Digital Manufacturing and Design Innovation Institute
Project Call 15-08

Course Content Expectations

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Course Areas: DMDII-15-08 Section 3.1

DMDII anticipates the development of up to nine DM&D-101 specialization courses with verified certificates for each course and a certificate for completing the full specialization track consistent with the Coursera specialization offering model. Each course will comprise on average 20-40 hours of study including at least one introductory lecture suitable for general audiences. More information is included in Project Call 15-08 available at http://dmdii.uilabs.org/projects

Introduction to Digital Manufacturing & Design (1 course)
What is digital manufacturing & design, and how does it differ from manufacturing & design today in many companies?

Introduction to the Digital Thread (up to 3 courses)
Digital manufacturing and data connections from cradle to grave
- Digital Thread
- Model Based Design
- Model Based Enterprise

Digital Manufacturing Research Thrust Areas (up to 5 courses)
- Advanced Analysis (AA)
- Intelligent Machining (IM)
- Advanced Manufacturing Enterprise (AME)
- Digital Manufacturing Commons (DMC)
- Digital Manufacturing Security
Digital Thread

The **Digital Thread** describes the electronic files and data pathways that enable the repurpose, reuse, and traceability of information in the development, definition, build and support of a part or system throughout its life. The Threads weave through connected machines, factories, and supply chains to enable data aggregation, analysis, and action forming a Digital Quilt that encompasses an entire product or system.
Model Based Design is a collaborative design and development approach that places the 3D CAD model in position to be the source from which all other documentation is developed.

Model Based Design
A **Model Based Definition** is a complete **3D Digital Product Definition** created at the beginning of the product lifecycle to be used throughout the enterprise, reducing costs, improving system performance, and enabling future systems upgrades.

Technology, processes, and standards need to be made available to support a complete Digital Thread – fully defined digital product definitions in reusable formats that facilitate the use of open, interoperable software tools for design, simulation, manufacture, and life cycle support systems.

**Standards:**
- ISO-16792:2006
- US DoD MIL-STD-31000 Revision A for Technical Data Packages (TDPs)
Model Based Systems Engineering is the formalized application of modeling to support the evolution of system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing through product end of life.
**Product Data Management (PDM)** is the use of software or other tools in a file system for managing 3D models and data surrounding a part or product. Content within a PDM system may include 3D CAD data, revision and release control, manufacturing data, bill of materials, vendor information, product configurations and other metadata.

**Product Lifecycle Management (PLM)** is the use of software to manage a database surrounding a product from concept through end of life that integrates PDM with other technical focused business systems such as Systems Engineering, Manufacturing Process Management, Quality Management, and Asset Life Management. The integration of PLM components provides the technical and product focused backbone of an expanded Enterprise Resource Planning (ERP) system.
Design and Manufacturing Tools

Describe current design and manufacturing tools while enabling understanding at multiple levels of educational background

- Value proposition
- Job/Career opportunities
- Identify tools and level of sophistication, with strengths and weaknesses
- Examples of impact upon market sector
- Describe the threads between design and manufacturing tools

**CAD**
Computer-Aided Design

Computer systems used to aid in the creation, modification, analysis or optimization of a product or system’s design.

**CAM**
Computer-Aided Manufacturing

Computer software used to develop machine tool commands from an existing 3D Model.

**AM & RP**
Additive Manufacturing & Rapid Prototyping

- Additive Manufacturing technologies build 3D objects layer-by-layer from an existing 3D Model.
- Rapid Prototyping is a group of techniques used to quickly fabricate a physical part or assembly from 3D CAD data for development or analysis.

For Public Release
Enterprise Management Tools and Systems

Describe current enterprise management tools while enabling understanding at multiple levels of educational background

• Value proposition
• Identify tools and level of sophistication, with strengths and weaknesses
• Examples of impact upon market sector
• Describe the threads between the enterprise tools and the model based enterprise

**MRP**

Material Requirements Planning

MRP is a production planning and inventory control system used to manage manufacturing processes.

- Ensure material availability for manufacturing and customers
- Maintain lean material levels
- Plan purchasing, manufacturing, and delivery

**MPM**

Manufacturing Process Management

MPM is a collection of methods used to define how a product is to be manufactured.

An MPM system may include;

- Production Process Planning
- CAM
- Work Instructions
- Time & Cost Estimates
- Quality Assurance Systems

**MES**

Manufacturing Execution Systems

MES are used in manufacturing to track and document the processing of raw materials into finished goods providing a traceable production record. An MES can interact throughout the enterprise down to individual PLCs and workers for resource scheduling, order execution, production analysis, downtime management, quality and traceability.

**ERP**

Enterprise Resource Planning

ERP is a business management system that is used to manage data from business activities that include;

- Finance Resource Management
- Supply Chain Management
- Human Resources Management
- Customer Resource Management
- Materials Resource Planning

Source: [http://homaggroupwebapp.homag.de/](http://homaggroupwebapp.homag.de/)

Source: [http://www.prerogative.co.uk/](http://www.prerogative.co.uk/)
Model Based Enterprise (MBE) is an integrated and collaborative environment, founded on a Model Based Definition shared across the enterprise, enabling rapid, seamless, and affordable deployment of products from concept to disposal.

MBE across Product Lifecycle

MBE Systems Architecture
Analysis Tools and Systems

Describe the current reality and future vision of manufacturing with digital linkage to analysis tools

- Value proposition
- Job / Career opportunities
- Identify tools and level of sophistication, with strengths and weaknesses
- Examples of impact upon market sector
- Describe the threads between engineering and manufacturing and associated analysis tools
- Identify the gaps analysis tools do not address, continuous versus batch production

Example Analysis Tools and Systems

ICME – Integrated Computational Materials Engineering ties material properties and microstructure prediction into manufacturing and product performance simulations

FEA/M – Finite Element Analysis / Method is a computational tool or method for performing engineering analysis on components and systems, in steady or transient states. The analysis can include stresses, heat transfer, magnetic fields, and other phenomena.

CFD/E – Computational Fluid Dynamics tools analyze fluid flow and interaction with components or systems.

Design for Affordability – Cost and Quoting Estimation for manufacturing a given design

Producibility and DFM – Producibility and Design for Manufacturing tools can be used to determine how a part or feature can be produced, assembled, tolerated or to examine simulated machining operations for machine conflicts in a CAD environment.

Quality Management – Software and Tools that enable the collection of process data for control and defect analysis

Source: http://materialsinnovation.tms.org/docs/pdfs/ICMEProgress.pdf
Source: SolidWorks – Automatic Manufacturing Cost Estimation

For Public Release
Shop Floor Tools and Systems

Describe the current reality and future state of manufacturing shop floor tools while enabling understanding at multiple levels of educational background

• Define the value proposition, could be broken into various scopes (MTConnect, Sensors, MES solutions, etc.)
• Job / Career opportunities
• Identify tools and level of sophistication, with strengths and weaknesses
• Examples of impact within market sectors
• Describe the thread between shop floor tools and other engineering and management systems
• Identify the gaps shop floor tools do not address

Example Shop Floor Tools and Systems

NDI/E – Nondestructive Inspection / Examination (Metrology) tools such as x-ray, ultrasound, eddy current, flash IR, magnetic particle inspection, and liquid penetrant testing are all methods of inspecting a material, part, or assembly without damage.

MES – Manufacturing Execution System is used to track the processing of raw materials into finished goods and may cover product definition, resource and labor scheduling, order dispatching, production analysis, downtime management and may be seen as an intermediate step to a full ERP system.

IoT – Internet of Things is a network of physical objects containing embedded electronics, software, sensors, and the ability to connect to the network through existing infrastructure to collect and exchange data.

Sensors – Instrumentation throughout product manufacturing, logistics, and service that can provide quality and operation feedback
Research Thrust Areas

Describe the current and future states of DMDII’s Research Thrust Areas while enabling understanding at multiple levels of educational background

- Define the value proposition and impact
- Job / Career opportunities
- Identify tools and level of sophistication, with strengths and weaknesses
- Describe the thread and role between the Research Thrust Areas and other Digital Manufacturing Systems

Advanced Analysis (AA) – The collection and analysis of data over sustained periods of time which enable manufacturing design.

Intelligent Machining (IM) – The integration of smart sensors and controls to enable equipment to automatically sense and understand the current production environment in order to conduct self-aware manufacturing.

Advanced Manufacturing Enterprise (AME) – The aggregation and integration of data throughout the manufacturing supply chain and product life-cycle.

Digital Manufacturing Commons (DMC) – An open source platform that enables data aggregation, analysis, and action.

Digital Manufacturing Security – How to secure all aspects of a digital manufacturing operation and protect operational technologies, systems, and resources.