AUBURN UNIVERSITY | SAMUEL GINN COLLEGE OF ENGINEERING

Digitally Enabling the Supply Chain

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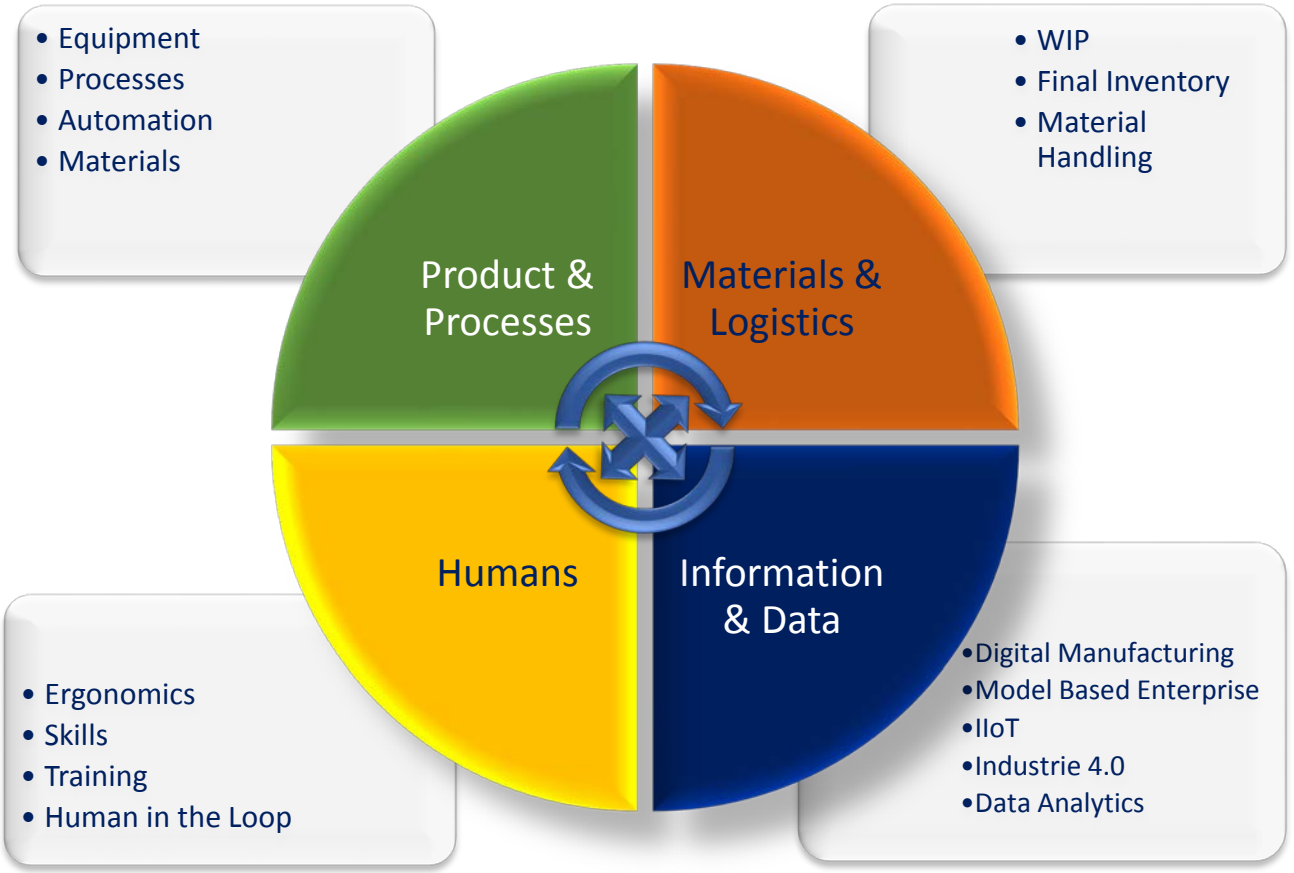
Some of our team have been working very hard on this!

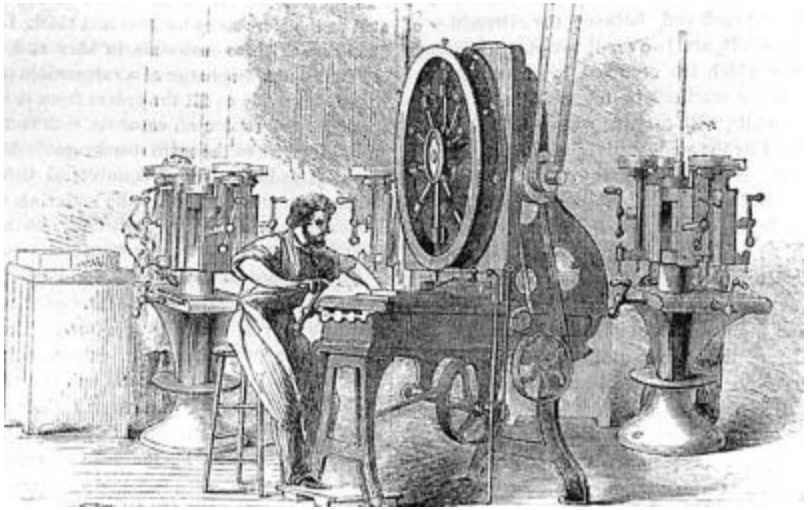
"One of the most noteworthy accomplishments in keeping the price of Ford products low is the gradual shortening of the production cycle. The longer an article is in the process of manufacture and the more it is moved about, the greater is its ultimate cost."

Henry Ford, 1926

Manufacturing Systems



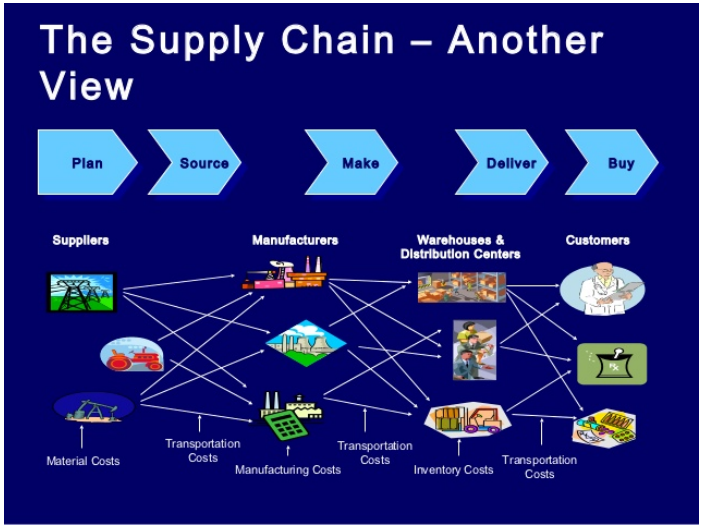
Manufacturing Data History



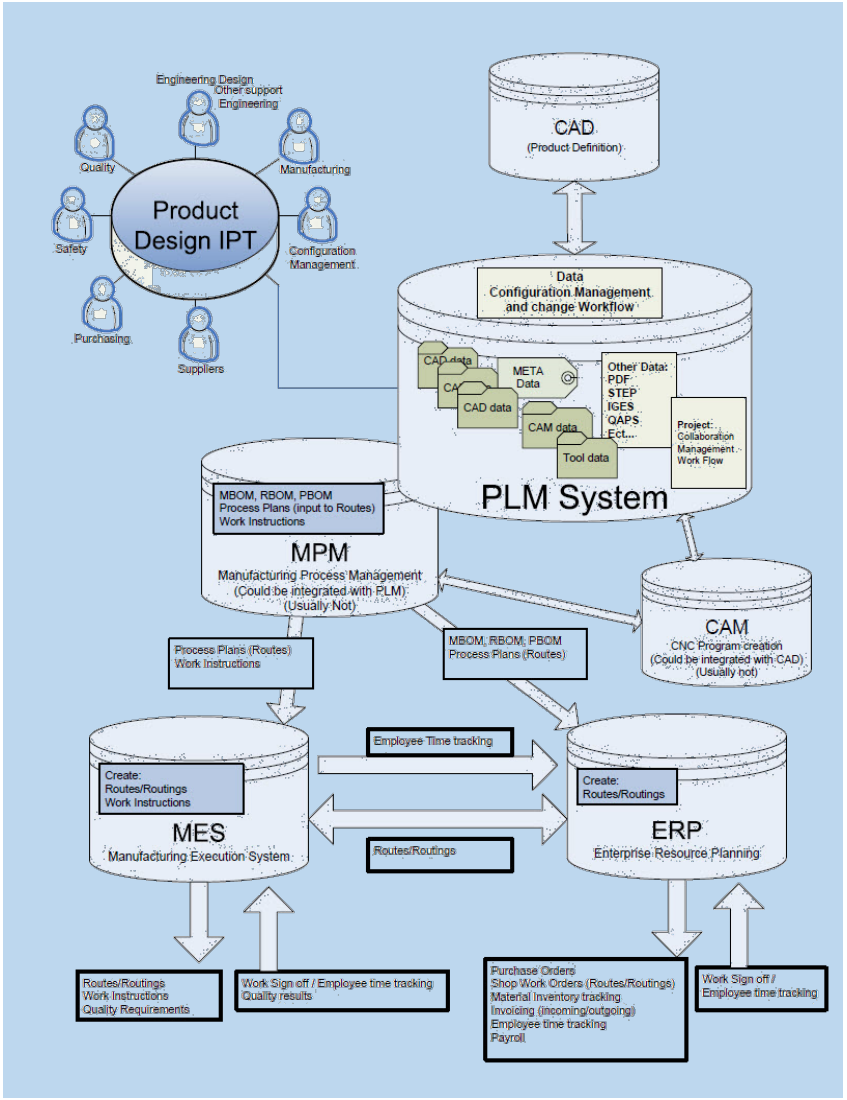
Antebellum Era of Manufacturing

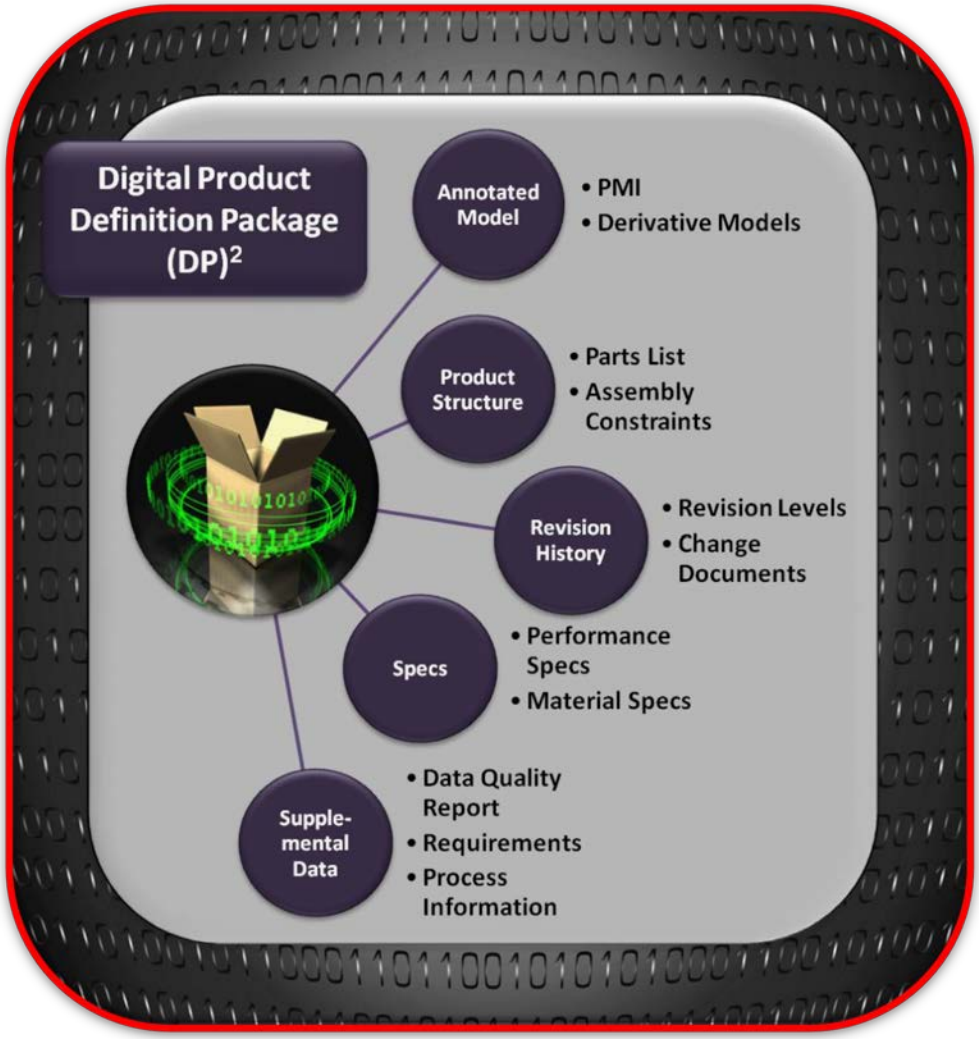
Mass Production

- Most engineering and manufacturing activities relied on 2 Dimensional (2D) drawings in hardcopy or digital form
- Today, it is possible to perform most engineering functions using data models.



Connected Digital Thread





Project Team

Rockwell Collins

Raytheon

lucrum the group

ROLLS ROYCE

NIST National Institute of Standards and Technology U.S. Department of Commerce

MBD 360

ITI International TechneGroup

The Problem and Assumptions

- Communications inefficiencies increase costs and time while stymying innovation.
- NIST research indicates that these challenges contribute to a $1 billion per year cost to the U.S. automotive supply chain.[1]
- Reduction in lead time and error rate have long been goals of manufacturers.
- A contributor to long lead times and increasing errors are interoperability problems between systems in the design, manufacture, deliver, and sustainment processes and is a significant source of pain, difficulty and increased costs.
- Information flow in the supply chain adds an additional level of complexity placed upon the product realization system.

[1] *NIST Interoperability Cost Analysis of the U.S. Automotive Supply Chain*

The Problem and Assumptions

- Even with a sustained effort by industry to become model centric, there is still a significant manual intervention in the supply chain to adapt to a Model Based Enterprise environment.
- Most collaborative exchanges around technical data are executed via unstructured communications.
- Unstructured data does not easily allow for capture, analysis and re-use.
- A comprehensive guide does not exist for an organization to use:
  - During the adoption and employment of digital manufacturing and design capabilities,
  - On how to utilize these tools and capabilities in the global supply chain,
  - On how to assure the integrity and protection of information.

Why Try?

- There is anecdotal evidence of the benefits of MBE and connecting within the digital thread.
- Areas in which there has been evidence of improvement include:
  - The elimination or reduction in the need to re-create downstream models,
  - Reduction in cycle time and costs,
  - Reduction in the risks of introducing downstream errors,
  - Increases in part yield,
  - Production of parts that meet customer requirements and expectations.
- There has not been a comprehensive effort to pull together and integrate the previous work performed by DoD, ManTech, NIST, DMDII and industry that produced tools and capabilities for providing a step by step approach to developing digital capability for supply chain engagement.
- There has never been a true implementation guide created and shared with all of industry, especially one that targets the SMMs.
- This project will weave together the good work that has been performed until now and create a picture of the digital thread in a manner designed to accelerate the depth and breadth of adoption.

Methodology

- This project delivers a set of playbooks designed to accelerate the adoption of digital supply chain practices and technologies.

- In this project we will:
  - Incorporate existing tools and technologies developed to create a roadmap and set of playbooks for Original Equipment Manufacturers (OEMs) and Small/Medium Manufacturers (SMMs) to guide the implementation of secure digitally-enabled supply chain practices and technologies.
  - Examine and define the current and desired state of digitally-enabled supply chain practices and technologies in both commercial and defense supply chains.
  - Document issues, pain points, current supply chain practices, identify critical information flows, and prioritize the gaps in technology that hinder the creation and adoption of a digitally enabled supply chain.
  - Establish the business case and identify the corporate, individual and financial incentives to implement the guidance and adopt the frameworks and applications.
  - Review the current state of model-based technology solutions and standards that affect how data is created, transferred and consumed by entities within the supply chain.
  - Address the supply chain for both new and legacy parts.

Some of the Projects to be Leveraged

Existing Projects Findings to be Leveraged					Lifecycle Management System					Application Categories							
ID No.	Project Title	Parent / Child	Sponsoring Organization	Relevancy	Materiel Solution	Technology Development	Eng & Mfg Development	Production & Deployment	Operations & Support	Supply Chain Mgmt	Digital Thread Tech / Modeling	Standards	System Architecture	MBx Tech	MBD Consumption	Cyber Security	Org Capability
1	Identified Research Directions for Using Manufacturing Knowledge Earlier in the Product Life Cycle	Parent	NIST	Addresses manufacturability in design reducing production cost by understanding the relationship of manufacturing knowledge with shape, behavior, and context characteristics.	x		x				x				x		x
2	Towards Identifying the Elements of a Minimum Information Model for use in a Model-Based Definition	Parent	NIST	The minimum set of required information to carry out all the tasks in a given work flow of a MBE	x	x	x	x	x				x				
3	Design and Configuration of the Smart Manufacturing Systems Test Bed	Parent	NIST	Outfitting of equipment to collect data and develop information analysis capability reducing manfuacturing cost and time to market			x	x					x		x		
4	Software Requirements Specification to Distribute Manufacturing Data	Parent	NIST	Enables a smart shop floor to reduce labor and time to market			x	x	x				x				
5	Measuring the PMI Modeling Capability in CAD Systems: Reports 1, 2 & 3	Parent	NIST	Seemless data sharing through out the enterprise to reduce time to market and non-reccuring engineering	x	x	x	x	x			x	x		x		
6	Gap Analysis of Integrating Product Design, Manufacturing, and Quality Data in the Supply Chain Using Model-Based Definition	Parent	NIST	Using standards for data exchange, gaps in tools standards and processes that result in interoperabilty and is CAM and CMM feedback to CAD possible.	x	x	x	x	x	x					x		
7	A Summary Report on the Model-Based Enterprise Capability Index and Guidebook Workshop	Parent	NIST	Enables the measuring and then planning for MBE implementation	x	x	x	x	x			x		x			
8	Toward a Lifecycle Information Framework and Technology in Manufacturing	Parent	NIST	A conceptual framework for lifecycle information management and integration of new technologies			x	x	x			x	x				
9	Investigating the Impact of Standards-Based Interoperability for Design to Manufacturing and Quality in the Supply Chain	Parent	NIST	high payback use cases in the supply chain for application of MBE and standards based exchange	x	x	x	x	x			x					
10	Testing the Digital thread in Support of Model-Based Manufacturing and Inspection	Parent	NIST	Validation of the MBE concepts and standards for removing issues with interoperability			x	x	x			x		x	x		
11	Network Centric Model Based Enterprise (NCMBE)	Parent	Army ManTech	Foundational work on MBE Concepts	x	x	x	x	x		x	x	x	x	x		x
11a	3D Technical Data Package	Child / NCMBE	OSD/Army ManTech	Standard method of conveying design intent to manufacturing	x	x	x					x			x		
11b	Certification of 3D Models as the Product Master	Child / NCMBE	OSD/Army ManTech	Validation of the model data	x	x	x	x	x			x			x		
11c	The MBE Capability Index	Child / NCMBE	Army ManTech	Enables the measuring and then planning for MBE implementation	x	x	x	x	x			x					x
11d	Dynamic Workinstructions and Technical Manuals	Child / NCMBE	Army ManTech	Enables the use of dynamic 3D based work instructions and tech manuals on both the shop floor or in field use			x	x	x		x			x	x		
12	Network Centric Model Based Enterprise II (NCMBE2)	Parent	Army ManTech	Issues with implementing MBE in Army organizations and strategy development for enabling	x	x	x	x	x		x	x	x	x	x		x
12a	PM Cargo Helicopter Process Assessment	Child / NCMBE	Army ManTech	Lessons learned from an Army perspective to validate the MBE concepts				x	x	x				x	x		x
12b	3D PDF Based TDPs	Child / NCMBE	Army ManTech	Standard method of conveying design intent to manufacaturing	x	x	x	x	x			x			x		
12C	Rock Island Arsenal MBE Capability Assessment	Child / NCMBE	Army ManTech	Assessment of MBE capability in the Army Organic Industrial Base and development of a plan to implement and enable new capabilities			x	x	x					x	x		x
13	Customer/Supplier Interoperability during Collaborative Design (CSI)	Parent	AFRL ManTech	Methods for reducing the cost and time of data transfers		x	x	x			x		x		x		
14	Accelerated Adaptive Army Innovation Fabrication Enterprise (A3FABE)	Parent	Army ManTech	Foundational work on MBE Concepts	x	x	x	x	x		x	x	x	x	x		x
14a	Prototype Integration Facilities MBE Capability Assessments	Child / A3FABE	Army ManTech	Assemnet of Prototype Integration Facility MBE capabilities in a quick response, job shop environment	x	x	x	x		x		x		x	x		x
14b	PLM Integration Into a Production Environment	Child / A3FABE	Army ManTech	Foundational work on the use of product lifecycle management tools in support of production activities			x	x			x		x	x			
15	AgilePod Digital Thread	Parent	AFRL ManTech	State of the industry for 10-15 companies (SMM's and OEM's) sharing information on a new product including major design modifications, outsourced fabrication/assembly and bid/proposal/quoting cycles.	x	x	x	x	x	x			x		x		
16	Reference Architecture Model Industrie 4.0 (RAMI4.0)	Parent	VDI/ZVEI	A model for semantic technologies and the benefits it will create for automation and advanced technologies			x	x	x				x		x		x

Some of the Projects to be Leveraged

17	DMDII 14-06-01: Supply Chain Model Based Enterprise and Technical Data Package Improvement	Parent	DMDII	The relevant outcome is the state of the industry for 10-15 companies (SMM's and OEM's) sharing		x	x	x	x	x		x		x	x		
18	DMDII 14-08-01: Integrated Design and Manufacturing Models with Metrology	Parent	DMDII	Digital twin framework for design, manufacturing, and cost optimization		x	x	x			x		x				
19	DMDII 14-10-01: AVM Standards Development and Promulgation	Parent	DMDII	DFx schemes and standard development		x	x	x							x		
20	DMDII 14-02-02: Mind the Gap – Filling the Gap between CAD and CNC with Engineering Services	Parent	DMDII	MBD/STEP standard for CNC applications		x	x				x	x			x		
21	DMDII 15-11-08: Capturing Product Behavioral and Contextual Characteristics through a Model-Based Feature Information Network	Parent	DMDII	Advanced MBE/MBD framework for broad based product information sharing throughout life cycle	x	x	x	x	x	x	x	x	x	x	x		x
22	DMDII 14-06-05: Operate, Orchestrate and Originate (O3)	Parent	DMDII	MBD/STEP standard for CNC applications		x	x	x			x	x			x		
23	DMDII 14-01-10: Elastic Cloud-based Make	Parent	DMDII	Should cost analysis based on "as designed" models	x	x	x	x			x				x		
24	DMDII 15-16-02: Democratizing the Model based Domain from Design to Verification: Automatic Generation of Optimized CMM Programs on the DMC	Parent	DMDII	STEP and QIF based model driven downstream CMM based inspection		x	x	x		x	x	x		x	x		
25	DMDII 15-05: Smart PCB Digital Factory	Parent	DMDII	Digital bi-directional data transfer between PCB design and manufacturing vendors eliminating error-prone manual re-entry, translation, and interpretation of data files.		x	x	x			x			x	x		
26	Information sharing and exchange in the context of product lifecycle management: Role of Standards	Parent	NIST	The role of standards in PLM suport systems and models of information flows. The hierarchy of existing and evolving standards in support of interoperability.	x	x	x	x	x			x					
27	Analysis of Standards for Lifecycle Management of Systems for US Army --- a preliminary investigation	Parent	NIST/DoD	Recommended standards and protocols that allow legacy systems as well as future technological innovations to interpret seamlessly.	x	x	x	x	x			x					
28	Technical Data Package (TDP) for Advanced Enterprises	Parent	IBIF/AFRL	MBD based TDP model transfer standard evaluation	x	x	x	x									
29	A novel process data analytics framework for IoT-enabled cybermanufacturing	Parent	NSF	How to analyze data from sensors in a manufacturing environment to monitor processes in such a way as to formulate hypotheses of normal behavior so as to detect early signs of equipment malfunction. The research is being applied to chemical processes.			x	x								x	
30	Cybersecurity within a system of systems	Parent	Army	How to instrument a cyber attack on one system with the objective of forcing connecting systems to reveal cyber vulnerabilities. The work is being validated by applying attacking an actual military command and control center and observing the effect on connected subsystems.	x	x	x	x	x							x	
31	Vulnerability assessment of Insight Explorer	Parent	Hexagon Intergraph	How to assess the vulnerability of web-based applications which control communication command centers. The result of the work was a technique for capturing cyber attacks and later replaying them on other systems.	x	x	x	x	x							x	
32	Introspection of virtual machines	Parent	Progeny Systems, Inc	Development of a cloud framework which enables legacy applications to be "packaged" with security monitoring software for deployment in a cloud environment. The project has produced a proof-of-concept in which Programmable Logic Controller software is deployed in a cloud and monitored for behavioral anomalies.	x	x	x	x	x							x	
33	Trusted Platform Management	Parent	IBM	Development of a software interface to hardware-assistive security devices for use in IIot environments. The result of the work demonstrates use of equipping IoT devices with the capability of authentication and encrypted communication.	x	x	x	x	x							x	
34	Fault Tolerance Mechanisms for MPI Libraries	Parent	Vertiv Corp	Techniques for attacking the integrity of specialized software libraries. The results show how to determine vulnerabilities of a commercial product using open source control software.	x	x	x	x	x							x	
35	Supply Chain Social Media Study	Parent	AFRL ManTech	Examined communications challenges within the supply chain. Identified how social network solutions could be used to increase collaboration and visibility in an engineering-centric environment.			x	x	x	x	x				x		x
36	Connecting American Manufacturing	Parent	AFRL ManTech	Research led to a greater understanding of how acquisition procedures and policies can negatively impact the ability for trading partners to communicate and collaborate. Findings identified areas in which sourcing, a key element in the design and assembly of a supply chain, can be improved to increase the ability to leverage digital manufacturing.			x	x	x	x	x				x		x

Major Issues Categories

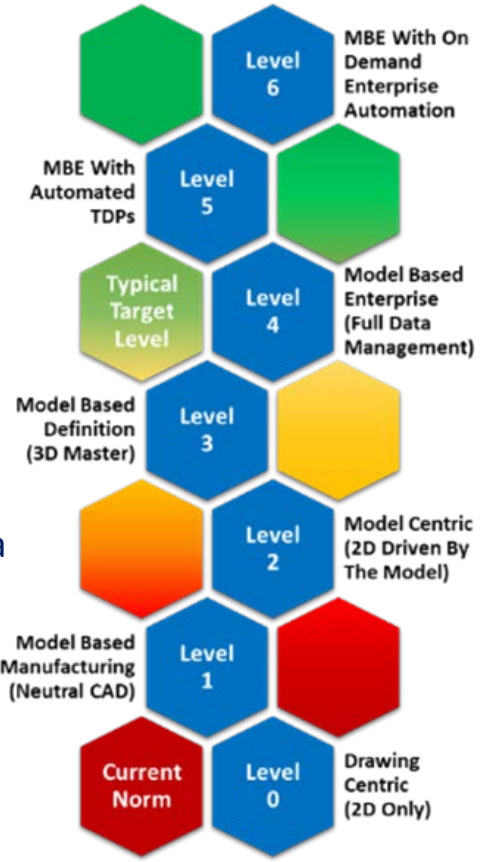
- Interoperability
- Data Reuse, Communication, and Archiving
- Advanced Manufacturing Vulnerabilities
- Analysis
- Infrastructure

Future State of MBE Capability (What is needed)

- More than just replacing drawing type information exchange to include design intent and context.
- Robust interoperability among disciplines and organizations.
- Responsive and adaptive to the changing market place and technology.
- Improved product life cycle time and costs.
- A building block for accelerating the maturation of the full MBD schema and communications across silos.

Future State

- Ability to quickly move from customer wants and desires to actionable requirements
- Un-constricted flow of information and product throughout the realization process
- A interoperable and networked system
- Agile and robust manufacturing strategies with integrated capabilities
- Smart design tools such as open source design libraries enhance design
- A 'Digital Thread" that enables designer, engineer, analyst, manufacturer, and maintainer collaboration
- Manufacturing modeling and simulation tools allow faster time to market
- Minimize multiple designs, prototypes, and test iterations typically required for product or process qualification
- High-performance computing is utilized to develop physics-based models of performance
- Does not matter whether products are unique "one of a kind", mass production or a combination such as mass customization
- The workforce is capable and confident in the use of "Apps" on the shop floor to minimize delays and improve flow
- Smart sensors, controls, metrology, analysis, decision and communication software tools for self-aware manufacturing provide data for continuous improvement & sustainability
- Plug and play equipment to utilize manufacturing knowledge and enable better decision-making while planning and processing components
- Worker and environmentally friendly`



Gap Analysis

- Specific gaps between the current state and future state of an organization will be examined.
- There are organizational and implementation gaps and issues that will have to be overcome.
- A functioning enterprise Product Data Management system.
- Documented business processes to guide MBE tool selection and configuration.
- Policy regarding the acquisition, contracting and use of 3D MBD.
- Consistent leadership emphasis to affect cultural change.
- MBE tools and processes must be common, but capable of being tailored.
- Systems thinking rather than solving each problem as a point solution.
- An era of fewer skilled personnel coming into the workforce.
- Support is needed is in the development of solutions to unique problems.

Summary

- This is a effort to develop as complete a picture as possible in the adoption and implementation of digital manufacturing capabilities in the commercial and defense supply chains.

- The team will pull in as many of the appropriate completed projects and technologies as possible in this project. Feel free to reach out and participate.

- This is an ambitious effort on a short timeline that we want to be as inclusive as possible of the MBE and digital manufacturing community.

Questions?

Thank You!

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