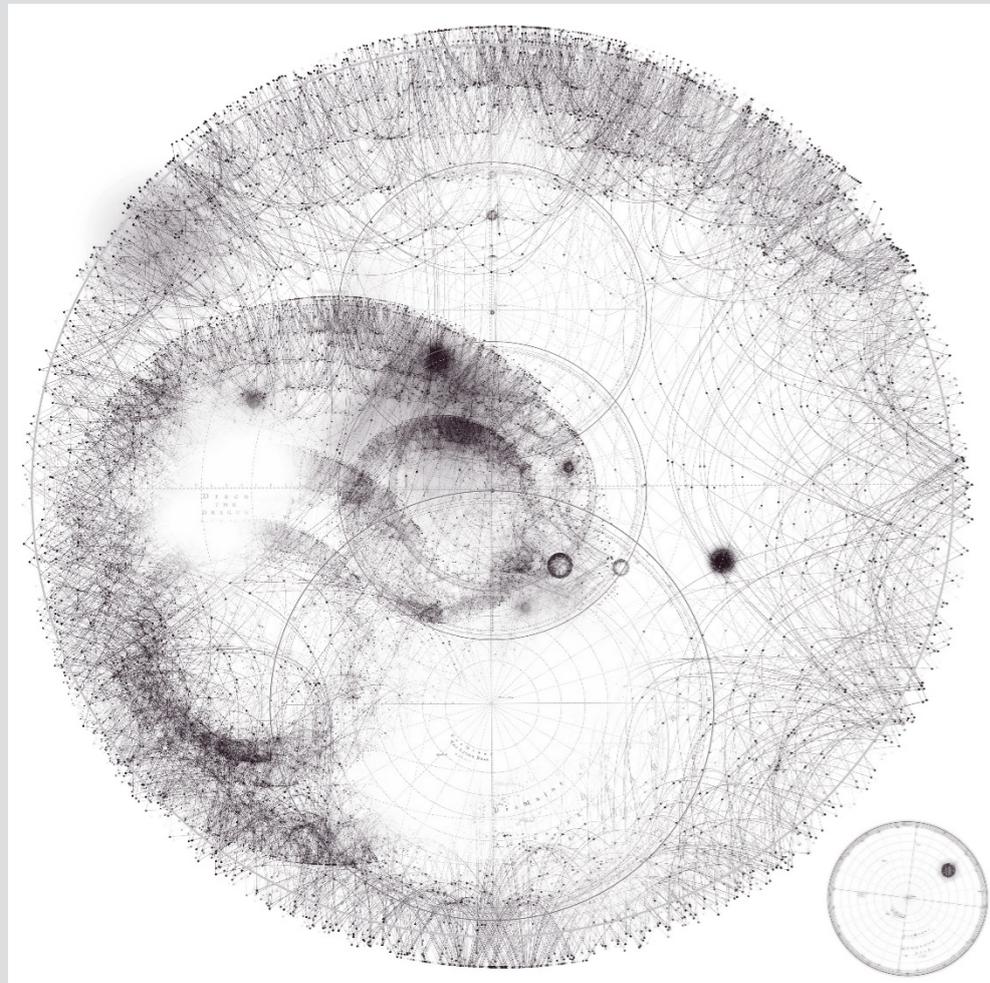


# Breakthrough Starshot

**Bidder's Briefing  
Phase 1 Sail RFP  
May 23, 2018  
Zoom Room**



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**BREAKTHROUGH**  
INITIATIVES

# Starshot Lightsail Industry Day Breakthrough Initiative

8:00 AM PDT, Wednesday 23 May 2018

8:00 – 8:10	Introduction Breakthrough Initiative
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Klupar

8:10 – 8:30 RFP Contract Discussions

8:30 – 8:45 Starshot Systems Model

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# Breakthrough Listen West Virginia

# Breakthrough Listen New South Wales





# Breakthrough Watch



ESO / DSS2

# Breakthrough Starshot

Pete Worden, Executive Director

Pete Klupar, Project Manager

## STARSHOT ADVISORY COMMITTEE

Avi Loeb, Harvard, Chairman

Harry Atwater, Chair Sail Subcommittee

Stephen Chu\*, Stanford

Saul Perlmutter\*, Berkeley

Freeman Dyson, Princeton

Ann Druyan

Lord Martin Rees, Astronomer Royal

Ed Turner, Princeton

Bruce Drain, Princeton

Mason Peck, Cornell

Phil Lubin, UCSB

Jim Benford,  $\mu$ Wave Sciences

Lou Friedman, Planetary Society

Giacario Genta, Polytechnic Univ of Turin

Olivier Guyon, Univ of Arizona

Mae Jemison, Astronaut, 100 Year Starship

Geoff Landis, NASA Glenn

Kelvin Long, J. British Interplanetary Soc.

Zac Manchester, Harvard

Greg Matloff, NYC College of Technology

Kaya Nobuyuki, Kobe University

Kevin Parkin, Parkin Research

Bob Fugate, NM Tech (Emeritus)

Mark Spencer, AFRL/RDL

Wesley Green, Chair Photon Engine Subcommittee

\* Nobel Laureate

# Starshot Objectives

1. **Send a spacecraft to nearby stars with planets in the habitable zone within 5 Parsecs of earth**
2. **Collect Science Data of star system focused on planets and beam data back to Earth**
3. **Launch within 30 years, at an affordable cost**
4. **Go FAST!**

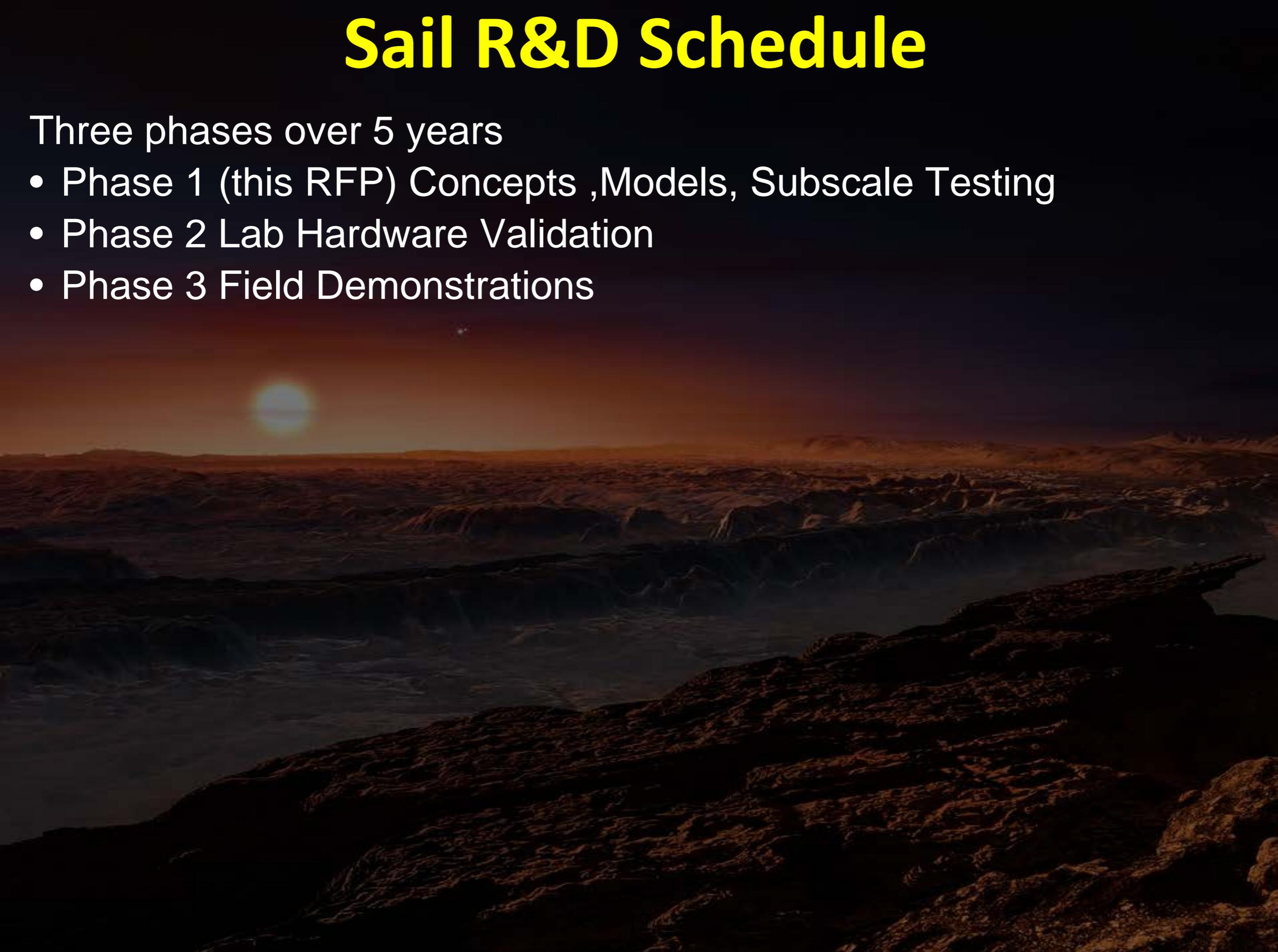
# Long Term Schedule

- \$100M R&D over next 5 years to determine feasibility of Laser and Sail
- Invest the value of the EELT from year 6 to year 11 build a low power prototype for space testing
- Invest the value of the Large Hadron Collider over 20 years for full scale laser system and space segment
- First Proxima Nanocraft launch in ~30 years
- 50 years from now first starchip arrives Proxima Centauri

# Sail R&D Schedule

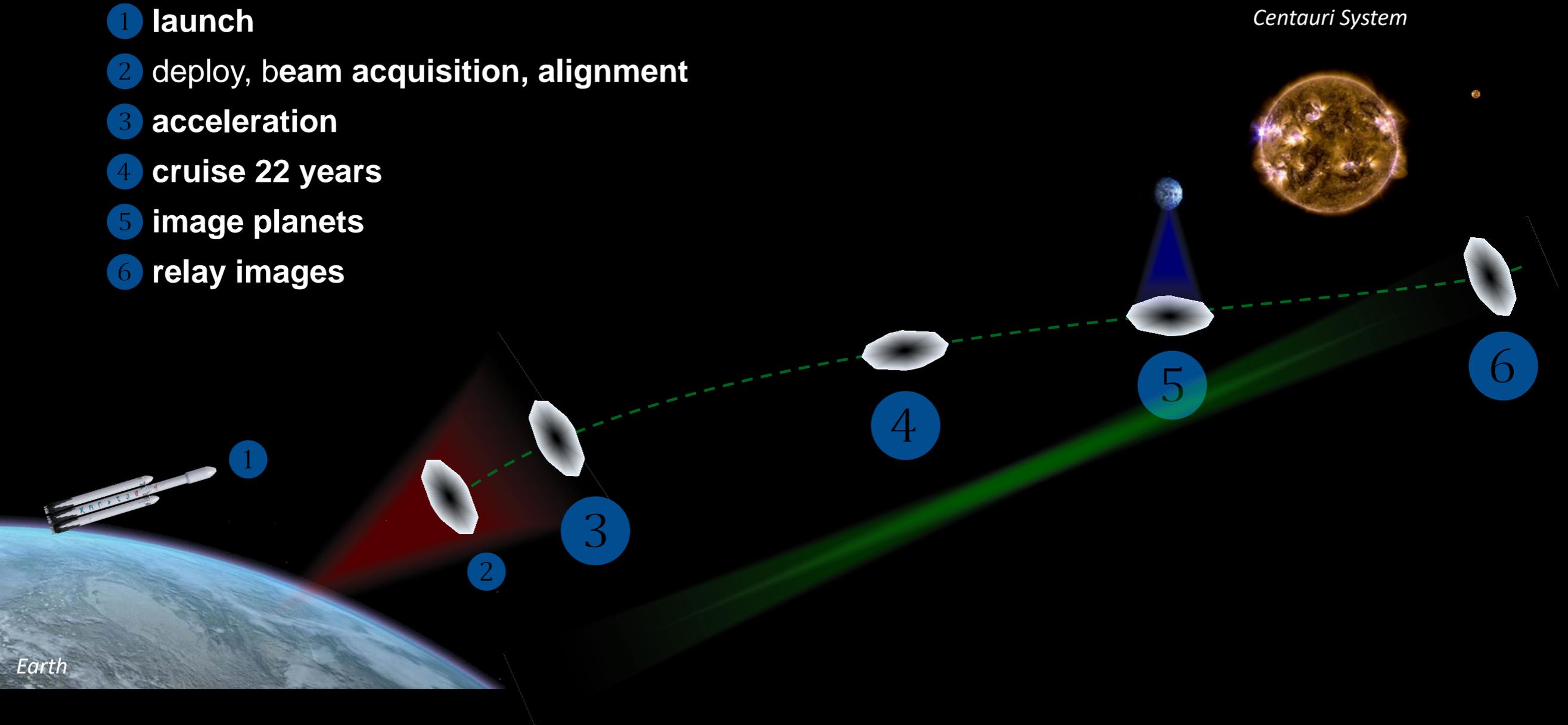
Three phases over 5 years

- Phase 1 (this RFP) Concepts ,Models, Subscale Testing
- Phase 2 Lab Hardware Validation
- Phase 3 Field Demonstrations



# BREAKTHROUGH STARSHOT

- 1 launch
- 2 deploy, beam acquisition, alignment
- 3 acceleration
- 4 cruise 22 years
- 5 image planets
- 6 relay images



**The constraints are:**

**Speed: 0.2 c**

**1064 nm wavelength**

**60 Mm initial range**

**Input parameters are:**

**Cost of lasers \$/W**

**Cost of optics \$/m<sup>2</sup>**

**Cost of power, energy storage \$/kWh**

**Sail parameters**

**System Model**

**Minimizes Photon Engine aperture to reach final speed**

**Aperture vs transmit power trade to minimize cost**

**50% wall plug efficiency**

# CENTAURI SYSTEM MISSION

## INPUTS

0.2 c target speed  
1.06 micron wavelength  
60,000 km initial sail displacement from laser source

### Sailcraft

1 g payload  
0.2 g/m<sup>2</sup> areal density  
0.001% absorptance  
70% reflectance  
970 K maximum temperature  
1.7 effective emissivity (2-sided)

### Beamer

\$0.01/Watt laser cost  
\$500/m<sup>2</sup> optics cost  
\$50/kWh storage cost  
50% wallplug to laser efficiency  
70% of beam power emerges from top of atmosphere

## POINT DESIGN

\$8.4B CAPEX comprised of:  
\$2.0B lasers (200 GW transmitted power)  
\$3.0B optics (2.8 km array effective diameter)  
\$3.4B energy storage (68 GWh stored pulse energy)  
\$7M energy cost per Starshot (68 GWh @\$0.1/kWh)

4.2 m sail diameter  
3.8 g sail mass

9 min (521 s) beam duration  
10 min (594 s) sail acceleration time

40 Pa temperature-limited photon pressure  
562 N temperature-limited force  
15,000 g's temperature-limited acceleration  
2,300 g's final acceleration (at 0.15 au, 73 ls from source)

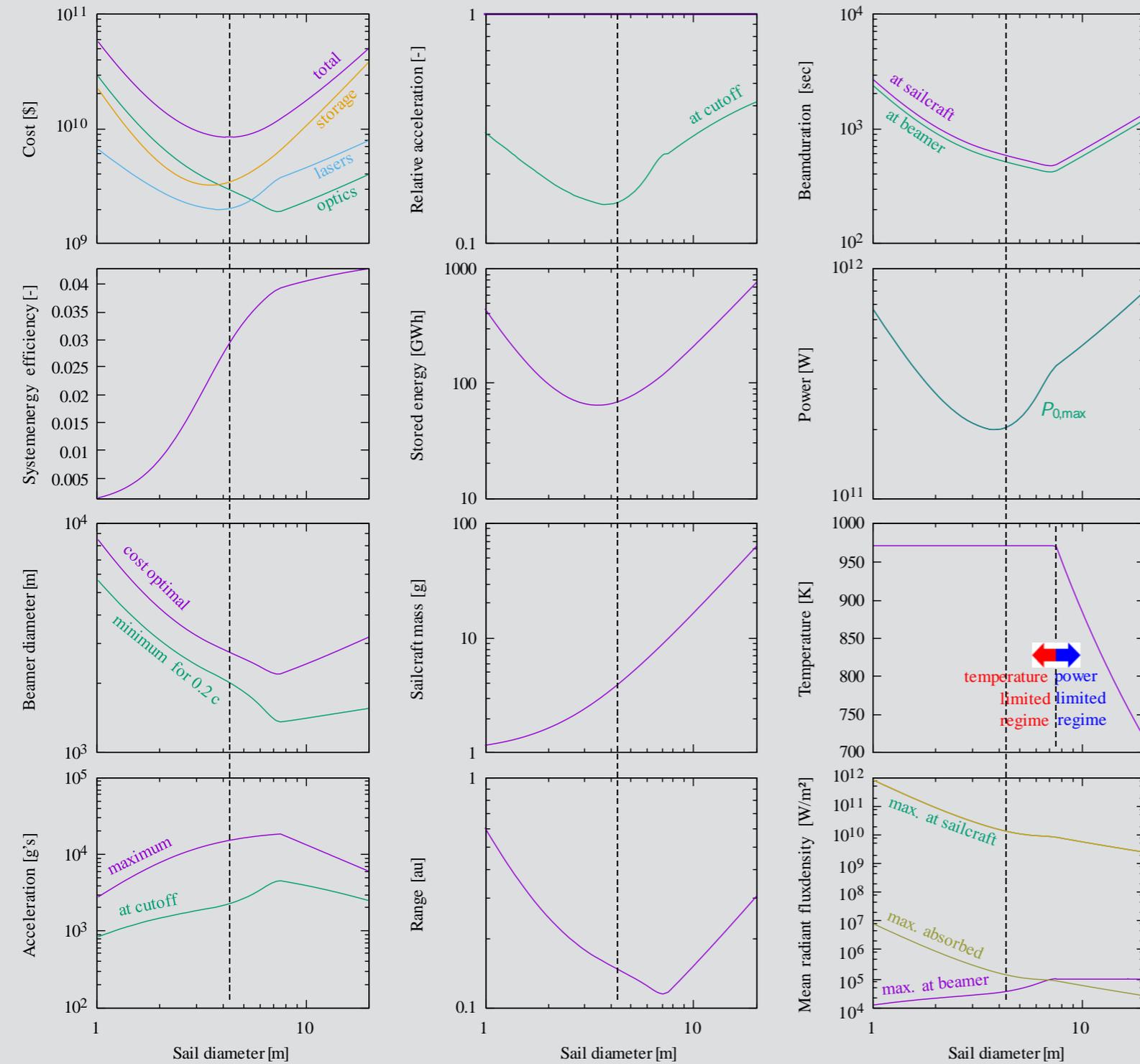
34 kW/m<sup>2</sup> beamer maximum radiant exitance  
14.4 GW/m<sup>2</sup> sailcraft theoretical maximum irradiance  
8.5 GW/m<sup>2</sup> sailcraft temperature-limited irradiance

# CENTAURI SYSTEM MISSION VARIATION WITH SAIL DIAMETER

This is the space that the optimizer sees (iteration 1 of the solution procedure)

Minimum cost is at 4.2 m

There is a qualitative change as sail goes from temperature-



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# RFP Schedule

- **Final RFP release: 22 May 2018**
- **5 page step A proposals due: 22 June 2018**
- **Invitation to submit step B proposals: 10 July 2018**
- **Finalist will be notified and contracts awarded summer of 2018**
- **Period of Performance 6 to 12 months**

# **Phase 1 Technology Development Scope**

**The scope of this RFP addresses the Technology Development phase - to explore LightSail concepts, materials, fabrication and measurement methods, with accompanying analysis and simulation that creates advances toward a viable path to a scalable and ultimately deployable LightSail.**

# Export Control

- We take seriously all Export Control processes and procedures Including ITAR and EAR.
- We will protect all Export Controlled data as marked.
- We have Export Controlled approved Email, servers and storage facilities.
- Please mark all Controlled material appropriately.
- Do Not send Breakthrough Export Controlled data without discussing the data with Breakthrough first.

# Data Rights

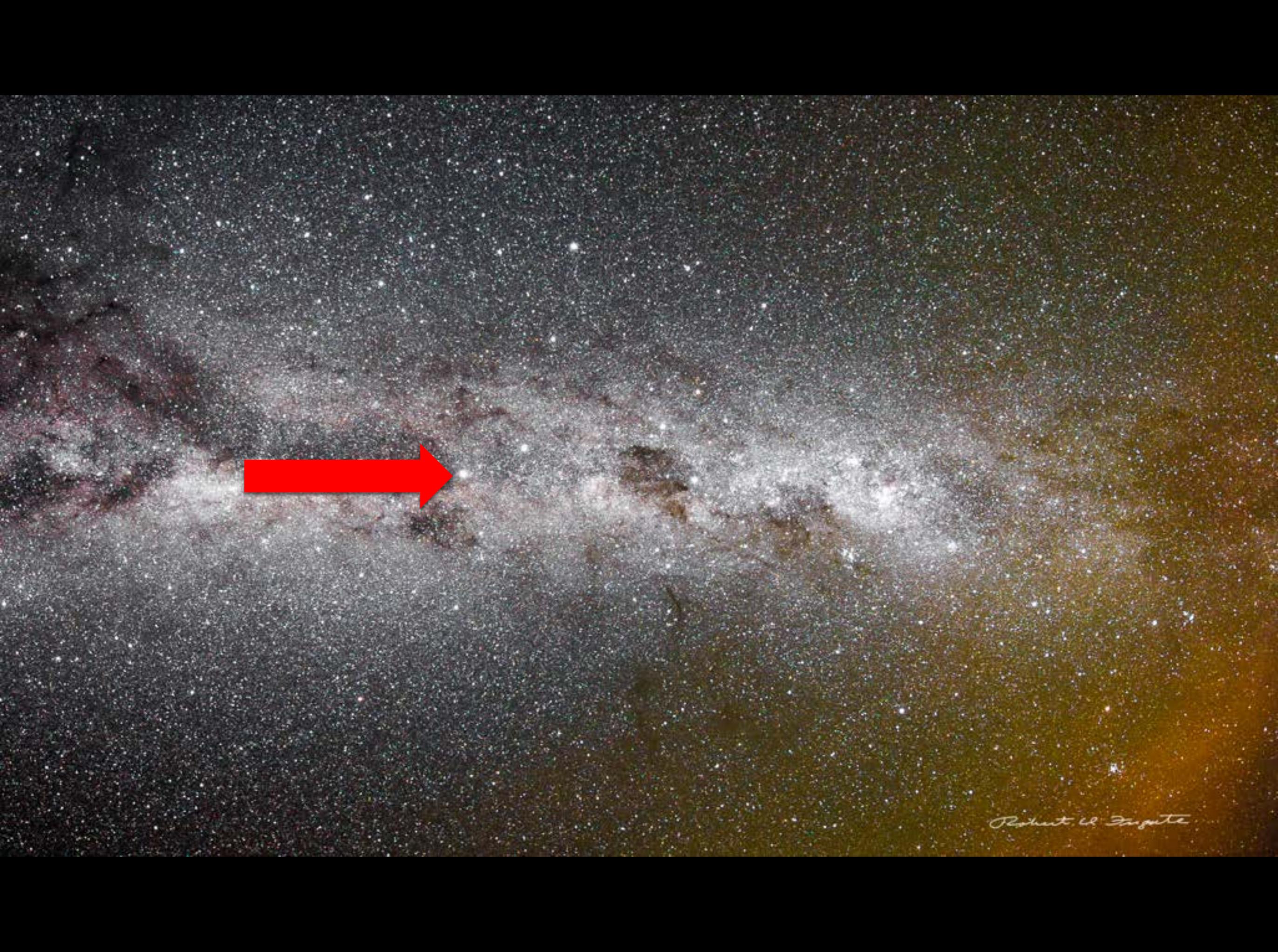
- **Breakthrough is private foundation with the charge to investigate Life in the Universe.**
- **All developed IP will be treated as work for hire unless expressly agreed to.**
- **Envision a period of exclusive use by the developing contractor then a transfer to free and open use for funded IP.**
- **All proprietary or confidential material will be protected as marked**

# Information for Bidders

- **Proposals may include all or part of the requested work**
- **Multiple awards are anticipated**
- **Deliverables are a final report documenting concepts, analyses, and simulations, and status and financial reports. No hardware is required – Phase 1 is a paper study**
- **Bidding is a two step process**
  - **Step A, 5 pages (evaluation may involve phone discussions and even site visits)**
    - **Evaluators are Harry Atwater, Kevin Parkin, Jim Benford and Pete Klupar**
  - **Step B by invitation, 15 pages - more detail, best and final**
    - **Other evaluators maybe included in discussions**
    - **Source Selection Authority Executive Director Breakthrough Starshot Foundation LLC**

# Information for Bidders

- **Evaluation Criteria**
  - **Demonstrated understanding of the problems**
  - **Evidence of innovation and creativity**
  - **Responsiveness to the requirements**
  - **Relevant past performance and experience, including applicable delivered hardware**
  - **Described path to operational system**
  - **Cost**
  - **In-kind contributions are encouraged**
  - **Minimizing Overheads charges is encouraged**
- **BT reserves right to make awards to bidders that provide the best value**
- **This is a commercial procurement we encourage discussions, If you have private questions please drop us a note.**



Robert W. Siegel

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9:00 – 9:30	Challenges for the Starshot Lightsail	Atwater
9:30 – 9:45	Lightsail Propulsion and Stability	Manchester
9:45 – 10:00	Questions	
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