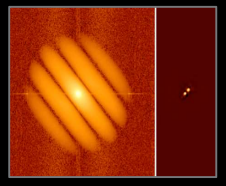
NN-EXPLORE



Keck Observatory



Large Binocular Telescope Interferometer



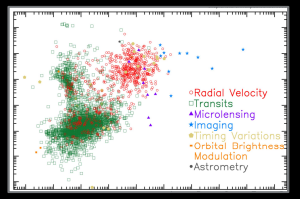
High Resolution Imaging

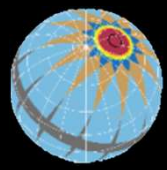
Technology Development

Coronagraph Technology Development

Starshade Technology Development (S5)

NASA Exoplanet Science Institute (NExScI)





Archives, Tools, Sagan Program, Professional Engagement

Acknowledgements

ExEP Contributors to the Starshade SIP

- Douglas Hudgins – ExEP Program Scientist, NASA HQ
- Renyu Hu – Starshade Scientist
- Kendra Short – ExEP Deputy Manager
- Ray Lemus – Program Business Administration Manager
- Phil Willems – S5 Manager
- Doug Lisman – S5 Lead System Engineer
- Stuart Shaklan – S5 Lead Optical Engineer
- David Webb – S5 Lead Mechanical Engineer
- Manan Arya - Inner Disk Subsystem Lead
- Flora Mechentel - Optical Edge Lead
- Jade Smith – Program Schedule Analyst
- Jennifer Gregory – Program Administrator

Agenda

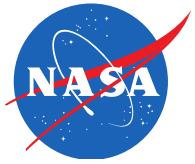
Agenda Item - Day 1 Feb 6	Presenter	Start	Duration
Introduction and overview	Gary Blackwood	8:00	0:10
Welcome from the TSWG chair	Simone D'Amico	8:10	0:10
Session 1: S5 Updates Chair: Phil Willems			
S5 programmatic and technical status and assessment of TSWG recommendations	Phil Willems	8:20	0:30
Report on TSWG recommendation: Vector diffraction and milestone #2	Stuart Shaklan	8:50	0:30
Report on TSWG recommendation: Edge scatter, milestone #3, and beyond	Stuart Shaklan	9:20	0:30
Break		9:50	0:20
Report on TSWG recommendation: Reflected bright body and other sources of straylight	Doug Lisman	10:10	0:30
Stray light analysis: sunlight scattering off out-of-plane petal deformations	Glenn Sellar	10:40	0:20
Report on mechanical milestones	Manan Arya	11:00	0:30
Discussion 1		11:30	0:30
Lunch		12:00	1:30
Session 2: Industry Partners Updates Chair: Kendra Short			
ATA	Laura Hoffman	13:30	0:30
Opterus	Patrick Rodriguez, Thomas Murphy	14:00	0:30
Zecoat	David Sheikh	14:30	0:30
Break		15:00	0:30
Session 3: Student and Postdoc Presentations Chair: Jon Arenberg			
Exoplanetary characterization through reflection spectroscopy	Mario Damiano (JPL)	15:30	0:25
The search for another Earth using space telescopes with starshades: realistic image simulation and signal detection	Mengya Hu (Princeton)	15:55	0:25
Enabling starshade missions in Earth orbit through optimal formation design	Adam Koenig (Stanford)	16:20	0:25
Fuel cost heuristics for starshade slews and station-keeping in exoplanet imaging mission simulations	Gabriel Soto (Cornell)	16:45	0:25
Discussion 2		17:10	0:20
TSWG Meet and Discuss		17:30	0:30
	End	18:00	

Agenda Item - Day 2 Feb 7	Presenter	Start	Duration
What we have learned from Day 1 and the objectives for Day 2	Renyu Hu	8:00	0:10
Session 4: Technology and Science Working Group Chair: Simone D'Amico			
Formation flying with Princeton Testbed	Anthony Harness	8:10	0:20
SISTER Imaging Simulation Tool	Stuart Shaklan	8:30	0:20
Data Challenges	Maggie Turnbull, Simone D'Amico, Anthony Harness	8:50	0:40
Break		9:30	0:20
Planet characterization and discoveries by GAIA and the impact on starhsade missions	Tim Brandt (remote)	9:50	0:20
Progress and Challenges of Earth-Orbiting Starshade	John Mather	10:10	0:20
What Science Can Do To Improve the Design of a Flagship Exo-Planet Mission: NG Perspective	Jon Arenberg	10:30	0:20
JATIS Special Issue	Jon Arenberg	10:50	0:10
Discussion 3		11:00	0:20
Summary and Next Steps	Gary Blackwood	11:20	0:10
Lunch and a short drive		11:30	1:30
Session 5: Starshade Testing Facility at Tendeg Chair: David Webb			
Starshade Testing Facility at Tendeg	Mark Thomson	13:00	1:30
	End	14:30	

Other Meeting Logistics

- Jennifer Gregory – Meeting Logistics
  - Will be posting slides to website when released

- Important Logistics:
  - Refreshments
  - Restrooms
  - Lunch
  - Optional Group Dinner tonight



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Acknowledgements

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Program Office – Key Participants

NASA Exoplanet Exploration Program (ExEP)

Science and Industry Partnership

- **Gary Blackwood**, NASA ExEP Manager, Starshade SIP Chair
- **Yuriy Tsurkan**, Subcontract Manager
- **Renyu Hu**, ExEP Scientist for Starshade Technology

Starshade Technology Development Activity (S5)

- **Kendra Short**, NASA ExEP Deputy Manager,
- **Phil Willems**, Manager of S5, LBTI Project Manager

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- **Jeff Volosin**, Deputy Division Director
- **Paul Hertz**, Division Director