CUSTOMER SUPPLIER INTEROPERABILITY

Building the Digital Thread

Reducing new product introduction time and cost through more effective collaboration

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ITI TranscenData
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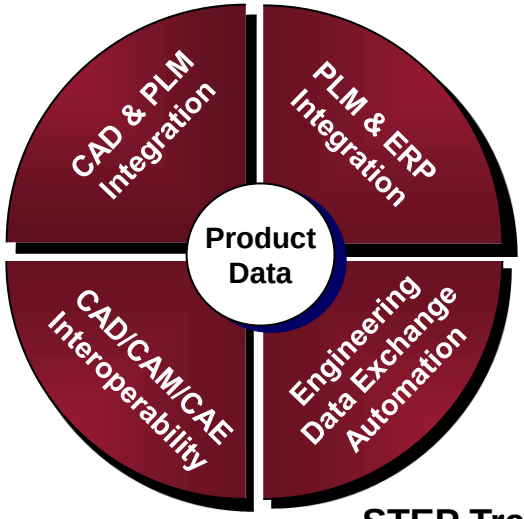
FOCUS INNOVATION CHALLENGE SOLUTION PARTNERSHIP INTEGRATION

International TechneGroup, Inc. (ITI)

- Background
  - Founded in 1983 by Dr. Jason Lemon
  - Privately held
  - Headquarters – Cincinnati, OH

- Global Presence
  - North America
  - Europe
  - Asia Pacific
- Business Offerings
  - Engineering Process Improvement Consulting (CP/PD™)
  - Analysis, Simulation, Test and Reliability Engineering Services
  - Product Data Integration & Interoperability (TranscenData Business)

ITI TranscenData History



Feature Based CAD Translation
Acquired Proficiency

Automation & Verification
Automation / collaboration (DEXcenter)
CAD Model Validation (CADIQ)

PLM Systems Integration
Vendor/OEM Programs (Matrix, UGS PLM, etc.)
PDM/CAD & PDM/ERP

CAD Interoperability
Acquired FEGS Ltd. (CADfix)
CAD Model Quality (CADIQ)

STEP Translator Development
ISO STEP Development Effort
Vendor/OEM Programs (PTC, SDRC, Autodesk, etc.)
IGESworks and STEPworks

IGES Translator Development
IGES Standard Development Effort
Major Industrial IGES Translators (Chrysler, Ford, etc.)
Vendor/OEM Programs (CV, Mentor Graphics, etc.)

"A billion here, a billion there and pretty soon you're talking real money."

– Attributed to the late Senator Everett Dirksen

- Senator Dirksen was referencing the US budget and how relatively small items in the budget ($1B < .03% of US budget) can add up to great costs

- Interoperability is similar
  - No one has an explicit "interoperability" budget. Rather interoperability costs are spread throughout other operating costs and are incurred with every technical data exchange.
  - An individual exchange is not unreasonably expensive (maybe an hour, a few hours, or even a few days)
  - When a program lasts 40+ years and includes more than 4 million exchanges, **the hidden "interoperability" costs can easily exceed $1 B**
  - **A modest savings of just ½ hour per interoperability exchange can save 12,000 person years and $200 M in labor costs alone**

Interoperability: A $ 1 Billion + Problem

- Interoperability Cost Analysis of the U. S. Automotive Supply Chain

  NIST, US Department of Commerce, March 1999

  "Interoperability is the ability to communicate product data across different production activities. It is essential to the productivity and competitiveness of many industries because efficient design and manufacturing require the coordination of many different participants and processes that rely on a digital representation of the product."

  "This study estimates that imperfect interoperability imposes at least $1 billion per year on the members of the U.S. automotive supply chain."

- Today's DoD annual imperfect interoperability costs likely exceed $2B

Why Is Interoperability Important?

- Drivers for Government / Defense
  - Reducing both development and sustainment costs
  - Deploying systems for use in the field sooner
  - Improved reliability during operation
  - Complying with new MIL STD 31000 initiative for MBD exchanges

- Strategies for success depend on collaboration and interoperability
  - Leverage supply chain
    - Use best resources effectively
      - Focus on core competencies
      - Rely on partners for their competencies and cost effectiveness
  - Eliminate inefficiencies
    - Shorten cycles and cost by eliminating non-value added work
  - Innovation
    - Focus resources on better designs
  - Quality
    - Reduce / eliminate mistakes to contain development and sustainment costs
  - Incorporate additional MBD requirements
    - More complete and readily usable technical data exchanges
    - Validated
    - Visualization

Exploring Solutions For Improved Interoperability

- Customer / Supplier Interoperability During Collaborative Design (CSI)
  - Solution addressing AFRL BAA: 08-08-PKM
    - Air Force Research Laboratory
    - Defense Manufacturing Science & Technology (MS&T)
    - High Performance Manufacturing: Model Based Enterprise

CSI Overview

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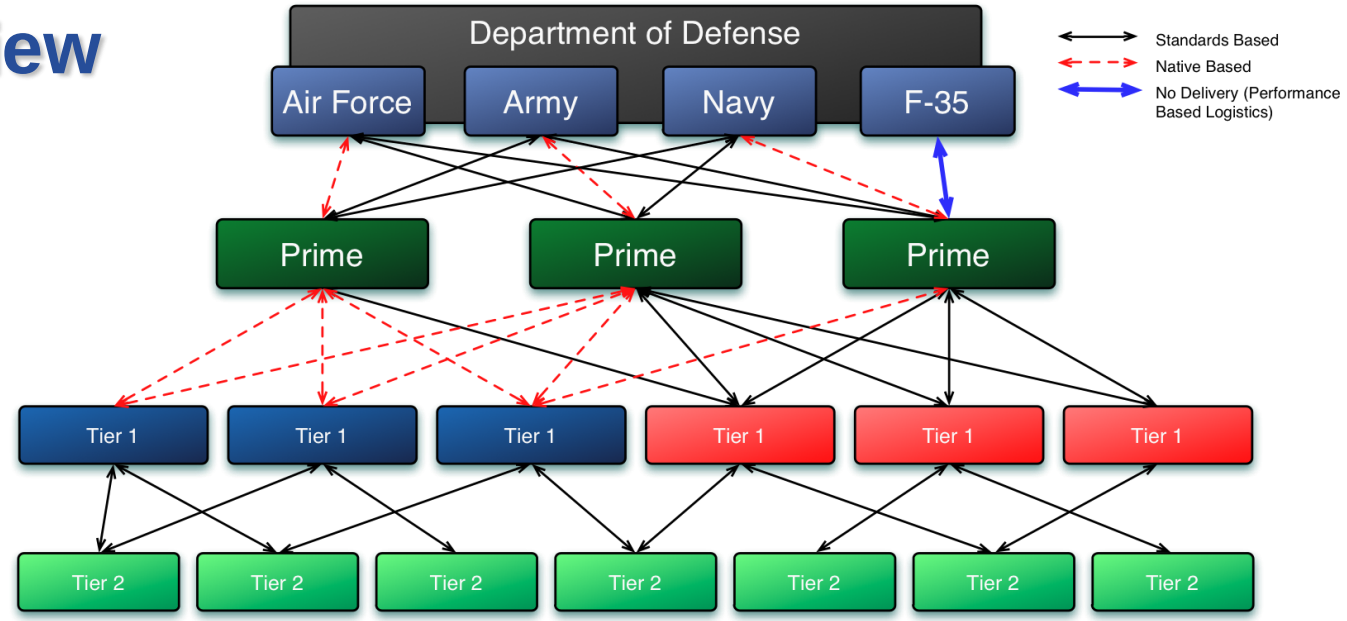


DoD Problem:

Lack of defined data exchange format requirements between suppliers and customers generate significant hidden costs for weapons systems

Approach:

- Capture, validate and test “data-contract” requirements by assessing the requirements, evaluating the highest priority requirements, and developing prototype solutions for the most critical requirements
- Using the DEXcenter, ITI will develop CSI modules, to include contract mapping tools, and software libraries
- Conduct a demonstration to highlight the savings achieved through automation and develop a commercialization plan

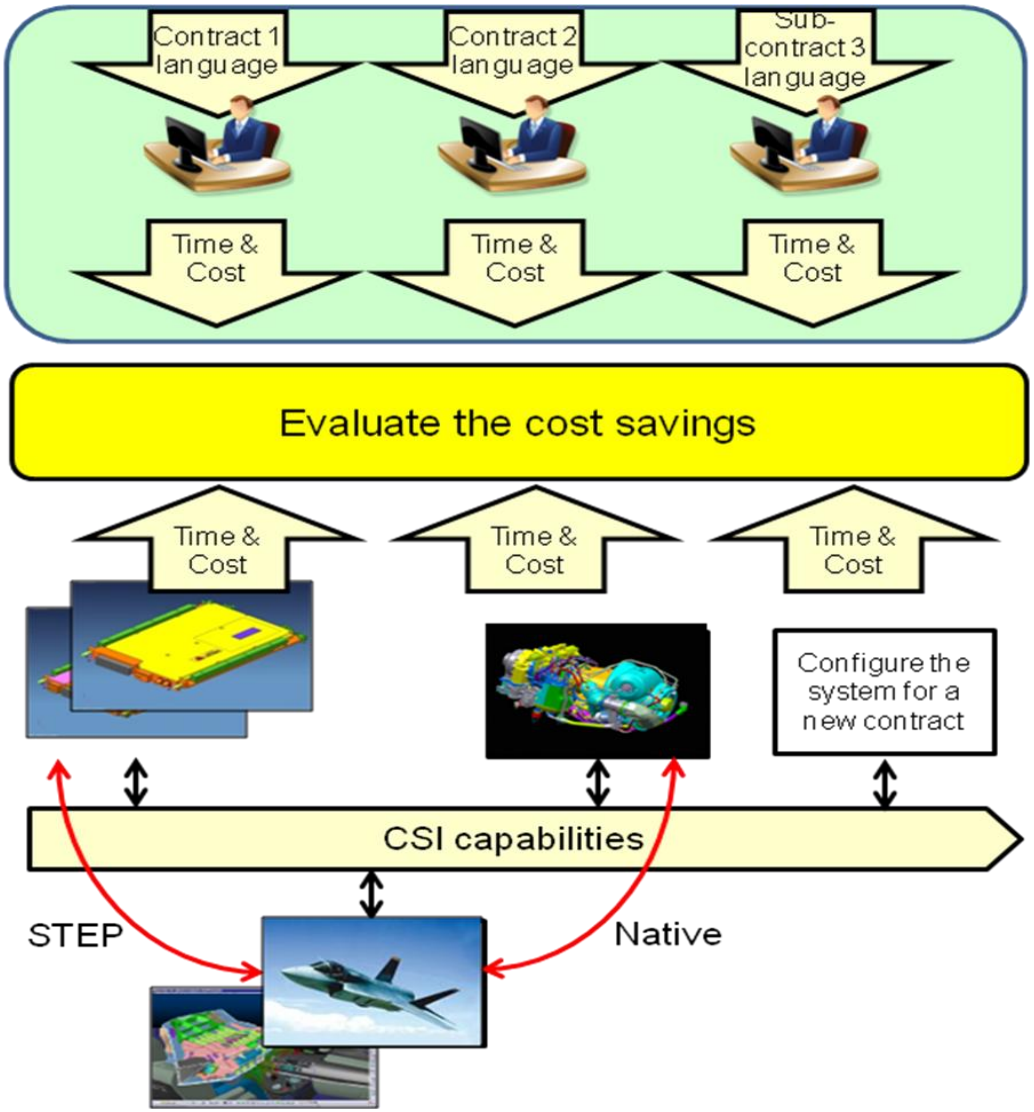
Warfighter Benefits:

Reduced costs and higher quality data. Improvements in business practices will be seen in:

- Less cost to deliver products to the warfighter by eliminating non-value added data manipulation tasks and elimination in errors introduced in the manual manipulation of the data
- Less time for new capabilities to reach the warfighter because of streamlined processes through the supply chain during early product development phases
- Cost savings are estimated to be over $35 million per major program

Focus of program

- **Review** “data contract” language and current methodologies used by industry to support contract requirements or negotiate changes to contract requirements
- **Analyze** failures (unable to comply or cost prohibitive to comply) in the process to support “data contracts”
- **Prioritize** these failures in terms of frequency of occurrence and impact if the failure occurs as well as the cost impact
- **Identify** processes that can be automated to improve compliance with “data contracts”
- **Demonstrate** some of these automation capabilities and the associated savings if deployed in the industrial base



Example contract language and non-value added tasks in organizing and reformatting data

Aerospace
(an OEM's requirement to suppliers)

- **CATIA V5** shall be used for 3D Solid Model
- No assembly constraints shall be active
- Red and orange colored geometry is not to be used
- Individual files sizes to be less than 30 MB
- All parts to be SolidM
- No hidden/no show elements
- Provide separate file with interface points and vectors
- Files must be in engine coordinates
- Provide list of differences/changes since last transmittal

Defense-Army
(a customers requirements to the prime contractor)

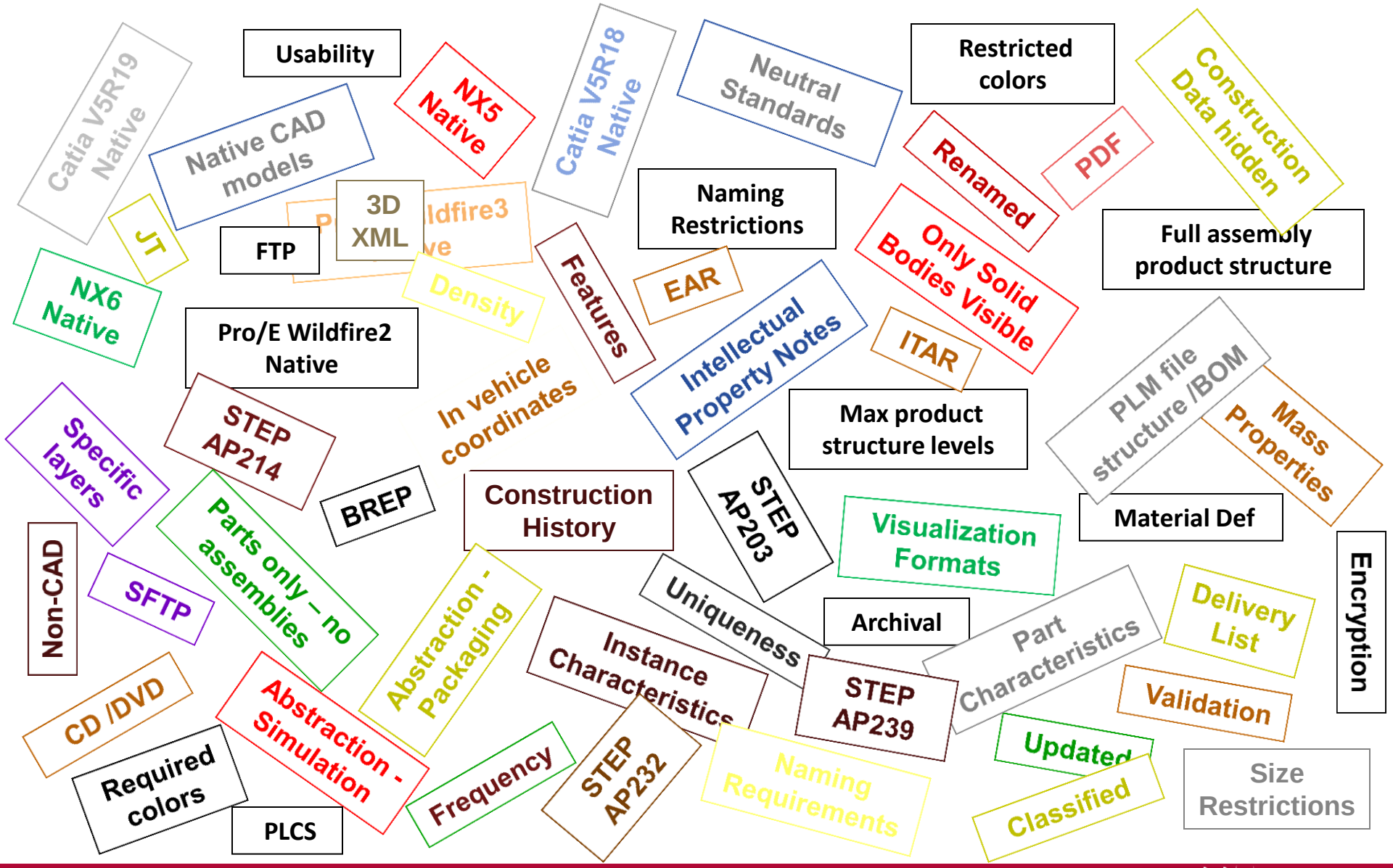
- Layers shall be named in accordance with the naming convention in ProE per xxxx Modeling STD 100T Rev G (26 pages of rules).
- The contractor shall provide a 3D Solid Model in **Pro/Engineer, Version Wildfire 3**, **Intralink 9.0-PDM and 9.0 Intralink 3.4** of all new parts.
- If the proposed change is adding a new part for which a drawing or solid model does not exist, the Contractor shall provide a solid model and 2D drawing of the entire affected assembly/installation with their package.

Automotive
(an OEM's requirement to suppliers)

3D CAD models must be **AutoCAD**:
- have geometry positioned relative to supplied origin (X0,Y0,Z0).
- be created in accordance with 3D Level of Detail CAD Modeling.
- use the layer key styles, system definitions and routing preferences contained within the supplied AutoCAD template.
- have a maximum of 50 layers for additional bespoke model space objects.
- use supplied custom fittings catalogue.
- use the default names for structural member styles.
- be saved showing a 'Top' (Plan) view of the geometry.
- be saved on the Model Space tab.

Deviations from optimal internal operations (inside customers, suppliers or prime contractors) cause delays, rework, changes, increased cost and inefficient use of staffing resources

Example Contract Requirements



F-35

The F-35 program has been used in CSI because it is typical of large, complex DoD programs.

Examples of CAD data interoperability issues and potential cost impacts:

- Lockheed Martin Aero attempted to enforce CATIA V4 model delivery on **F-35** SDRL's
  - Response to bids by several suppliers showed an impact in excess of $1M for some suppliers – contract clause not invoked.
  - Alternative approach – use STEP and/or take native models and convert at LM Aero
  - Early design activity resulted in several hundred models being exchanged/year
- Lockheed Martin Aero heritage program impacts
  - Several instances occurred over last 5 years on **F-16** contracts where LM Aero was required to take complex designs in NX for conversion to V4 & V5 for internal design activities (several hundred man hours for conversion/clean-up incurred)
  - **F-22** Tooling task requiring NX engine envelope model being converted to V4 (6 month conversion/cleanup task)

Example Problem Areas and Estimated Cost

Issue Area	Problem Desciption	Effort per model	Frequency of occurrences	Hours per 1000 models	$ @ $100/hr	
Automation				**31000**	**$ 3,100,000**	**$ 15,230,000**
	Lack of automation	16	10%	1600		
	DMU process issues	16	70%	11200		
	Store multiple models vs create on demand	8	70%	5600		
	can't translate	16	40%	6400		
	ITAR	16	10%	1600		
	non value added time	16	10%	1600		
	manual metadata reentry	2	70%	1400		
	non automated translation	16	10%	1600		
	better use of licenses	2	30%	600		
PLM Exchanges				**29400**	**$ 2,940,000**	
	DMU process issues	16	70%	11200		
	metadata	5	10%	500		
	plm to plm product structure	16	10%	1600		
	general plm to plm	16	70%	11200		
	maintain assemblies	16	10%	1600		
	PLM access	2	70%	1400		
	manual metadata reentry	2	70%	1400		
	manual exchange	5	10%	500		
Model Content / Structure				**21750**	**$ 2,175,000**	
	Extraneous entities	16	70%	11200		
	renaming	5	70%	3500		
	no modeling standards	16	25%	4000		
	metadata	5	10%	500		
	change coordinates	5	10%	500		
	file naming	8	10%	800		
	specific structure	5	25%	1250		

Example Problem Areas and Estimated Cost

Reduce Model Size				**18400**	**$ 1,840,000**
	Model too large for customer	16	70%	11200	
	File size increases	16	40%	6400	
	file too large	8	10%	800	
Improve translations / quality				**17900**	**$ 1,790,000**
	Bad Translations	16	10%	1600	
	Version upgrade errors	16	10%	1600	
	can't translate	16	40%	6400	
	broken asm structure	5	70%	3500	
	maintain assemblies	16	10%	1600	
	non value added time	16	10%	1600	
	non automated translation	16	10%	1600	
Validation				**8800**	**$ 880,000**
	Bad Translations	16	10%	1600	
	Version upgrade errors	16	10%	1600	
	no validation of supplier models	16	25%	4000	
	non value added time	16	10%	1600	
Other				**5750**	**$ 575,000**
	ITAR	16	10%	1600	
	Kinematics	5	25%	1250	
	obsolence	8	10%	800	
	not all parts available	5	10%	500	
	process for adding suppliers	16	10%	1600	

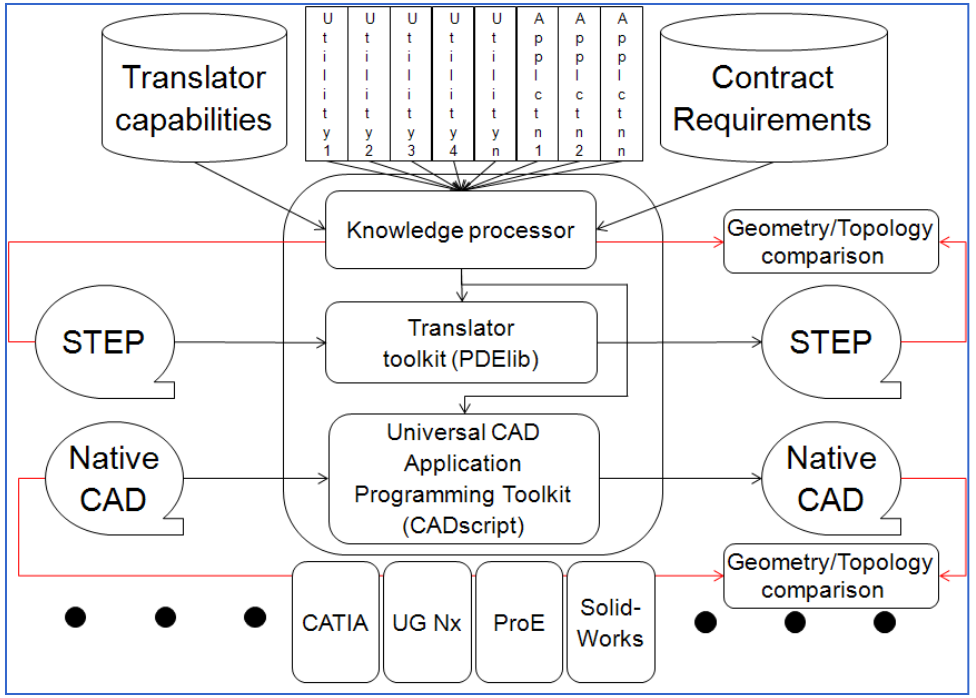
Model Based Enterprise Capability Levels

- **Level 0: Model Centric Drawings for Design and Manufacturing**
  - All activity based upon a 2D drawing package throughout lifecycle
- **Level 1: Model Based Manufacturing**
  - The 2D drawing is master but manufacturing uses natural CAD files
- **Level 2: Native CAD Based Manufacturing**
  - The 2D drawing is master but manufacturing uses native CAD files
- **Level 3: Model Based Definition**
  - The 3D annotated CAD model is the master file for the enterprise
- **Level 4: Model Based Definition With Data Management**
  - The master 3D annotated CAD model and viewable are delivered via PLM
- **Level 5: Model Based Definition With Automated Technical Data Package**
  - Full digital product definition with associated TDP is delivered via PLM
- **Level 6: MBD With Automated TDP and On Demand Enterprise Access**
  - Both the digital definition and TDP are delivered via the web in real time

Source – NIST MBE/TDP Workshop 2010

CSI Vision

- A flexible, configurable, standards based system which automates common tasks associated with Customer Supplier Interoperability
  - Easily / quickly configurable to handle different contract requirements
  - Leverages existing ITI technologies (DEXcenter, PDElib, CADscript, CADfix, CADIQ, etc)
  - Supports typical requirements like:
    - Model preparation
      - Removing / adding / hiding data
      - Organization
      - Coordinate systems
      - Renaming
      - Abstraction / simplification
      - Adding IP / ITAR notes
    - Translation
      - Neutral standards (STEP, IGES)
      - CAD Native formats
      - Visualization
    - Validation
      - Geometry, topology, PMI
    - Delivery
      - Encrypted
      - IP protection
      - ITAR controls
      - Direct (https web, sftp) or via PLM
    - Tracking / auditing



Existing Capabilities and Tools

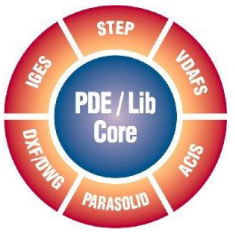
- Standards
  - STEP AP203, AP214, AP232, AP239
  - CAD vendor STEP translator support
- ITI DEXcenter / CADIQ
  - Existing flexible, highly configurable automation framework
    - Database driven
    - Workflow engine
  - Translations with automated validation
  - Delivery
    - https, sftp, ftp
    - Security, encryption, tracking
    - Regulatory compliance
- ITI PDElib toolkit
  - Toolkit for working with standards (STEP, IGES, DXF)
  - Conversions between various formats
  - Geometry manipulation
- ITI CADscript toolkit
  - Abstracted CAD API access
  - Generalized functions which can access enabled CAD systems
  - Read data from native CAD models
  - Modify data in native CAD models
- ITI Proficiency direct Feature Based Translator
  - Translate between CAD systems while maintaining features
  - Convert 3D Model plus associated drawing to MBD PMI
- ITI CADfix
  - Direct BREP translation
  - Model healing and repair

NIST National Institute of Standards and Technology

PDES, Inc.

DEXcenter™

CADIQ®



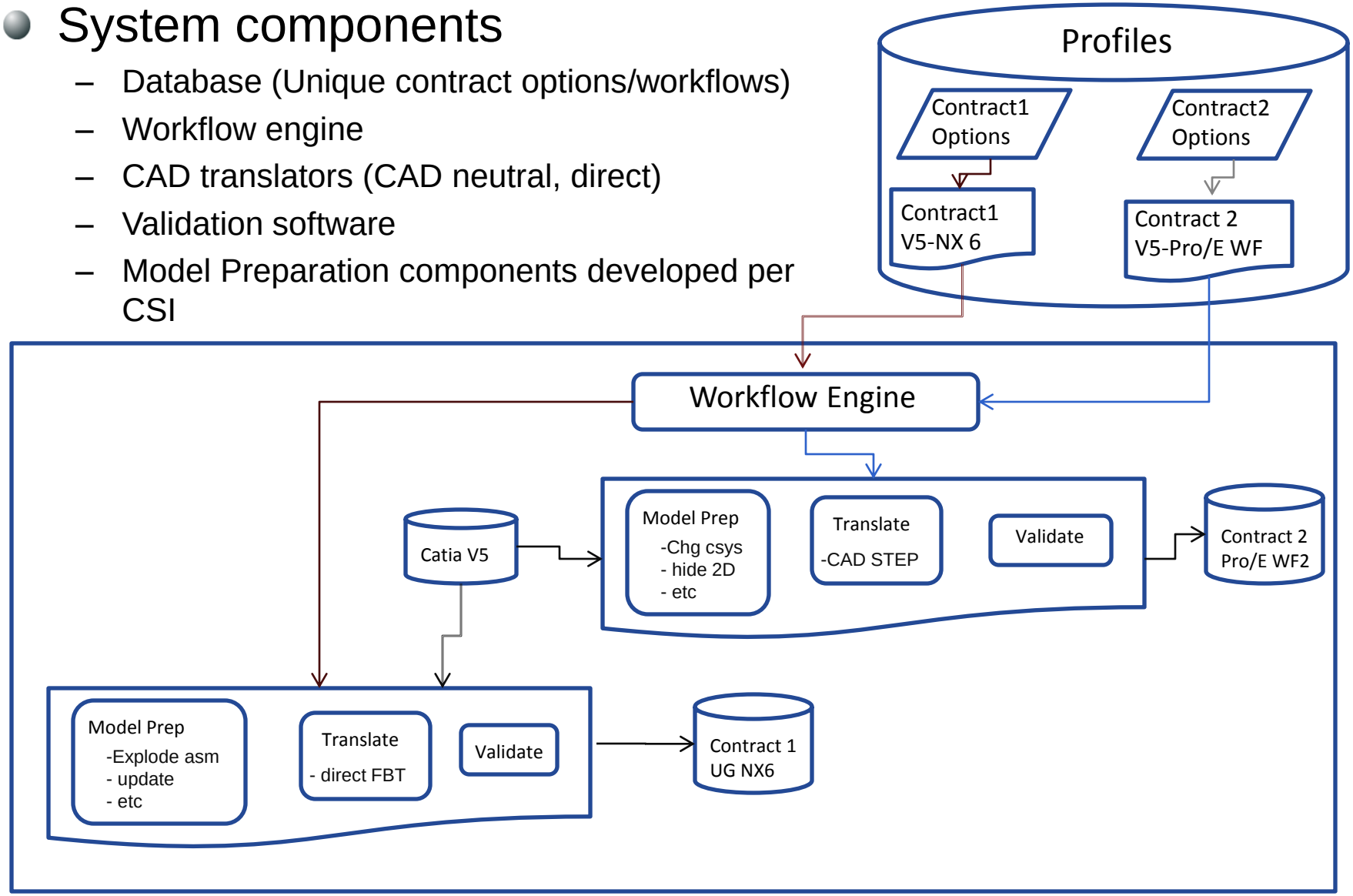
Proficiency

CADfix®

CSI Customer Supplier Interoperability

Scenario With Automated System

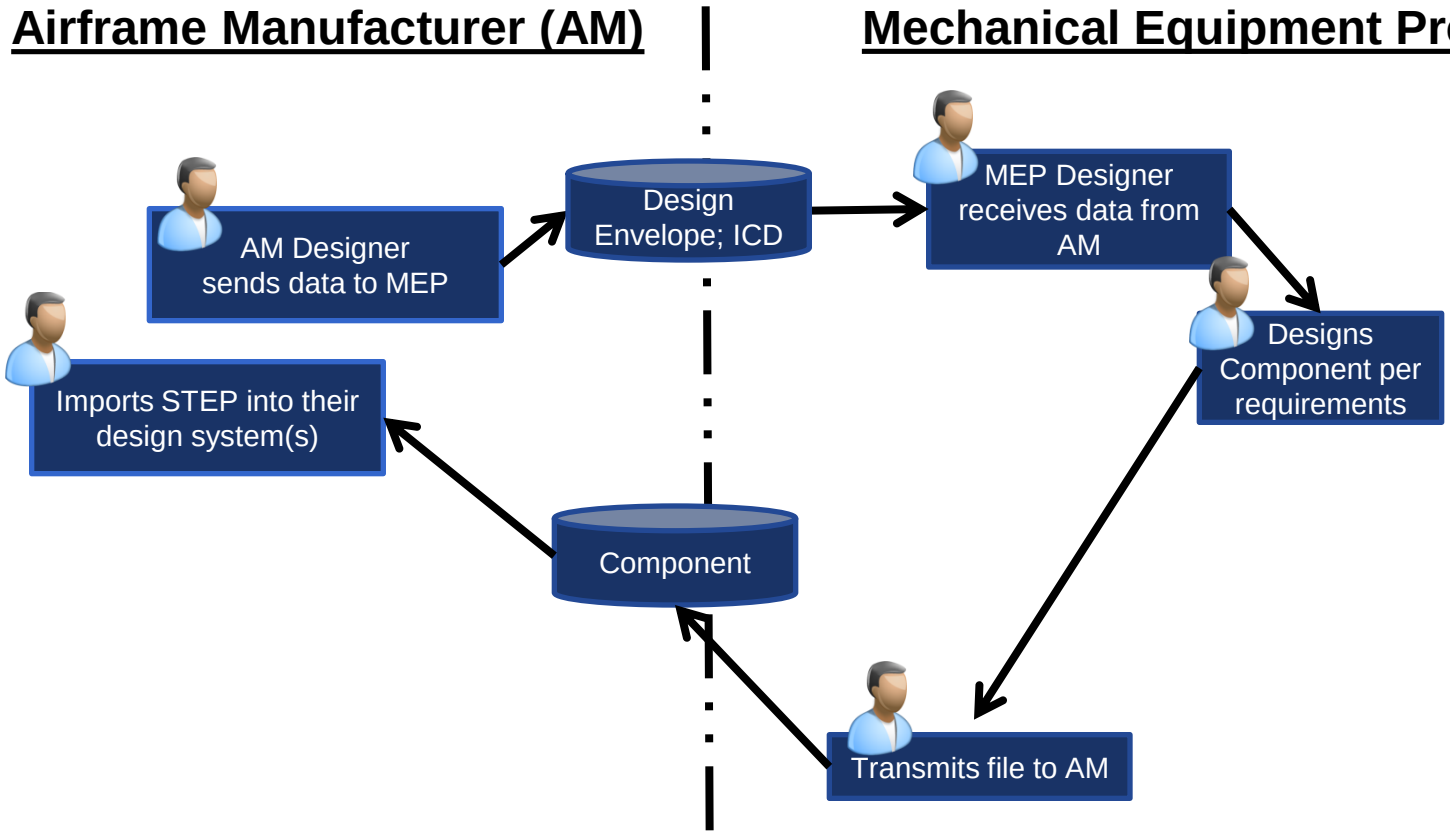
- System components
  - Database (Unique contract options/workflows)
  - Workflow engine
  - CAD translators (CAD neutral, direct)
  - Validation software
  - Model Preparation components developed per CSI



Example Demonstration Scenario (High level view)

Original Process (High Level Summary)

= Requires Human Interaction

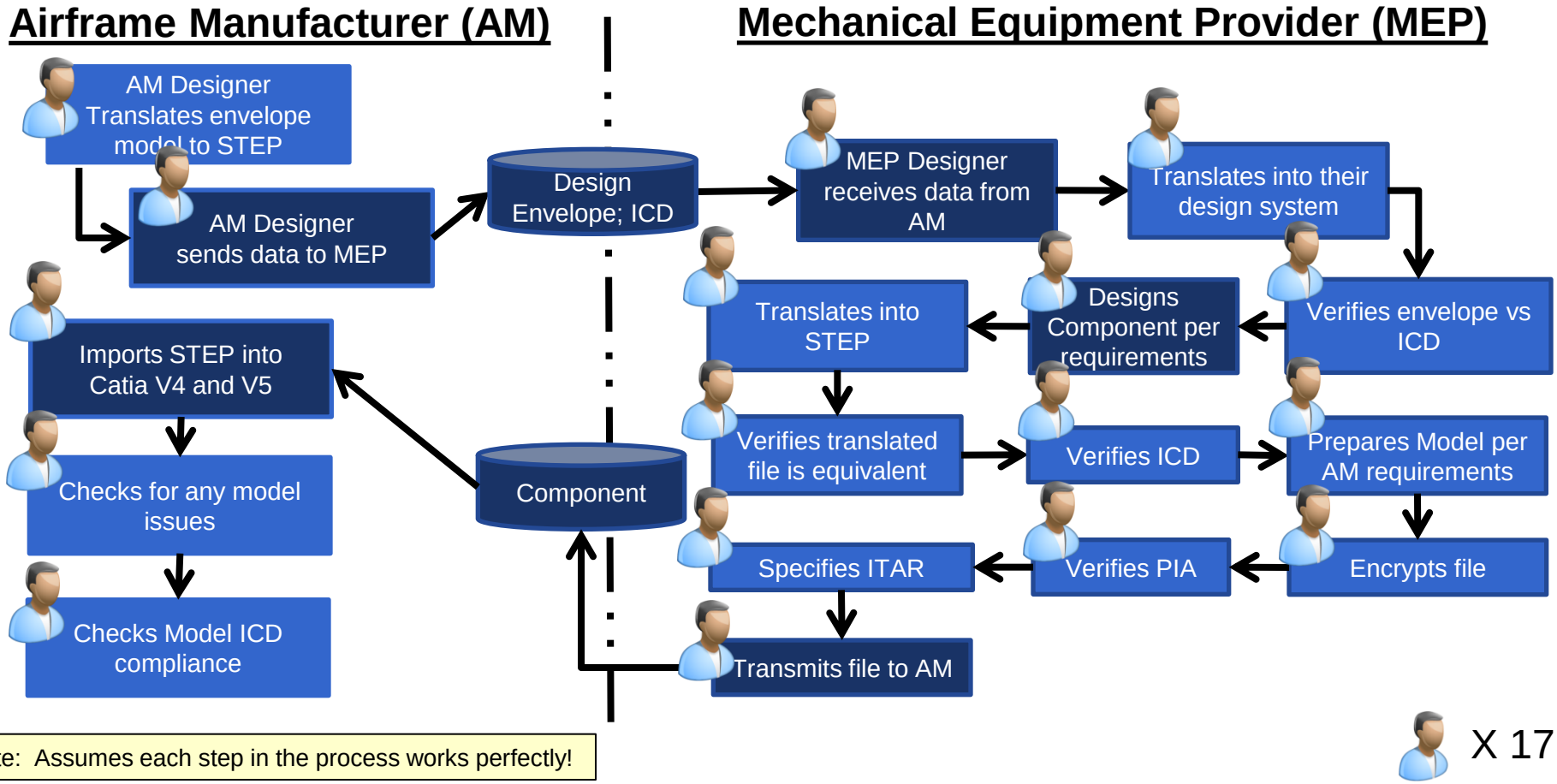


*Note: Assumes each step in the process works perfectly!

Example Demonstration Scenario (Detail view)

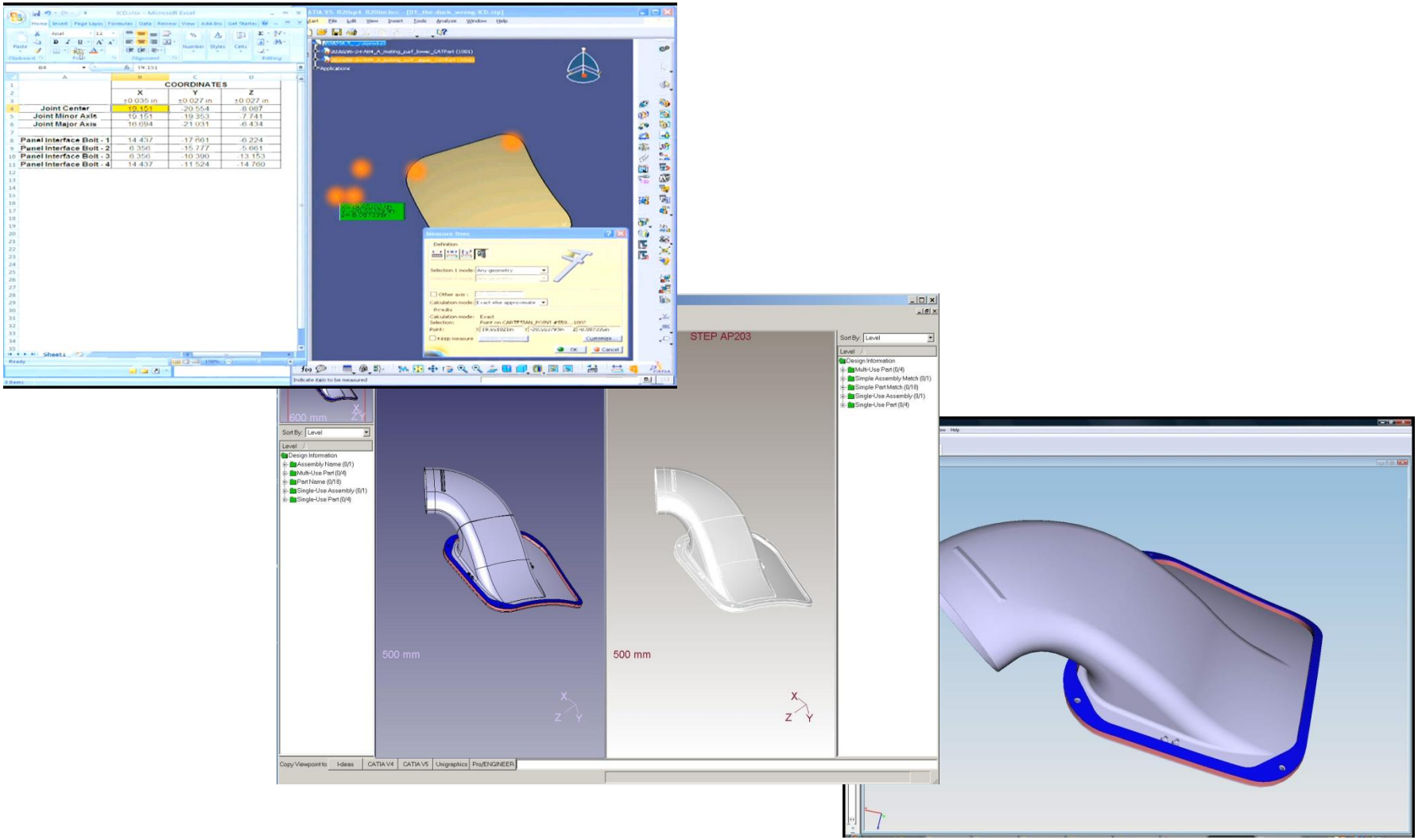
Original Process (Detailed)

= Requires Human Interaction

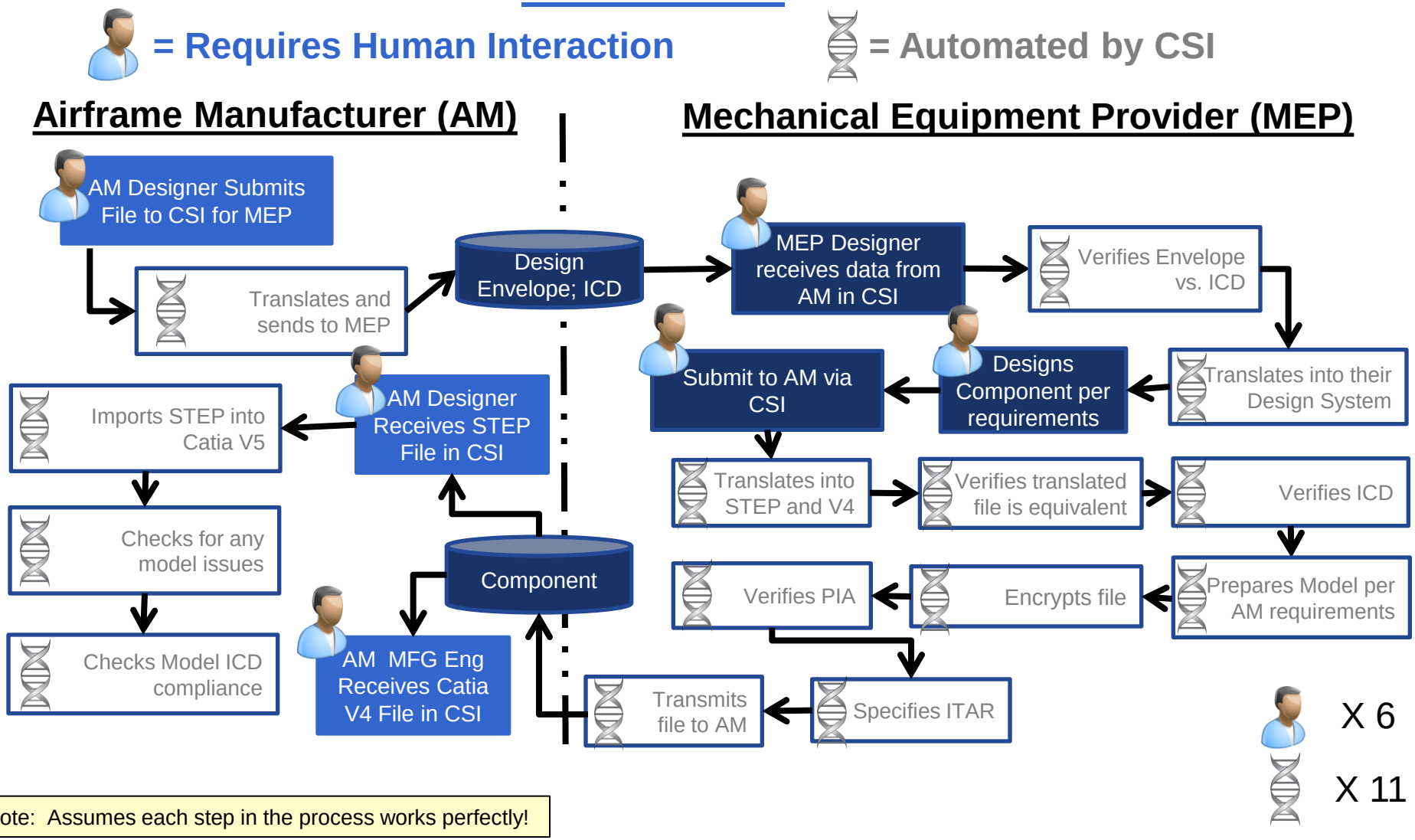


*Note: Assumes each step in the process works perfectly!

Video Demonstration of CSI developed technology
Lockheed Martin – Honeywell
Typical Data Exchange

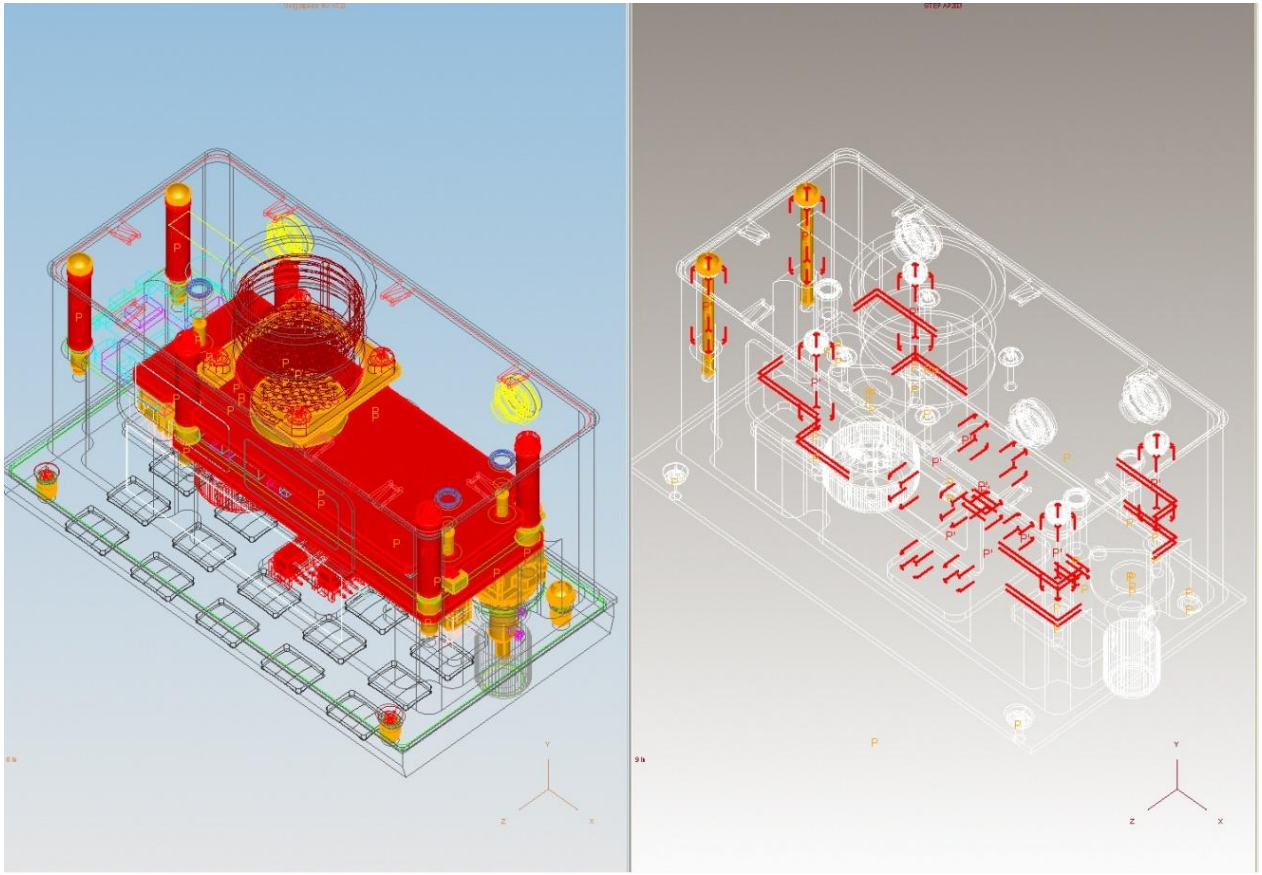


Example Demonstration Scenario (Detail view)



*Note: Assumes each step in the process works perfectly!

Video Demonstration of CSI developed technology
Lockheed Martin – Rockwell Collins
Model Simplification

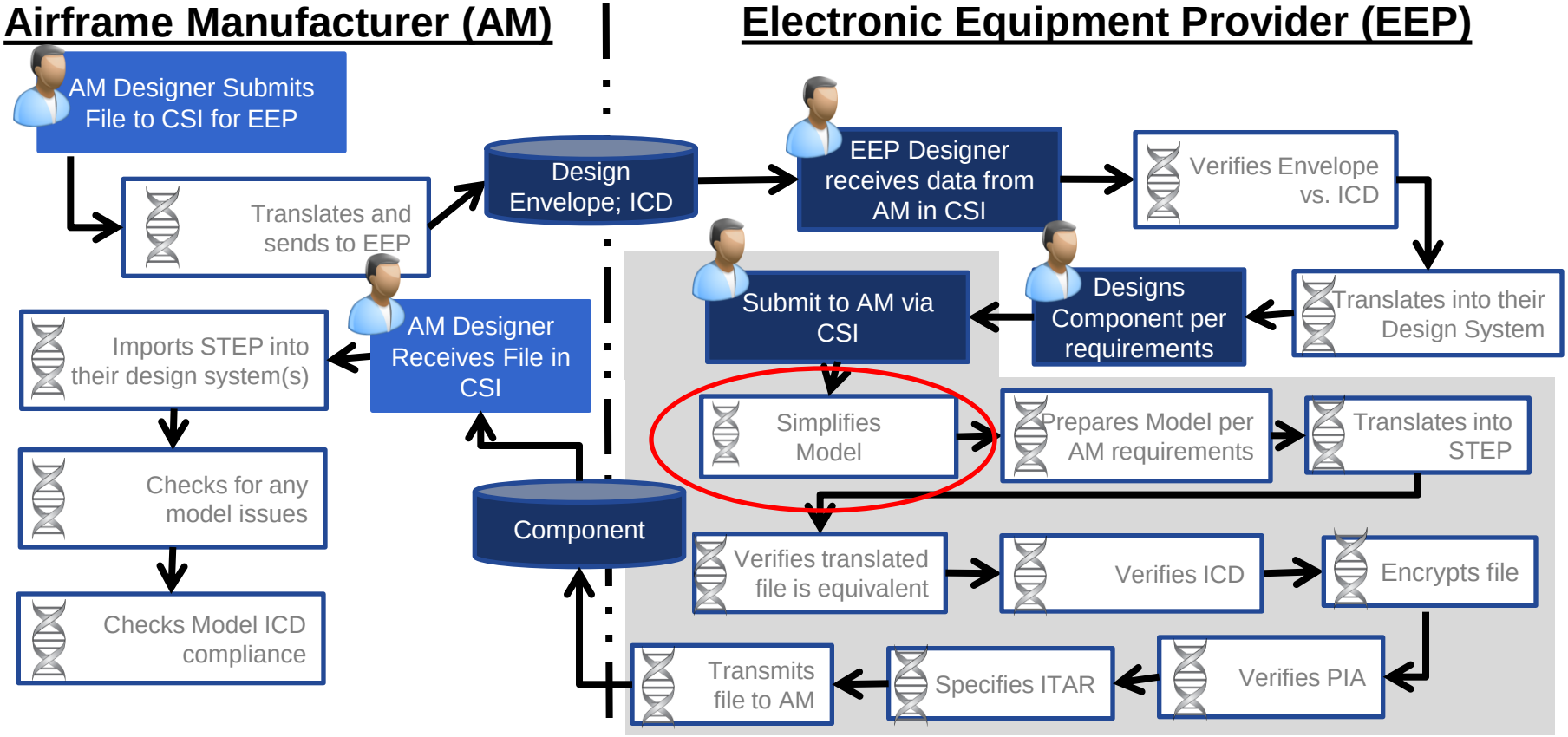


Simplification Demonstration Scenario

CSI PROCESS

= Requires Human Interaction

= Automated by CSI



*Note: Assumes each step in the process works perfectly!

*Note: Unique tasks

CSI Demonstrated Savings – Phase 1 Results

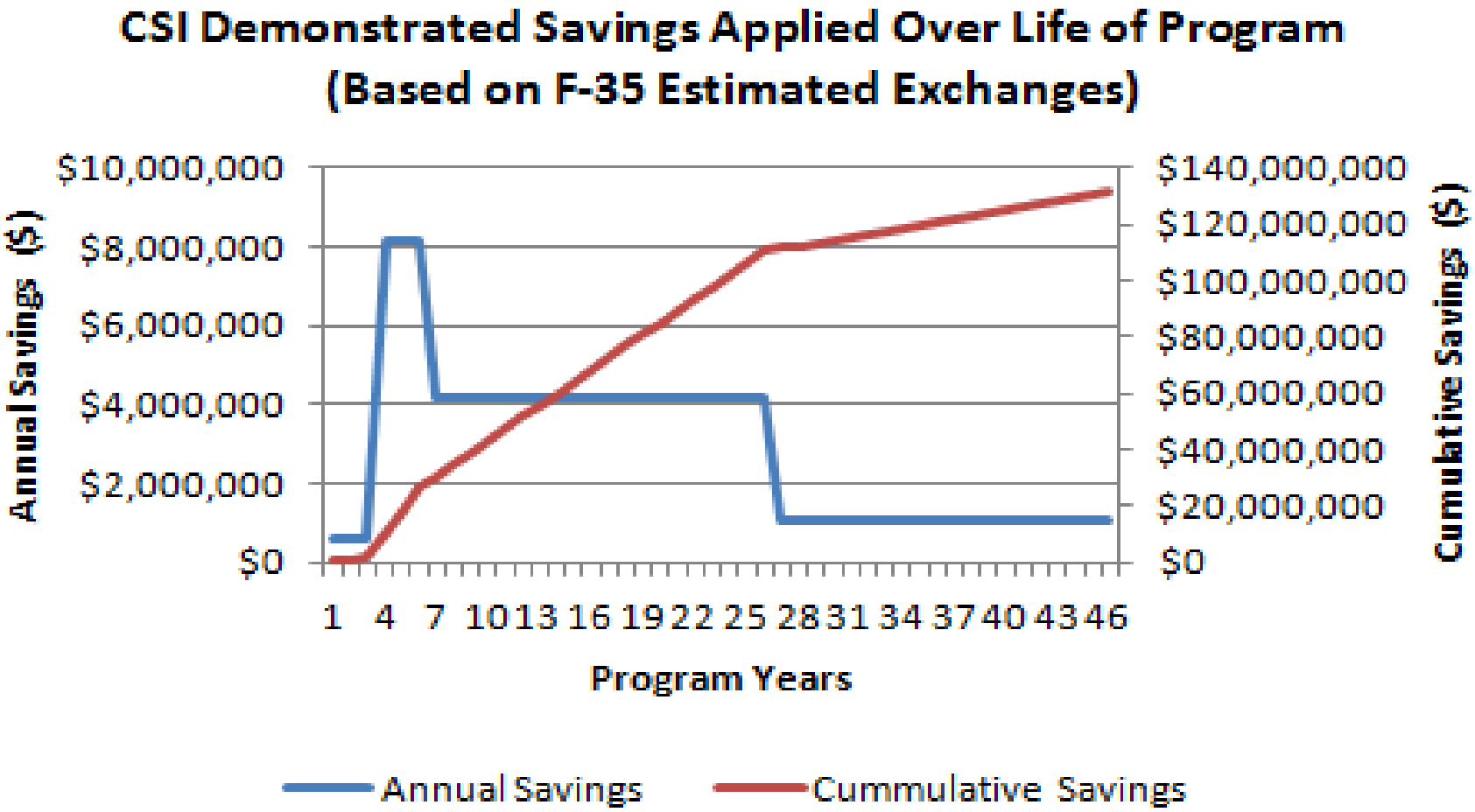
Category	Problem Desciption	Effort per model	Frequency of occurrences	% functionality enabled in Phase I	% Reduction
Automation/ Model Structure	Lack of automation	16	10%	75%	**43%**
	Store multiple models vs create on demand	8	70%	100%	
	ITAR	16	10%	100%	
	Non value added time	16	10%	75%	
	Non automated translation	16	10%	100%	
	Better use of licenses	2	30%	100%	
	Manual exchange	5	10%	100%	
	Extraneous entities	16	70%	80%	
	No modeling standards	16	25%	35%	
	Specific structure	5	25%	35%	
Visualization / Other Formats	DMU - consistent processes	16	10%	25%	**29%**
	DMU process issues	16	70%	25%	
	Visualization processes	5	50%	50%	
Reduce Model Size	Model too large for customer	16	70%	50%	**33%**
	File too large	8	10%	50%	
Improve translations / quality	Bad Translations	16	10%	50%	**68%**
	Can't translate	16	40%	75%	
	Broken asm structure	5	70%	75%	
	Maintain assemblies	16	10%	75%	
	Non value added time	16	10%	75%	
	Non automated translation	16	10%	100%	
Validation	Version upgrade errors	16	10%	100%	**77%**
	No validation of supplier models	16	25%	100%	
	Non value added time	16	10%	75%	
				TOTAL as a percentage	**35%**

Analysis estimates based on FMEA study

Basis for ITI estimated savings on F-35 program

- Program phases
  - Initial design
  - Detail design
  - Production
  - Support
- Number of file exchanges per month from prime to tier 1 suppliers based on phase
  - Initial design - 250
  - Detail design – 2500-4000
  - Production - 2500
  - Support – 625
- Categories of Tier 1 suppliers
  - Suppliers with design responsibility
  - Suppliers with manufacturing responsibility (build to print or build to spec)
- Transactions per file based on type of supplier:
  - Design responsibility (6 transactions)
    - 1 exchange from prime
    - 1 exchange to prime
    - 1 exchange to (2) tier-2 suppliers
    - 1 exchange from (2) tier-2 suppliers
  - Manufacturing responsibility (4 transactions)
    - 1 exchange from prime
    - 1 exchange to prime
    - 1 exchange to (1) tier-2 supplier
    - 1 exchange from (1) tier-2 supplier
- Savings per file per transaction .35 hours from CSI demonstration
- $100 per hour labor rate

CSI Demonstrated Savings (ITI generated analysis)



Savings based on functions developed in Phase 1, integrated into CSI platform and deployed throughout supply chain

Other benefits

- Delivering systems to field quicker ($??)
- Improved reliability through a controlled, repeatable process ($??)

Accelerating MBE deployment – CSI contract addendums

Benefits

- Potentially enables a more efficient transition from drawing to model-based definition
- May provide an alternate path to translation of featured models

Honeywell

Draw-to-PMI (MBD Generator)

Automation to merge associative 2D GD&T into the model and produce associative 3D PMI

Rockwell Collins

Critical Problem Resolution (CPR) Process

Detects and resolves model issues in design for manufacturability

Benefits

- Eliminate un-producible features – better quality model
  - Identify potential problems; collaboratively resolve with supply chain
    - Reduce rework or scrap due to design escapes
      - Eliminate model ambiguity that otherwise drives design revision
      - Improve model translation success and designer productivity

Benefits

- Support MBE approach - maintain the digital thread
- Streamlines design to manufacturing process within supply chain
- Increased product quality due to higher confidence in data handoff
- Reduce scrap due to conversion/interpretation issues
- Reduce cycle time through automation of conversion & validation

3D PMI Translation

Translation of associative 3D models and 3D PMI between dissimilar CAD environments

Lockheed Martin

3D ECO Documentation

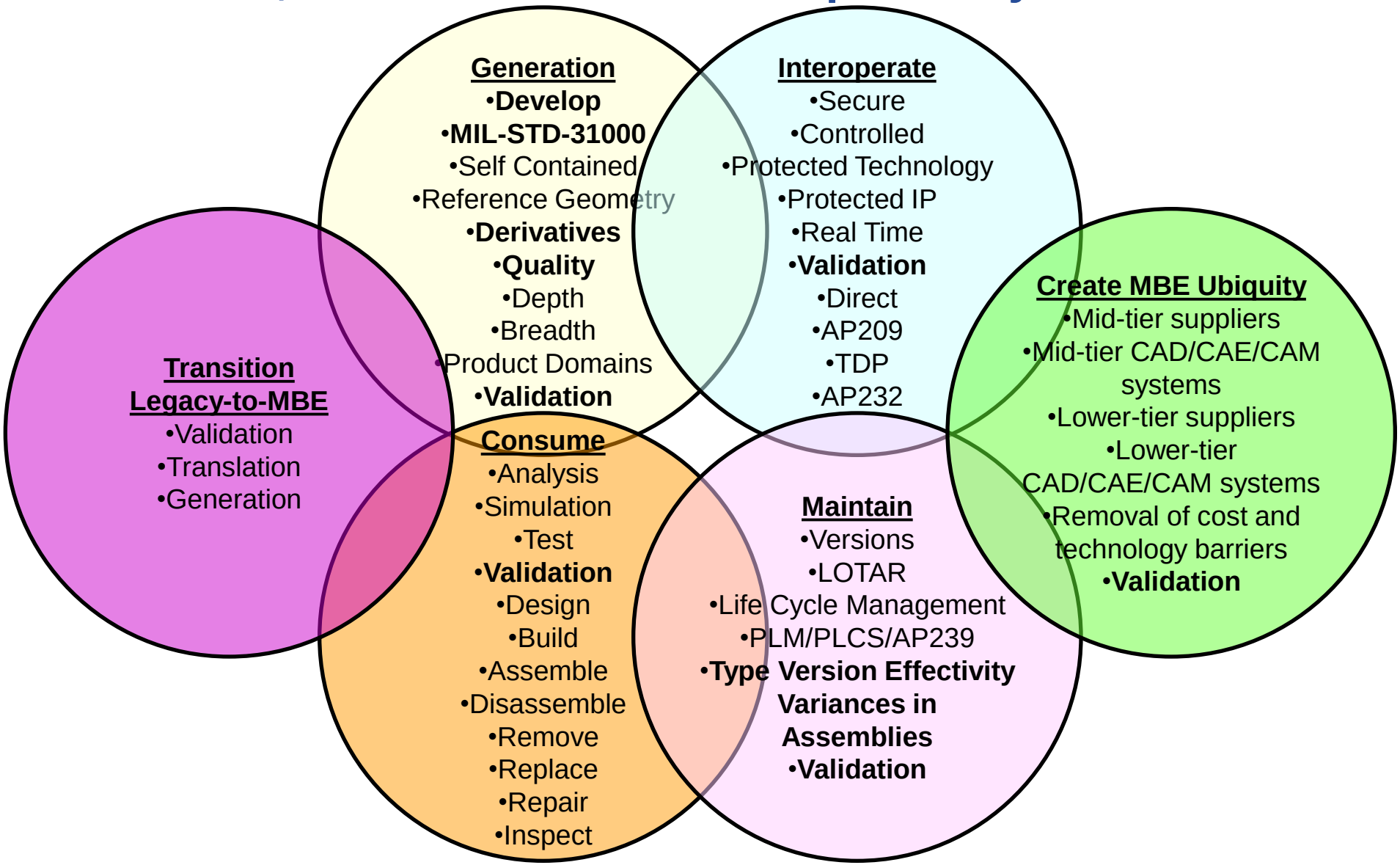
Document model changes in a 3D format that greatly improves communication in the MBE

Rockwell Collins

Benefits

- Eliminates need for drawing-based documentation of design change
- Improves designer productivity (reduces time) in model/drawing revision
- Improves quality; model is explicit master; fully represents/documents change
- Necessary step toward full model based design (eliminating drawing)

CSI Team Brain Storming Concept Synthesis - MBE Model Generation, Maintenance and Interoperability



Questions?

For More Information:

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CUSTOMER SUPPLIER INTEROPERABILITY

Building the Digital Thread

Raising the Value of Your Product Data

Product Data Integration & Interoperability Solutions