Jet Propulsion Laboratory
California Institute of Technology

Starshade Science and Industry Partnership

Telecon #5

NASA Exoplanet Exploration Program

Gary Blackwood

July 9, 2019

CL # 19-1960

Telecon Agenda

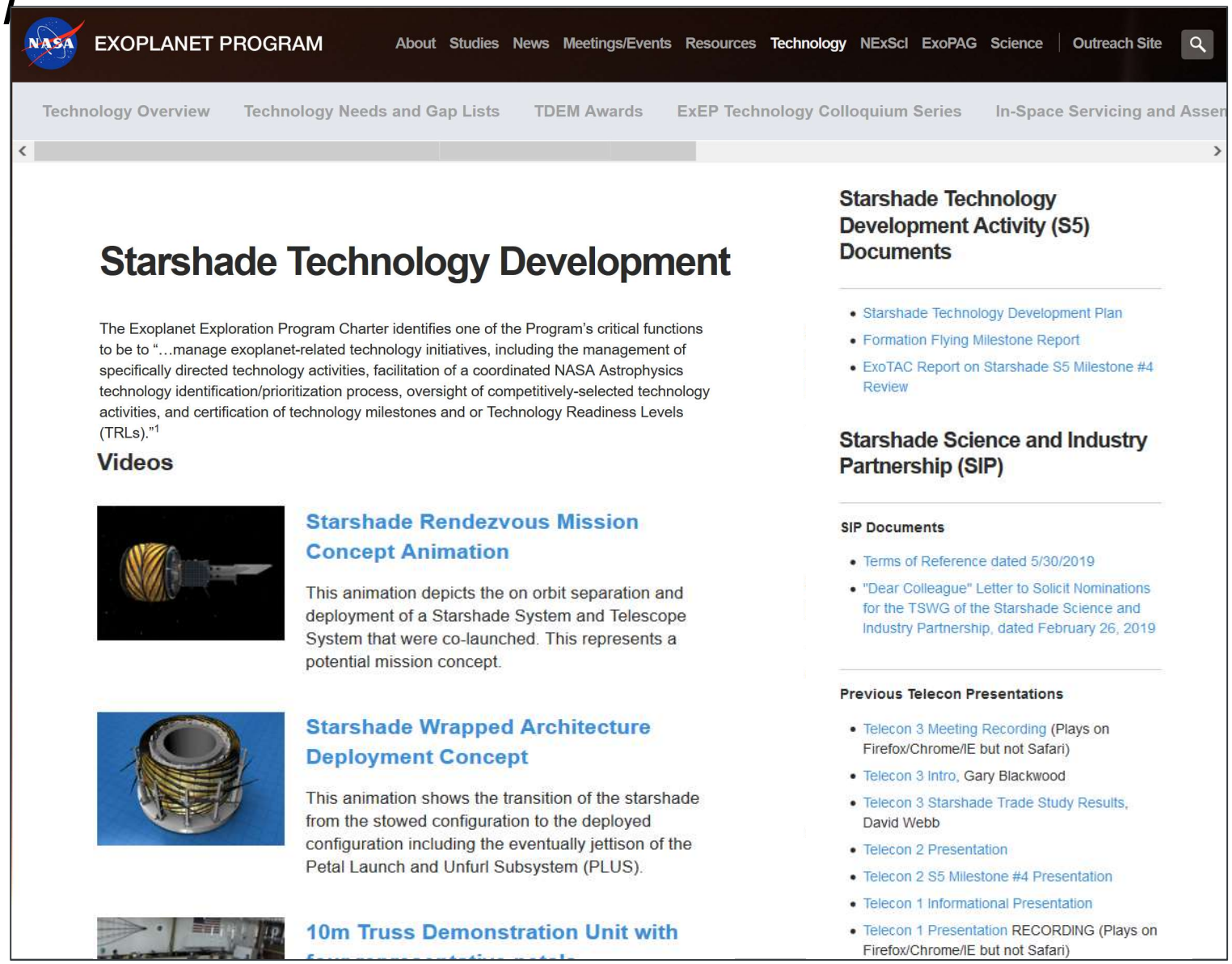
- SIP Updates - **Gary Blackwood**
- Starshade Technology Introduction / Context – **Phil Willems**
- Mechanical Milestones and Development Updates – **David Webb**
- Future Telecons / Next Steps
- Open Floor for Discussion

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.

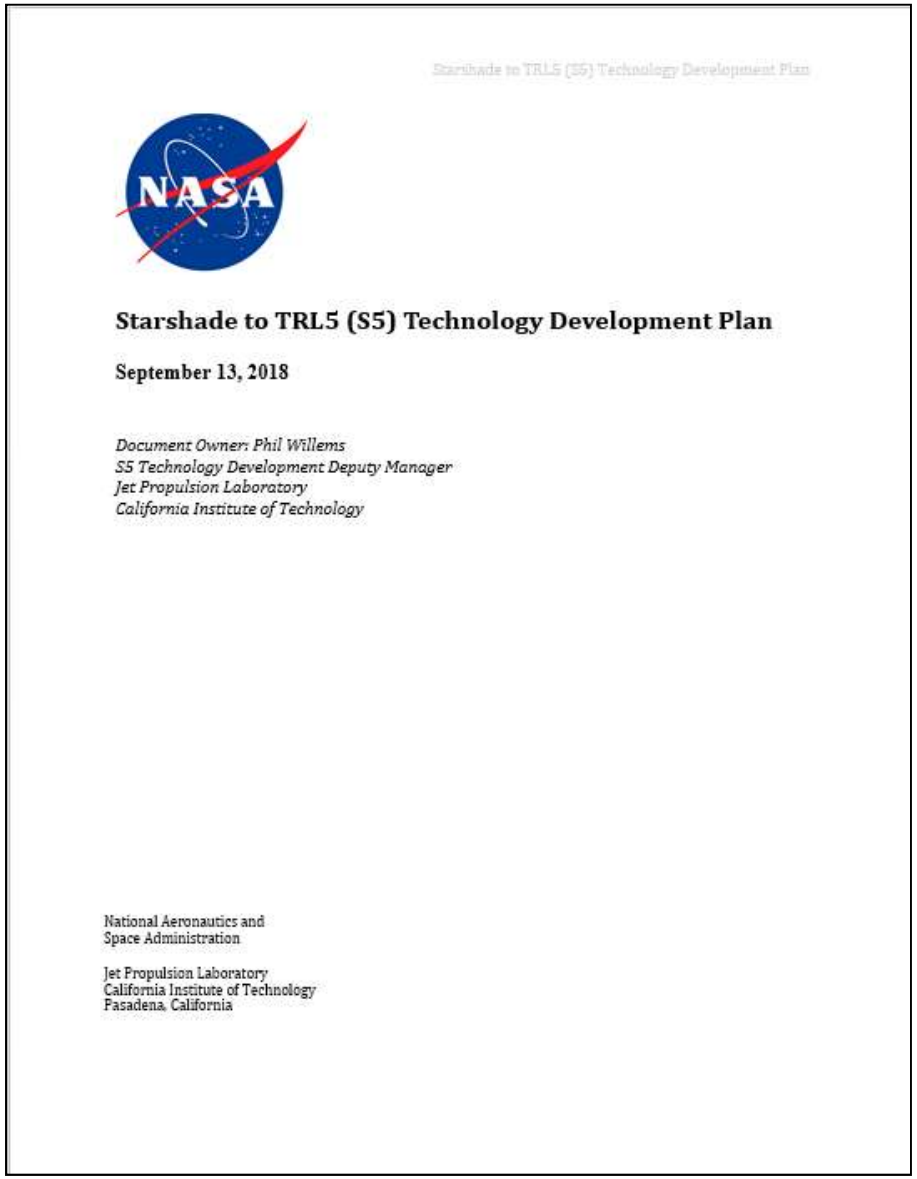
- Starshades (or External Occulters) are **one of the starlight suppression technologies** for high contrast imaging of exoplanets and are baselined for large- and probe-class mission concept studies funded by the NASA Astrophysics Division for submission to the Astro2020 Decadal Survey.
- Recently the 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/



Technology Development Plan

- 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 to TRL5 (S5) Technology Development Plan

Starshade to TRL5 (S5) Technology Development Plan

September 13, 2018

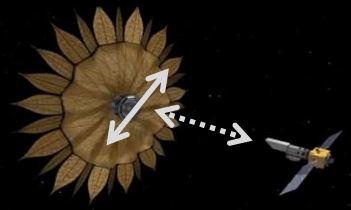
Document Owner: Phil Willems
S5 Technology Development Deputy Manager
Jet Propulsion Laboratory
California Institute of Technology

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

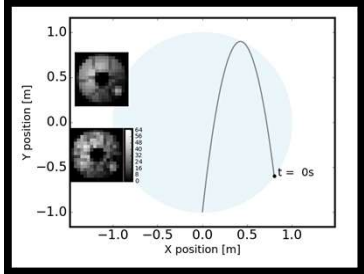
Starshade Technology Development Activity

Formation Flying



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

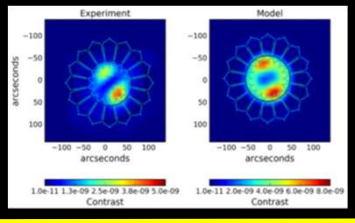
Testbed validated model of sensing accuracy; simulated control performance under flight-like conditions.



TGL S-3

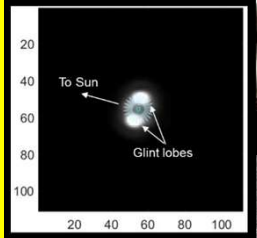
Starlight Suppression

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

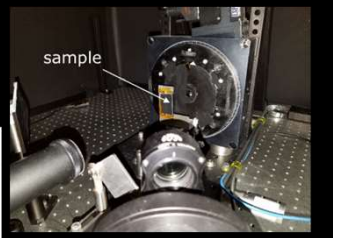


TGL S-1

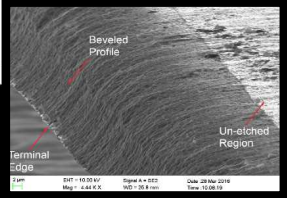
Scattered Sunlight



TGL S-2



Amorphous Metal

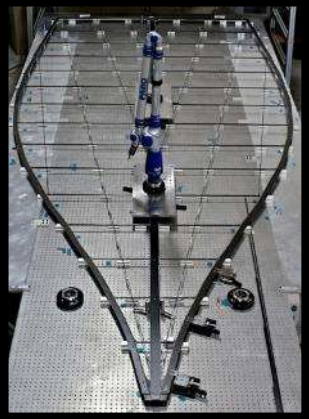


Scatterometer measurements of half-scale petal edge segments show scattered sunlight less than Vmag 25 in image simulations.

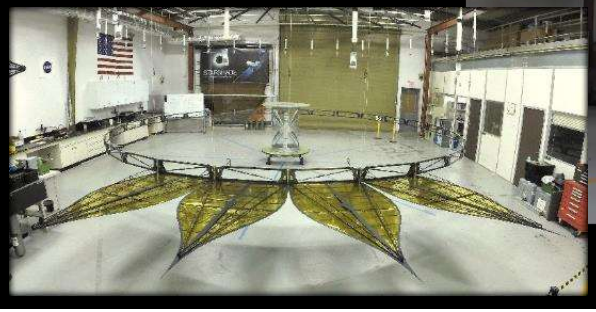
Petal Shape and Position Accuracy
Petal Shape and Position Stability

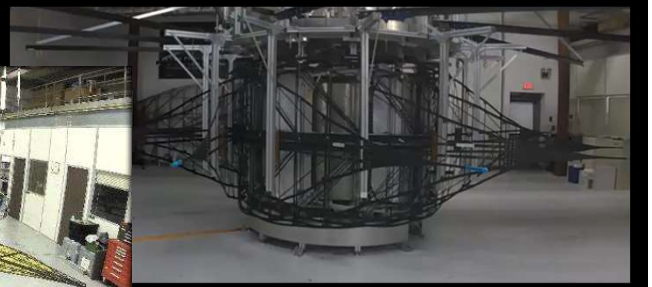
Fabricate petals shape to a pre-launch accuracy of +/- 70um and demonstrate by analysis an on-orbit shape stability of +/- 80um

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

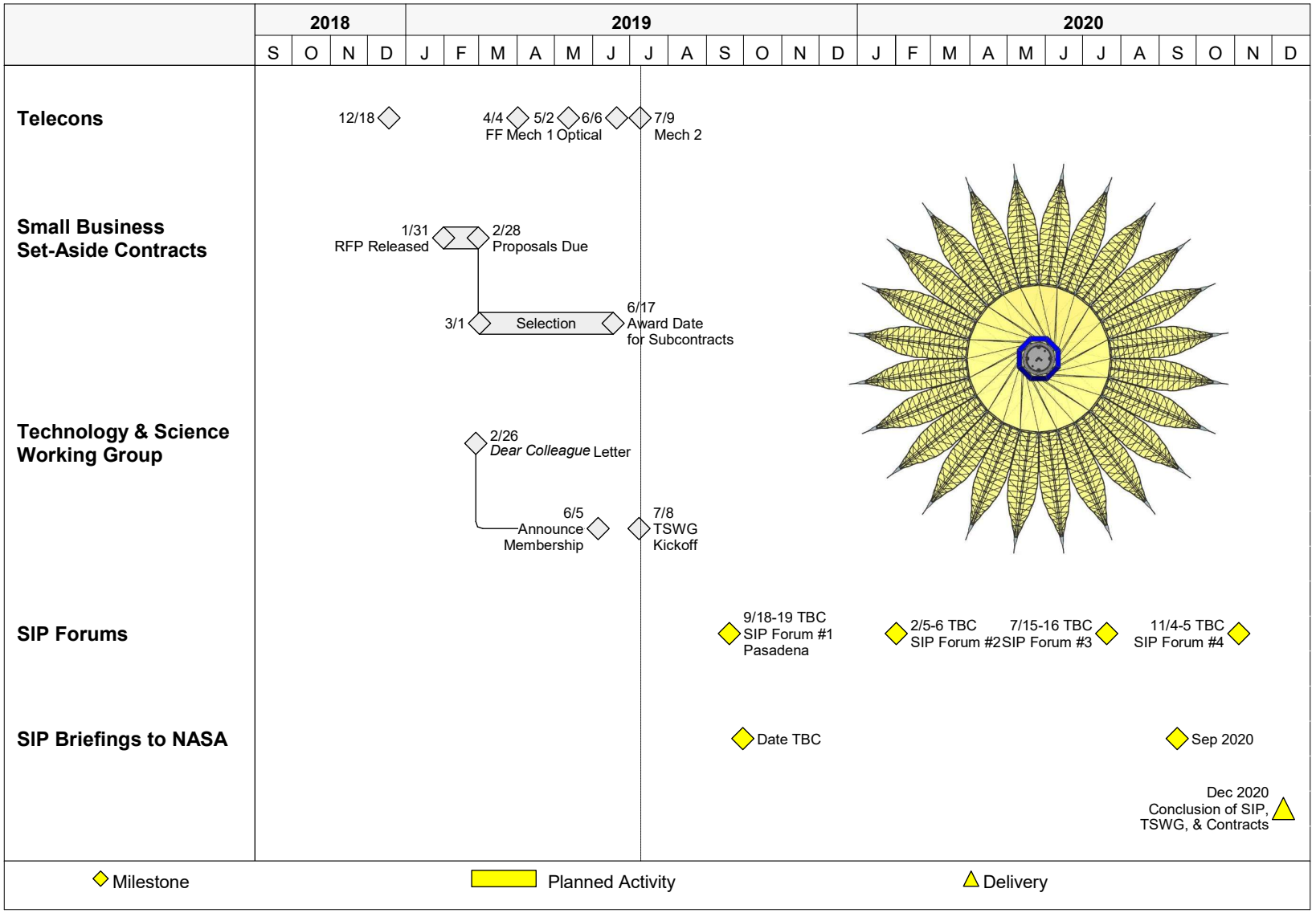
Expected Outcomes of the Starshade SIP

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 Parnership (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
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Stahl	Phil	NASA Marshall Space Flight Center	Senior Engineer	h.philip.stahl@nasa.gov
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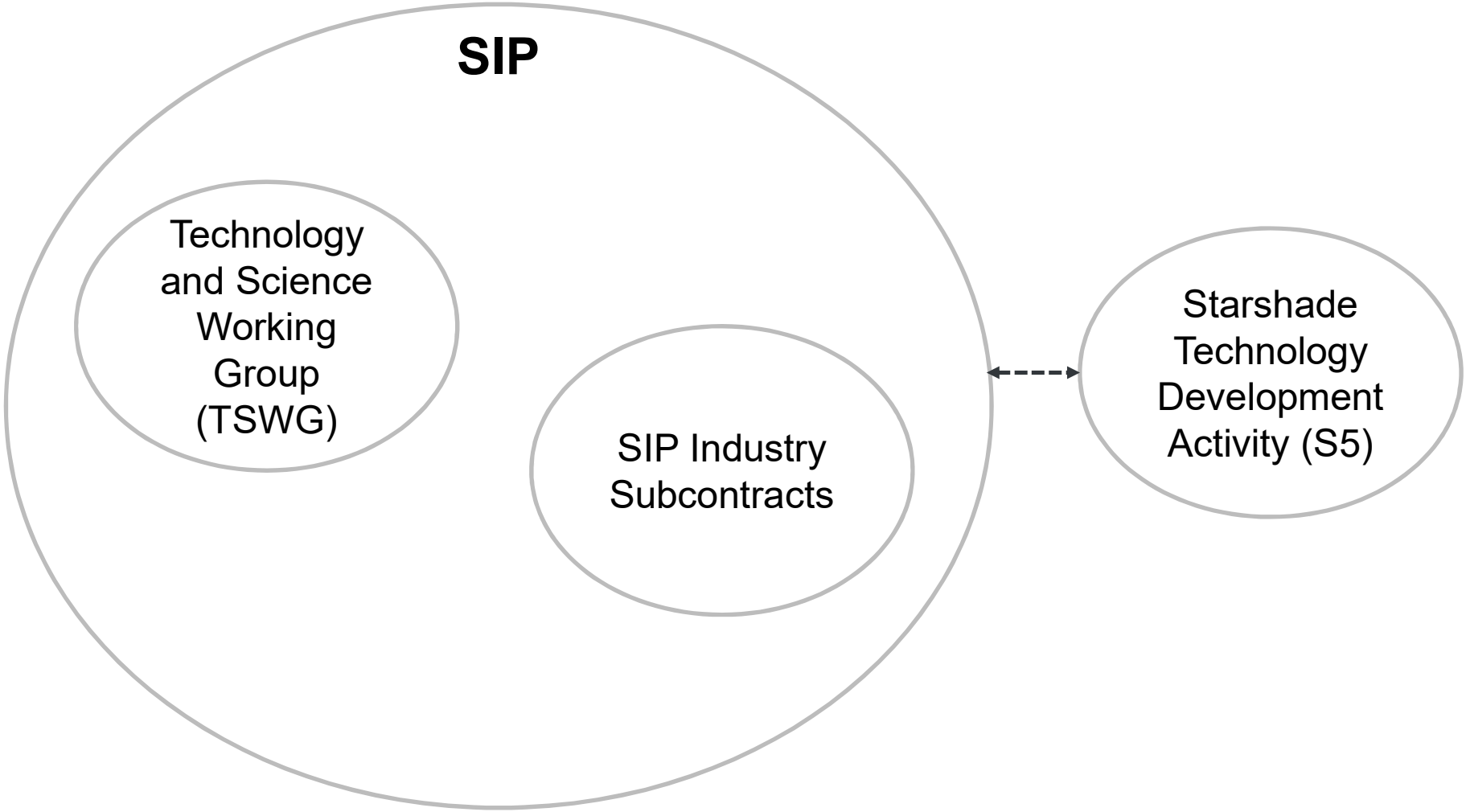
** Chair

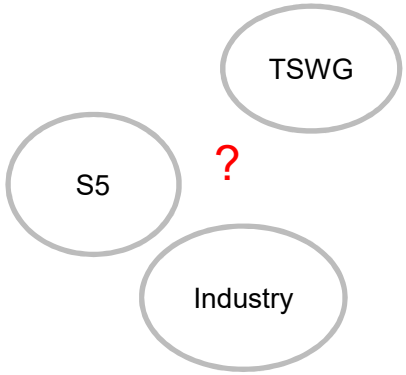
Starshade Science and Industry Partnership

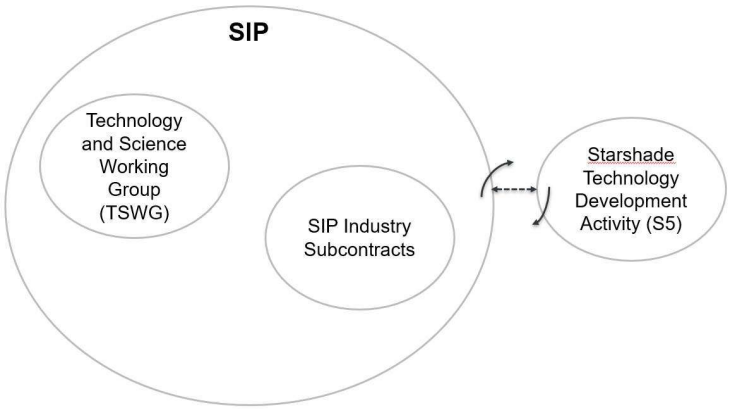


Technology and Science Working Group

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

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Agenda for F2F#1

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

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;
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6. Enable **continued participation** of the community in NASA's starshade technology development activities.

Day 1

- Morning
  - S5: Status from project; progress and challenges — Chair: Willems
  - Starshade Lab Tours
- Afternoon
  - Small business contract awardees: work scope — Chair: Short
  - Working Group Breakout, organized by — Chair: Hu
    - Outcomes (1,2), (3,4), (5,6) and (report to Hertz)

Day 2

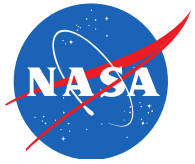
- Morning
  - TSWG presentations — Chair: D'Amico
  - Presentations by any SIP member — Chair: Hu
- Afternoon
  - Breakout Groups report back / capture next steps — Chair: Blackwood

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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Acknowledgements

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- **Kendra Short**, S5 acting Manager, NASA ExEP Deputy Manager
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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