Capturing Product Behavioral and Contextual Characteristics through a Model-Based Feature Information Network (MFIN)

MBE Summit: April 2, 2019

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The Digital Manufacturing Institute

Capturing Product Behavioral and Contextual Characteristics through a Model-Based Feature Information Network (MFIN)

Project Background

Problem: Build Data is in various formats from various sources

Result: Inconsistencies And/or Incomplete Data Packages

- **Manual, Error-prone Processing**
- **Increased Production Costs**

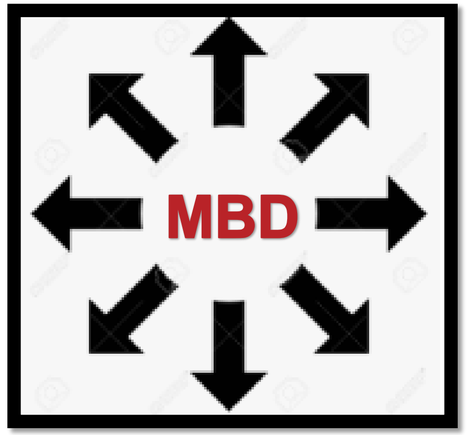
Project Background

Unintelligent Links Make Data Transfer Difficult To Communicate & Interpret Accurately

Result: Inconsistencies And/or Incomplete Data Packages

- **Manual, Error-prone Processing**
- **Increased Production Costs**

Project Goals



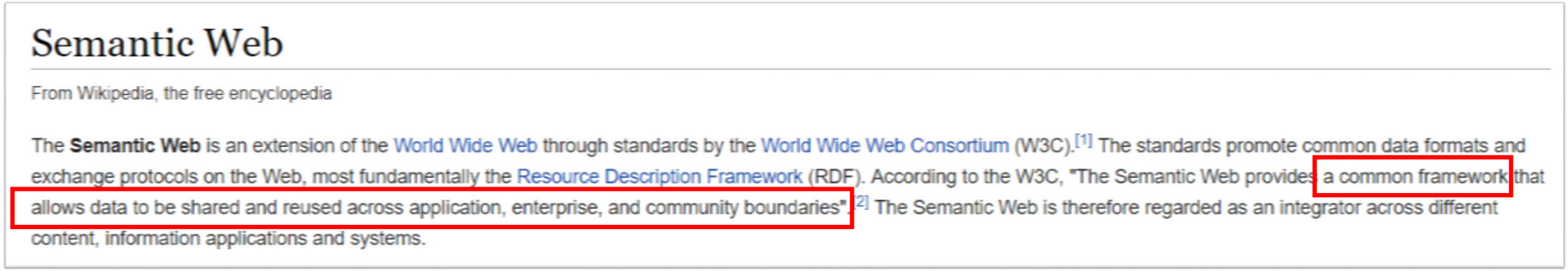
- Expand MBD beyond geometry & PMI
  - Include all aspects of data in the product's lifecycle
- Automate data retrieval
- Feature-level linkage between CAD model and related data
- Educate the workforce on the benefits of intelligent data
- Release developed technology/methodology via software tools

Project Benefits

- Single, digital source to locate connected data
  - Any required Information for activities available through the product lifecycle
- More efficient retrieval of necessary data
- Reduced Interpretation Error And Manufacturing Cycle Times
- Neutral framework to be implemented & customized by any software

How is this different than PLM?

- PLM is a process
- MFIN is a model-centric file with semantic organization of data
- Similar to Sematic Web Concept



Semantic Web

From Wikipedia, the free encyclopedia

The **Semantic Web** is an extension of the World Wide Web through standards by the World Wide Web Consortium (W3C).[1] The standards promote common data formats and exchange protocols on the Web, most fundamentally the Resource Description Framework (RDF). According to the W3C, "The Semantic Web provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries".[2] The Semantic Web is therefore regarded as an integrator across different content, information applications and systems.

How is this different than PDM?

- PDM is how you store the data
  - Data revisions, Security, Backup
- MFIN is information with semantic organization of data
- Yes – PDM systems *could* read MFIN data *if you set it up to*
  - New CAD revision = new MFIN file?

Architecture

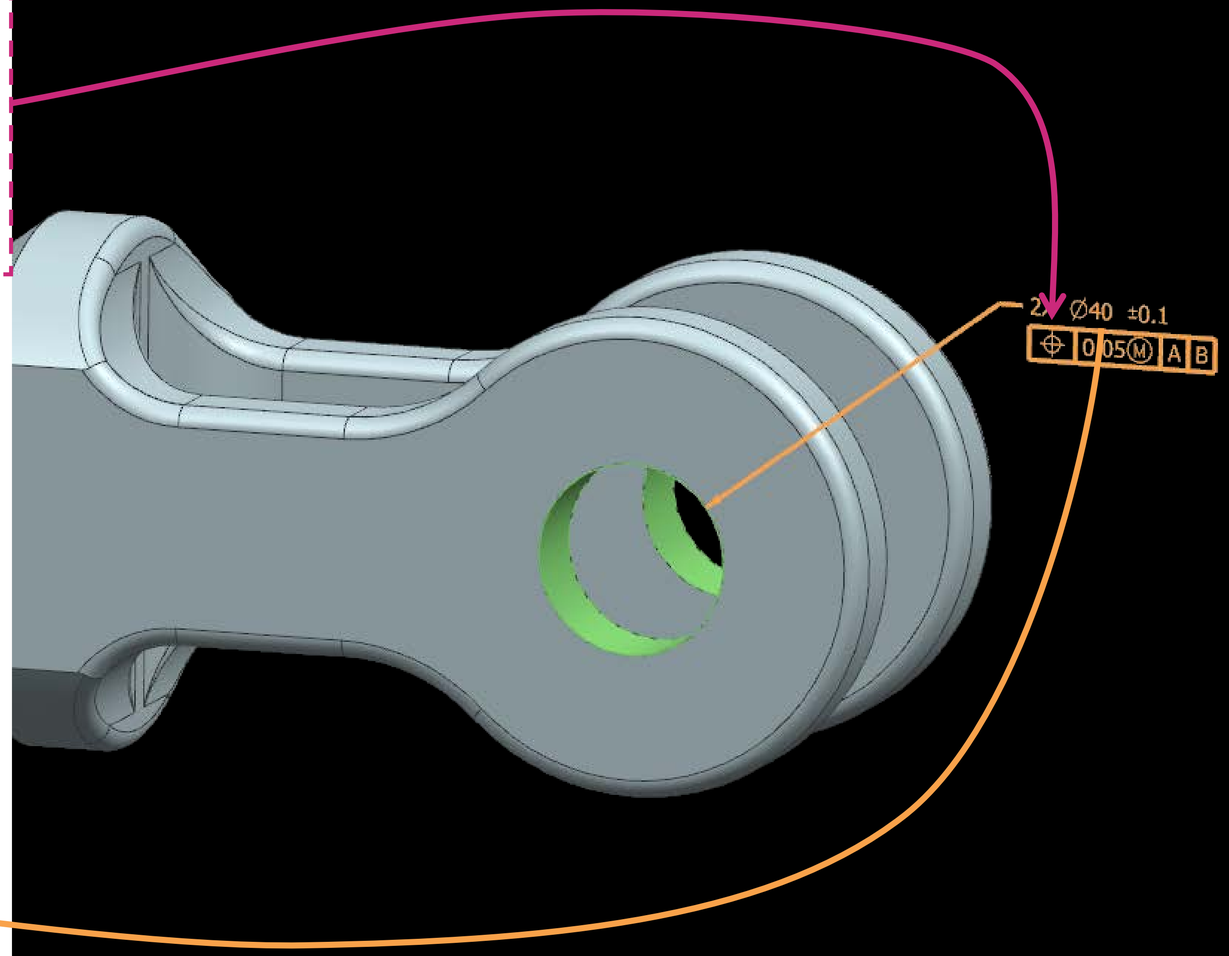
MFIN – QIF XML Schema

Model-Based Feature Information Network (MFIN)

- Based on ANSI 2.1 Standard for QIF
  - ANSI - American National Standards Institute
  - QIF - Quality Information Framework http://qifstandards.org/
    - XML - Extensible Markup Language
      - Lightweight
      - Human-readable and machine-readable
      - Free & open non-proprietary standard developed by World Wide Web consortium

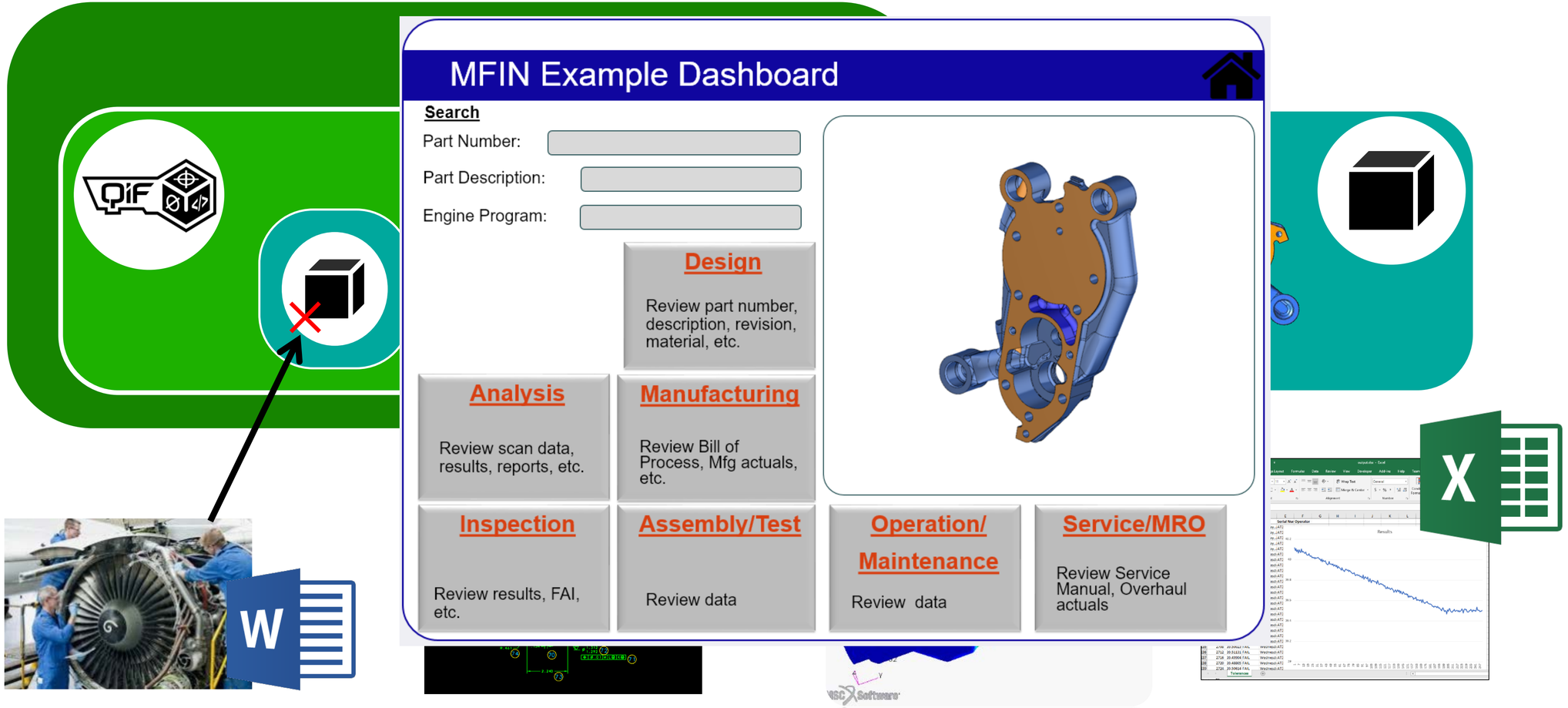
QIF MBD Example

```
<PositionCharacteristicNominal id="1720">
    <Attributes n="4">
    <CharacteristicDefinitionId>1719</CharacteristicDefinitionId>
    <FeatureNominalIds n="1">
      <Id>1696</Id>
    </FeatureNominalIds>
    <Name>Fastener Hole Position</Name>
    <KeyCharacteristic>
  </PositionCharacteristicNominal>

  <FeatureNominals n="4">
  <CylinderFeatureNominal id="1696">
    <Attributes n="2">
    <Name>Fastener Hole</Name>
    <FeatureDefinitionId>1697</FeatureDefinitionId>
    <EntityInternalIds n="4">
    <Axis>
      <AxisPoint>-70 120 0</AxisPoint>
      <Direction>1 0 0</Direction>
    </Axis>
    <Sweep>
  </CylinderFeatureNominal>

<FeatureDefinitions n="4">
  <CylinderFeatureDefinition id="1697">
    <InternalExternal>INTERNAL</InternalExternal>
    <Diameter>40</Diameter>
    <Length>90</Length>
    <Bottom>
  </CylinderFeatureDefinition>
</FeatureDefinitions>
```



MFIN Data Model

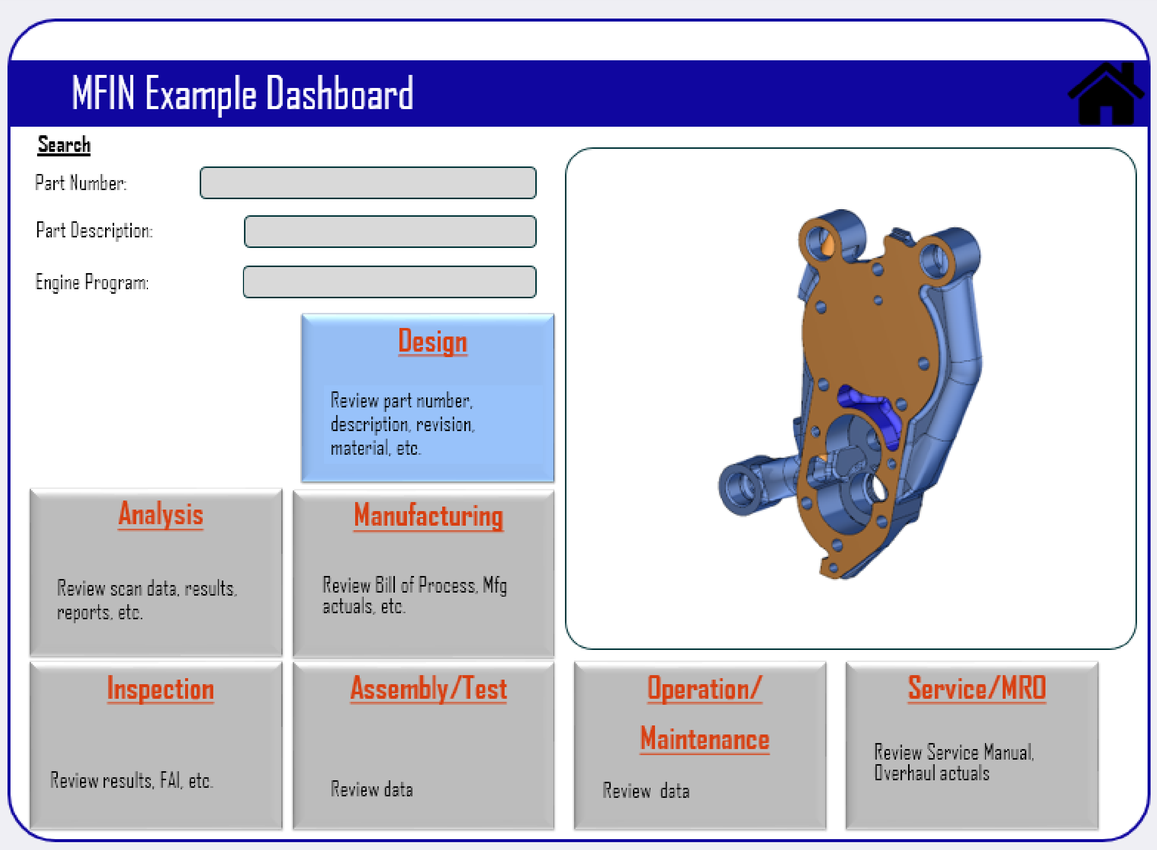
The “glue” that connects the data to the authority model



What does the MFIN look like?

- How can you access info in the MFIN?
  - API
  - Python
  - C#
  - C++

- Example GUI



MFIN GUI Concept

Home page

**This is a conceptual representation only of what an MFIN GUI might look like based on Rolls-Royce operation.*

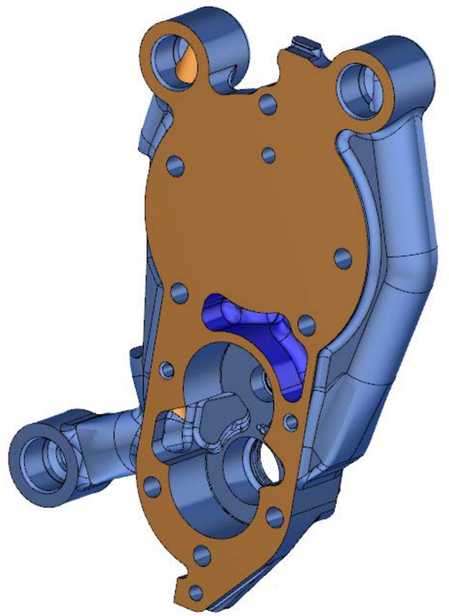
MFIN Example Dashboard

Search

Part Number:

Part Description:

Engine Program:



Design

Review part number, description, revision, material, etc.

Analysis

Review scan data, results, reports, etc.

Manufacturing

Review Bill of Process, Mfg actuals, etc.

Inspection

Review results, FAI, etc.

Assembly/Test

Review data

Operation/ Maintenance

Review data

Service/MRO

Review Service Manual, Overhaul actuals

MFIN GUI concept

Design Data –

Second level choices

**This is a conceptual representation only of what an MFIN GUI might look like based on Rolls-Royce operation.*

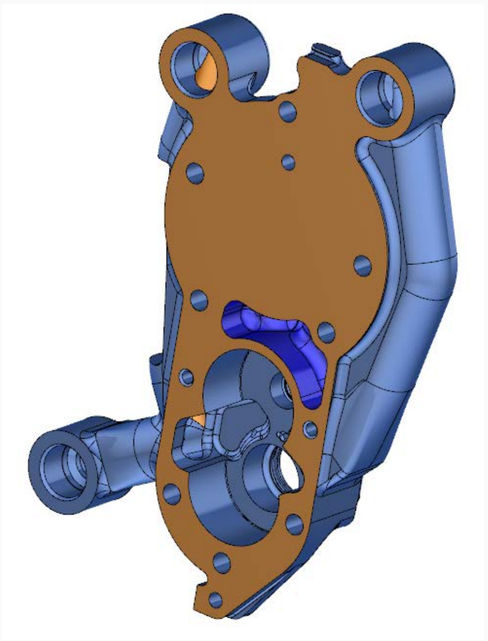
MFIN Dashboard – Design Data

- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

View engine status

View hardware dispositions

View inventory



MFIN GUI concept

Design Data –

Third Level information

**This is a conceptual representation only of what an MFIN GUI might look like based on Rolls-Royce operation.*

MFIN Dashboard – Design Data

Design

Analysis

Manufacture

Inspection

Assembly

Operation

Service

Engine Status

Filter **Plot**

Select	Eng S/N	Reason for removal	Removal date	In-bound Test	Pass-off MGT	…
✓	CAE130abc	Low power	01/02/2013	P792-R5		
	CAE130xyz	Low oil pressure	03/04/2015	Q3298-1		

Selection: **View Operation** **View Inspection**

MFIN GUI concept

Design Data –

Second level choices

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MFIN Dashboard – Design Data

- Design
- Analysis
- Manufacture
- Inspection
- Assembly
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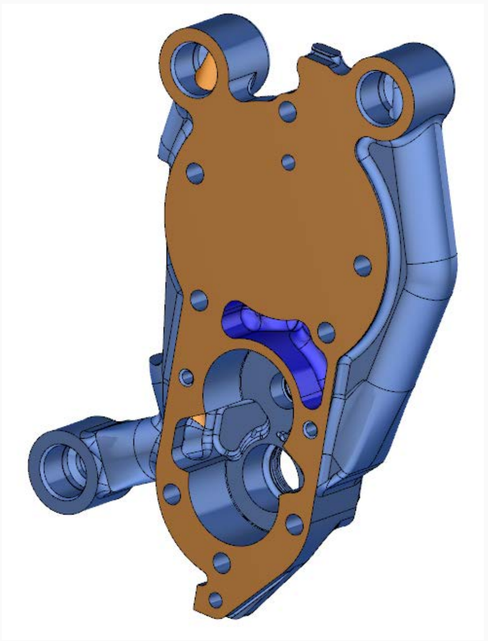
- Service

View engine status

View hardware dispositions

View inventory



MFIN GUI concept

Design Data –

Third level information

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MFIN Dashboard – Design Data

Design

Analysis

Manufacture

Inspection

Assembly

Operation

Service

View Inventory

Filter

Plot

Select	P/N	Qty	Serial #	Application	…
✓	230xxx	147	E734	AE1107C	
	231xxx	25	E735	AE1107D	

Selection: View Operation | View Inspection

MFIN GUI concept

Design Data –

Second level choices

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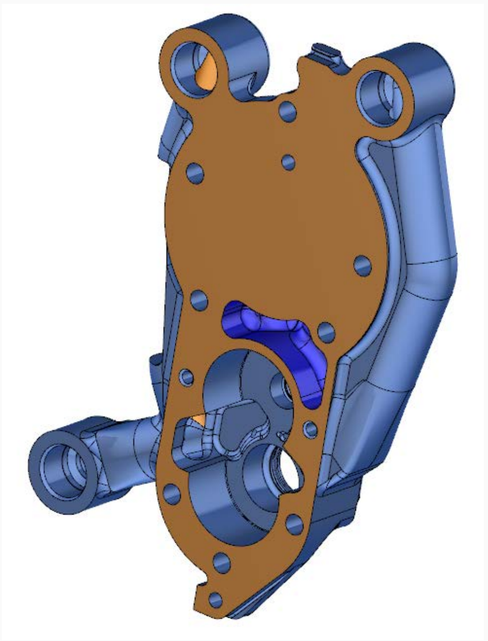
MFIN Dashboard – Design Data

- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

View engine status

View inventory

View hardware dispositions



MFIN GUI concept

Design Data –

Third Level Information

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MFIN Dashboard – Design Data

- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

View Hardware Dispositions

Filter **Plot**

Select	Eng S/N	Work request #	…				…
✓	CAE130abc	123456					
	CAE130xyz	999999					

Selection: **View Operation** **View Inspection**

MFIN GUI concept

Analysis Data –

Second level choices

**This is a conceptual representation only of what an MFIN GUI might look like based on Rolls-Royce operation.*

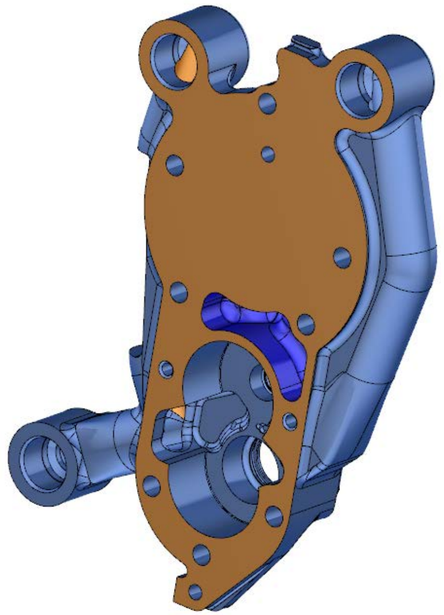
MFIN Dashboard – Analysis Data

- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

View Available Scans

Upload Scans

View Results



MFIN GUI concept

Manufacturing Data –

Second level choices

**This is a conceptual representation only of what an MFIN GUI might look like based on Rolls-Royce operation.*

MFIN Dashboard – Manufacturing Data

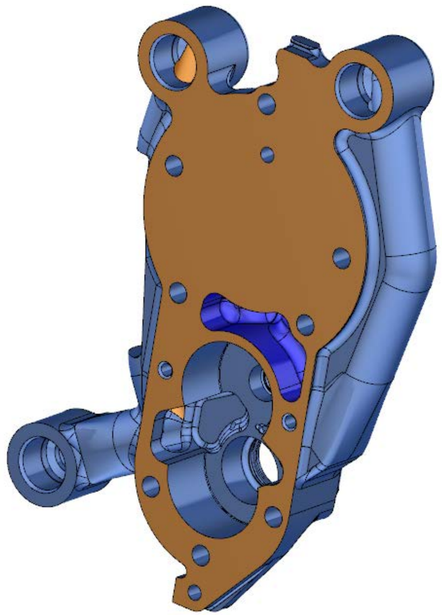
- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

Bill of Process

Manufacturing Actuals

Manufacturing Data

Manufacturing Data



MFIN GUI concept

Inspection Data –

Second level choices

**This is a conceptual representation only of what an MFIN GUI might look like based on Rolls-Royce operation.*

MFIN Dashboard – Inspection Data

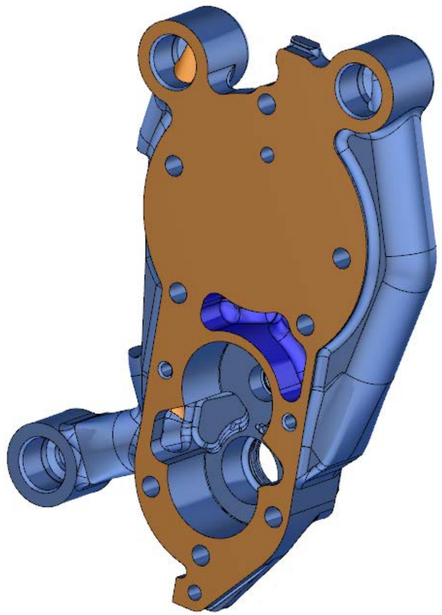
- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

Review Results

Review First Article Inspection

Inspection Data

Other Inspection Data



MFIN GUI concept

Assembly/Test Data –

Second level choices

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MFIN Dashboard – Assembly/Test Data

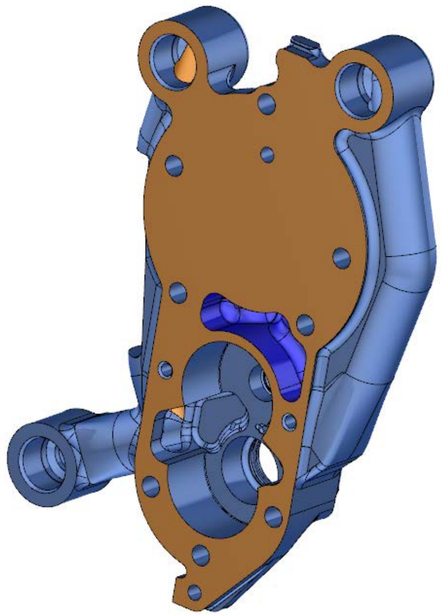
- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

Assembly Data 1

Assembly Data 2

Assembly Data 3

Assembly Data 4



MFIN GUI concept

Operation/

Maintenance Data –

Second level choices

**This is a conceptual representation only of what an MFIN GUI might look like based on Rolls-Royce operation.*

MFIN Dashboard – Operation/Maintenance Data

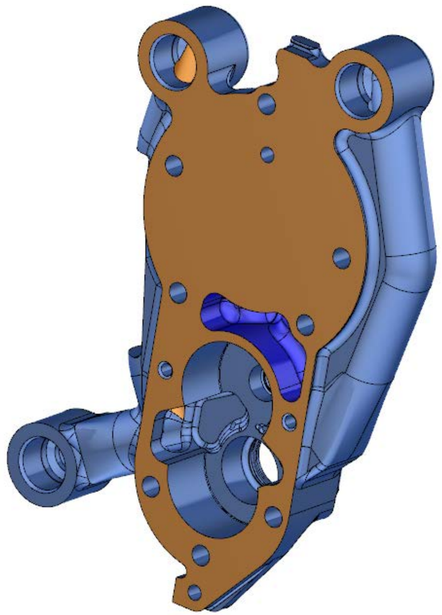
- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

Operation Data 1

Operation Data 2

Maintenance Data 1

Maintenance Data 2



MFIN GUI concept

Service/MRO data –

Second level choices

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MFIN Dashboard – Service/MRO Data

- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

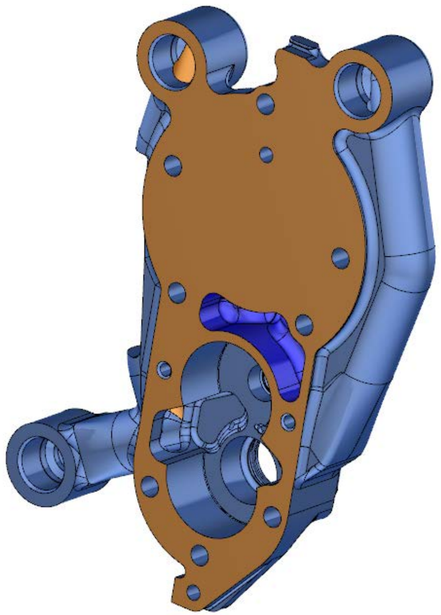
Engine Manual

Overhaul Actuals

Illustrated Parts Catalog

Engine Repair Process Manual

MRO Data Upload



MFIN GUI concept

Service/MRO data –

Third level choices

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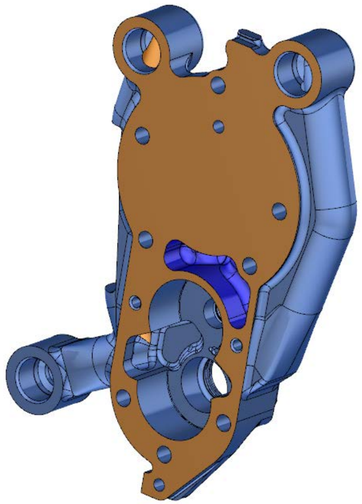
MFIN Dashboard – Service/MRO Data

- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

Engine Manual

Filter

Select	Eng S/N	Manual #	…				…
	CAE130abc	123456					
	CAE130xyz	999999					



MFIN GUI concept

Service/MRO data –

Second level choices

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MFIN Dashboard – Service/MRO Data

- Design
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- Service

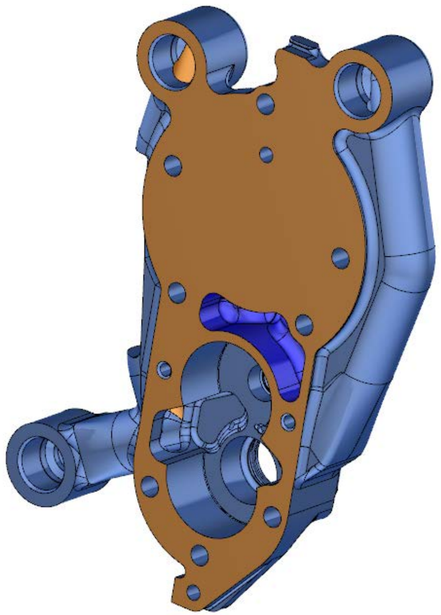
Engine Manual

Overhaul Actuals

Illustrated Parts Catalog

Engine Repair Process Manual

MRO Data Upload



MFIN GUI concept

Service/MRO data –

Second level choices

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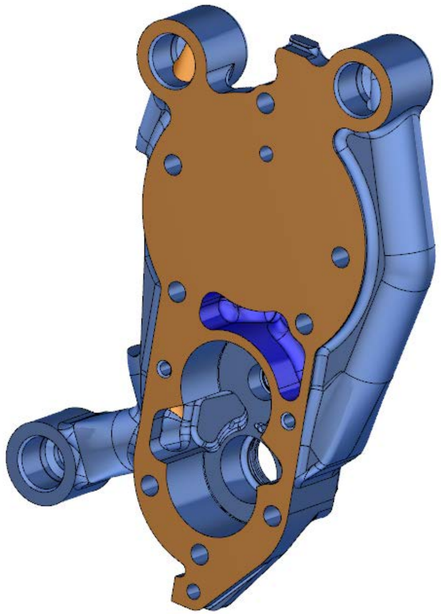
MFIN Dashboard – Service/MRO Data

- Design
- Analysis
- Manufacture
- Inspection
- Assembly
- Operation
- Service

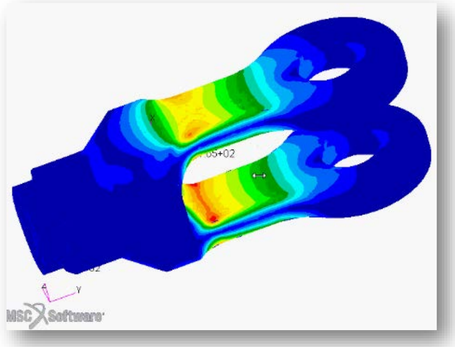
MRO Data Upload

- Record of Investigation
- Record of Decision Making
- Record of Material Accessed

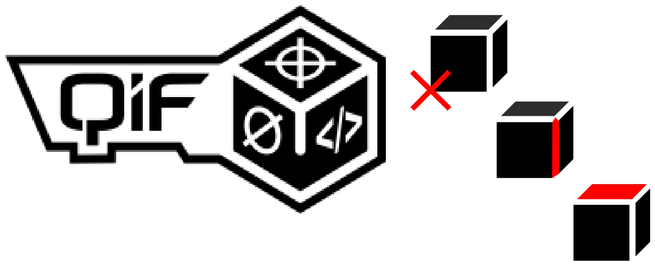


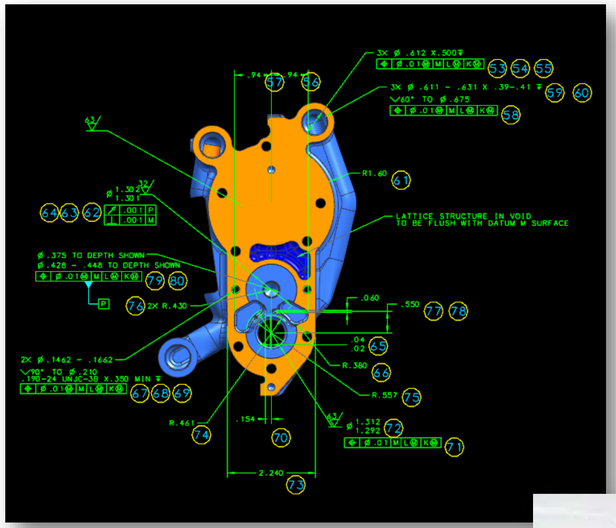
Summary

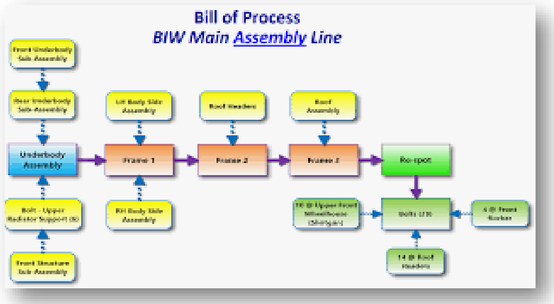
MFIN is a Framework Utilizing the QIF Schema to Expand MBD



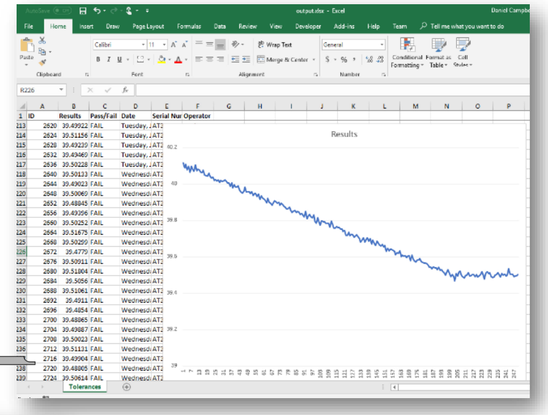
Analysis



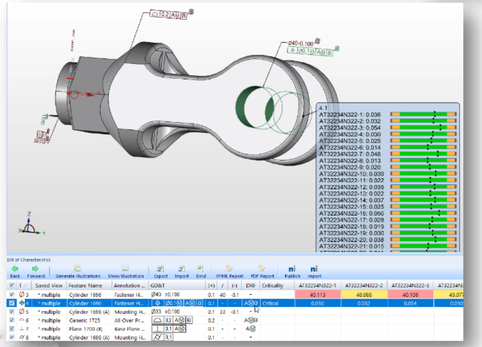




Assembly

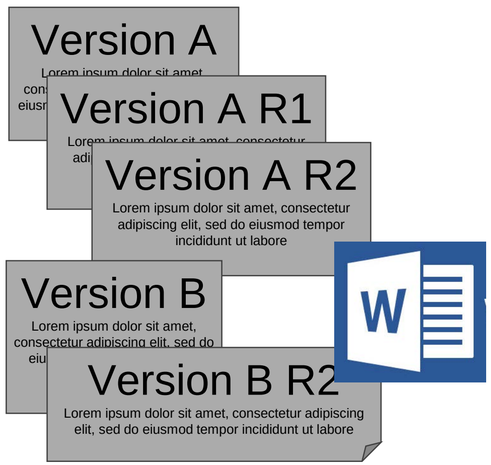


Data Collection



Inspection

Maintenance / Repair



Design Changes

End of Life

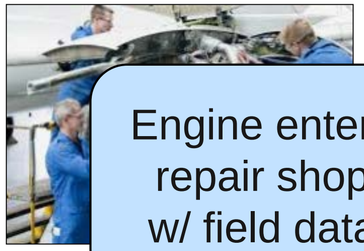
Use Case: Maintenance & Repair Operation

Rolls-Royce

- Sustainment Engineer or Field Support Specialist
  - Utilize the MFIN to upload and access lifecycle data
  - Supporting sustainment activities

- Result: This will streamline diagnosis of quality defects or part failures in the field
  - Drive design optimization efforts

Maintenance Repair Overhaul (MRO) Workflow



Engine enters repair shop w/ field data

Test/Clean/ Inspect

Part with issue identified

1

Part repairable?

2

Yes

Repair

Test Re-assemble

No

Damage Disposition

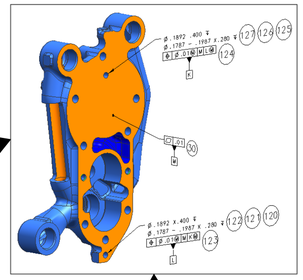
3

Out of Design Limit

Out of Repair Limit

Out of Service Limit

Replace Part



Record of Investigation

4

Tech Variance Request

Service Investigation

Repair Part

5

MFIN API LAYER

MFIN Data (PLM Database)

6

Investigation complete

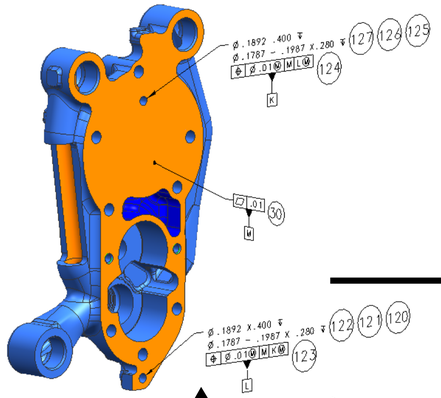
Use Case: Process Planning

Lockheed Martin

- Process Planner
  - Utilize the MFIN to automate the generation of process planning documentation
  - Leveraging relevant PMI and associated data libraries (standard text, specifications, etc.) linked within the MFIN.

- Result: This will reduce the amount of labor and errors associated with legacy processes
  - Link results back to specific geometry via MFIN.

Manufacturing Process Planning Workflow



Part Code

Define / Locate Part Family

Prepare / Retrieve **Part** Process Plan

1

2

Standard Process Plans

&

Part Process Plans

Edit Process Plan

3

Complete Process Plan

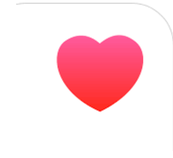
4

MFIN API LAYER

MFIN Data

Results mapped to model via MFIN API

The MFIN is an Evolution of MBD



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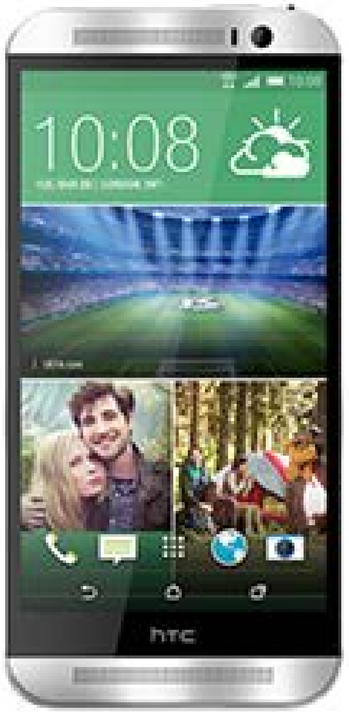
MFIN Solutions Will Vary

iPhone 6



HTC
One M8

Samsung
Galaxy S5

Sony
Xperia Z3

Nokia
Lumia 930

Lessons Learned to Date

- Learning Curves associated with different schema, software products, etc.
  - Reviewed standards/documentation to drive QIF solution
- Settling on best formatting/structure for data consumption
  - Project will focus mostly on linking rather than embedding
- Understanding PMI requirements for broader industry use cases
  - Schema structure is customizable for accommodating broader applications
  - Open source MFIN tools/utilities to enable expanded applications

Lessons Learned to Date

- Supportable Implementation
  - Proprietary Software Would Leverage MFIN as an Interoperability format
  - Allows end users to string together a digital thread based on independent best in class solutions

Technology Transition Plan

- Develop and demonstrate a “neutral” framework for semantic PMI and feature-level linkages that extend MBD through the product lifecycle.
  - Organizations would adapt their methods and tools to support their needs
- Develop a user interface and utilize multiple workflows to demonstrate the benefits of embracing MBE
- Lessons learned will be shared with QIF standards body

Thanks!

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Project team consists of approximately 40 DMDII members from various companies and universities.

Thanks to the entire team for hard work and support of project and presentation.

“This work was funded by MxD with support in part by the U.S. Department of the Army. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of the Army.”

Thanks!

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Project team consists of approximately 40 DMDII members from various companies and universities.

Thanks to the entire team for hard work and support of project and presentation.

“This work was funded by MxD with support in part by the U.S. Department of the Army. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of the Army.”