PLM Leadership

Ensuring the Dependability of Smart Connected Products

CIMdata PLM Leadership Webinar Series
23 June 2016
#cimdatawebinar

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CIMdata® | Global Leaders in PLM Consulting
www.CIMdata.com

Venki Agaram, Ph.D., MBA

Director, Quality & Reliability Engineering Practice

- 25+ years of experience from industry & academia
- 16 years at Fiat Chrysler Automobiles
- Growing the Quality & Reliability Engineering Practice
- R&D, virtual engineering, complex material systems, controlled mechanical systems, design-for-six-sigma, structured innovation, regulatory compliance, process modeling, market strategy, and business transformation
- technical & business background: ideally suited for leading industry transformation to improve the robustness of smart connected products and processes
- Education: aerospace engineering, business strategy

Our Mission...

Strategic management consulting for competitive advantage in global markets

CIMdata is the leading independent global strategic management consulting and research authority focused exclusively on the PLM market.

We are dedicated to maximizing our clients' ability to design and deliver innovative products and services through the application of PLM.

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Our Services...

Creating, disseminating, and applying our intellectual capital



Research
- *Market research & analysis*
- *Technology research & analysis*
- *Reports & publications*
- *Market news*
- *Member services...*

Education
- Executive seminars
- PLM Certificate Programs
- Technology seminars
- Int'l conferences & workshops
- Best practices training...

Consulting
- Strategy & vision
- Needs assessment
- Solution evaluation
- Best practices
- Quality assurance
- Program management
- Market planning...

Delivering strategic advice and counsel through a comprehensive, integrated set of research, education, and consulting services

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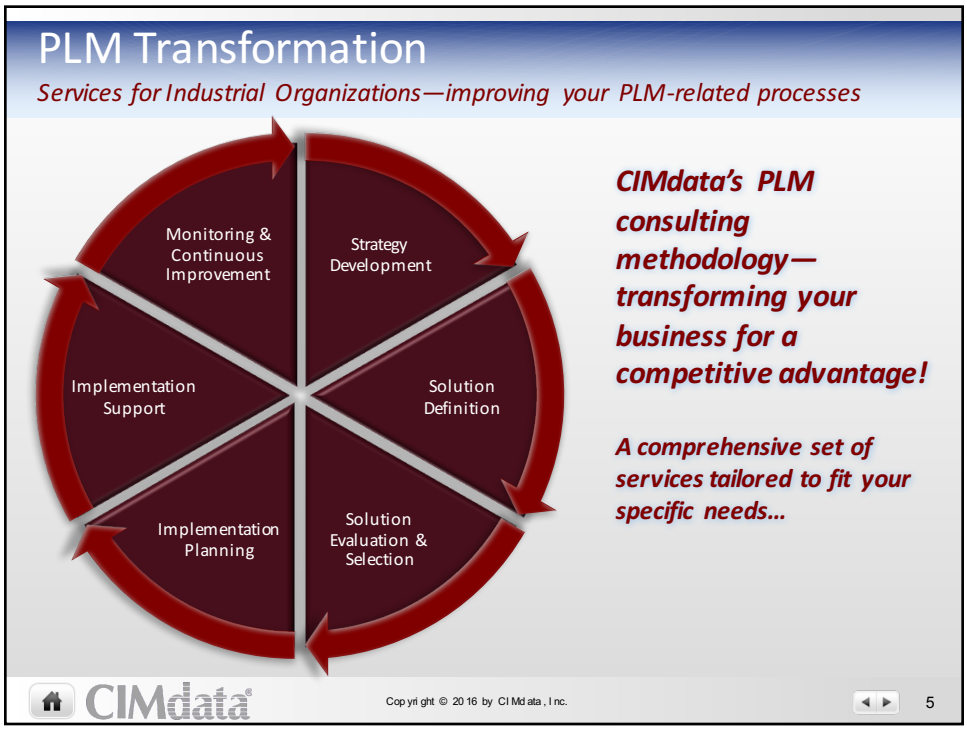

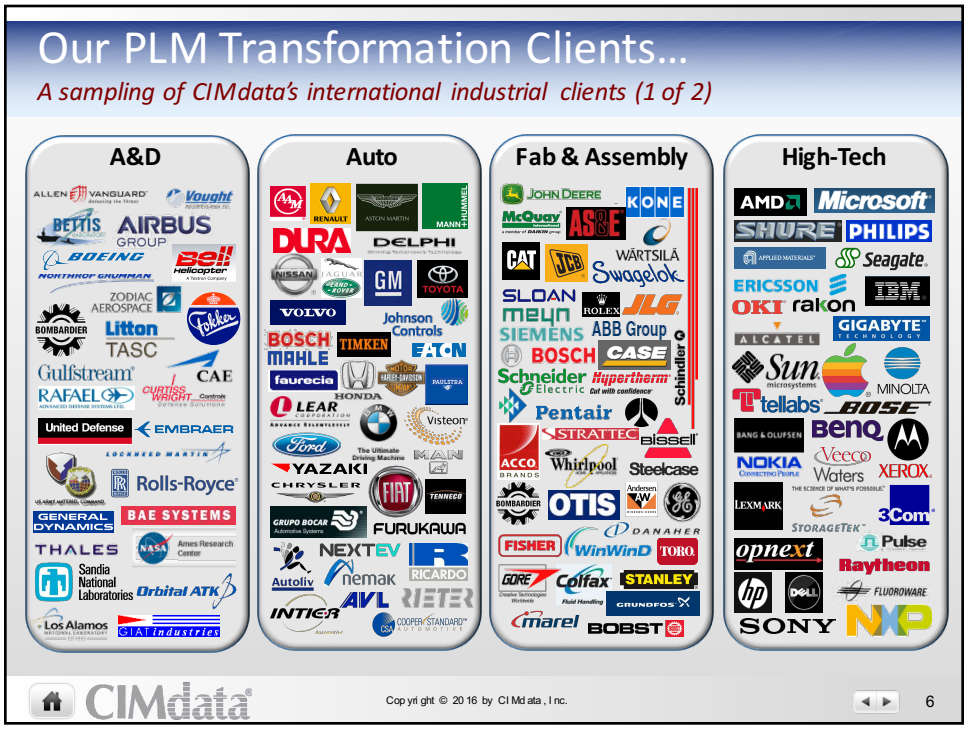

Our PLM Transformation Clients…

A sampling of CIMdata's international industrial clients (2 of 2)

CPG/F&B/Process

Kimberly-Clark, Dow, GMCR, Altria, JTI, Coca-Cola, P&G, McCormick, CSM, Goodyear, LEGO, DSM, amcor, Imperial Tobacco

Medical/Pharma

Baxter, Edwards, Alcon, Siemens, Medrad, Dräger, DePuy, Playtex, Bang & Olufsen, Johnson & Johnson, smith&nephew, Ethicon Endo-Surgery, Abbott, GE

Emerging Ind.

National Oilwell Varco, PBMR, Outotec, EDF, Iberdrola, Areva, Doosan, Doosan Power Systems, EAB Engineering, Rijkswaterstaat, adidas, Nike, JPL, Samsonite, IHC Merwede

Other

Savonia, VTT, Kongsberg, IDS Infotech Ltd., Cranfield University, NTNU – Trondheim Norwegian University of Science and Technology, 財團法人資訊工業策進會, Lincoln Laboratory Massachusetts Institute of Technology

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Questions?

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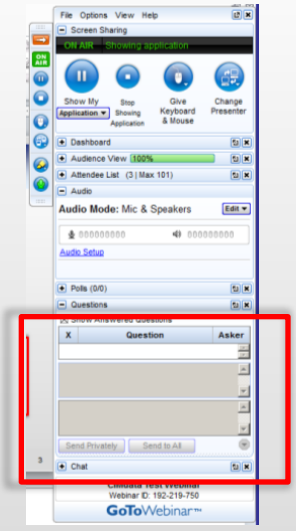

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Agenda

- Smart Connected Products
- Quality & Reliability Risks Today
- Systems & Reliability Engineering Disconnect
- Bridging Systems & Reliability Engineering
- Failure Knowledge Capture & Reuse
- Business Opportunity at the Intersection
- Q&A

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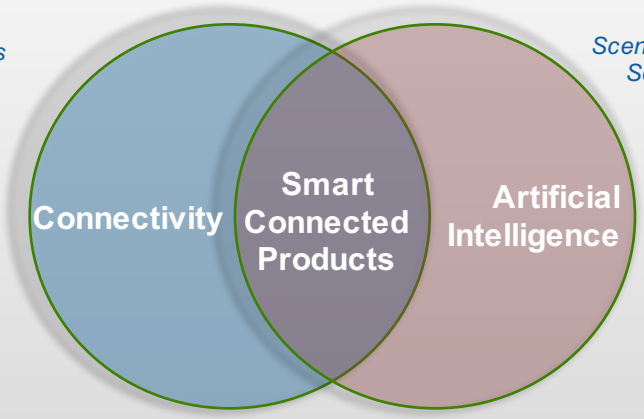
Smart Connected Products (I)

Functions and enablers

Information Communication
Internet
Cellular
Wireless

Data Interpretation
Sensor analytics
Data fusion
Scenario Recognition
Scenario updating



Control Strategy
Decision
Planning
Action
Correction

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Smart Connected Products (II)

Examples from different Fields of Application

- Automotive
  - Autonomous/Automated Vehicles – *Google self-driving car, Tesla Autopilot*
  - Advanced Drive Assist Systems – *ACC, AEB, lane keep assist, park assist, night vision*
- Mining
  - Autonomous Mining Vehicles – *higher productivity & utilization, less damage*
  - Remote Fleet Monitoring – *system optimization, preventive maintenance*
- Farming
  - Autonomous Farming Equipment – *electric, row crops, 24 hours working*
  - Adaptive Irrigation & Fertilization – *precision farming, system level optimization*
- Medical devices
  - Remote Monitoring and Updating – *MRI, X-Ray, CT Scanners*
  - Remote Patient Monitoring and Adjustment – *digital pill, deep brain stimulation*
- Manufacturing
  - Remote Monitoring/Control – *robots/devices adapt, as needed maintenance*
  - Automatic Production Line Control – *product deviation shuts line*

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- Smart Connected Products P (I)
- Quality & Reliability Risks Today
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Quality & Reliability Risks Today (I)

Complexity of Electronically Controlled Software-Intensive Products

Automotive Industry

Toyota recalls 625,000 cars over software malfunction

The world's largest carmaker, Toyota, has recalled around 625,000 hybrid vehicles over a software malfunction that can bring the gas-electric cars to a sudden stop. The call backs mostly affected the popular Prius model.

Jeep 9-speed needs a reset again

Software tweak aims to smooth out issues with Cherokee shifting

The dog clutch, shown here, is the linchpin that allows Chrysler's nine-speed transmission to be compact. Chrysler delayed the Jeep Cherokee's launch to tweak the transmission's software. N under its second software reset.

Report Receipt Date: MAY 07, 2014
NHTSA Campaign Number: 14V237000
Component(s): AIR BAGS
Potential Number of Units Affected: 594,785

All Products Associated with this Recall

Details — 10 Associated Documents

Manufacturer: Ford Motor Company

SUMMARY:
Ford Motor Company (Ford) is recalling certain model year 2013-2014 C-MAX, and Escape vehicles. In the affected vehicles, the restraint control module (RCM) may have errors in the programming software which may result in a delayed deployment of the side-curtain rollover air bag.

CONSEQUENCE:
If the side-curtain rollover air bag is delayed in deploying in certain rollover circumstances, the risk of injury to the passengers is increased.

REMEDY:
Ford will notify owners, and dealers will reprogram the RCM, free of charge. The recall began on May 30, 2014. Owners may contact Ford customer service at 1-800-392-3673. Ford's number for this recall is 14S04.

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Quality & Reliability Risks Today (II)

Complexity of Electronically Controlled Software-Intensive Products

	1983-1991[1]	1992-1998[5]	1999-2005[8]	2005-2011 (this study)
Radiology	19%	34%	33%	49%
In Vitro Diagnostics	18%	24%	35%	19%
Cardiology	23%	19%	8%	13%
Other	10%	5%	9%	8%
General Hospital	11%	10%	13%	8%
Anesthesiology	14%	8%	1%	3%
Surgery	5%	0%	1%	1%

Medical Device Industry

Year	Total Recalls	Software-Related Recalls	Percent
2005	604	84	13.9%
2006	663	119	17.9%
2007	638	119	18.7%
2008	847	192	22.7%
2009	782	146	18.7%
2010	981	147	15.0%
2011	1,277	315	24.7%

Source: Software related recalls: An analysis of records, USFDA

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Quality & Reliability Risks Today (II)

Complexity of Electronically Controlled Software-Intensive Products

- Boeing 787:
  - Software bug in the Boeing 787 was found to be capable of shutting down the plane's electric generators every 248 days
  - Software counter, internal to the generator control units (GCUs) could overflow after 248 days of continuous power
  - This could cause the GCU to go into failsafe mode, resulting in a loss of all electrical power regardless of the flight phase
- F-35 Joint Strike Fighter:
  - Expected to be further behind in its combat-readiness due to issues with its RADAR software and vulnerability to cyber-attacks
  - Requires the system to be rebooted every four hours of flight time while the desired reboot interval of the F-35 is eight to ten hours of flight time

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Systems & Reliability Engineering Disconnect

Engineering complex products in silos

Systems Engineering Technical Processes
- *Stakeholders' Requirements Identification*
- *System Requirements Definition*
- *System Architectural Design*
- *System Elements Definition*
- *System Analysis*
- *System Elements Realization*
- *System Elements Integration*
- *System Design Verification*
- *Verified System Transition*
- *System Performance Validation*
- *System Operation*
- *System Maintenance*
- *System Disposal*

Reliability Engineering Tools
- *Affinity Diagrams (KJ Analysis)*
- *Quality Function Deployment (QFD)*
- *Kano Analysis*
- *SysML Diagrams*
- *FMECA*
- *TRIZ*
- *Robust Optimization*
- *Design of Experiments (DOE)*
- *Monte Carlo Simulations*
- *Conjoint Analysis*
- *Kepner-Tregoe Analysis (KTA)*
- *Fault Tree Analysis (FTA)*
- *Reliability Block Diagrams (RBD)*
- *FRACAS*
- *CAPA*
- *Markov Analysis*
- *Weibull Analysis*
- *System Maintainability Analysis*
- *System Availability Analysis*
- *Accelerated Life Testing (ALT)*

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Agenda

- Smart Connected Products: Functions, enablers, and applications
- Quality & Reliability Risks Today
- Systems & Reliability Engineering Disconnect P (II)
- Bridging Systems & Reliability Engineering
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Bridging Systems & Reliability Engineering

Relationship between Reliability Tools and Systems Engineering Practices

Systems Engineering Technical Processes		Reliability Engineering Tools	Affinity Diagrams	QFD (HOQ)	Kano Analysis	Functional Flow Block Diagram	SysML Diagrams	IDEF	N^2 Charts	Specification Tree	FMECA	TRIZ	Physics of Failure Analysis	Robust Optimization	Design of Experiments (DOE)	Response Surface Analysis	Monte Carlo Simulations	Conjoint Analysis	Kepner-Tregoe Analysis	Analytic Hierarchy Process (AHP) Models	Multi-Attribute Untility Analysis (MAUA)	Fault Tree Analysis (FTA)	Event Tree Analysis (ETA)	Reliability Block Diagrams (RBD)	FRACAS	CAPA	Markov Analysis	Weibull Analysis	System Maintainability Analysis	System Availability Analysis	Asset Performance Management	Accelerated Life Testing
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Stakeholders' Requirements Definition	1		■			■	■			■					■			■							■	■						
System Requirements Definition	2			■		■	■			■	■	■	■												■	■			■	■	■	
System Architectural Design	3					■	■			■	■	■		■	■	■	■					■		■	■	■	■	■				
System Elements Definition	4			■		■	■	■		■	■	■	■	■	■	■	■					■	■	■			■	■	■			
System Analysis	5			■		■	■	■		■	■	■	■	■	■	■	■		■	■	■											
System Elements Realization	6									■	■	■	■	■	■	■	■								■	■						
System Elements Integration	7					■	■	■		■	■	■		■	■	■	■					■	■		■	■			■	■	■	■
System Design Verification	8					■	■	■	■	■	■		■	■	■	■	■					■	■		■	■			■	■		
Verified System Transition	9					■	■	■	■	■	■	■	■	■	■	■	■					■	■	■	■	■				■		
System Performance Validation	10					■	■	■		■	■	■	■	■	■	■	■					■	■	■	■	■						
System Operation	11					■	■	■		■	■	■	■	■	■	■	■					■	■	■	■	■	■					
System Maintenance	12					■	■	■		■	■	■	■	■	■	■	■	■							■	■		■	■	■	■	
System Disposal	13					■	■	■		■	■	■																				

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Failure Knowledge Capture & Reuse (I)

Developing machine-readable failure knowledge

- Systems dependability issues occur at the intersection of different disciplines of engineering and at the interfaces between different subsystems where engineering intuition tends to be low.
- Learning deals with implicit knowledge which is not immediately accessible and in particular cannot be acquired from conventional databases.
- Problem of reusing pre-existing knowledge about failure modes could be solved effectively through the definition of an ontology.
- Ontology enables a common understanding of the domain specific concepts without need for interpretation, while making the ontology-held knowledge explicit and machine-readable.

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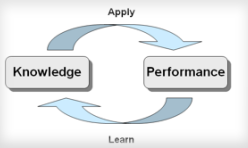
Failure Knowledge Capture & Reuse (II)

Developing machine-readable failure knowledge

- Ontology as a way of converting implicit system failure knowledge into machine-readable explicit knowledge for reuse, has often been mentioned in technical literature.
- Ontology for system failure knowledge and reuse is not currently offered commercially by software providers either as part of systems engineering or reliability engineering tool suites.
- Ontology-based or similar knowledge capture and reuse tools are needed at the enterprise level, in earnest, to deliver complex products that are dependable, affordable, and available on time.



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Business Opportunity at the Intersection (I)

Seamlessly tying systems engineering and reliability engineering

- Systems engineering helps in dealing with product complexity of smart connected products
- Verification and validation iterations in systems engineering are opportunities for new learning about the failure modes of complex, smart connected products
- Reliability engineering tools are needed to leverage product failure knowledge and they are mostly disconnected from systems engineering tools
- Bridging the tools and processes used in systems engineering and reliability engineering via knowledge management is imperative to minimize recall and launch risks

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Business opportunity at the intersection (II)

Seamlessly tying systems engineering and reliability engineering

- All tools used in systems engineering, reliability engineering, and knowledge management are not likely to be provided by a single software provider
- System integrators will play a major role in closing the loop between reliability engineering and systems engineering
- Perhaps system integrators should lead this effort with strategic initiatives, consulting, planning, and execution
- Systems integrators could benefit greatly from this opportunity by driving standards for interoperability between the systems engineering and reliability engineering tools

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Quality & Reliability Engineering Output

What is coming from CIMdata's QRE Consulting Practice ?

- Survey to be filled by OEMs/Suppliers, SIs and SW Providers
  - Topic: Bridging Systems & Reliability Engineering through Knowledge Management, August 2016
- Whitepaper:
  - Quality & Reliability Engineering – Learning Systems based Design-for-Reliability
  - August 2016
- Conference Paper:
  - Bridging Reliability Engineering & Systems Engineering, Author: Venki Agaram
  - Ground Vehicle Systems Engineering and Technology Symposium (GVSETS)
  - August 2 – 4, 2016, Novi, MI
- Education Webinars
  - August 11, 2016, October 22, 2016, December 15, 2016

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- Smart Connected Products
- Quality & Reliability Risks Today
- Systems Engineering & Reliability Engineering Disconnect
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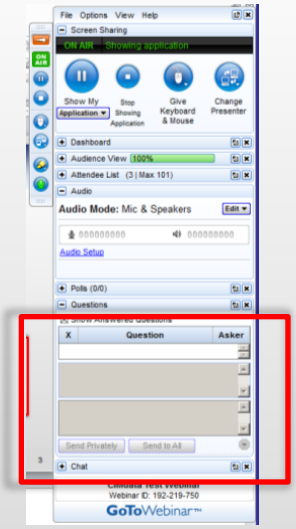

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