http://www.mel.nist.gov/programs/slim.htm#sars

Sustainable and Lifecycle Information-based Manufacturing

Program Manager: Ram D. Sriram

Annual FTEs: 8.75 NIST FTEs

9 Guest Researcher FTEs

17.75 Total FTEs

Challenge:

The United States needs to prepare for a future where products are 100% recyclable, manufacturing itself has a zero net impact on the environment, and complete disassembly and disposal of a product at its end of life is routine. To document and monitor these changes, US industry will require key resources and methods that will enable it to measure sustainability along several dimensions (such as carbon foot print, energy accounting and recyclability of materials) allowing accurate assessment of status and progress. These resources and methods require identification of dimensions, associated measurements and classification of information relevant to sustainable product design and manufacturing. Such a base of information is critical to product designers and manufacturing engineers so that they can incorporate sustainability in their efforts. Hence, the primary challenge is to develop requirements, formal models, and validation methods for sustainability-based and lifecycle information-based manufacturing that support interoperability among tools and standards for design, analysis, simulation, and lifecycle assessment and information management.

Overview

Sustainability and globalization are two forces shaping the future of product engineering and manufacturing. Globalization responds to the need for product variety to deal with differentiated demands around the world and to the ability of producing different parts and subsystems of products in distributed locations. The needs of sustainability and the global distribution of design and production require seamless exchange of vast quantities of information across the design and manufacturing network. Specifically, demands of sustainability are causing companies to implement new design and analysis procedures, energy reduction methods, material reduction efforts, and improved materials handling practices. Minimizing environmental impact has become a critical driving force for the manufacturing industry throughout the product lifecycle.[1, 2] In order for manufacturing to be cleaner, more efficient, and environmentally benign, industry needs to be able to make informed decisions throughout a product's life. This requires better interoperability among tools and standards for design, analysis, simulation, lifecycle assessment and information management. NIST is equipped to define the needed requirements, formal models, and validation methods for sustainability-based and lifecycle information-based manufacturing. It is critical to the success of companies and their suppliers that this supporting IT infrastructure for sustainable manufacturing be done correctly, efficiently, and inexpensively.

Failures in information exchange at the interfaces between design, engineering, manufacturing and other functions can be viewed as the Achilles heel of good product design.[3] The ability of a firm to share relevant product descriptions and other information across the functional domains throughout the product lifecycle is critical to the firm's performance in the context of the forces of sustainability and globalization. A significant challenge of this program is to infuse information and methods for sustainability assessment in the design and manufacturing of products. To achieve sustainability goals across the product life cycle, the information infrastructure has to move beyond silos of information to a networked information infrastructure servicing all phases of the life cycle.

A lifecycle support system that supports sustainability evaluations requires a move from product data exchange to product information and knowledge exchange across different disciplines and domains. Sustainability-based lifecycle support systems will need both syntactic and semantic interoperability through well-defined standards. The projects in this program address the challenges of information-based support of sustainable and globally distributed product lifecycle management.

Why NIST?

NIST can provide the unifying intellectual base to develop the requirements for and implement the standards to support a diverse range of industries, from discrete parts to continuous processes. Currently, the limited success in the implementation of integration, interoperability and information management technologies by some manufacturers impedes their ability to further capitalize on the emerging need for sustainable manufacturing directions. As companies venture into sustainable manufacturing, the need to integrate systems is further emphasized due to the inherent cross-disciplinary, multi-model nature of the work. The multi-model aspects reveal further interoperability problems because outputs from multiple application models must be combined to reach the desired results. Unlike corporations or universities, NIST sits at the interface between industry and academic research and has the capabilities, legitimacy and contacts to address such multi-disciplinary issues.

Program Objectives

The program has three major objectives:

Objective 1: Establish standards requirements for sustainable manufacturing

The following tasks will be undertaken to achieve this objective:

- Survey the standards and performance metrics landscape for sustainable manufacturing. Perform case studies of existing implementations of sustainable manufacturing to generate information requirements for the support of sustainability and characterize the economic, ecological and societal interactions in a product's lifecycle. Propose new or harmonized standards and metrics for sustainable manufacturing.
- Characterize business and engineering information in support of a unified resource accounting scheme for supporting sustainable design, manufacturing, use and disposal of products. Develop green accounting principles to trace the environmental impacts from the part level to the system level and for the full lifecycle, including assembly, disassembly, and recycling.
- Characterize engineering information in support of long-term archival access to all lifecycle information, including sustainability aspects. Develop and test a framework for digital engineering information archives.

The following projects will address this objective:

- Project 1.1. Survey and analysis of relevant standards for sustainable manufacturing.
- Project 1.2. Scheme for computing carbon weight (footprint) for manufactured products.
- Project 1.3. Long term knowledge retention for digital technical product documentation.

Objective 2: Provide formal models of product and process information

The following tasks will be undertaken to achieve this objective:

- Develop information models for products and manufacturing processes that contain key attributes necessary for sustainable and lifecycle information-based manufacturing (such as energy and environmental costs of manufacturing equipment or material recovery costs of product components). Present the resulting integrated formal models to industry, consortia and standards development organizations.
- Work with partners to develop and validate high-priority standards for seamless information exchange between engineering and production, and between production and manufacturing business functions. Enable reuse of existing manufacturing data standards within an evolving standards infrastructure, and help manufacturers ensure that established and widely-implemented engineering and product data standards can be retooled as needs or supporting information technologies change.

The following projects will address this objective:

- Project 2.1. Information models for sustainable manufacturing.
- Project 2.2. STEP evolution and extensions for sustainable manufacturing.

Objective 3: Develop validation, simulation and testing methodologies for information models and standards

The following tasks will be undertaken to achieve this objective:

- Develop model-based validation and testing techniques for sustainable and lifecycle information-based manufacturing.
- Develop the necessary extensions of current discrete-event simulation concepts and tools to incorporate attributes and metrics for the simulation of various sustainability aspects in manufacturing enterprises and supply chains. With the extensions, demonstrate the simulation of representative aspects of sustainability, for example, simulating regulatory compliance (e. g., RoHS, REACH, WEEE) and voluntary standards compliance (e. g., ISO 14000).
- Create test scenarios in the context of sustainable manufacturing for globalized manufacturing networks by validating information model standards for interoperability of tools and systems. Develop a testbed that validates the different aspects of the work conducted throughout this project by applying metrics for the performance of specific applications or procedures for sustainable and lifecycle information-based manufacturing.

The following projects will address this objective:

- Project 3.1. Model-based engineering for sustainable manufacturing.
- Project 3.2. Simulation of manufacturing enterprises for sustainability.
- Project 3.3. Standards and testbeds for sustainable manufacturing.

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[1] http://trade.gov/competitiveness/sustainablemanufacturing/index.asp

[2] Technology Roadmap Workshop for Automotive Manufacturing Energy Reduction, DOE Industrial Technologies Program, 2008

[3] 3. James Stark, Product *Lifecycle Management: Paradigm for 21st century Product Realisation*, Springer, September 2004

Project 1.1. Survey and analysis of relevant standards for sustainable manufacturing

Anticipated Completion Date: Q4, 2009

Project 1.2. Scheme for computing carbon weight (footprint) for manufactured products

Anticipated Completion Date: Q4, 2011

Project 1.3. Long term knowledge retention for digital technical product documentation

Anticipated Completion Date: Q2, 2011

Project 2.1. Information models for sustainable manufacturing

Anticipated Completion Date: Q4, 2011

Project 2.2. STEP evolution and extensions for sustainable manufacturing

Anticipated Completion Date: Q4, 2010

Project 3.1. Model-based engineering for sustainable manufacturing

Anticipated Completion Date: Q4, 2011

Project 3.2. Simulation of manufacturing enterprises for sustainability

Anticipated Completion Date: Q4, 2011

Project 3.3. Testbed for standards and methods for sustainable manufacturing

Anticipated Completion Date: Q4, 2011

Project 2.1. Information models for sustainable manufacturing

Anticipated Completion Date: Q4, 2011

Project Overview:

The principal objectives of the project are to: (1) provide formal representations of information to support the full range of the product lifecycle beyond the representation of form (geometry and material), (2) complete the standardization of the OMG reference model for managing product lifecycle information and (3) define formal models to supply the representation needs for sustainable manufacturing, including reuse, recycle (disassembly) and remanufacturing. The current lack of formal models (syntactically and semantically consistent representations) of product life cycle information makes it difficult to standardize and validate support systems for product life cycle management.

To meet the project's objectives, the following activities will be undertaken:

- Extend the formal representation developed to date by synthesizing prior work on product, assembly and systems models, leading to comprehensive and rigorous models that facilitate automated reasoning, maintenance of consistency, semantic interoperability, and concurrent product development.
- Develop a standardized terminology of terms and concepts for products and processes (ontology), with an emphasis on sustainability.
- Analyze the standards requirements for sustainable manufacturing, including reuse, recycle (disassembly), remanufacturing identified in other projects.
- Develop smart disassembly techniques and supporting standards.
- Create lifecycle information models for interoperability among systems and tools that support sustainable manufacturing.
- Extend the Core Product Model (CPM) to support information related to sustainability issues in simulation.
- Integrate product and process models by developing design process models using PSL, SysML and related methodologies.

Deliverables and Intermediate Milestones:

Q4/FY10	Standardized terminology of terms and concepts for products and processes (ontology)
Q4/FY09	Prototype information model for the disassembly and material content of mechanical products
Q4/FY10	Demonstration of a prototype standard use for sustainable assembly and disassembly
Q4/FY10	Demonstration of disassembly, reuse and recycle of a selected engineering design in a CAD model using the developed information model prototype
Q4/FY09 Q4/FY10 Q4/FY11	Information models forming the basis of new ISO or OMG standards: Standardization proposal Proposal accepted First draft international standard proposed
Q2/FY09 Q4/FY11	Shareable information models for integrating simulation with other product life-cycle tools: Use case analysis for defining interfaces Information models for simulation software tool integration
Q4/FY09 Q4/FY10 Q4/FY11	Integration of existing product and process models through ontological representations using PSL, SysML, and related methodologies: First draft Second iteration, based on feedback from the industry Final model

Collaborators:

- CHALMERS University (Sweden)
- Carnegie Mellon University (CMU)
- IMS Project partners
- OMG
- ISO
- Department of Energy
- Environmental Protection Agency

Customers:

- Automotive industries (GM, Ford, Toyota)
- Aerospace industries (Boeing)
- Simulation software vendors (Delmia, Rockwell)
- Other NIST OUs

Project 3.3. Testbed for standards and methods for sustainable manufacturing

Anticipated Completion Date: Q4, 2011

Project Overview:

The principal objective of the project is to develop testbeds to validate the information standards and methods through testing in different sustainable manufacturing contexts.

To meet the project's objective, the following activities will be undertaken:

- Develop a methodology for testbeds based on prior experiences at NIST and develop a reference testbed architecture.
- Test information standards that support carbon output reporting and carbon credit trading
- Test information standards that support recycling, reuse, or disposal of manufactured products
- Validate and test information models for sustainable design and manufacturing.

Deliverables and Intermediate Milestones:

Q2/FY09	Survey report of existing standards relevant to sustainable manufacturing
Q2/FY10	Website on standards for sustainable manufacturing and their scope.
Q4/FY10	Research report on the analysis of the standards landscape including gaps and overlaps.
Q4/FY11	Proposal on harmonized standards and metrics.

- Demonstration testbed to validate the different aspects of the work conducted throughout this program. The testbed will apply metrics for the performance of specific applications or procedures for zero-impact manufacturing (Q4, 2011).
- Development of model-based validation and testing techniques (Q4, 2011).
- Testing tools and test artifact definitions that support the validation of sustainability-related standards. (Q2, 2010).
- Prototype testing tools for validation of sustainability-related standards (Q4, 2011).

Collaborators:

- George Washington University (GWU)
- IBM
- SDOs: OMG, OAG, OASIS, ISO
- PDES Inc., ProSTEP
- IMS Project partners

- Other NIST OUs

Customers:

- Federal Agencies
- Standards development organization
- Testing services such as UL for information standards.

[4] Conformance classes partition a standard's specifications to a particular subset of conformance requirements.