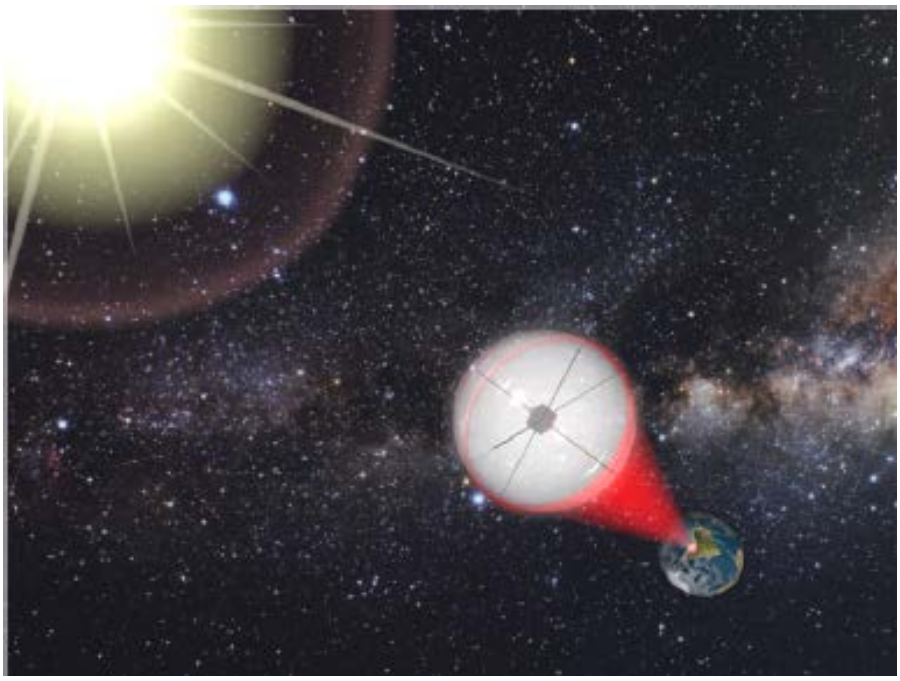
BREAKTHROUGH INITIATIVES

BREAKTHROUGH STARSHOT



LIGHTSAIL

REQUEST FOR PROPOSALS

Phase 1: Concepts and Analysis

SOLICITATION NUMBER: 2018-101

Issued: May 21, 2018
Step A Proposals Due: June, 22 2018 (5:00 pm PST)

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Key Information

Solicitation Name: Breakthrough Starshot LightSail Request for Proposals, Phase 1: Concepts and Analysis

Objective: **Develop and assess materials and stability approaches for the Starshot LightSail and Nanocraft with performance that meets Breakthrough Starshot mission objectives.**

Key Dates:
Draft RFP Pre-Release: April 23, 2018
Final RFP Release: May 21, 2018
Partnership Day/Bidder's Meeting: May 23, 2018
Step A Proposals Due: June 22, 2018
Step B Follow Up Invitations Issued: July 10, 2018
Selections: August 15, 2018
Awards: Anticipated summer 2018

Proposal Submission & Selection Process: Two-step Process; Step A is fully- open; Step B by invitation only

Award Details:
Approximate Award Duration: 10-12 Months

Expected Award Amount: Up to $300,000 USD, depending on the category of the work
Expected Number of Awards: Multiple, at discretion of Breakthrough Initiatives

Funding vehicles for awards: Contracts and grants

Selection Official: The Executive Director of the Breakthrough Initiatives will make award decisions, following the receipt of recommendations from the Starshot Sail committee

Point of Contact:
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Breakthrough Initiatives
NASA Research Park
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Request for Proposals
LightSail
Phase 1: Concepts and Analysis

Breakthrough Starshot

January 29th, 2018

1 Introduction and Project Overview

The Breakthrough Initiatives are a suite of scientific and technological programs investigating life in the Universe. This RFP focuses on the Breakthrough Starshot (https://breakthroughinitiatives.org/Initiative/3) initiative, a mission to send spacecraft to nearby stars. The concept is based on gram-scale vehicles ("Starchips") attached to meter-scale sails ("Laser/LightSails") (together called "Nanocraft") propelled to approximately 20% the speed of light by means of a gigawatt-scale ground-based laser ("Photon Engine"). The Starshot mission timeline consists of ~ 20-30 years to develop and build the system and ~ 20 years of interstellar flight, followed by data transmission back to Earth.

There are three main phases to the development project: (1) Technology Development, (2) Prototype Missions, and (3) Alpha-Centauri/Proxima-Centauri Missions. The overall objective of the Technology Development phase is to determine the feasibility of current and future technologies to meet the requirements to successfully conduct the Alpha Centauri/Proxima-Centauri Missions.

The Technology Development program for the LightSail is divided into three Phases: (1) concept investigation and analysis, which includes investigation of candidate LightSail materials and approaches to demonstrate a stable sail while under thrust (the subject of this RFP, Phase I); (2) validation of LightSail materials and stable sail designs via proof of concept demonstrations in the laboratory; and (3) laboratory testing of scalable prototypes, providing a path forward to a Prototype Mission with the goal of launching a Nanocraft to a target in the Solar System.

The five-year Technology Development phase will be managed by three committees: The Photon Engine committee, the Sail committee and the Systems Engineering committee.

The work funded by this RFP is focused on Phase 1, and will expand the knowledge base of viable component materials, photonic designs, and conceptual designs for the Starshot Nanocraft. This RFP is soliciting proposals for quantitative multiphysics models that can generate testable predictions of LightSail performance, mathematical models that define the conditions for LightSail stability, experimental methods for LightSail material fabrication, and precision measurements to validate optical, thermal and mechanical stability of materials under Starshot-relevant laser irradiation conditions.

The objectives of this RFP are to:

1. **Identify candidate LightSail materials and photonic designs that meets the Starshot mission objectives.**

Key issues and requirements for the LightSail materials include:

- Design of a reflector consistent with the mission requirement of achieving 0.2c for ~1g payload and LightSail area of >1 m^2
- Design of passive, adaptive or active features that enable or enhance stability, damage resistance, thermal robustness, and durability under deformation
- Assessment of candidate materials (including thin-films, micro/nanopatterned structures, 2D materials) for thermal/mechanical stability
- Development of measurement techniques and protocols for LightSail material properties (absorption, reflectivity, temperature, stress state, etc.)
- Identification of materials for which scale-up and manufacture at the >1 m^2 scale is feasible
- Materials that facilitate integration of the LightSail with the Starchip
- Development of the next generation Starchip scale spacecraft with a path towards incorporation into the Nanocraft

2. **Identify and assess designs of optimal shape at meter-scale of LightSail structures that are dynamically stable, thermally and mechanical durable during acceleration and which ensure safety of the payload.**

Key issues and challenges for the LightSail design and dynamic stability include:

- Validation via, e.g., multi-physics simulation (optical, mechanical, thermal, etc.) of LightSail durability and dynamic stability and sensitivity to Photon Engine laser propulsion beam geometry and ground demonstrations
- Evaluation of spacecraft stability in the context of a LightSail integrated with a Starchip payload
- Development of optimization-based tools for evaluating LightSail designs matched to corresponding laser beam profiles.
- Defining a roadmap for test and verification, including:
    - Measurement techniques for thin membranes at a small (<1 cm^2) scale
    - Developing diagnostics and instrumentation needed for LightSail stability measurements

2 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.

3 Information for Bidders

Bidders are encouraged to make proposals in either or both of the following Categories:

i) concept development and analysis
ii) analysis coupled to initial validation

This RFP is anticipated to result in multiple awards. Multiple awards are expected in the range from US$25,000 to US$150,000 for proposals in category i) and up to 2 awards ranging up to $300,000 are expected for proposals in category ii), depending on the scope of the proposed effort. The period of performance for Phase 1 is nominally 12 months.

The procurement is a two-step process, consisting of a short white paper proposal, evaluated by the Starshot LightSail committee and subject matter experts. The selection of finalists, invitation for final proposals, review of final proposals, recommendation for award(s), and contract negotiations will be performed by the Starshot LightSail committee.

Bidders are encouraged to contact Breakthrough during the proposal development process with questions or issues as they arise. We will make every attempt to respond as time permits.

Step A Proposal Process

Step A proposal document requirements:
Page limit: Five, 8.5” x 11” inch pages, 12-point font minimum
File format: Microsoft Word or PDF
Required Sections:
1. Technical approach. Includes a problem description/challenges with proposed solution.
2. Proposed effort scope and approach
3. Past performance, including description of facilities, personnel and relevant previous work.
4. Description of team qualifications and experience relative to proposed effort.
5. Brief Cost Proposal
6. A brief description on any proprietary conditions that limit the scope of the proposed effort or the ability of Breakthrough Initiatives to utilize the results obtained in the proposed effort.

Step B Proposal Process

Finalists selected from Step A proposals will be interviewed either in person, by site visit, or by video conference. If the interview is satisfactory, a Step B written proposal will be requested with more detail on the technical approach.

Step B proposal document requirements:
Page limit: Fifteen, 8.5x11 inch pages, 12-point font minimum
File format: Microsoft Word or PDF
Sections:
1. Technical approach. This includes a problem description and challenges with proposed solution
2. Proposed Statement of Work, including work tasks to be accomplished.
3. A detailed cost proposal indicating the personnel, equipment, materials and supplies, and total costs, including subtotals for all direct costs and indirect costs.
4. Optional Appendix section. This section is not counted in the page limit and is not considered in the evaluation of the proposal effort. It may be used to detail technical issues or provide more background on a particular topic that cannot be concisely cited via references to open literature.

Electronic copies of Step A and Step B proposals should be submitted to:

Pete Klupar
klupar@breakthrough-initiatives.org

Breakthrough Initiatives
NASA Research Park Building 18, Second Floor P.O. Box 1 Moffett Field, CA 94035-0001

Evaluation Criteria for Steps A and B
• Demonstrated responsiveness to and understanding of the challenges addressed by this RFP
• Evidence of innovation and creativity applied to the proposed effort
• Relevant past performance and experience of the team, including scientific accomplishments, application of scientific advances in delivered prototypes if applicable and specific examples of previous work.
• Reasonableness of the proposed costs relative to proposed staff
• Cost, including evidence of partnership and/or reuse of resources
• The Breakthrough Initiatives reserves the right to make awards to bidders that provide the best value to the project

Contract Management
It is the intent of the Starshot project to create and form partnerships with individuals, academia, and industrial organizations having like-minded motivation to achieve a lasting legacy for intelligent life on planet Earth, advancing human knowledge and helping answer -- "Are we Alone?" The Breakthrough Initiatives therefore, intends to be closely engaged during the performance of awarded contracts and grants to provide guidance, gauge progress, and understand the details of the work being performed. Deliverables for each award include quarterly progress reports, briefing material as needed, and a final written report and briefing presented to the Advisory Committee of the Starshot project.

4 Contract and Legal Agreements

A successful bidder will enter into a Research Contract with respect to the subsequent Technology Development activities. The contract will be with the Breakthrough Initiatives via its legal entity, the 'Breakthrough Starshot Foundation, LLC'. The terms and Conditions of the Research Contract shall include, among other matters, representations and warranties, payment terms, covenants regarding the stages of the project and delivery of progress reports, indemnification and liability matters, dispute resolution, termination procedures, covenants regarding confidentiality, publication and no-publicity, covenants regarding compliance with all laws and export control policies and the ownership and licensing of developed intellectual property.

All Intellectual property, proprietary data and export-controlled information with respect to such further research and development work will be clearly marked and handled according to applicable laws, rules and procedures as established by the U.S. government and other applicable governmental regulations, as well as Breakthrough Initiatives' policies.

All research and development activities of the Breakthrough Initiatives shall comply with all applicable U.S. export control laws and regulations as well as other applicable export controls of those nations where the research and development is conducted. The Breakthrough Initiatives requires all contractors to follow the Breakthrough Initiatives Export Compliance Program ("ECP") when conducting the research and development work.

5 References

1. "The Breakthrough Starshot System Model", (2018) K. L. G. Parkin, Link https://arxiv.org/abs/1805.01306
2. "Materials Challenges for the Starshot Lightsail" (2018) H.A. Atwater, A.R. Davoyan, O. Ilic, D. Jariwala, M.C. Sherrott, C.M. Went, W.S. Whitney and Joeson Wong, Nature Materials, https://doi.org/10.1038/s41563-018-0075-8
3. "Stability of a Light Sail Riding on a Laser Beam" (2016) Z. Manchester and A. Loeb. Link: https://arxiv.org/abs/1609.09506
4. "On The Stability Of A Sail Vehicle Riding On An Intense Laser Beam", E. Popova , M. Efendiev and I. Gabitov, Math. Meth. Appl. Sci. 2016, 40 1346–1354
5. "A Roadmap to Interstellar Flight" (2016) P. Lubin, Link: https://www.jbis.org.uk/paper.php?p=2016.69.40
6. "A terrestrial planet candidate in a temperate orbit around Proxima Centauri" (2016) Anglada-Escudé et. al. . Link: https://arxiv.org/pdf/1609.03449v1.pdf
7. "Beamed Energy Propulsion", AIP Conf. Proc. 664, A. Pakhomov, ed., (2003).