



BREAKTHROUGH INITIATIVES

BREAKTHROUGH STARSHOT

PHOTON ENGINE

REQUEST FOR PROPOSALS

Phase 1: Concepts and Analysis

SOLICITATION NUMBER: 2017-102

Issued: October 6, 2017

Proposals Due: November 3, 2017 (5:00 pm PST)

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Key Information

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

Objective: Develop and analyze a concept for phasing lasers that is scalable to the required size, power, and performance that meets Breakthrough Starshot (“Starshot”) mission objectives.

Key Dates:

Draft RFP Pre-Release: September 20, 2017
Partnership Day/Bidder’s Meeting: September 25, 2017
Final RFP Release: October 6, 2017
Step A Proposals Due: November 3, 2017
Step B Follow Up Invitations Issued: November 10, 2017
Selection Announcements: December 18, 2017
Awards: Anticipated winter 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 \$150,000 USD
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 Photon Engine committee

Point of Contact:

Pete Klupar
klupar@breakthrough-initiatives.org

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

Request for Proposals

Photon Engine

Phase 1: Concepts and Analysis

Breakthrough Starshot

October 6, 2017

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 project’s timeline consists of ~ 20-30 years to develop and build the system and ~ 20 years of interstellar flight, followed by approximately 4.3 years of data transmission back to Earth.

There are three main phases to the 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 evolving technologies to meet the requirements to successfully conduct the Alpha Centauri/Proxima-Centauri Missions.

The Technology Development phase for the photon engine is envisioned to last approximately five years and is divided into three activities: (1) concept investigation and analysis (the subject of this RFP); (2) hardware proof of concept demonstrations in the laboratory; and (3) field demonstrations to specific exit criteria in realistic atmospheric turbulence and environmental conditions, providing a path forward to a decade long Prototype Mission (the second main mission of the Starshot project) 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 to conceive and analyze one or more viable laser system architectures consisting of lasers, cooperative beacons, sensors, processors, photonics modules, wavefront controllers, optical subassemblies, tracking systems, and other required components and subsystems. These laser system architectures should provide performance predicted by scaled experiments, analysis and simulations which satisfy the Photon Engine requirements of the Starshot project. This RFP is soliciting proposals of innovative concepts, components, subsystems,

and system level designs employing advanced laser and atmospheric compensation technologies.

The objectives of this RFP are to:

- 1. Develop a theoretical concept for coherently combining lasers that is scalable in a practical way to the required size and power that meets mission objectives.**
- 2. Develop a path to single frequency amplifiers which could achieve orders of magnitude cost reduction in the final MOPA.**

Nominal Photon Engine

Performance based parameters for the Photon Engine:

- Run time: up to several hundred seconds at full power
- Nominal wavelength: 1060±20 nm (other wavelengths to be proposed)
- Location: Earth-based in the southern hemisphere
- Maximum beam irradiance at the sail: 8 GW/m² (TBR)
- Beam profile on the sail: Gaussian or ring-like symmetry, minimum in the center (TBD by Sail committee)
- Beam irradiance profile: ±30% (TBR) of the specified profile
- Total encircled power incident on sail: 30% of output power
- Laser pointing accuracy with respect to fixed stars: ±3.5 microradians
- Minimum range for sail illumination: 60,000 km
- Final sail velocity uncertainty: ±1.5% (TBR)
- Low cost systems approach

2 Scope and Tasks

The scope of this RFP addresses the first activity of the Technology Development phase - to design a theoretical laser system architecture with accompanying analysis and simulation that demonstrates a viable path to an operational system. Quantifying scalability is a prerequisite to any hardware demonstration.

3 Information for Bidders

Bidders are encouraged to make proposals on any or all of the following: an end-to-end architecture solution, a subsystem for a critical part of a total system, a component that advances a critical aspect of a system, or new methods for building optical phased arrays, signal processing, and analysis and simulation of the performance of such large-scale systems. Bidders are also encouraged to team with others having specialized skills.

This RFP is anticipated to result in multiple awards. Awards are expected to range from US\$25,000 to US\$150,000 depending on the contribution proposed.

The procurement is a two-step process, consisting of a short white paper proposal, evaluated by the Starshot Photon Engine 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 Photon Engine committee.

Step A Proposal Process

Step A proposal document requirements:

Page limit: Five 8.5x11 inch pages, 12-point font minimum

File format: Microsoft Word or PDF

Required Sections:

1. Technical approach. This includes a problem description and challenges with proposed solution.
2. Proposed work
3. Qualifications. Section may include description of facilities, personnel and relevant previous work.
4. Brief Cost Proposal

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. Best and final cost offer.
4. Optional bidders section. This section is not counted in the page limit and is not considered in the evaluation of the proposal. It may be used to detail technical matters or provide more background on a particular topic.

Written 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 understanding of the challenges addressed by this RFP
- Evidence of innovation and creativity applied to the proposed problems
- Relevant past performance and experience, including delivered hardware if applicable and specific examples of previous work

- Documented technical expertise of bidder and bidder's 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

"A Roadmap to Interstellar Flight" (2015) by Prof. Phil Lubin at UC Santa Barbara, a member of the Starshot Committee. Link: <http://arxiv.org/abs/1604.01356>

“Stability of a Light Sail Riding on a Laser Beam” (2016) by Prof. [Zachary Manchester](#) and Prof. Avi Loeb of Harvard University. Link: <https://arxiv.org/abs/1609.09506>

“A terrestrial planet candidate in a temperate orbit around Proxima Centauri” (2016) Prof. Anglada-Escudé et. al. . Link: <https://arxiv.org/pdf/1609.03449v1.pdf>