MBSE, IoT and PLM

MBSE and IoTization of PLM Systems for Validation, Testing and Support
Structure

HCL in Aerospace CAE

HCL IoTWorks and PLM Vision for 2020

Bringing them together MBSE, PLM & IoT

Technical Challenges

Future Expansion Areas

Conclusion
HCL Areas of Expertise in Aerospace Engineering

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- **Flight Controls & Actuation**
  - Airbus
  - Boeing
  - Rockwell Collins

- **Flight Management System**
  - Flight Warning System
  - Display System
  - Crew Alerting System
  - Com, Navigation, Surveillance
  - Thales
  - EADS
  - Airbus

- **Cabin & Interiors**
  - IFE, Cabin Electronics, Monuments, F2F, Seats
  - Thales
  - Rockwell Collins
  - Panasonic
  - Gulfstream

- **Fire Protection Systems**
  - Meggitt
  - Parker
  - Hamilton Sundstrand

- **Composites**
  - Kaman Aerospace
  - so! helicopter

- **Hydraulics**
  - Meggitt
  - Parker

- **Landing Gears Wheels & Brakes**
  - Meggitt
  - Parker
  - Goodrich
  - Crane

- **Engine Control Systems**
  - Hamilton Sundstrand
  - Pratt & Whitney
  - Volvo Aero

- **Power Systems**
  - AMETEK
  - United Technologies
  - Boeing
  - Rockwell Collins

- **Sensors & Integrated Systems**
  - GE Aviation
  - Rockwell Collins
  - United Technologies

- **Environmental Control & Air Management System**
  - GE Aviation
  - United Technologies
  - Boeing

- **Aero-structures**
  - Bombardier
  - ADA Ministry of Defence
  - Airbus
  - Alenia Aeronautica
  - Kaman Aerospace
  - so! helicopter

- **Fuel System**
  - Meggitt
  - United Technologies

- **Engines**
  - SR Technics
Marquee Clients

Boeing
Bombardier
Gulfstream
Alenia Aeronautica
Dassault Aviation
Bell Helicopter
A Textron Company
Ada
Ministry of Defence
United Technologies
SR Technics
Kaman Aerospace Structures
Atos

Meggitt
Parker
Rockwell Collins
Thales
Ametek Aerospace

Honeywell Technology Solutions Lab Pvt Ltd.

Zodiac Aerospace
Cobham
ITT
Industry 4.0 in Europe and Smart Manufacturing in US define the renaissance of Manufacturing in the western world.

IoT is the central gluing element in this approach and is the basis for more than a $1.0T opportunity in the next 10 years.
IoT in the Product LifeCycle

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Product Planning → Product Design → Testing → Sourcing → Production → Sell & Service

Product Engineering
- MCAD & ECAD
- CAE
- Embedded Software
- Ideas
- Requirement Engg
- Design
- Verification
- Code Generation

Enterprise Optimization (ERP)
- Plan, Buy, Make, Sell, Collect, Report, Manage
  - Production Mgmt
  - Purchase Mgmt
  - Plant Maint.
  - Financials

Product Lifecycle Management
- Product Data
- Procurement Part Data
- Sales Data
- Service Data
- Manufacturing Data

Manufacturing Engineering
- Digital Factory
  - Plant Layout
  - Process Planning & Tool Design
  - CMM/CAM
  - Line Balancing

Digital Manufacturing
- Manufacturing Operations Management
  - Production Operations
  - Quality Operations
  - Maintenance Operations
  - Inventory Operations

Industrial Automation
- Control Systems SCADA, Historians
  - Design
  - Develop
  - Deploy
  - Support

Asset Management
- Plant Maintenance
  - Buy Asset
  - Maintain Machine
  - RCM
  - Optimize

Data Exchange / IoT

Software Layer

Process Layer
Role of IoT in the Product Life Cycle (Design – Build – Service)

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IoT would be the bridge to connect the Physical Device or Machine with the ‘Digital Twin’ and then leveraging Analytics and the cloud multiple value added services can be created.
MBSE and the IoT Play

Model Based Systems Engineering (MBSE)

Model Based Definition (MBD) {Product Definition}

Model Based Manufacturing (MBM) {Process Definition}

Model Based Operations (MBO) {Tool & Process Definition}

3D CAD as the single source of 3D engineering data

Reuse 3D engineering data to generate manufacturing documents

IoT Data Acquisition and Analytics Layer

Product Planning
Product Design
Testing
Sourcing
Production
Sell & Service

Engineering IT infrastructure
IoT Related Field Requiring a Cross Functional Approach

IoT Enablement
- Iot Data will be leveraged across all these functions like Reliability, CAE and Value Engineering
- Linkage to CAE cloud for Loads and BCs

Manufacturing Engineering Services
- Process Planning- Fabrication
- Process Planning- Assembly
- CNC Programming
- Jigs, Fixtures & Tooling

Value Engineering
- Cost Modeling
- Value Analysis
- Tear down
- Analysis
- Benchmarking
- Sourcing

Reliability
- Reliability prediction
- FMEA (Design, function, process)
- Life data analysis
- Warranty analysis

CAE
- Structural analysis
- Thermal analysis
- Computational fluid dynamics
- Kinematic simulation
- Hand calculations
- F&D

Centers of Excellence

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Domains

**Structural Analysis**
- Static Stress Analysis
- Fatigue & Damage Tolerance (F&DT)
- Aero Elasticity
- Flight Load Computation
- Dynamic Analysis
  - Modal Analysis
  - Transient Analysis
  - Frequency response Analysis
  - Random response Analysis
  - Shock spectrum Analysis
- Impact Simulation – Bird Strike
- Drop Simulation
- Kinematics simulation

**CFD Analysis**
- Compressible and incompressible flow
- Steady and transient analysis
- Conjugate heat transfer analysis
- Fluid structure interaction
- Thermal Design and Analysis of Electronic systems

**IoT Enablement**
- IoT enabled product can be used to capture the static and dynamic loads
- Validation of Results and Measurement of deflections in realtime.

**Tools and Servers**
- ANSYS, MSC. Nastran, ABAQUS, LS-DYNA, IDEAS, Pro/MECHANICA, MSC. Adams, LMS Sysnoise, HyperMesh, FLUENT, CFX, ICEM-CFD, Icepak, Flotherm, CF-Design, Moldflow
- Server with 100 cores extendable up to 200 Cores for high end analysis

**Productivity Tools**
- Macros created for Post Processing. ~ 78% time reduction
- Multiframe Restart Methodology
- Elastic-plastic curve generation automation for internal use
- Neuber correction Tool – Calculate Elasto-plastic behavior
- Macros- Fatigue Life calculator of moving parts

**IoT In ENGINEERING ANALYSIS : Loads and Boundary Conditions**
IOT Platform development for remote services and monitoring solution for a global industrial conglomerate covering 26 different business units, 1 Million + devices and 18,000 customers of the customer spanning multiple geographies. Scope of the services cover develop, deploy and operate.

**Business Challenges**

- One seamless data acquisition and data management platform for all business units
- Open new avenues by exploiting the potential of value-added-services;
- Assist in New Product Development using big data techniques
- contracts/integrated solutions to end customers - cross-sell and up-sell business BU services to across different customer segment

**HCL Solution**

The Scope of the services covers 'Develop', 'Deploy' and 'Operate' of an IOT based data platform.

**Operational Efficiency of 20% achieved through implementation of Remote Services (Predictive Maintenance, Asset Management etc.)**

**Remote Services for Predictive Maintenance**

**AS IS State**

Different BUs using different apps and different means to collect and store data from the devices

**Target State**

A common platform that standardizes the communication to the devices and way data is collected and stored.

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**IOT in AfterMarket Service : Predictive Maintenance**

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IoT in Reliability, Maintainability and Safety (RM&S)

- Reliability Plan & Approach
- PSSA & SSA reports
- Reliability Prediction (Parts count / Parts Stress)
- Functional Hazard Analysis (FHA)
- Fault Tree Analysis (FTA)
- FMEA / FMECA (LRU & System level)
- Common Mode Analysis
- Intrinsic & Environmental Condition Hazard Analysis
- BIT / testability Analysis
- Logistic Support Analysis (LSA)
- Warranty & Reliability Analysis with Failure Data
- MMEL Analysis
- Maintainability & MSG3 Analysis
- Reliability Test Plan (HALT/RGT/ALT)

IoT Enablement

- IoT Enablement for System Uptime, MTBF and Safety.
- Analytics of IoT Data to work with Predictive algorithms

Software

- Reliasoft – Blocksim, Weibull++, Alta Pro, MPC3
- Cafta – FTA

Services

- Reliability Plan & Approach
- PSSA & SSA reports
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- Warranty & Reliability Analysis with Failure Data
- MMEL Analysis
- Maintainability & MSG3 Analysis
- Reliability Test Plan (HALT/RGT/ALT)

Reliability Across Lifecycle

- Design Certification requirement to FAR & ARP 4761
- Supporting Design
- Feasibility
- Design
- Reliability Analysis
- Production
- Development
- Services
- In-Service
- Reliability Analysis

Team consists of Reliability Engineers from Mechanical and Electronics engineering background
The HCL IoT platform will enable a standardized layer for the onboarding of Husqvarna connectivity hubs.

- **IoT Solutions**
  - Connected Products: Remote Services, Predictive Maintenance, Smart Replenishment, Field Service Management
  - Connected Operations: Condition Monitoring, Smart Inventory Management, Production Planning, Track and Trace
  - Connected Users: Guided Operations, User Safety
  - Connected Infrastructure: Building Automation, Smart Facilities, Smart Cities

- **Service Enablement Layer**
  - Service Management: API Management, Usage Tracking and Billing, Identity and Access Management / SSO
  - Device Management: Service Bus

- **Connectivity Layer**
  - Remote Monitoring: Data Collection and Ingestion
  - Device Management: Command and Control
  - Connectivity: REST, AMQP, MQTT

- **Sites Layer**
  - Site Gateway
  - Site Software Platform
  - Equipment (Zigbee, Bluetooth, Wi-Fi, RS-232, RS-485)

- **Partners for Technology Platforms**
  - IBM
  - Amazon
  - Microsoft
  - Intel

- **Customer**
  - Customer 1
  - Customer 2
Getting Started with IoT with PLM and MBSE

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IoT Solution Components
- Device & Equipment Connectivity
- Central Compute & Data Store Platform
- Big Data Platform
- Analytics
- Business Applications

HCL Services
- Technical Consulting
- Platform design
- Platform development & deployment
- Operate
- Support

Comprehensive Services
- Smart Energy Management
- Remote Monitoring and Diagnostics
- Asset Tracking
- Preventive Maintenance
- Fleet Management
- Reduction in unplanned outages and equipment downtime
- Spare part management
- XaaS based service
HCL

Relationship™
BEYOND THE CONTRACT

$6.4 BILLION | 95,000 EMPLOYEES | 31 COUNTRIES

WATCH THE FILM
### Engineering Analysis Overview

#### Services

**Structural Analysis**
- Static Stress Analysis
- Fatigue & Damage Tolerance (F&DT)
- Aero Elasticity
- Flight Load Computation
- Dynamic Analysis (Modal, Transient, Frequency/random response, Shock spectrum)
- Impact Simulation – Bird Strike
- Drop Simulation
- Kinematics simulation

**CFD Analysis**
- Compressible and incompressible flow
- Steady and transient analysis
- Conjugate heat transfer analysis
- Fluid structure interaction
- Thermal Design and Analysis of Electronic systems

### Expertise

- More than 1 Mn man hours in aerospace simulation
- Average Experience: Manager 15+ years; Team lead 8+ years; and Team members with 5+ years

### Tools and Servers

- ANSYS, MSC. Nastran, ABAQUS, LS-DYNA, IDEAS, Pro/MECHANICA, MSC. Adams, LMS Sysnoise, HyperMesh, FLUENT, CFX, ICEM-CFD, Icepak, Flotherm, CF-Design, Moldflow
- Server with 100 cores extendable up to 200 Cores for high end analysis
- 64 High performing computing licenses (flow regimes)
- Handled 48 million cell count grid for external aerodynamic problem

### Productivity Tools

- Macros created for Post Processing ~ 78% time reduction
- Multi Frame Restart Methodology
- Elastic-plastic curve generation automation for internal use
- Neuber correction Tool—Calculate Elasto-plastic behavior
- Macros-Fatigue Life calculator of moving parts

### Advanced Simulation / Analysis Services

- High-end structural analysis
  - Aero Elasticity
  - Flight Load Computations
  - F & DT
- Fatigue & Damage Tolerance
- External Aerodynamics
- High-end Computational Fluid Dynamics