Research for Advanced Manufacturing in Pennsylvania (RAMP) Program

RAMP Mission
The RAMP Program is collaboration among the Pennsylvania Department of Community and Economic Development (DCED), the Institute for Complex Engineered Systems (ICES) at Carnegie Mellon University (CMU), and the Center for Advanced Technology for Large Structural Systems (ATLSS) at Lehigh University. The mission of RAMP is to leverage the research and innovation capabilities of some of the Commonwealth’s leading research universities and the technology-rich manufacturing sector of Pennsylvania’s industry, to form a unique university-industry program that will lead to the following outcomes in the Commonwealth:

1) Create a program that is PA manufacturing company influenced and uses a competitive proposal process to select and enable projects that will drive innovation in PA’s manufacturing job creators.
2) Create an environment linking PA companies with students to create high paying manufacturing jobs and to interest and retain highly educated students in the field of manufacturing.
3) Provide PA companies with a competitive technology edge by introducing them to researchers and universities with equipment and skill sets to which they do not currently have access.
4) Open the floodgates of technology assistance and innovation to PA companies by breaking down the barriers to academic expertise.
5) Focus the innovation and educational capabilities of PA’s world-class research universities on real-world manufacturing solutions for PA.

The Institute for Complex Engineered Systems (ICES) at Carnegie Mellon University pursues multi-disciplinary research and education both within the College of Engineering and across colleges at Carnegie Mellon University. Primary goals of ICES are to identify, seed, and grow multi-disciplinary research projects within designated strategic areas and to foster vibrant research relationships between industry and the College of Engineering. Technical foci currently being investigated through ICES include: Bioengineering Technologies; Engineering Design Research; Interactive Real-Time Computer Systems; Microsystems; the Center for Sensed Critical Infrastructure Research (CenSCIR); and the Center for Nano-enabled Devices and Energy Technology (CNXT). Through these activities, ICES promotes collaboration across Carnegie Mellon University while creating sustainable multi-disciplinary research infrastructure.

The Center for Advanced Technology for Large Structural Systems (ATLSS) at Lehigh University is a national center for research that, in partnership with industry and public agencies, provides technological innovations leading to cost effective, high-performance large structural systems for bridges, buildings, ships, power plants, and other major structures. Activities focus on developing new structural systems and advanced materials applications, and on structural performance and durability issues for both new and existing structures. The performance of our infrastructure strongly influences the international competitive position of our Commonwealth and the safety and quality of life for our people.

Manufacturing Technology Development Program
The RAMP Manufacturing Technology Development Program is designed to produce technological developments that significantly improve the competitiveness of the Commonwealth’s manufacturing sector and/or to sponsor technology projects which address a combination of short-term and long-term needs of Commonwealth agencies and businesses. RAMP also serves to plan, conduct and manage research and technology development on a systematic, cross-disciplinary and sustained basis to achieve the PA DCED mission. RAMP supports the following research Technology Areas (from the President’s Council of Advisors on Science and Technology (PCAST) report entitled “Capturing Domestic Competitive Advantage in Advanced Manufacturing” prepared by the Advanced Manufacturing Partnership (AMP) Steering Committee in July, 2012):

Advanced Sensing, Measurement, and Process Control (including Cyber-Physical Systems): This set of technologies has applicability across almost all industry domains. These technologies are critical for enhancing tradability by way of end-to-end supply chain efficiency (e.g., low cost and pervasive sensors in plants and logistics systems, automatic control and coordination of systems-of-systems). In addition, megatrends of energy and resource efficiency, better safety, and higher quality also depend highly on advances in sensing and automatic process control. Finally, emerging technologies such as nanomanufacturing and biomanufacturing need specialized sensors and control models.

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**Advanced Materials Design, Synthesis, and Processing**: These technologies include the design and synthesis of small molecules, nanomaterials, formulated solutions, coatings, composites, and integrated components (e.g., photovoltaic devices). They entail integration of computational modeling, state-of-the-art synthesis tools (e.g., high throughput), and advanced research analytics (e.g., materials genome). Almost all the megatrends for the future—energy efficiency or alternate energy devices, new materials to counter resource shortages, next-generation consumer devices, and new paradigms in chemical safety and security—depend heavily on advanced materials. Advanced materials will fuel emerging multi-billion dollar industries.

**Visualization, Informatics, and Digital Manufacturing Technologies**: This area entails research focused on embedded sensing, measurement and control systems for highly corrosive, high temperature processes impacting everything from chemical synthesis to lightweight materials to aircraft engines. It also includes control systems enabling manufacturing of high performance, highly-controlled structures and devices. Finally, it entails modeling, simulation and visualization technologies that can optimize a product and its manufacturing in virtual space before actual physical production is started (therefore bypassing time-consuming and expensive physical testing and experimentation). The data generated can also potentially support conclusions regarding product warranties and product reliability. Examples of these technologies include integrated enterprise level smart manufacturing methodologies, e.g., moving directly from computational/digital design to chemical and materials planning, purchasing, and delivery to manufacturing of customized products and components. One aspect deals largely with manufacturing competitiveness through end-to-end supply chain efficiency—reduced manufacturing cycle time, lower worker injury and illness rates, higher process yields, higher energy efficiency, etc.—brought about by more networked information, and the control and management of information across various entities in the value chain spanning multiple enterprises. The other aspect deals with the speed with which products are designed, manufactured, and brought to market, which will be a key differentiator.

**Sustainable Manufacturing**: This approach aims to maximize every atom of matter and joule of energy. As a key national need, sustainable manufacturing involves technologies and systems that enable optimal raw material, energy, and resource utilization, including areas as diverse as high performance catalysis, novel separations, and new reactor and waste management systems. A major area of focus will be energy efficient manufacturing—where high energy-consuming manufacturing processes need to be substituted by lower energy-consuming alternatives. Areas such as re-manufacturing (i.e., using recycled components) also need to be researched. In addition to savings in energy consumption and higher profitability, many accompanying benefits can aid the competitiveness of industry.

**Nanomanufacturing**: Nanomaterials are forecasted to play a game-changing role in applications ranging from high-efficiency solar cells and batteries, environmental control through nanotech-based filters, and nano-biosystem-based medical applications to next-generation electronics and computing devices. Similarly, microstructures on devices will play a key role in delivering new features or enhancing current functionality. The possibilities are limitless, but processes and quality control systems must be developed to reach the full potential of nanomanufacturing. The challenge will be to scale up and reduce costs.

**Flexible Electronics Manufacturing**: Technologies for flexible electronics manufacturing will be major differentiators in the next generation of consumer and computing devices. Some of these devices are expected to be among the fastest growing product categories over the next decade.

**Biomanufacturing and Bioinformatics**: Technologies to improve healthcare will require newer, more effective, and cheaper molecules. Food security is a key concern of the future, where biomanufacturing, proteomics, and genomics will play a critical role. In addition, this technology has the inherent potential to enable energy efficiency in manufacturing. For instance, it offers room-temperature synthesis routes that can possibly replace current high-temperature processes. Innovations in the bio–nano interface such as bio-inspired manufacturing using self-assembly have the potential to simplify and scale up many complex and expensive nanomanufacturing technologies and make them economically viable.

**Additive Manufacturing**: A growing application of manufacturing is the production of highly customized and personalized products. Additive manufacturing (e.g., three-dimensional printing) is a key technology that holds this promise. In addition, the technology has several characteristics that enable unique capabilities and features. For example, multiple materials can be processed, enabling smart components to be fabricated with embedded sensors and circuitry. Internal features can be produced that significantly enhance performance and therefore differentiate products (e.g., internal cooling channels that are optimized for thermal performance that are not possible with current manufacturing techniques). Also, materials can be processed efficiently with little waste, enhancing the sustainability of organizations that adopt additive manufacturing technologies.

**Advanced Manufacturing and Testing Equipment**: Advanced manufacturing takes place worldwide. In those cases where it occurs outside of the United States, it is still possible for U.S. firms to maintain a significant advantage through the production and supply of high-value manufacturing equipment, such as bioreactors, CNC machine tools, or other high-technology production tools. Being the
supplier of choice of advanced capital equipment will continue to yield advantages in terms of innovation and advanced engineering, as well as economic benefits.

**Industrial Robotics:** Automation and use of industrial robots in labor-intensive manufacturing operations, such as assembly, product inspection, and testing can enable high endurance, speed, and precision. Equally important is their use in processing high temperature, corrosive and toxic substances, and materials. This technology has great potential to enhance safety and productivity of the U.S. workforce and enable the United States to compete with low-cost economies, both for domestic and export markets. Future needs in this area are being driven by the intersection of bio-nanotechnologies and their associated manufacturing needs.

**Advanced Forming and Joining Technologies:** Most current mechanical manufacturing processes continue to depend largely on traditional technologies, mainly for metals, such as casting, forging, machining, and welding. These technologies will continue to be mainstays of future production processes. However, there are new and expanding needs for joining a wider variety of materials with greater energy and resource efficiency. In addition, improved performance requires continued innovation and the search for transformative technologies that will help maintain U.S. competitiveness in industries ranging from transportation to infrastructure.

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