



NASA Frontier Development Lab  
189 N Bernardo Ave #200, Mountain View, CA 94043, USA  
[www.frontierdevelopmentlab.org](http://www.frontierdevelopmentlab.org)

January 2, 2018

**Invitation for involvement:**  
**NASA Frontier Development Lab (FDL) 2018**

Dear Colleagues,

We are reaching out to solicit interest in the 2018 cycle of our FDL graduate workshop program based at NASA Ames Research Center and the SETI Institute in Mountain View, CA.

FDL, Frontier Development Laboratory, is an **applied artificial intelligence research program** that leverages NASA data and other open-source datasets, to surface new knowledge, accelerate new discoveries and support science workflows that are suited to applied AI techniques.

Visit <http://frontierdevelopmentlab.org> for more information and background

FDL is an international public-private partnership between NASA and commercial and academic partners such as IBM, Intel, Lockheed Martin, Kx Systems, USC, and Space Resources, Luxembourg. AI research efforts over the past three years have closely aligned with NASA's new directive to "lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities."

Over the past two years, FDL has successfully demonstrated the potential for interdisciplinary approaches at the Postdoc level, paired with public-private partnerships and sprint methodologies. Initial projects in planetary defense, space weather and lunar prospecting are delivering promising results. *For example:*

- The application of DL to detect c-class solar flares and better understand the salience of solar activity and Space Weather - crucial for future human spaceflight missions. ("FlareNet") (**Supported by Lockheed / IBM / KX**)
- The use of CNNs to automate the production of crater maps of the lunar poles - a requirement for prospecting these water-rich regions and future expansion of the human race into the solar system. (**Supported by Intel / Space Resources.lu**)

- Automation of 3D shape models of potentially hazardous asteroids from sparse 2D radar data, for better assessment of their orbits and center of mass. **(Supported by Nvidia / IBM)**
- Assessment of the most effective deflection strategies for moving a potentially hazardous asteroid on collision course with Earth. **(Supported by Nvidia)**
- Discovery of yet un-categorized meteor showers, which may suggest the presence of long-period comets that cross the orbit of Earth on millennial time scales. **(Supported by IBM / Nvidia)**
- Demonstration of AI as a tool for scientific progress, via ‘discovery’ of the (previously known) equatorial ring currents of Earth’s Magnetosphere. **(Supported by Lockheed / IBM )**



FDL researchers have shown the utility of breaking down complex problems using a broad-spectrum of AI techniques, such as DNNs, dimensionality reduction (t-SNEs), Variational Auto-Encoding (VAEs), adversarial approaches (GANs), bayesian optimization and decision trees, over extremely accelerated timeframes.

**It is this capacity to apply the ‘full stack’ of AI through interdisciplinary approaches to scientific workflows that, FDL exploits to achieve faster results and deeper levels of understanding.**

FDL 2018 is looking to build on the success of the first two years by repeating the formula with expanded research topic scope and improved hardware and AI tools from our commercial partners. Virtual briefings to help develop this year’s challenges, will take place in early January in preparation for a “Big Think” planning workshop to be held in Mountain View, CA on 1/25/2018.

The outputs of FDL 2016 & 2017 are available on [www.frontierdevelopmentlab.org](http://www.frontierdevelopmentlab.org)



***Your inputs are solicited:***

We invite you to support FDL's 2018 challenges in an advisory capacity and help shape the challenge definitions and build our expert network.

This request solicits suggestions for research challenge questions from the NASA and AI research communities, in the following domains:

**FDL 2018 Challenge Areas:**

- 1) Space Resources**
- 2) Orbital Debris / Space Traffic Management**
- 3) Space Weather**
- 4) Earth Observation**
- 5) Astrobiology**
- 6) NEOs: threats and opportunities**

Research questions and topics outside these domains will also be considered, provided they address critical problems for NASA with the prospect of delivering uniquely beneficial solutions.

The FDL Science Advisory and AI Technical Committees will review all submittals aligned to NASA's goals, focusing on proposals that can save critical time and resources for the Agency or private sector partners.

For each challenge question submitted, please address all of the following requirements:

- 1) Articulate the specific research question that should be considered and prioritized within the given domain - *required*
- 2) Identify the knowledge gaps that exist and what capabilities are missing in the domain that AI could help resolve, and state why these are important - *required*

- 3) Identify all available data sources relevant to the challenge question, where AI tools could be effectively applied to accelerate research - *required*
- 4) Identify by name and affiliation, potential mentors with appropriate expertise, who could support the research team and help ensure a quality work product – *optional*
- 5) Identify any PhD or postdoc researchers you know, who might be interested in participating in the program, with a view to support continuity for this work in the longer term. - *optional*
- 6) Based on your proposed topic, suggest corporations or academic institutions who might be approached as potential partners for the program and identify any points of contact you may have within these organizations. – *optional*

Required items 1) through 3) must be submitted on single page 8.5" x 11" or A4 document. Optional items 4) through 6) may be included, or submitted on a separate single page.

**You can support FDL 2018 in the following ways:**

- a. Submit your Ideas on opportunities for leveraging AI in the above Challenge Areas per the guidelines above
- b. Suggest Mentors, Postdocs, institutions or commercial organizations, who can provide deep domain background and continuity.
- c. Participate in a series of conference calls in early January to discuss opportunities and exchange ideas
- d. Join our “Big Think” workshop in Mountain View, CA on 1/25/2018
- e. Support the FDL program as a mentor, advisor or guest speaker during the workshop research lab phase, over the Summer of 2018

**FDL 2018 Schedule:**

Challenge Definition phone calls - January 2018

Big Think 1/25/2018 - finalize Challenge Focus - January/February 2018

Post formal *Call for Researchers* - February 2018

Select Researchers and Mentors - April 2018

Lab Phase, Mountain View, CA – Late June through August, 2018

Presentation of results to review panels – Late August 2018

Follow-on Planning and research continuity, (publications, conference participation,

Preparation of *Proceedings* document - October & November 2018

Final Report and submission of Proceedings - December 2018

Presentation at NIPS in Montreal – December 3 – 8, 2018

**We welcome your inputs by the 22nd of January 2018.**

**Point of Contact:**

Lisa Vestal, lisa.d.vestal@nasa.gov, 650-604-1857

NASA Ames Research Center

**Thank you.**

**Madhulika Guhathakurta (Lika) , PhD**

Lead Program Scientist for New Initiatives

Exploration Technology Directorate, NASA Ames Research Center

Madhulika.Guhathakurta@nasa.gov

**Daniel J. Rasky, PhD**

Chief, Space Portal Office

Senior Scientist/Engineer, NASA Ames Research Center

daniel.j.rasky@nasa.gov

**James Parr**

Director, NASA Frontier Development Lab

james@frontierdevelopmentlab.org

**Bill Diamond**

CEO, The SETI Institute

189 N Bernardo Ave #200, Mountain View, CA 94043, USA

bill.diamond@seti.org

Example:

### **AI and Orbital Debris and Space Traffic Management (STM)**

FDL is looking to explore opportunities to apply AI to the pressing challenges in Space Situational Awareness (SSA), Orbital Safety, LTSSA, and STM. Although the exact challenge has yet to be defined, FDL already has an investment in AI-assisted space weather inference that we could bring into the mix for STM to link to space objects and infer natural causes behind observed patterns of dynamic behavior of orbital objects.

Initial ideas include developing DNNs trained on physical models to learn and characterize debris features, such as vectorized energy and momentum states and other parameters (such as solar-terrestrial interactions) to develop behavioral ontologies. Integrating machine learning classifiers and probabilistic reasoning would enable decision intelligence style work product similar to those already demonstrated by FDL for Planetary Defense.