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Guide to FY2014 Research Funding at the National Aeronautics and Space Administration (NASA)

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Executive Summary and Index

This document provides succinct insights into the various NASA funding opportunities for University research, with special attention to significant changes anticipated in FY2014. NASA's mission is to pioneer the future in space exploration, scientific discovery, and aeronautics research. Funding for university research at NASA is principally distributed among the four - Science, Aeronautics, Human Exploration and Operations, and Space Technology – Mission Directorates. As a primary premise for research funding, NASA is only interested in work that utilizes or contributes to its space or airborne assets, or the data derived from them. More information on the NASA opportunities, including the NASA charts identified in the following text, is provided at the Central Desktop "Mission Agency Program Summary" (MAPS) website.

Descriptive of NASA basic research funding opportunities pages 2-10
An overview of the NASA headquarters directorate/office and NASA Center-based funding opportunities pertinent to Universities.

Table 1: FY09/11 NASA basic and applied research funding at Universities (~$400M/yr) 8

Table 2: FY2014 requested R&D funding in programs pertinent to Universities 9-10

Appendix 1: FY2014 New Programs and/or Significant Change
While the NASA budget request shows level funding compared to FY2012, there are some selected programs showing significant growth in FY2014:

	Projected Funding ($M)	page(s)
Earth Science Technology	From 51 in FY2012 to 55	11
Planetary Science Research and Analysis	From 174 in FY2012 to 221	11
Human Research Program	From 158 in FY2012 to 165	11
Advanced Exploration Systems	From 145 in FY2012 to 199	11
Crosscutting Space Technology Development	From 184 in FY2012 to 278	11
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Overview

NASA's mission is to pioneer the future in space exploration, scientific discovery, and aeronautics research. Funding for university research at NASA is principally distributed among four directorates, each with its own particular research interests:

Science Mission Directorate (SMD)
Focus: the frontiers of earth science, heliophysics, planetary science, and astrophysics.
Aeronautics Research Mission Directorate (ARMD)
Focus: research in traditional aeronautical disciplines and emerging fields to help transform the nation's air transportation system and future air and space vehicles.
Human Exploration and Operations Mission Directorate (HEO)
Focus: develop capabilities and supporting research and technology that will make human and robotic exploration possible
Space Technology Mission Directorate (STMD)
Focus: develop and demonstrate advanced space systems concepts and technologies

As a primary premise for research funding, NASA is only interested in work that utilizes or contributes to its space or airborne assets, or the data derived from them. Each of the Directorates has continuing research programs. Research opportunities appropriate to University PIs are advertised through NASA research announcements (NRAs). NSPIRES (nspires.nasaprs.com/external/) is the NASA website through which announcements can be accessed and proposals submitted. Those announcements are amended periodically during the fiscal year to open additional, or modify existing, topics. Not all topics are competed in any given year.

Useful guidance on proposal preparation is provided at the website Service and Advice for Research and Analysis (SARA, http://science.nasa.gov/researchers/sara/how-to-guide/). Proposers may opt to submit proposals in response to NASA NRAs via either of two different electronic proposal submission systems: either the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) (http://nspires.nasaprs.com), or the Grants.gov (http://www.grants.gov). Paper submission is not accepted. Peers of the proposing personnel will be used to assess the proposal using the criteria:

intrinsic scientific and technical merit,
relevance to NASA's stated objectives, and
cost realism.

For further details on these criteria and their relative weights see Appendix C.2 of the *NASA Guidebook for Proposers* (www.hq.nasa.gov/office/procurement/nraguidebook). In addition, a given program may have specific guidance incorporated into its announcement.

Table 1 shows data on the NASA funding to University/College by academic discipline for FY2009 and FY2011 (the most recent available). In addition to basic research (which correlates with the NASA Technology Readiness Levels 1-2, NASA also funds applied research (TRLs 2-3), and advanced technology demonstration (TRLs 3-5). The NASA research budget has declined somewhat since 2006 (but innovative technology funding has grown significantly). The NASA FY2014 budget lines more closely associated with University PI research are shown in Table 2, parsed vertically by the identified Directorate program.

Science Mission Directorate (SMD) http://science.nasa.gov/
NASA's Science Mission Directorate conducts scientific exploration that is enabled by access to space. It projects humankind's vantage point into space with observatories in Earth orbit and deep space, spacecraft visiting the Moon, and other planetary bodies, and robotic landers, rovers, and sample return missions.

Broadly defined, research and analysis (R&A) covers the concept studies that provide the science basis for a mission, the necessary technology and techniques for implementing the mission, the calibration, validation, and analysis of data as a mission is underway, and the analysis of archived data after a mission ends. Dr. Max Bernstein, formerly of the NASA Ames Research Center, now focuses specifically on the operation and balance of the SMD's Data Analysis, Research, and Technology Development programs.

Most calls for proposals from SMD can all be found in the omnibus solicitation, called Research Opportunities in Space and Earth Science (ROSES, Research Announcement NNH13ZDA001N for 2013). A SMD website (nasascience.nasa.gov/researchers/) and a RSS feed provide up-to-date changes for the ROSES NRA. The website also provides a listing of the various program managers (and contact information). (See NASA Charts 8-18)

The 2013 ROSES NRA itemizes some 80 topics (each as its own appendix) and provides a table that specifies the due dates for notice of intent (NOI – not always required) and proposal submission (see NASA charts 8-18). Awards range from under $100K per year for focused, limited efforts (e.g., data analysis) to more than $1M per year for extensive activities (e.g., development of science experiment hardware). The usual maximum period of performance is four years. It is possible for funded performers to reapply at the end of their project; those applications will be competed with neither advantage nor disadvantage.

The Stand Alone Mission of Opportunity Notice (SALMON, NNHI2ZDA006O for 2012) announcement of opportunity (AO) is intended to provide opportunities for science and technology investigations on space flight missions that advance the high priority science, technology, and exploration objectives of NASA's Mission Directorates. (See NASA chart 19)

Aeronautics Research Mission Directorate (ARMD) http://www.aeronautics.nasa.gov/
NASA's Aeronautics Research Mission Directorate (ARMD) works to solve the challenges that still exist in our nation's air transportation system: air traffic congestion, safety and environmental impacts. NASA's ARMD pursues the development of new flight operation concepts, and new tools and technologies that can transition smoothly to industry to become products.

The Research Opportunities in Aeronautics (ROA), NRA NNH13EA001N for FY2013, identifies competitions for five ARMD programs: Fundamental Aeronautics Program; Aviation Safety Program; Airspace Systems Program; Integrated Systems Research Program; and the Aeronautics Strategy and Management Program. The typical period of performance for an award is three years, although a few programs may specify shorter or longer (maximum of five years) periods. (See NASA charts 20-22)

NASA's Fundamental Aeronautics Program http://www.aeronautics.nasa.gov/fap/index.html
NASA's Fundamental Aeronautics Program (FAP) works to enable a future where a variety of advanced aircraft exist that improve the flexibility, efficiency and environmental impact of air travel. The FA Program consists of four research projects.

- The Fixed Wing Project explores and develops technologies and concepts for improved energy efficiency and environmental compatibility of fixed wing, subsonic transports.
- The Rotary Wing Project develops and validates tools, technologies and concepts to overcome key barriers for rotary wing vehicles.
- The High Speed Project enables tools, technologies and validation capabilities necessary to overcome environmental and performance barriers to practical civil supersonic airliners.
- The Aeronautical Sciences Project enables fast, efficient design and analysis of advanced aviation systems by developing physics-based tools and methods for crosscutting technologies.

Human Exploration and Operations Mission Directorate (HEO)
http://www.nasa.gov/directorates/heo/home/index.html
HEO provides the Agency with leadership and management of NASA space operations related to human exploration in and beyond low Earth orbit. Exploration activities beyond low Earth orbit include the management of Commercial Space Transportation, Exploration Systems Development, Human Space Flight Capabilities, Advanced Exploration Systems, and Space Life Sciences Research & Applications.

Research opportunities in human research come available both directly through the Human Research Program (HRP, humanresearch.jsc.nasa.gov/) and the National Space Biomedical Research Institute (NSBRI, www.nsbri.org/Announcements/). The NSBRI is a nonprofit consortium funded by the HRP. The total annual cost (direct and indirect costs) for a NASA NRP award averages $350K and cannot exceed $400K; the typical duration is three years. (See NASA charts 23-25).

Space Technology Mission Directorate (STMD)
http://www.nasa.gov/directorates/spacetech/home/index.html
STMD rapidly develops, demonstrates, and infuses revolutionary, high-payoff technologies through transparent, collaborative partnerships, expanding the boundaries of the aerospace enterprise. (See NASA charts 26-30).

Space Technology Research Grants: Space Technology Research Opportunities (STRO)
http://www.nasa.gov/directorates/spacetech/strg/archives_stro.html
The Space Technology Research Grants Program is accelerating the development of "push" technologies to support the future space science and exploration needs of NASA, other government agencies, and the commercial space sector. Innovative efforts with high risk and high payoff are encouraged. The Program is composed of two competitively awarded components: STRO Early Career Faculty and STRO Early Stage Innovations Opportunities.

NASA Innovative Advanced Concepts (NIAC)
http://www.nasa.gov/directorates/spacetech/niac/index.html
NIAC projects study innovative, technically credible, advanced concepts that could one day "Change the Possible" in aerospace. The NRA NNH13ZUA001N solicits Phase II studies, each of which will investigate an architecture, mission, or system concept with the potential to enable a great leap in space or aeronautics; a Phase I solicitation is expected in FY2014.

The Game Changing Technology Program http://www.nasa.gov/directorates/spacetech/game_changing_development/index.html
The Game Changing Development (GCD) program investigates novel ideas and approaches that have the potential to revolutionize future space missions and provide solutions to significant national needs. GCD will identify and rapidly mature innovative, high-impact capabilities and technologies and complement them with "new start" and competitively selected projects by using a balanced approach of guided technology development efforts and competitively selected efforts from across NASA, academia, industry and other government agencies. GCD work is done primarily in the laboratory with ground testing instead of space work.

Small Spacecraft Technology Program
http://www.nasa.gov/directorates/spacetech/small_spacecraft/index.html
This program undertakes both development of small spacecraft technologies and flight demonstrations of new technologies, and does not perform operational missions with small spacecraft.

Office of the Chief Technologist (OCT)
http://www.nasa.gov/offices/oct/about_us/index.html
The Office of the Chief Technologist (OCT) is responsible for the coordination and tracking of all technology investments across the agency. The office is responsible for developing and executing innovative technology partnerships, technology transfer and commercial activities and the development of collaboration models for NASA.

Office of Education
(http://www.nasa.gov/offices/education/contacts/hqdirectory.html)
In support of the Administration's FY 2014 STEM education plan, NASA's education efforts will be fundamentally restructured into a consolidated education program funded through the Office of Education, which will coordinate closely with the Department of Education, the National Science Foundation, and the Smithsonian Institution. Starting in FY 2014, mission-based K-12 education, public outreach, and engagement activities, traditionally funded within programmatic accounts, will be incorporated into the Administration's new STEM education paradigm in order to reach an even wider range of students and educators. The projects within the STEM education and accountability (SEA) Program are: the Minority University Research and Education Project (MUREP), and the STEM Education and Accountability Project. The FY2013 solicitation, NRA NNH13ZHA002N, is limited to Minority University Research and Education. The National Space Grant College and Fellowship Program (Space Grant) is a competitive grant opportunity project, enabling the active involvement of the entire country in NASA activities.

Young (Early Career) Investigators
The SMD has a New (Early Career) Investigator Program (NIP, Appendix A.34 in ROSES 2013).

Proposers must: a) be a U.S. citizen or have lawful status of permanent residency (i.e., holder of a U.S. Permanent Resident Card, also referred to as the Green Card), and b) be a recent Ph.D. recipient, defined as having graduated on or after January 1 of the year that is no more than five years before the issuance date of the NRA. The award range is between $80-$120K per year for a period of up to three years. The selected Fellows have the opportunity to apply directly to the Early Career Fellowship program for up to $100K in start-up funds when they obtain a tenure-track or equivalent position. There are also an Early Career Fellowship program for Planetary Science (See Appendix C.21 in ROSES 2013), and the Space Technology Research Opportunities for Early Career Faculty
http://www.nasa.gov/offices/oct/stp/strg/2012_space_tech_research_opps.html.

Teaming Research Efforts
NASA does not normally have the equivalent of the DOD Multidisciplinary University Research Initiative (MURI) program or the various NSF Center competitions. Occasionally NASA competes center-scale efforts, such as the National Center for Advanced Manufacturing (Marshall Space Flight Center in concert with Univ. of New Orleans) and the now defunct NASA University Research, Engineering & Technology Institutes (URETI).

University Instrumentation
NASA does not have an equivalent of the NSF Major Research Instrumentation or DOD Defense University Research Instrumentation Program. The SMD has a Planetary Major Equipment (PME) topic where proposals may be submitted in conjunction with new science research proposals to ROSES or as an augmentation to Planetary Science Research Program multiple year awards. Instrumentation purchases or upgrades that may be requested through this program are to be over $40K. Cost-sharing and substantial institutional contributions are encouraged but not required of Universities. The annual budget is ~$1.5M with 5-10 awards typical.

High End Computing (www.hec.nasa.gov/)
SMD provides a specialized computational infrastructure to support its research community (NASA sponsored scientists/engineers), managed by NASA's High-End Computing (HEC) program. A proposal should include identification of the computing system and location, rationale and justification of the need, how it supports the investigation, when the resources will be required, and an estimate of needed processor hours and storage capacity. Computing time awards are for one year and nontransferable.

NASA Laboratory/Center Opportunities
In addition to the NASA headquarters solicitations, there are occasions when the NASA Centers themselves provide support to Universities/University students. Examples include:
Jet Propulsion Laboratory http://surp.jpl.nasa.gov/collaborations/2012surpcallguidelines/
Glenn Research Center https://rt.grc.nasa.gov/main/university-affairs/
Ames Research Center http://www.nasa.gov/centers/ames/education/index.html
Johnson Space Flight Center
http://www.nasa.gov/centers/johnson/external_relations/university/about_urao.html

Resources
NASA e-mail alerts for ROSES clarifications/corrections/amendments
http://science.nasa.gov/researchers/sara/grant-solicitations/roses-2013/
NASA open solicitations are posted at:

http://nspires.nasaprs.com/external/solicitations/solicitations.do?method=open&stack=push

For access to the information on the Research Advancement's Central Desktop website **Mission Agency Program Summary (MAPS)**, contact NLWalker@usc.edu for user name and password.

The MAPS site has:

Under "Wiki" Tab - how to use the site

Under "Files/Discussion" Tab

- Mission Agency (DHS, DOD, DOE, ED, EPA, NASA, NIST, NOAA and various cross-agency programs in Adv Manuf, Sustainability, STEM Education)
  - Guide to Agency Funding for FYXX
  - Agency Research Funding (charts)
  - Agency Planning Documents
  - Program Officer Data sheets (with contact info, biosketch, program descriptive, personal pubs)
  - Program Officer presentations (when available)

Under "Database" Tab

- USC MAPS - table of all program officers / programmatic interest

The file labeled "Agency (NASA) Research Funding" at the Central Desktop MAPS website provides a compilation of numbered charts with detailed information on the various NASA funding agencies; the various program interests; the program managers, their research interests and contact information; and how to best navigate the agency websites. Chart numbers in the text above reference that file. In addition, at the website there are other useful reports/presentations, a database to identify program officer interests, and program officer data sheets (see illustration in Appendix 2). If you are interested in exploring an opportunity, contact with the appropriate NASA program officer is strongly recommended.

Assistance in Locating Funding and Preparing Proposals

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Table 1: FY2009 and FY2011 NASA Research Funding ($M)
Obligations for Research Performed at Universities/Colleges

	2009		2011	
	Basic	Applied	Basic	Applied
TOTAL NASA ($M)	**1022**	**682**	**1021**	**731**
TOTAL University Performer	**327**	**91**	**332**	**99**
Physical Sciences	**129**	**9**	**131**	**10**
Astronomy	80.0	6.0		
Chemistry	6.0	0.3		
Physics	37.3	2.2		
Other	5.8	0.4		
Environmental Sciences	**93**	**14**	**94**	**15**
Atmospheric	57.0	9.7		
Geological	23.1	1.0		
Oceanology	0.57	2.6		
Other	0.76	0.8		
Mathematics and Computer	**3**	**3**	**3**	**3**
Computer Sciences	2.4	0.7		
Mathematics	0.2	0.1		
Other	0.7	1.7		
Engineering	**61**	**58**	**61**	**63**
Aeronautical	38.4	36.6		
Astronautical	9.2	9.0		
Chemical	0.4	0		
Civil	0	0		
Electrical	1.9	0.5		
Mechanical	1.3	0.3		
Metal/Materials	2.1	0.1		
Other	7.3	1.2		
Life Sciences	**14**	**7**	**15**	**8**
Agriculture	0.1			
Biological	9.3	2.2		
Environmental	0.7	0.2		
Medical	2.0	4.1		
Other	2.4	0.3		
Psychological	**0.6**	**0.6**	**0.6**	**0.6**
Social Sciences	**0.1**	**0**	**0.1**	**0**
Other Sciences	**2.7**	**0.6**	**27**	**0.6**

From NSF "Federal Funds for Research and Development: FY2009-2011," NSF 12-318, July 2012

Basic Research	2009	Tables 65 and 68-71
Applied Research	2009	Tables 73 and 76-79
Basic Research	2011	Table 67
Applied Research	2011	Table 75

Table 2: NASA Budget Request for FY2014
(University Pertinent Items)

	Directorate/Topic	2014 ($M Req)			2012 ($M Actual)		
SMD Heliophysics		**654**			**645**		
	Heliophysics Research		196			167	
	Research and Analysis			33			33
	Sounding Rocket Operations			52			52
	Other Missions and Data Analysis			90			61
	Living with a Star		216			196	
	Other Missions and Data Analysis			56			124
	Heliophysics Explorers		95			66	
	Other Missions and Data Analysis			95			66
SMD Astrophysics		**642**			**648**		
	Astrophysics Research		148			166	
	Research and Analysis			66			69
	Balloon Project			33			32
	Other Missions and Data Analysis			65			49
	Cosmic Origins		240			228	
	Other Missions and Data Analysis			57			44
	Physics of the Cosmos		110			108	
	ExoPlanet Exploration		55			51	
	Astrophysics Explorer		101			83	
	Other Missions and Data Analysis			101			83
SMD Planetary Science		**1218**			**1501**		
	Planetary Science Research		221			174	
	Research and Analysis			130			122
	Other Missions and Data Analysis			46			27
	Near Earth Object Observations			40			20
	Lunar Quest		18			140	
	Lunar Science			15			67
	Lunar Atmosphere and Dust Explorer			2			70
	Surface Science Lander Technol			0			3
	Discovery		258			173	
	New Frontiers		258			144	
	Other Mission and Data Analysis			39			44
	MARS Exploration		234			587	
	Other Mission and Data Analysis				184		341
	Outer Planets		79			122	
	Technology		151			162	
SMD Earth Science		**1846**			**1766**		
	Earth Science Research		443			441	
	Research and Analysis			329			333
	Computing and Mgmt			115			108
	Earth Systematic Missions		788			881	
	Other Missions and Data Analysis			415			406
	Earth System Science Pathfinder		354			188	
	Other Missions and Data Analysis			60			41
	Earth Science Multi-Mission Operations		172			169	

	Earth Science Technology		55			51	
	Applied Sciences		35			36	
Aeronautics		566			570		
	Fundamental Aeronautics		168			186	
Exploration		3916			3707		
	Human Research Program		165			158	
Space Technology		743			575		
	Cross cutting Space Technol Devel		278			184	
	Exploration Technology Development		245			190	

Appendix 1: New Project or Significant Change in FY2014

Science Mission Directorate (SMD) From $5079M in FY2012 to $5018M
In FY 2014, in response to solicitations in Research Opportunities in Space and Earth Sciences 2013 (ROSES-13) and ROSES-12, NASA anticipates awarding over 85 new 3-year investigations.

Earth Science Technology (EST) From $51M in FY2012 to $55M
The ESTO anticipates the release of both Advanced Component Technologies (ACT) and Advanced Information Systems Technology (AIST) solicitations during FY 2014, which will focus on technologies to enable future missions and help improve science data analysis.

Planetary Science Research and Analysis From $174M in FY2012 to $221M
In FY 2014 NASA will aggressively pursue an expanded Near Earth Orbit (NEO) observation program that will increase the detection and characterization of NEOs of all sizes by increasing the observing time on ground-based telescopes such as PanSTARRs. In support of the future human mission to an asteroid, the Science Mission Directorate and the Human Exploration and Operations Mission Directorate will release a joint Announcement of Opportunity for a space-based NEO infrared telescope.

Human Research Program (HRP) From $158M in FY2012 to $165M
In FY 2014, HRP will complete and test a prototype individualized stress detection system, which will track physiological signals (heart rate and rate variability) and behavioral signals (sleep-wake patterns) to detect chronic stress, high anxiety, and insomnia during space missions. Another key activity is a new pressure swing adsorption technology.

Advanced Exploration Systems (AES) From $145M in FY2012 to $199M
AES will begin addressing the technical barriers to successfully deploying an asteroid capture mechanism, which will include development of several potential design concepts, an analysis of alternatives, and downselect to an option for proof-of-concept ground demonstrations, including structural integrity testing.

Crosscutting Space Technology Development From $184M in FY2012 to $278M
Space Technology has combined the Edison and Franklin programs into the Small Spacecraft Technology program. Increased funding supports early stage concepts and technologies useful for asteroid detection, characterization, proximity operations, mitigation, and resource utilization. NASA will initiate new Phase I NIAC awards and further develop the most promising concepts for Phase II NIAC studies. Initiate at least two new Centennial Challenges, including one relevant to near Earth asteroid detection, characterization and mitigation efforts.

Exploration Technology Development (ETD) From $190M in FY2012 to $245M
Within ETD, FY 2013 program activities and FY 2014 plans have been organized into several human exploration-specific Game Changing Development projects: Solar Electric Propulsion Technologies; Next-Generation Life Support; Human-Robotic Systems; Composite Cryogenic Propellant Tanks; Energy systems Technologies; and In–Space Power.

Appendix 2: Example (abbreviated) Program Officer Data Sheet

Dr. Madhulika (Lika) Guhathakuta
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Biosketch:
As a NASA astrophysicist, Dr. Madhulika Guhathakurta (also known as Lika) has had the opportunity to work as a scientist, mission designer, instrument builder, directing and managing science programs and teacher and spokesperson for NASA's mission and vision in the Heliophysics Division. Also Research Associate Professor with Catholic University of America. She has been a Co-Investigator on five Spartan 201 missions and has authored over 70 publications.

Education
BS in physics from Delhi Univ, India
MS in physics and astrophysics from Delhi Univ, India
Ph.D. in Physics from University of Denver and Univ of Colorado at Boulder

Program:
NASA ROSES 2012
Appendix B6: Living with a Star Targeted - Research and Technology
The goal of NASA's Living With a Star (LWS) Program is to develop the scientific understanding needed for the United States to effectively address those aspects of Heliophysics science that may affect life and society.

Appendix B7: Living with a Star Targeted Research and Technology - Strategic Capability
A primary goal of NASA's Living With a Star (LWS) Program is the development of first principles-based models for the coupled Sun-Earth and Sun-Solar System, similar in spirit to the first-principles models for the lower terrestrial atmosphere.

Illustrative Papers Reflecting Personal Research Interests:
Semiempirically derived heating function of the corona heliosphere during the Whole Sun Month
Guhathakurta M.; Sittler E. C. Jr.; Ofman L.
J OF GEOPHYSICAL RESEARCH-SPACE PHYSICS 111(A11), Article N0: A11215 2006

The large-scale density structure of the solar corona and the heliospheric current sheet Guhathakurta M; Holzer TE; MacQueen RM
ASTROPHYSICAL JOURNAL 458(2), 817-831 FEB 20 1996

Appendix 3: Acronym Glossary

ACT	Advanced Component Technologies (ESTO Program)
AES	Advanced Exploration Systems
AIST	Advanced Information Systems Technology (ESTO Program)
AO	Announcement of Opportunity
ARCD	Aerospace Research and Career Development
ARMD	Aeronautics Research Mission Directorate
DHS	Department of Homeland Security
DOD	Department of Defense
E/PO	Education and Public Outreach
EPA	Environmental Protection Agency
ESD	Exploration Systems Development Division (in HEO)
ESM	Earth Systematic Missions
ESTO	Earth Science Technology Office (in SMD)
ETD	Exploration Technology Development (program in STMD)
FAP	Fundamental Aeronautics Program (in ARMD)
HEC	High end Computing
HEO	Human Exploration and Operations Mission Directorate
HRP	Human Research Program
GCD	Game Changing Development
GNSS	Global Navigation Satellite System
GOES	Geostationary Operational Environmental Satellite
HRP	Human Research Program (in HEO Directorate)
LWS	Living with a Star
MO	Missions of Opportunity
MUREP	Minority University Research and Education Project
MURI	Multidisciplinary University Research Initiative (DOD program)
NASA	National Aeronautics and Space Administration
NEO	Near Earth Orbit
NIAC	NASA Innovative Advanced Concepts (program in STMD)
NIP	New (Early Career) Investigator Program
NIST	National Institute for Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOX	Nitrogen oxides
NRA	Notice of Research Opportunity
NSBRI	National Space Biomedical Research Institute
NSPIRES	NASA Solicitation and Proposal Integrated Review and Evaluation System
NSF	National Science Foundation
OCT	Office of the Chief Technologist
PCOS	Physics of the Cosmos
PME	Planetary Major Equipment
POES	Polar Operational Environmental Satellite
R&A	Research and Analysis
R&D	Research and Development
RALV	Reliable Air breathing Launch Vehicles
ROSES	Research Opportunities in Space and Earth Sciences (NRA for SMD)
ROA	Research Opportunities in Aeronautics (NRA for ARMD)

SALMON	Stand-alone Missions of Opportunity Notice (from SMD)
SARA	Service and Advice for Research and Analysis (NASA website)
SEA	STEM Education and Accountability
SMD	Science Mission Directorate
STMD	Space Technology Mission Directorate
STP	Solar Terrestrial Probes
STRG	Space Technology Research Grants (program in STMD)
STRO	Space Technology Research Opportunities
TRL	Technology Readiness Level
URETI	University Research, Engineering & Technology Institutes

Technology Readiness Levels and Manufacturing Readiness Levels
(from the DARPA Transition Guide 2010)

Technology Readiness Level	Description
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Example might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of 'ad hoc' hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include 'high fidelity' laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and 'flight qualified' through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system 'flight proven' through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

Hardware (HW) and Software (SW)

Technology Readiness Level	Description
1. Basic principles observed and reported	**HW/S:** Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties. **SW:** Lowest level of software readiness. Basic research begins to be translated into applied research and development. Examples might include a concept that can be implemented in software or analytic studies of an algorithm's basic properties.
2. Technology concept and/or application formulated	**HW/S/SW:** Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or de-tailed analysis to support the assumptions. Examples are limited to analytic studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	**HW/S:** Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative. **SW:** Active research and development is initiated. This includes analytical studies to produce code that validates analytical predictions of separate software elements of the technology. Examples include software components that are not yet integrated or representative but satisfy an operational need. Algorithms run on a surrogate processor in a laboratory environment.
4. Component and/or bread-board validation in laboratory environment	**HW/S:** Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of ad hoc hardware in the laboratory. **SW:** Basic software components are integrated to establish that they will work together. They are relatively primitive with regard to efficiency and reliability com-pared to the eventual system. System software architecture development initiated to include interoperability, reliability, maintainability, extensibility, scalability, and security issues. Software integrated with simulated cur-rent/legacy elements as appropriate.
5. Component and/or bread-board validation in relevant environment	**HW/S:** Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components. **SW:** Reliability of software ensemble increases significantly. The basic software components are integrated with reasonably realistic supporting elements so that it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of software components. System software architecture established. Algorithms run on a processor(s) with characteristics expected in the operational environment. Software releases are "Alpha" versions and configuration control is initiated. Verification, Validation, and Accreditation (VV&A) initiated.
6. System/subsystem model or prototype demonstration in a relevant environment	**HW/S:** Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment. **SW:** Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in software-demonstrated readiness. Examples include testing a prototype in a live/virtual experiment or in a simulated operational environment. Algorithms run on processor of the operational environment are integrated with actual external entities. Software releases are "Beta" versions and configuration controlled. Software support structure is in development. VV&A is in process.

7. System prototype demonstration in an operational environment	**HW/S:** Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft. **SW:** Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in a command post or air/ground vehicle. Algorithms run on processor of the operational environment are integrated with actual external entities. Software support structure is in place. Soft-ware releases are in distinct versions. Frequency and se-verity of software deficiency reports do not significantly degrade functionality or performance. VV&A completed.
8. Actual system completed and qualified through test and demonstration	**HW/S:** Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications. **SW:** Software has been demonstrated to work in its final form and under expected conditions. In most cases, this TRL represents the end of system development. Examples include test and evaluation of the software in its in-tended system to determine if it meets design specifications. Software releases are production versions and configuration controlled, in a secure environment. Soft-ware deficiencies are rapidly resolved through support infrastructure.
9. Actual system proven through successful mission operations	**HW/S:** Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions. **SW:** Actual application of the software in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of the system development. Examples include using the system under operational mission conditions. Software releases are production versions and configuration controlled. Frequency and severity of software deficiencies are at a minimum.