AME Topics

Advanced Manufacturing Enterprise (AME) consists of agile and robust manufacturing strategies and integrated capabilities that dramatically reduce the cost and time of producing complex systems and parts. Broadly, AME technologies and methods support the design and realization of products, processes, and systems from an integrated whole life perspective with the goal of reducing costs, reducing time to market, and increasing value through innovation and high quality in today's manufacturing enterprises.

AME1: Systems Design in the Digital Thread

Currently, tools and methods used in the design of products and systems have very limited, or no capacity, to support real-time automated, or semi-automated, guidance for decision making in light of life cycle considerations, or "ilities" such as producibility, serviceability, usability, sustainability, and more. Early design for "ilities" guidance would enable more producible, serviceable, usable, sustainable, safe, and customer valued lower-cost designs and shorter product development cycles with fewer design iterations. Whether embodied in intelligent systems or more human guided, solutions are needed that enable and integrate the wide array of stakeholders across the eco-system in the design of products and systems (e.g., suppliers, OEMs, ODMs, end users.).

AME2: Smart Factory Visibility and Real-Time Optimization

The visualization of real-time data within a factory, and the use of this data for real-time optimization of factory efficiency, robustness, and profitability hold great promise for bringing about a significant reduction in the design-build cycle. The digital integration of the manufacturing enterprise will feature the seamless flow of data between different stages of the product lifecycle, and between different parts of the value chain. This data can be analyzed to improve factory operations and shared within a value chain to benefit others. It is desirable to aggregate and analyze process data within a factory in order to make real-time decisions that improve factory operations, and to make this critical data available to factory operators and to other parts of the value chain. Real-time optimization of factory operations will result in improved asset utilization, higher product quality, and more efficient use of energy, labor, and materials. Visibility of these factory operations by others will result in increased supply chain efficiency, more effective procurement, and faster time to market.

AME3: End to End Supply Network Synchronization

The success of a modern company greatly depends on the ability to collect and use data to plan and manage the manufacture and distribution of its products.

Supply network optimization is difficult given today's globally distributed businesses and marketplace, where businesses experience increased variability in market demand, increased complexity in transportation, and distributed manufacturing. Hence, it is important to define and implement a more efficient equilibrium between demand, production capacity and agility and inventory management. It is important to include suppliers in the need for defining and implementing a more efficient equilibrium. The use of technology to support supply chain analytics and supply chain visibility are key to network synchronization and optimization.

AME4: Full System Integration of the Digital Fabric

Product information often does not flow smoothly through manufacturing processes, between organizations or across the life cycle of manufactured products. This discontinuity can arise for many reasons; gaps in technological integration or capability, organizational structure, individual or team incentives, and combinations of each. Limited ability for information sharing and extraction across different disciplines and needs causes substantial wastes in terms of time, materials, and labor. These limitations also affect the quality and performance of products. Data, information, and knowledge can be found in a variety of formats in an organization and include quantitative and qualitative measures, making the flow and integration even more challenging. Moreover, true integration requires orchestrating and connecting sources within and between organizations that are in varying formats, purposes, and distributed widely.

AME 5: Completing the Model-Based Definition

Current industrial implementations of model-based definition (MBD) primarily deal with shape capture of a product. Moreover, it is inherently dependent upon the software system that authors the model, which is most often a commercial CAD software. In order to enable additional consumers of information among the stakeholders in the life cycle, the model-based definition must address not only shape, but behavior and context as well. It must also be able to be dynamically scaled with respect to level of detail regarding shape, behavior and context in order to enable and promote consumption throughout the life cycle. For example, in addition to shape, behavior and context, product manufacturing information (PMI) should be accommodated. MBD should also include process data and as-built variability during the manufacturing life cycle. This has the potential to reduce cost, increase quality, and enable better (and more accurate) communication within the supply chain and sustainment efforts. Model-based definition is fundamental to the digital thread; a critical communication conduit for the product life cycle.

AME6: Closing the Gap in SME Engagement in Digital Manufacturing

Large OEMs with the resources available are often sophisticated users of digital manufacturing technologies, while small and medium-sized enterprises (SMEs) with fewer resources are not. This capability gap creates significant inefficiencies along the value chain, where the size, scope and challenges of SMEs can be quite varied. Significant problems can result when large companies use digital manufacturing technologies and small to medium size companies do not. Benefits from technologies for data sharing, life-cycle data availability, and supply chain analytics, to name a few, are severely limited without participation of the full value chain. Ultimately, the goal is to enable all of the organizations within a value chain to use digital manufacturing technologies for the design and production of new products. Solving this problem would result in greater innovation, quality and value to customers, at reduced costs and speed the time to market.

IM Topics

An IM will be envisioned to consist of the following highly-integrated functional software and/or hardware entities such as:

- Physical Embodiment of the machine consisting of its structural, power, sensing, actuation, fixturing, transportation, computing and other requisite hardware entities.
- Communication Function in association with a Database Function providing for internal to the machine as well as external communications.
- Diagnostics and Maintenance Function assuring a trouble-free operation of the machine.
- Task Execution Function providing the central ability of the IM to execute its tasks in light of the uncertainties caused by environmental, processing and machine-induced changes by proper heuristic and/or control and adaptation methods supported by a knowledge-base and learning abilities. Conditionally, this function can also be referred to as the Reasoning Function of the IM manifesting itself in the nature of the control and decision-making processes the machine performs.

The central overarching aim of the IM activity of DMDII involves developing an open-architecture, ‘plug-and-play’ and user-friendly hardware and software platform with its associated functional component technologies that allows the seamless integration of the IM functions into next-generation digital manufacturing systems at the machine, enterprise and supply-chain levels. The technologies to be developed will target both new generations of IMs to be developed as well as legacy machines to bring them up to the target standards established for the new generations of IMs.

IM1: Communication Standards for Intelligent Machines

The realization of digital manufacturing critically hinges on the ability to securely and easily capture, transfer, and analyze data from production machine tools. This requires multi-functional, simply discoverable, and affordable sensing technologies that can be easily integrated into both new and legacy systems, and that possess plug-and-play functional characteristics. While many modern machine tools possess sensing and control systems, the data communications and digital interfaces are frequently complex and/or proprietary. The lack of plug-and-play type digital integration is an obstacle to achieving seamless digital operation of these machines within the manufacturing enterprise. This project call focuses on applying standards and demonstrating plug-and-play digital integration that enables machine tool data collection, transfer, and analysis. The expected result is significant reduction in the cost and complexity of machine tool digital integration. The ultimate goal is a smart factory that has full systems integration of hardware, software, and data.

IM2: Cyber Security of Intelligent Machines

In spite of the ever increasing use of computers and data exchanges between machines and operators on the shop floor there is a marked absence of adequate cyber security measures and technologies for the prevention of potentially catastrophic security breaches. Shop floor level security has been enforced in many cases by completely restricting any network capability of the equipment. Such restrictions prohibit the adoption of digital manufacturing technologies. The realization of the envisioned digital tapestry that requires real-time connectivity, communications and data exchanges from the lowest machine to the highest enterprise-levels necessitates the development of structured and standardized security measures and protocols.

IM3: Operating System for Cyber Physical Manufacturing

Most factories consist of multiple machine tools, robots, and inspection tools that originate from various vendors. The dynamic organization, and reorganization, of these resources can be costly and slow. The challenge is particularly acute for small businesses, which often do not have access to software tools such as MES and MRP. An Operating System for Cyber Physical Manufacturing (OSCM) will make it possible to efficiently and dynamically organize and integrate heterogeneous manufacturing hardware resources. The OSCM will result in an accessible and standardized manufacturing capacity to allow manufacturing enterprises to streamline and dynamically control and configure their internal resources and external supply networks.

IM4: Intelligent Machining Toolkit

A key limitation of conventional machine tools is their lack of intelligence. In general, manufacturing equipment is not self-monitoring, error-correcting, or capable of adapting to variations without custom developed application-specific algorithms. The development and maintenance of such intelligent systems is expensive and often requires technical expertise that is not widely available. There is a need for commercially available intelligent machine tool solutions that are low cost, scalable, and capable of plug-and-play type interoperability. This topic will also promote the adoption of machine tool standards (IM1).

AA Topics

The methodology, tools, techniques and algorithms associated with the functional description, performance analysis, predictive modeling and simulation and interactions of a system with an environment. The core of AA is the ability to predict the outcome of a process, design, or manufactured part before the fact. AA requires data, whether design data or real-time process data. It also includes multi-physics and/or data driven computational models, simulation methods including uncertainty quantification, computational platforms, mathematical methods, optimization methods, algorithms, measurement methods, data collection, and network information flow.

AA includes the following key capabilities:

- Advanced analytics to drive productivity
- Modeling and Simulation
- Equipment and systems diagnostics
- Design optimization
- Intelligent Networks

AA1: Agile Manufacturing to Compensate for Production Variability

Agile Manufacturing is defined to be the tools, processes, and training to be able to respond quickly to market changes. The typical output of Agile Manufacturing is to quickly deliver new products to respond to these market changes. It is desirable to extend Agile Manufacturing processes to respond to variability in a product rather than market changes. Production variability exists for all manufactured components in a product regardless of manufacturing process or processing order. The cost of variability is typically quantified in terms of part yield, where nonconforming components are reworked or scrapped which is a short sighted perspective because the variation in the performance of the assembled system requires more intensive maintenance, shorter maintenance cycles, designed-in margins and tighter tolerances, all of which contribute more to the lifecycle cost of a system than costs associated with low component process yields. Performance prediction should focus on the lifecycle costs of the entire product.

AA2: Shop Floor Augmented Reality and Wearable Computing

Shop floor technicians and assembly operators spend significant amounts of time looking for work instructions, recording information, and attempting to share information with others. Many tasks performed by shop floor technicians could be significantly accelerated by capturing what the technician is doing, and by delivering dynamic work instructions based on those actions. The largest opportunities for productivity improvements involve complex, non-routine tasks including machine maintenance and product re-work, as well as training and re-training on the shop floor. Natural, convenient, and relevant information provided to the technician could lead to higher resource utilization, operational effectiveness, and product quality.

AA3: Virtually Guided Certification

The cost and time to certify a manufacturing process, material, and design can be significant. Depending on the application, current estimates place the insertion of a single materials system into a complex design at tens of millions of dollars (or more) and 15 years. This time and cost is not acceptable in a competitive worldwide market. Any change in a certified process can almost be impossible to make, even if the improvement is large, due to the time and cost of certification.