CIMdata® 2016 PLM Road Map for Aerospace & Defense

Global Collaboration

Improving Collaboration in the Aerospace & Defense Design Chain

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Introduction

PLM Global Collaboration is a major topic of concern in the A&D industry

Global Collaboration for the purposes of this research is defined to be comprised of data standards and work processes used for sharing and working with product data among A&D OEMs and their product design and manufacturing engineering partners and suppliers.

Motivation for investment

- Identifying, characterizing and remediating the points of friction in the flow of product information across locations, collaboration entities and between applications during product development
- Identifying and providing justification of the need for PLM software providers to support development and then to implement data exchange standards within their products

Phase 1 Overview

Define taxonomy and identify improvement priorities for future in depth research

- Taxonomy of six dimensional global collaboration space
  - Program phase (When)
  - Collaboration entity (Who)
  - Collaboration purpose (Why)
  - Collaboration environment (Where)
  - Collaboration content (What)
  - Collaboration process & technical capabilities (How)
- Survey of members
  - Determine Improvement Priorities – i.e., nodes with greatest improvement potential within the six dimensional global collaboration space
  - Initial characterization of gaps and trends for identified Improvement Priorities

Current State Assessment

Collaboration characterization – volume by entity by program phase

Table below shows collaboration entities and volume of collaboration during various program phases

Program Phase	Collaboration Entity					
	OEM Remote Site (Internal)	Design & Build Partner	Equipment & System Supplier	Design Supplier	Build to Print Supplier	Tooling Design Supplier
Concept	2.5	1.5	1.3	1.1	0.5	0.2
Initial Development	3.5	3.2	2.3	2.5	1.0	1.6
Detailed Development	4.3	4.8	3.0	3.3	2.0	3.3
Test (partial)	4.0	3.7	2.7	3.3	3.0	2.3

Very High (4.4-5.0)
High (3.7-4.3)
Moderate (3.0-3.6)
Low (2.0-2.9)

Current State Assessment

Collaboration characterization – volume by purpose by entity

Table below shows the purpose and volume of collaboration with various collaboration entities

Collaboration Entity	Collaboration Purpose						
	Work assignment & des'n delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change	Supplier selection – RFx and response	Contractual Discussions
OEM Remote Site (Internal)	4.0	4.5	4.6	4.3	3.8	0.2	1.0
Design & Build Partner	4.0	4.4	3.8	4.3	3.8	1.6	2.3
Equip't & System Supplier	2.3	2.7	2.3	2.7	2.3	2.3	2.0
Design Supplier	3.6	3.8	3.4	3.4	3.7	1.6	1.7
Build to Print Supplier	2.3	1.7	1.7	1.3	2.0	2.3	1.3
Tooling Design Supplier	2.3	1.6	2.3	1.5	2.0	1.1	1.3

Very High (4.4-5.0)
High (3.7-4.3)
Moderate (3.0-3.6)
Low (2.0-2.9)
Very Low (<2.0)

Current State Assessment

Collaboration characterization – volume by environment by purpose

Table below shows collaboration environments and volume of collaboration for various collaboration purposes

Collaboration Purpose	Collaboration Environment			
	Joint session (inside firewall)	Joint project repository (inside firewall)	Joint sharing repository (outside firewall)	Send/receive files (outside firewall)
Work assignment & design delivery	1.6	2.6	1.4	4.1
Simultaneous design & eval'n	3.2	4.4	3.0	2.7
DMU Baselining	4.0	4.6	3.5	1.8
Design review & approval	2.8	3.1	1.5	1.4
Engineering change	1.8	3.3	2.4	1.9
Supplier selection – RFx and response	0.2	1.1	0.1	1.7
Contractual Discussions	0.0	0.3	0.0	1.3

Very High (4.4-5.0)
High (3.7-4.3)
Moderate (3.0-3.6)
Low (2.0-2.9)
Very Low (<2.0)

Current State Assessment

Collaboration characterization – volume by type of geometric content by purpose

Table below shows types and volume of geometric content shared for various collaboration purposes

Collaboration Purpose	Collaboration Content Type – Geometry				
	Complete native 3D model	Simplified native 3D model	Standard format 3D model (STEP, IGES, other)	Visualization model (JT, 3D PDF…)	2D models (images, drawings…)
Work Assignment & Design Delivery	4.2	2.8	2.2	1.1	2.3
Simultaneous design & eval'n	5.0	2.6	1.8	1.5	2.3
DMU Baselining	4.3	2.8	1.0	1.6	1.5
Design review & approval	3.3	3.0	1.1	2.2	3.4
Engineering change	3.8	2.1	1.5	1.9	1.8
Supplier Selection – RFx and Response	3.2	1.8	1.1	1.0	2.2
Contractual Discussions	0.0	1.0	1.0	0.0	2.0

Very High (4.4-5.0)
High (3.7-4.3)
Moderate (3.0-3.6)
Low (2.0-2.9)
Very Low (<2.0)

Current State Assessment

Collaboration characterization – volume by type of ancillary content by purpose

Table below shows types and volume of ancillary content shared for various collaboration purposes

Collaboration Purpose	Collaboration Content Type – Ancillary Information					
	Requirements	Interface control specification	Technical standards	Simulation, analysis & test results	Bill of material	Planning Information *
Work Assignment & Design Delivery	3.0	3.1	3.5	1.9	3.4	1.7
Simultaneous design & eval'n	2.9	3.1	2.8	2.5	4.0	0.7
DMU Baselining	1.8	3.4	2.3	2.8	2.8	1.0
Design Review & Approval	3.0	3.3	4.0	3.8	4.0	1.3
Engineering Change	2.9	2.8	2.9	2.4	3.3	1.3
Supplier Selection – RFx and Response	1.2	0.8	1.1	0.3	0.8	0.7
Contractual Discussions	0.7	1.7	1.0	0.7	1.0	1.7

Very High (4.4-5.0)
High (3.7-4.3)
Moderate (3.0-3.6)
Low (2.0-2.9)
Very Low (<2.0)

Current State Assessment

Evaluation – Collaboration importance self-assessment (Importance~= Volume)

Table below shows for each collaboration entity, how the importance of collaboration varies by collaboration purpose

Collaboration Entity	Collaboration Purpose						
	Work assignment & des'n delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change	Supplier select'n – RFx & response	Contractual Discussions *
OEM Remote Site (Internal)	4.0	4.5	4.6	4.6	4.1	0.2	n.a.
Design & Build Partner	4.3	4.4	3.8	4.6	4.3	1.8	2.7
Equip't & System Supplier *	3.0	3.0	2.3	3.0	3.0	2.7	2.3
Design Supplier	3.8	3.8	3.4	3.7	4.2	1.8	2.0
Build to Print Supplier *	2.7	1.7	1.7	1.7	2.3	2.3	1.7
Tooling Design Supplier	2.5	1.6	2.3	1.8	2.3	1.6	2.0

Very High (4.4-5.0)
High (3.7-4.3)
Moderate (3.0-3.6)
Low (2.0-2.9)
Very Low (<2.0)

Current State Assessment

Evaluation – Collaboration performance self-assessment

Table below shows for each collaboration entity, how the collaboration performance varies by collaboration purpose

Collaboration Entity	Collaboration Purpose						
	Work assignment & des'n delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change	Supplier select'n – RFx & response	Contractual Discussions
OEM Remote Site (Internal)	3.6	3.8	3.8	3.9	4.2	1.7	n.a.
Design & Build Partner	2.2	2.3	2.8	2.8	3.1	1.7	2.0
Equip't & System Supplier	1.3	1.3	1.7	1.7	2.0	1.3	2.0
Design Supplier	2.4	2.5	2.6	2.8	3.3	1.7	2.0
Build to Print Supplier	1.7	0.7	0.7	0.7	2.3	1.3	2.0
Tooling Design Supplier	1.6	1.4	1.8	2.3	2.3	1.3	2.0

Very High (4.4-5.0)
High (3.7-4.3)
Moderate (3.0-3.6)
Fair (2.0-2.9)
Poor (< 2.0)

Current State Assessment

Evaluation – Improvement priorities – Importance minus performance

The original method devised for rating improvement priorities was to subtract the performance rating from the importance rating.

Collaboration Entity	Collaboration Purpose						
	Work assignment & des'n delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change	Supplier select'n – RFx & response	Contractual Discussions
OEM Remote Site (Internal)	0.4	0.8	0.8	0.7	-0.1	-1.5	n.a.
Design & Build Partner	2.1	2.2	1.0	1.9	1.2	0.1	0.7
Equip't & System Supplier	1.7	1.7	0.6	1.3	1.0	1.4	0.3
Design Supplier	1.4	1.3	0.8	1.0	0.9	0.1	0.0
Build to Print Supplier	1.0	1.0	1.0	1.0	0.0	1.0	-0.3
Tooling Design Supplier	0.9	0.2	0.5	-0.5	0.0	0.3	0.0

Very High (2.1-3.0)
High (1.6-2.0)
Moderate (1.1-1.5)
Low (0.6-1.0)
Very Low (<0.6)

Topics to Probe More Deeply

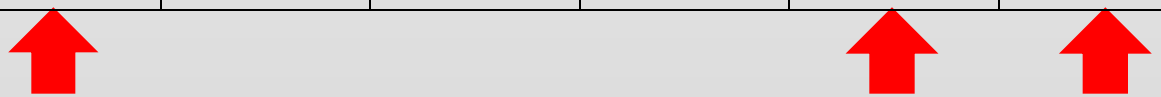
Focus on collaboration processes most frequently cited for performance problems

Collaboration process steps with performance problems:								
Opp'y #	Collaboration environment set up	Security Admin'n	Information Preparation	Information Send or Post & Notify	Inquiry & Response	Information Receive	Information QA & Remediation	Information Post & Notify Internally
1	**XX**	**X**	**XX**	**XXX**	**XXX**		**X**	**X**
1c	**X**		**X**	**X**	**X**		**X**	
2	**XX**		**XX**		**X**			
2c	**X**		**X**					
3	**X**		**X**	**X**		**X**		
3c	**X**		**X**	**X**		**X**		
4	**X**		**X**	**X**	**X**	**X**	**X**	**X**
5			**X**	**X**	**X**	**X**		
Total	**10**	**1**	**10**	**8**	**7**	**4**	**3**	**2**

Topics to Probe More Deeply

Focus on technical capabilities most frequently cited for performance problems

Collaboration technical capabilities with performance problems:						
Opp'y #	Shared views	View manipulation	Markup	Metadata view & edit	Evaluation	Simulation
1	**X**			**X**	**X**	**X**
1c				**X**		
2	**XX**				**X**	**X**
2c						**X**
3	**X**	**X**	**X**		**X**	**X**
3c	**X**	**X**	**X**		**X**	**X**
4	**X**				**X**	**X**
5			**X**	**X**	**X**	
Total	**6**	**2**	**3**	**3**	**6**	**6**



Phase 2 Overview

Research probes deeper across a broader cross-section of the industry

Scope

- Phase 1: Develop a taxonomy of product development collaboration, and survey Members to characterize PLM global collaboration as currently practiced and experienced within Member OEMs and their extended product development ecosystem.
- Phase 2: Conduct a deeper investigation of the high priority improvement areas identified in Phase 1, and heighten confidence in the findings by gathering information from a broader, statistically significant community.

Phase 2 Focus

Collaboration Entity	Collaboration Purpose						
	Work assignment & des'n delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change	Supplier select'n – RFx & response	Contractual Discussions
OEM Remote Site (Internal)	0.4	0.8	0.8	0.7	-0.1	-1.5	n.a.
Design & Build Partner	2.1	2.2	1.0	1.9	1.2	0.1	0.7
Equip't & System Supplier	1.7	1.7	0.6	1.3	1.0	1.4	0.3
Design Supplier	1.4	1.3	0.8	1.0	0.9	0.1	0.0
Build to Print Supplier	1.0	1.0	1.0	1.0	0.0	1.0	-0.3
Tooling Design Supplier	0.9	0.2	0.5	-0.5	0.0	0.3	0.0

Very High (2.1-3.0)
High (1.6-2.0)
Moderate (1.1-1.5)
Low (0.6-1.0)
Very Low (<0.6)

Information Gathering

Extended effort yielded statistically acceptable level of response

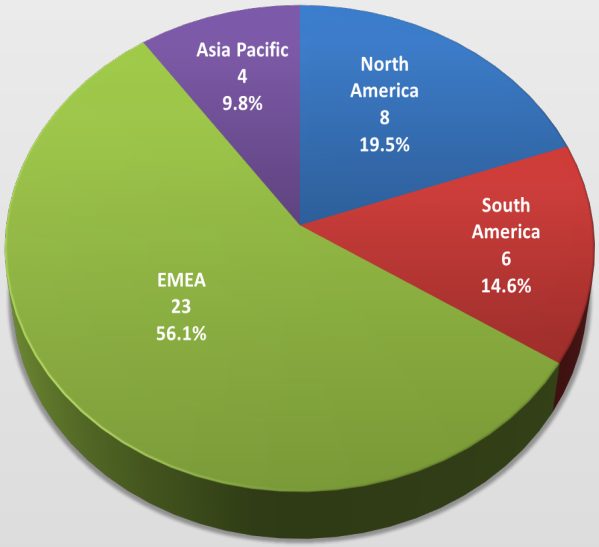
Effort

- Response period extended from 6 weeks to 4 months
- Significant effort from A&D Members and CIMdata staff

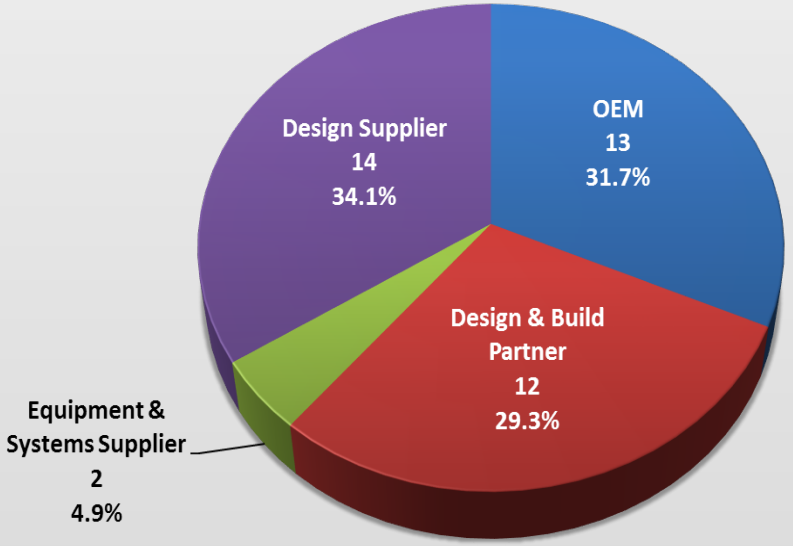
Response demographics

- 41 survey responses from 20 companies received

Geographic Distribution of Responses



Respondent Companies Self-Identification



Survey Results: Environments

Collaboration ENVIRONMENT versus Collaboration PURPOSE

- All four environments used equally on average
  - Environments inside firewall most used for Work Assignment & Design Delivery as well as Engineering Change
  - Environments outside firewall most used for DMU Baselining
- OEMs work most often:
  - Inside the firewall with Design & Build Partners
  - Outside the firewall with Design Suppliers

Summary View (All Respondents)

Collaboration Environment	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
Joint Session (inside firewall)	3.3	3.6	2.7	3.2	3.2
Joint Project Repository (inside firewall)	3.4	2.8	2.8	3.2	3.6
Joint Sharing Repository (outside firewall)	2.6	2.9	3.3	3.7	2.6
Send/Receive Files (outside firewall)	2.9	3.0	3.6	2.7	2.7

Very High (4.4-5.0)
High (3.7-4.3)
Moderate (3.0-3.6)
Low (2.0-2.9)
Very Low (<2.0)

Survey Results: Content (Geometric)

Collaboration CONTENT (Geometric Data) versus Collaboration PURPOSE

- Pattern of usage similar across all Collaboration ENTITIES
- Highest volume for Work Assignment & Design Delivery
- Simplified native 3D CAD is most used by Design & Build Partners and least used by OEMs

Summary View (All Respondents)

Collaboration Content	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
Complete Native 3D CAD Model	3.7	2.5	2.5	2.9	3.4
Simplified Native 3D CAD Model	4.1	2.9	2.3	2.9	2.7
Standard Format 3D Model (STEP, IGES, etc.)	4.0	3.3	2.6	3.0	2.7
Visualization Model (JT, 3D PDF, etc.)	3.9	2.7	2.2	3.0	3.3
2D Models (images, drawings, etc.)	3.6	2.5	2.2	2.7	3.3

Very High (4.4-5.0)
High (3.7-4.3)
Moderate (3.0-3.6)
Low (2.0-2.9)
Very Low (<2.0)

Survey Results: Process Problems

Collaboration ENTITY versus Collaboration PROCESS STEP

- Design & Build Partners voiced the most concerns

Respondents' Self-Selected Collaboration Entity	Collaboration Process							
	Collaboration Environment Set Up	Security Administration	Information Preparation	Information Send or "Post & Notify"	Inquiry & Response	Information Receive	Information QA & Remediation	Information "Post & Notify" Internally
OEM	2.0	2.1	2.3 (1)	1.0	1.4	1.0	2.0	1.2
Design & Build Partner	(2) 2.3	2.1 (3)	1.8 (1)	1.8	2.3 (1)	1.7 (1)	(1) 2.0 (1)	1.5
Equipment & Systems Supplier	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0
Design Supplier	(2) 2.4 (1)	(1) 1.9	1.5	1.3	1.5	1.5	1.6 (1)	1.3

None
Severe (>4.0)
Very Bad (3.1-4.0)
Bad (2.1-3.0)
Moderate (1.1-2.0)
Minor (<=1.0)

(n) - Number of responses with problems rated as Severe

(n) - Number of responses with problems rated as Very Bad

Survey Results: Technical Problems

Collaboration ENTITY versus Collaboration TECHNICAL CAPABILITY

- Design & Build Partners and Design Suppliers voiced the most concerns
- Often respondents answered that a capability was not used (CIMdata inferred that a collaboration tool was not used)

Respondents' Self-Selected Collaboration Entity	Collaboration Technical Capabilities						
	Shared Views	View Manipulation	Markup	Metadata View & Edit	Evaluation	Simulation	Geometry Edit
OEM	1.7	2.0	2.0	0.8	1.6	2.2	1.8
Design & Build Partner	2.0 (1)	1.6	1.6	2.0 (1)	1.9	2.1	1.9 (1)
Equipment & Systems Supplier	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Design Supplier	1.4	1.2	1.0 (1)	0.7	1.1	1.5 (1)	(2) 1.8

None
Severe (>4.0)
Very Bad (3.1-4.0)
Bad (2.1-3.0)
Moderate (1.1-2.0)
Minor (<=1.0)

n - Number of responses with problems rated as Severe

n - Number of responses with problems rated as Very Bad

Telephone Interview Results: Use of Standards

Subset of respondents interviewed to understand use of standards in collaboration

- Interview comments
  - Standards for CAD data exchange such as STEP are rarely used internally by OEMs. They use native data and direct translators for most internal exchanges. Exchange is often automated.
  - OEMs often do CAD data exchange with Suppliers using STEP (AP 203, AP214, AP 242), and sometimes IGES
  - JT is used for visual collaboration at some OEM sites
- CIMdata observations
  - OEMs tend to want their supply chain to use CAD data in its native format, yet
    - Some participants have older versions of CAD solutions that can't open data from newer versions
    - IP is more difficult to protect when native CAD files are used
  - All felt standard-based exchange was desirable and needed
    - Yet converters often fail on large data sets
    - Use of standards does not mitigate bandwidth issues

Conclusions

Collaboration Problems

- Majority of reported problems were related to process rather than technology
- Collaboration Environment Set Up is the most problematic
- Rather than the assumed belief that use of CAD data exchange standards would improve collaboration, surveyed respondents instead listed standardization of:
  - IP protection and export control
  - Workflow processes
  - CAD data quality validation
  - Stable data segmentation guidelines
- Improved logging and tracking of information requests needed
- Metadata sharing (configuration, change process, …) needed
- Most severe technical problem is network latency and data transfer rate

Conclusions

Use of Standards

- Standards-based data exchange is working in production today in the A&D supply chain
  - Could be used within OEMs, however, direct translators are already built into OEM processes
- In the A&D supply chain heterogeneity is a fact of life
  - Use of standards accepted and applied on a regular basis
  - View of standards is positive and “good enough”

Recommendations

Actions that can be taken in the near- and mid-terms (1 of 3)

- Geometry validation should be performed before data is shared
  - CAD solution providers and third-parties already offer geometry validation tools, most of which can be customized to best fit a user's specific needs
  - At minimum the tools should validate that geometry does not have holes or gaps in the surfaces and solid model structures
- Companies should do a market review to identify any existing tools that can provide a solution to an inquiry and response tracking requirement
  - An inquiry and response tracking system should be put into place between collaboration entities
  - If an appropriate tool cannot be found, companies should work with their primary PLM solution providers to define and implement a collaboration inquiry and tracking tool that can be used between Collaboration Entities

Recommendations

Actions that can be taken in the near- and mid-terms (2 of 3)

- Explore possibility of having solution providers implement a "Where located" capability for components and subassemblies
  - Companies should explore with their CAD solution provider the possibility of implementing a "Where Located" (i.e. in storage) capability
  - The solution providers already provide a "Where Used" function and the basic building blocks should already be in place to implement "Where Located"
- Investigate possibility of implementing PDF-building scripts for packaging data exchange between collaboration entities
  - Suppliers complain that each OEM with whom they deal has different standards of how to package and transfer data
  - Processes can be put in place when data is to be shared with a Collaboration Entity, the appropriate script is identified and run to build the necessary data package

Recommendations

Actions that can be taken in the near- and mid-terms (3 of 3)

- Available COTS collaboration solutions should be investigated, selected, and used
  - The response “not used” is repeated several times in the comments to indicate that a collaboration capability available in COTS collaboration solutions is not used

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