How do you ensure your Connected Intelligent Products can be trusted?
*Deploy Knowledge Systems for Reliability Design*

CIMdata PLM Leadership Webinar Series
15 December 2016
#cimdatawebinar

Venki Agaram, Director, Quality & Reliability Engineering Practice
e-mail: v.agaram@cimdata.com
Tel: +1.734.668.9922

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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
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*CIMdata PLM Education Webinar*

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.

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
- InfI 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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PLM Transformation

Services for Industrial Organizations—Improving your PLM-Related Processes

CIMdata's PLM consulting methodology—transforming your business for a competitive advantage!

A comprehensive set of services tailored to fit your specific needs...

Our PLM Transformation Clients...

A sampling of CIMdata's international industrial clients (1 of 2)

A&D

Auto

Fab & Assembly

High-Tech
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Agenda
Towards Developing Knowledge System based Design-for-Reliability Capability

- Quality & Reliability Risks Today
- Three-Legged Stool for Connected Intelligent Products
- Connected PLM with Feedback Analytics
- Bridging Reliability Engineering & Systems Engineering
- Failure Knowledge Capture & Reuse
- Exploring the Business Opportunity
- Q&A

Quality & Reliability Risks Today
Complexity of Electronically Controlled, Software-Intensive Products

Auto. SW Related Recalls
- 0.3% of recalls in 2005
- 4.3% of recalls in 6 months of 2015

NHTSA’s Safety Complaints
- 2010 – 2014: 197 SW related

Med. Dev. SW Related Recalls
- 2005: 14% of recalls
- 2011: 25% of recalls

Trending upward since 1983


Aerospace SW Related Issues
- Boeing 787: generator control unit (GCU) SW counter overflow after 248 days of continuous power resulting in loss of all electrical power regardless of flight phase
- F-35 Joint Strike Fighter: RADAR SW vulnerability to cyber-attacks, requires system reboot every 4 hrs of flight time while desired interval is 8 – 10 hrs of flight time
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**Dependable Connected, Intelligent Products**

*Need the 3-Legged Stool of Systems Engineering, Reliability Engineering & Failure Knowledge*

- Must-have bridge for enterprise level design-for-reliability capability
- Design Complexity
  - Multiple Disciplines
  - Complex Functions
  - Functional Interactions
  - Functional Loops
  - Software Content
- Connection
  - Internet Cellular Wireless Combination
- Control
  - Decision Planning Action Correction
- Information
  - Sensor Analytics Scenario Recognition
  - Data Fusion Scenario Updating
- Reliability Engineering Tools
  - Inaccurate Root Causes Missed Failure Modes Inadequate Redundancy
  - Engineering Intuition
- Failure Knowledge Capture & Reuse System

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Connected PLM with Feedback Analytics
Realizing the Closed-Loop Product Development Capability

Elements of Product Lifecycle

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Bridging Reliability Engineering & Systems Engineering

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Bridging Reliability Eng. & Systems Eng.
First step towards building a Knowledge System based Design-for-Reliability

Relationship between Reliability Tools and Systems Engineering Processes
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Problems posed by complex, software-intensive products:
- Root causes of failures are hard to find because they exist at the interfaces between different subsystems, and at the intersection of different disciplines of engineering
- Prior knowledge about failure modes often exists in the language of the expert community, not immediately accessible, and in particular, cannot be acquired from conventional databases

Potential Solution:
- Step I: Establish a common understanding of domain specific failure modes without need for interpretation. Example – Ontology applied to failure knowledge
- Step II: Make failure knowledge explicit, machine-readable/searchable.
- Step III: Establish enterprise level connection between the machine-readable/searchable failure knowledge capture and reuse system, the systems engineering technical processes, and the reliability engineering tools
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Failure Knowledge Capture & Reuse
Modeling Framework for Ontology Based Knowledge System

Ontology is an Explicit Specification of a Conceptualization

Application Area  Perception  Mental Model  Formalization  Inside Computer

Level of Abstraction

Meta-Meta-Level
Meta-Level
Class Level
Instance Level

Knowledge


Failure Knowledge Capture & Reuse
Concepts and Relations in FMEA Domain (Meta Level & Class Level)

ROOT_CONCEPT

fmea

mechanical_component

examines_component

hydraulic_component

electrical_component

everything

component

is_part_of

transform

fullfills_a_function

transmit

has_failure_mode

join

has_control_method

containment_action

examines

has_rpn

control_method

has_containment_action

risk_priority_number

risk_priority_number

failure_mode

has_control_method

containment_action

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**Failure Knowledge Capture & Reuse**

*Instantiation of an Ontology based FMEA (Instance Level)*

- FMEA Lamp Moon (fmea)
- Electric Components (lamp_electric_component)
- Lamp Moon (electric_light_component)
- Electric does not work (failure_mode)
- Bulb is broken (failure_mode)
- Illuminates with electricity (electric_illumination_function)
- Lamp does not illuminate (failure_mode)
- Illuminates environment (illumination_function)
- Electric does not work (failure_mode)
- Broken bulb containment action (containment_action)
- Broken bulb RPN (risk_priority_number)
- Broken bulb control method (control_method)
- New broken bulb RPN (risk_priority_number)


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**Exploring the Business Opportunity**

*Realizing Enterprise Knowledge System based Design-for-Reliability*

- Systems engineering helps in dealing with product complexity of intelligent, connected products
- Verification and validation iterations in systems engineering are opportunities for new learning about the failure modes of complex, intelligent, 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 while leveraging failure knowledge capture and reuse is imperative to minimize recall and launch risks

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**Exploring the Business Opportunity**

*Realizing Enterprise Knowledge System based Design-for-Reliability*

- All tools used in systems engineering, reliability engineering, and failure knowledge capture and reuse will not likely be provided by a single software provider
- System integrators are likely to play a major role in closing the loop between reliability engineering, systems engineering, and knowledge capture and reuse
- CIMdata believes that connected products will enable closed-loop quality based product development but will additionally need failure knowledge capture and reuse
- CIMdata would like to collaboratively explore with OEMs, suppliers, and solution providers, a maturity model pertaining to “Knowledge Systems based Design-for-Reliability”
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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: Knowledge Systems Based Design-for-Reliability, December 2016
- Whitepaper:
  - Quality & Reliability Engineering – Knowledge Systems based Design-for-Reliability
  - January 2017
- Knowledge Council Kick-off:
  - February 2017
- Education Webinars
  - February 9, 2017
  - July 13, 2017
  - November 9, 2017

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World Headquarters
3909 Research Park Drive
Ann Arbor, MI 48108 USA
Tel: +1.734.668.9922
Fax: +1.734.668.1957

Main Office - Europe
Oogststraat 20
6004 CV Weert, NL
Tel: +31 (0) 495.533.666

Main Office - Asia-Pacific
Takegahana-Nishimachi 310-31
Matsudo, Chiba 271-0071 JAPAN
Tel: +81.47.361.5850
Fax: +81.47.362.0472

www.CIMdata.com

Serving clients from offices in North America, Europe, and Asia-Pacific