



Starshade Science and Industry Partnership

Telecon #3

NASA Exoplanet Exploration Program

Gary Blackwood

May 2, 2019

Telecon Agenda

- SIP Updates - **Gary Blackwood**
- Starshade Technology Introduction / Context – **Phil Willems**
- S5 Mechanical Technology: “Wrapped Petal Starshade Mechanical Architecture” – **David Webb**
- Future Telecons / Next Steps - **Gary Blackwood**
- 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 describing the Exoplanet Exploration Program Charter's critical functions. To the right of this text is a section titled "Starshade Technology Development Activity (S5) Documents" with a list of three links. Below the text is a "Videos" section with three entries, each featuring a thumbnail image and a title: "Starshade Rendezvous Mission Concept Animation", "Starshade Wrapped Architecture Deployment Concept", and "10m Truss Demonstration Unit with". To the right of the "Videos" section is another section titled "Starshade Science and Industry Partnership (SIP)" with a sub-section "SIP Documents" containing two links and a "SIP Telecon #2" section with a date and a "Join Webex" link.

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 eventual 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 \(draft\) dated 4/3/2019](#)
- ["Dear Colleague" Letter to Solicit Nominations for the TSWG of the Starshade Science and Industry Partnership, dated February 26, 2019](#)

SIP Telecon #2

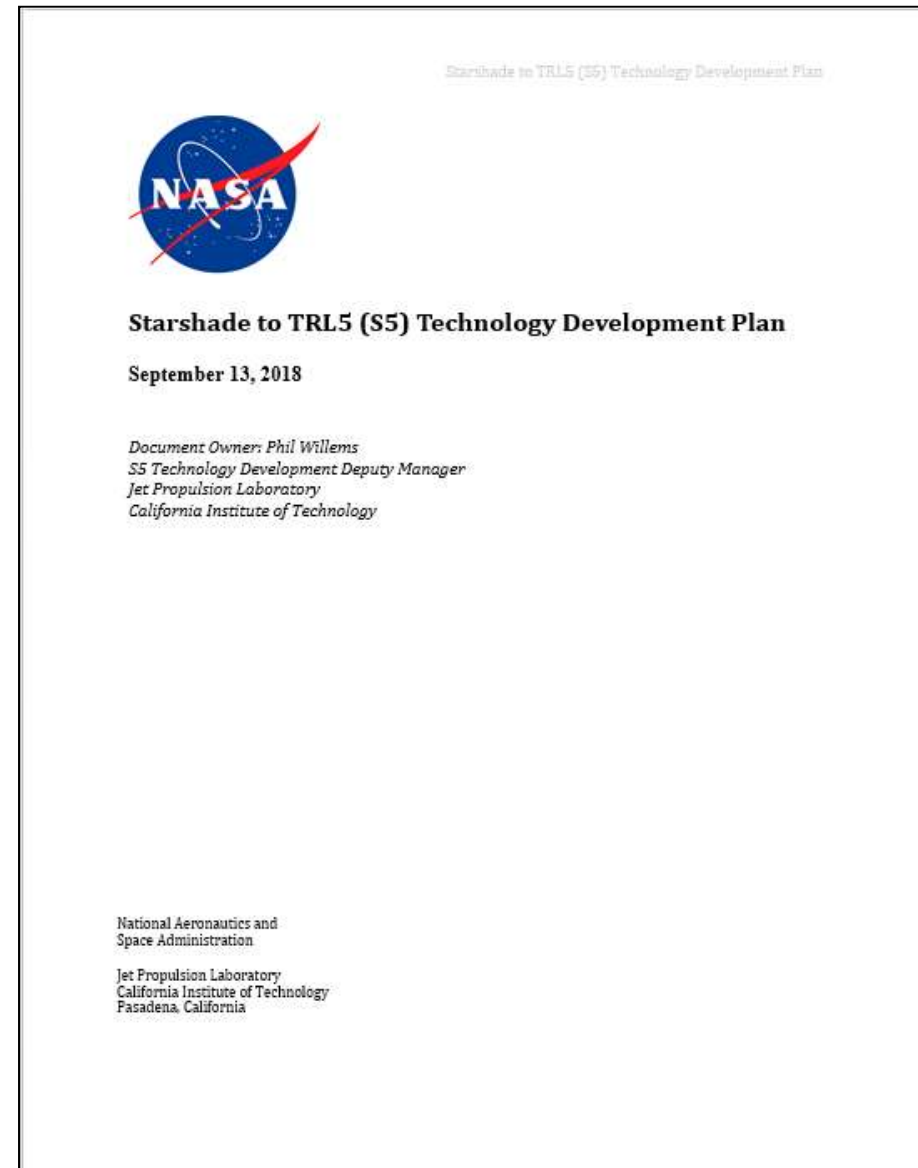
- Thursday, April 4, 2019 10amPT = 1pm ET
- [Join Webex](#) Audio: 844-575-9329 Meeting ID: 907 398 166
- Agenda:

Technology Development Plan



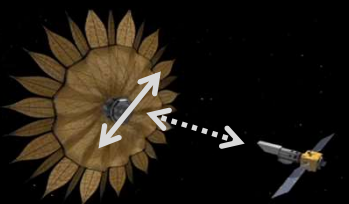
ExoPlanet Exploration Program

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



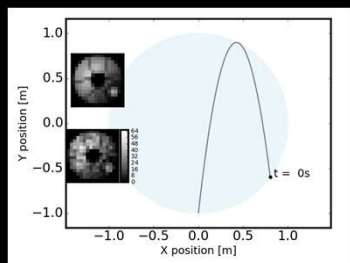
Starshade Technology Development Activity

Formation Flying



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

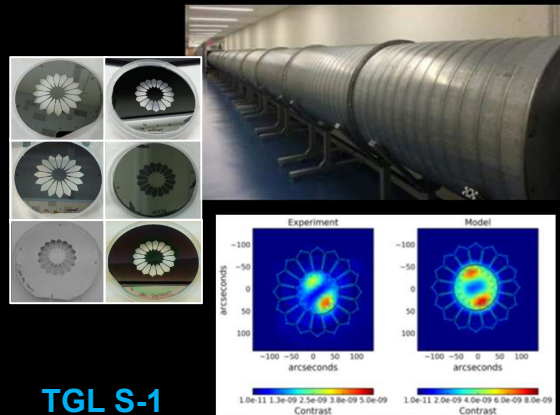
Testbed validated model of sensing accuracy; simulated control performance under flight-like conditions.



TGL S-3

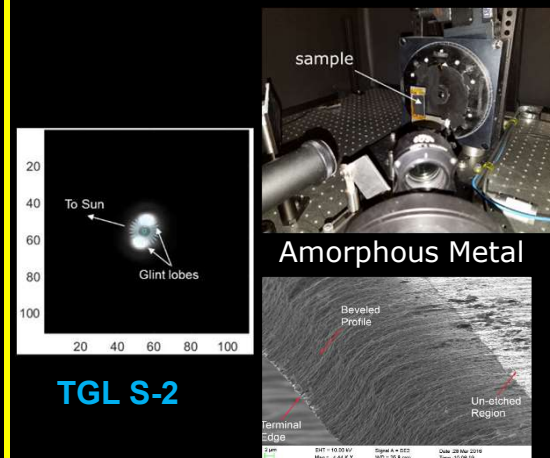
Starlight Suppression

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 $V_{mag} 25$ 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

Starshade SIP – Terms of Reference

Starshade Science and Industry Partnership – Terms of Reference
4/3/2019

DRAFT

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 studies¹ 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 Plan² 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

¹ <https://science.nasa.gov/astrophysics/2020-decadal-survey-planning>

² <https://exoplanets.nasa.gov/exep/technology/starshade/>

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.

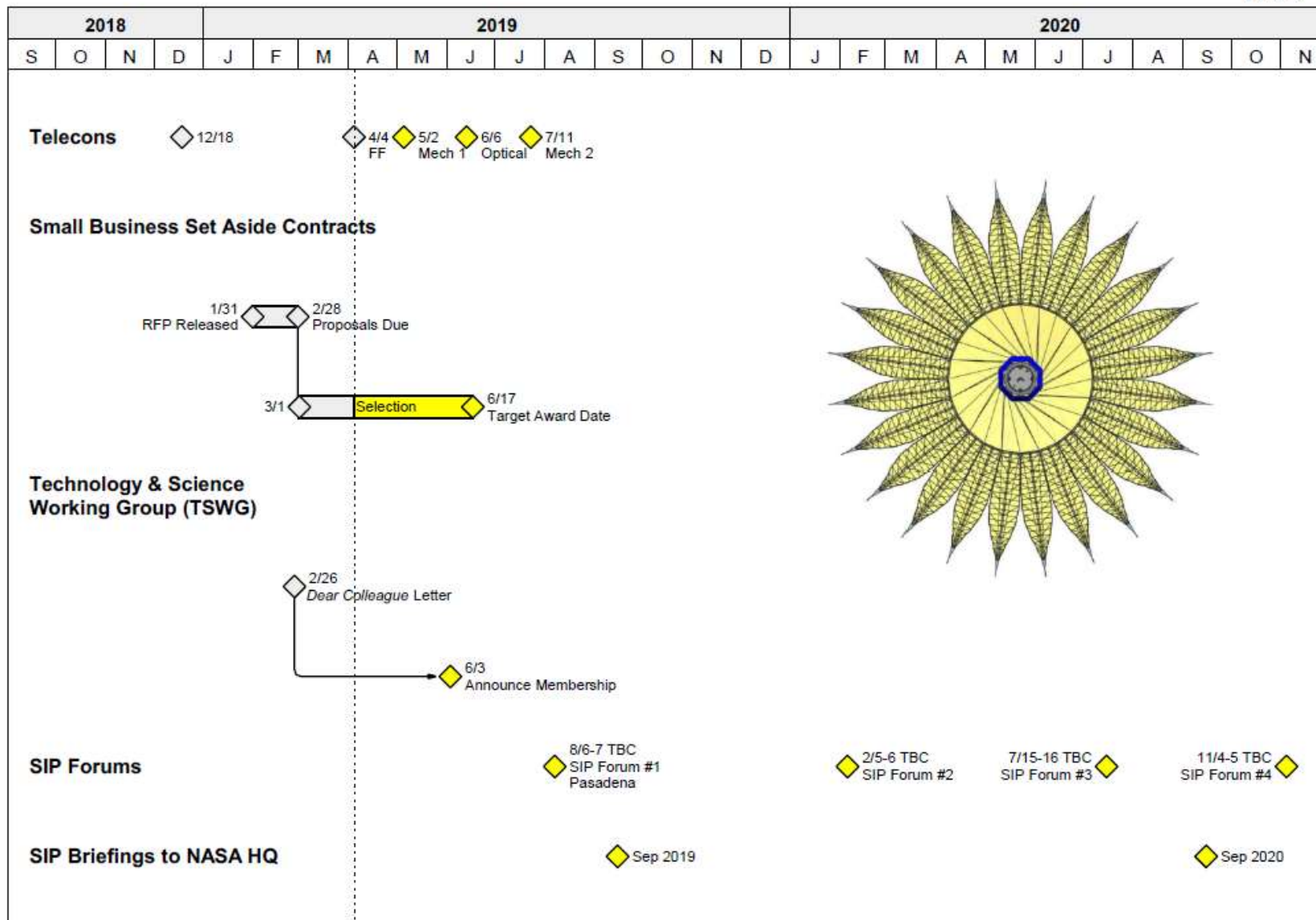
Expected Outcomes of the Starshade SIP

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

4/4/2019



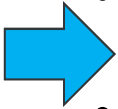
Status Since 12/18 Kickoff Telecon

Changes since April 4 Telecon

- Milestones:
 - M4: Lateral Position Sensor, report approved by ExoTAC
 - M1a, 1b: Narrowband and Broadband contrast exceeding $1e-10$, approved by ExoTAC
- FY19 appropriations budget sets starshade technology at \$10M – increase of \$2.7M. Investment plan submitted to NASA HQ
- Remote Occulter (Mather, Peretz) study funded – GSFC Workshop 5/14-15, JPL Team X study week of 5/21-23
- Plans for whitepapers
 - S5 Team, alongside flagship and probe reports
 - ExEP Technology, tentatively July 1 2019
 - Exoplanet Community Google Spreadsheet

Telecon Agenda

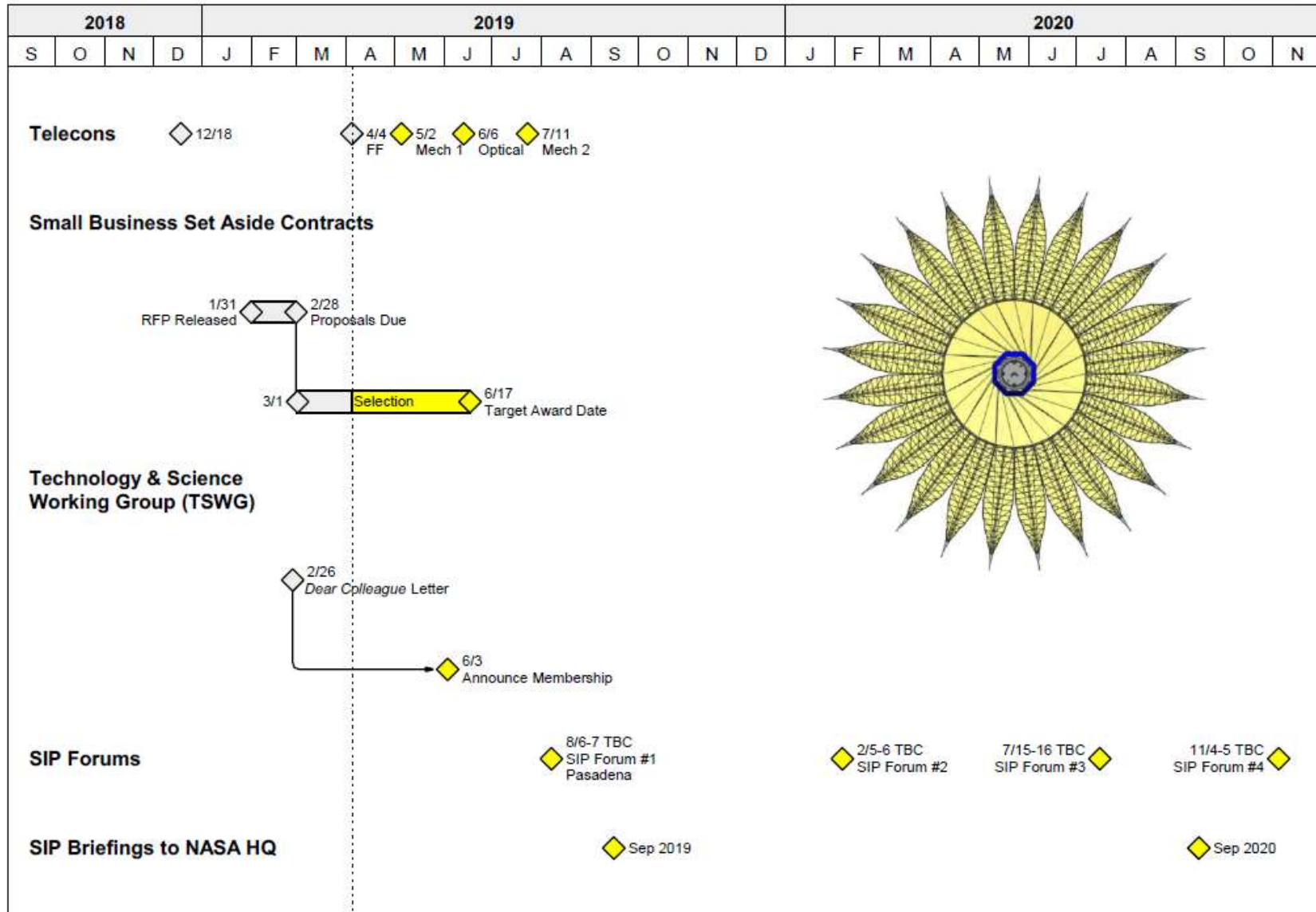
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- Future Telecons / Next Steps - **Gary Blackwood**
- Open Floor for Discussion



Starshade Science and Industry Partnership (SIP)

Tier 2 Schedule

4/4/2019



Agenda (draft) for F2F#1

JPL, Pasadena CA, August 6-7 2019

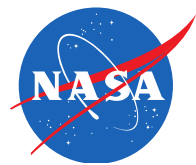
- S5 Technology Development: Status from project; progress and challenges
- Small business contract awardees: proposed work
- TSWG – new mission concept drivers, new approaches, techniques, research
- Starshade Lab tours
- Presentations from any SIP member: HabEx and Rendezvous
- Working Group Breakout, organized by
 - Outcomes 1-3
 - Outcomes 4-6
- 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.

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: will confirm date/logistics for 8/6-7 in Pasadena CA. Remote participation available.
- Open the floor for further discussion



Jet Propulsion Laboratory
California Institute of Technology

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Acknowledgements

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Contact Information

Starshade Science and Industry Partnership

- **Gary Blackwood**, NASA ExEP Manager, Starshade SIP Chair
 - Gary.blackwood@jpl.nasa.gov
 - W: 818 354 6263
 - M: 818 458 0507
- **Yuriy Tsurkan**, Subcontract Manager
 - Yuriy.Tsurkan@jpl.nasa.gov
 - W: 818 393-8052
 - M: 747 261-8928
- **Renyu Hu**, ExEP Starshade Scientist
 - Renyu.Hu@jpl.nasa.gov
 - W: 818 354 6090
 - M: 818 281-9459
- **Kendra Short**, S5 acting Manager, NASA ExEP Deputy Manager
 - Kendra.Short@jpl.nasa.gov
 - W: 818 354 9286
 - M: 818 634 3918

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

Starshade and Exoplanet Whitepapers

- **The S5 team** will be composing a status update on their starshade technology development activities that will be presented by NASA to the Decadal Survey committee **alongside the final reports** of the flagship and probe mission studies.
- **The ExEP Technology Team** intends to submit a whitepaper in support of the Astro 2020 decadal survey committee's call for Activity, Project, or State of the profession whitepapers, tentatively due **July 1**. This whitepaper will inform the committee of key technology challenges for studying the diversity of worlds in the Galaxy and in searching for habitable planets using a space telescope, including the status of coronagraph technology, starshade technology, ultra-stable structures, spectroscopic stability, detector sensitivity, astrometric and radial velocity sensitivity.
- Astro2020 Decadal Survey on Activities, Projects and the State of the Profession: **Exoplanet Community Google Spreadsheet:**
https://docs.google.com/spreadsheets/d/1_utB2FPZHBs8JvE9zgs_MOq3O5pF9pFm5IRILV58Ujo/edit#gid=327882028. Please contact Johanna Teske (jteske@carnegiescience.edu) with any questions or concerns.

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

Technology and Science Working Group

- A Technology and Science Working Group (TSWG) of approximately 8 technologists and scientists will be formed
 - Nomination solicited through a NASA *Dear Colleague* letter (https://exoplanets.nasa.gov/internal_resources/1113/)
 - Nomination due on April 12, 2019
 - Selection by the ExEP Program Scientist: June 3, 2019
 - Travel expenses will be reimbursed to TSWG members
- TSWG members will:
 - Identify solutions to challenges faced by the S5 development activity
 - Propose new approaches, techniques, and research beyond planned S5 activities that can maximize starshade technology readiness
 - Document new mission concept drivers for starshade technology performance requirements
 - Maintain alignment between S5 technology development activities and future mission needs
 - 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)