Smart Factories, Using the Digital Thread from Design to Production to Quality

Kingsley Edgar

&

Shripathi Vittal Rao

MSC Software

56 years of Innovation

Where It All Began: The 10 Original Software Companies

www.MaximumPC.com | Posted June 28, 2011 at 12:47pm | by Gord Goble

In compiling a list of the world's oldest software companies, one comes face to face with an inevitable question. Namely, what is it? What the heck is this thing we call "software?"

We searched the darkest corners of our brains and perused the online dictionaries for quickie text bytes and never really could come up with a single, all-purpose answer. Is it the overtly simplistic "Anything that is not hardware but is used with hardware" or the seemingly too limiting "The programs used to direct the operations of a computer?" How about this metaphysical beauty: "Unlike hardware, software can't be touched." Ouch. That makes our heads hurt.

While it's easy to say that Windows or Office or even the wanton dismemberment of Dead Space 2 are obvious examples of software, where does one draw the line? Did software, for instance, exist before the advent of computers? In our minds, it did. Though the concept of altering the performance of mechanisms by feeding them independent sets of instructions has clearly become rampant in the computer age, it in fact started long before that – the early 18th century, to be exact. And that is precisely where we'll start our journey.

Please remember as you read that software – and for that matter, computers – were with us long before the desktop PCs that so radically changed everything. Moreover, just because Joe Blow in some dungeon in Joe Blow Land cranked out a few lines of code before one of the key players, we've elected for the purposes of this article to ignore Joe and highlight instead those companies that history will see as having made a serious impact. Ergo, our countdown may seem a bit scattered. It isn't. It's perfect.

MSC SOFTWARE

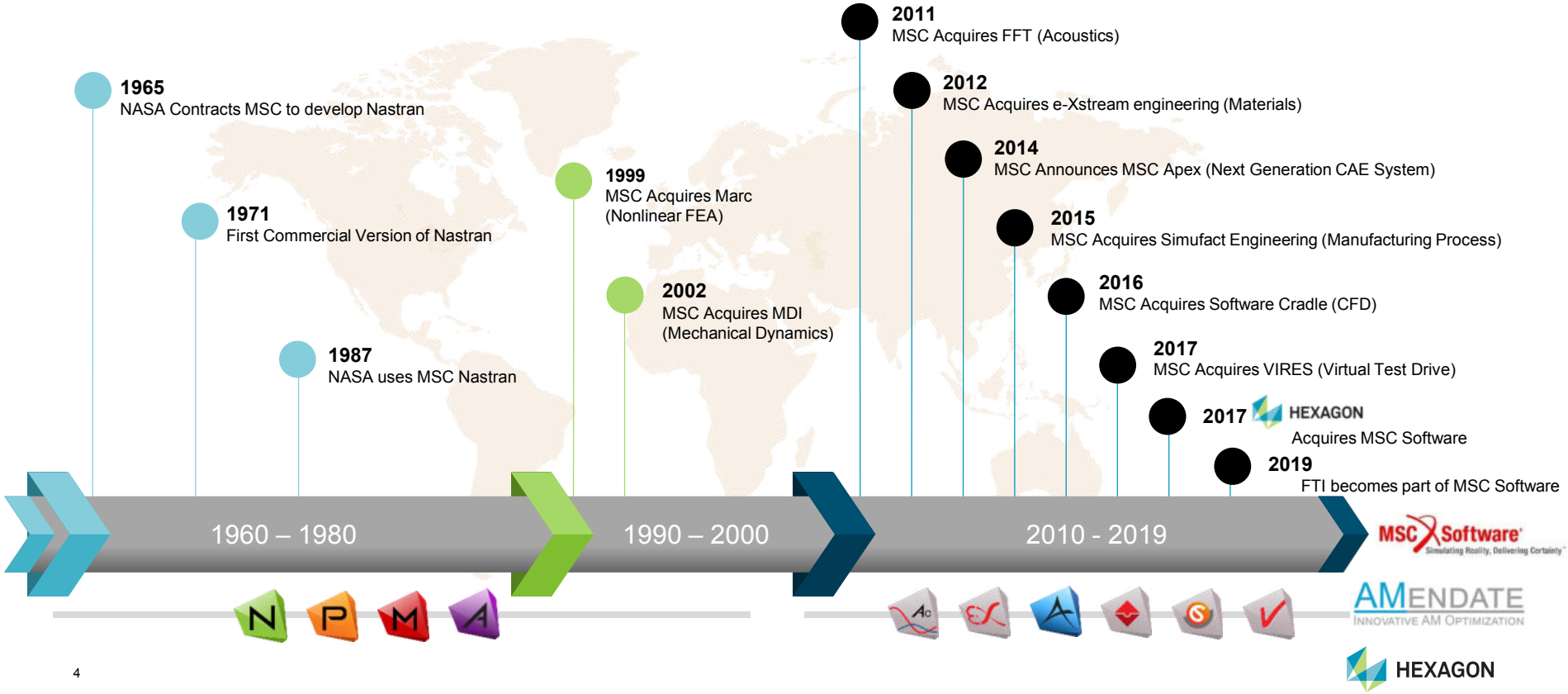
In May of 1962, President John F. Kennedy predicted America would by the end of the decade place a man on the moon. Just a year and a half later, the world had lost one of its great leaders. Yet there was no shortage of folks ready to keep Kennedy's grand dream alive

over the course of the next six years. Certainly MSC Software was in there doing its share. Debuting in 1963 as MacNeal-Schwendler Corporation, the company specialized from the start in structural analysis, developing software for pre-PC computers that simulated the functionality of complex engineering designs. Its first product, SADSAM (Structural Analysis by Digital Simulation of Analog Methods), was designed specifically for the aerospace industry, and by 1965, MSC was involved heavily with NASA.

Today, MSC Software employs over 1,000 people in 20 countries and says it can count virtually every OEM manufacturer in the world as an MSC customer.

MSC Corporation will celebrate its 50th Anniversary in February 2013.

MSC Software Company History & Evolution



MSC Software is now part of Hexagon AB

Completion of Hexagon's acquisition of MSC Software

Stockholm, Sweden, 26 April 2017 - Hexagon AB, a leading global provider of information technologies that drive productivity and quality across geospatial and industrial enterprise applications, today announced the completion of the previously announced acquisition of MSC Software ("MSC"), a US-based leading provider of computer-aided engineering (CAE) solutions, including simulation software for virtual product and manufacturing process development. Completion of the transaction was subject to regulatory approvals and other customary conditions, which have now been obtained.

Hexagon AB

- ~ US$4.5 Bn Net Sales in 2018, 10-12 % of Net Sales invested in R&D
- Headquarters in Stockholm, Sweden, 20,000 employees in 50 countries
- Wide range of Portfolio, including Auto, Aero, Shipbuilding, Electronics, GeoSpatial
- Balanced revenues between Geospatial and Industrial solutions

Hexagon Manufacturing Intelligence

- Part of Industrial solutions, ~ US $2.2 Bn in sales
- Focused on Quality in Manufacturing
- Headquarters in London
- Includes AICON 3D Systems, Leica cameras, Forming Technologies Inc. (FTI), etc.

MSC Software

- Headquarters in Newport Beach, California
- 1,400 employees in 23 countries
- CAE Pioneer and Leading Global Player
- Wide range of Portfolio, including Auto, Aero, Machinery, Defense & Shipbuilding

MSC Software Business Units / Acquired companies

2011 FFT Actran Acoustics	2012 e-Xstream Digimat Materials	2015 Simufact Forming Additive, Welding	2016 Cradle Tetra - Stream CFD	2017 Vires VTD Autonomous Mobility

2019 AMENDATE INNOVATIVE AM OPTIMIZATION

HEXAGON

Meta-Materials
Edge Technology
Cloud Computing
Bluetooth
Internet of Things
Open Source
LiFi Technology
WiFi Technology
Big Data
5G
Advanced Battery Technology
Meta-Materials
Edge Technology
Cloud Computing
Bluetooth
Internet of Things
Open Source
LiFi Technology
WiFi Technology

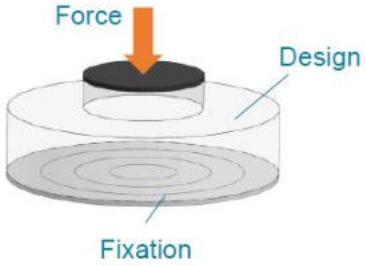
Enabling Technologies

Machine Learning
Augmented Reality
Open Source Software
Generative Design
Additive Manufacturing
Synthetic Biology
Nanotechnology
Advanced Robotics
Meta-Materials
Blockchain
Artificial Intelligence
Machine Learning
Augmented Reality
Open Source Software
Generative Design
Additive Manufacturing
Synthetic Biology
Nanotechnology
Advanced Robotics

Transformative Technologies

Because Time Matters

AMENDATE
INNOVATIVE AM OPTIMIZATION

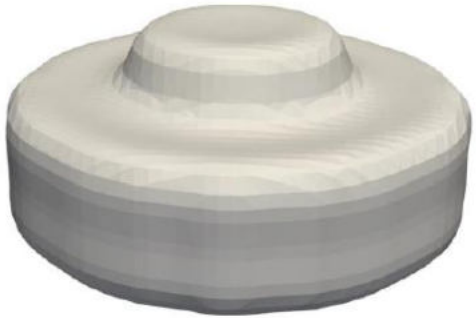


What does AMENDATE do?

Enabling the efficient production of highly complex components and providing customers with numerous benefits, from material-saving, weight reduction and efficient, cost-effective production. AMendate's technology eliminates the inefficient manual effort that significantly slows today's workflows, allowing work steps to be completed in days that would otherwise take several weeks

Start with solid material

Reduce material based on the load



Start of Optimization

3 Minutes* / Iteration 1

Design Direction visible

3 Minutes* / Iteration 8

Final & Printable Design

36 Minutes* / Iteration 62

*solved on a standard CAD-Workstation with Nvidia Quadro P5000 GPU

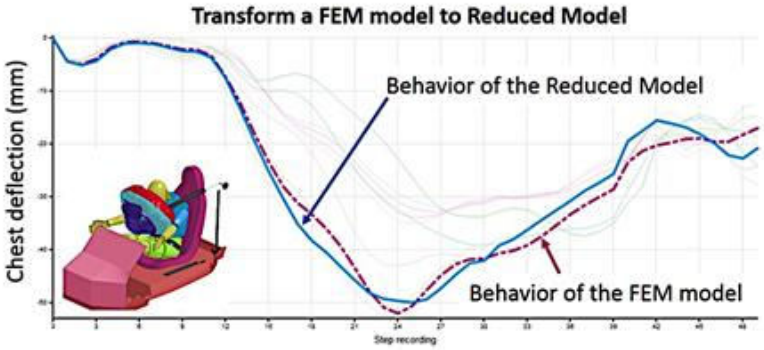
HEXAGON
MANUFACTURING INTELLIGENCE

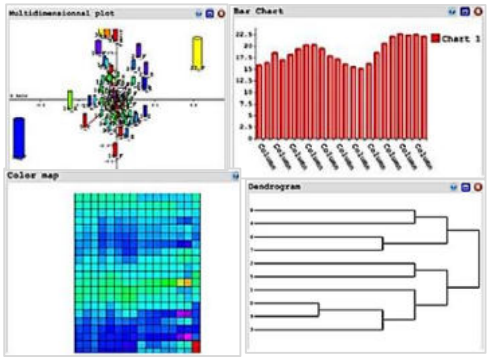
Machine Learning & Artificial Intelligence (AI)

Leverage user's experience and historical results to boost CAE productivity

CADLM
TRANSFORMING DATA INTO INTELLIGENCE

- AI-powered **Real-time CAE** to accelerate product design and development
- Reduced Order Modeling (ROM) techniques to **accurately predict outcomes** and allow to focus only on relevant scenarios and design options
- Capture and leverage your **CAE knowledge**, boost your engineering team productivity





Hexagon Autonomous Vehicle Simulation & Testing Solution Suite

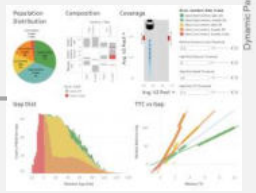
Real World Testing & Measurement

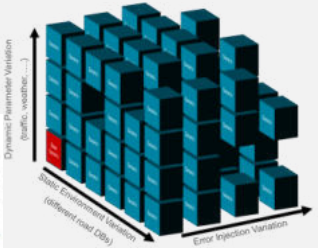
Digital Twin Simulation & Analysis

HPC Cluster

- Vehicle Model
- AI Driver
- Traffic
- Sensors
- 3D Environment

X 100





HEXAGON | MSC Software

Emerging.. take aways

- Additive manufacturing
- Autonomous

Thank You.

HEXAGON
empowering an autonomous future

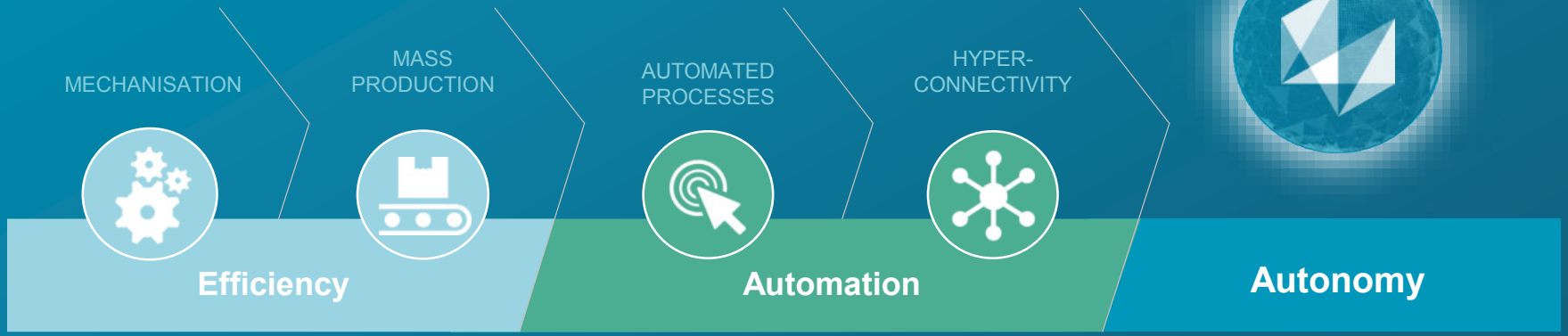
Smart Connected Factories

Shripathi V
Technical Manager, Aerospace
MSC Software Indo-Pacific

Leading a Revolution

From Automation to Autonomy

Autonomy is the ultimate form of putting data to work



HEXAGON

The Road to Autonomy

Our core capabilities

CORE CAPABILITY
Reality Capture

CORE CAPABILITY
Positioning

SENSOR SOLUTIONS

data capture

AUTONOMOUS SOLUTIONS

data leverage

CORE CAPABILITY
Autonomous Technologies

SOFTWARE SOLUTIONS

data intelligence

CORE CAPABILITY
Design and Simulation

CORE CAPABILITY
Location Intelligence Mapping

HEXAGON

Smart Factories

that learn and adapt quickly to changing conditions in real time, pursuing perfect quality with optimised design, requiring fewer inputs and producing zero waste

SUSTAINABLE VALUE CREATION
- Fewer inputs
- Zero waste
- Perfect quality

PRIMARY APPLICATIONS
- Aerospace
- Automotive
- Electronics
- Medical
- Heavy industry
- Power & energy

Did you know?

Each year, Hexagon technology touches:

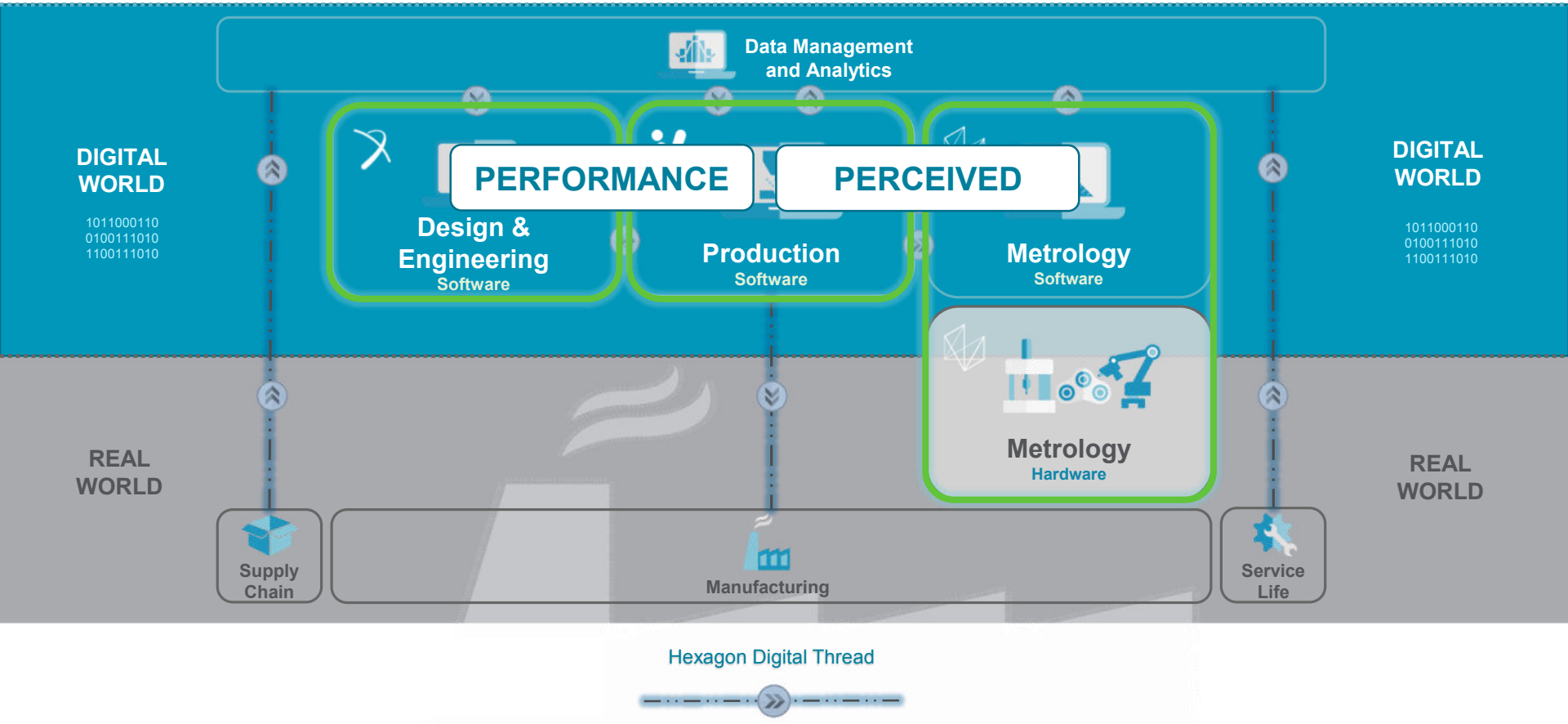
- **90%** of aircraft produced
- **85%** of smart phones produced
- **75%** of cars produced

We have expertise in and connect all stages of the manufacturing lifecycle:

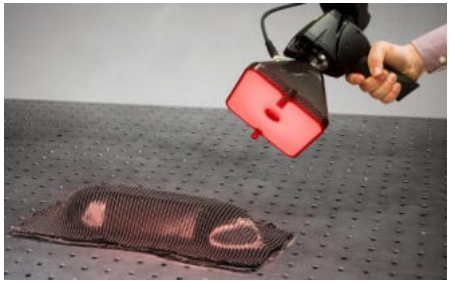
DESIGN AND ENGINEERING (CAE)
Optimise designs and ensure manufacturability

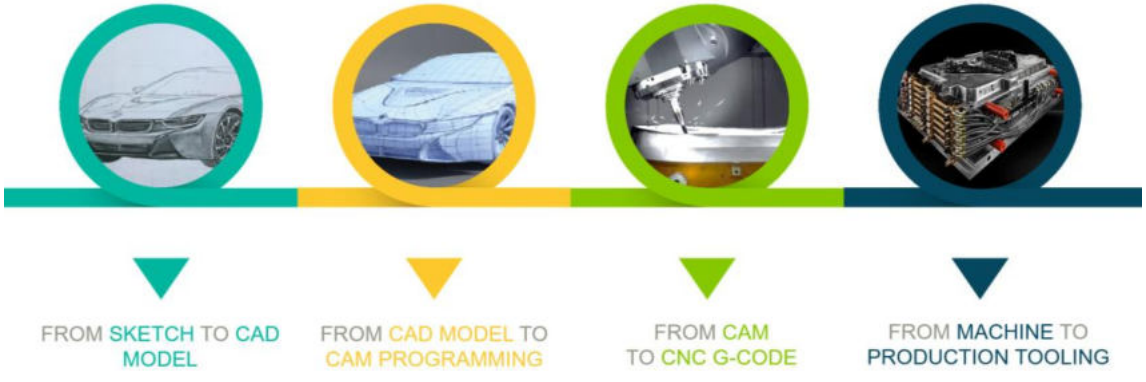
PRODUCTION (CAD/CAM)
Deliver on design intent and product quality with minimal waste

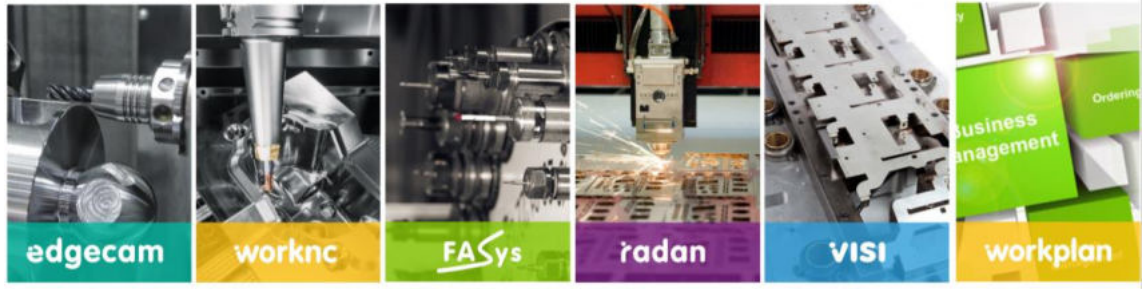
METROLOGY HARDWARE/SOFTWARE
Capture real-world data for positioning and inspection


Data Management and Analytics
DIGITAL WORLD
1011000110
0100111010
1100111010
PERFORMANCE
PERCEIVED
Design & Engineering
Software
Production
Software
Metrology
Software
Metrology
Hardware
DIGITAL WORLD
1011000110
0100111010
1100111010
REAL WORLD
REAL WORLD
Supply Chain
Manufacturing
Service Life
Hexagon Digital Thread

Industrial Metrology Applications: World Leader in Quality Measurement



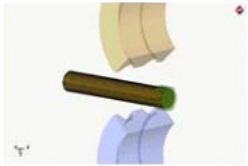
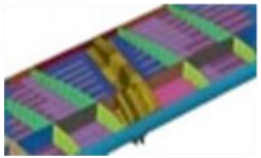
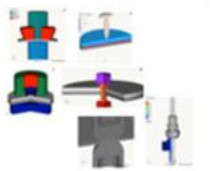




- CADCAM to address ***metal, sheet metal and woodworking industries***
- MES for die/mold processes, small scale ERP tools, machine simulation technologies
- Direct offices in 13 countries, development teams in 7 countries, ***700+ employees***, 140 resellers in 45 countries
- Strong relationships with all the largest machine tools OEMs

MSC Software®
Simulating Reality, Delivering Certainty™

Materials | Fabrication | Parts | Assembly | Systems | Quality







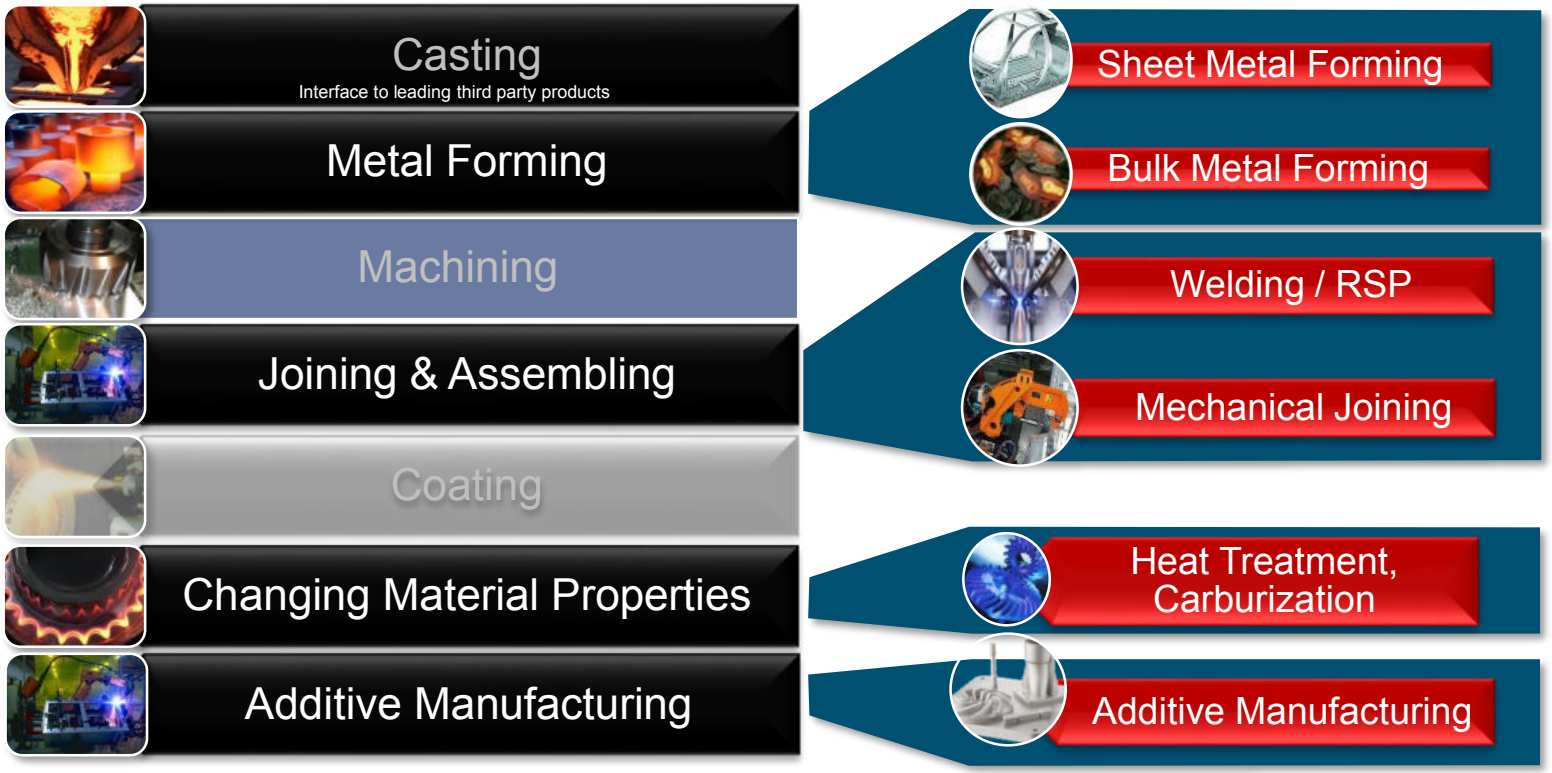


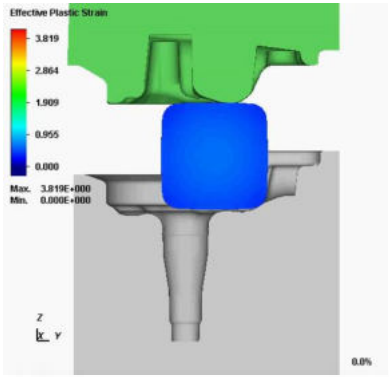


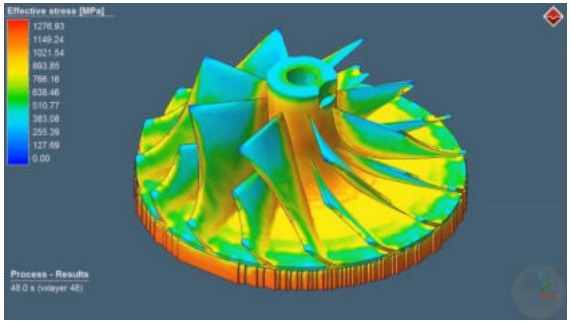


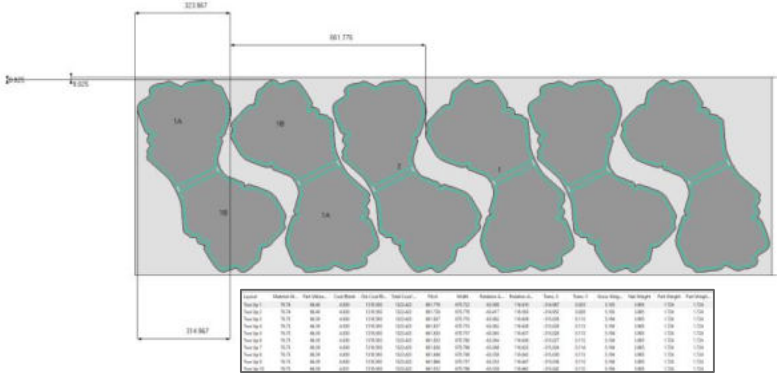


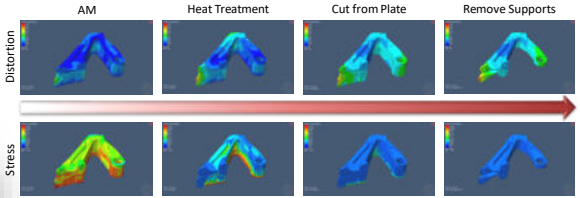
MSC's Virtual Factory Ecosystem

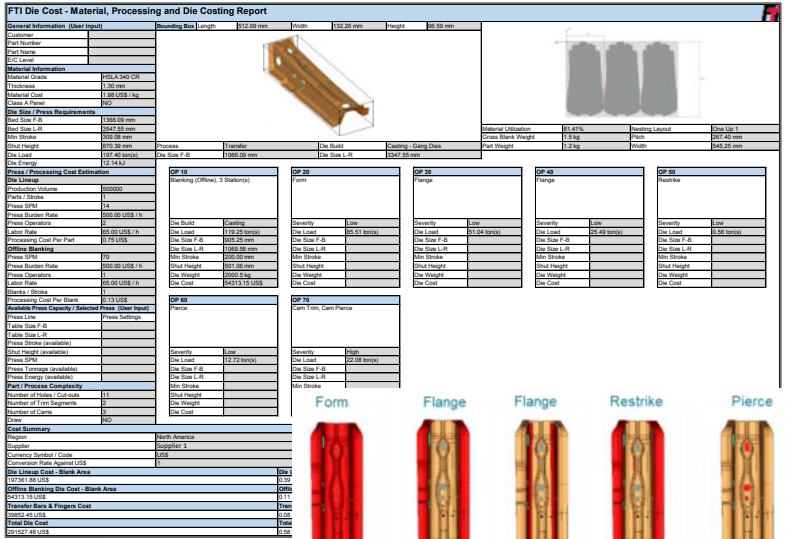


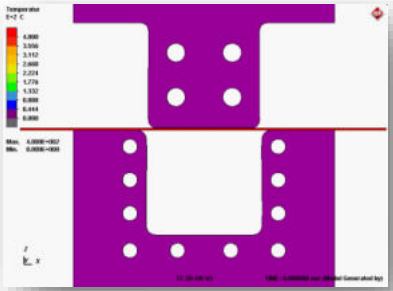

Effective Plastic Strain
3.819
2.864
1.909
0.955
0.000
Max. 3.819E+000
Min. 0.000E+000
0.0%

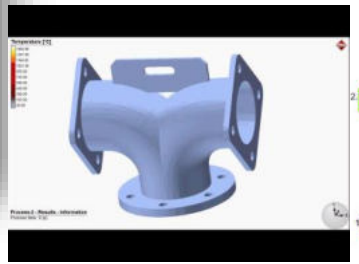

Effective stress [MPa]
1276.93
1149.24
1021.54
893.85
766.16
638.46
510.77
383.08
255.39
127.69
0.00
Process - Results
48.0 s (vlayer 48)

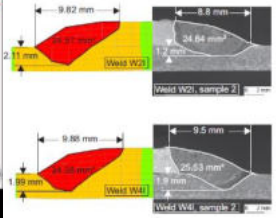



AM
Heat Treatment
Cut from Plate
Remove Supports
Distortion
Stress


FTI Die Cost - Material, Processing and Die Costing Report
General Information (User Input)
Material Information
Die Size / Press Requirements
Press / Processing Cost Estimation
Die Lineup
Offline Blanking
Cost Summary
OP 10
Blanking (Offline), 3 Station(s)
OP 20
Form
OP 30
Flange
OP 40
Flange
OP 50
Restrike
OP 60
Pierce
OP 70
Cam Trim, Cam Pierce

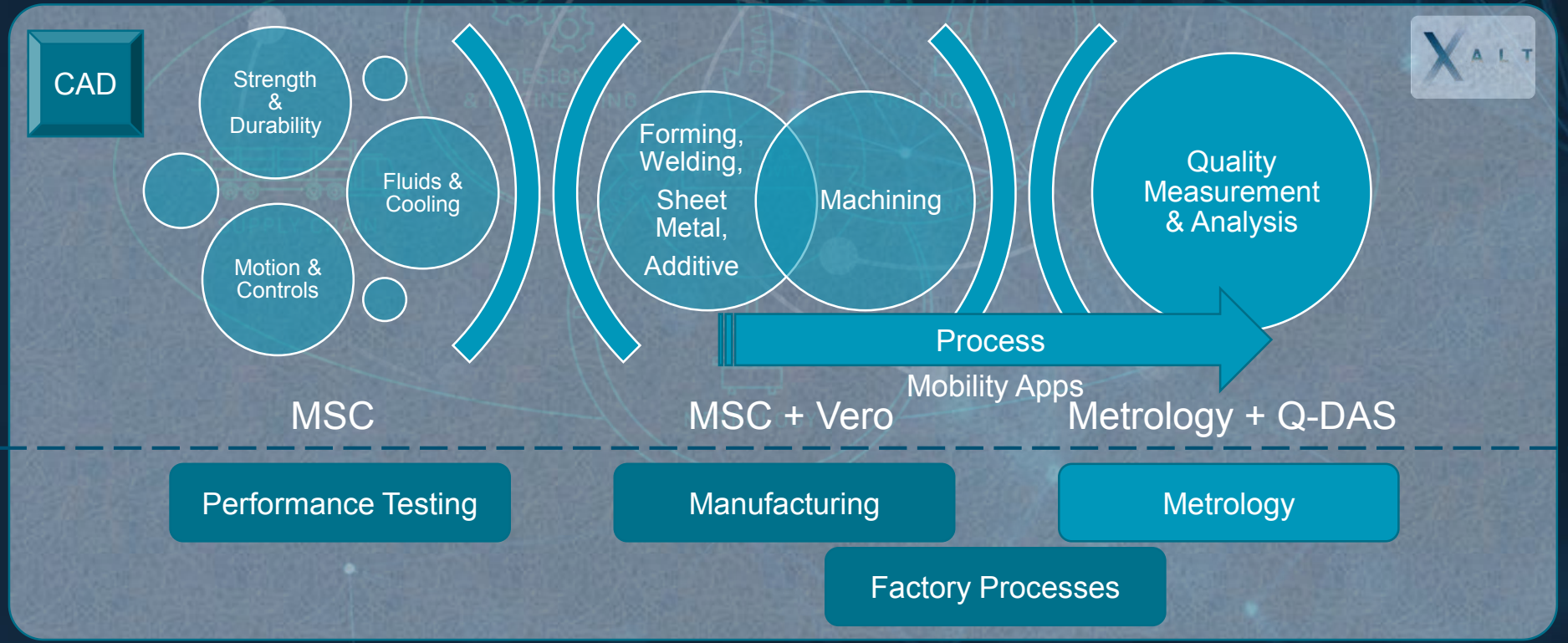





9.82 mm
8.8 mm
24.97 mm²
24.84 mm²
2.11 mm
1.2 mm
Weld W2i
Weld W2i, sample 2
9.88 mm
9.5 mm
24.98 mm²
25.53 mm²
1.99 mm
1.9 mm
Weld W4i
Weld W4i, sample 2

Form
Flange
Flange
Restrike
Pierce

The Digital Twin and The Smart Factory



Challenges faced by Manufacturing Industry

Connected Plant Floor to Improve Operational Efficiency

Manufacturers are missing out on a critical opportunity: Leveraging real-time data on cycle times, quality yields by machines, production run, utilization and other metrics to improve Operational Efficiency of the plant.

Preventive maintenance without affecting throughput

Keeping equipment functioning is an essential part of running a manufacturing facility. By collecting real-time data, and comparing with failure scenarios, it is possible to predict the appropriate time frames that the machines in the factory should be maintained.

Connected Quality for Final Inspection

Process of quality assurance, quality control, and QC inspections need to be optimized to increase productivity and lower costs

Better supply chain visibility

It is essential to integrate all the business applications including ERP, CRM, PLM with MES systems for a better visibility of supply chain

Customer-facing self-service applications

An organization’s customers typically consist of end-customers, partners (or service providers), and sub-contractors, or any combination of these. These customers have different needs, concerns and requirements for working with and interacting with manufacturers.

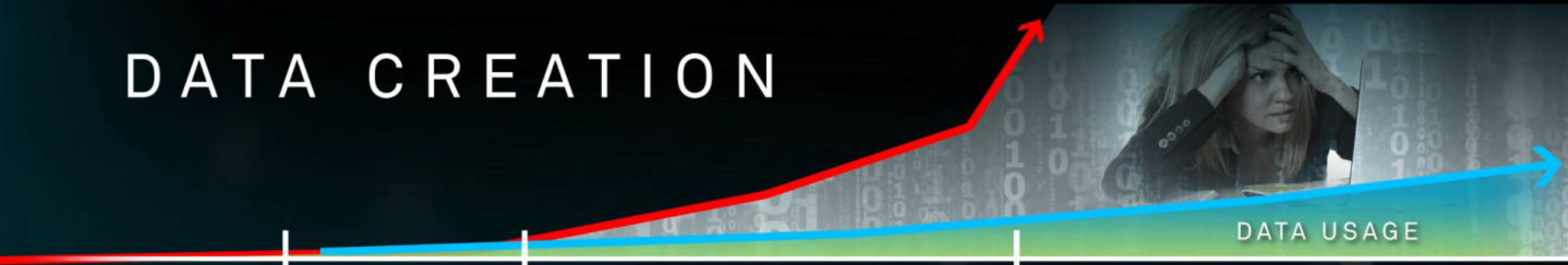
References

[10 greatest Manufacturing Challenges for CIOs]

[Top five challenges facing Manufacturing Industry]

[Six challenges facing Modern Manufacturing Companies]

DATA CREATION



DATA USAGE

DAWN OF TIME | PRINTING PRESS | INTERNET | IoT

INTERNET OF THINGS

Introducing Xalt

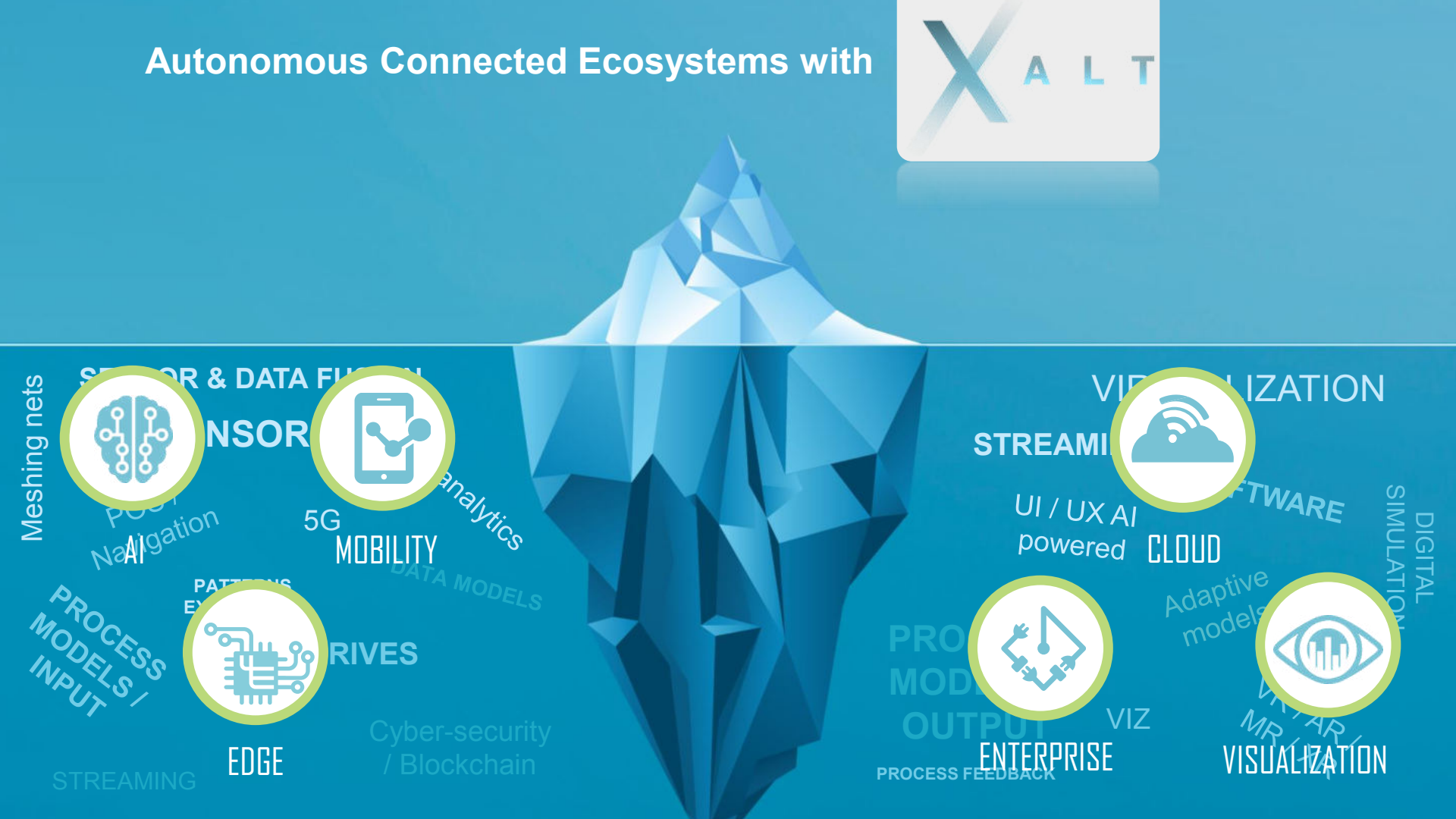
One of our major R&D initiatives is a technology framework called Xalt, which will eventually underpin all of our solutions – making them faster, easier to use, more connected, and autonomously intelligent.

Xalt framework:

- Artificial intelligence
- Edge computing
- Mobility
- Advanced visualization
- Enterprise integration

HEXAGON

Autonomous Connected Ecosystems with XALT



Infinite Connectivity for Disconnected Data

CLOUD ENABLEMENT

Connecting B2B with an orchestrated microservice framework and cloud analytics for big, fast data.

EDGE CONNECTIVITY

Processes, combines, and analyses IoT and sensor data at the edge of the network and puts it to work with AI.

ENTERPRISE INTEGRATION

Plug-in enterprise integration for legacy connections, databases, and IT systems. equipped with middleware for messaging, file, system, and database connectivity and transformation.

MOBILITY

Secure and nimble framework that is native iOS- and Android-ready with zero client footprint and network-optimized for visualization of multiple georeferenced 3D & 2D data sets

UBIQUITOUS A.I.

Multiple AI data sources including imagery, video, and big data for applications such as predictive maintenance, change, and anomaly detection.

VISUALIZATION

Visualizes 2D/3D data, including point clouds, and is optimized for all mainstream OS, mobile, and web platforms. Augmented reality applications are validated on HoloLens, Daqri, and Oculus, and can process enormous datasets at high speeds.

Security without Rigidity: Xalt is HIPAA and PCI-compliant, is SOC2 certified, and has passed the United States Department of Defense regulatory process.

HEXAGON

Addressing the Complex Real-life Challenges in Manufacturing – not just Connectivity

THE BIG DATA DISCONNECT

Organizations have limited visibility to at-source data

QUALITY / COST INVERSION

Produce more at higher quality; deliver it faster at lower costs

4.0 MODELS & MARKETS

Lost revenue due to untapped, data-driven models and channels

PROCESS OPTIMIZATION

Real-time logistics, line uptimes, edge analytics of machinery

SMART QUALITY ASSURANCE

Real-time updates and alerts for on-premises, cloud, and sensor assets

CONNECTED WORKERS

Real-time mobile access to consolidated data (sensors, alerts, and workflows)

Leverage Your Existing OS

=

OPEN CONNECTORS

LOW/NO-CODE IMPLEMENTATION

+

INTEGRATION

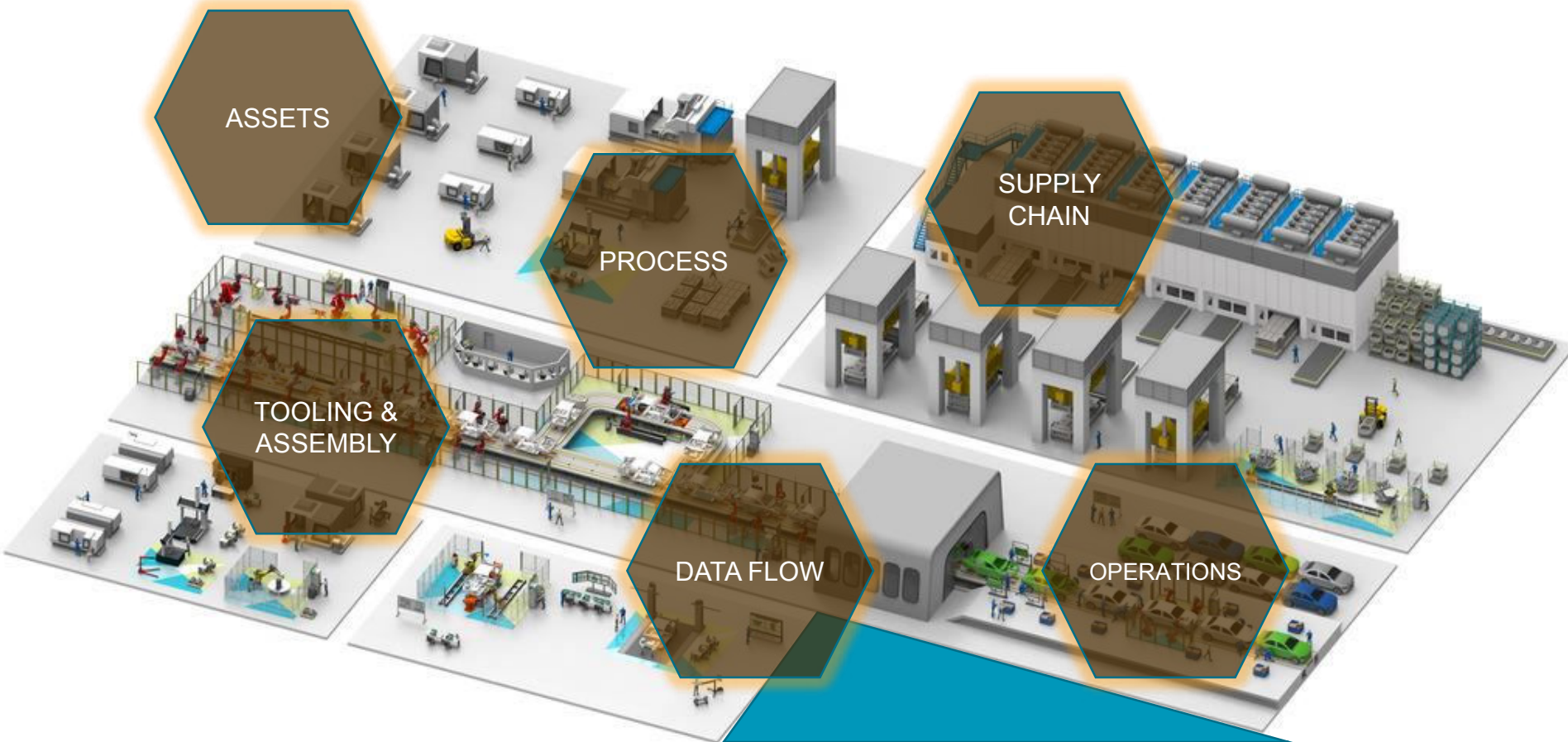
FLEXIBLE DEPLOYMENT

+

SMART WORKFLOWS

DATA ACCESSIBILITY

HEXAGON


ASSETS
PROCESS
SUPPLY CHAIN
TOOLING & ASSEMBLY
DATA FLOW
OPERATIONS

Connected Worker

Innovating Work in the Field

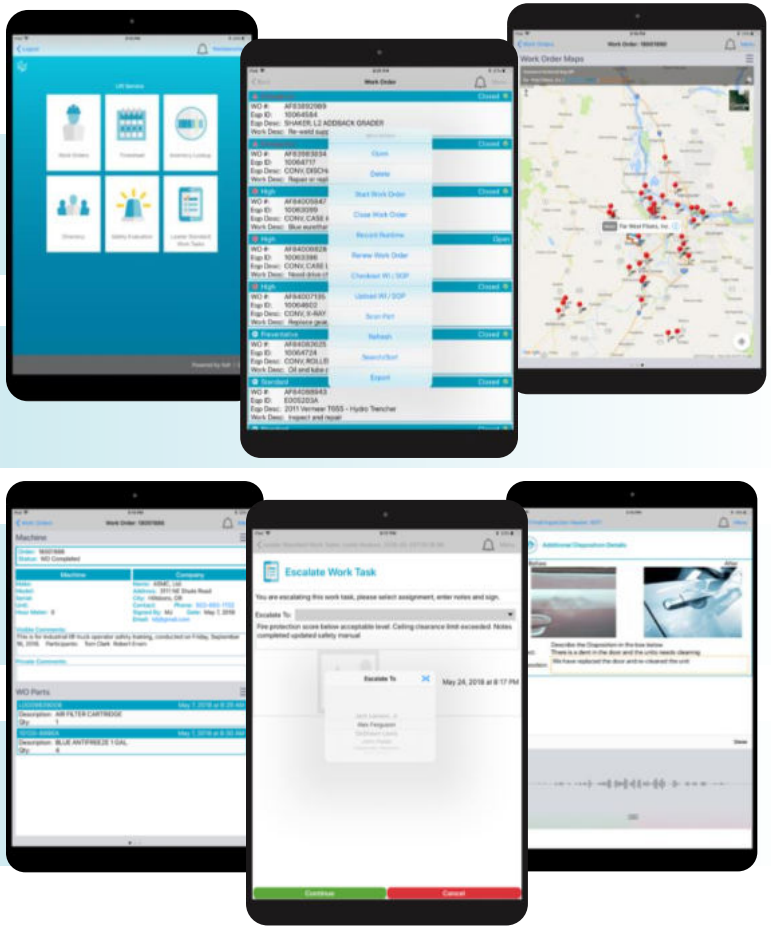
HEXAGON

AUTOMATED MAINTENANCE + SERVICE WORK-ORDERS

ACCURATE TIME PLANNING + PRIORITY ESCALATIONS

TOOL + EQUIPMENT TRACKING

SUPPLY + INVENTORY LOOK-UP AND REQUISITIONS



Smart Factory

Sensor Fusion with User Enablement

HEXAGON

Smart Factory Solutions

MANUFACTURING

TRANSPORTATION

Body + Finished Good MFG
- Motor Vehicle + Truck
- Heavy Duty Vehicle
- Specialty Vehicle
- Aerospace

METAL + MACHINERY

- Packaging Machinery
- Door + Window
- Elevator + Convery
- Material Handling
- HVAC +Industrial Refrigeration

Quality Inspections

- Inspection Plans
- Times Tests
- Shared File Specs
- Rework WOs
- Production to Delivery Tracking

Field Service Suite

- Workorder Mgmt
- Time Allocation
- Supply Reqs
- Inventory
- Mileage Tracking

Maintenance

- Workorder Mgmt
- Time Allocation
- Supply Reqs
- Inventory
- Emergent Alerting

PLANT OPERATIONS

ELECTRICAL

Sub Contracting Of:
- Electrical Site Prep
- Commercial Bldgs
- Electrical Finishing
- 100 Employees+

MECHANICAL

Installation Of:
- HVAC System
- Plumbing + Piping
- Drywall + Structural
- Elevator+Equipment

UTILITY SYSTEMS

Construction Of:
- Oil + Gas Pipelines
- Power + Comm. Lines
- Water + Sewage Systems

Time Planning

- Jobsite HR
- Timesheets
- Payrate plan
- Project time Budgeting

Material Requisitions

- Inventory
- Prefab Reqs
- Equipment Rentals
- Supplier Orders

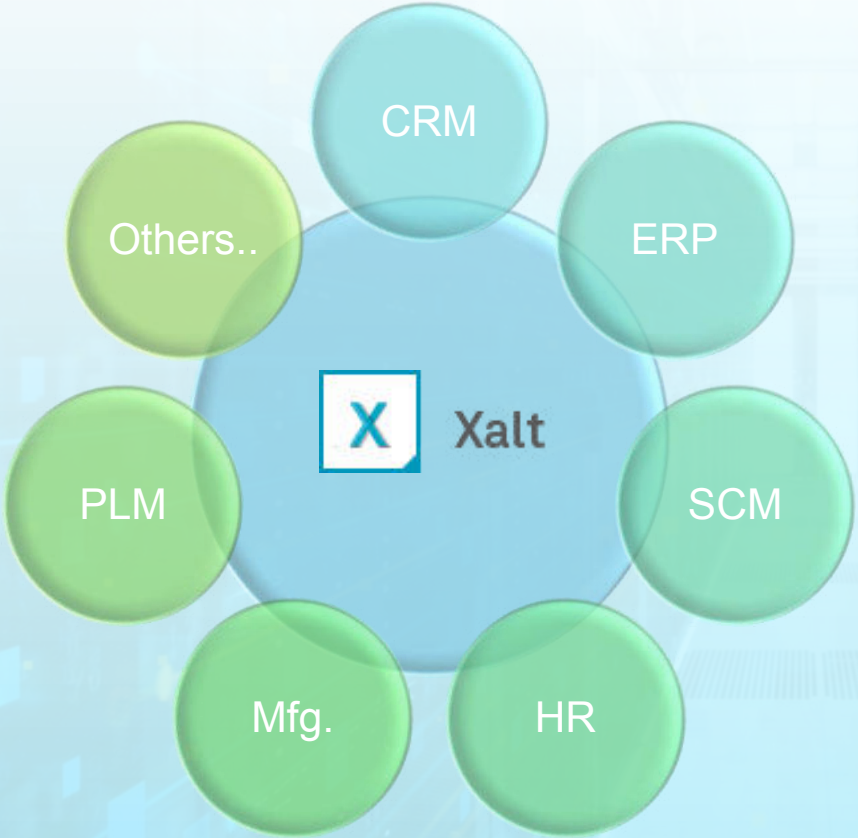
Tool Tracking

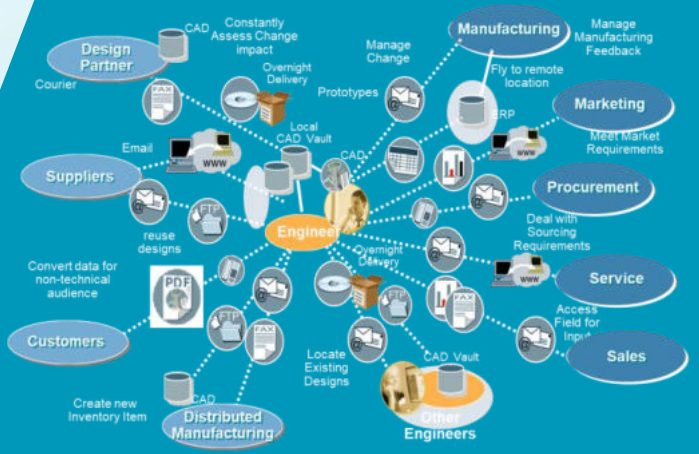
Asset Mgmt:
- Tools
- Equipment
- Rentals
- Maintenance Schedules

Project Reporting + Analysis

- Job Status
- Daily Site Reporting
- Project Budget
- Deadline Tracking

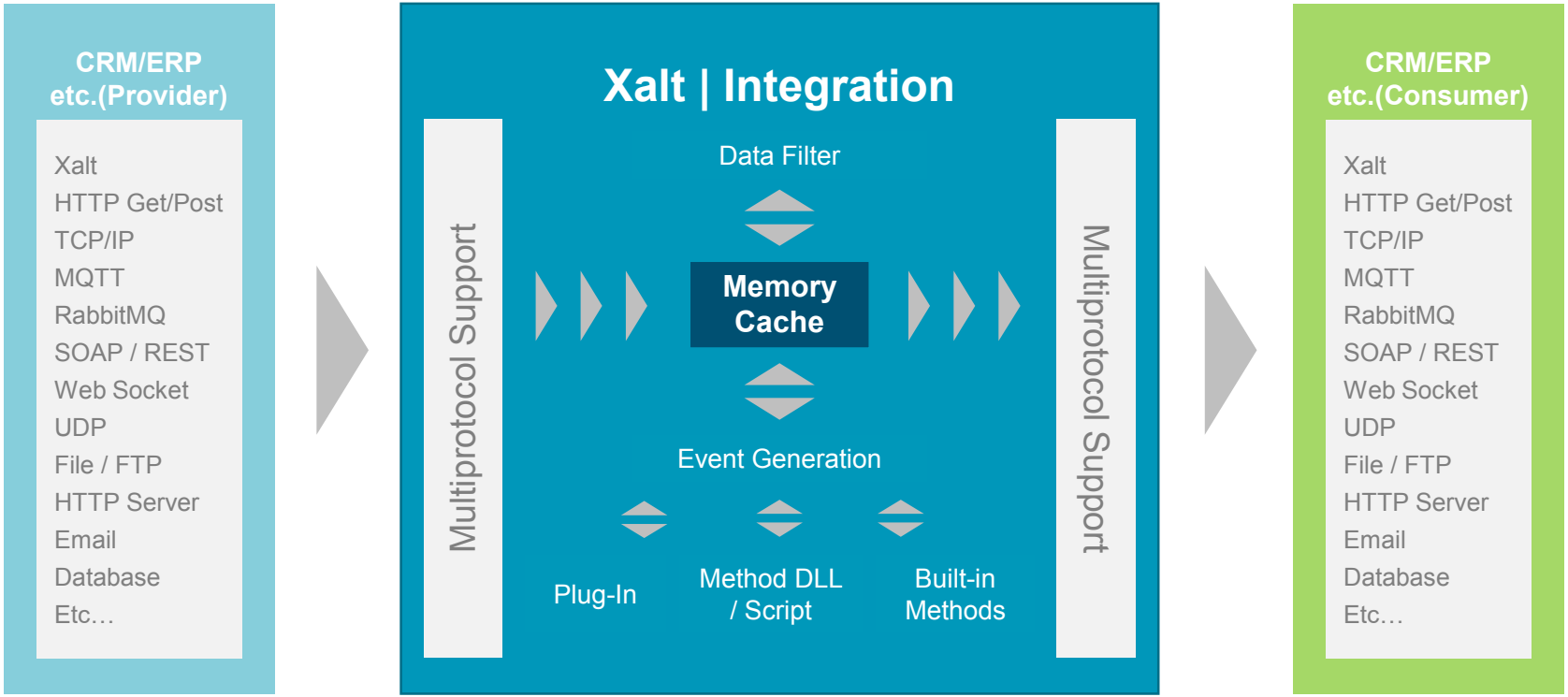
Connections to Business Applications





Xalt | Integration

Xalt | Integration provides interfaces to connect multiple software applications and a highly configurable *no-code* business rules engine to solve enterprise-level integration challenges.

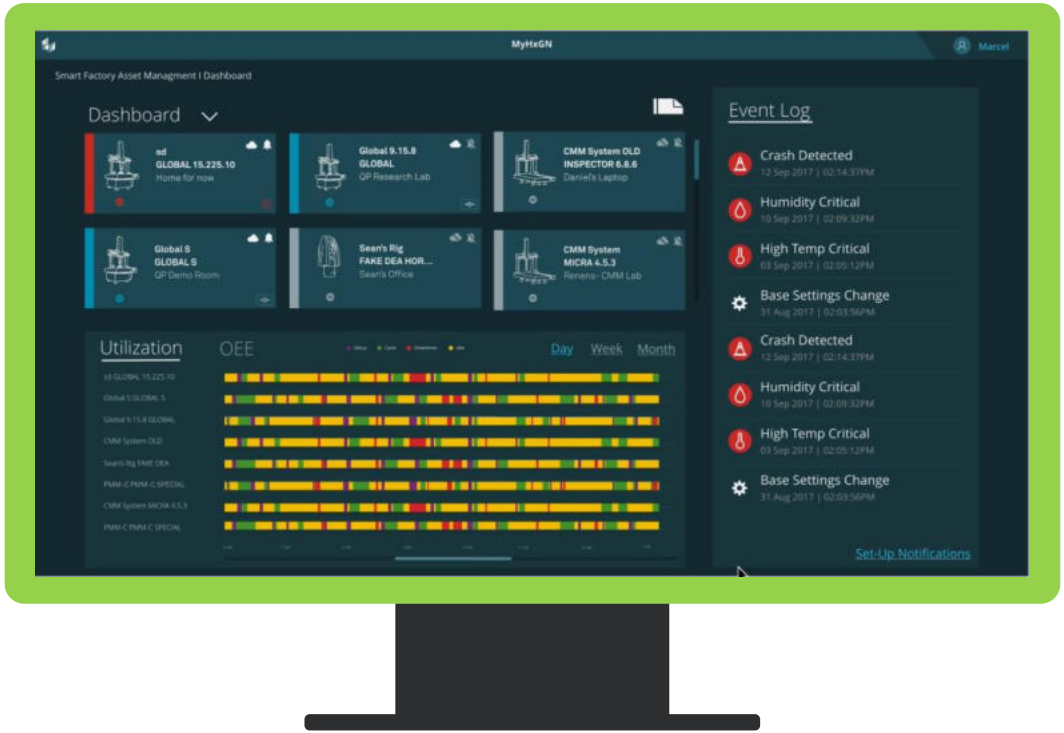


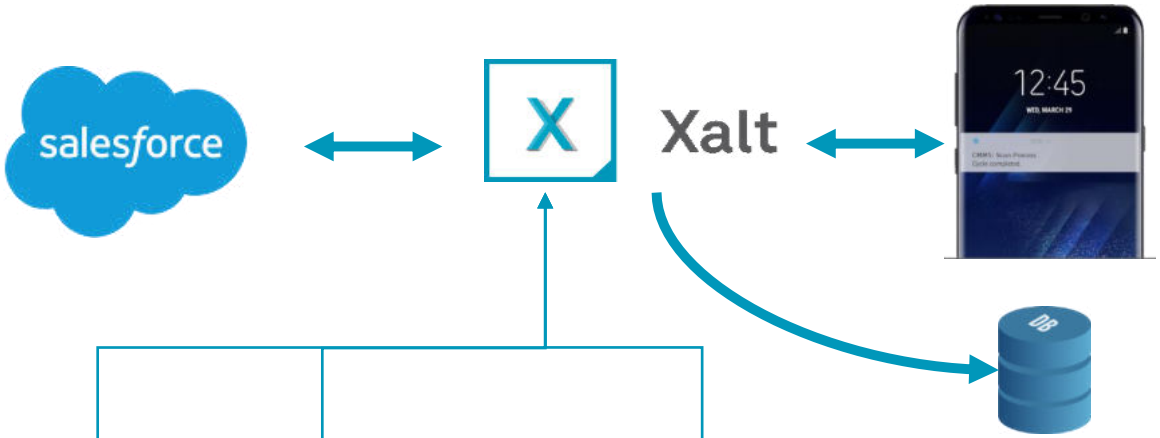
It’s the glue that holds solutions together

Asset Management

Minimize Downtime.
Maximize Efficiency.

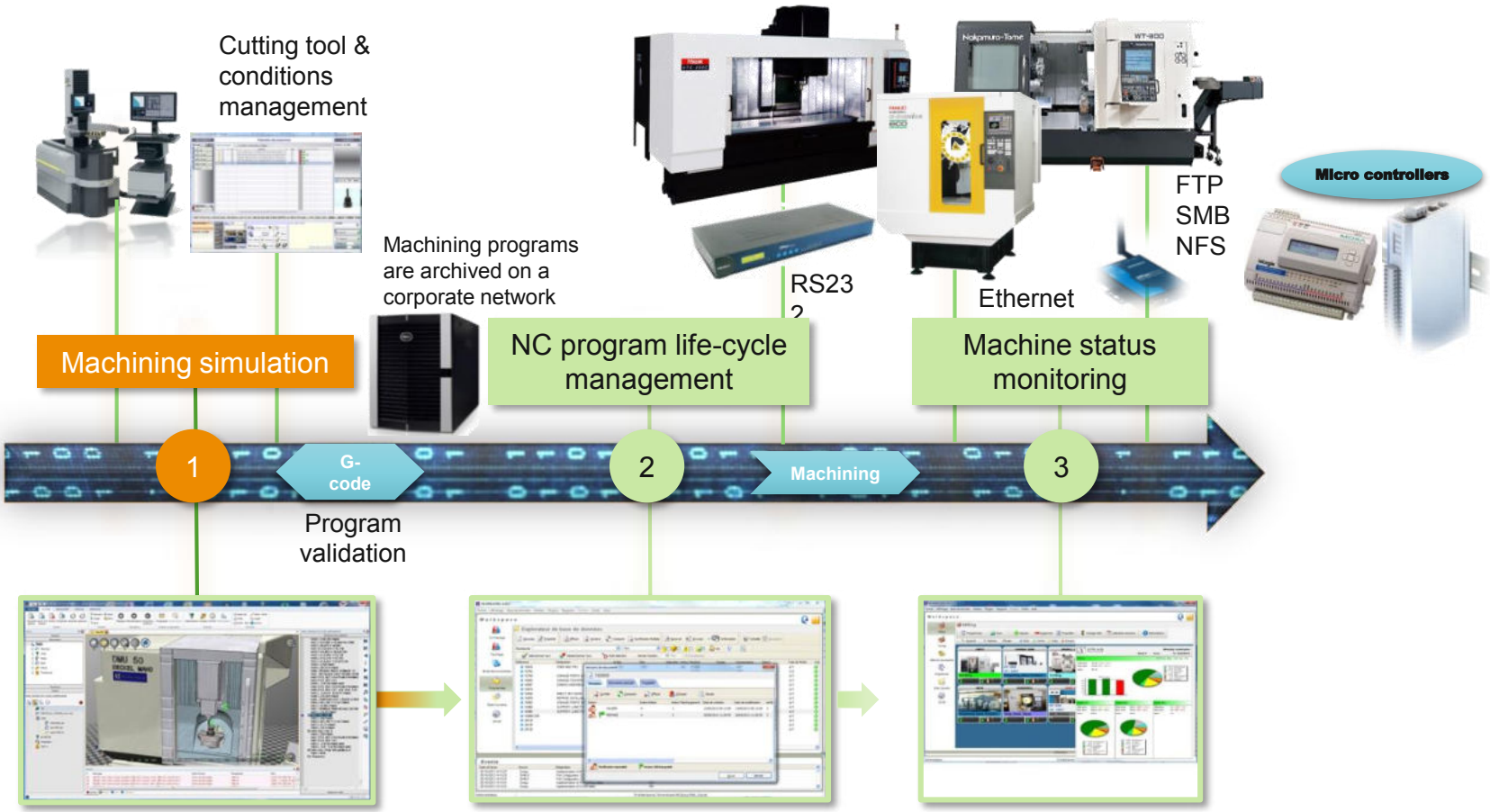
- System Health
- Asset Utilization Charting
- Facility Environment Tracking
- “OEE”
- System Notifications
- HMI Service Connection





Scope

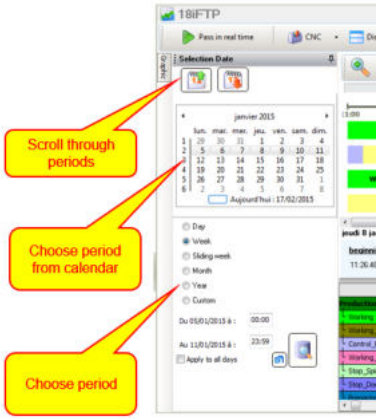
- Manage and see Assets in Smartphones
- Receive Notifcations on CMM Started, Busy, Idle, Crash, Error
- Master complextiy of setups in OEM environment
- Autodiscover assets
- Manage loads based on availability

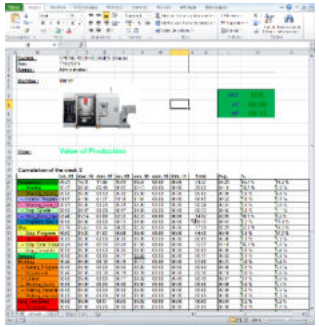

Cutting tool & conditions management
Machining programs are archived on a corporate network
RS23
2
Ethernet
FTP
SMB
NFS
Micro controllers
Machining simulation
NC program life-cycle management
Machine status monitoring
1
G-code
2
Machining
3
Program validation

Real-time Status Monitoring

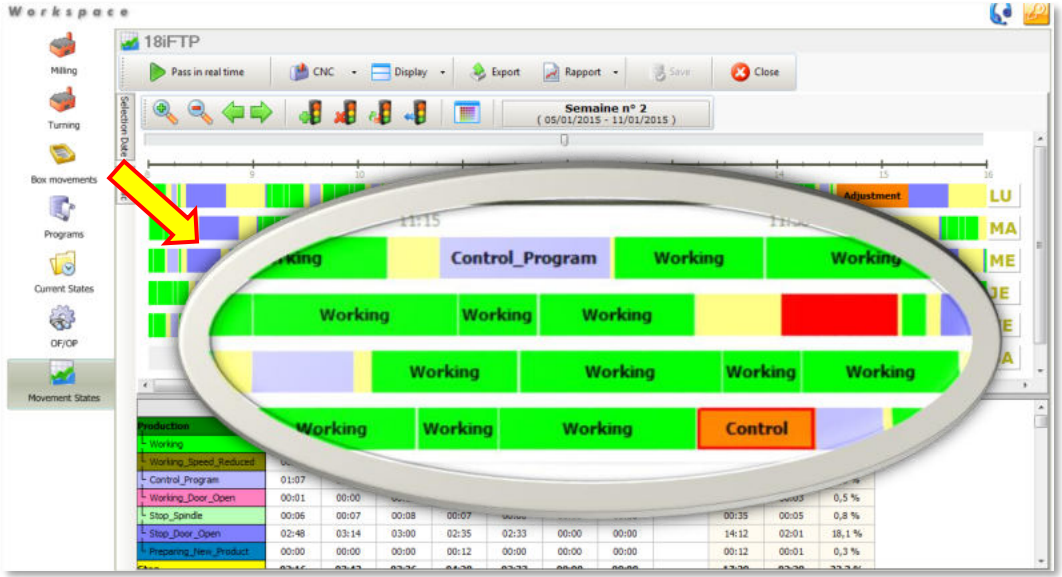
- Presents the chronology of the statuses per period
- Provides real-time indicators of machine activity
- Details the timeline of machines status
  - The horizontal axis indicates the times
  - The vertical axis indicates the days in the period
- Select a status to find out when it started and how long it lasted
- A user-friendly user interface to select the date and type of the period

View / Export Historical Data

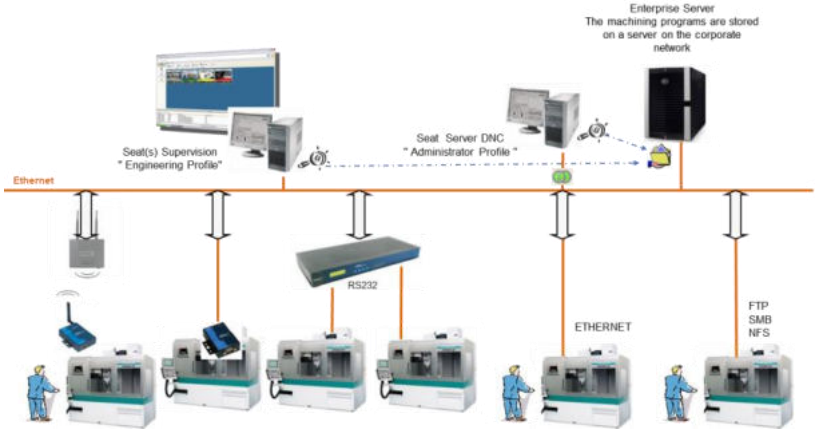




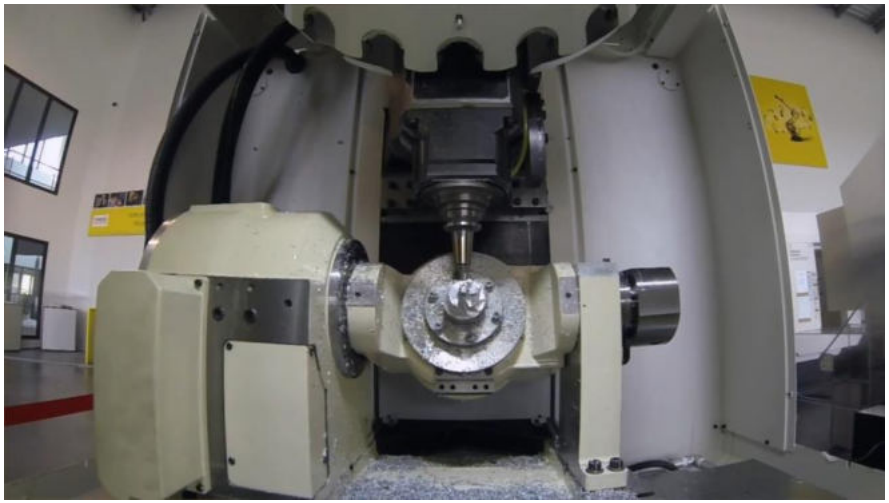
View Real-time Factory Status



Real-time Activity Monitoring & Control

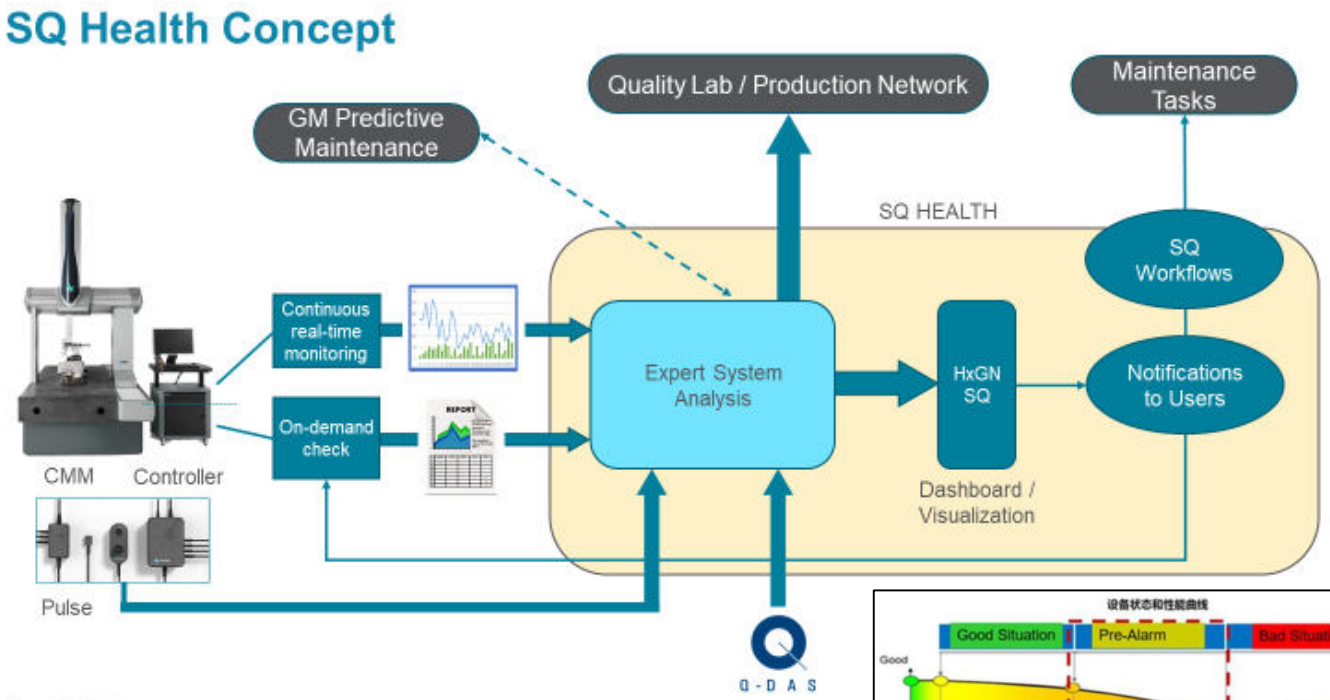


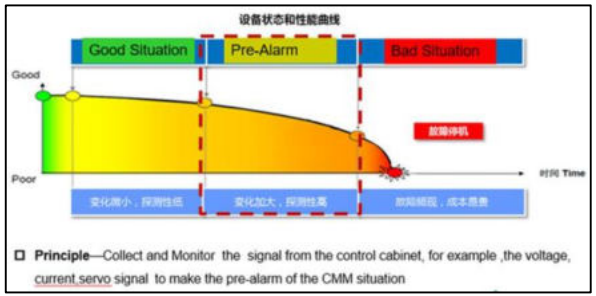
Factory & Machines



Machining Process & G-Code Execution

Towards Predictive Maintenance



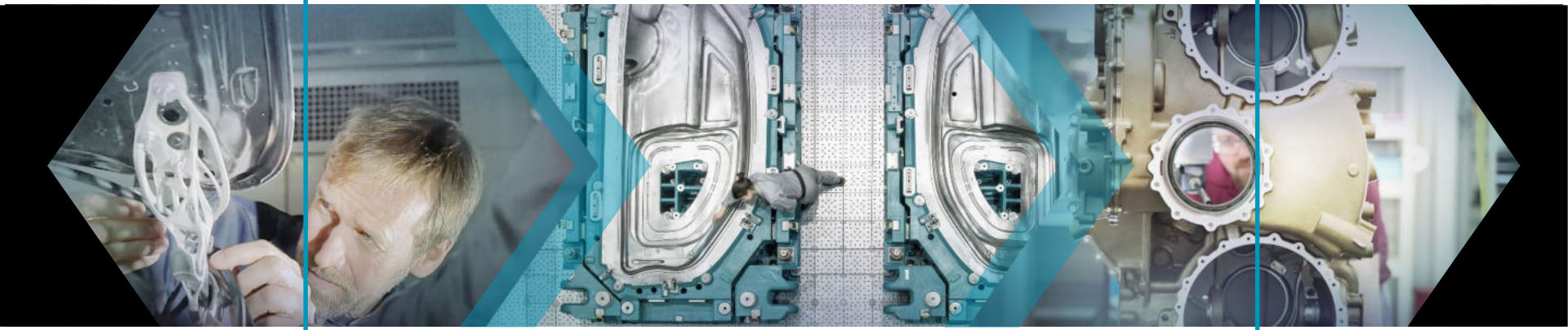


Stepwise approach:

- **Step 1:** Rules-based notifications on pre-defined thresholds
- **Step 2:** Condition monitoring on parameters based on statistical methods
- **Step 3:** Predictive maintenance with ML algorithms trained on historical telemetry (machine, environment), failure/service events and process data

HEXAGON

Machine Learning / AI & Design Improvement



Feedback and Learning

Robot System

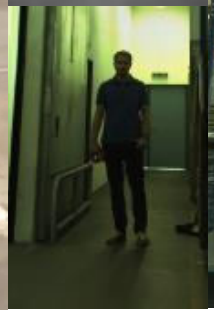
BLK 360
(incl. IR-Camera)

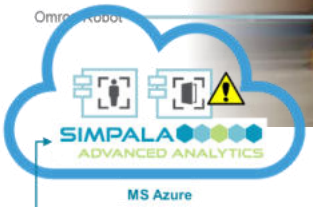
Axis Camera

Orbbec Sensor

Notebook
(Application Processor)

Omron Robot





MS Azure

Robot performs patrol
and tasks

Downloads WPs as
Instruction set to Robot

Enter Patrol
as Waypoints

Warehouse

On-Premise Servers

Catavolt

Anywhere

Few Casestudies to glance at……

SUPPLIERS

CUSTOMERS

Thank you