Sustainable Manufacturing Update

The Sustainable Manufacturing Advances in Research and Technology Coordinating Network (SMART-CN) is funded by the National Science Foundation (NSF) and managed by CACHE Corporation as part of the Research Coordination Networks program. It is a coalition of national leaders who have joined together to promote collaboration in process systems engineering applied to sustainable manufacturing. The purpose of SMART-CN is to bridge the gap between academic knowledge and industrial technology innovation to advance sustainable manufacturing. To accomplish this goal, the SMART-CN team is conducting an in-depth review of research and technological development for sustainable manufacturing, defining a roadmap for moving toward sustainable manufacturing, and identifying bottlenecks in research areas. The workshop described here is typical of SMART-CN activities in bringing together academia, industry, and government to explore both the challenges and the solutions for a more sustainable and profitable future. The ultimate achievement of SMART-CN will be the delivery of prioritized and coordinated R&D portfolios that improve the competiveness, environmental sustainability, and energy responsiveness of U.S. manufacturing. The SMART-CN website is at http://www.research.che.utexas.edu/susman/about.html.

The Workshop and Roadmap

On August 15-16, 2013, SMART-CN conducted a roadmapping workshop. Fifty three participants, specifically selected for their expertise and representing a mix of academic, industry, and government interests, participated in a structured process of information gathering and knowledge extraction. Much of the workshop was conducted in small groups addressing three areas: Technology Development, Process and Systems Management, and Enterprise Management. Crosscutting topics of Workforce Education and Management; Water Management, Land, and Air Quality; and Life Cycle Assessment and Design for Sustainability were addressed by all three groups. The groups addressed the vision for future success, the barriers and challenges, and corresponding goals for a sustainable future. The final output from the workshop was a set of prioritized goals.

The information from the workshop was then compiled into the document presented here. The opening chapter provides foundational materials and presents the key themes and roadmaps. The subsequent chapters present the detailed work of the small groups.

Key Themes

After the workshop, the facilitation team conducted an in-depth analysis distilling the 10 key themes that encapsulate the most important content. The vision elements, barriers and challenges, and goals were mapped to the key themes in a matrix. From this matrix, technology roadmaps were produced for the key findings. The definition of the key themes and the roadmaps are presented in this document.

The key themes represent high-level needs that should be addressed by the sustainable manufacturing community. The themes include:

1) **Standards and Platforms for Information Exchange** – Standard structures for data and toolsets related to sustainable manufacturing are essential for addressing the key issues in an inclusive and systematic way. Platforms and frameworks that enable interoperability of diverse data sets and tools are prerequisite to addressing the scope of the challenge and supporting common communication.

2) **Clear Definition and Semantic Understanding of Sustainable Manufacturing**– A deep understanding of the terms and scope of sustainable manufacturing is foundational for integrated solutions. That definition should include the creation of a common taxonomy and ontology that enable a common semantic understanding.

3) **Pervasive Adoption of Sustainability Practices** – The issues associated with sustainability include technical challenges, business process requirements, and a culture of value assessment and investment in sustainability. This key theme embraces all areas of need for pervasive adoption, but focuses mostly on the cultural challenges.

4) **Comprehensive Characterization and Quantification of Manufacturing Processes** – The complete understanding of materials and their interaction in manufacturing processes enables optimized design of products and processes. Quantification of processes is a major factor in product development, and characterization of processes facilitates rapid quantification.

5) **Comprehensive Life-Cycle Assessment** – Life-Cycle Assessment (LCA) has become common in product development. Unfortunately, in many cases, it has become more of an administrative and accounting requirement than a value-added design aid. The adoption of a systems engineering methodology and the inclusion of a rich enabling technology toolset can allow LCA to move forward as a keystone in sustainable design.

6) **Sustainable Manufacturing Education** – The pervasive adoption of sustainability practices requires education of all stakeholders in the global community. This key theme specifically addresses the necessity of sustainability education in all educational disciplines, with an emphasis on the engineering community.

7) **Model-Based Assessment and Control for Sustainability** – A model-rich environment is essential for efficiently developing material systems, products, and processes and for managing the manufacturing enterprise. Model development for LCA, materials evaluation, process development, and all other applications tends to be ad hoc. There does not exist a structure to define modeling priorities and systematically fill the voids. The use of modeling systems for process control, is, likewise, applied on a case-by-case basis. A coordinated systems approach is needed.

8) **Data and Model Access for Sustainability** – Characterization of materials and processes requires a rich underpinning of data and models. While there are excellent examples of data management, there is no comprehensive system by which data are developed, screened, and managed. The result is that most researchers and developers must invest their energies in data access at the expense of applications development. A shared repository for managed access to data and models to support sustainable manufacturing is needed.

9) **Optimized Design for Sustainability** – A systems approach to product and process design should begin with product requirements and extend, in a seamless digital thread, through the evaluation of alternatives and the selection of the best solutions, to mature designs. The

system should be integrated to ensure that best total value takes clear priority over point optimization.

10) **Systematic Sustainability Achievement** – While the key themes are important individually, coordinated implementation of a fully integrated roadmap is required for success. This theme acknowledges that a well managed, collaborative effort is needed.

Path Forward

The workshop is one step in the work of SMART-CN and the pursuit of manufacturing sustainability. It is a major milestone in the provision of a foundational roadmap that can be socialized, refined, and integrated with other documents to produce a comprehensive and integrated guide for collaboration. One of the most important messages is that manufacturing sustainability is not a goal that can be pursued in isolation. Sustainability must always be balanced with profitability, manufacturability, and socio-economic success. Many organizations are working on the digital threads of manufacturing competitiveness and their integration into a tapestry. It makes no sense, for example, to produce a national repository for sustainability data while investments are being made to create such repositories for all of manufacturing. It makes perfect sense for the sustainable manufacturing community to establish partnerships and work alongside these organizations to assure that the sustainability needs are met.