



Starshade Science and Industry Partnership

Telecon #5

NASA Exoplanet Exploration Program

Gary Blackwood

July 9, 2019

Telecon Agenda

- SIP Updates - **Gary Blackwood**
- Starshade Technology Introduction / Context – **Phil Willems**
- Mechanical Milestones and Development Updates – **David Webb**
- Future Telecons / Next Steps
- Open Floor for Discussion

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.

- 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 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.
- The Starshade **Technology Development Activity to TRL5, or S5**, follows an approved **Technology Development Plan** 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.

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

The screenshot shows the NASA Exoplanet Program website. The top navigation bar includes the NASA logo, 'EXOPLANET PROGRAM', and links for 'About', 'Studies', 'News', 'Meetings/Events', 'Resources', 'Technology', 'NExSci', 'ExoPAG', 'Science', and 'Outreach Site'. A search icon is also present. Below the navigation bar, a secondary menu lists 'Technology Overview', 'Technology Needs and Gap Lists', 'TDEM Awards', 'ExEP Technology Colloquium Series', and 'In-Space Servicing and Assen'. The main content area features a large heading 'Starshade Technology Development'. Below this heading is a paragraph of text explaining the program's critical functions. To the right of the main text are three sections: 'Starshade Technology Development Activity (S5) Documents' with a list of links, 'Starshade Science and Industry Partnership (SIP)' with a sub-section for 'SIP Documents' and a list of links, and 'Previous Telecon Presentations' with a list of links. On the left side of the main content area, there are three video thumbnails with titles: 'Starshade Rendezvous Mission Concept Animation', 'Starshade Wrapped Architecture Deployment Concept', and '10m Truss Demonstration Unit with...'. The first video thumbnail shows a yellow and white spherical object with a telescope-like structure. The second shows a cylindrical object with a blue background. The third shows a large white truss structure in a laboratory setting.

Starshade Technology Development

The Exoplanet Exploration Program Charter identifies one of the Program's critical functions to be to "...manage exoplanet-related technology initiatives, including the management of specifically directed technology activities, facilitation of a coordinated NASA Astrophysics technology identification/prioritization process, oversight of competitively-selected technology activities, and certification of technology milestones and or Technology Readiness Levels (TRLs)."¹

Videos

Starshade Rendezvous Mission Concept Animation

This animation depicts the on orbit separation and deployment of a Starshade System and Telescope System that were co-launched. This represents a potential mission concept.

Starshade Wrapped Architecture Deployment Concept

This animation shows the transition of the starshade from the stowed configuration to the deployed configuration including the eventually jettison of the Petal Launch and Unfurl Subsystem (PLUS).

10m Truss Demonstration Unit with...

Starshade Technology Development Activity (S5) Documents

- [Starshade Technology Development Plan](#)
- [Formation Flying Milestone Report](#)
- [ExoTAC Report on Starshade S5 Milestone #4 Review](#)

Starshade Science and Industry Partnership (SIP)

SIP Documents

- [Terms of Reference dated 5/30/2019](#)
- ["Dear Colleague" Letter to Solicit Nominations for the TSWG of the Starshade Science and Industry Partnership, dated February 26, 2019](#)

Previous Telecon Presentations

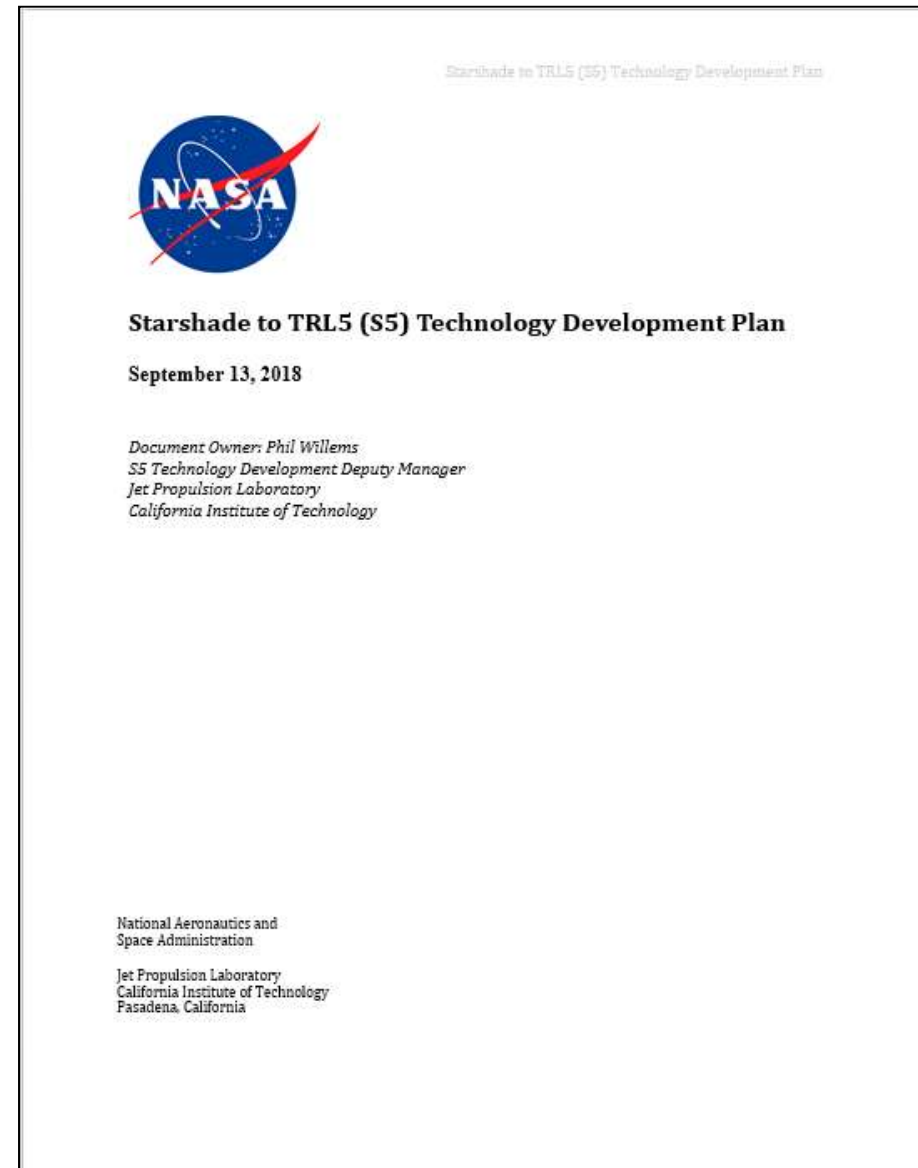
- [Telecon 3 Meeting Recording](#) (Plays on Firefox/Chrome/IE but not Safari)
- [Telecon 3 Intro](#), Gary Blackwood
- [Telecon 3 Starshade Trade Study Results](#), David Webb
- [Telecon 2 Presentation](#)
- [Telecon 2 S5 Milestone #4 Presentation](#)
- [Telecon 1 Informational Presentation](#)
- [Telecon 1 Presentation RECORDING](#) (Plays on Firefox/Chrome/IE but not Safari)

Technology Development Plan



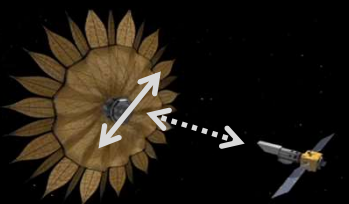
ExoPlanet Exploration Program

- Signed and posted on S5 website.
- Contains in-depth description of technology baseline, performance parameters, development and test plans.
- Highlights:
 - The comprehensive error budget based on the mission key performance parameters
 - The specific milestones defined as necessary to meet TRL 5



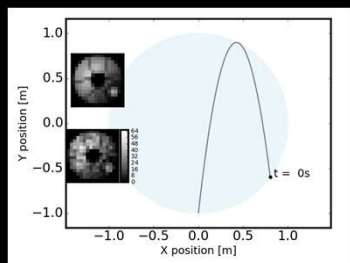
Starshade Technology Development Activity

Formation Flying



+/- 30 cm sensing accuracy
+/- 1 m control

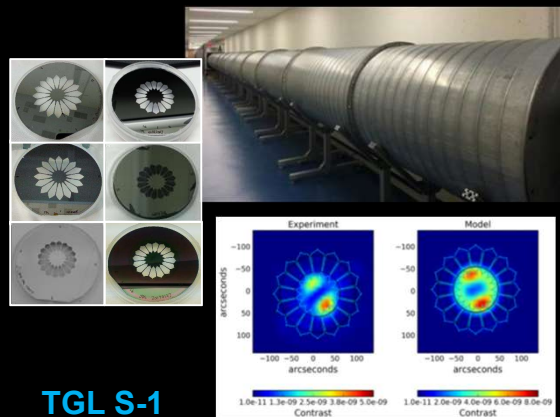
Testbed validated model of sensing accuracy; simulated control performance under flight-like conditions.



TGL S-3

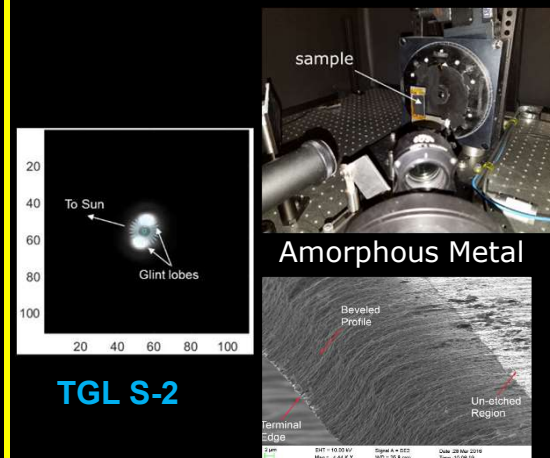
Starlight Suppression

Subscale demonstration of $1e-10$ contrast at both narrow and broadband; optical model validation to 25% accuracy.



TGL S-1

Scattered Sunlight



TGL S-2

Scatterometer measurements of half-scale petal edge segments show scattered sunlight less than Vmag 25 in image simulations.

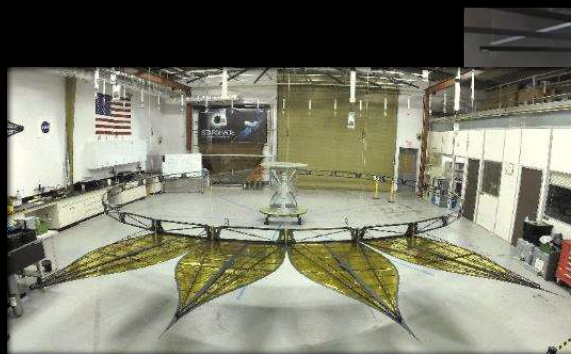
Petal Shape and Position Accuracy Petal Shape and Position Stability

Fabricate petals shape to a pre-launch accuracy of +/- 70um and demonstrate by analysis an on-orbit shape stability of +/- 80um

Perform petal deployment to a position accuracy of +/- 300um and demonstrate by analysis an on-orbit position stability to +/- 200 um



TGL S-4 TGL S-5



TGL S-# is the ExEP Technology Gap List reference number

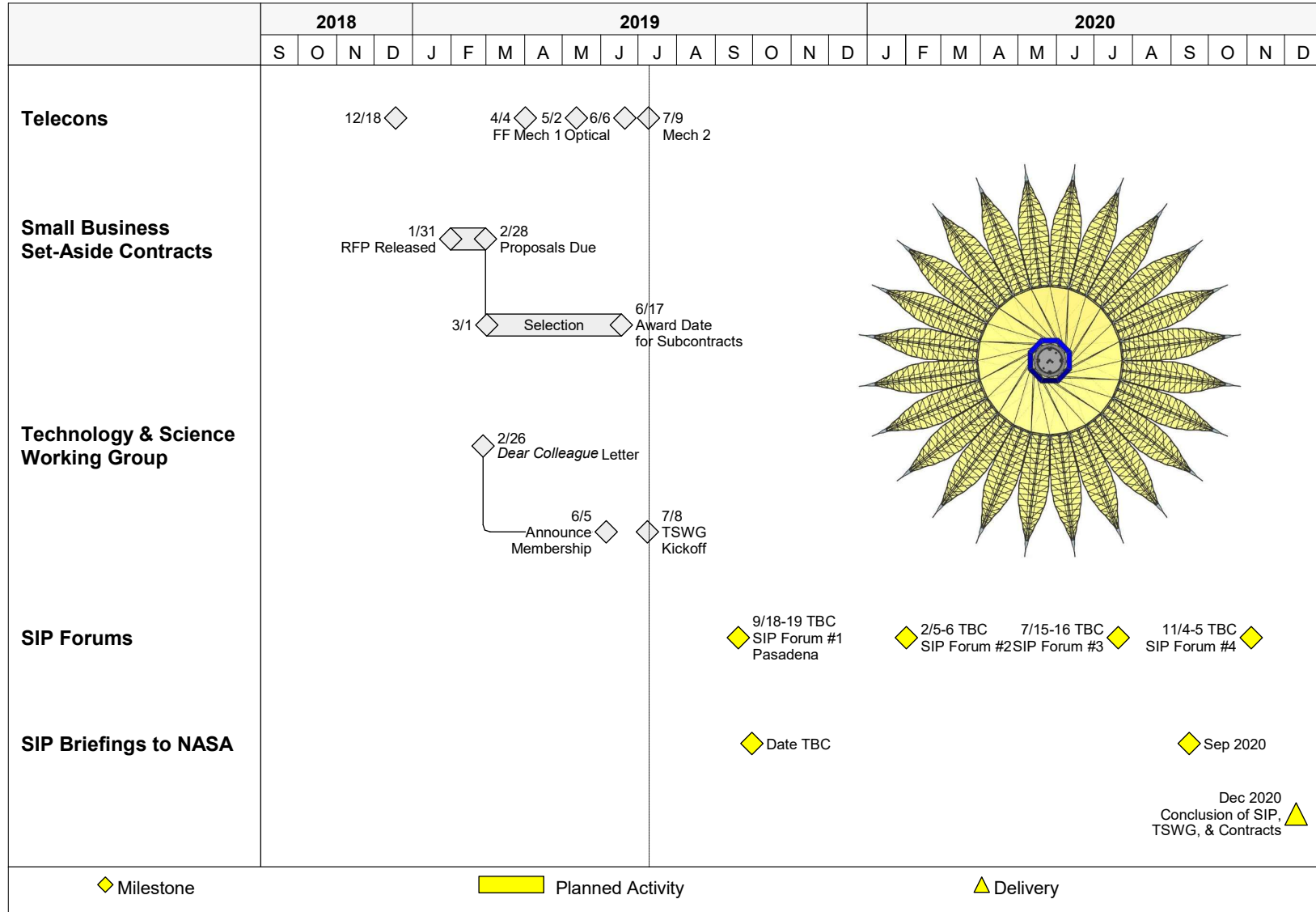
Expected Outcomes of the Starshade SIP

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.

Starshade Science and Industry Partnership (SIP)

Tier 2 Schedule

7/9/2019



Status Since June 6th Telecon

- Small business subcontracts awarded
 - 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.
- Held kickoff with TSWG and program office

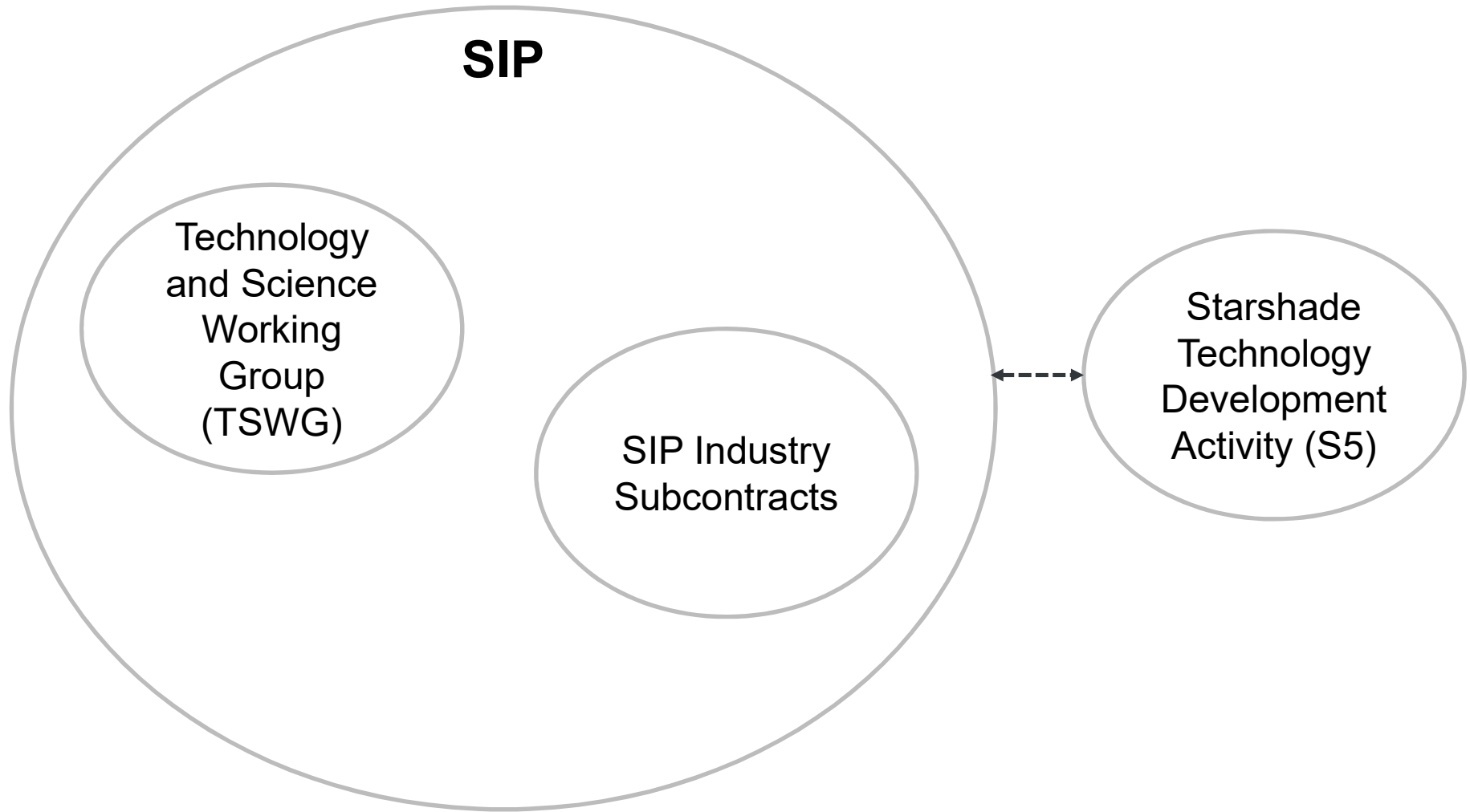
Technology and Science Working Group

Congratulations and Welcome!

Last Name	First Name	Institution	Title	Email
Seager	Sara	Massachusetts Institute of Technology	Professor	seager@mit.edu
Turnbull	Margaret	SETI Institute	Principal Investigator	turnbull.maggie@gmail.com
Arenberg	Jon	Northrop Grumman Aerospace Systems	Chief Engineer	jon.arenberg@ngc.com
d'Amico **	Simone	Stanford University	Assistant Professor	damicos@stanford.edu
Harness	Anthony	Princeton University	Postdoc	anthony.harness@princeton.edu
Mather	John	NASA Goddard Spaceflight Center	Senior Project Scientist	john.c.mather@nasa.gov
Romero-Wolf	Andrew	NASA Jet Propulsion Laboratory	Technologist	Andrew.Romero-Wolf@jpl.nasa.gov
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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

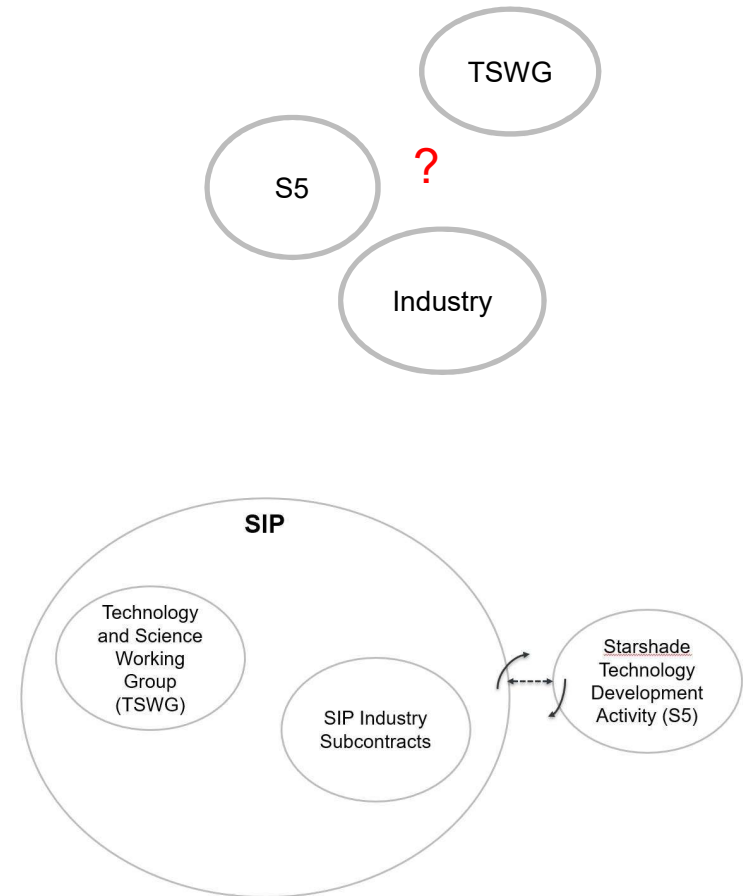
Starshade Science and Industry Partnership



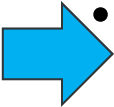
Technology and Science Working Group

Thoughts on operational implementation

- Fundamentally, TSWG has to:
 - Define interfaces or information flow
 - Zoom-in and –out current SIP activities
 - Close the loop through feedback
- Proposed tasks for TSWG's members:
 1. Get knowledgeable about SIP activities
 - Attend teleconferences
 - Read material on SIP's website
 2. Provide inputs to SIP activities:
 - Survey starshade tech and science world
 - Identify topics of relevance
 - Give/propose talks at meetings
 3. Establish a basic review process
 4. Meet regularly (1-2 months)
- Brief Paul Hertz annually on how SIP is doing



Telecon Agenda

- SIP Updates - **Gary Blackwood**
-  Starshade Technology Introduction / Context – **Phil Willems**
- Mechanical Milestones and Development Updates – **David Webb**
- Future Telecons / Next Steps
- Open Floor for Discussion

Agenda for F2F#1

JPL, Pasadena CA, Sept 18-19, 8-5 PT

Day 1

- Morning

- S5: Status from project; progress and challenges
- Starshade Lab Tours

- Afternoon

- Small business contract awardees: work scope
- Working Group Breakout, organized by
 - Outcomes (1,2), (3,4), (5,6) and (report to Hertz)

Day 2

- Morning

- TSWG presentations
- Presentations by any SIP member

- Afternoon

- Breakout Groups report back / capture next steps

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.

Chair: Willems

Chair: Short

Chair: Hu

Chair: D'Amico

Chair: Hu

Chair: Blackwood

[Go to Google Doc for Detailed Agenda](#)

Closing

Future agenda, future forum,

- **Starshade SIP mailing list:** Follow instructions at <https://exoplanets.nasa.gov/exep/technology/starshade/>
- Suggest future telecon (or Forum) agenda topics to:
 - Gary Blackwood and Renyu Hu
- **Starshade Forum #1:** Sept 18-19 at JPL in Pasadena CA.
 - Remote participation available.
 - Early registration (free) required for JPL visitor access. Will send invitation to SIP email addresses
- **Next Telecon:** Propose August 8 10 am, review Technology Development Plan
- Open the floor for further discussion



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California Institute of Technology

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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

NASA Headquarters Leadership

Astrophysics Division

- **Shahid Habib**, Program Executive for ExEP
- **Douglas Hudgins**, Program Scientist for ExEP
- **Martin Still**, Deputy Program Scientist for ExEP
- **Nasser Barghouty**, Division Technology Lead
- **Jeff Volosin**, Deputy Division Director
- **Paul Hertz**, Division Director

Small Business Set Aside Subcontracts

- Proposals solicited only from small businesses and any resulting award will be made to a small business
- Up to three cost-sharing contracts are planned by the Jet Propulsion Laboratory
- Contract type is cost type
- Procurement Schedule Milestones:

– RFI release in FedBizOpps	7/25/2018	Complete
– RFI responses due	9/05/2018	Complete
– RFP release in FedBizOpps	1/31/2019	Complete
– Proposals due	2/28/2019	Complete
– Target Award Date	6/17/2019	
- Only responsive, responsible proposers will be considered for award