Manufacturing Innovation Network for Developing Sustainable Materials and Adaptively Reconfigurable Technologies for Innovative Products and Processes
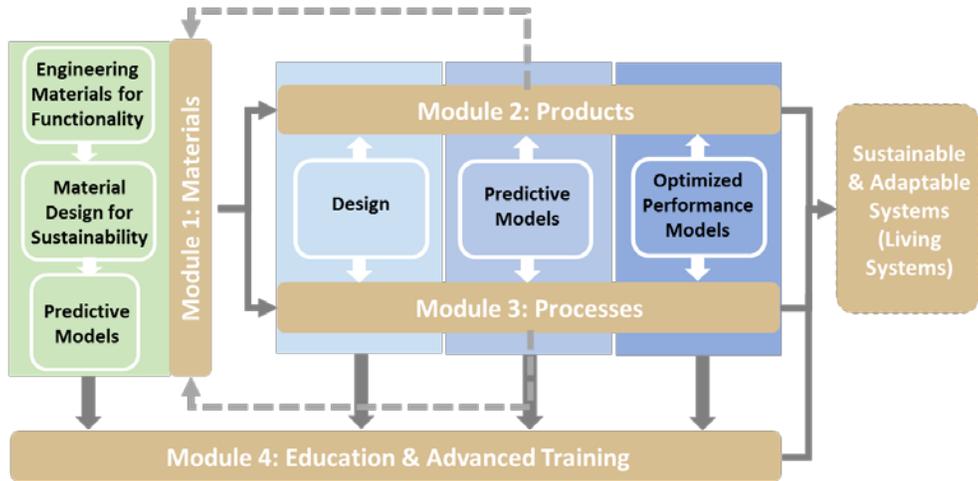
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Manufacturing innovation through transformative research that leads to the development of superior materials and advanced technologies for manufacturing processes and product development can enable advancing the manufacturing ecosystem in the commonwealth and the nation. Such advanced technologies are essential to ensure next generation manufacturing can promote greater economic growth while ensuring environmental and societal benefits. The specific project objectives are:

(a) Developing an advanced *predictive capability* for developing novel and engineered materials, innovative products and processes for next generation manufacturing;

(b) Generating *new knowledge* for designing engineered materials for developing functionally-superior and sustainable products and manufacturing processes; and

(c) Developing *advanced educational and training programs* for producing the next generation workforce in materials, and product and process development.

This project integrates three large research modules (Materials, Products and Processes) associated with advanced manufacturing. Current state of material development focuses on achieving improved product functionality through the use of material science principles and advanced engineering. However, designing new materials for improved sustainability poses scientific and technological challenges, particularly for achieving properties such as recyclability, repairability, processability, energy-efficiency and cost-effectiveness. Therefore, the '*Materials*' module is aimed at developing novel and functionally-superior materials that can be used to manufacture components and products for sustainable, multi-generational use. The design and manufacture of next generation products requires moving away from the conventional take-make-dispose (linear) approach to a strategy that considers the total product life-cycle and closed-loop material flow. The '*Products*' module will develop transformative capabilities for digitally-enabled, total life-cycle-based next generation product design, to utilize the advanced and superior materials developed in the 'Materials' module, linking to, and sharing information, from across the total product life-cycle. Next generation manufacturing processes can be developed using sustainable technologies to offer improved energy and resource efficiency, waste reduction, reduced toxicity and emissions including reduced carbon footprints, reduced use of, or elimination of, coolants/lubricants, etc. The '*Processes*' module will, therefore, focus on developing novel manufacturing processes for improved process performance and sustainability of operations and developing capabilities for digitally-enabled next generation manufacturing processes. These three integrated modules will focus on developing capabilities for iteratively and adaptively developing advanced materials necessary to produce more sustainable products using more sustainable manufacturing processes. The transformative nature of this project is reflected in the proposed development of novel, model-based manufacturing methodologies and their integration of *predictive analytics, data-driven models utilizing Big Data, IoT and machine learning techniques* incorporated within each module to *enable a cyber-physical manufacturing environment*.

The goal of the fourth module, '*Education and Advanced Training*', is to prepare the technology-adept and data-capable future manufacturing workforce by formulating curricula and developing course materials, developing advanced computer serious-games using virtual- and augmented-reality technologies to simulate various design and manufacturing activities and creating a state-wide network of instructors well-equipped to disseminating the educational materials developed through the project.

Figure 1 text elements:

Engineering Materials for Functionality

Material Design for Sustainability

Predictive Models

Module 1: Materials

Module 2: Products

Design | Predictive Models | Optimized Performance Models

Module 3: Processes

Sustainable & Adaptable Systems (Living Systems)

Module 4: Education & Advanced Training

Figure 1: Integrated Project Modules

	NSF Vision	Proposed Project Modules			
		1	2	3	4
Relevant Research Ideas	Harnessing Data for 21st Century Science and Engineering	√	√	√	√
	Work at the Human-Technology Frontier: Shaping the Future	√	√	√	√
Relevant Process Ideas	Mid-Scale Research Infrastructure	√		√	
	NSF 2050	√	√	√	√
	Growing Convergent Research at NSF	√	√	√	
	NSF INCLUDES: Enhancing STEM through Diversity and Inclusion				√

Figure 2: Project Relevance to NSF's 10 Big Ideas