



DIGITAL TRANSFORMS PHYSICAL

PTC AEROSPACE AND DEFENSE OVERVIEW

Marc Riviere

Senior Director Federal Aerospace Defense

Oct 20th, 2023



INTRO LT COL RIVIERE, (RETIRED)



- **Current Role** – Senior Director Federal, Aerospace & Defense. Thought leadership, Strategic planning and business development in the FA&D market vertical
- **Background** – 30+ years Aerospace experience - 22 Years French Air Force,
 - Program director OT&E (800 staff): A400M Program, new equipment experimentation
 - Head of design, engineering and manufacturing of special ops changes all fleet.
 - US Air Force Academy liaison officer and instructor researcher Aerodynamic
 - 2 assignments as head of maintenance facility, up to 250 staff
- **Logistician and maintainer by Trade** – Directed maintenance facilities of up to 250 staff, reorganized and audited maintenance organizations at French Air Force level , Airworthiness expert and Lean Six Sigma Black Belt certified.
- **Business consulting** – Directed 2 consulting units : Aerospace in service and support consulting and Operational excellence (LSS) consulting



INTRODUCTION PTC IN A NUTSHELL



- \$1.5B global software company, headquartered in Boston, MA
- ~\$330M Govt sector + A&D business
- Consistently Rated as Industry Best/Leading in:
 - Computer Aided Design (CAD) **Creo**
 - Product Lifecycle Management (PLM) **Windchill**
 - Industrial Internet of Things (IIoT) **Thingworx**
 - Augmented and Virtual Reality (AR/VR) Solutions **Vuforia**
- 28,000 active customers
- 6,000 employees
- Strategic technology partner to U.S. Govt
- NASDAQ: PTC - market cap ~\$13B



HOW DIGITAL TRANSFORMS PHYSICAL

DIGITAL THREAD

DIGITAL
Defines
PHYSICAL

DIGITAL
Controls
PHYSICAL

DIGITAL
Manages
PHYSICAL

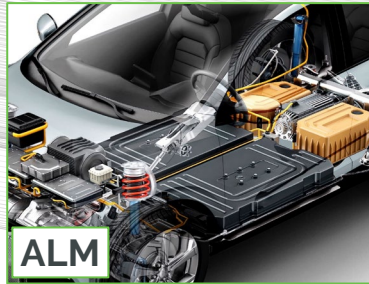
DIGITAL
Connects
PHYSICAL

DIGITAL
Sustains
PHYSICAL

DIGITAL
Augments
PHYSICAL



CAD



ALM



PLM



IoT



SLM



AR

creo®
onshape®

codebeamer™
windchill® modeler

windchill®

thingworx
kepware®

servigistics®
servigistics® arbortext®
SERVICEMAX

vuforia™



PTC IN AEROSPACE AND DEFENSE

PTC IN THE INDUSTRY

Industries



Air, Naval & Ground Defense



Defense Logistics Command & Control



Space Systems



Airframes OEM



Aerospace and Propulsion



Aviation MRO



Airlines and Airports



Drones, VTOL, UAM

Why PTC FA&D

Market Leader

Largest PLM provider in US A&D, Space

\$340M Contribution to PTC

ARR #2 Vertical

Customer Base

Major defense and Aviation OEMs across the globe

Dedicated Team

Industry Experts

Digital Transformation

Strategic Partners to Defense & Aerospace Industries

Secure Cloud

DISA, IL-5

Mil Program Focus

Monitoring largest programs across the globe

Industry Trends

AI, Digital Engineering, Hypersonics

WHY PTC IN FA&D

- 1. Wrap / extend across multiple vendors / solutions—MOSA (Modular Open System Architecture)**
- 2. Speed is key in peer competition – Fastest Time to Value**
 - ONTIC PLM in 12 weeks;
 - MAZAK Catia-Enovia PLM Displacement in 6 Months
 - Entire US Army 12 Mths - Additive Manufacturing with PLM SaaS, IoT Backbone
- 3. Step by Step Implementation**
 - Move at Your Pace / Not Big Bang
- 4. An Innovative Partner with a Vision**
 - Top Right Quadrant Leader across the Digital Landscape
 - ALM / PLM / CAD / IoT / SLM / AR
 - DoD Lead Innovator

FA&D MAJOR BUSINESSES

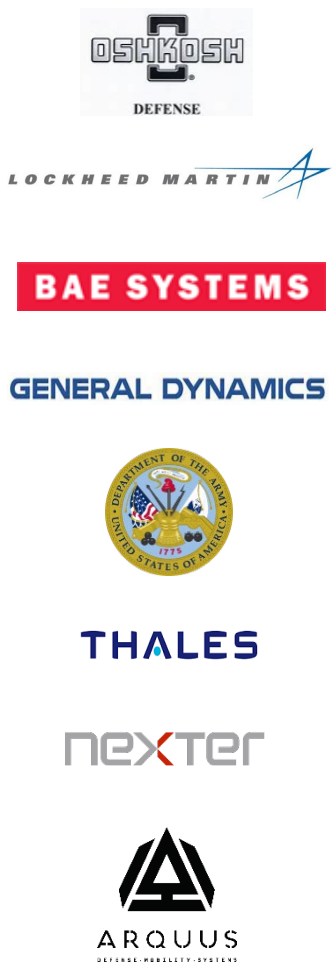
DEFENSE



SPACE AND MISSILE



GROUND VEHICLE



NAVAL SYSTEMS



AVIATION/MRO



VTOL/ E-VTOL



THE STARTING POINT: PTC OVERALL VALUE PROP



- Applies to : Products, Systems, Programs, equipment, facilities
- Enables full extended enterprise + Partners & Supply chain collaboration environment
- Promotes architecture openness and enables real data powered AR experience
- Is SaaS enabled

PLM FOR A FULLY INTEGRATED CONNECTED DIGITAL THREAD

PLM



Role & Task Based Applications



Navigate / Digital Twin / Digital Manufacturing / Service Optimization / Sales and Marketing, /Engineering Excellence

Marketplace
(Partner/OEM)

Platform

Extend PLM: Contextualize / Synthesize / Orchestration / Engage

Powered by:

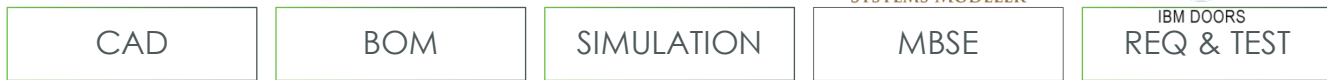
Strategic Enterprise Systems



(Lifecycle Management including CAD-Data, BOM, Change), System and Software

MES / SCM / ERP / MRO / CRM / DEVICE CLOUD

Source Data

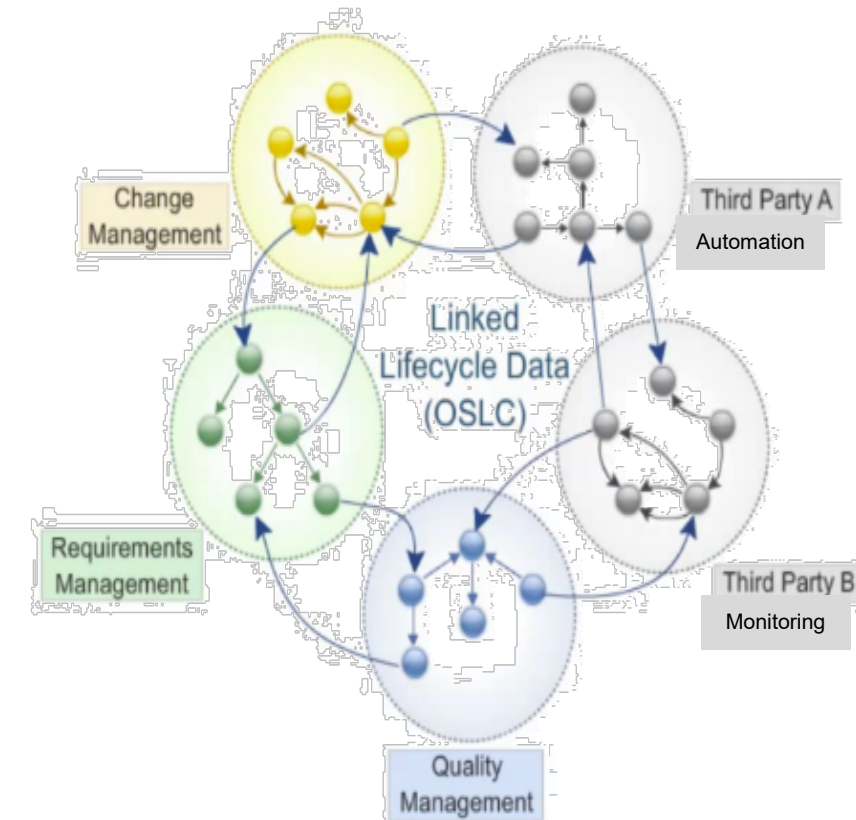


UPGRADABLE / SCALABLE / WEB BASED / CLOUD / ON-PREMISES

DIGITAL THREAD WITH COLLABORATIVE SYSTEMS

Open Services for Lifecycle Collaboration (OSLC)

- Standards-based
 - Based on OSLC standard, extended for PTC solutions to deliver greater customer value
 - RESTful Web Services architecture
- Designed for maintainability
 - Source application owns both data and UX
 - Data change events inform participating systems
 - No data transformations, replication or synchronization
- Open / extensible
 - Recommends use cases for cross-vendor interoperability
 - Supports N:N relationships – ideal for selective data sharing across supply chain



Source: http://open-services.net/uploads/resources/intro_to_OSLC_and_linked_data.ppt

AEROSPACE & DEFENSE



DEFENSE EXPENDITURE OF NATO MEMBERS WAS 1.23 BILLION DOLLARS IN 2023



MACRO TRENDS

Regional threats driving military spend around the globe

Increased demand for modern weapon systems & ammunition

Large-scale projects: Next gen fighters in EU-Japan / Shipbuilding in AUS/KOR / Ground vehicles Eastern Programs

Increased need for **mission readiness optimization**

SOLUTIONS

Complex programs collaboration:

- WC – TWX – Codebeamer: Collaborative working Environment
- Codebeamer : SW/HW integration and digital thread for MBSE

Manufacturing optimization:

- WC / MES integration
- TWC / MES integration: DPM – CWC – AMU
- Creo – WC – TWX: Digital Thread for Advanced Manufacturing

Mission readiness:

- WC: in service configuration management – MRO system integration
- Servigistics inventory optimization
- TWX : Connected maintenance – Digital work instructions
- TWX analytics: Condition Based maintenance
- Vuforia: AR based starting guide – Instruct - VEC



COMPLEX PROGRAMS COLLABORATION

OPEN ARCHITECTURE COLLABORATION PLATFORM TO:

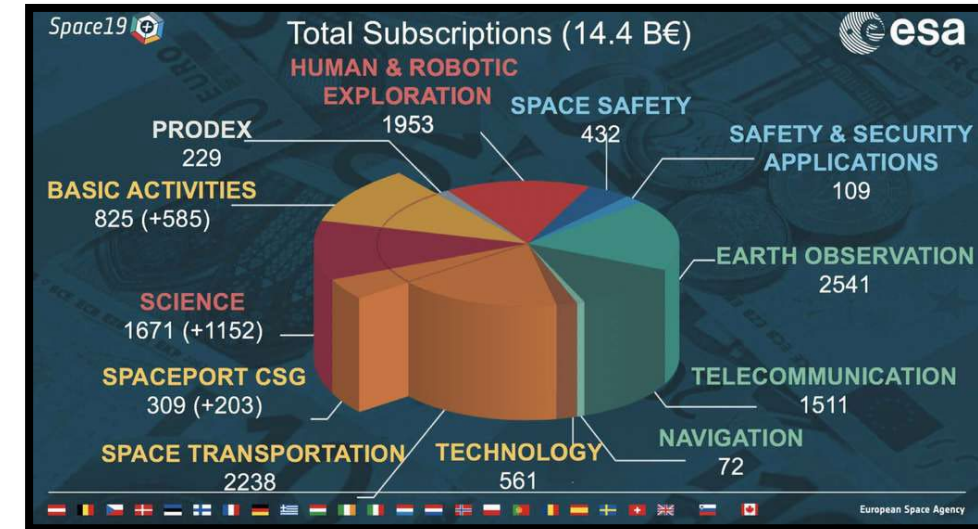
- Interact on multi-CAD, multi ALM, multi modelling, and multi-PLM environment
- Protect each partner IP.
- Offer a digitized MBSE approach accross companies internationally
- Digitize and automatize processes
 - from beginning (acquisition and requirements management) to final delivery
 - Change management accross organizations
 - Digital design sharing
 - Centralized configuration management

COMPLEX PROGRAMS – EMEAI EXAMPLES

€ 50-80B

€ 50-80B

€ 15B



FCAS

TEMPEST

ESA Programs



THALES

BAE SYSTEMS



MBDA

LEONARDO



THALES

Space Rider

Galileo

Callisto

Copernicus

THALES



SECURE COLLABORATION FRAMEWORK FOR COMPLEX PROGRAM MANAGEMENT INVOLVING PARTNERS AND SUPPLIERS

- MBSE at the core of the strategy
 - From document centric approach to digital models (products and systems)
 - System modelling: Design, Engineering, Manufacturing, Support, Analysis
 - Requirements management: Hardware and Software
 - Configuration management:
 - Impact of requirements changes
 - Simulation Process and Data Management
- Extended Enterprise project management dimension
 - Program management decision processes
 - Processes Workflow management: approvals, signatures etc.
 - Change control
 - Risk Sharing management
 - Problem reporting
- Technical data sharing
 - the right **Data**, to the right **People** at the right **Time**
 - **Accurate** data, **Anywhere**, **Anytime**, to anyone **Authorized** to access it



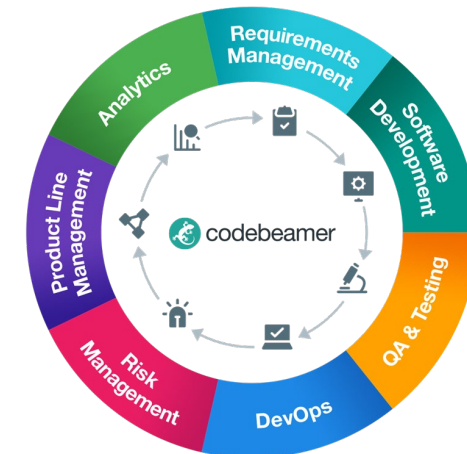
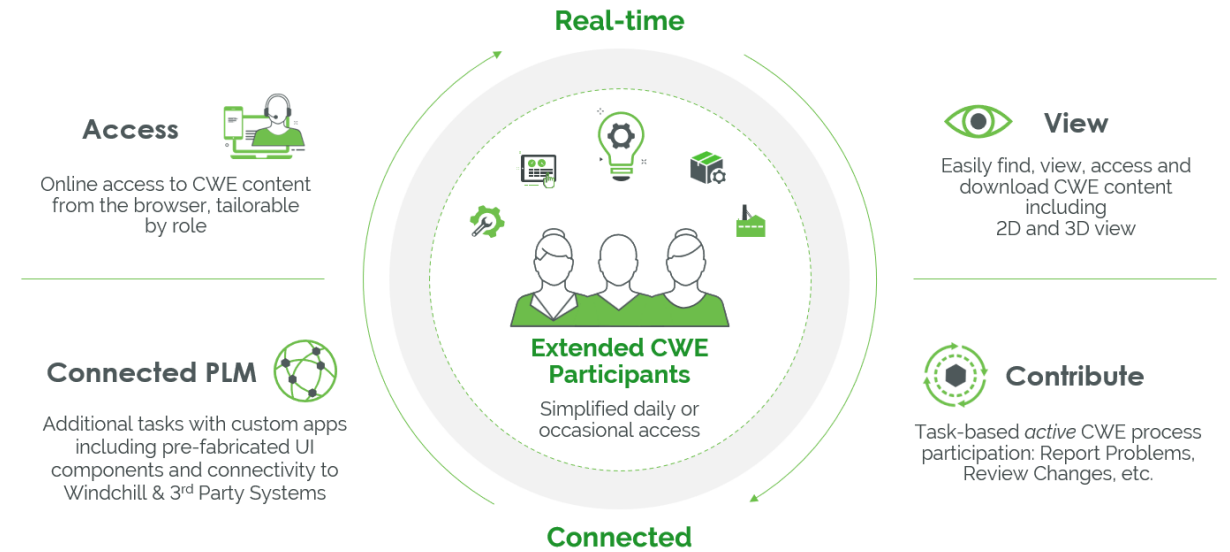
CORE FEATURES

- Open architecture
 - Capability to integrate third party applications
 - Multi CAD, Multi PLM approach
 - Flexible to react on new emerging Digital Transformation Technologies

- An integration platform
 - Harmonized processes
 - Unified user interfaces
 - Standard based data exchange
 - Scalable

- A core PLM engine
 - As the Authoritative Source of Truth
 - Real time access to relevant participants and decision makers throughout the system lifecycle
 - Collaboration with tight security model/access control

- ALM dimension becomes key across all program E2E
 - Software part is growing and becoming critical in the systems capabilities
 - Software need be managed from design to operation and maintenance
 - Collaboration between software and hardware development is key





BAE Systems plc is a British multinational arms, security, and aerospace company based in London, England. It is the largest defense contractor in Europe.

BAE SYSTEMS

BAE SYSTEMS

The Solution

Due to a UK Ministry of Defense mandated industry consolidation, BAE merged with VT Shipbuilding (formerly Vosper Thornycroft) in 2007. PTC platforms were the chosen PLM platform used to attain program efficiencies.

Capabilities include: Shared data environment, visualization of 3rd Party CAD systems and program management for the Queen Elizabeth Class (QEC) Aircraft Carrier Alliance and Type 26 Global Combat Ship. Systems integration with greater emphasis on through life reliability and support.

The Impact

- Enables groups of engineers to work simultaneously on design and verification of the same assemblies.
- Shared data environment, established real-time collaborative team for BAE and 9 industrial partners. Cross functional/partner collaboration, dramatically reducing cost of stage-gate transitions.



SECURE COLLABORATION

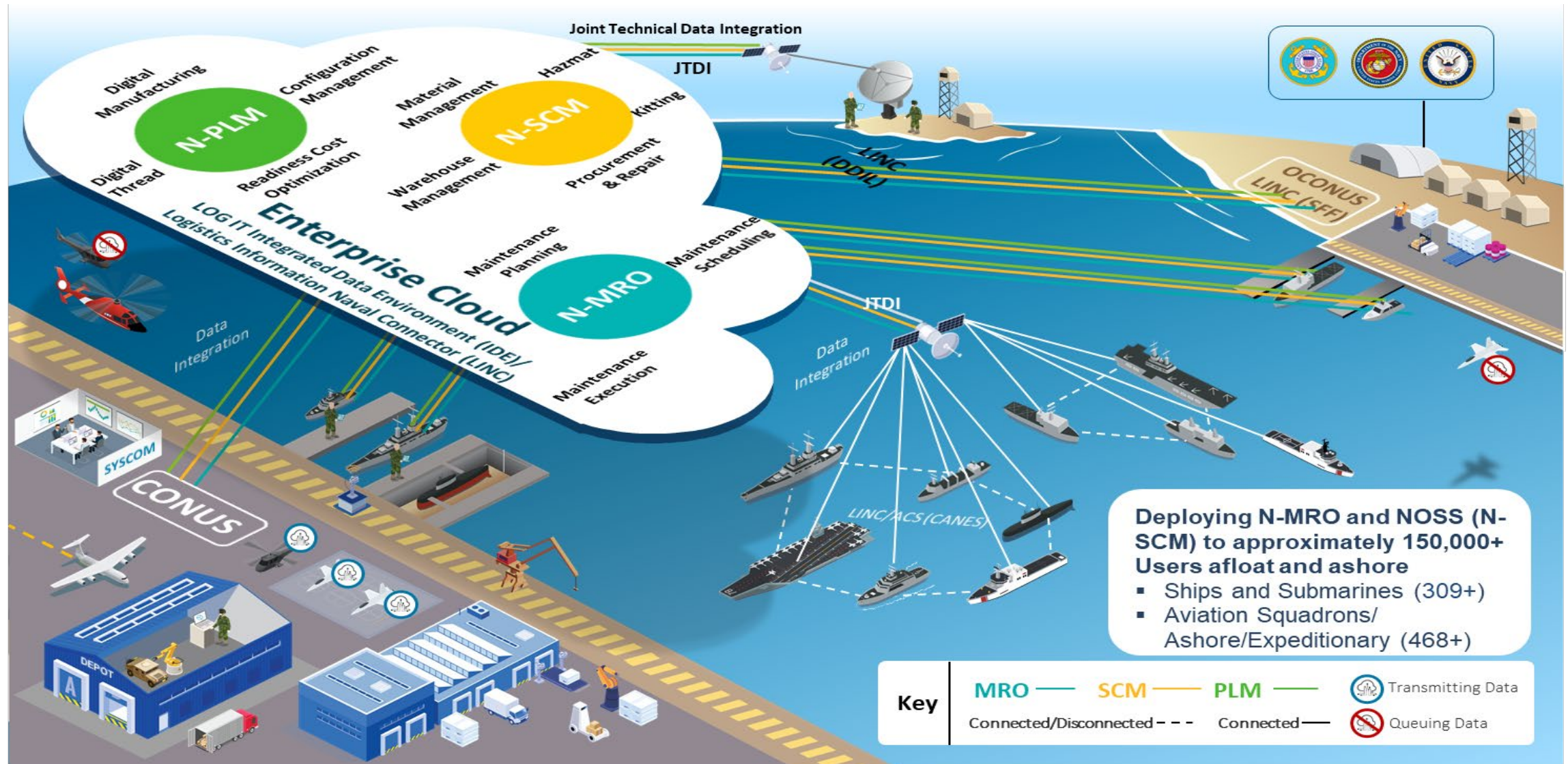
The United States Navy selected Windchill SaaS to enhance collaboration with internal stakeholders and external suppliers.



Certifications



MODEL BASED PRODUCT SUPPORT : US NAVY - LOG IT



US NAVY - MBPS UX

PART TASKS COLLECTION

View Design Files

View Drawing

View & Measure in 3D

View Part Properties

View Parts List

View Part Structure

Search and view Ship/Hull configuration data (i.e. DDG-1000)

DOCUMENT TASKS COLLECTION

View Document

View Document Structure

Search and View Technical Manuals and Engineering Drawings

Access MBPS Information, capabilities, training and Help

CUSTOM TASKS COLLECTION

About

FAQ

View External Links

Contract Technical Package Creator

Training

NPDM

NDART Library



MANUFACTURING OPTIMIZATION

DIGITAL THREAD ASSEMBLY WORK INSTRUCTIONS



- Advanced manufacturing
- Process Planner
- Plant & Tool designer



- Front-line worker
- Operator



- Production Supervisor
- Continuous Improvement

Author (PLM)

Process and work instruction master data, under PLM change control

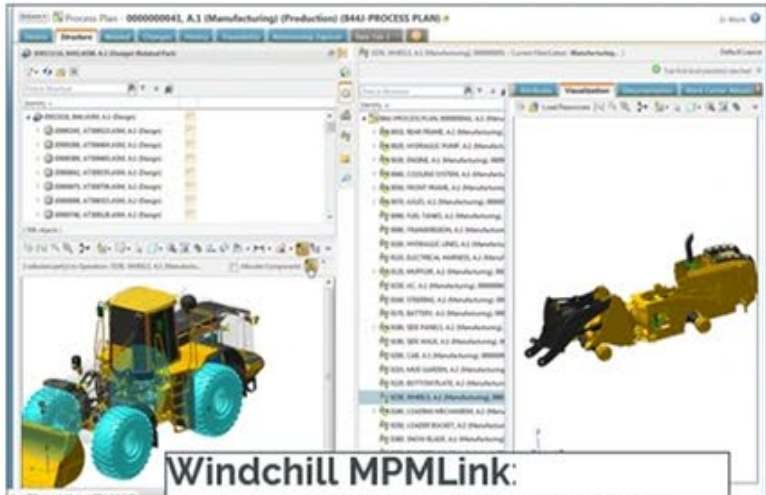
Execute (IoT+AR)

work instructions for every order, collect data and ensure quality/compliance

Improve (IoT)

review performance to identify labor losses, and improvement opportunities

Closed-loop change process



Windchill MPMLink:

- Associative eBOM/mBOM
- 3D Process planning
- Resources, tools, skills
- Work Instructions
- PLM change & config



ThingWorx CWC & Vuforia Studio

- Text, 2D, 3D, Videos, AR
- Step-by-step guidance
- Time & quality data collection
- Capture losses
- Ensure compliance



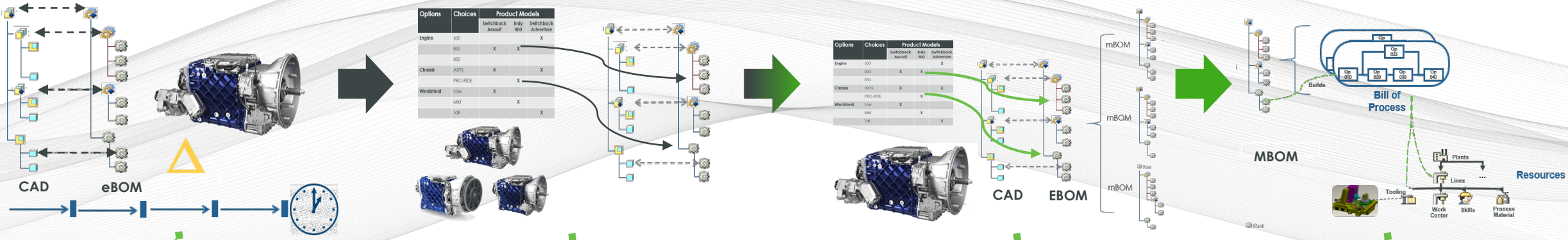
ThingWorx DPM

- Production losses
- Time loss waterfall
- Labor analytics

DESIGN ENGINEERING > MANUFACTURING ENGINEERING

PLM Engineering BOM
Configuration Management
Platform / Family Management

PLM Manufacturing BOM
Digital Process Planning
Change Management



- Manage and link CAD/BOM/visualization for a modular EBOM structure

- Plan product families, manage options and generate variants for multi-year product structures.

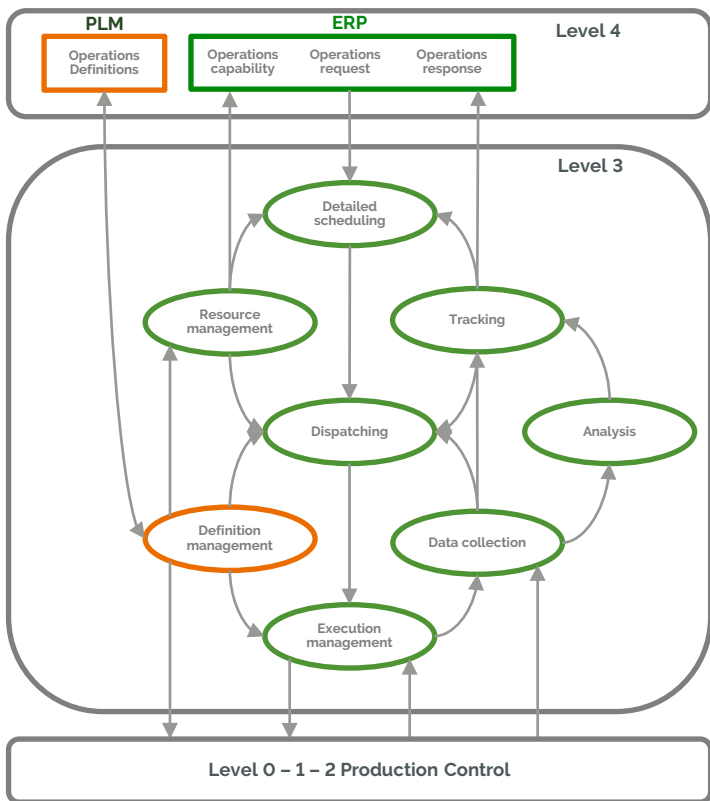
- Associatively transform EBOM to MBOM with options and logic

- Concurrently develop mixed-model assembly process plans, AR for visualizing process plans

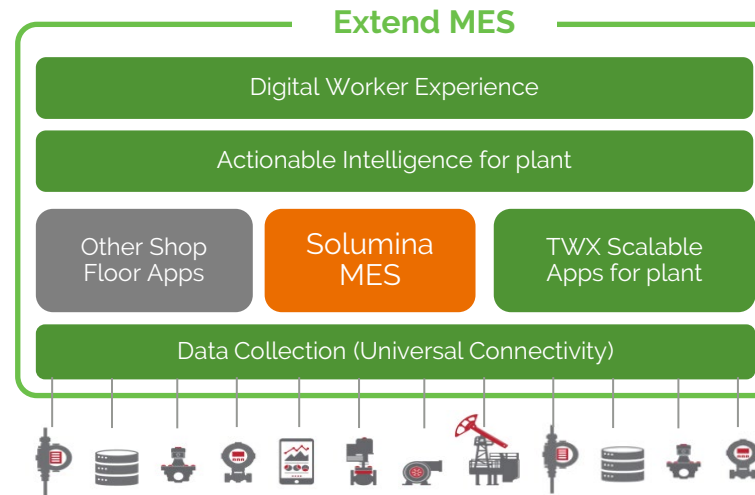
CONNECT CUSTOMERS MES TO THE ENTERPRISE DIGITAL THREAD

- Extend its functionalities with Thingworx
- Enhance digital worker experience
- Automate data collection
- Provide actionable intelligence from shop floor to top floor
- Trigger and track change request process from engineering to manufacturing and from manufacturing to engineering
- Connect the PLM as the authoritative source of truth

POSITIONING WITH IBASET SOLUMINA IN MANUFACTURING



ISA 95



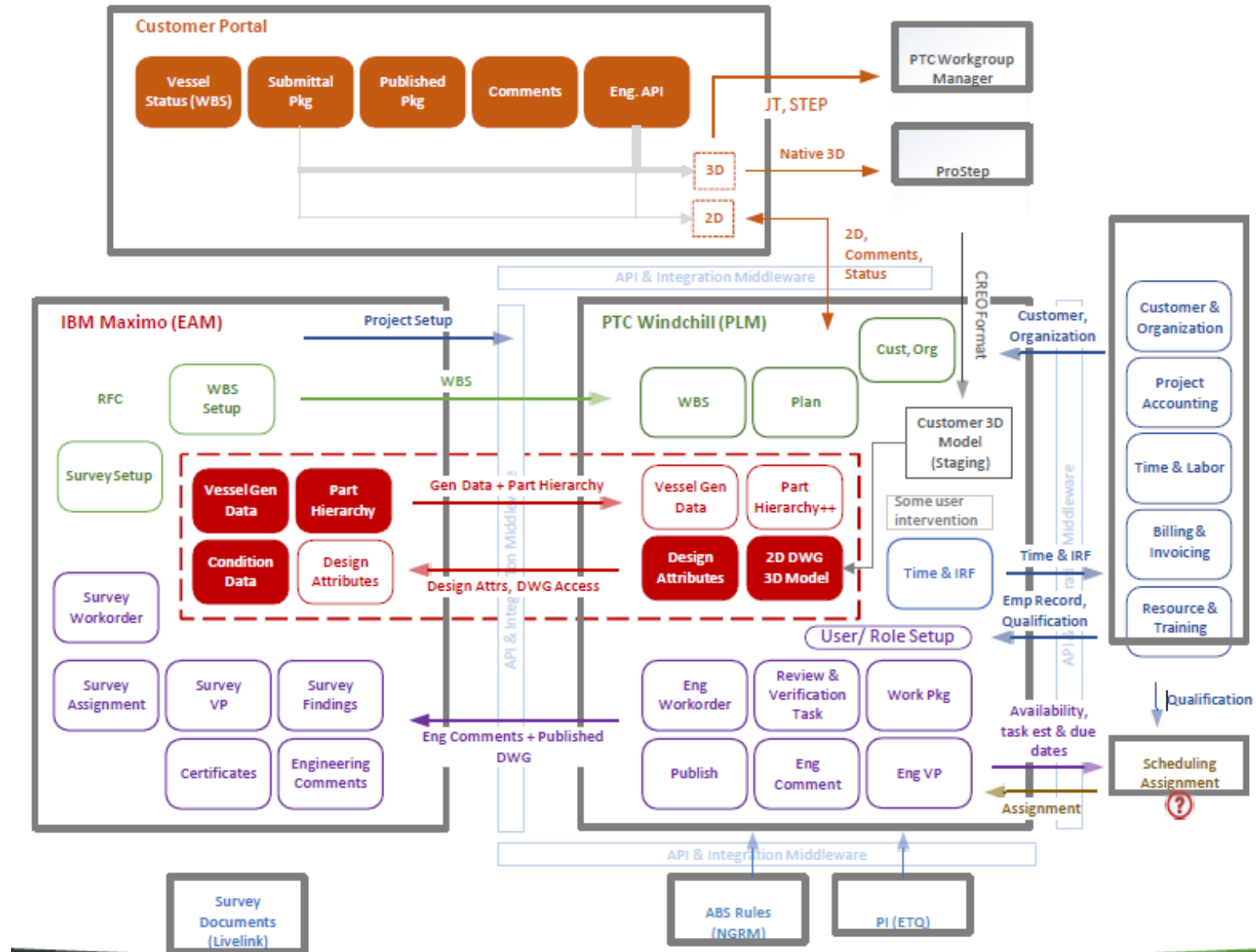
- automated data collection
- augment MES with simplified and unified UI
- actionable intelligence from shop floor to top floor
- detailed scheduling and planning
- work order dispatching & execution & tracking
- quality inspection

MOM Functions*

- **Analysis & Analytics** - Predictive Quality & Maintenance, Energy Analysis & Optimization, Real Time Dashboarding
- **Digital Workforce Productivity** - Connected Work Cell, Digital & Augmented Work Instructions, Digital Shift Handover
- Business Process **Orchestration**


*list depends on Complexity Features required, non-exhaustive list

AMERICAN BUREAU OF SHIPPING



BAE SYSTEMS Naval ships UK

- The plan is to digitize and make available all information required for manufacturing operations, using a common platform (Thingworx).
- Capabilities include: Digitization of 2D drawings, cable parts, operation sequence etc. Generation of work instructions from Windchill 3D visualization, Foran CAD, AVEVA ERP through Thingworx as common platform.
- A Ship liaison organization takes back concessions and generates Change requests in Windchill when needed
- Future capabilities will include: Augmented Reality, DPM, link back to Engineering.
- Same solution considered at BAE Australia and Canada



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BAE SYSTEMS

SAFRAN

SAE MADAM PROJECT & OTHER SAFRAN ENTITIES (SHE, SAB)

BUSINESS EXPECTATION

Due to the cost of some Raw Material (Titanium metal), Safran Aircraft Engine was looking for a solution to gather the automate process data capture in order to get optimal performance and quality avoiding non-compliance and Improving the First past yield.

SOLUTION

By deploying ThingWorx + Kepware for all CN Machines to gather and to retrieve customer production Flow, Safran was able to answer to this new business and choose Thingworx as their enterprise MCS (Manufacturing Control System) solution

IMPACT

Deployed at multiple sites across SAE (5 to 15) for all Machines, ThingWorx has been chosen to Safran AB, HE.


- TRS/TRG first MVP live after weeks.
- Production Line Cockpit MVP live after 3 weeks





ELEMENTS OF THE SMART FACTORY SUMMARY


Smart Factories

✓ Automated machine health, maintenance, and quality reports 

✓ Automated alerts and Predictive Alerts 

✓ Automated maintenance recommendations and appropriate corrective action 

✓ Repository/Warehouse for Maintenance and Quality Data 

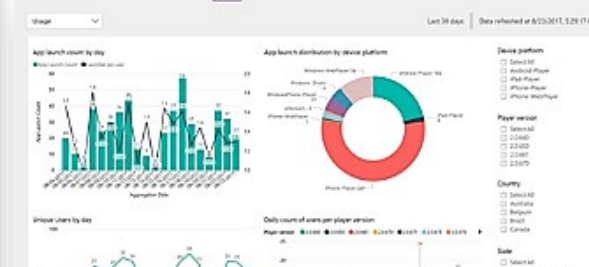
✓ Recommendations for optimized operations and maintenance schedules 



Real-time Visibility Driving Operational Efficiencies Within the Factory



Real-time Visibility



Advanced Analytics



Advanced Automation



MISSION READINESS

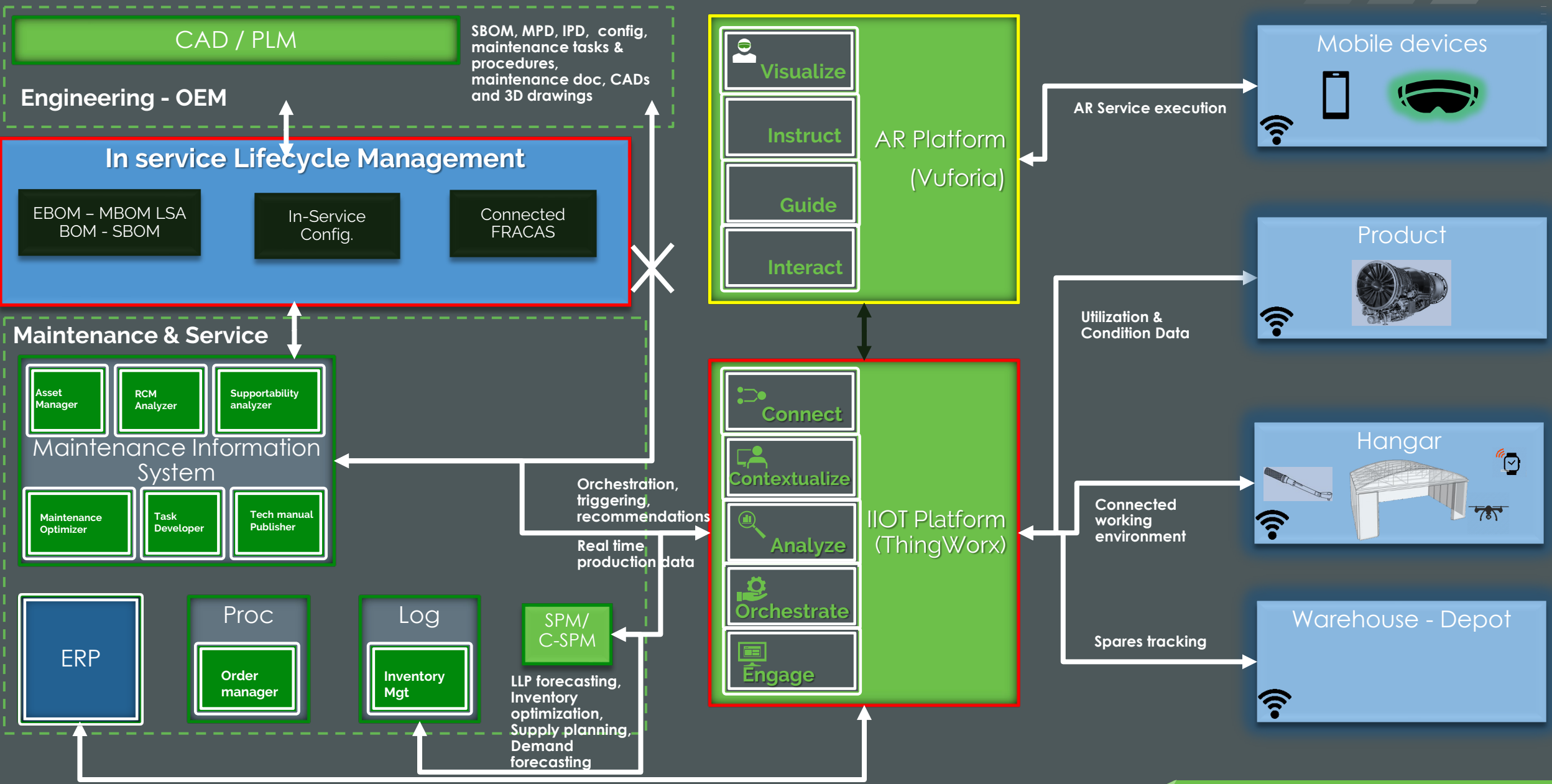
DIGITIZE SERVICE EXECUTION PROCESSES & CAPABILITIES WITHIN A UNIFIED IT/OT ECOSYSTEM.

- Achieve best in-service support combining real life products and engineering data
- Reduce redundant information
- Provide better orchestration of operations, better analysis
- Provide true readiness optimization and condition-based maintenance
- An in-service PLM platform monitors serialized configuration and all the corresponding required information
- An IoT based integration layer allows the MRO system, central piece of in-service support to interact with the PLM platform and the other systems

DIGITAL CLOSED LOOP WORKFLOW

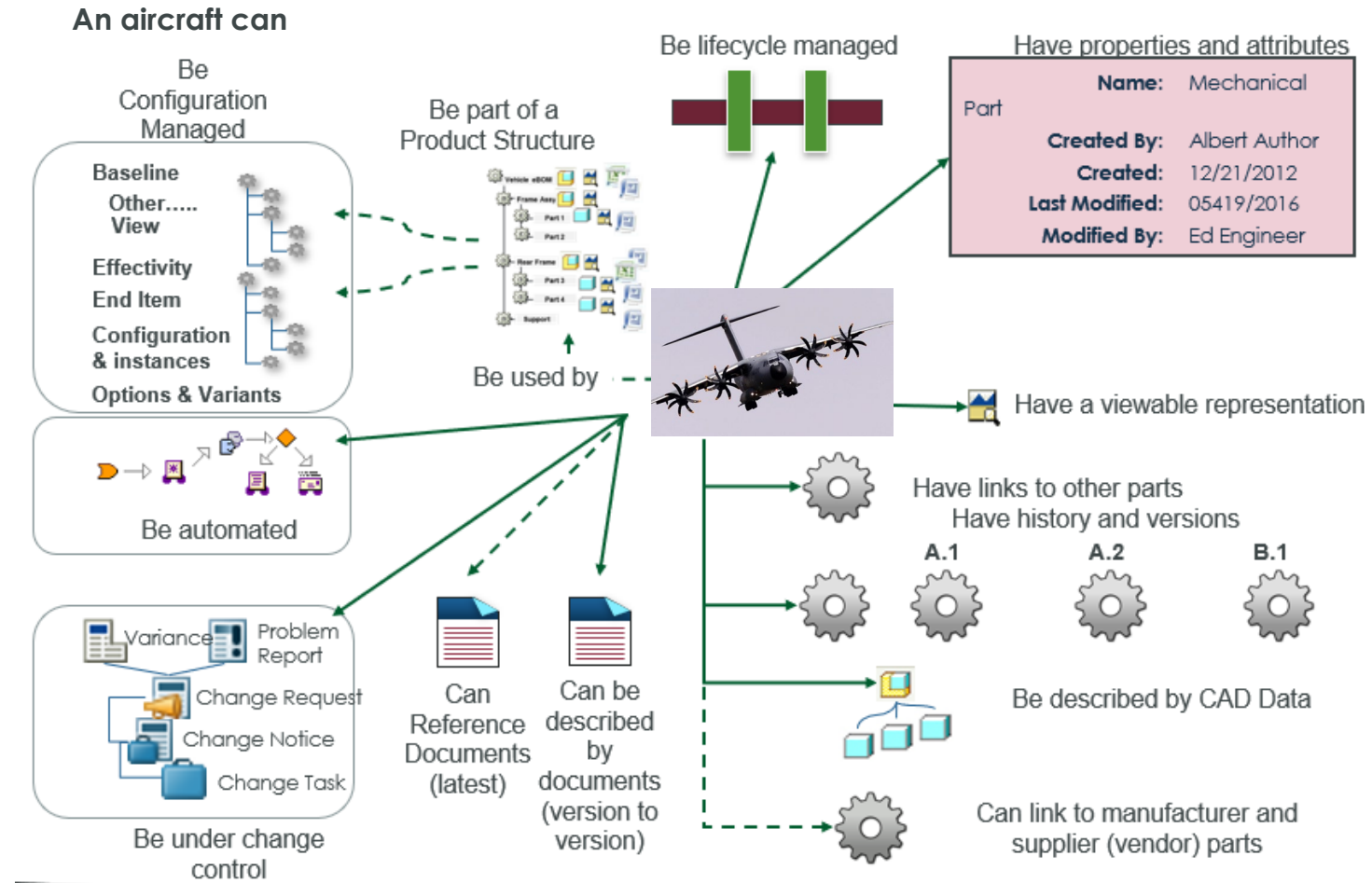


BUILDING BLOCKS



CAPABILITIES

- In service configuration management
- Supported by Visualization
- Under Changed Control
- Configuration Managed
- Described by Documents
- Multi View Support (Functional, Engineering, Manufacturing, Service)



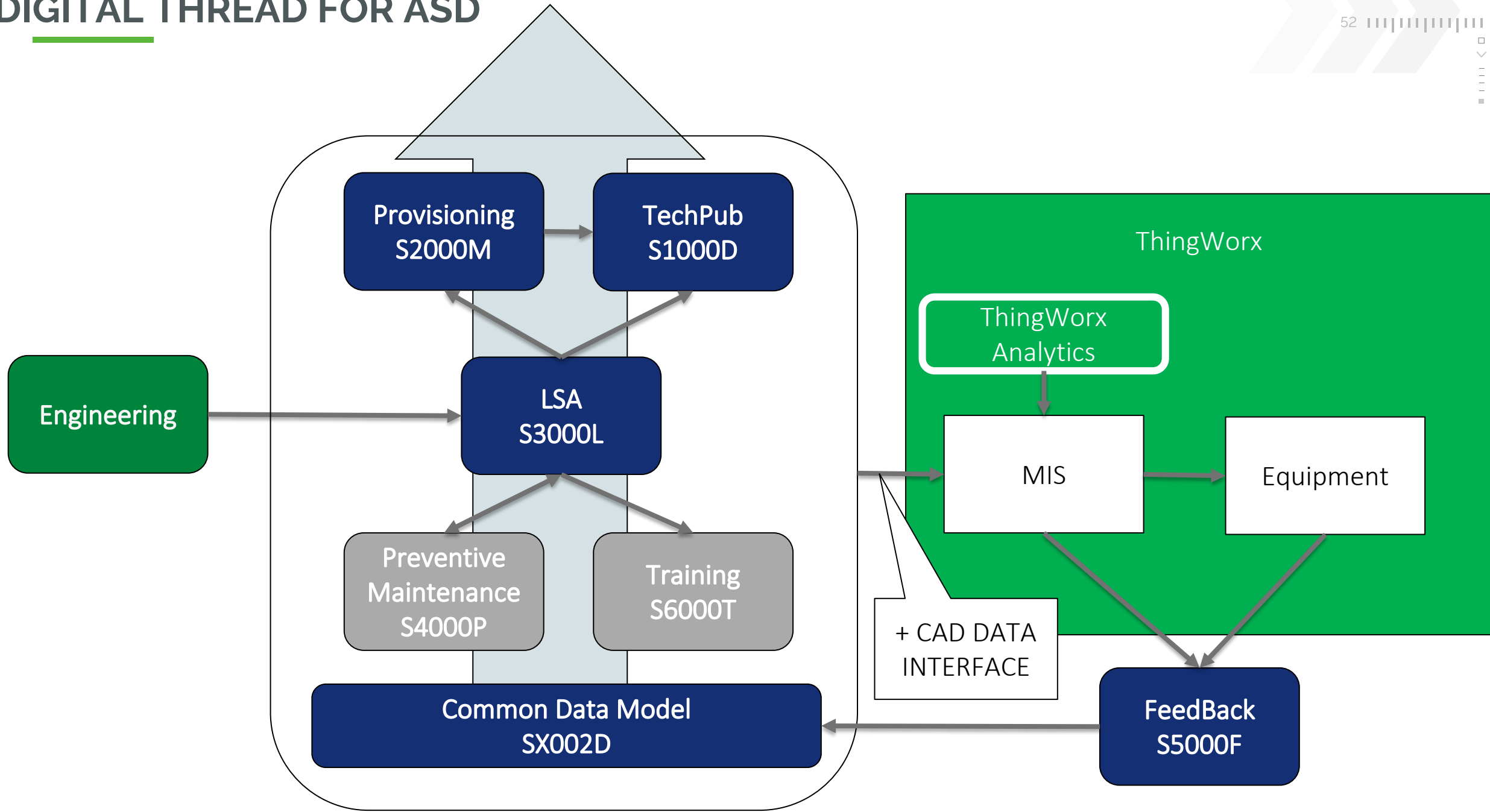
BENEFITS

Authoritative Source of Truth

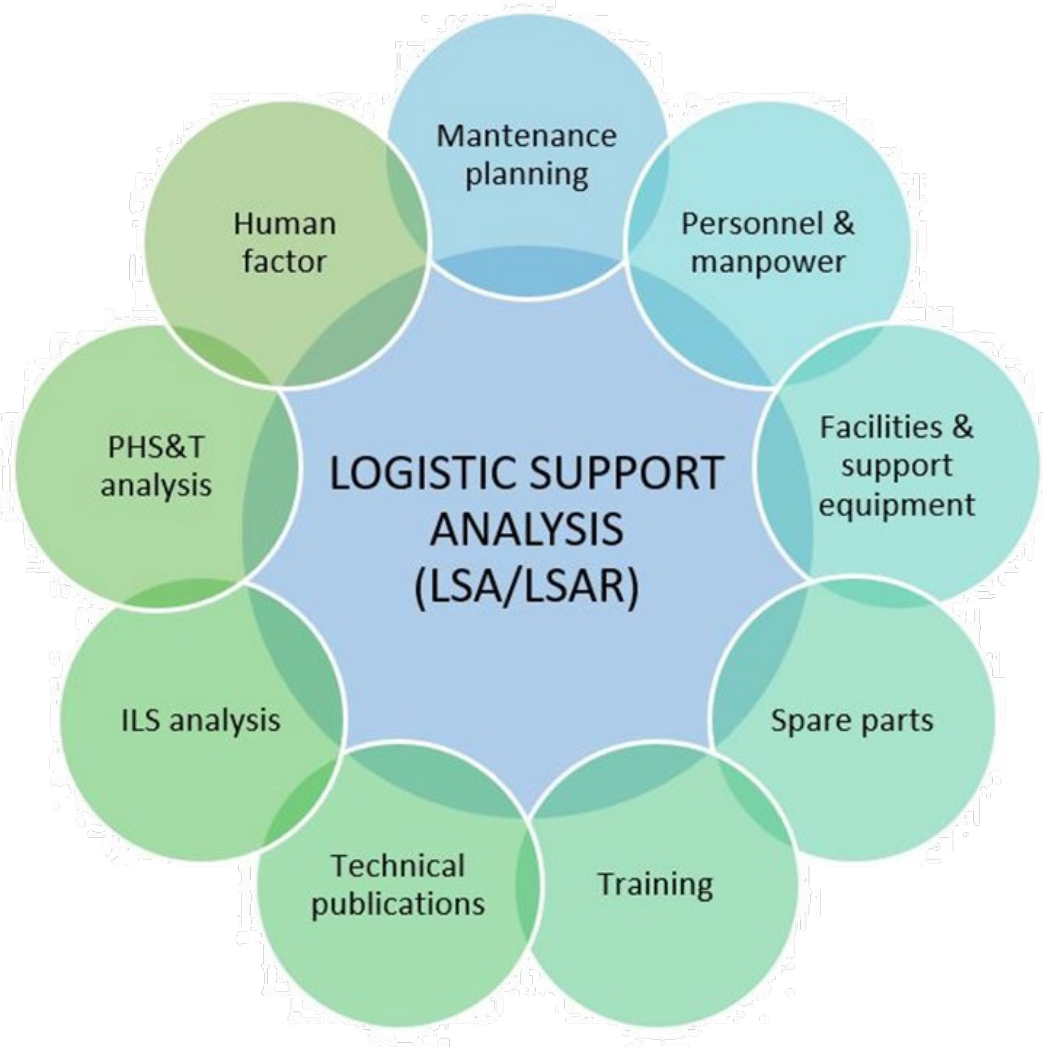
Make it easy for enterprise users to gather and use this information

Deliver enterprise coordination, access & visibility

Complete and accurate Aircraft definition

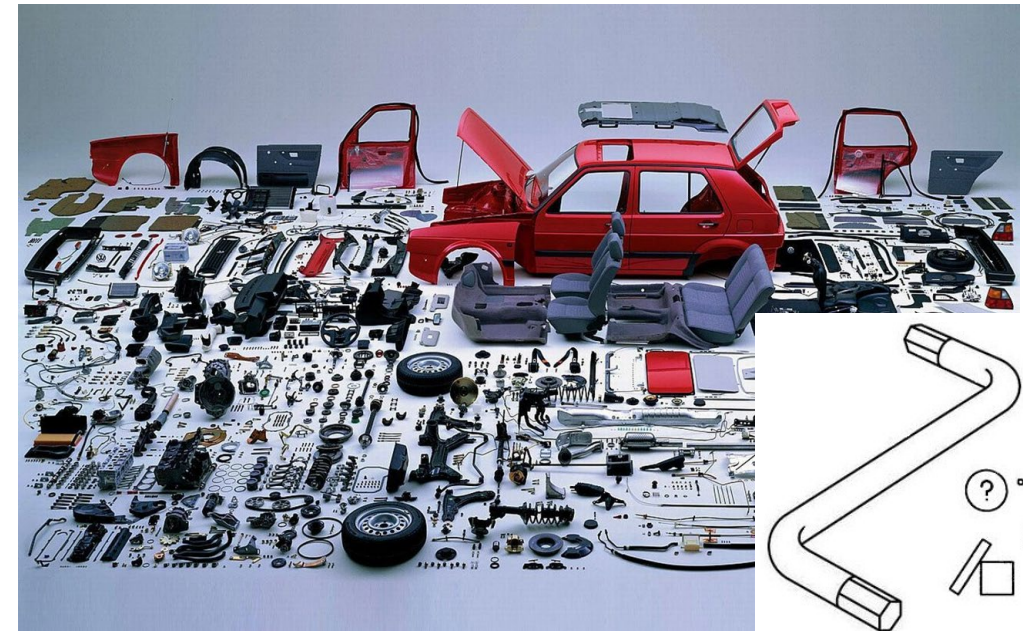


WHAT IS LSA ?

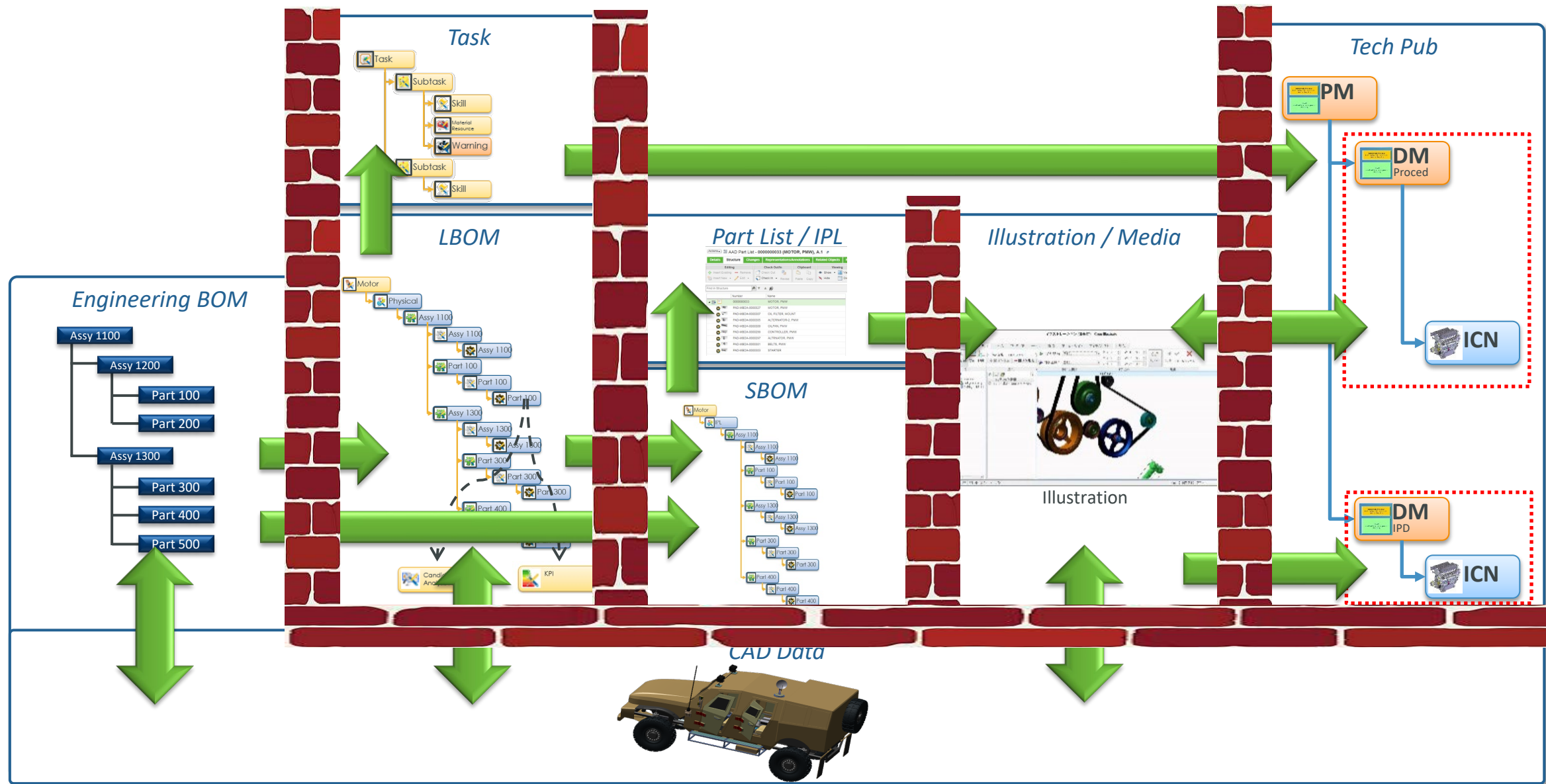


• LSA : Logistic Support Analysis

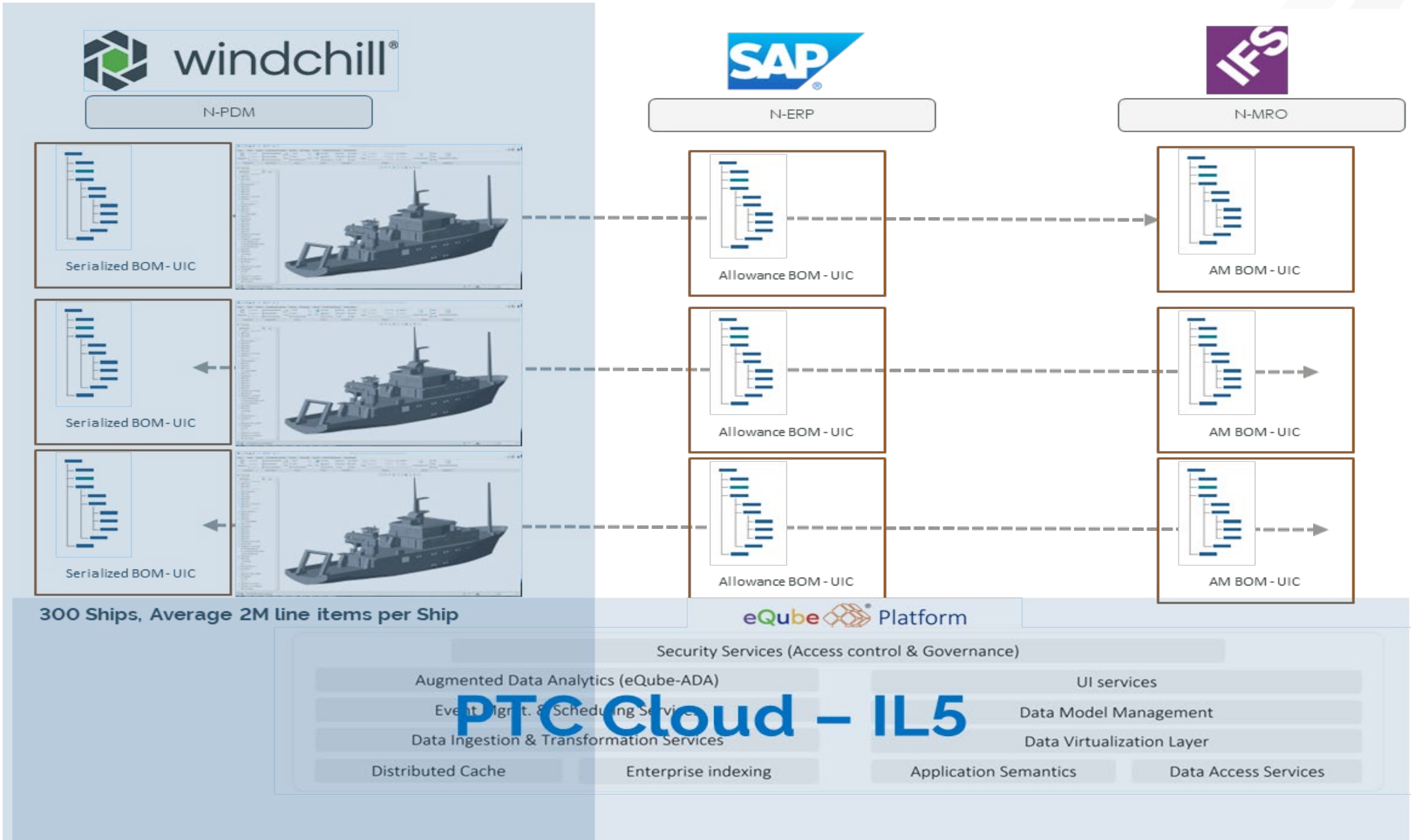
- LSA organizes, drives and records the process of the support engineering also called Integrated Logistic Support (ILS)
- This is an iterative activity, done thru the whole product lifecycle, from the conception to the disposal of a system, system of system or product.
- It is a structured approach to increase efficiency of maintenance and reduce the cost of providing support by replanning all aspects.



END TO END SOLUTION



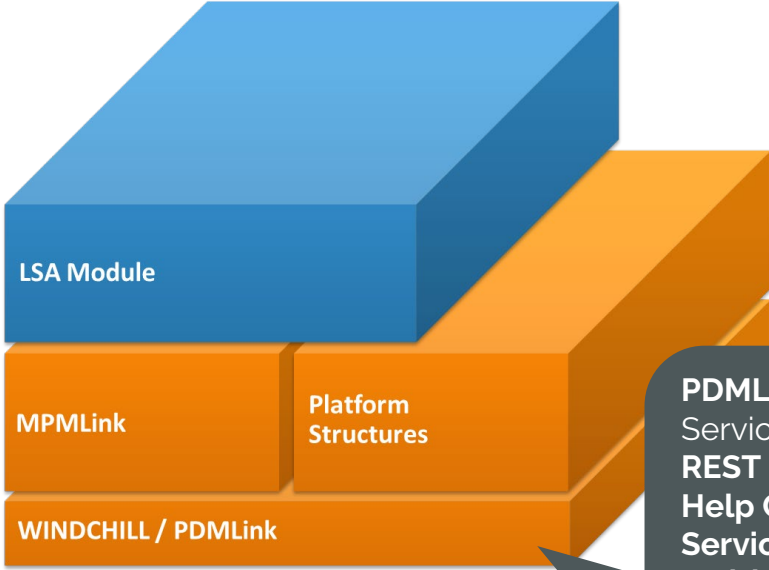
US NAVY – WINDCHILL IFS & SAP INTEGRATION



PTC Cloud - IL5

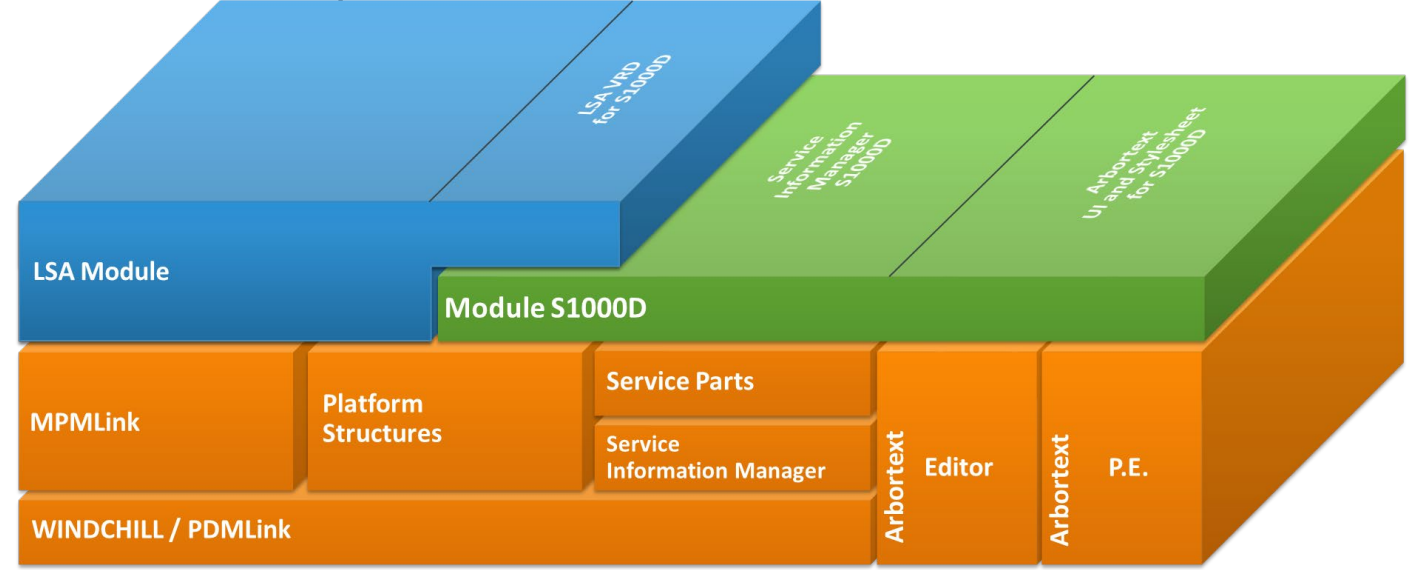
ARCHITECTURE DETAILS

Architecture 1: LSA Module without S1000D Integration
Without digital continuity with Tech Pub



PDMLink Services
REST Services
Help Center
Service Pack
Multi-language Pack
Info*engine
Common Base

Architecture 2: LSA Module and S1000D Authoring / Publishing
Includes authoring & publishing and digital continuity with Tech Pub



PTC TRANSFORMS TECHNICAL INFORMATION

PTC's end-to-end, dynamic publishing solution streamlines how organizations create, manage, and deliver technical publications.

A "Digital Thread" of dynamic data ensures end-to-end consistency.

Create reusable content components maintained in a database.

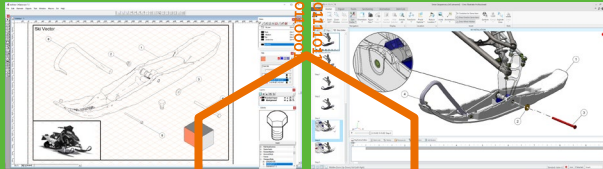
Automatically publish up-to-date content across multiple audiences and formats.

Arbortext Styler / Layout Developer
Layout configuration

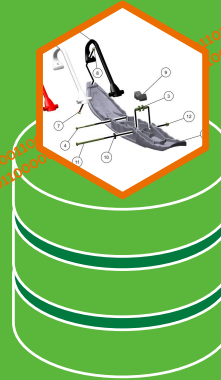
Create

Manage

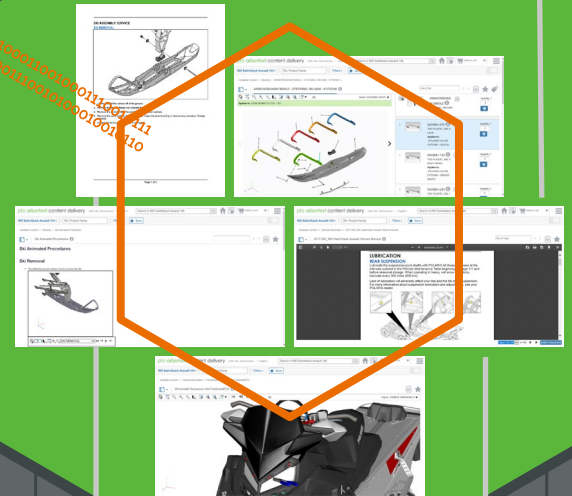
Deliver



- Content Management
- Make/Model/SN Range
- Product-based Organization
- Options and Variants
- Document Structures
- Translation Management



BOM Transformation
eBOM-sBOM-Parts List



Arbortext IsoDraw
Vector Drawing Tool

Arbortext Editor & Styler
Structured Authoring (XML) and Stylesheets

Creo Illustrate
3D Illustration Tool

Windchill Base
Doc Management

Windchill Advanced Service Parts Information & Instructions
Context-Based Content Management

Windchill Premium Service Parts Information & Instructions
Service Parts Catalog

Arbortext Publishing Engine
Published Documents

Vuforia Studio/View
Augmented Reality Delivery

Arbortext Content Delivery
Electronic Delivery

PTC WINDCHILL SERVICE INFORMATION MANAGER

CAPABILITIES

- Manage all the information necessary to service the product (DMRL)
- Apply set of applicability conditions to enable context specific information delivery
- Enforce project business rules by use of the BREX module
- Enables enterprise change management process
- Seamless integration with upstream source data

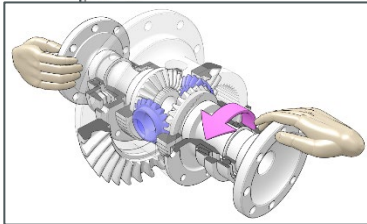
The screenshot shows the 'Information Element List' interface. On the left, a list of parts is displayed with columns for Name, Issue Number, and In Work. The selected part is 'DMC-STY401-A-00-00-00-00A-00HA-A'. On the right, a detailed view of the information element is shown, including fields for Extension, Attributes, and S1000 data. A callout box points to the 'Information / Publication Service Structures' section of the detailed view.

Information Element Management (DM, PM, ICN)

Information / Publication Service Structures

Item	Part Number	Description	Quantity
A	PL-48973	Removal Ring Filters	1
B	PP-78953	Pin Installation & Removal Tool	1
C	BE-48872	Piston Ring Expander	1
D	-	Hydraulic Press (for Bearings)	1

Note
When removed from the engine, all pistons, connecting rods and engine cylinder numbers were given matching marks. The disassembled pistons and connecting rods must be marked during assembly and installed in the same engine cylinder number. Do not interchange the parts or cylinder locations.
Keep all parts clean from contaminants. Contaminants may cause increased wear and shortened component life.



Filter on Applicability, Technical conditions

Lifecycle, version and workflow management



The 'Edit Filter' dialog box is shown, with tabs for Configuration Specification, Attribute Filter, Service Effectivity, and Option Filter. The 'Option Filter' tab is active, showing a list of options with checkboxes. Below the dialog, a table shows the results of the filter.

Name	Choices	Group	dmtype
S8123		DMC-STY401-A-00-00-00-00...	dmtype=checklist
airfield		DMC-STY401-A-00-00-00-00...	dmtype=crew
dmtype	dmtype=checklist, dmtype=crew, dmtype=description, dmtype=fault	DMC-STY401-A-00-00-00-00...	dmtype=description
inline		DMC-STY401-A-00-00-00-00...	dmtype=fault
		DMC-STY401-A-00-00-00-00...	dmtype=pidp

BENEFITS

Improved service information quality

Improved technician efficiency

Increase authoring productivity

Improve customer satisfaction

PTC WINDCHILL SERVICE PARTS

CAPABILITIES

- Define and manage Service Bill of Material (SBOM)
- Create 2D & 3D callout graphics for illustrated parts catalogs
- Automatically generate \$1000D IPD Data Modules from Service BOM
- Product configuration specific delivery of parts information
- Enable enterprise Change Management an understand engineering changes impact

Associative Service BOM Definition

2D Illustrated Parts Catalog Output

The screenshot displays the PTC Windchill software interface. At the top, it shows the product path: Products > m_sty401_20150902 > Part List. Below this is the 'AAD Part List - 000000400 (AAD Part List), A.2' with tabs for Details, Structure, Changes, Representations/Annotations, Related Objects, History, and Where Used. The main area is divided into several sections: Editing (Insert Existing, Remove, Insert New, Edit), Check Out/In (Check Out, Check In, Revise), Clipboard (Paste, Copy), Viewing (Views, Show/Hide, Display), Add To (Add to), Filter (Current Filter, Saved Filters), Related Objects (Add BOM, Illustration), Publish (Representation, Open in), and Tools. Below these are search and navigation icons. The central table lists parts with columns for Number, Name, Attributes, Visualization, Service Replacement Information, Service/Model Information, and Items. A 3D model of a landing gear assembly is shown in the bottom left, with callout numbers 1 through 20. A detailed table of items is visible in the bottom right, listing item numbers, sequence numbers, names, interchangeability, and attaching storage or shipping parts.

Item Number	Item Sequence Number	Name	Interchangeability	Attaching Storage or Shipping Part	Select
0	0A	Nut		1	f
1	0A	Screw		2	f
2	0A	Hub		2	f
1	0A	Drive Shaft		1	r
2	0A	Drive Shaft		2	r

The 2D Illustrated Parts Catalog Output shows a technical drawing of a landing gear assembly with numbered callouts (1-6) pointing to various components. Below the drawing is a table with the following columns: Fig, Item, Units per assembly/unit of issue, NCAGE, Part No., NATO Stock Number, Description, and *Usable on code asy MV/Effect. The table contains one row of data for the assembly.

Fig	Item	Units per assembly/unit of issue	NCAGE	Part No.	NATO Stock Number	Description	*Usable on code asy MV/Effect
0	1A	AR	KA296	123-45678	Description for Part	• MB	

3D Illustrated Parts Information Delivery

BENEFITS

Improve part identification

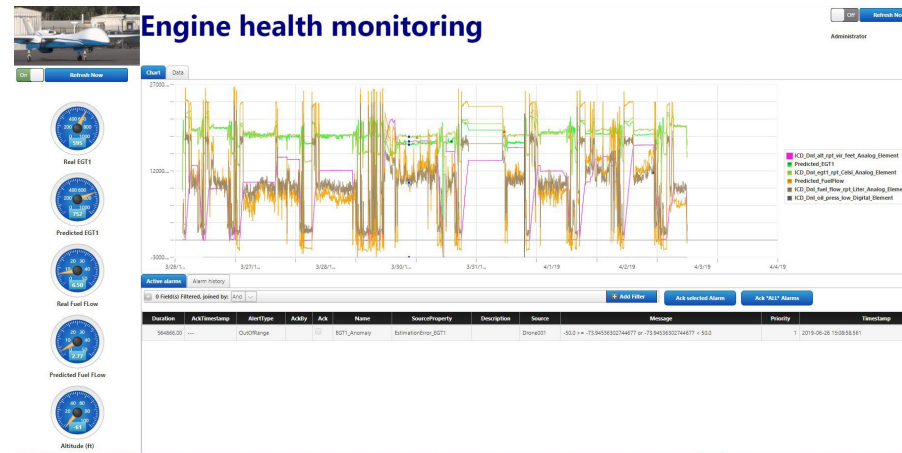
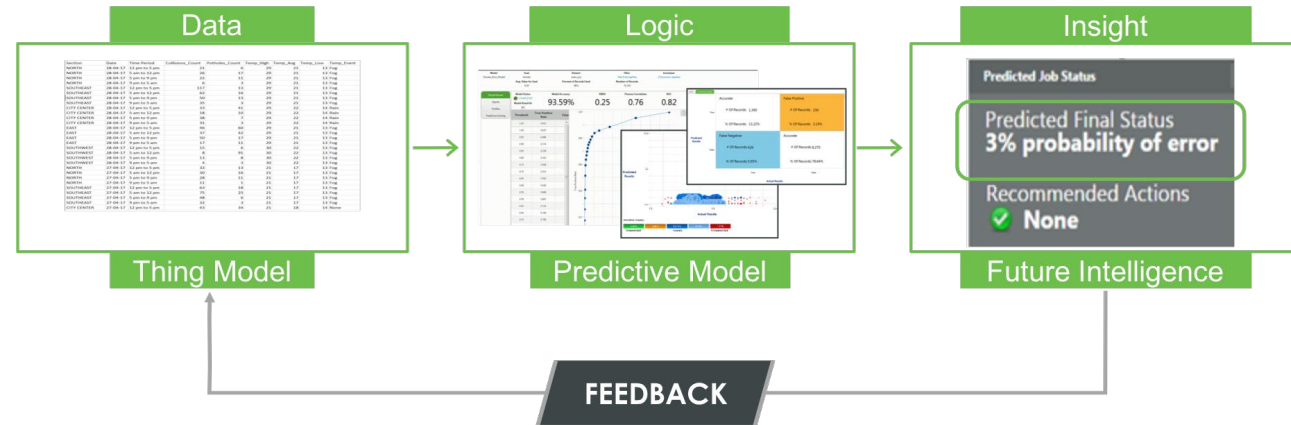
Improve part ordering accuracy

Improve service efficiency and costs

Increase service parts revenue

CAPABILITIES

- At-a-glance overview of asset health and performance trends
- Understand for how much longer your equipment is likely to perform
- Highlight contributing factors to get a data-driven view of the "why" behind a prediction
- Improve maintenance planning
- Integrate with 3rd party analytics and simulations



- Define and trigger analysis events
- Map incoming data to model, created with ThingWorx or externally
- Map analytic outputs to applications

BENEFITS



Increase asset utilization



Decrease Maintenance Events



Reduce planned & unplanned downtime

Complete and accurate definition

Assets health monitoring, fault and failure prediction

- Sensor data captured and gathered from equipment on board in various modes:
 - In-flight mission
 - Pre-flight mission readiness tests
 - Take-offs and landings
 - Etc..
- Data log files downloaded in the depot after mission and uploaded into ThingWorx-based CBM system
- Predictive models have been built in ThingWorx, based on analysis of:
 - 500 flight with 18 critical equipment failures



IAI Heron UAV

Objective: failure alerts/alarms 48-24 hours prior actual equipment failure





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THANK YOU

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