Ensuring the Dependability of Smart Connected Products

CIMdata PLM Education Webinar Series
23 June 2016
#cimdatawebinar

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

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

---

This presentation is copyright © 2016 by CIMdata, Inc. Clip art may be copyrighted. No use, reproduction or modification is permitted without prior written permission. CIMdata is a registered trademark of CIMdata, Inc.
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...

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

Education
- Executive seminars
- PLM Certificate Programs
- Technology seminars
- IFI conferences & workshops
- Best practices training...

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

This presentation is copyright © 2016 by CIMdata, Inc. Clip art may be copyrighted. No use, reproduction or modification is permitted without prior written permission. CIMdata is a registered trademark of CIMdata, Inc.
Ensuring the Dependability of Smart, Connected Products
CIMdata PLM Education Webinar

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)
Our PLM Transformation Clients...
A sampling of CIMdata’s international industrial clients (2 of 2)

Questions?
Please use the GoToMeeting chat panel

- We’re hoping that the anonymity of the chat window might help participants ask more questions
- If you want to ask a question on the record, we’ll certainly let everyone know you’re asking
- The most important thing is interaction – let us hear from you on the call

This presentation is copyright © 2016 by CIMdata, Inc. Clip art may be copyrighted. No use, reproduction or modification is permitted without prior written permission. CIMdata is a registered trademark of CIMdata, Inc.
Ensuring the Dependability of Smart, Connected Products

CIMdata PLM Education Webinar

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

Smart Connected Products (I)

*Functions and enablers*

Information Communication

- Internet
- Cellular
- Wireless

Data Interpretation

- Sensor analytics
- Data fusion
- Scenario Recognition
- Scenario updating

Connectivity

Smart Connected Products

Artificial Intelligence

Control Strategy

- Decision
- Planning
- Action
- Correction

This presentation is copyright © 2016 by CIMdata, Inc. Clip art may be copyrighted. No use, reproduction or modification is permitted without prior written permission. CIMdata is a registered trademark of CIMdata, Inc.
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*

---

**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**
Ensuring the Dependability of Smart, Connected Products

CIMdata PLM Education Webinar

Quality & Reliability Risks Today (I)
Complexity of Electronically Controlled Software-Intensive Products

Automotive Industry

Jeep 9-speed needs a reset again
Software needs to speed up issues with Chrysler shifting

Toyota recalls 625,000 cars over software malfunction
The world’s largest carmaker, Toyota, has recalled around 500,000 vehicles over a software malfunction that can bring the gas-electric cars to a sudden stop. The recall mostly affected the popular Prius model.

Quality & Reliability Risks Today (II)
Complexity of Electronically Controlled Software-Intensive Products

Medical Device Industry

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Recalls</th>
<th>Software-Related Recalls</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>604</td>
<td>84</td>
<td>13.9%</td>
</tr>
<tr>
<td>2006</td>
<td>663</td>
<td>119</td>
<td>17.9%</td>
</tr>
<tr>
<td>2007</td>
<td>619</td>
<td>119</td>
<td>18.7%</td>
</tr>
<tr>
<td>2008</td>
<td>847</td>
<td>192</td>
<td>22.7%</td>
</tr>
<tr>
<td>2009</td>
<td>782</td>
<td>146</td>
<td>18.7%</td>
</tr>
<tr>
<td>2010</td>
<td>981</td>
<td>147</td>
<td>15.0%</td>
</tr>
<tr>
<td>2011</td>
<td>1,277</td>
<td>315</td>
<td>24.7%</td>
</tr>
</tbody>
</table>
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

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
Ensuring the Dependability of Smart, Connected Products
CIMdata PLM Education Webinar

Systems & Reliability Engineering Disconnect

Engineering complex products in silos

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)

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

Agenda

- Smart Connected Products: Functions, enablers, and applications
- Quality & Reliability Risks Today
- Systems & Reliability Engineering Disconnect

Bridging Systems & Reliability Engineering

- Failure Knowledge Capture & Reuse
- Business Opportunity at the Intersection
- Q&A
Ensuring the Dependability of Smart, Connected Products

CIMdata PLM Education Webinar

### 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**
Ensuring the Dependability of Smart, Connected Products
CIMdata PLM Education Webinar

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.

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.
Ensuring the Dependability of Smart, Connected Products
CIMdata PLM Education Webinar

Agenda

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

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
Ensuring the Dependability of Smart, Connected Products

CIMdata PLM Education Webinar

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

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

This presentation is copyright © 2016 by CIMdata, Inc. Clip art may be copyrighted. No use, reproduction or modification is permitted without prior written permission. CIMdata is a registered trademark of CIMdata, Inc.
Ensuring the Dependability of Smart, Connected Products

CIMdata PLM Education Webinar

Agenda

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

Questions?

Please use the GoToMeeting chat panel

- We’re hoping that the anonymity of the chat window might help participants ask more questions
- If you want to ask a question on the record, we’ll certainly let everyone know you’re asking
- The most important thing is interaction – let us hear from you on the call