Notes and Information for Proposals to Software and Infrastructure for Sustained Innovation (SSE, SSI, S^{2}I^2) Program through the National Science Foundation (NSF)

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April 7, 2017

Abstract

The necessary information resources to create a proposal for the SSE, SSI and S^{2}I^2 NSF program is presented, with emphasis on developing proper contacts with relevant program officers in various NSF directorates. Important keywords are defined, as well as important NSF-related acronymns. This information is gleaned from the solicitation website[1] and the NSF resources referenced in the solicitation. Several insights are gained by reviewing the solicitation. First, there are already interdisciplinary initiatives with which this proposal should interact. One example is EarthCube, a large collaboration between data scientists and geoscientists. Second, there are many directorates involved, including physics (PHY), mathematics (DMS), and engineering (ENG). This implies that a successful proposal will address needs felt by researchers in those areas, and not just the needs of the ultra-high energy neutrino (UHE-ν) groups.

1   Relevant Acronymns and Definitions

This section contains acronymns defined in the solicitation, organized into three areas: the program targets, the NSF initiatives, and the relevant NSF directorates.

There are three program targets under this solicitation:

- SSE: *Scientific Software Elements.* SSE awards target small groups that will create and deploy robust software elements for which there is a demonstrated need that will advance one or more significant areas of science and engineering.

- SSI: *Scientific Software Integration.* SSI awards target larger, interdisciplinary teams organized around the development and application of common software infrastructure aimed at

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[1] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503489

solving common research problems faced by NSF researchers in one or more areas of science and engineering. SSI awards will result in a sustainable community software framework serving a diverse community or communities.

- S^2I^2: *Scientific Software Innovation Institutes.* This program target represents a large initiative to build a center of excellence for software design for many scientific frontiers. It is likely not a good fit for this project, but consultation of the solicitation is recommended.

There are several NSF initiatives involved in the solicitation:

- CIF21: *Cyber Infrastructure Framework for 21st Century.* See `https://www.nsf.gov/cise/aci/cif21/CIF21Vision2012current.pdf`

- SI^2: *Software Infrastructure for Sustained Innovation.* This is the name of the solicitation with the three program targets (SSE, SSI, S^2I^2)

- SWAMP: *Software Assurance Marketplace.* An external coding educational resource recommended in the solicitation, related to security.

- Software Carpentry: An additional educational resource recommended in the solicitation, related to teaching researchers to code.

  There are many NSF directorates and divisions mentioned in the solicitation:

- CISE: *Computer and Information Science, and Engineering/Advanced Cyberinfrastructure.* The NSF directorate, with several divisions mentioned in the solicitation.

- ACI: *Advanced Cyberinfrastructure.* A CISE division.

- CCF: *Computing and Communication Foundations.* A CISE division.

- NSCI: *National Strategic Computing Initiative.* A whole-of-nation effort to advance high performance computing (HPC) research. This initiative is newly connected to the usual SI^2 solicitation.

- MPS: *Mathematical and Physical Sciences.* An NSF directorate.

- PHY: *Division of Physics.* The physics division under MPS.

- DMS: *Division of Mathematical Sciences.* The math division under MPS.

- BIO: *Biological Sciences.* The biological sciences directorate. This directorate is mentioned in the solicitation, inviting biological researchers to submit proposals to further computing initiatives in biological research.

- EHR: *Education and Human Resources.* This is an NSF directorate supporting STEM education.

- ENG: *Engineering.* An NSF directorate.

- GEO: *Geosciences.* An NSF directorate.

2 Goals of this Project

Broadly, the goal of this project is to unify the design, building, and integration processes of Antarctic UHE-ν software. **The specific goals may be separated into three parts: scientific goals, engineering goals, and educational goals**. The scientific objectives are to boost our understanding of UHE-ν data by unifying and integrating the simulation tools, to generalize Askaryan emission models, to incorporate interdisciplinary geophysical techniques, and to provide insights to other scientific efforts by sharing both software and relevant data. The engineering objectives are to facilitate the interface between software and instrumentation, to develop database tools for storing key instrumentation information, and to streamline data-set production into forms accessible through the integrated software.

2.1 Scientific and Engineering Goals of the Project

The organizers of the project must agree upon an appropriate scope, to focus limited manpower resources on topics that maximize the chances of gaining an award. The following list is a starting-point, meant to be honed as time progresses.

1. This project represents an opporunity to direct man-power within ARA and ARIANNA to scientific software development for hardware modeling, Monte Carlo simulation, and finished data production. **The top priority of this project must be a complete, from-scratch re-write of all Antarctic Askaryan-based UHE-ν scientific software**. There are two groups of scientific goals within this branch:

   (a) Astroparticle physics based:

      i. The generalization and encapsulation of every Askaryan-effect model into a single set of modules, interchangeable within the broader code, must be accomplished

      ii. Models for UHE-ν production in the cosmos must be integrated, along with constraints from other experiments.

      iii. The software needs to be modular, and organized by a build system accessible to all researchers.

   (b) Interdisciplinary topics:

      i. Glaciological data incorporated into the software must be shaped into a data product that is shareable with projects such as EarthCube and CReSIS.

      ii. Conversely, the code must have the ability to incorporate data from projects such as EarthCube and CReSIS.

      iii. Antenna modeling results should be exportable to other areas of radio-frequency science, in a form readable by products such as NEC-4 and WIPL-D

      iv. Conversely, antenna modules within the code should accept standard characterizations of antennas created in external packages such as NEC-4 and WIPL-D

2. Achieving the following set of engineering and software design goals will boost the success of the project:

   (a) Data production from raw to finished product must be incorporated into the general design.

(b) Integration between simulated and acquired data structures must be accomplished.

(c) Hardware modeling, including database interfaces to measured hardware properties, must be incorporated.

2.2 Educational Outreach and Coding Support

The educational goal of this project should be to educate young researchers at the high-school and undergraduate level in the art of software design. This can be accomplished by professors and post-doctoral fellows tapping established workshops and resources, and those provided in the solicitation. There are two classes of educational goals: *internal education benchmarks*, and *outreach activities*.

1. Internal education benchmarks:

   (a) Students at participating institutions should be encouraged to participate in coding workshops and meetings not exclusively associated with astroparticle physics. Examples of such meetings and workshops are:

       i. CHEAPR2017

   (b) Students should be encouraged to share code and educate others at worshops and meetings associated with astroparticle physics, such as:

       i. IPA (IceCube Particle Astrophysics)
       ii. ARENA (Acoustic and Radio EeV Neutrino Detection Activities)

   (c) Students should be encouraged to take advantage of educational resources outlined in the solicitation, and to teach each other best practices through regular meetings:

       i. Software Assurance Marketplace
       ii. Software Carpentry
       iii. SoloLearn
       iv. Ohio Supercomputing Center Workshops (XSEDE workshops)

2. Outreach activities:

   (a) Holding coding workshops for high-school students (ASPIRE, QuarkNet)
   (b) Hosting workshops to advance knowledge of algorithms (CHEAPR2017)
   (c) Creating programs to teach computer programming to under-served populations

2.3 Imporant Motifs in the Solicitation, Connections to the Stated Goals

2.3.1 Reusability and Portability in Architecture Development

2.3.2 High-speed computations, and Massive Data Archives

2.3.3 Hardware interfaces to Embedded Sensors

2.3.4 Frontier Science, and Interdisciplinary Science

2.4 Decisions Regarding Manpower

This project will require all-levels of academic participation: professors, post-doctoral fellows, graduate students, and undergraduate students. Additionally, industry The following list of potential participants seeks to encompass all phases of the project:

- Lead professors: Jordan Hanson, Amy Connolly (Carl Pfendner, Stephanie Wissel). Consultation/Advice: Dave Seckel, Dave Besson

- Post-Doctoral Fellows: (Carl Pfendner), Anna Nelles, Cosmin Deaconu, Eric Oberla

- Graduate Students: Brian Clark, Oindree Banerjee, Jorge Torres Espinosa, Chris Persichilli, Yue Pan (Kaeli Hughes)

- Undergraduates: Jude Rajasekara, Hanah Hasan

- Non-academic consultation: Kai Staats (LIGO)

2.5 Decisions Regarding Institutions

This project requires participation from the following institutions:

- Ohio State University

- Whittier College

- UC Irvine

- University of Chicago

- Bartol Research Institution

2.6 Decision Regarding Specific Program to Target

The most likey program target for this solicitation is the SSI program, given that the SSE is a smaller initiative, and that the deadline for the SSE has passed. The larger program target is clearly too broad given the goals of this project.

3 Relevant Program Officers and Contact Information