Future Manufacturing (FM)

PROGRAM SOLICITATION
NSF 20-552

National Science Foundation

Directorate for Engineering

Directorate for Computer and Information Science and Engineering

Directorate for Biological Sciences

Directorate for Mathematical and Physical Sciences

Directorate for Education and Human Resources

Directorate for Social, Behavioral and Economic Sciences

Office of International Science and Engineering

Office of Integrative Activities

Letter of Intent Due Date(s) ***(required)*** (due by 5 p.m. submitter's local time):

April 10, 2020

Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

June 05, 2020

IMPORTANT INFORMATION AND REVISION NOTES

A revised version of the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 20-1), is effective for proposals submitted, or due, on or after June 1, 2020. Please be advised that, depending on the specified due date, the guidelines contained in NSF 20-1 may apply to proposals submitted in response to this solicitation.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Future Manufacturing (FM)

Synopsis of Program:

As stated in the *Strategy for American Leadership in Advanced Manufacturing*, worldwide competition in manufacturing has been dominated in recent decades by the maturation, commoditization, and widespread application of computation in production equipment and logistics, effectively leveling the global technological playing field and putting a premium on low wages and incremental technical improvements.[1] The *next* generation of technological competition in manufacturing will be dictated by inventions of new materials, chemicals, devices, systems, processes, machines, design and work methods, social structures and business practices. Fundamental research will be required in robotics, artificial intelligence, biotechnology, materials science, sustainability, education and public policy, and workforce development to take the lead in this global competition. The research supported under this solicitation will enhance U.S. leadership in manufacturing far into the future by providing new capabilities for established companies and entrepreneurs, improving our health and quality of life, and reducing the impact of manufacturing industries on the environment.

The goal of this solicitation is to support fundamental research and education of a future workforce that will enable Future Manufacturing: manufacturing that either does not exist today or exists only at such small scales that it is not viable. Future Manufacturing will require the design and deployment of diverse new technologies for synthesis and sensing, and new algorithms for manufacturing new materials, chemicals, devices, components and systems. It will require new advances in artificial intelligence and machine learning, new cyber infrastructure, new approaches for mathematical and computational modeling, new dynamics and control methodologies, new ways to integrate systems biology, synthetic biology and bioprocessing, and new ways to influence the economy, workforce, human behavior, and society.

Among this array of technologies and potential research subjects, three thrust areas have been identified for support in FY 2020 under this solicitation:

Future Cyber Manufacturing Research,

Future Eco Manufacturing Research, and

Future Biomanufacturing Research.

This solicitation seeks proposals to perform fundamental research to enable new manufacturing capabilities in one or more of these thrust areas.

This solicitation will support the following three award tracks:

Future Manufacturing Research Grants (FMRG) - Two types of awards will be

supported in FY 2020:

Type I: $500,000 to $750,000 per year for up to five years,

Type II: $750,000 to $2,000,000 per year for up to five years;

Future Manufacturing Seed Grants (FMSG) - Awards in this track will provide support for up to two years at a level not to exceed $250,000 per year; and

Future Manufacturing Networks (FMNet) - Awards in this track will provide up to five years of support at a total amount of $500,000.

Interdisciplinary teams commensurate with the scope of the proposed research, education plan, and budget are required. Proposals must include demonstrated expertise among the team members to carry out the proposed research, education, and workforce development activities. The use of a convergence approach is expected[2].

The goal of this solicitation is to enable new manufacturing that represents a significant change from current practice. Therefore, proposers responding to this solicitation must include within the Project Description a section titled Enabling Future Manufacturing. Please see "Full Proposal Preparation Instructions" for additional details.

Realization of the benefits of the fundamental research supported under this solicitation will require the simultaneous education of a skilled technical workforce that can transition new discoveries into U.S. manufacturing companies. The National Science Board has recently emphasized this perspective in its report, "THE SKLLED TECHNICAL WORKFORCE: Crafting America's Science and Engineering Enterprise."[3] Therefore, proposers responding to this solicitation must include within the Project Description a section titled Education and Workforce Development Plan that describes plans to equip students and upskill the workforce to enable Future Manufacturing. Please see "Full Proposal Preparation Instructions" for additional details.

FURTHER INFORMATION: An informational webinar will be held on March 26, 2020 at 1:00 PM EST to discuss the Future Manufacturing program and answer questions about this solicitation. Details about how to join this webinar will be posted at https://www.nsf.gov/div/index.jsp?div=CMMI.

[1] https://www.whitehouse.gov/wp-content/uploads/2018/10/Advanced-Manufacturing-Strategic-Plan-2018.pdf

[2] https://www.nsf.gov/od/oia/convergence/index.jsp

[3] https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsb201923

Cognizant Program Officer(s):

Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

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- Carole J. Read, Program Director, (ENG/CBET), telephone: (703) 292-2418, email: cread@nsf.gov
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- Sandip Roy, Program Director, (CISE/CNS), telephone: (703) 292-8950, email: saroy@nsf.gov
- Usha Varshney, Program Director, (ENG/ECCS), telephone: (703) 292-8339, email: uvarshne@nsf.gov
- Ralph F. Wachter, Program Director, (CISE/CNS), telephone: (703) 292-8950, email: rwachter@nsf.gov

Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.041 --- Engineering
- 47.049 --- Mathematical and Physical Sciences
- 47.070 --- Computer and Information Science and Engineering
- 47.074 --- Biological Sciences
- 47.075 --- Social Behavioral and Economic Sciences
- 47.076 --- Education and Human Resources
- 47.079 --- Office of International Science and Engineering
- 47.083 --- Office of Integrative Activities (OIA)

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 20

In FY 2020, depending on the quality of submissions and the availability of funds:

-- approximately five Type I FM Research Grants will be awarded as Standard awards or Continuing grants for a period up to five years;

-- approximately two Type II FM Research Grants will be awarded as Standard awards or Continuing grants for a period up to five years;

-- approximately ten FM Seed Grants will be awarded as Standard awards or Continuing grants for a period up to two years; and

-- approximately three FM Research Network Grants will be awarded as Standard awards or Continuing grants for a period up to five years.

Proposals Involving Multiple Organizations. The Proposal & Award Policies & Procedures Guide (PAPPG) describes two kinds of collaborative proposal formats. This solicitation allows only a single proposal submission with subawards administered by the lead organization (Chapter II.D.3.a). For proposals involving multiple organizations, a lead organization must submit a proposal that describes the entire project. Funds may be distributed to other participating organizations as subawards from the lead organization. A budget on the standard NSF budget form and budget justification should be included for each subawardee. The other format of a collaborative proposal, in which each participating

institution submits its own proposal, will not be accepted.

Anticipated Funding Amount: $40,000,000

Eligibility Information

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E. Unaffiliated individuals are not eligible to submit proposals in response to this solicitation.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

An investigator may be a PI, co-PI or Senior Personnel on only one proposal in each track (FMRG, FMSG, and FMNet). In the event that an investigator exceeds this limit, proposals received within the limit will be accepted based on earliest date and time of proposal submission . The remainder will be returned without review. This limitation includes proposals submitted by a lead organization and any subawards included as part of a proposal involving multiple institutions.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Submission of Letters of Intent is required. Please see the full text of this solicitation for further information.
- **Preliminary Proposal Submission:** Not required
- **Full Proposals:**
  - Full Proposals submitted via FastLane: *NSF Proposal and Award Policies and Procedures Guide* (PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
  - Full Proposals submitted via Grants.gov: *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov* guidelines apply (Note: The *NSF Grants.gov Application Guide* is available on the Grants.gov website and

on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide).

B. Budgetary Information

- **Cost Sharing Requirements:**

  Inclusion of voluntary committed cost sharing is prohibited.

- **Indirect Cost (F&A) Limitations:**

  Not Applicable

- **Other Budgetary Limitations:**

  Not Applicable

C. Due Dates

- **Letter of Intent Due Date(s)** ***(required)*** (due by 5 p.m. submitter's local time):

  April 10, 2020

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

  June 05, 2020

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review criteria apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions:

Additional award conditions apply. Please see the full text of this solicitation for further information.

Reporting Requirements:

Standard NSF reporting requirements apply.

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I. INTRODUCTION

Future Manufacturing is a cross-directorate program supported by NSF's Directorates for Engineering (ENG), Computer and Information Science and Engineering (CISE), Biological Sciences (BIO), Education and Human Resources (EHR), Mathematical and Physical Sciences (MPS), and Social, Behavioral, and Social, Behavioral, and Economic Sciences (SBE), the Office of International Science and Engineering (OISE) and the Office of Integrative Activities (OIA).

The goal of the Future Manufacturing program is to support fundamental research that will enable manufacturing approaches that are either entirely new or that can be done today but not at a sufficient scale to make them economically viable. Future Manufacturing will complement existing efforts, supported by NSF and other federal agencies, in advanced manufacturing, but the focus of this program is to enable new, potentially transformative, manufacturing capabilities rather than to improve current manufacturing. Some benefits of the approaches used in advanced manufacturing may translate to projects in Future Manufacturing, but the important distinction is that Future Manufacturing addresses fundamental research to enable manufacturing that is currently not possible or is not possible at a scale that makes it viable. Proposals that are incremental improvements over existing advanced manufacturing technologies will not be competitive.

Proposals should provide examples of how the research results could lead to transformational manufacturing advances that address significant problems. They should provide a vision statement describing the new manufacturing capabilities that could be enabled by the proposed research, and the potential industrial and societal benefits. They should also describe the implications of the proposed activities on the education of the skilled technical workforce.

Future Manufacturing will involve the production of new materials, chemicals, devices and systems, new chemical and biological processes, new methods to make manufacturing commercially viable at scale, new approaches such as origami-based manufacturing, integration of manufacturing processes in novel ways, new mathematical and computational methods for process design and control, new data mining and predictive analytics for manufacturing, and new modalities of work. Results will help the manufacturing enterprise minimize environmental impact, manage waste, and optimize the use of resources. The results of this program, when translated to practice, should lead to the formation of new industries and organization structures, enable new manufacturing capabilities among a broad range of producers, enhance U.S. competitiveness in the development and production of new products, bolster economic growth, benefit society at large, and educate students and other workforce participants with the skills required for leadership in Future Manufacturing.

Future Manufacturing proposals in all three tracks should demonstrate the need for sustained support of a multidisciplinary team using a convergence research approach. Inclusion of minority-serving institutions is especially encouraged. Proposals must describe how the project team is appropriate to realize the project's goals and how the team will assure effective collaboration. A compelling rationale must be presented for a multi-institution structure of the project, if appropriate. Therefore, proposers responding to this solicitation must include a Project Management and Collaboration plan. Please see "Full Proposal Preparation Instructions" for additional details.

Proposals may take advantage of significant efforts underway to improve the nation's manufacturing capabilities. For example, proposals may leverage activities of other manufacturing initiatives such as the Manufacturing USA Institutes, NSF's Engineering Research Centers, EPSCoR-supported advanced manufacturing research collaborations, and NSF's manufacturing-focused Industry-University Cooperative Research Centers. Educational efforts are encouraged to leverage, interface with, or adapt aspects of proven NSF funding opportunities such as Non-Academic Research Internships for Graduate Students (INTERN), the Division of Undergraduate Education's Advanced Technological Education (ATE) and Improving Undergraduate STEM Education (IUSE) Programs, EPSCoR, Research Experiences for Undergraduates (REU), Research Experiences for Teachers (RET), Research in the Formation of Engineers (RFE), and Professional Formation of Engineers (PFE), and programs for Research Initiation in Engineering Formation (RIEF) and Revolutionizing Engineering Departments (RED).

II. PROGRAM DESCRIPTION

This Future Manufacturing solicitation will support fundamental research and education in the following three tracks:

Future Manufacturing Research Grants (FMRG)

Awards in this track will support fundamental, multidisciplinary, and integrative research and education to enable Future Manufacturing in one or more of the thrust areas described below. Type I awards in this category will provide up to five years of support at a level between $500,000 and $750,000 per year. The funding is intended to provide support for several principal investigators with complementary expertise, graduate students, some senior personnel (including post-doctoral researchers), and their

collective research needs (e.g., materials, supplies and travel). Type II awards in this category will provide up to five years of support at a level between $750,000 and $2,000,000 per year. The funding is intended to provide support for larger numbers of investigators, graduate students, senior personnel, and staff, and equipment and supplies. A compelling argument justifying Type II funding, based upon the Intellectual Merit and Broader Impacts of the proposal, is required. For both types of awards, the integrative contributions of the team should clearly be greater than the sum of the contributions of each individual member of the team.

FMRG proposals must describe the current state of art in the relevant manufacturing area and the specific challenges that will be addressed by the proposed research. They must present a compelling technical rationale and convincing technical approach to enable Future Manufacturing to address these challenges. An essential part of this argument is to explain clearly how the proposed research will provide new manufacturing capabilities that are not currently available. Proposals must include a prospective vision for translation of fundamental research results to manufacturing practice, even if that translation is not part of the proposed research. They must explain the potential benefits and challenges of new manufacturing to the economy, communities and to society as a whole. Partnerships with two-year institutions to educate the skilled technical workforce are encouraged.

Future Manufacturing Seed Grants (FMSG)

Awards in this track will provide support to stimulate fundamental research and education in one or more of the thrust areas described below through multidisciplinary teambuilding, the development of fundamental research concepts, and the initiation of research and educational activities that could provide the basis for a subsequent proposal for an FMRG. Awards in this category will provide support for up to two years at a level not to exceed $250,000 per year.

FMSG proposals should describe the building of multidisciplinary research teams that will engage community stakeholders to develop new directions in Future Manufacturing. Proposals must describe innovative and creative methods to establish new research directions and demonstrate their feasibility. A variety of activities may be proposed, including pilot research projects to obtain preliminary results to strengthen a subsequent proposal to a future solicitation, workshops, development of new partnerships, especially those involving industrial partners, benchmarking current manufacturing capabilities, especially on a global scale, and prototyping new educational activities. Prototypes of educational activities that focus on the skilled technical workforce and involve collaborations with two-year institutions are particularly encouraged.

Future Manufacturing Networks (FMNet)

Awards in this track will support the formation of a community and establishment of a network of multidisciplinary researchers, educators and stakeholders in one or more of the thrust areas described below. The network will collectively advance Future Manufacturing research and education through community efforts that include exchange of ideas, development of fundamental research directions, exploration of ways to translate results from Future Manufacturing fundamental research to industrial practice, and other approaches. Each of these awards will provide up to five years of support at a total amount of $500,000.

FMNet proposals should describe how groups of investigators will communicate and coordinate research, education, workforce development, and translation of research to manufacturing practice

across disciplinary, institutional, organizational and geographical boundaries. Proposals should not include the development or conduct of individual research projects or activities to enhance existing collaborations. Instead, they should describe how the FM Network will stimulate growth of a research and education community around Future Manufacturing and will promote new collaborations to communicate and share information, experiences, and novel ideas that will support the Future Manufacturing enterprise in research, education and community engagement. The inclusion of new researchers, postdocs, graduate students, and undergraduates is encouraged. Partnerships with faculty at two-year institutions to plan for and educate the skilled technical workforce are especially encouraged. The network can enable Future Manufacturing program and project information sharing and coordination, facilitate technical discussions and meetings on current and emerging topics, support annual Future Manufacturing grantee meetings, develop long-range community research roadmaps, engage in broad community outreach and education about the future of manufacturing and American competitiveness, make possible discussions on developing open interfaces and component interoperations, and/or provide community web-based curated archives. When the proposed activity involves generation and maintenance of community information and resources such as databases or unique materials, a plan for their timely release and the mechanism of sharing beyond the membership of the FMNet must be described in the Data Management Plan, a required Supplementary Document. FMNet proposals can include international associates as unsupported partners that advance the FMNet's goals and the NSF mission.

Successful proposals in every track will reflect interdisciplinary convergence research to enable new manufacturing capabilities, innovative education and workforce development plans, and research into the benefits and challenges of new manufacturing to communities and society.

The research and educational plans proposed in all three tracks may be complementary to efforts in other programs in participating directorates, including standing programs. However, this solicitation provides the level of support required to form multidisciplinary teams and pursue the convergence approaches required to address fundamental research and educational challenges of enabling Future Manufacturing. International collaborations in all three tracks of Future Manufacturing are welcome, and proposers may take advantage of opportunities provided by existing NSF programs that promote international collaborations; NSF funds should be used to support only U.S.-based participants in any international collaboration.

New materials and new processes may be inextricably linked in some applications of Future Manufacturing. If new materials are involved in Future Manufacturing activities, proposals must address explicitly the coupling between those new materials and new processes that will be required to produce them.

Partnerships with industry, including GOALI proposals, are encouraged in proposals for all tracks. When industrial collaborators are involved, the proposal must contain a rationale for the collaboration, an explanation of the industrial collaborators' contributions and responsibilities to the project, and a description of how the collaboration will be managed. The proposal must contain a letter of collaboration from each industrial organization participating in the project that specifies the tasks that the industrial partner will carry out. GOALI proposals must be prepared in accordance with the guidance provided in Chapter II.E.4 of the PAPPG.

To take advantage of potential synergies among activities supported by awards in the three tracks, a

Future Manufacturing kickoff meeting will be held within three months of the award issuances. Awardees in all three tracks will present their research and educational plans, discuss community engagement and explore strategies to build research and education communities in Future Manufacturing. Every PI and co-PI from all participating institutions are required to attend the kickoff meeting, and proposers should include costs of participating in their budgets.

There will also be an annual grantees' conference for sharing of successes, challenges and future plans, and for NSF program officers to review progress. At least one PI and one co-PI from each award will be required to attend, and all PIs and coPIs will be encouraged to participate. Proposers should include costs of participating in their budgets.

This solicitation focuses on three thrust areas described below. Proposals should address Future Manufacturing in one or more of the thrust areas. *The discussion of each thrust area is not intended to be limiting, and examples mentioned in each area are not intended to indicate any special interest on the part of NSF in the example topics. They are presented only to illustrate possible considerations in each thrust area*.

Future Cyber Manufacturing research

Future cyber manufacturing exploits research opportunities at the intersection of computing and manufacturing with the potential to radically transform concepts of manufacturing. It anticipates new abstractions in design and manufacturing, the availability of a data infrastructure that exploits the convergence of innovative sensors and actuators, fast and reliable secure communications, cloud and edge computing, data analytics, computational modeling, advanced controls and artificial intelligence and machine learning to increase the generality and reliability and reduce the expense of manufacturing process and system control. Cyber and cyber-enabled technologies for manufacturing cut across the manufacturing supply chain, the system engineering life-cycle, and manufacturing control systems, wherever information technology can affect production control, facilitate integration, and influence societal acceptance and demand.

Recent advances in information technologies, e.g., cloud, edge, and hybrid computing, wireless communications, machine learning and predictive analytics, autonomy, wireless communications, cyber-physical-human systems, the industrial internet of things, and advanced computing systems and services provide powerful incentives to rethink, reconceptualize, reinvent, and explore new possibilities for manufacturing. While experience has demonstrated that it is possible to control most manufacturing processes, controllers typically must be tailored to fit individual processes at great expense. As a result, process control is implemented only in the production of very expensive or high-volume products. Topics of interest include research on new generations of intelligent systems, logistics and networks for real-time secured sensing and machine learning, in-situ sensing that drives feedback loops to control process parameters, and methods for enabling the safe and secure communication and sharing of data among manufacturers, which together can provide generalizable and guaranteed execution of process plans. Research in this thrust area may also explore real-time metrology, quality control and assurance, uncertainty quantification, risk analysis, network control methods, and new techniques for multi-objective optimization that can reduce costs, minimize disruptions, improve safety, and increase yield and purity.

Opportunities also exist for transforming and expanding the manufacturing sector by researching and deploying tools that facilitate the delivery of manufacturing as a service. Such tools can increase the

access of entrepreneurs to manufacturing services, enable manufacturers to offer their services more widely and allow customization of products and processes. Topics of interest include design language and compiler-like production capabilities for manufacturing services, methods for categorizing, indexing and searching 3D solid models to exploit the implicit design and manufacturing knowledge that is incorporated in the library of previously manufactured parts, approaches to data-driven adaptation of manufacturing processes, seamless cybersecurity across the manufacturing enterprise, and tools to generate manufacturing process plans by parametric adjustment of process plans for 'similar' parts.

Research in this thrust area could leverage basic understandings of evolutionary, ecological, organismal, and molecular scale processes to generate novel cyber manufacturing algorithms for Future Manufacturing systems.

This thrust area also may explore autonomous chemical and materials design, discovery and development for the acceleration of the characterization, validation, production, and optimization of high-value chemical targets and/or high-performance engineered products.

Future Eco Manufacturing research

Research in this thrust area will enable holistic manufacturing processes that encompass the entire manufacturing lifecycle and account for energy consumption, health and environmental impact, and cost effectiveness. Fundamental research could enable manufacturing processes that are designed from the start to produce products that either degrade naturally or on cue, or can be re-purposed into high quality products without harmful byproducts and without reliance on technologies that are potentially harmful to the environment and society at large. Research in this thrust area could lead to new processes or synthesis of manufacturable materials, chemicals, devices and systems that enable facile and direct re-purpose, re-use, or up cycling into environmentally benign products. The goal of such research in eco manufacturing is to keep resources in use for as long as possible, extract their maximum value while in use, and recover materials at the end of their service life. Research in this thrust area could seek biological approaches that could lead to new materials and products, new processes to valorize waste, new methods to remediate contaminants, or new catalysts to enable processes such as biomass conversion. In every case, research outcomes in eco manufacturing will benefit from a convergence approach that integrates expertise from a variety of disciplines including chemistry, biology, materials science, engineering, and economics. Such projects could benefit from fundamental research to predict how consumers, companies and society at large will respond to more environmentally friendly options.

For example, research in this thrust area could enable new manufacturing processes that avoid plastics and polymers that pose significant challenges in recycling and disposal. Research could enable new manufacturing that either eliminates the use of a commodity polymer such as PET, or it could enable new recycling processes that are economically favorable for commodity polymers despite their intrinsic low cost, which could make widespread use of recycled commodity polymers more economically favorable.

Research could leverage recent advances in bio/nano interfaces combined with improved understanding of how biological systems communicate on molecular to eco-scales. Such research could enable the development of highly integrated bio/nano manufacturing systems such as agromanufacturing with bio/plant-based sensors that serve as monitoring systems or virtual tracks for autonomously directing manufacturing equipment.

Research on origami-based manufacturing could revolutionize the design of new structures and materials, and provide strong and lightweight alternatives to solid concrete or steel for sustainable building. Fundamental research on materials that facilitate folding, active and programmable materials, and the structural stability of unfolded products could enable new approaches in eco manufacturing.

Future Biomanufacturing Research

Research in this thrust area will enable production of therapeutic cells and molecules, chemicals, pharmaceuticals, polymers and fuels, as well as bio-based technologies for computing, signal processing and communication. Fundamental research to enable new biomanufacturing will expand knowledge in biology and engineering to create products that interact effectively and seamlessly with cells, living tissues, and synthetic substrates. The capability to fabricate at large scales interacting synthetic cells, cellular components and biological communities capable of conducting complex information processing and biofabrication processes could lead to a variety of new manufacturing industries. Research in this thrust area should complement and leverage advances at NSF centers for manufacture of cell-based therapeutics, pharmaceuticals, living tissues for cardiac therapies, and multicellular engineering of living systems. Research in this thrust area has the potential to enable a new biomanufacturing paradigm that can benefit personalized healthcare, sustainable energy, environmental sustainability, and society.

For example, research in this thrust area could focus on the development of biofoundries to produce new cell-based and small-molecule therapeutics that can be scaled up and diversified to produce organ-on-chip devices and personalized therapeutics. Recent advances in personalized medicine, including new manufacturing of patient-specific therapeutics, need to be expanded on multiple fronts and scaled up to make them available on demand to wider populations and to broaden the range of therapeutic constructs. Enabling the manufacturing of these and similar constructs will require integrating knowledge from systems biology, chemistry, genomics, materials science, bioreactor engineering, and separations and purifications - all integrated in novel ways. It will also require research into how composition, structures, and properties of synthetic support materials affect cell-based processes.

Research could address challenges associated with cell-free protein manufacturing that has potential advantages over cell-based processes, including elimination of unwanted byproducts, better reproducibility, and improved stability. Research could expand and intensify platforms for cell-free manufacturing that maintains specific activity for diverse feedstocks. The result of the research could enable cell-free manufacturing enzyme biocatalysts, biosensors, vaccines and other therapeutics.

Research could seek to take advantage of advances in understanding microenvironment-cell-phenotype interactions and synthetic biology tools to develop sensors, actuators, nanomaterials or nanomachines that work at the nano/bio interface, and computational tools that could modulate cellular responses. Results could enable the optimal design of robust systems that are scalable, reproducible, and programmable for on-demand biomanufacturing of personalized therapeutics and enable future manufacturing outside of brick and mortar factories.

III. AWARD INFORMATION

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 20

In FY 2020, depending on the quality of submissions and the availability of funds:

-- approximately five Type I FM Research Grants will be awarded as Standard awards or Continuing grants for a period up to five years;

-- approximately two Type II FM Research Grants will be awarded as Standard awards or Continuing grants for a period up to five years;

-- approximately ten FM Seed Grants will be awarded as Standard awards or Continuing grants for a period up to two years; and

-- approximately three FM Network Grants will be awarded as Standard awards or Continuing grants for a period up to five years.

Proposals Involving Multiple Organizations. The Proposal & Award Policies & Procedures Guide (PAPPG) describes two kinds of collaborative proposal formats. This solicitation allows only a single proposal submission with subawards administered by the lead organization (Chapter II.D.3.a). For proposals involving multiple organizations, a lead organization must submit a proposal that describes the entire project. Funds may be distributed to other participating organizations as subawards from the lead organization. A budget on the standard NSF budget form and budget justification should be included for each subawardee. The other format of a collaborative proposal, in which each participating institution submits its own proposal, will not be accepted.

Anticipated Funding Amount: $40,000,000

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

The categories of proposers eligible to submit proposals to the National Science Foundation are identified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG), Chapter I.E. Unaffiliated individuals are not eligible to submit proposals in response to this solicitation.

Who May Serve as PI:

There are no restrictions or limits.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

An investigator may be a PI, co-PI or Senior Personnel on only one proposal in each track (FMRG, FMSG, and FMNet). In the event that an exceeds this limit, proposals received within the limit will be accepted based on earliest date and time of proposal submission . The remainder will be returned without review. This limitation includes proposals submitted by a lead organization and any subawards included as part of a proposal involving multiple institutions.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Letters of Intent *(required)*:

Letters of Intent (required for all tracks):

A one-page Letter of Intent is required. The letter should be submitted via FastLane no later than the date specified in this solicitation. The subject heading of the letter should include a brief title of the proposal and the name of the lead organization. Each letter must include the following:

1. Title of the proposal, preceded by the words “FMRG:” for Future Manufacturing Research Grants, “FMSG:" for Future Manufacturing Seed Grants, or "FMNet:" for Future Manufacturing Networks;

2. Names, departmental and organizational affiliations, and expertise of the Principal Investigator and co-Principal Investigators. For proposals involving multiple organizations, the same information should be provided for all subawardees; and

3. A brief description of the specific goals of the proposal and how the proposed research will enable Future Manufacturing.

Letters of intent are required for proposals in all tracks of this solicitation. They are non-binding with respect to the team members, title, and specific goals of the research, but the track and thrust area(s) of the research in the full proposal must match what was stated in the letter of intent. The letters of intent will not be used as pre-approval mechanisms for the submission of proposals, and no feedback will be provided to submitters. The letters of intent will be used by NSF to assess requirements for proposal review. For more information on letters of intent, please review the NSF Proposal & Award Policies & Procedures Guide (PAPPG).

Letter of Intent Preparation Instructions:

When submitting a Letter of Intent through FastLane in response to this Program Solicitation please note the conditions outlined below:

- Submission by an Authorized Organizational Representative (AOR) is not required when submitting Letters of Intent.
- A Minimum of 0 and Maximum of 4 Other Senior Project Personnel are permitted
- A Minimum of 0 and Maximum of 4 Other Participating Organizations are permitted
- Submission of multiple Letters of Intent is not permitted

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via FastLane or Grants.gov.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.
- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov*. The complete text of the *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

See PAPPG Chapter II.C.2 for guidance on the required sections of a full research proposal submitted to NSF. Please note that the proposal preparation instructions provided in this program solicitation may deviate from the PAPPG instructions.

Letters of intent (LOI) are required for proposals in all tracks of this solicitation. A proposal submitted without a corresponding LOI will be returned without review.

The title of the proposal must be preceded by the words “FMRG:” for Future Manufacturing Research Grants, “FMSG:" for Future Manufacturing Seed Grants, or "FMNet:" for Future Manufacturing Networks.

The Project Description of a proposal for a Research Grant may not exceed 20 pages. The Project Description of a proposal for a Seed Grant or FM Network may not exceed 15 pages.

In addition to the content specified in the PAPPG, the Project Description must contain the following

subsections:

Research Description: The Research Description section must describe the technical rationale and approach of the proposed activities. It should describe the challenges that drive the research problem. This section should describe the research plan including descriptions of major tasks, the primary organization responsible for each task, and milestones. It should present metrics for success. This section should also describe major program risks and potential mitigation approaches.

Scope and Scale (FMRG proposals only): This section should justify the proposed scope and scale of work. It should explain why the project requires the selected researchers and scope of expertise, why it needs the types and length of time for specific research activities, and how the transferability and scalability of the proposed solutions justify the scale. The section is not intended to be a rehashing of budget justifications, but a discussion of what resources are needed to accomplish the activity and the difference that accomplishing the proposed tasks will make.

Enabling Future Manufacturing: This section should describe how the proposed fundamental research will enable Future Manufacturing. This section should describe the significant impacts of the proposed research, what field(s) of manufacturing will be transformed, and the major challenges that must be overcome. It should describe how results from the proposed research could be translated to enable new manufacturing and how that manufacturing differs from current practice. This section should describe how the proposal's interdisciplinary research team is equipped to address research aimed at Future Manufacturing. Because the Future Manufacturing program strives to sustain U.S. competitiveness in manufacturing, proposals must include a brief description of the global context for their proposed work that explains what other leading countries are doing in the proposal's area of fundamental research, its translation to manufacturing and/or in future manufacturing advances.

Project Management and Collaboration Plan: This section should describe how the project and collaborations will be managed. The plan should identify organizational responsibilities and how the project will be managed, including approaches for meeting project goals. The plan should include: 1) the specific roles of the project participants in all involved organizations; 2) information on how the project will be managed across all the investigators, institutions, and/or disciplines; 3) approaches for integration of research components throughout the project and, 4) identification of the specific coordination mechanisms that will enable cross-investigator, cross-institution and/or cross-discipline integration. The plan should include a Gantt chart that lays out the sequence of activities and identifies the responsible organization for each of them. It should include a description of the milestones to be achieved in the project and evaluation criteria to assess success.

Education and Workforce Development Plan: This section must describe how the proposed research will form a basis for training a new generation in Future Manufacturing, including members of the skilled technical workforce. Commensurate with the scope of the proposal and project budget, the plan may encompass training and/or curricula for a range of future workforce participants, including graduate and undergraduate students, students in technical certification and associate degree programs, professionals in continuing education, and students in online education programs. Evidence-based pedagogical approaches should be used. This section should provide plans for integrating research outcomes into education.

Convergence research produces a new content domain at the intersection of participating content

domains. The plan could describe how curricula will be developed once a new content domain has been identified. The plan could identify evidence-based practices grounded in learning theory (e.g., experiential learning) that are likely to be successful in the new content domain. The plan could define the knowledge, skills, and abilities (KSAs) required to conduct the proposed research beyond those obtained in a traditional curriculum, how students will acquire them, and how these skills will prepare students to enter the Future Manufacturing workforce, including the skilled technical workforce students.

Specific skills will depend on the proposed research, but it is likely that students in Future Manufacturing would benefit from training in such subjects as data management, robotics, virtual reality to optimize workflows, practical process control, and workforce integration. Regardless of the proposal's thrust area, students in Future Manufacturing should be instilled with a systems-level view of manufacturing processes that is informed by rational models. In addition, students should have adequate awareness or training on relevant educational, social and behavioral aspects that will affect the acceptance of Future Manufacturing in the workplace and in society as a whole. The plan could describe efforts to develop materials and mentoring that will enable faculty to implement the proposed strategies. The plan should describe how the educational and instructional activities will be assessed and how the readiness of participants to engage in Future Manufacturing with skills and competencies desired by industry will be evaluated.

The plan could also describe activities to educate a broader community of students and other workforce participants about the potential for Future Manufacturing. Activities may be designed to engage K-12 students, advanced technical education trainees or industrial practitioners. If proposers suggest leveraging existing programs (e.g., INTERN, ATE, IUSE, REU, RET, CSforAll, campus and community programs) as part of the plan, then the plan should describe the added value for Future Manufacturing that they will contribute to these programs. Proposers should use specific evidence-based pedagogical approaches and frameworks in the design of their plans, and they should include persuasive and meaningful evaluations of proposed activities.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

C. Due Dates

- **Letter of Intent Due Date(s)** ***(required)*** (due by 5 p.m. submitter's local time):

  April 10, 2020

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

  June 05, 2020

D. FastLane/Research.gov/Grants.gov Requirements

For Proposals Submitted Via FastLane or Research.gov:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: https://www.fastlane.nsf.gov/a1/newstan.htm. To prepare and submit a proposal via Research.gov, see detailed technical instructions available at: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_pageLabel=research_node_display&_nodePath=/researchGov/Service/Desktop/ProposalPreparationandSubmission.html. For FastLane or Research.gov user support, call the FastLane and Research.gov Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov or rgov@nsf.gov. The FastLane and Research.gov Help Desk answers general technical questions related to the use of the FastLane and Research.gov systems. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: https://www.grants.gov/web/grants/applicants.html. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

Proposers that submitted via FastLane or Research.gov may use Research.gov to verify the status of their submission to NSF. For proposers that submitted via Grants.gov, until an application has been received and validated by NSF, the Authorized Organizational Representative may check the status of an application on Grants.gov. After proposers have received an e-mail notification from NSF, Research.gov should be used to check the status of an application.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review

process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in PAPPG Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: https://www.nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 – 2022*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the strategic objectives in support of NSF's mission is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions must recruit, train, and prepare a diverse STEM workforce to advance the frontiers of science and participate in the U.S. technology-based economy. NSF's contribution to the national innovation ecosystem is to provide cutting-edge research under the guidance of the Nation's most creative scientists and engineers. NSF also supports development of a strong science, technology, engineering, and mathematics (STEM) workforce by investing in building the knowledge that informs improvements in STEM teaching and learning.

NSF's mission calls for the broadening of opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and

managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (PAPPG Chapter II.C.2.d(i). contains additional information for use by proposers in development of the Project Description section of the proposal). Reviewers are strongly encouraged to review the criteria, including PAPPG Chapter II.C.2.d(i), prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and

- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
    a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
    b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

- How effectively does the proposal present a compelling argument that the proposed fundamental research will enable future manufacturing capabilities which either do not exist today or exist only at such small scales that they are not viable?
- How effectively does the proposal present a compelling argument that the proposed educational activities will equip students and other workforce participants with the skills to engage in Future Manufacturing and broaden participation by building on best practices and evidence-based approaches?
- How effectively does the proposal anticipate translation of research results to practice and the effects of Future Manufacturing on the economy, labor force, industry and/or society at large?
- Is the composition of the multidisciplinary team appropriate for the scope of the proposed activities?

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Panel Review.

Reviewers will be asked to evaluate proposals using two National Science Board approved merit review criteria and, if applicable, additional program specific criteria. A summary rating and accompanying narrative will generally be completed and submitted by each reviewer and/or panel. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

Once an award or declination decision has been made, Principal Investigators are provided feedback about their proposals. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers or any reviewer-identifying information, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process.)

B. Award Conditions

An NSF award consists of: (1) the award notice, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award notice; (4) the applicable award conditions, such as Grant General Conditions (GC-1)*; or Research Terms and Conditions* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award notice. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

Special Award Conditions:

Awardees will be required to attend the kickoff meeting described above and annual FM grantees' conferences for the duration of their award.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer no later than 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). No later than 120 days following expiration of a grant, the PI also is required to submit a final project report, and a project outcomes report for the general public.

Failure to provide the required annual or final project reports, or the project outcomes report, will delay NSF review and processing of any future funding increments as well as any pending proposals for all identified PIs and co-PIs on a given award. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through Research.gov, for preparation and submission of annual and final project reports. Such reports provide information on accomplishments, project participants (individual and organizational), publications, and other specific products and impacts of the project. Submission of the report via Research.gov constitutes certification by the PI that the contents of the report are accurate and complete. The project outcomes report also must be prepared and submitted using Research.gov. This report serves as a brief summary, prepared specifically for the public, of the nature and outcomes of the project. This report will be posted on the NSF website exactly as it is submitted by the PI.

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the points of contact.

General inquiries regarding this program should be made to:

- William Olbricht, Program Director, (ENG/CBET), telephone: (703) 292-4842, email: wolbrich@nsf.gov
- Andrew B. Wells, Program Director, (ENG/CMMI), telephone: (703) 292-7225, email: awells@nsf.gov
- Senay Agca, Program Director, (SBE/SES), telephone: (703) 292-2459, email: sagca@nsf.gov
- Edward J. Berger, Program Director, (ENG/EEC), telephone: (703) 292-7708, email: eberger@nsf.gov
- Annalisa Calini, Program Director, (MPS/DMS), telephone: (703) 292-7921, email: acalini@nsf.gov
- Celeste Carter, Program Director, (EHR/ATE), telephone: (703) 292-4651, email: vccarter@nsf.gov
- Jose Colom-Ustariz, Program Director, (OIA), telephone: (703) 292-7088, email: jcolom@nsf.gov
- David Corman, Program Director, (CISE/CNS), telephone: (703) 292-8754, email: dcorman@nsf.gov
- John Jackman, Program Director, (EHR/DUE), telephone: (703) 292-4816, email: jjackman@nsf.gov
- Bruce M. Kramer, Program Director, Senior Advisor, (ENG/CMMI), telephone: (703) 292-5348, email: bkramer@nsf.gov
- Elizabeth E. Lyons, Program Director, (OISE), telephone: (703) 292-7256, email: elyons@nsf.gov
- Debasis Majumdar, Program Director, (MPS/DMR), telephone: (703) 292-4709, email: dmajumda@nsf.gov
- Elebeoba E. May, Program Director, (BIO/MCB), telephone: (703) 292-2100, email:

emay@nsf.gov

- Eduardo A. Misawa, Program Director, (ENG/EEC), telephone: (703) 292-5353, email: emisawa@nsf.gov
- Kenneth Moloy, Program Director, (MPS/CHE), telephone: (703) 292-8441, email: kmoloy@nsf.gov
- Erik Pierstorff, Program Director, (ENG/IIP), telephone: (703) 292-2165, email: epiersto@nsf.gov
- Carole J. Read, Program Director, (ENG/CBET), telephone: (703) 292-2418, email: cread@nsf.gov
- Gregory Reed, Program Director, (ENG/IIP), telephone: (703) 292-2003, email: gregreed@nsf.gov
- Sandip Roy, Program Director, (CISE/CNS), telephone: (703) 292-8950, email: saroy@nsf.gov
- Usha Varshney, Program Director, (ENG/ECCS), telephone: (703) 292-8339, email: uvarshne@nsf.gov
- Ralph F. Wachter, Program Director, (CISE/CNS), telephone: (703) 292-8950, email: rwachter@nsf.gov

For questions related to the use of FastLane or Research.gov, contact:

- FastLane and Research.gov Help Desk: 1-800-673-6188

  FastLane Help Desk e-mail: fastlane@nsf.gov.

  Research.gov Help Desk e-mail: rgov@nsf.gov

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

General inquiries regarding this program should be made to futuremanufacturing@nsf.gov.

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF

Grants Conferences. Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on NSF's website.

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this mechanism. Further information on Grants.gov may be obtained at https://www.grants.gov.

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

Facilitation Awards for Scientists and Engineers with Disabilities (FASED) provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.E.6 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and

to access abstracts of awards, visit the NSF Website at https://www.nsf.gov

- **Location:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **For General Information** (NSF Information Center)**:** (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**

  Send an e-mail to: nsfpubs@nsf.gov

  or telephone: (703) 292-7827
- **To Locate NSF Employees:** (703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

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Suzanne H. Plimpton
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