Supply Chain MBE/TDP Improvement

DMDII-14-06-01

Rolls-Royce North America

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Members and Consultants:

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Presentation Agenda and Preamble

- Project Overview/Success Criteria
- Project Walk-through
- Project Details
- Technical Progress and Lessons Learned
- Questions – please hold questions until end

Preamble Note:
This project tries to be software-agnostic in our testing/reporting. The software and standards in many cases are early in their implementation.

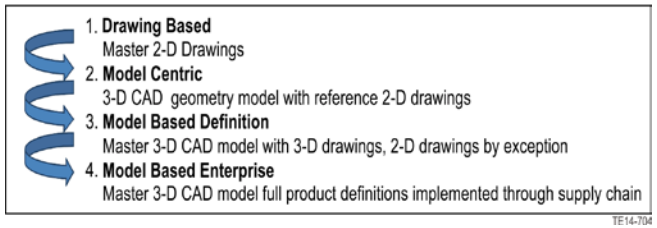
The interpretation and implementation of standards varies at different software companies.

This project reviewed the capabilities offered by a limited number of companies, as a snap shot in time with the understanding that there are still development activities, which may not completely represent their latest capabilities.

Project Overview

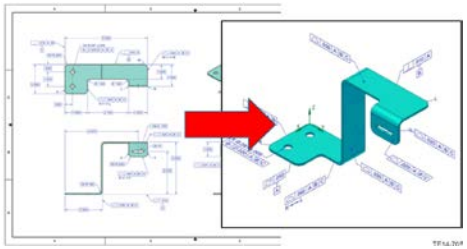
Current State of MBE/TDP Technology

- Focus on geometric related information with no/limited associativity.
- Multiple CAD/CAM environments in the supply chain are a reality.
- Lack of Interoperability among different systems.
- Most operations in organizations are still in different degree of 'silo' effect.
- Supply chain collaboration: still have room to improve.
- Lack of in-depth model exchange validation capability.
- Semantic PMI is still not widely utilized in the industry.



Desired Future State of MBE/TDP Technology

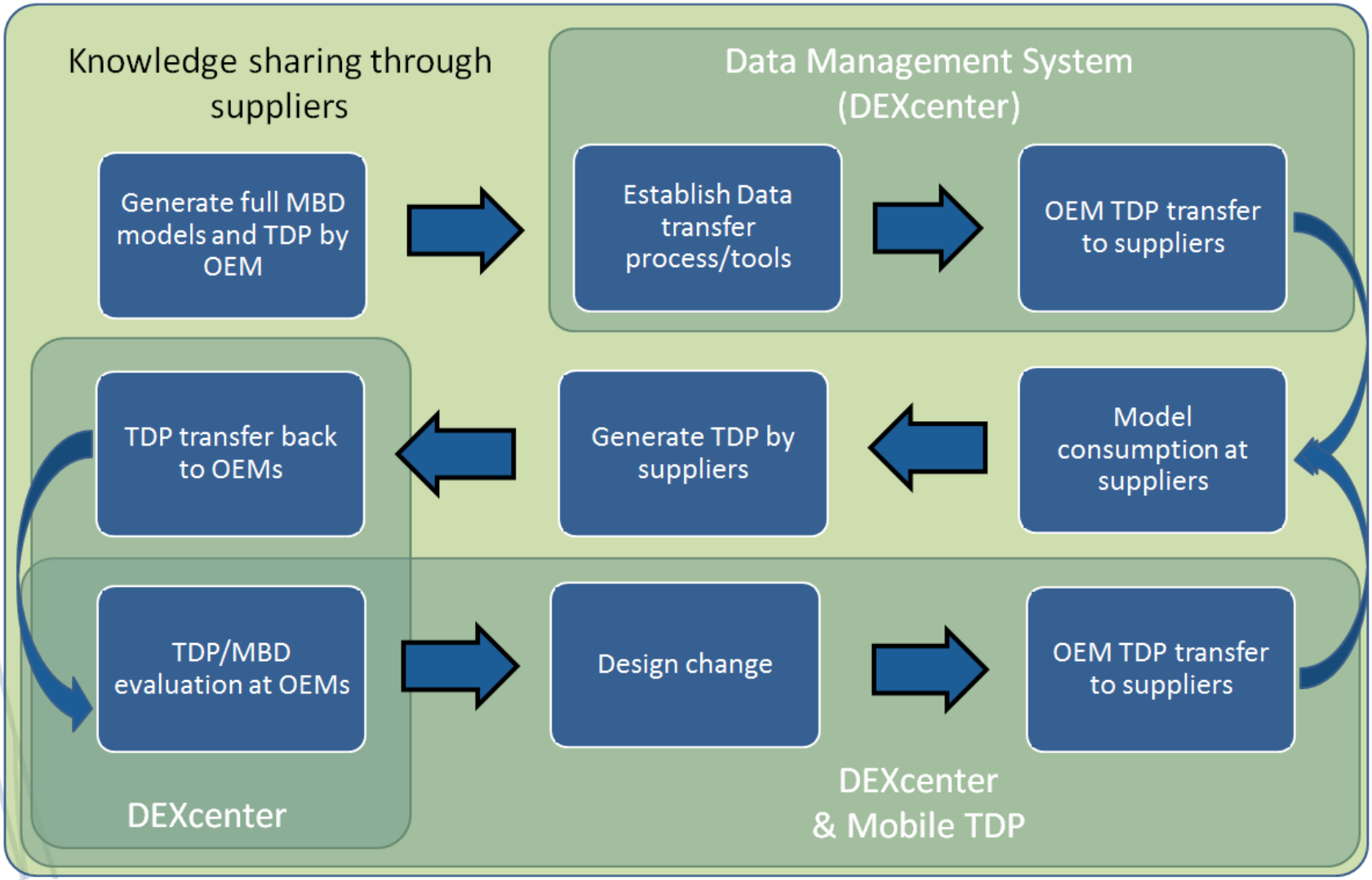
- Future MBE/MBD should be beyond just replacing the drawing type information exchange, include the design intent, and contextual information.
- Robust interoperability among different disciplines and organizations.
- Upon success, the benefits will include
  - Improve competitiveness – organization and nation
  - Responsive and adaptive to the changing market place and technology enhancement.
  - Improve product life cycle time and cost
  - This project will provide a building block for accelerating the maturation of the full MBD, targeting the downstream consumption of PMI



Project Success Criteria

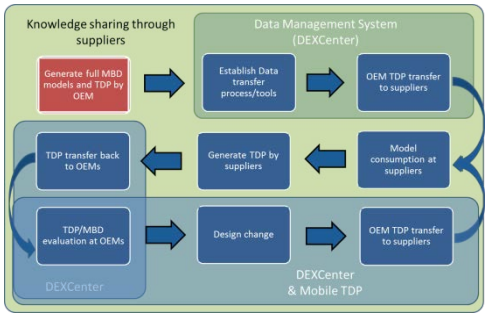
- Complete “roundtrip” of MBD by project team, simulating a real life product lifecycle, including:
  - Multiple neutral data formats: STEP AP 242, 3D PDF, JT
  - Semantic Product Manufacturing Information (PMI) and attribute data
  - Using latest software for creation (Siemens NX11, Catia V5R26), translation/validation (ITI DEXcenter & CADIQ, Anark 3D PDF), and consumption (Inspection: Zeiss Calypso, Additive Mfg: 3MF reader)
  - Visualized with tablet-based Technical Data Package
  - Capturing lessons learned and curriculum

MBD/TDP through Supply Chain

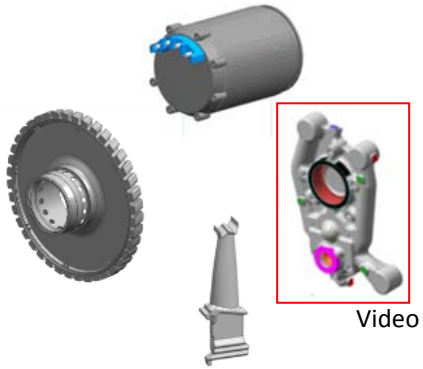


Video

Generate MBD/TDP by OEM

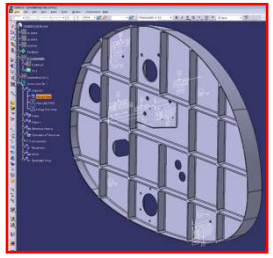


Generate full MBD models and TDP by OEM

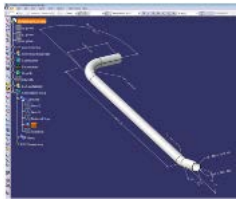


Video

RR MBD Data
(NX9 & 11)



Video



LM MBD Data
(Catia V5R26)

<u>Model Based Definition (MBD)</u> (for 14-06-01)
an annotated model and its associated data elements (i.e. geometry) that define the product in a manner that can be used effectively without a drawing

<u>Technical Data Package (TDP)</u> (for 14-06-01)
a technical description of an item that defines the required design configuration or performance requirements consisting of models with semantic PMI, associated lists, and derivatives (STEP, JT, PDF)

Model Based Definition – Data Value

- Requirements (e.g. CAD, CAM, CAE, PMI, Metadata, etc.…) created must support business needs – consumption
- Data Quality is important :
  - Trust of the data
  - Enhances re-use
  - Increases efficiency
- Culture Change
  - Understand product definition data consumption
    - Recommend training and command media to support PMI (e.g. GD&T, Metadata, part type specific information etc.…) creation
  - Data must be validated / verified

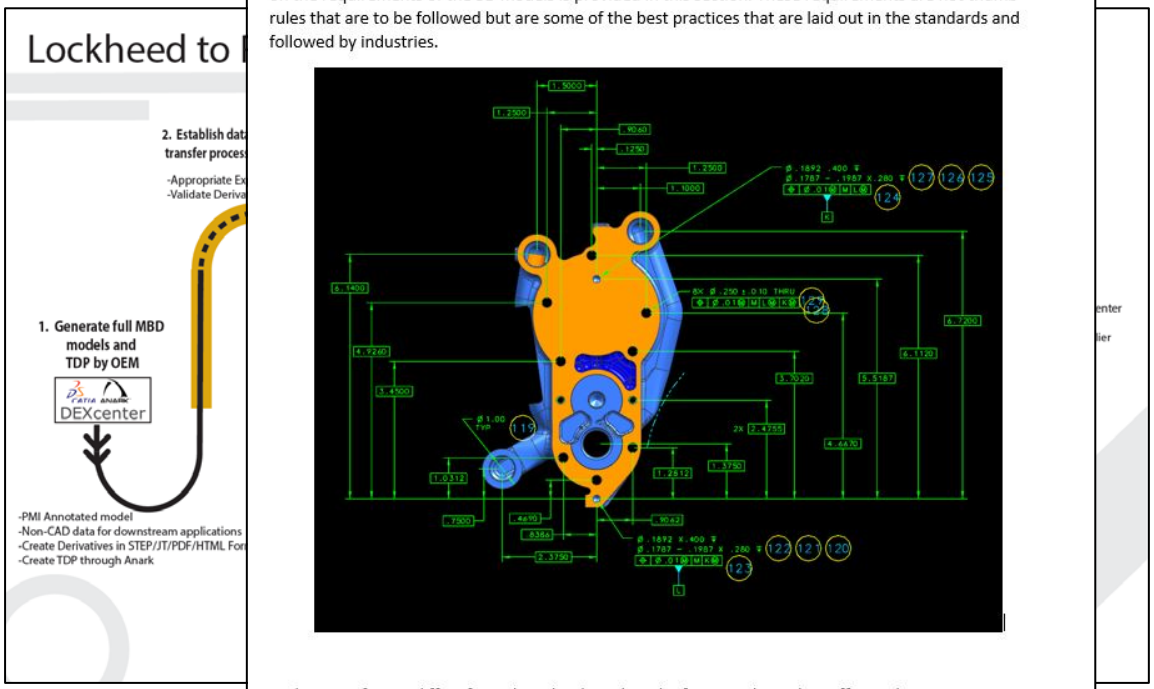
CURRICULUM

TDP Training Document

- Training document will provide an overview of TDP and MBD creation (with 3D models only).
  - Distribution:
    - Via an expanded version for a certificate program via Purdue PLM Center
- Provide a neutral organization perspective to the project.
- Training document is based on industry standards and best practices: NAS3500, MIL-STD-31000A and ASME Y14.41.
- Captures the lessons learned in the project and best practices used in industry. The findings from the 14-06-01 project are generalized.

TDP Training Outline

- The proposed outline for the training document
  - Introduction/overview
  - Assumptions
  - Definitions
  - Model Creation for TDP
  - Advanced MBD Guidelines
  - Software needed/used
  - TDP Creation
  - Use case from project
  - Lessons Learned/ Best Practices



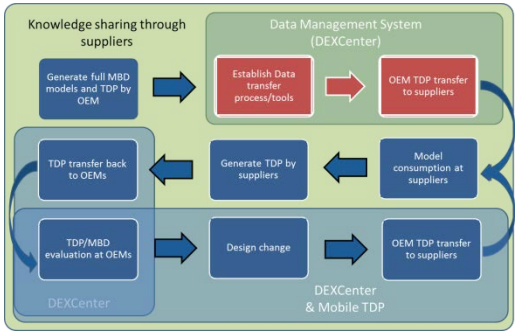
Model Creation for TDP

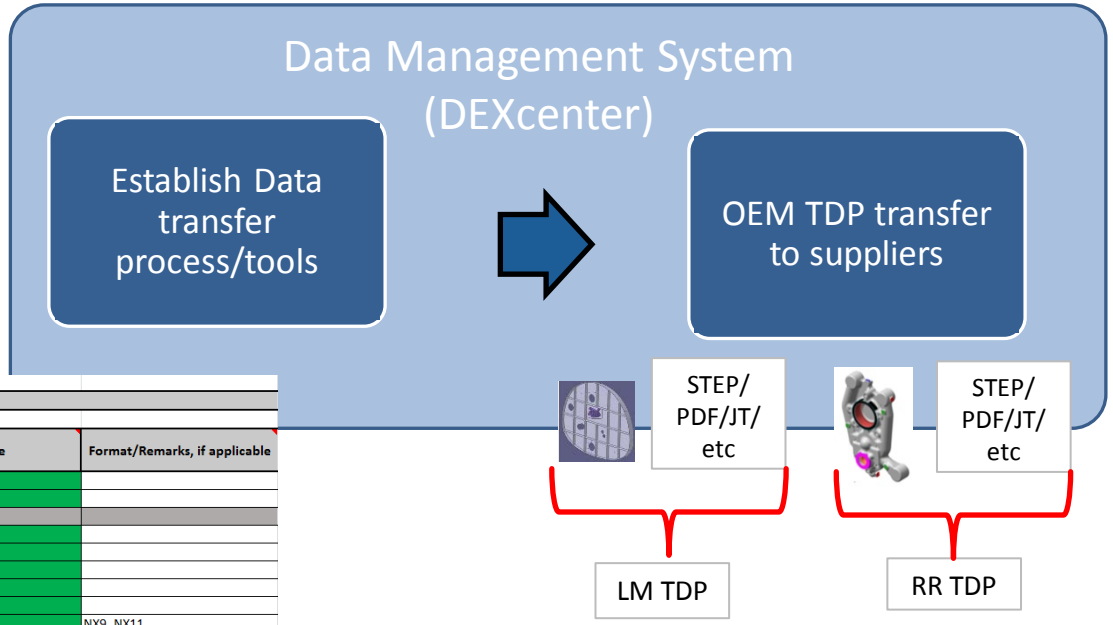
This section focuses on the MBD embedded 3D models that are used to build the TDP. A brief overview on the requirements of the 3D models is provided in this section. These requirements are not thumb rules that are to be followed but are some of the best practices that are laid out in the standards and followed by industries.

Each CAD software differs from the other based on the functionalities they offer to their customer. Several tools are available within these software's that allows organizing the product data in the 3D model. Organization's focus on utilizing the tools to structure the 3D models so that the downstream users can consume the data. A major consideration needs to be given to the translation process where native formats are converted to neutral and lightweight representation formats. In order to replace a 2D drawing from all the process within an organization a 3D model should have product definition and geometry that includes but is not limited to,

- Title block, revision history and other legal information
- Well documented GD&T by annotating elements or features
- Annotations are grouped onto layers, based on their purpose
- Views or combination of views are saved to display appropriate annotations

OEM TDP transfer to suppliers





TDP Transmittal Template

Sets and Subsets	Technical Data Package Contents	ty/Type	Format/Remarks, if applicable
1	What is the TDP Type*		
2	What is the TDP Level*		
3	Product Manufacturing Information*		
3.1	GD&T		
3.2	GD&T	YES	
3.3	Title Block in 3D	YES	
3.4	Surface Finish	YES	
3.5	Material Specifi	YES	
4	Native Format o	nd Version YES	NX9, NX11
5	Neutral Format o	Model and Version YES	STEP203, STEP242 PDF, JT
5.1	Alternate Formats and Version	NO	

TDP Transmit Doc

AS/EN/SJAC 9102 Rev A First Article Inspectio
Form 3: Characteristic Accountability, V atibility Evaluation

1. Part Number TCG04023052360 | 3. Serial

Characteristic Acc sults

5. CN	6. DWG grid	7. Cha	quirement Nominal	Upr Tol	Upr Lim	9. Results
11	0-	Radius	-9999	0.03	9999	9999.03
12	0	Dimension	9999	0.36	9999	9999.36

First Article Inspection

PROGRAM DMDII14-06 SEPARATE NOTES LIST

Part Number		Part Name	Rev
1DMDII001-001		FWD BULKHEAD	-
Note #	Flag Note		St Nu
1		THE CATIA SOLID SE ON FOR THE BASIC FO DIMENSI SIONED PA	
2		TO BILATERALLY	
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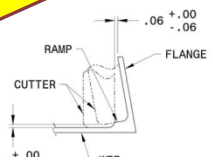
Definition Notes



TDP Transfer Process - Use Case1A (Level 1 OEM to Level 2 OEM)

From	To Supplier	Received	Consumable				
To	RR			Geometry		PMI (S=semantic/ NS=non-sema	
When (by date)	21-Oct	✓	In CAD (NX11)	In Other (e.g. Adob			
What	Bulkhead & docs						PDF not provided
What							no PMI or views in NX11, Vis or IDA Step
What						NS	S
What				na	X	na	na
What	Catia R26	✓	X	na	X	na	na

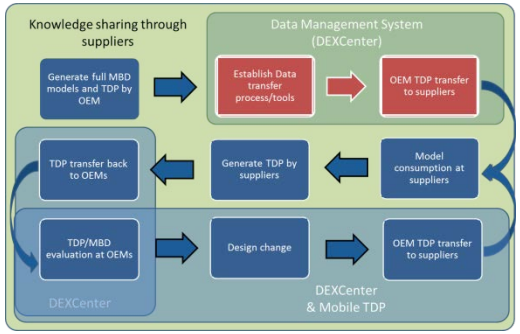
JT Inspector: no issues; PMI is "assorted parts" in NX

no PMI in NX11

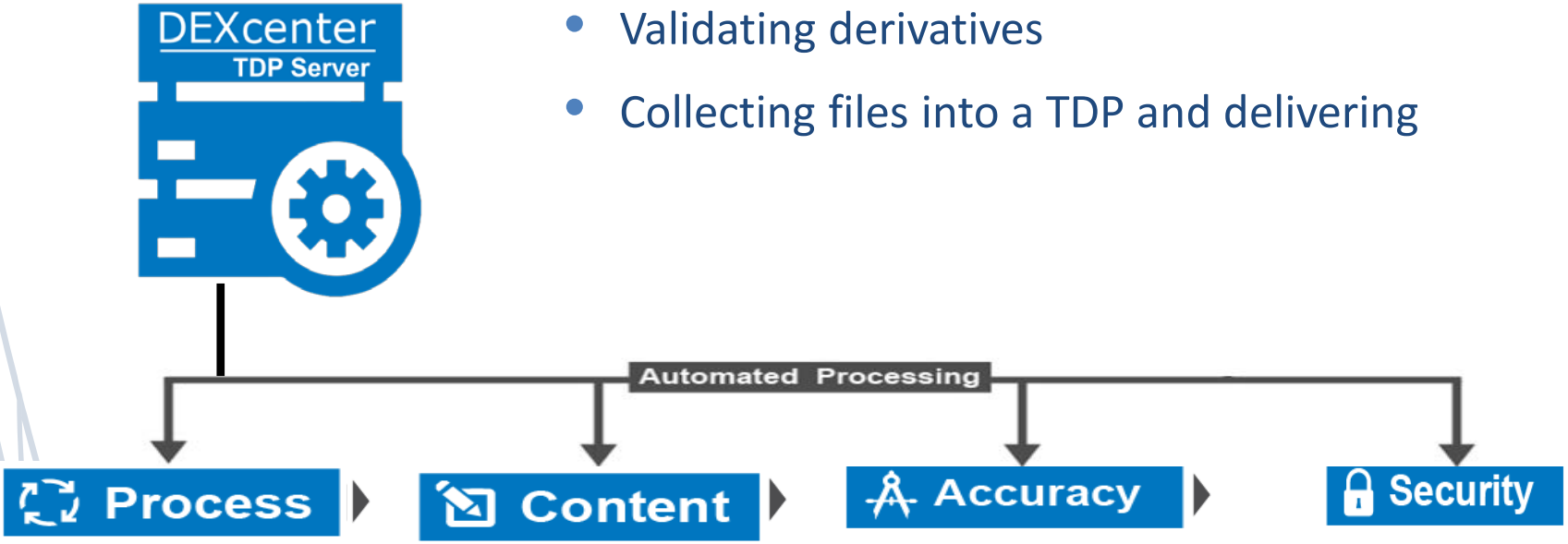
R26 not supported, only 1 point converted

Tracked results of multiple derivative transfers thru supply chain

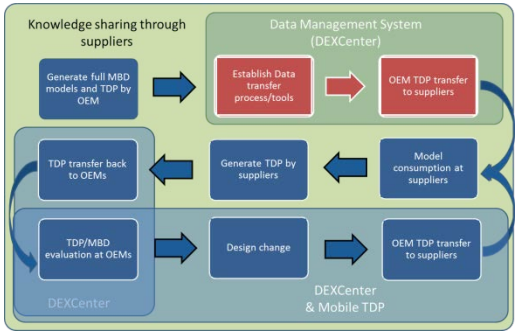
OEM TDP transfer to suppliers

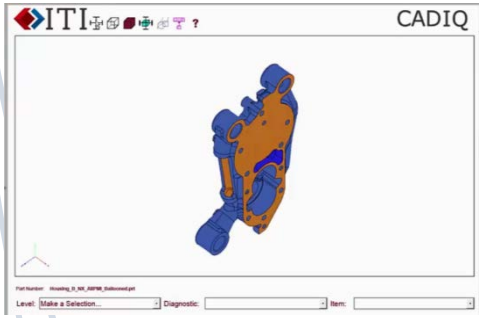


- ITI DEXcenter was deployed at Purdue to facilitate MBD operations and TDP exchange
- DEXcenter automates:
  - Verifying MBD models
  - Generating derivative files (step, jt, PDF, native)
  - Validating derivatives
  - Collecting files into a TDP and delivering



OEM TDP transfer to suppliers

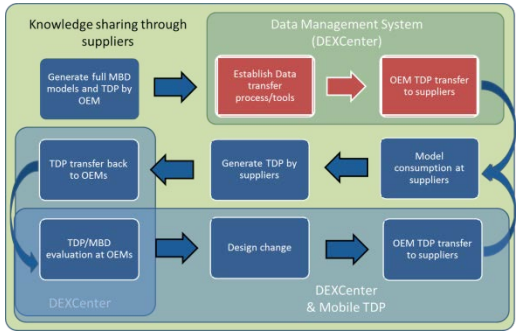




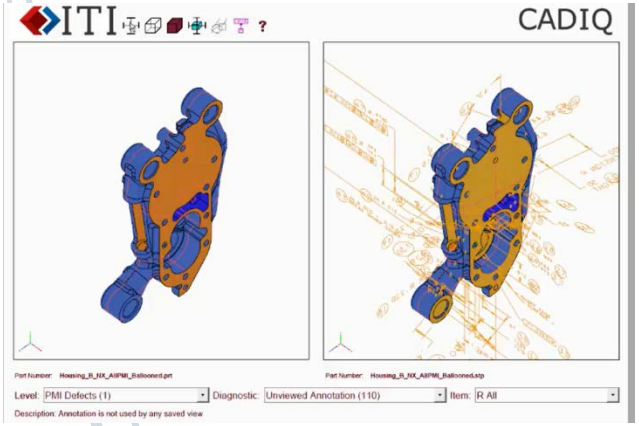
Video

- DEXcenter uses ITI CADIQ to verify that MBD models are complete and accurate
- With drawings in the past, recipients may have made assumptions about intent if the drawings were ambiguous or had mistakes
- MBD models are used directly by downstream recipients for manufacturing, inspection, and other purposes.
  - Ambiguity must be eliminated
  - Costly, difficult, or impossible to manufacture geometry conditions must be removed
- CADIQ is used to perform a Producibility Analysis to verify that the MBD model is complete, unambiguous, and can be used directly downstream

OEM TDP transfer to suppliers



- A TDP generally consists of multiple file types such as:
  - Native CAD model
  - STEP
  - JT or 3D PDF visualization file
- Each time a derivative is created, it should be validated against the original native CAD model to ensure there are no significant changes
- DEXcenter automates creation and validation of these derivatives
  - Multiple derivative files can be created and validated with one DEXcenter operation



Video

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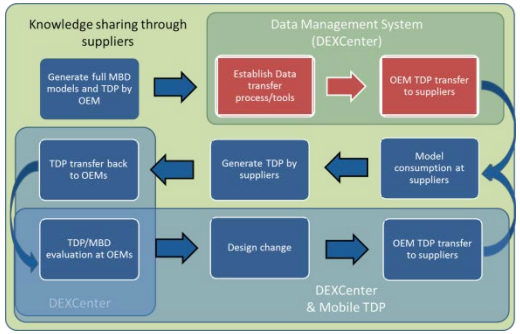
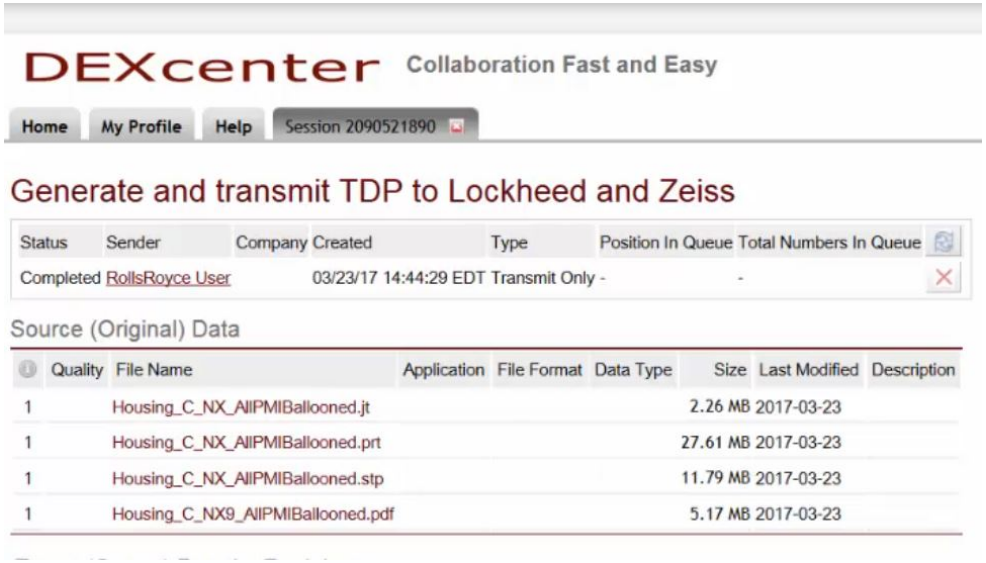
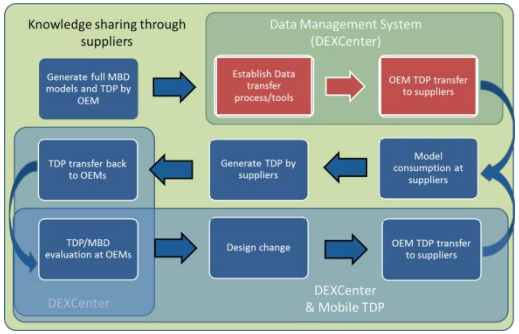


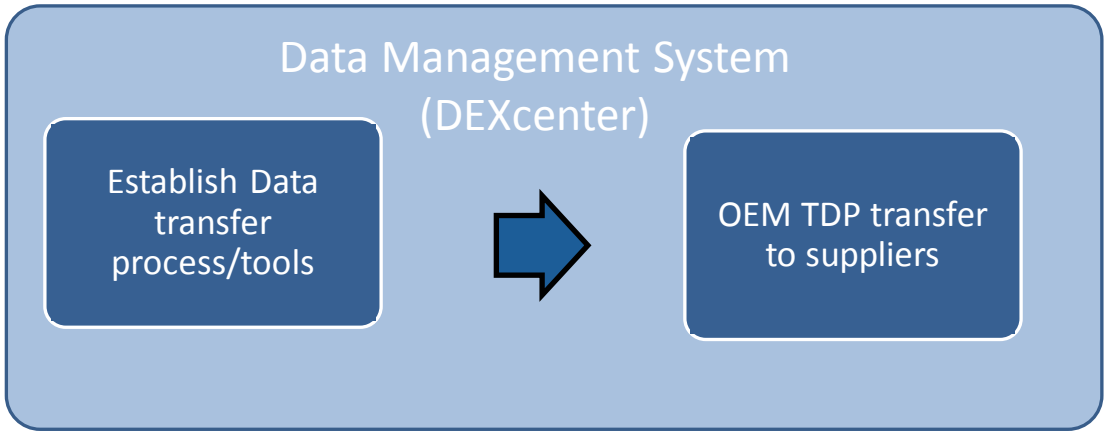
- Once all derivatives have been generated and validated, then can be combined together into a Technical Data Package and delivered to suppliers and partners
- Using DEXcenter, the files can be sent
  - As individual files
  - As a zip file
  - As a PDF with attachments



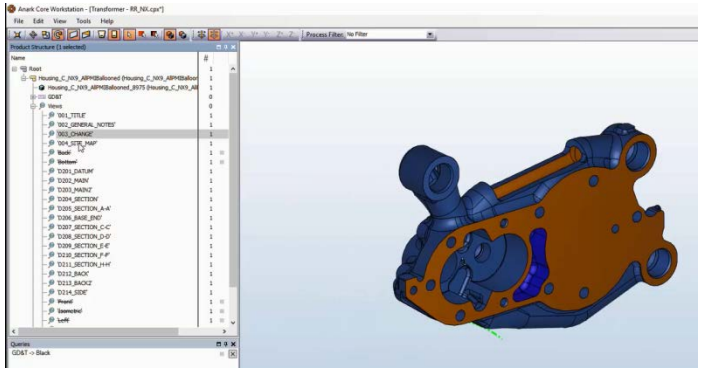
Video

OEM TDP transfer to suppliers



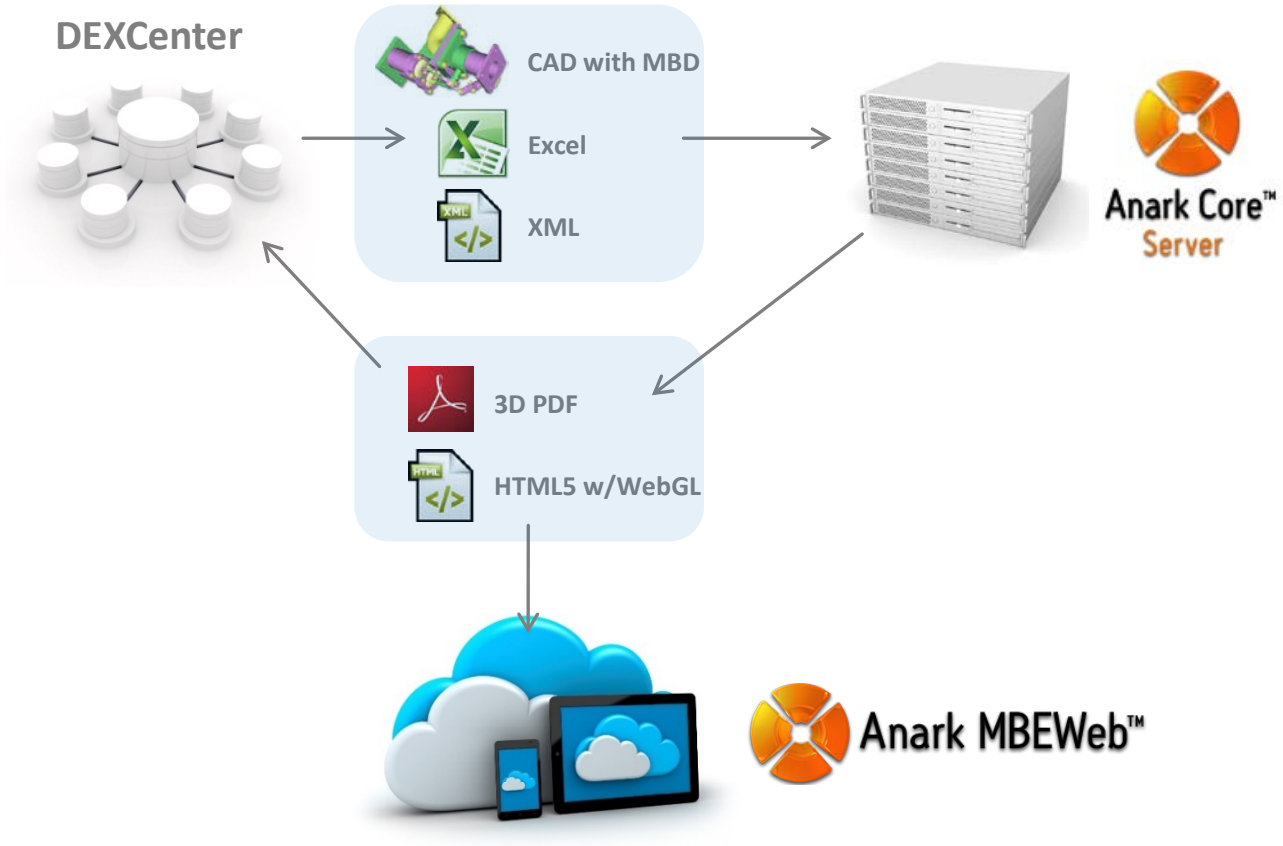


- Create model-based 3D PDF and HTML- based derivatives from native CAD and other master data
- Publish technical data packages as PDF documents and as HTML applications
- Accessible on laptops, desktops, smartphones, and tablets
- Anark Core MBE Publishing Workflow Video



Video

MBE Publishing Workflow



[MBEWeb Demo](https://tinyurl.com/anark-dmdii)
https://tinyurl.com/anark-dmdii

[3D PDF TDP]

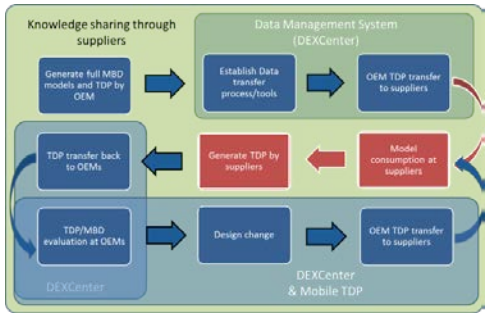
STEP AP242

- Proposed as unification of AP203/214/232 with PMI support by NIST at MBE Summit in 2009
- Adopted as ISO 10303-242 standard ~2014
- Supports PMI two ways: Presentation (graphical) & Representation (semantic)
- Presentation (graphical) PMI is ***intended for human consumption*** in exchanging PMI between CAD systems or between CAD and downstream systems
- Representation (semantic) PMI is ***needed for machine readable exchange*** between CAD systems or between CAD and downstream systems
- AP242 with semantic PMI is just now becoming available in common CAD systems
  - NX 11 (Presentation and Representation) (Oct 2016)
  - Catia V5-6R2016 (R26) (Presentation)
  - Catia V5-6R2017 (R27) (Presentation and Representation) (SP3 LA TBD ~ 2017)
  - Creo 4.0 (Presentation)
  - Creo 4.0 (Presentation and Representation*) (M020 – late 2017)

STEP AP242 Results

- NX 11
  - First release to support AP242
  - Supports both Representation (graphical) and Semantic (functional) PMI
  - Separate AP242 feature
- Catia V5-6R2016 (V5R26)
  - Supports only Representation (graphical) PMI
  - Requires FTA license
  - R26 bug requires units to be metric to see PMI
- Issues:
  - V5-V5
    - Some captures lose orientation and zoom capability
    - Imported PMI is graphical only
    - No success with assemblies with PMI
  - NX – V5
    - Imported PMI is graphical only
    - No section views
    - Incomplete PMI
    - Extraneous sets
- Conclusion
  - NX- V5 Achieved better results using AP203 but no functional PMI
  - V5 – V5 achieved best results using AP242

Model consumption/Generate TDP at suppliers



Generate TDP by suppliers

Model consumption at suppliers

LM TDP

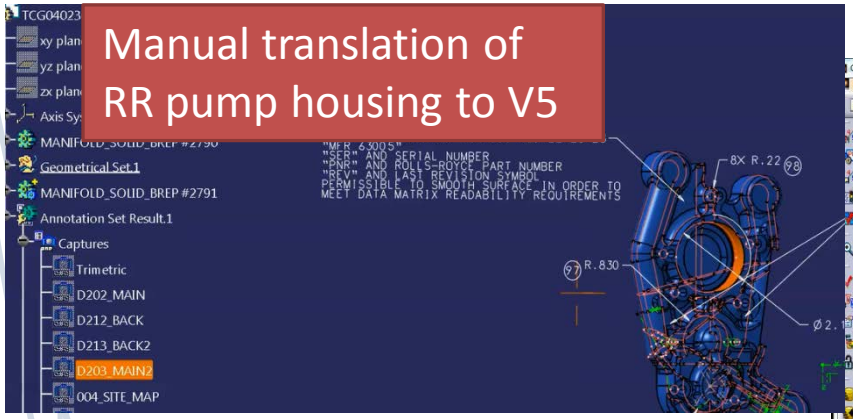
RR TDP

Marked RR TDP

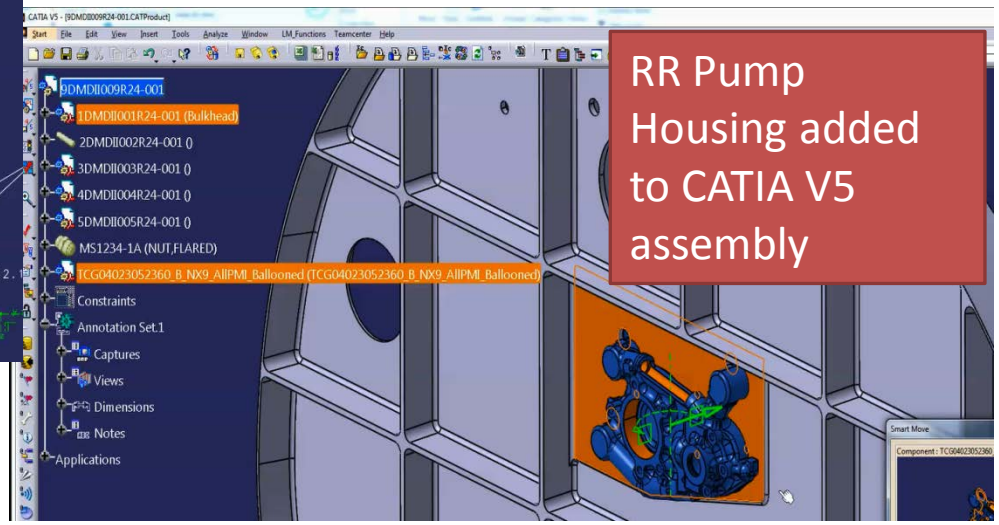
STEP/ PDF/JT/ etc

Marked LM TDP

STEP/ PDF/JT/ etc

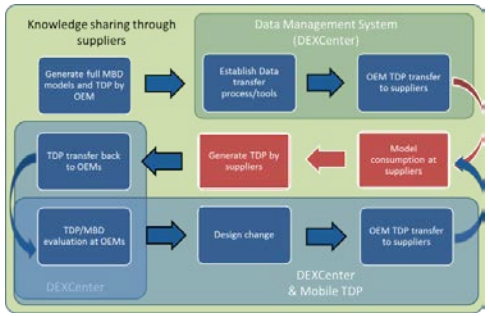


Video1



Video2

Model consumption/Generate TDP at suppliers



Generate TDP by suppliers

Model consumption at suppliers

LM TDP

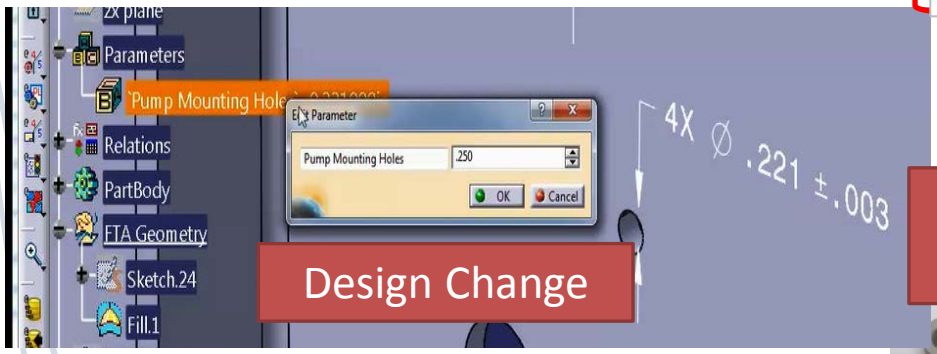
RR TDP

Marked RR TDP

STEP/ PDF/JT/ etc

Marked LM TDP

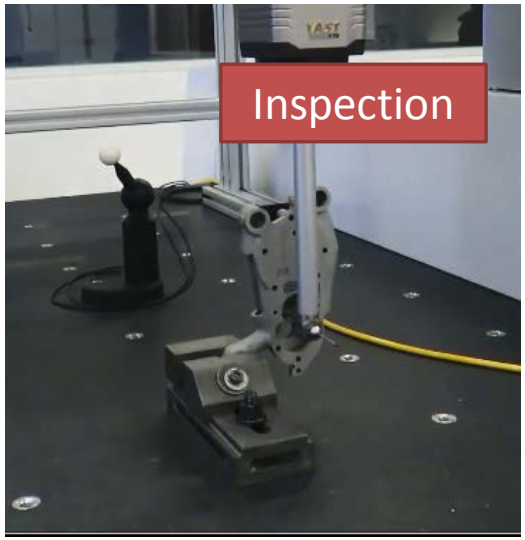
STEP/ PDF/JT/ etc



Video1

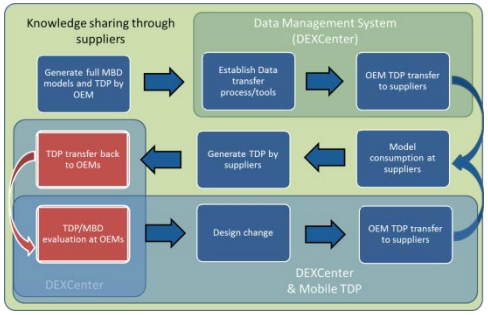
Additive Manufacturing

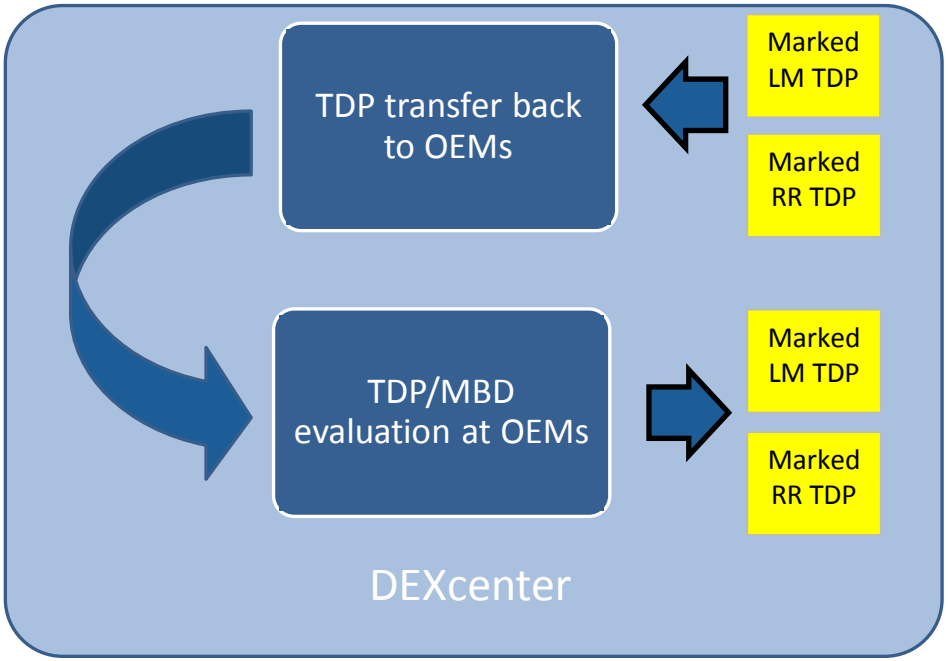
Video2

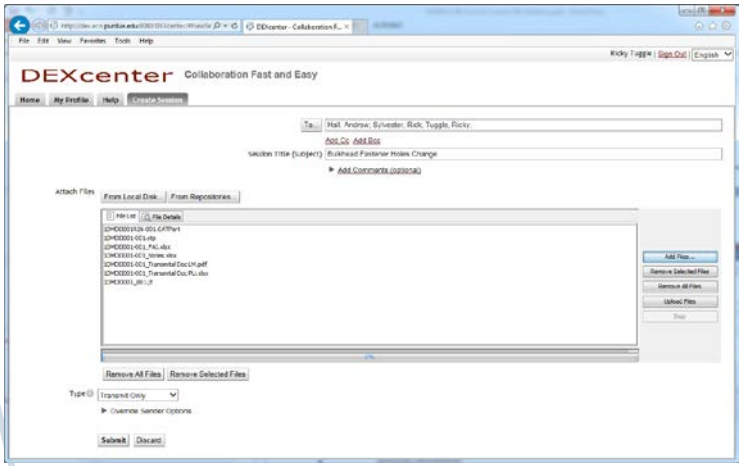


Video3

TDP transfer back to OEMs

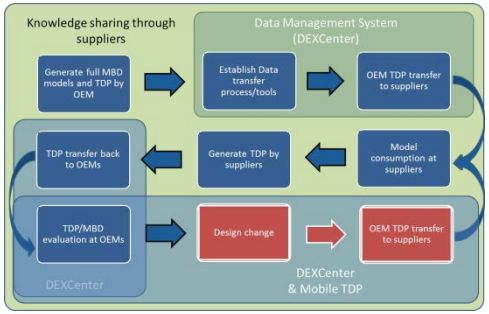


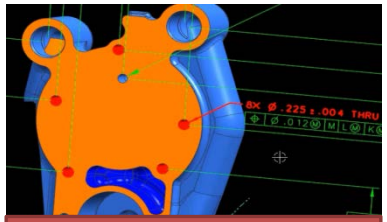




- Modified Bulkhead TDP is transferred thru DEXcenter to RR for incorporation in pump housing

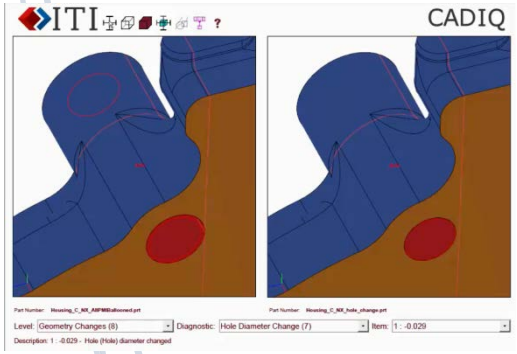
Design Change back to Supplier



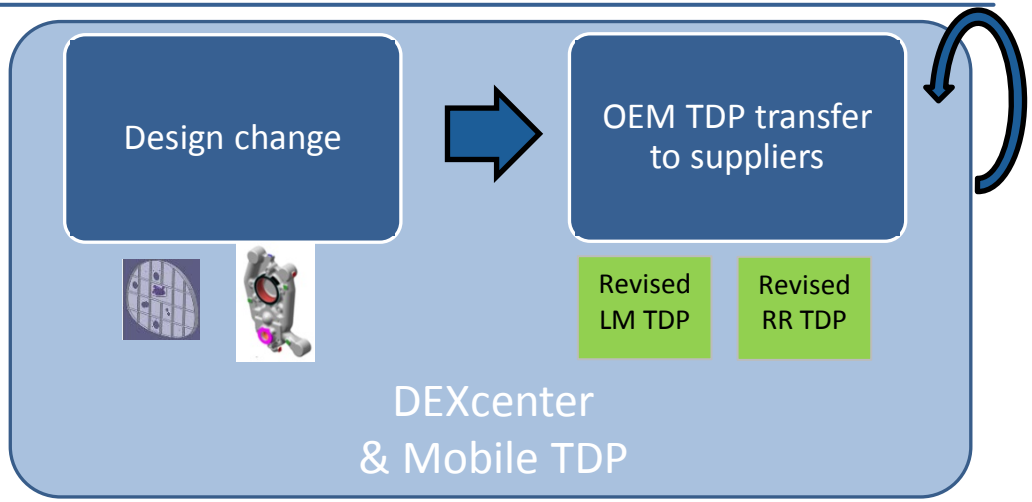


Housing model change

Video1



Video2



- Documenting Engineering Changes with drawings is usually done by marking up a drawing
- Documenting Engineering Changes with MBE models is more complicated
  - Often involves making screen shots
  - Manual, time consuming, easy to miss changes
- With DEXcenter and CADIQ, there is an automated programmatic process
  - Submit a pair of models
  - CADIQ programmatically identifies differences

Technical Progress to date

- MBD design **Creation** at RR/Lockheed Martin
- TDP (3D PDF, JT, STEP, native CAD and documents) created
- New/updated software capabilities investigated (NX11, STEP242, 3MF)

- Data **Translation** performed by Lockheed Martin, Purdue, ITI and RR
  - DEXcenter support for NX11 and Catia, translation / validation processes
  - Anark PDF template developed

- Data **Validation** performed by Lockheed Martin and ITI
  - Using ITI CADIQ to perform validation of original CAD to STEP, PDF, JT

- Data **Consumption** at 3rd Dimension, Zeiss, Lockheed Martin, Purdue, RR
  - 3rd Dimension produced RR Housing (from STEP and PDF) using Additive Manufacturing
  - Purdue and 3rd Dimension investigated 3MF Additive Mfg file format
  - Zeiss inspection of RR Housing using Calypso
  - Purdue creating training material

Lessons Learned

- Primary deliverable is Lessons learned:

Creation

- STEP AP242 semantic capability not yet mature
- NX11 has deficiencies with STEP AP242
- Modeling practices schemas affect 3D PDF/HTML
- Different modeling schemas may require different PDF/HTML templates

Translation

- Translation options from CAD depends on use case
- Settings for derivative export/import of data need considered and communicated

Translation

- STEP AP242 semantic capability not mature yet
- Catia STEP Export captures work well with mm units
- 3MF will be supported in Catia V5-6R2017, 3DEXP 2017x, Solidworks 2017 and future NX software enhancement.
- Catia V5R24 confirmed to NOT support semantic PMI into STEP242
- Catia V5R26 for STEP AP242

Consumption

- Manufacturing using PMI information limitedly
- Quality of MBD, even complying to standards, could still limit the usability
- Success depends on semantic vs presentation PMI.
- 3MF (Add. Mfg format) not able to consume PMI yet
- 3MF supported in Catia V5-6R2017 & NX11 & JT export

Is MBD ready for Prime-time?

Final thoughts from project team on near-term future of MBE/MBD and how they will support future MBD capabilities

- **Anark**
  - HTML Collaboration Tools
- **ITI**
  - Continue to monitor and incorporate MBE technology
  - Assist customers in adopting MBE
- **Zeiss**
  - Consuming PMI downstream in inspection provides many benefits
  - ZEISS continues to invest in PMI tools to make our customers successful

Is MBD ready for Prime-time?

Final thoughts from project team on near-term future of MBE/MBD and how they will support future MBD capabilities

- **Purdue**
  - Continue to provide training on MBD and PLM for current and future workforce.
  - Continue researching on topics that promotes model based digital product data.
- **Lockheed**
  - Stronger Commitment from Major PLM Vendor to Support the Interoperability through Standards in Order to Enable the Digital Thread/Digital Tapestry.
  - Lack of Industry Standard for Assembly Level PMI through ASME and ISO.
- **Rolls-Royce**
  - Supply chain has demonstrated limited MBE/MBD maturity for full downstream consumption, without need for human interpretation
  - Linking all relevant information to the design master along with the massive amounts of related data is critical for full product lifecycle consumption
  - Software companies need to adopt and support standards organization (ISO, ASME, etc.) in a more timely manner

Questions???

Thank you

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