Nathan W. Hartman, Ed.D.
Dauch Family Professor of Advanced Manufacturing
Director, Product Lifecycle Management Center

EXPLORING APPLICATION LIFECYCLE MANAGEMENT AND ITS ROLE IN PLM

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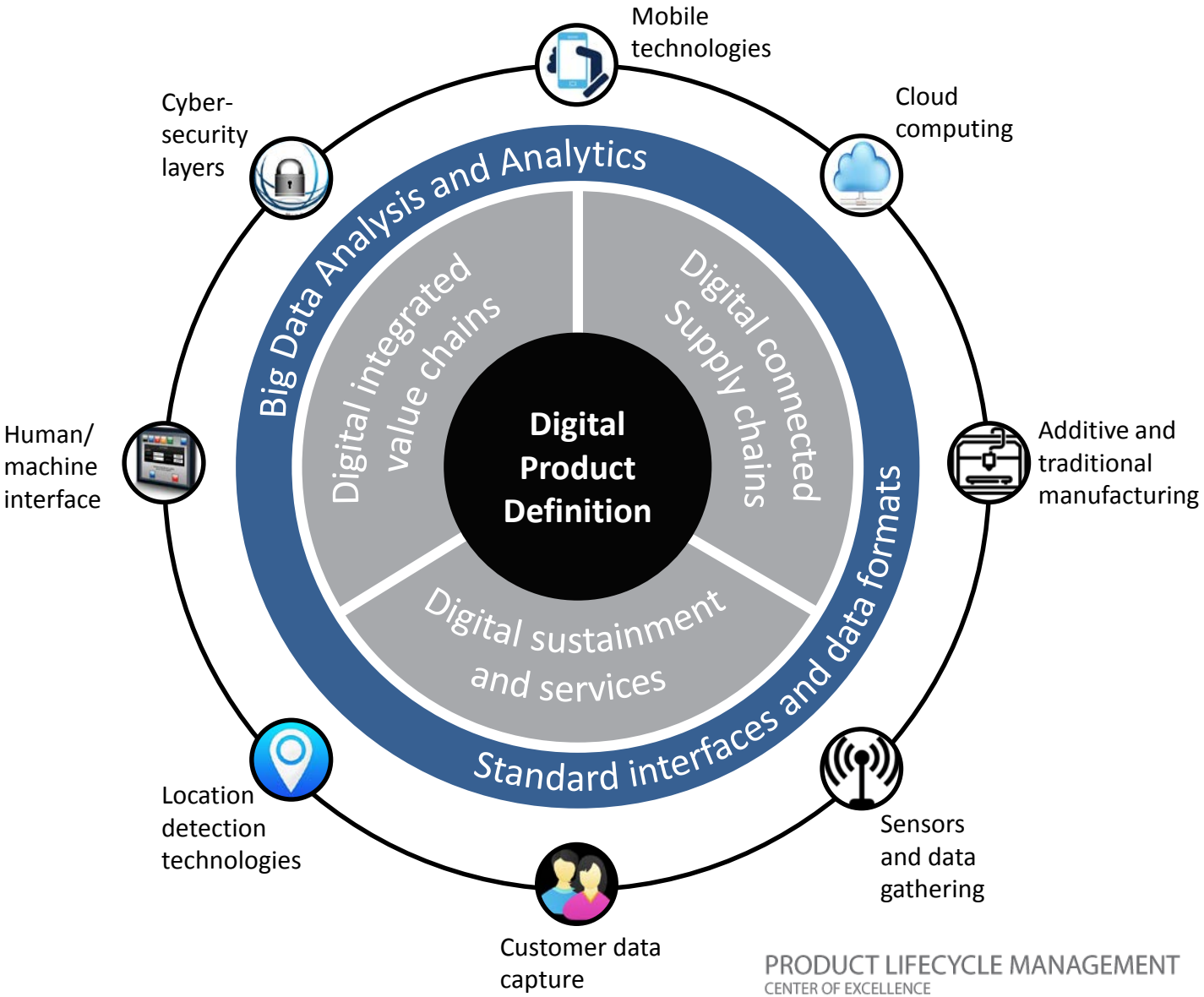
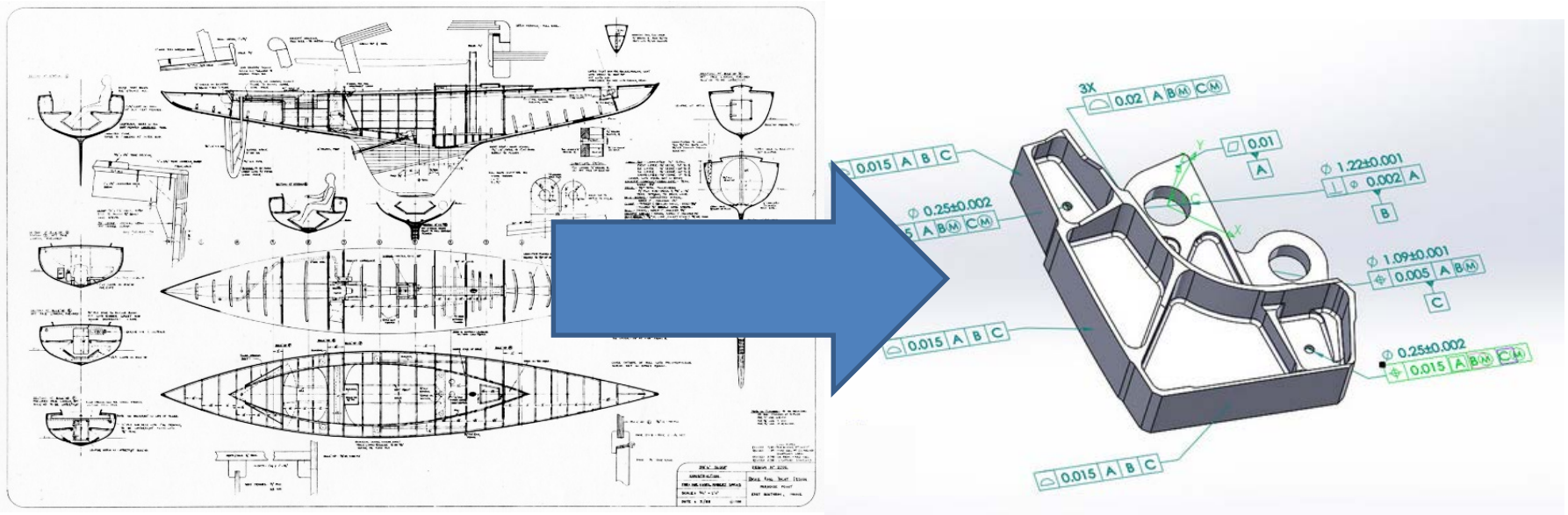
What is a digital enterprise?

A digital enterprise changes the way people work and how they use information



What should go into a model-based definition?

Implicit and explicit information must be included

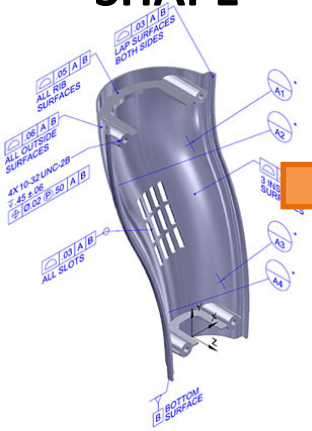


Historically, drawings contained both implicit and explicit information. Context was important for understanding. However, CAD tools require explicit definition of information.

The communications spectrum…

A complete MBD supports lifecycle communication

SHAPE

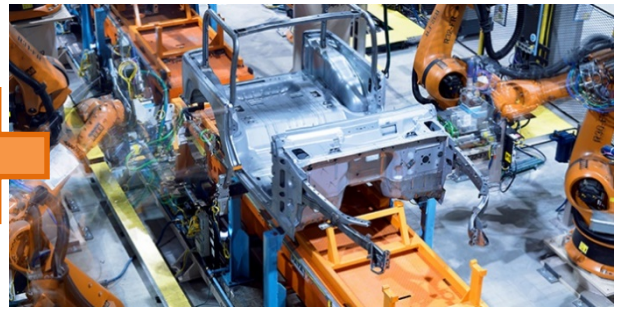


BEHAVIOR

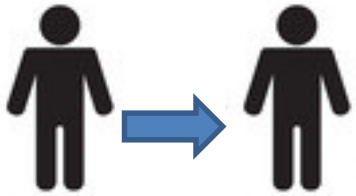
3.

Property	Test Standard DIN/ON EN ISO	corr.to ASTM	Unit	Value				Testing Frequency
Nominal Thickness			mil	78	100	98	196	
			mm	2.0	2.5	3.0	5.0	
	DIN EN ISO 14632	D 5994	%	+10/-5	+10/-5	+10/-5	+10/-5	every hour
Density (Black)	ISO 1183	D792	g/cm3	≥ 0.94				per production run 1)
Density (base/coloured)			g/cm3	≥ 0.931/935				
Melt Flow Rate (190°/5kg)	ISO 1183 Cond T	D 1238 Cond P	g/10	≤ 3	≤ 3	≤ 3	≤ 3	per production run 1)
(190/2 ,16kg)		D 1238 Cond E	min	≤ 1	≤ 1	≤ 1	≤ 1	
Heat Reversion (110°C/1, 5h)	DIN EN ISO 14632	D 1204 modified	%	≤ 3	≤ 3	≤ 3	≤ 2	per productio
Tensile Stress at Yield	DIN EN ISO 527	D 6693	MPa (PSI)	≥ 15 2,200	≥ 15 2,200	≥ 15 2,200	≥ 15 2,200	per production run 1)
Elongated at Yield	DIN EN ISO 527	D 6693	%	≥ 9	≥ 9	≥ 9	≥ 9	per production run 1)
Elongated at Break	DIN EN ISO 527	D 6693	%	≥ 300	≥ 300	≥ 300	≥ 300	per production run 1)
Instrumented Puncture Test (Penetration Test)	ON EN ISO 6603-2	D 4833	N N (lbs)	≥ 1500 ≥ 337	≥ 1800 ≥ 625	≥ 2000 ≥ 750	≥ 2500 ≥ 1250	Approval Testing

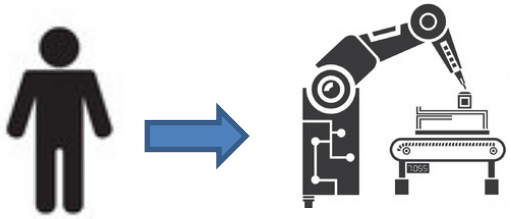
CONTEXT



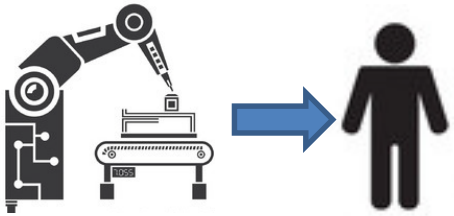
HUMAN TO HUMAN



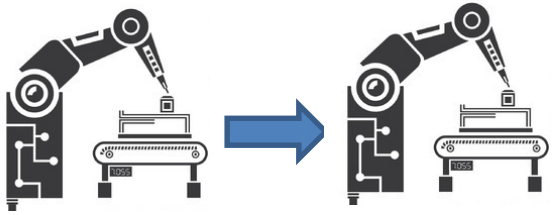
HUMAN TO MACHINE



MACHINE TO HUMAN



MACHINE TO MACHINE



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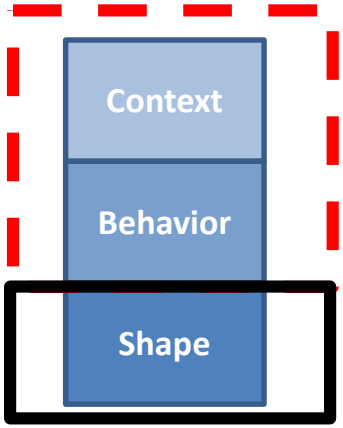
MBD and the Digital Twin

MODEL-BASED DEFINITION

Multiple Connected Representations



Future

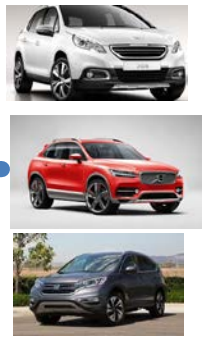
Today

Shape	Behavior	Context
• geometry • topology • logic • constraints	• materials • process • dim./tol. • physics	• assembly • machining • in use • retirement

Interfaces
Standards
Requirements

DIGITAL TWIN

- Product Line
- Model 1
  Model 2
  Model N
  Subsystem
- Component



Temporal, lifecycle-based levels of a model-based definition

DIGITAL THREAD

MBD + IT architecture + Connectivity

PLM Center of Excellence

- The mission of Purdue University's Product Lifecycle Management (PLM) Center of Excellence is to promote the advancement and implementation of PLM through research and education in partnership with industry.

The objectives of the Purdue PLM Center are:

- Conducting research that promotes PLM as a methodology and practice
- Establishing industry partnerships that guide, support, and validate PLM research and education activities
- Promoting the evolution and use of model-based digital product data
- Promoting the use and development of tools and practices that emphasize the concept of a “digital twin” for products
- Promote the author/consumer communication model around the use of digital product data
- Assisting with the integration of PLM into curriculum
- Facilitating the pursuit of PLM career opportunities by Purdue graduates
- Enabling PLM adoption by industry

Cummins

TEXTRON

Rockwell Collins

LOCKHEED MARTIN

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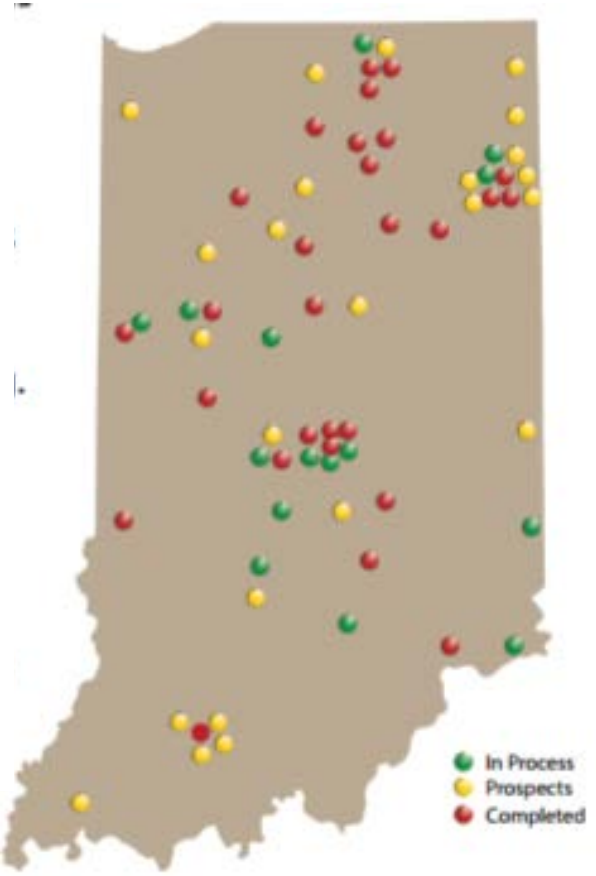
IN-MaC

Indiana Next-generation Manufacturing Competitiveness Center

A THREE THRUST APPROACH

The Indiana Next Generation Manufacturing Competitiveness Center (IN-MaC) seeks to transform manufacturing in the State of Indiana via a seamless "Lab to Market" three thrust approach: Technology Adoption & Transfer, Education & Workforce Development, and Long-term Research Innovation.



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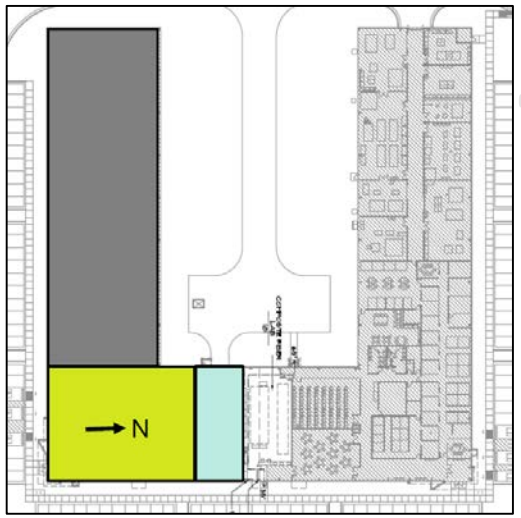
Digital Manufacturing Enterprise Testbed

FTE Chart	Minimum	Alternate
Full-Time	5	6
Graduate Student	10	16
Transient / Guest	24	40



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Today's Agenda

8:00 – 8:30 am	Continental Breakfast and Registration
8:30 – 8:45 am	**Welcome, PLM Center Updates, and Meeting Overview** *Nathan Hartman – Dauch Family Professor of Advanced Manufacturing and Director, Product Lifecycle Management Center* A short brief on activities with the PLM Center and an overview of the day's topics.
8:45 – 9:15 am	**ALM: Framing the Needs, Challenges and Opportunities** *Paul Streit – IT Business Services Architect, Rockwell Collins* Our opening presentation will help to establish a foundation for the audience on what ALM is (and is not), review the needs and challenges, and outline the intersection between ALM and PLM.
9:15 – 9:45 am	**Achieving the digital thread through PLM and ALM integration using OSLC** *Axel Reichwein, Ph.D. – Chief Executive Officer, Koneksys* The Web provides a reliable, scalable, and open infrastructure. Open Services for Lifecycle Collaboration (OSLC) is an initiative to reuse Web standards for the purpose of integrating engineering data. Currently, OSLC is mainly used for integrating software engineering artifacts such as requirements, change requests, and test cases. However, OSLC can also be used beyond software engineering for linking engineering artifacts across different engineering disciplines and applications. OSLC can therefore be viewed as a possible foundation for achieving the digital thread, including PLM/ALM integration.

Today's Agenda

9:45 – 10:45 am	**Panel 1: A Customer's View of ALM Tools and Methods through the Lifecycle** *Paul Streit – IT Business Services Architect, Rockwell Collins* *Christopher Hoffman – Director-Engineering Information Systems Owner, Cummins* *Laxmi Sivashankar – Senior Manager, Global Process, Methods, Tools and Information & Systems Engineering, Ford Motor Company* This panel will take a broad look at customer expectations and requirements viewed from a perspective of traditional, physical products as well as software development. For instance, a customer's expectation that an automaker routinely update GPS maps in onboard navigation systems. It will also expand the discussion by looking at short and long-life products (autos vs. defense platforms), end-users, cybersecurity issues, and visible to the customer (e.g., navigation system) versus non-visible (e.g., engine monitoring/control).
10:45 – 11:15 am	Networking Break
11:15 – 11:45 am	**Embedded software in products: the convergence of ALM with Systems Engineering** *Robert Wirthlin – Model-based Systems Engineering Leader, General Motors* The Convergence of ALM and PLM has recently gained traction with Systems Engineering emerging as a key contributor to bridge these communities. In like manner, as embedded software in products becomes more ubiquitous and complex, systems engineering is playing a critical role for the successful integration and execution in this environment. The presentation will explore some of the critical issues practitioners must acknowledge and the challenges that remain.
11:45 am – 1:45 pm	Lunch and Presentation **Integrating Data Streams Across the Enterprise for ALM** *Christopher Hoffman – Director-Engineering Information Systems Owner, Cummins* A look at defining the strategy and initiatives for "business" application lifecycle management for the entire engineering workflow – 1000+ applications and 1000s of data locations.

Today's Agenda

1:45 – 2:15 pm	**Panel 2: Views from the Front Lines: Developing and Deploying Software Tools Across the Lifecycle using ALM** *Craig Brown – PLM Leader, General Motors* *Chris Ziehr – Senior Engineering Manager, Systems, Process, & Support, Rockwell Collins* *Axel Reichwein, Ph.D. – Chief Executive Officer, Koneksys* A round-robin discussion of lessons learned and other stories. This contrasts with Panel 2 (what you need to do) by answering (what we would do if we had to do it again). What are the employee skills needed? How do we handle regulatory compliance issues, unanticipated organizational hurdles, customer demands, etc.?
2:15 – 2:45 pm	Networking Break
2:45 – 3:15 pm	**Managing Software Applications Once the Customer Has the Product** *Craig Brown – PLM Leader, General Motors* This presentation will take a broad look at how companies manage the software and systems lifecycle of their products once the customer has ownership. Implications for customer expectations and requirements, as well as product enhancement, are viewed from a perspective of traditional, physical products as well as software development.
3:15 – 3:45 pm	**ALM Trends and Drivers: Where do we go from here?** *Stephen Crescenti – ALM Solutions Consultant, Siemens* This presentation will address current and planned ALM research and development programs, educational initiatives, and future-looking topics of interest to the community. It may expose as many questions as answers.
3: 45 – 4:00 pm	**Summary and Closing Remarks** *Nathan Hartman – Professor, Computer Graphics Technology and Director, Product Lifecycle Management Center*

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