

PLM Global Collaboration Phase 2 Research Report

Investigation of High Potential Improvement
Opportunities

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Sponsored by
Aerospace & Defense PLM Action Group

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PLM Global Collaboration Phase 2 Research Report

Investigation of High Priority Improvement Areas

INTRODUCTION

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.

Within its 2014-15 research agenda, the A&D PLM Action Group identified PLM Global Collaboration as a high priority topic. The Group commissioned CIMdata to develop a taxonomy of product development collaboration, and prepare a survey to capture a generalized characterization of PLM global collaboration as currently practiced and experienced within the extended A&D product development ecosystem.

As part of its 2015-16 research agenda, the A&D PLM Action Group commissioned CIMdata to conduct a deeper investigation of the high priority improvement areas identified in Phase 1 of global collaboration research, and to heighten confidence in the findings by gathering information from a broader, statistically significant community. The Phase 1 survey experience provided lessons that were incorporated as refinements to the structure, format, and process for conducting the Phase 2 survey.

The Phase 2 research used a more formal survey that concentrated on the most critical global collaboration areas identified in Phase 1. The survey was completed by both A&D Action Group members as well as people from other aerospace companies. Interviews were performed with selected companies to gather additional insight into collaboration issues. Methods were applied to avoid disclosing each company's product and process strategies to other research participants.

This report presents a characterization and assessment of processes, data formats, and other aspects of collaboration between A&D OEMs and their design partners and suppliers in collaboration scenarios with high potential for improvement. The report also presents recommendations that the A&D PLM Action Group members can pursue to improve their collaboration capabilities, including a draft position statement that the Members can use to influence solution provider future developments.

PHASE 1 SUMMARY

The primary goals of the Phase 1 research were to develop a PLM Global Collaboration Taxonomy and to evaluate the Members' current collaboration ecosystem in order to identify and prioritize collaboration improvement opportunities. These goals were accomplished. The research also helped identify and provide insights on weaknesses, barriers, and problems in the current state of collaboration.

The Taxonomy developed in the Phase 1 research project (attached to this report for reference as Appendix A) sets forth a representation of PLM global collaboration in six primary dimensions:

- Program Phase (When)
- Collaboration Entity (Who)
- Collaboration Purpose (Why)
- Collaboration Environment (Where)
- Collaboration Content (What)
- Collaboration Process & Technical Capabilities (How)

The top five PLM global collaboration improvement opportunities identified in the Phase 1 research are shown in Table 1.

Table 1—Top Five PLM Global Collaboration Improvement Opportunities

Collaboration Entity	Collaboration Purpose							
	Work Assignment & Des'n Delivery	Simultaneous Design & Evaluation	DMU Baselineing	Design Review & Approval	Engineering Change	Supplier Selection – RFx & Response	Contractual Discussions *	
OEM Remote Site (Internal)							n.a.	Very High (7.1-9.0)
Design & Build Partner	1 8.1	2 7.2	3 3.9	4 3.8	5 3.3			High (5.1-7.0)
Equip't & System Supplier *	↓	↓	↓					Moderate (3.1-5.0)
Design Supplier	↓ 4.4	↓ 3.3	↓ 3.8					Low (1.1-3.0)
Build to Print Supplier *								Very Low (<1.1)
Tooling Design Supplier								

The space highlighted by a red box in Table 1 indicates the areas of greatest interest for further research investigation.

RESEARCH SCOPE

This Phase 2 research investigated the subset of three Collaboration Entities and five Collaboration Purposes that were identified during the Phase 1 project as offering the highest potential for improvement. The Phase 2 research explored a narrower scope in greater depth, targeting a sample size of 40-50 respondents so that results would be statistically reliable and broadly representative of the A&D industry.

Research Focus

The Phase 2 survey was refined to focus on the five high priority Collaboration Purposes identified in Phase 1, and to explore the first two more deeply:

- Work Assignment & Design Delivery

- Simultaneous Design & Evaluation
- DMU Baselineing
- Design Review & Approval
- Engineering Change

The Phase 2 survey explored the following Collaboration Process steps:

- Collaboration environment set up
- Security administration
- Information preparation
- Information send or post and notify
- Inquiry & response
- Information receive
- Information QA and remediation
- Information post & notify internally

The Phase 2 survey explored the following Collaboration Technical Capabilities:

- Shared views
- View manipulation
- Markup
- Metadata view & edit
- Evaluation
- Simulation

Research Sources

Sources were selected to provide information and insights from three key perspectives within the “design chain”:

- A&D OEMs
- Design & Build Partners
- Equipment & System Suppliers

RESEARCH GOALS AND METHODOLOGY

The following goals and methodology for the Phase 2 research were defined and agreed with the Members and documented in the project plan in advance of project approval and initiation.

Goals

CIMdata conducted this research on Global Collaboration processes, data formats, and other collaboration aspects applicable to A&D global product design activities and design partner collaboration. The research was intended to develop recommendations that the A&D PLM Action Group members can pursue to improve their collaboration capabilities, including a draft position statement that the Members can use to influence solution provider future developments. To achieve this intent, the Phase 2 research plan was crafted with two main goals:

- Broaden the size and breadth of the surveyed community so that the results would be statistically representative of the industry
- Explore more deeply the high potential collaboration performance improvement opportunities identified in the Phase 1 research

A secondary outcome of achieving the first goal is a measure of the degree to which the members' characterizations and self-evaluations in the Phase 1 project are consistent with those of the broader A&D industry.

Methodology

The primary research method for Phase 2 was an online survey (offered in paper form as required) based on the PLM Global Collaboration Taxonomy that was developed and agreed with the A&D PLM Action Group members in Phase 1 of this research. The Phase 2 survey focused on those areas of the Taxonomy deemed of high potential as revealed in the Phase 1 results. The survey was followed by telephone interviews of a subset of respondents to clarify and expand upon the information they provided.

The research plan included specific features that addressed lessons learned during the Phase 1 project:

- Respondents' knowledge is limited; so incomplete surveys need to be accommodated
- Respondents' interpretations vary, so survey has to be unambiguous
- Survey must be much shorter than the survey used in Phase 1
- Participation incentives will be needed

All research was done without disclosing any A&D PLM Action Group member's practices or strategies to other members or to research survey respondents. The same level of confidentiality was applied to information from other survey respondent companies.

The Phase 2 research proceeded according to the following five stages and steps.

Survey Design

1. CIMdata prepared a revised DRAFT online survey of ~30 questions focused on the high potential areas identified in Phase 1
2. CIMdata submitted the DRAFT survey to the A&D PLM Action Group members for review and comment

3. CIMdata revised the DRAFT survey based on comments and submitted a final Survey for the A&D PLM Action Group members' approval

Participation Plan

4. CIMdata with guidance and approval from the A&D PLM Action Group members developed a specific target list of 60 to 80 companies¹ to provide the desired information and insights from three industry communities:
 - A&D OEMs
 - Design & Build Partners
 - Equipment & System Suppliers
5. CIMdata and the A&D PLM Action Group members jointly developed a strategy and communication process to achieve a high level of participation. The process anticipated sensitivity of communication with partners and suppliers and include the following points:
 - Members informed their Supplier Management organizations that they will be inviting suppliers to participate as information sources for this research
 - Suppliers were informed that participation was without obligation and voluntary

During the planning process, methods to contact potential participants and means to increase the likelihood of their completing the survey were considered, including:

- Individual targeting and personal invitation and follow-up by CIMdata and Members
 - Providing a gift or other incentive
6. Approximately 40 companies (OEM & Tier 1) were to take the survey; appropriate contacts were to be made with at least double that number, soliciting their agreement to participate.

Survey Execution

7. CIMdata posted the final survey online and communicated the location of the survey to companies who had agreed to participate
8. Invitees were to be given four weeks to respond. CIMdata and Members e-mailed reminders and applied other methods according to plan if participation was not readily forthcoming

Analysis

9. CIMdata analyzed the results of the research survey in detail to discover commonalities and causal relationships between collaboration conditions and effectiveness

¹ The list of invited and respondent companies and contacts is available upon request.

10. CIMdata identified gaps with current capabilities and industry practices and processes based on the research findings
11. CIMdata developed observations, conclusions and recommendations

Final Report

12. CIMdata developed a full DRAFT report on the findings, as well as a PowerPoint summary presentation
13. CIMdata delivered the DRAFT report [this document] to the A&D PLM Action Group members for their review and comment. A&D PLM Action Group members are to review and comment on the DRAFT Report
14. As a “thank-you” for participating, CIMdata will e-mail the Survey respondent companies with their Survey summary response and its comparison to the overall aggregate response of all respondents
15. CIMdata will incorporate the comments of the A&D PLM Action Group members and publish a final Report

INFORMATION GATHERING

It was anticipated during initial project planning that extraordinary measures would be required to achieve a sufficient number of responses to provide a statistically significant sample size. The survey response period was extended from 6 weeks to four months and during the extension period several of the members invested significant effort to secure agreement from their contacts in the industry to participate. During that period invitations were sent to 164 individuals at 83 companies. In the end, these efforts proved successful and 41 survey responses were received from 20 companies.²

Survey Demographics

The following demographic information represents completed responses. As can be seen in Figure 1, the survey results are heavily influenced by EMEA responses.

² This is a response rate of 25%, which compares very favorably to the normal survey response rate of 3 to 5%.

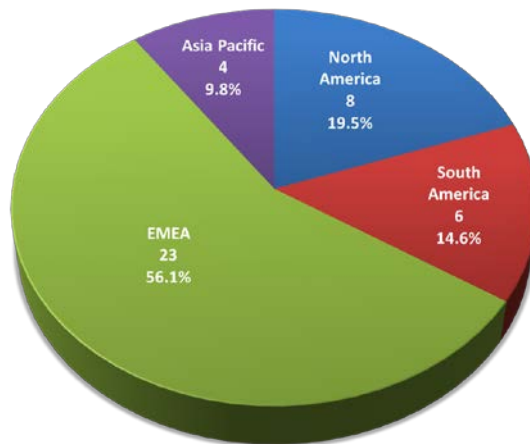


Figure 1—Geographic Distribution of Respondents

All industry responses came from aerospace and defense companies.

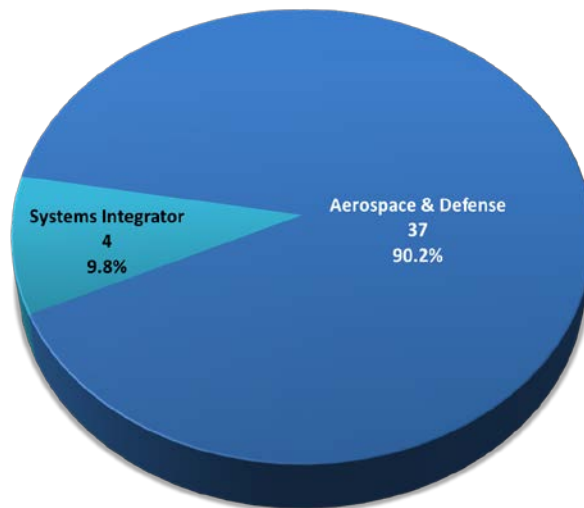


Figure 2—Industry Distribution of Respondents

As shown in Figure 3, the responses were well distributed among the Collaboration Entities with the exception that equipment and system suppliers were not well represented. This was a self-selected classification, and some inconsistencies in responses are present for Assystem and Tata Consultancy. However, these may be due to the perceptions of the different respondents from each company.

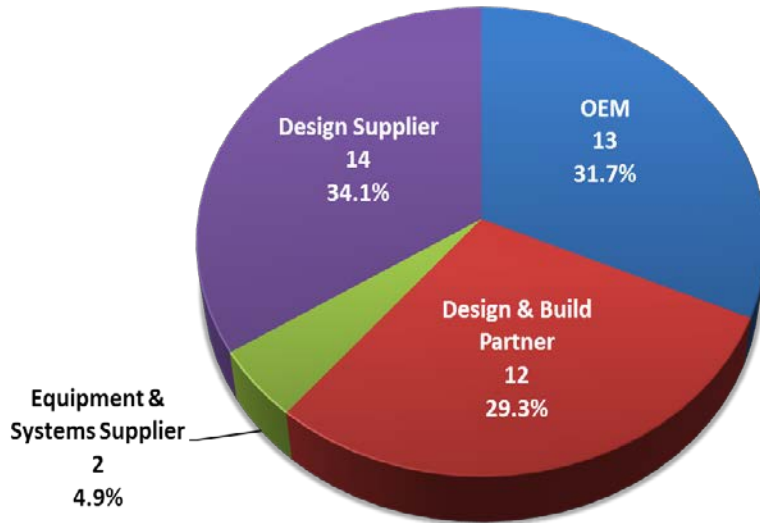


Figure 3—Self-Selected Collaboration Entity

Participation

Table 2 lists the 20 companies that responded to the survey. It should be noted that Altran, Assystem, Embraer, and Tata Consultancy Services each submitted several responses. It is also noteworthy that two A&D PLM Action Group members declined to participate in the survey.

Table 2—Responding Companies

Company	Collaboration Entity Type*	No. of Resp.	Company	Collaboration Entity Type*	No. of Resp.
Airbus	OEM	2	LATECOERE	D&B Partner	1
Alenia Aermacchi	D&B Partner	1	Lockheed Martin Aeronautics Co.	OEM	1
Altran	D&B Partner	1	Nordam	E&S Supplier	1
	E&S Supplier	1			
	Des. Supplier	6			
Assystem	Des. Supplier	4	Northrop Grumman	OEM	1
Belcan LLC		1	Orbital ATK	D&B Partner	2
Bombardier	OEM	1	Parker-Hannifin Corporation	D&B Partner	1
CIMPA	OEM	1	Rolls-Royce	OEM	2
East Kilbride Engineering Services	Des. Supplier	1	SABCA	D&B Partner	1
Embraer	OEM	5	SONACA	D&B Partner	1
	D&B Partner	1			
Fokker Aerostructures	D&B Partner	1	Tata Consultancy Services	D&B Partner	2
				Des. Supplier	2

* As self-selected by the survey respondent

SURVEY RESULTS

In this section, summary responses are tabulated for each of the areas of inquiry addressed in the survey. For each area, the summary responses provided by the Group members in the Phase 1 project are presented for comparison. The presentation of summary responses is followed by CIMdata observations highlighting key points and implications.

Importance, Performance & Improvement Priorities

A lesson learned in execution of the Phase 1 test of survey strategy is that the researchers' intention and the respondents' interpretation of questions do not always align. In the matter of self-evaluation, the intention and the interpretation diverged on several key points. In response, the researchers modified their original methodology. From analysis of Phase 2 responses it appears that the divergence between researcher intent and respondent interpretation was not fully resolved.

Importance

Respondents were asked to indicate, for each Collaboration Entity with which they collaborate, how the **importance** of the collaboration varies by Collaboration Purpose.³ Table 3 shows for each collaboration entity, how the importance of collaboration varies by collaboration purpose, and, for each collaboration purpose, how the importance of collaboration varies by collaboration entity. The data are presented in total to provide the summary view of all respondents and also split by collaboration entity to provide the separate views of OEMs, Design & Build Partners, and Design Suppliers. The view of Equipment & System Suppliers is not shown since only one response was received from this category and the results are not statistically significant.

Table 3 – Collaboration Importance Self-Assessment (Importance - Volume)

Collaboration Entity	Collaboration Purpose					
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change	
OEM	4.3	3.7	3.7	3.9	4.0	Very High (4.4-5.0)
Design & Build Partner	4.1	3.9	4.4	4.0	4.2	High (3.7-4.3)
Equip't & System Supplier	3.5	3.0	3.2	3.0	3.5	Moderate (3.0-3.6)
Design Supplier	3.9	3.7	3.9	3.9	3.8	Low (2.0-2.9)
						Very Low (<2.0)

OEMs' View

Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
OEM	4.0	3.2	4.2	4.4	4.4
Design & Build Partner	4.1	3.8	4.4	4.0	4.2
Equip't & System Supplier	3.5	3.2	3.4	3.0	3.5
Design Supplier	3.6	3.5	3.9	3.6	3.5

Design & Build Partners' View

Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
OEM	4.3	3.6	3.3	3.8	3.9
Design & Build Partner	4.5	4.5	5.0	5.0	4.5
Equip't & System Supplier	3.6	2.7	2.9	3.0	3.6
Design Supplier	4.0	3.9	3.7	4.0	4.1

Design Suppliers' View

Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
OEM	4.5	4.1	3.8	3.8	3.8
Design & Build Partner	3.3	3.5	3.7	2.3	3.8
Equip't & System Supplier	3.5	3.3	3.5	3.0	3.5
Design Supplier	4.2	3.7	4.0	4.3	3.8

³ Refer to *Appendix A: PLM Global Collaboration Taxonomy* for definitions of terms

Importance is uniformly high for all *collaboration purposes*. Importance is uniformly high for all *collaboration entities* except for Equipment & System Suppliers. This may be due to the underrepresentation (only one response) of Equipment & System Suppliers in the survey.

For each *collaboration entity*, highest importance is for internal collaboration, which is not surprising, since the nature of work effort inside each company is expected to be highly collaborative.

For OEMs, second highest important is for collaboration with Design & Build Partners. For Design & Build Partners, second highest importance is for collaboration with Design Suppliers. For Design Suppliers, second highest importance is for collaboration with their customer OEMs. Collaboration importance at various levels of the supply chain is illustrated in Figure 4.

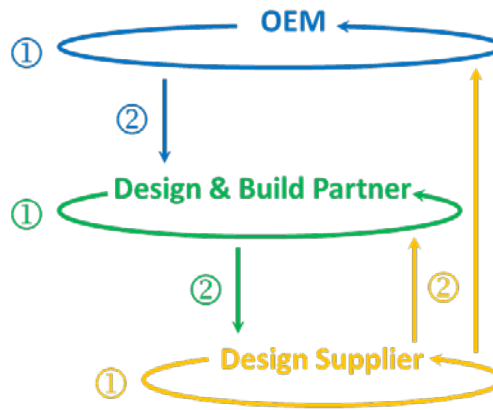


Figure 4—Collaboration Importance for Various Collaboration Entities

The highest importance *collaboration purpose* is DMU Baselineing, especially involving OEMs and their Design & Build Partners.

The second highest importance *collaboration purpose* is Work Assignment & Design Delivery, especially for Design Suppliers collaboration with their customer OEMs.

Performance

Respondents were asked to indicate, for each Collaboration Entity with which they collaborate, how the *performance* of the collaboration varies by Collaboration Purpose.⁴ Table 4 shows for each collaboration entity, how the performance of collaboration varies by collaboration purpose, and, for each collaboration purpose, how the performance of collaboration varies by collaboration entity. The data are presented in total to provide the summary view of all respondents and also split by collaboration entity to provide the separate views of OEMs, Design & Build Partners, and Design Suppliers. The view of Equipment & System Suppliers is not shown since only one response was received from this category and the results are not statistically significant.

⁴ Refer to *Appendix A: PLM Global Collaboration Taxonomy* for definitions of terms

Table 4 – Collaboration Performance Self-Assessment (Performance = Effectiveness)

Summary View (All Respondents)

Collaboration Entity	Collaboration Purpose					
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change	
OEM	3.7	3.4	3.4	3.6	3.2	Very High (4.4-5.0)
Design & Build Partner	3.7	3.6	3.7	3.3	3.5	High (3.7-4.3)
Equip't & System Supplier	3.2	2.6	2.8	2.9	3.1	Moderate (3.0-3.6)
Design Supplier	3.7	3.5	3.6	3.5	3.7	Low (2.0-2.9)
						Very Low (<2.0)

OEMs' View

Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change
OEM	4.2	3.8	4.0	4.0	4.2
Design & Build Partner	3.8	3.3	3.3	3.2	3.4
Equip't & System Supplier	3.3	2.5	2.8	2.7	3.1
Design Supplier	3.8	3.4	3.5	3.1	3.7

Design & Build Partners' View

Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change
OEM	3.5	3.3	3.5	3.6	3.4
Design & Build Partner	4.0	4.8	4.5	4.8	4.3
Equip't & System Supplier	3.0	2.4	2.8	3.2	3.0
Design Supplier	3.6	3.6	3.3	3.6	3.4

Design Suppliers' View

Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change
OEM	3.5	3.4	3.0	3.3	2.5
Design & Build Partner	3.0	3.0	3.7	2.0	3.0
Equip't & System Supplier	3.0	3.0	3.0	3.0	3.0
Design Supplier	3.7	3.7	4.0	4.2	3.8

In the summary view, performance is uniformly moderate or high for all *collaboration entities* except for Equipment & System Suppliers. This may be due to the underrepresentation (only one response) of Equipment & System Suppliers in the survey.

The highest performance *collaboration purpose* is Work Assignment & Design Delivery, especially from the OEMs' point of view.

For each *collaboration entity*, highest performance is for internal collaboration, which is not surprising since each entity has full control to optimize their internal collaboration solution.

Improvement Priorities

The method devised for rating improvement potential was to request a self-assessment of collaboration importance and of collaboration performance, each on a scale of 1 to 5, and then subtract the performance rating from the importance rating. In that way, a collaboration

condition with high importance and low performance would be assigned a high improvement priority rating. The results of this method are presented in Table 5. The highlighted region in the OEMs' View corresponds to the region of high performance improvement potential that was identified in Phase 1 and that became the focus for this Phase 2 research.

Table 5 – Improvement Potential (Importance Rating Minus Performance Rating) from Phase 2 Research
Summary View (All Respondents)

Collaboration Entity	Collaboration Purpose					
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change	
OEM Remote Site (Internal)	0.6	0.3	0.3	0.3	0.8	Very High (>2.0)
Design & Build Partner	0.4	0.3	0.7	0.7	0.7	High (1.6-2.0)
Equip't & System Supplier	0.3	0.4	0.4	0.1	0.4	Moderate (1.1-1.5)
Design Supplier	0.2	0.2	0.3	0.4	0.1	Low (0.6-1.0)
						Very Low (<0.6)

OEMs' View

Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
OEM Remote Site (Internal)	-0.2	-0.6	0.2	0.4	0.2
Design & Build Partner	0.3	0.5	1.1	0.8	0.8
Equip't & System Supplier	0.2	0.7	0.6	0.3	0.4
Design Supplier	-0.2	0.1	0.4	0.5	-0.2

Design & Build Partners' View

Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
OEM Remote Site (Internal)	0.8	0.3	-0.2	0.2	0.5
Design & Build Partner	0.5	-0.3	0.5	0.2	0.2
Equip't & System Supplier	0.6	0.3	0.1	-0.2	0.6
Design Supplier	0.4	0.3	0.4	0.4	0.7

Design Suppliers' View

Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
OEM Remote Site (Internal)	1.0	0.7	0.8	0.5	1.3
Design & Build Partner	0.3	0.5	0.0	0.3	0.8
Equip't & System Supplier	0.5	0.3	0.5	0.0	0.5
Design Supplier	0.5	0.0	0.0	0.1	0.0

This analysis method did not provide significant indicators of improvement opportunities, in contrast to the result from analysis of the Phase 1 survey responses shown in Table 6. In fact, none of the results from this Phase 2 research are consistent with the results from Phase 1. A complete comparison is presented in Appendix B.

Table 6 – Improvement Potential (Importance Rating - Performance Rating) from Phase 1 Research

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.	Very High (2.1-3.0)
Design & Build Partner	2.1	2.2	0.9	1.8	1.3	0.2	0.7	High (1.6-2.0)
Equip't & System Supplier *	1.7	1.7	0.7	1.3	1.0	1.3	0.3	Moderate (1.1-1.5)
Design Supplier	1.4	1.3	0.8	0.9	0.8	0.2	0.0	Low (0.6-1.0)
Build to Print Supplier *	1.0	1.0	1.0	1.0	0.0	1.0	-0.3	Very Low (<0.6)
Tooling Design Supplier	0.9	0.2	0.4	-0.6	-0.1	0.3	0.0	

CIMdata Observations

The integration step for assembling the designs from all Collaboration Entities that occurs during DMU Baselining appears to be the kingpin for collaboration. It requires the merging of large amounts of data to enable sophisticated verification processes, such as interference checking.

The failure of the Phase 1 research analysis method to yield meaningful improvement indicators in Phase 2 may be due to the diversity of OEMs that responded in Phase 2 (i.e. commercial airframe, aero engine, and defense) in contrast to the narrow community of commercial airframe OEMs that responded in Phase 1. Another possible explanation is the diversity of Phase 2 respondents' backgrounds. In particular, those positioned at a distance from the direct activity of making collaboration work may assess current performance less severely than those who are directly involved in collaboration activities day to day.

Since this thread of analysis was unproductive, the researchers shifted their attention to other elements within the survey responses for indicators and insights into potential improvement opportunities.

Collaboration Environment

Response Summary

Respondents were asked to indicate, for each Collaboration Purpose, which Collaboration Environments they use and with what intensity. The rows in Table 7 represent four common environments within which collaboration occurs. The table shows for each collaboration purpose, which collaboration environments are used and with what intensity (volume). The data are presented in total to provide the summary view of all respondents and also split by collaboration entity to provide the separate views of OEMs, Design & Build Partners, and Design Suppliers. The view of Equipment & System Suppliers is not shown since only one response was received from this category and the results are not statistically significant.

Table 7 – Collaboration Environments and Volume of Collaboration for Various Collaboration Purposes

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	Very High (4.4-5.0)
Joint Project Repository (inside firewall)	3.4	2.8	2.8	3.2	3.6	High (3.7-4.3)
Joint Sharing Repository (outside firewall)	2.6	2.9	3.3	3.7	2.6	Moderate (3.0-3.6)
Send/Receive Files (outside firewall)	2.9	3.0	3.6	2.7	2.7	Low (2.0-2.9)
						Very Low (<2.0)

OEMs' View

Collaboration Environment	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
Joint Session (inside firewall)	2.8	3.6	2.6	3.9	3.0
Joint Project Repository (inside firewall)	3.6	2.6	3.0	3.1	3.8
Joint Sharing Repository (outside firewall)	2.2	3.3	3.2	3.8	2.0
Send/Receive Files (outside firewall)	2.7	2.9	3.8	3.0	3.1

Design & Build Partners' View

Collaboration Environment	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
Joint Session (inside firewall)	3.4	3.8	2.7	2.9	3.2
Joint Project Repository (inside firewall)	3.2	2.9	2.8	3.1	3.3
Joint Sharing Repository (outside firewall)	3.2	2.8	3.1	3.4	3.1
Send/Receive Files (outside firewall)	3.1	3.0	3.3	2.9	2.8

Design Suppliers' View

Collaboration Environment	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
Joint Session (inside firewall)	3.8	3.5	2.7	2.8	3.4
Joint Project Repository (inside firewall)	3.2	2.9	2.5	3.3	3.6
Joint Sharing Repository (outside firewall)	2.3	2.6	3.6	3.8	2.7
Send/Receive Files (outside firewall)	2.9	3.1	3.5	2.4	2.3

Overall, the four *collaboration environments* are used with about equal intensity, though the intensity of each environment's use varies significantly by *collaboration purpose*.

The patterns of collaboration volume are fairly consistent across the perspective of OEMs, Design & Build Partners, and Design Suppliers.

For Work Assignment & Design Delivery, the highest intensity *collaboration environments* are Joint Session and Joint Project Repository, both inside the firewall.

For Simultaneous Design & Evaluation, the highest intensity *collaboration environment* is Joint Session inside the firewall.

For DMU Baselineing, the highest intensity *collaboration environment* is Send/Receive Files outside the firewall.

For Design Review & Approval, the highest intensity *collaboration environment* is Joint Sharing Repository outside the firewall.

For Engineering Change, the highest intensity *collaboration environment* is Joint Project Repository inside the firewall.

CIMdata Observations

Collaboration environments inside the firewall are used more commonly for purposes of Work Assignment & Design Delivery and for Engineering Change. Collaboration environments outside the firewall are used more commonly for the purpose of DMU Baselineing.

OEMs seem to work most often with *Design & Build Partners* while inside the firewall whether in a Joint Session or using a Joint Project Repository, while most often working with *Design Suppliers* outside the firewall except when sending work assignments and receiving final design delivery.

Collaboration Content

Response Summary

The content shared during collaboration falls into two general categories, geometric data and ancillary data. The types and volumes of geometric and ancillary data shared during collaboration vary depending on the purpose for collaboration.

Respondents were asked to indicate, for each Collaboration Purpose, which types of Geometric Content⁵ they share and with what intensity. Table 8 shows for each collaboration purpose, which types of geometric data are shared and with what intensity. The data are presented in total to provide the summary view of all respondents and also split by collaboration entity to provide the separate views of *OEMs*, *Design & Build Partners*, and *Design Suppliers*. The view of *Equipment & System Suppliers* is not shown since only one response was received from this category and results are not statistically significant.

⁵ Refer to *Appendix A: PLM Global Collaboration Taxonomy* for definitions of terms

Table 8 – Types and Volume of Geometric Content Shared for Various Collaboration Purposes

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	Very High (4.4-5.0)
Simplified Native 3D CAD Model	4.1	2.9	2.3	2.9	2.7	High (3.7-4.3)
Standard Format 3D Model (STEP, IGES, etc.)	4.0	3.3	2.6	3.0	2.7	Moderate (3.0-3.6)
Visualization Model (JT, 3D PDF, etc.)	3.9	2.7	2.2	3.0	3.3	Low (2.0-2.9)
2D Models (images, drawings, etc.)	3.6	2.5	2.2	2.7	3.3	Very Low (<2.0)

OEMs' View

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	2.2	1.9	2.8	3.1
Simplified Native 3D CAD Model	3.8	2.3	1.9	2.5	2.1
Standard Format 3D Model (STEP, IGES, etc.)	4.3	3.1	2.4	2.1	2.4
Visualization Model (JT, 3D PDF, etc.)	4.0	2.8	1.9	2.4	3.0
2D Models (images, drawings, etc.)	4.0	2.4	1.8	2.3	3.1

Design & Build Partners' View

Collaboration Content	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
Complete Native 3D CAD Model	3.3	2.8	2.8	3.1	3.8
Simplified Native 3D CAD Model	4.5	2.9	2.1	3.2	3.5
Standard Format 3D Model (STEP, IGES, etc.)	3.7	2.8	2.5	3.3	3.0
Visualization Model (JT, 3D PDF, etc.)	4.3	2.8	1.8	3.0	3.6
2D Models (images, drawings, etc.)	3.2	2.3	2.0	2.8	3.2

Design Suppliers' View

Collaboration Content	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselining	Design review & approval	Engineering Change
Complete Native 3D CAD Model	3.8	2.4	2.7	2.6	3.4
Simplified Native 3D CAD Model	4.1	3.6	2.6	2.9	2.5
Standard Format 3D Model (STEP, IGES, etc.)	3.8	3.9	2.6	3.2	2.7
Visualization Model (JT, 3D PDF, etc.)	3.5	2.4	2.6	3.4	3.4
2D Models (images, drawings, etc.)	3.4	2.5	2.6	2.8	3.4

Overall, the five types of *geometric content* are used in about equal volume, though the volume varies significantly by *collaboration purpose*.

The patterns of *geometric content* type usage are fairly consistent across the perspective of OEMs, Design & Build Partners, and Design Suppliers.

The highest volume of *geometric content* usage is for Work Assignment & Design Delivery. The second highest volume is for Engineering Change. The next highest volume is for Design Review & Approval.

For Design & Build Partners, Simplified Native 3D CAD is the highest usage *geometric content* type. For OEMs, Simplified Native 3D CAD is the lowest usage *geometric content* type.

CIMdata Observations

The vast majority of data exchange happens at the start and end of work projects and occurs in all possible data formats.

Collaboration Processes & Capabilities

Respondents were asked to rate the level of problems experienced during collaboration and then to provide descriptions and commentary on the most serious problems experienced.

Collaboration Process Steps

Respondents were asked to indicate, for each Collaboration Process Step, what level of problems they experienced. Table 9 shows collaboration process steps and a summary view of the level of problems experienced.

On average, the level of problems experienced ranges from Minor to Bad. The colored circles indicate the number of responses with problems rated as Very Bad or Severe. This overlay provides useful indicators of areas for deeper investigation. Researchers examined, organized and summarized comments submitted by the respondents regarding performance problems experienced with collaboration processes. This analysis yielded significant insights that support the conclusions and recommendations presented later in this report.

Table 9 Level of Performance Problems Experienced with Collaboration Processes

Respondents' Self-Selected Collaboration Entity	Collaboration Process								None (<=1.0)
	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	Severe (>4.0)
Design & Build Partner	2 ² 2.3	2.1 ³	1.8 ¹	1.8	2.3 ¹	1.7 ¹	2.0 ¹	1.5	Very Bad (3.1-4.0)
Equipment & Systems Supplier	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	Bad (2.1-3.0)
Design Supplier	2 ² 2.4 ¹	1 ¹ 1.9	1.5	1.3	1.5	1.5	1.6 ¹	1.3	Moderate (1.1-2.0)

Respondent Comments

Comments from respondents who rated performance problems experienced with collaboration processes as Bad, Very Bad, or Severe are summarized here for each Collaboration Process. The actual comments are available upon request.

Collaboration Environment Set Up

Design & Build Partners and *Design Suppliers* report that they experience considerable difficulty in establishing their initial collaboration environments, especially with multiple, globally distributed sites. Issues include technical difficulties with collaboration software, IT infrastructure and data transfer rates. These difficulties are compounded by shortage of experienced support staff. The net impact is slow implementation and high overall cost. Respondents are all seeking more streamlined solutions that can be rapidly installed.

Security Administration

Design Suppliers report issues with intellectual property (IP) protection and export control ratings that add delays in accessing needed data. They seek the establishment of stable data segmentation guidelines and tools that streamline the separation of data based on access permissions.

Information Preparation

OEMs and *Design Suppliers* report difficulties in the collection of all the data necessary for collaboration, and the quality of the geometry once the data is available. Problems are often attributed to data located in multiple systems and the data complexity found with multiple product configurations. They seek better multi-system connectivity, improved documentation of where data is located, and the use of geometry validation tools before data is shared.

Information Send or “Post & Notify”

Design & Build Partners and *Design Suppliers* report the lack of engineering change workflows between OEMs and suppliers, including notification tools that keep users, administrators, and management informed about data that is sent or received. Suppliers complain that each OEM with whom they deal has different standards of how to package and transfer data. They seek PLM collaboration tools that allow them to easily configure the packaging of data based on the standards of the company with whom they are collaborating, and tools for tracking data exchanges and notifying proper individuals on either side of the communication.

Inquiry & Response

Design & Build Partners and *Design Suppliers* report the lack of tools for tracking information requests and responses. They complain that tracking is usually manual and can result in duplicate data entry. They seek a PLM solution and tools that log and track requests and responses between collaborating partners. In addition, the solution should have the capability of escalating a request if a response is not forthcoming.

Information Receive

Design & Build Partners and *Design Suppliers* report the lack of consistency in the way data is received from collaborating partners. In addition to similar complaints found with Information Send or “Post & Notify” and Inquiry & Response process steps, respondents report network latency results in slow data transfers. They seek solutions to improve performance and tracking as noted previously.

Information QA & Remediation

Design & Build Partners and *Design Suppliers* report many issues as previously noted for lack of standard workflow processes and “poor” data that requires validation before it can be used. Recommendations for improvement include data tracking tools and data validation tools used before data exchange occurs.

Information “Post & Notify” Internally

OEMs report many of the same issues as previously noted for data exchange between collaborating partners. Recommendations for improvement include improved logging and tracking of information requests and responses.

Cross-Process Comments

OEM

Collaboration is a difficult activity if the parties do not talk the same language (same CAD, same PDM, same data bases).

Design & Build Partner

Many of the process steps had issues when we first started attempting [to use] these processes, but we have learned the 'idiosyncrasies' of the tools with most of our partners and overcome those errors so they are generally no more than a minor nuisance.

Metadata sharing (configuration, change process...) is weak. Standards are almost never used (still looking for a STEP AP242 implementation).

Design Supplier

Export control rating and separation of export controlled data has caused major problems with accessing information especially for our low cost resource. Other major problems are the use of multisite type hubs where data can fail to transfer or in some cases objects in models become dissociated.

Significant volumes of design and simulation engineering activities that we perform for the OEM are completed on our own independent network. Inputs and deliverables can only be shared in controlled and restricted environments which have limitations on file sizes. This often necessitates use of encrypted media devices.

Collaboration Technical Capabilities

Respondents were asked to indicate, for each Collaboration Technical Capability, what level of problems they experienced. Table 10 shows collaboration process steps and the level of problems experienced.

On average, the level of problems experienced ranges from Minor to Bad. The colored circles indicate the number of responses with problems rated as Very Bad or Severe. This overlay provides useful indicators of areas for deeper investigation. As with the comments regarding collaboration process steps, researchers examined, organized and summarized comments submitted by the respondents regarding performance problems experienced with collaboration processes. This analysis yielded significant insights that support the conclusions and recommendations presented later in this report.

Table 10 – Level of Problems Experienced with Collaboration Technical Capabilities

Respondents' Self-Selected Collaboration Entity	Collaboration Technical Capabilities							None (<=1.0)
	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	Severe (>4.0)
Design & Build Partner	2.0 ¹	1.6	1.6	2.0 ¹	1.9	2.1	1.9 ¹	Very Bad (3.1-4.0)
Equipment & Systems Supplier	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Bad (2.1-3.0)
Design Supplier	1.4	1.2	1.0 ¹	0.7	1.1	1.5 ¹	1.8 ²	Moderate (1.1-2.0)

Respondent Comments

Comments from respondents who rated problems with collaboration technical capabilities as Bad, Very Bad or Severe are summarized here for each Collaboration Process. The actual comments are available upon request.

Note that CIMdata interprets the comment “not used,” which is repeated several times in the comments, to indicate that the Collaboration Capability is not currently used because a collaboration tool is not used, and that collaboration would be potentially improved if one were used.

Shared Views

OEMs report Shared Views has very limited use for legacy aircraft and when used suffers from poor data link performance.

View Manipulation

Design Suppliers report that View Manipulation is either not used or it suffers from slow data access performance or bad connections to servers.

Markup

Again, *Design Suppliers* report that Markup is either not used or it suffers from lack of tools to support markup capture, slow data access performance, or bad connections to servers.

Metadata View & Edit

Design & Build Partners report that Modification Workflow is only metadata editing, sharing the workflow between stakeholders is almost impossible, and the process suffers from poor data access performance.

Evaluation

Design Suppliers report that Evaluation is either not used or it suffers from slow data access performance or bad connections to servers.

Simulation

Design & Build Partners and *Design Suppliers* report that Simulation is either not used or it suffers from slow data access performance or bad connections to servers. Respondents also noted that unless both collaborating partners are using the same PLM solution, fly through, motion, and collision detection all raise as many false positives as negatives during

reviews. One respondent indicated that mesh points could be missing or moved during a multi-site data transfer, affecting data accuracy.

Geometry Edit

Design & Build Partners and *Design Suppliers* report that Geometry Edit is not used or suffers from distorted or moved data when collaborating partners are not using the same PLM solution. Some respondents report similar problems even when using the same PLM solution. Performance is noted as an issue when working with large assemblies.

Cross-Process Comments

Design Supplier

“The OEM has recently installed a Global Wide Area Network in our offices which has greatly improved the sharing of data and ensures that we are working better together. Therefore, the engineering effort on both sides is closer to concurrent engineering.”

CIMdata Summary and Observations

Respondents indicate many more serious problems related to collaboration process steps than to technical capabilities.

Collaboration Process Steps

Process steps with the most serious problems listed in rank order are:

- Collaboration Environment Set Up (10)
- Security Administration (6)
- Information Quality Assurance & Remediation (4)
- Information Preparation (2.5)

The most serious problems cited by respondents include:

- Difficulty in establishing initial collaboration environments, including technical difficulties with collaboration software, IT infrastructure, and data transfer rates
- Intellectual property (IP) protection and export control ratings that add delays in accessing needed data
- Lack of standard workflow processes, and “poor” data (i.e. quality and completeness) that requires validation before it can be used
- Gathering all the data necessary for collaboration
- Other significant problems include:
 - Improved logging and tracking of information requests and responses
 - Export control rating and separation of export controlled data
 - Network latency results in slow data transfers
 - Metadata sharing (e.g. configuration, change process) is weak, standards are almost never used (still looking for a STEP AP242 implementation)

Significant remedies cited by respondents include:

- More streamlined collaboration solutions that can be rapidly installed
- Stable data segmentation guidelines and tools that streamline the separation of data based on access permissions and export controls
- Data tracking tools and data validation tools used before data exchange occurs
- Better multi-system connectivity, improved documentation of where data is located, and the use of geometry validation tools before data is shared.

Collaboration Technical Capabilities

Technical capabilities with the most serious problems listed in rank order are:

- Geometry Edit (3)
- Simulation (2)
- Metadata View & Edit (2)

The most common problems cited by respondents are:

- Slow data access performance or bad connections to servers
- When attempting Simulation, fly through, motion, and collision detection all raise as many false positives as negatives during reviews, unless both collaborating partners are using the same CAD solution
- When attempting Geometry Edit, distorted or moved data when collaborating partners are not using the same CAD solution

A significant remedy cited by one respondent is:

- An OEM has recently installed a Global Wide Area Network in our offices which has greatly improved the sharing of data and ensures that we are working better together. Therefore, the engineering effort on both sides is closer to concurrent engineering.

Use of Standards in Collaboration

The survey was followed by telephone interviews of a subset of respondents to clarify and expand upon the information they provided. The main purpose of these interviews was to further understand the use of standards in collaboration.

Interview Comments

The following comments are derived from the follow on telephone interviews with a subset of survey respondents.

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. In many cases, the data exchange is automated within the OEM's PDM solution. When exchanging CAD data with suppliers, it is more common to use STEP (AP 203, AP214, AP 242), and sometimes IGES. JT is used for visual collaboration at some OEM sites. The OEMs tend to want their supply

chain to use CAD data in its native format, but this is limited by two factors: First, some participants have older versions of CAD solutions that can't open data from newer versions. Second, IP is more difficult to protect when native CAD files are used as opposed to viewable data in formats such as JT.

The strength of standards-based exchange is ubiquity. The main shortcomings are in the realms of reliability and quality. Translators sometimes fail, especially on very large datasets. The quality impacts are dependent on whether a particular object type is supported by the standard and what happens when it is unsupported or only partially supported. For larger companies, there can be a lot of variation in the use of standards—even within the company itself. This is aggravated for the suppliers because each OEM can have its own set of allowable standards—there is not a common set of standards across the A&D industry.

All respondents who were interviewed felt strongly that standards-based exchange is desirable and needed. The general sentiment expressed by the interviewees was that as long as the quality and speed of the standards-based exchange is good enough, then standards-based exchange can, and should, be used.

Standards-based exchange is commonly used within the supply chain and appears to be good enough to support most use cases. For use cases where this practice is not acceptable, staying within a solution provider's tool suite and data formats is a reasonable mitigation.

The technical infrastructure, 3D graphics support, bandwidth, latency cause issues throughout the collaboration process—these are not mitigated simply by adopting standards.

Management expectations are not aligned with capabilities their personnel and the enabling technologies available to them. That is, implemented technologies (including standards) do not support the level of collaboration expected by management teams within any of the Collaboration Entities.

CIMdata Observations

OEM policy for use of data exchange standards is driven by a complex set of economic factors and business objectives. Standards for CAD data exchange such as STEP are rarely used internally. Since the internal CAD environment is usually homogeneous, OEMs use native data formats and commercial integration tools to provide data to downstream consumers. Externally, native CAD data is not always a practical option because the CAD environments are not homogeneous. Also, for many use cases, visualization formats are more economical, better performing, and more protective of IP ownership. These divergent considerations have produced inconsistent practices across OEMs and even across Programs within an OEM, all interacting with the same set of supply chain participants.

Within the OEMs' supply chains, where heterogeneity is a fact of life, use of standards is accepted and applied on a regular basis. The view toward standards is generally positive and they are accepted as “good enough” today.

The technical infrastructure, 3D graphics support, bandwidth, and latency issues that occur throughout the collaboration process are real issues of substance that cannot be addressed by standards.

The view conveyed by respondents at all levels in the supply chain that there is significant misalignment between management expectations and current collaboration reality can be a serious barrier to progress.

CONCLUSIONS

The following conclusions were derived from analysis of survey responses and follow on interviews.

Fulfillment of Research Goals

Support for Recommendations

The intent of this research was to 1) develop insights sufficient to support recommendations that the A&D PLM Action Group members can pursue to improve their collaboration capabilities, and 2) provide sufficient evidence to support a draft direction statement that the Members can use to influence solution provider future developments.

This first goal was fulfilled. Several recommendations are presented in the *Recommendations* section of this report.

The researchers believe that the results of this research are sufficient to support development of a direction statement for solution providers and standards bodies regarding global collaboration. Member assessment will determine to what degree this goal has been achieved.

Participation

Implicit in the second goal is the need to obtain a statistically significant quantity of responses from each tier in the A&D supply chain. CIMdata researchers on their own and within the original project timeline were not able to secure participation of a sufficient number of aerospace and defense companies. With additional time and exceptional effort, it was possible to secure adequate industry participation. The survey response period was extended from 6 weeks to four months and during the extension period several of the members invested significant effort to secure agreement from their contacts in the industry to participate. During that period response rate was increased to 25%, which compares very favorably to the normal survey response rate of 3 to 5%.

Validation of Phase 1 Research Results

A third goal of the research was to determine the degree to which the members' characterizations and self-evaluations in the Phase 1 project are consistent with those of the broader A&D industry.

As noted and discussed in the *Importance, Performance & Improvement Priorities* section above, results from this Phase 2 research are not consistent with the results from Phase 1⁶. A lesson learned from this Phase 2 research is that not only the respondent companies but also the specific individuals within those companies must be carefully selected and instructed in order to obtain reliable responses to the survey questionnaire.

⁶ Comparison of Phase 1 and Phase 2 research results is provided in Appendix B.

Collaboration Characterization

At each level of the supply chain from *OEM* to *Design Supplier*, internal collaboration is rated as most important, and performance is rated highest.

Overall, multiple *collaboration environments* are used with high intensity, though the intensity of each environment's use varies significantly by *collaboration purpose* and by *collaboration entity*. *OEMs* seem to work most often with *Design & Build Partners* while inside the firewall, while most often working with *Design Suppliers* outside the firewall.

The vast majority of data exchange happens at the start and end of work projects for the purpose of Work Assignment & Design Delivery, and occurs in multiple data formats.

Collaboration Problems

Since analysis of the collaboration self-assessment and characterization sections of the survey was largely unproductive, the researchers shifted their attention to the more open ended responses regarding collaboration processes and capabilities for indicators and insights into potential improvement opportunities. In this section of the survey, respondents provided not only rich insight and commentary on collaboration problems, but also a rich set of practical solution proposals.

The majority of serious collaboration problems within the supply chain are related to process rather than to technology. This finding is consistent with CIMdata's experience across a broad range of clients and industries.

Collaboration Environment Set Up is by far the most problematic *collaboration process step*, and comments such as the following from a *Design & Build Partner* illustrate that standardization of collaboration practices would reduce cost and improve efficiency for all:

“Many of the process steps had issues when we first started attempting [to use] these processes, but we have learned the ‘idiosyncrasies’ of the tools with most of our partners and overcome those errors so they are generally no more than a minor nuisance.”

In contrast to the widespread perception that CAD data exchange standards are of primary importance for improving collaboration within the supply chain, respondents listed other areas for standardization instead:

- Intellectual property (IP) protection and export control
- Workflow processes
- CAD data quality validation
- Stable data segmentation guidelines

The most common and severe technical problem impeding collaboration within the supply chain is network latency and data transfer rate.

Other significant problems to be addressed include:

- Improved logging and tracking of information requests and responses
- Metadata sharing (configuration, change process...)

Use of Standards

In an effort to expand the range and volume of quality input, the researchers inserted an activity into the project plan to conduct follow on interviews with a subset of survey respondents focused on assessing current practice, trends, and attitudes toward the use of standards for collaboration within the supply chain. Through these interviews, respondents provided additional useful insight and commentary.

Standards-based data exchange is working in production today within the A&D supply chain and could also be used for data exchange to downstream users within the OEMs. The only impediment is that direct translators are already built into the OEM's processes so there is little immediate business value in changing one set of technology for another.

Within the OEMs' supply chains, where heterogeneity is a fact of life, use of standards is accepted and applied on a regular basis. The view toward standards is generally positive and they are accepted as "good enough" today.

RECOMMENDATIONS

Recommendations include actions that Members can take in the near- and mid-terms.

Direction Statements

Publish a direction statement for internal adoption, application within the supply chain, and promotion of adoption by solution providers and standards bodies regarding CAD data exchange use cases and standards, with expanded description and supporting evidence derived from this research.

Collaboration Problems

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. Each Collaboration Entity should investigate and review the tools currently offered in the market and select and customize as appropriately for their use. At minimum the tools should validate that geometry does not have holes or gaps in the surfaces and solid model structures. Processes should then be put in place that require each Collaboration Entity that is sending geometric data to first pass a validation test on that data. Over time, the validation tools can be expanded to check for additional issues.

An inquiry and response tracking system should be put in place between collaboration entities

The A&D membership should do a market review to identify any existing tools that can provide a solution to an inquiry and response tracking requirement. Most PLM solution providers already offer tools for recording and tracking data items as part of their workflow implementations. If an appropriate tool cannot be found, the A&D membership 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. The tool should have the ability to have set timelines for when a response to an inquiry is expected and automatically

notify identified individuals if the deadlines are missed. The tool should have the ability to generate reports of the responses to all closed inquiries and status of all open inquiries.

Explore possibility of implementing a “Where Located” capability for part components and subassemblies

An additional recommendation to help solve the reported difficulties in the collection of data necessary for collaboration is that the A&D membership should explore with their CAD solution provider the possibility of implementing a “Where Located (in storage)” capability for part components and subassemblies. 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 a PDF-building script for each collaborating entity

In order to solve the packaging problem—Suppliers complain that each OEM with whom they deal has different standards of how to package and transfer data. Each Collaborating Entity should investigate the possibility of implementing a PDF-building script for each Entity with whom they collaborate. A PDF package can contain any type of file so that should not be a limiting factor. Processes can then 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. Note the script could also trigger geometry validation tools as noted above.

Available collaboration solutions should be investigated and an appropriate solution chosen and used

When looking at the Collaboration Technical Capabilities results, if CIMdata’s interpretation is correct that the comment “not used,” which is repeated several times in the comments to indicate that the Collaboration Capability is not currently used because a collaboration tool is not used, the obvious recommendation is that available collaboration solutions should be investigated and an appropriate solution chosen and used. The tools should have the ability to do redlining and general markup.

Research Methods

Develop new incentives for increasing participation of aerospace and automotive industry thought leaders.

More seriously evaluate characteristics necessary in respondents in order to ensure quality of information received.

APPENDIX A: PLM GLOBAL COLLABORATION TAXONOMY

The taxonomy developed by CIMdata and approved after review and revision by the A&D PLM Action Group members sets forth a representation of PLM global collaboration in six primary dimensions:

- Program phase (When)
- Collaboration entity (Who)
- Collaboration purpose (Why)
- Collaboration environment (Where)
- Collaboration content (What)
- Collaboration process & technical capabilities (How)

This taxonomy, as presented in Table 1 below, provided the framework to capture a generalized characterization of PLM global collaboration as it is currently practiced and experienced within the extended A&D product development ecosystem.

Table 1 – PLM Global Collaboration Taxonomy

Collaboration Dimension		Description
1.	Program Phase (When)	Subset of product lifecycle stages that focus on product design
1.1	Concept phase	Front-end research, program KPIs, requirements analysis, partner selection, conceptual design
1.2	Initial development phase	Joint development, product structure definition, systems engineering and interface design
1.3	Detailed development phase	Design and tooling supplier selection, detailed 3D modeling, analysis, BOM creation & release
1.4	Tests phase (partial)	Requirements verification, issues resolution and changes implementation and monitoring through to certification of supplier parts
2.	Collaboration Entity (Who)	Party with whom the OEM is collaborating
2.1	OEM remote site (internal)	Party internal to OEM at geographically different site(s)
2.2	Design & build partner	Program partner responsible for system or major subsystem design and build; data certified within OEM process (e.g. wing)
2.3	Equipment & system supplier	Supplier under evaluation or contracted for component design and build; data certified through testing or TSO (e.g. engine)
2.4	Design supplier	Supplier under evaluation or contracted for subsystem or component design
2.5	Build to print supplier	Supplier under evaluation or contracted for subsystem or component build
2.6	Tooling design supplier	Supplier under evaluation or contracted for tooling or mold design or design and build

Table 1 – PLM Global Collaboration Taxonomy (continued)

3.	Collaboration Purpose (Why)	Business purpose for the collaboration
3.1	Work assignment and design delivery	Deliver requirements and technical information to and receive design solution from supplier
3.2	Simultaneous design & evaluation	Synchronous modeling, simulation and or analysis
3.3	DMU baselining	Digital mockup generation for validation and baseline context for concurrent design
3.4	Design review & approval	Review of requirements and evaluation of design solution, with response and sign-off
3.5	Engineering change	Deliver changed requirements to and process proposal revision from supplier
3.6	Supplier selection – RFX and response	Request for information, request for proposal to support supplier evaluation and selection
3.7	Contractual discussions	Claims and decisions register; technical analysis workflows regarding issues
4.	Collaboration Environment (Where)	Location of the data used in the collaboration
4.1	Joint session (inside firewall)	Shared dataset during a live joint session of an application running inside OEM firewall
4.2	Joint project repository (inside firewall)	Data files accessible by role within the OEM PDM project repository inside OEM firewall
4.3	Joint sharing repository (outside firewall)	Data files accessible in OEM established and managed PDM repository outside OEM firewall
4.4	Send/receive files (outside firewall)	Data files sent from and received to an OEM established address outside the OEM firewall

Table 1 – PLM Global Collaboration Taxonomy (continued)

5.	Collaboration Content (What)	Data that is the focus of the collaboration
5.1	Geometry	Geometric model of the design subject, alone or within its geometric context
5.1.1	Complete native 3D model	CAD native format mechanical or electrical data including design intent
5.1.2	Simplified native 3D model	CAD native format mechanical or electrical data without design intent
5.1.3	Standard format 3D model (STEP, IGES, other)	CAD data converted to industry standard format
5.1.4	Visualization model (JT, 3D PDF...)	CAD data converted to lightweight format
5.1.5	2D models (images, drawings...)	CAD data that is not 3D
5.2	Ancillary information	Information in addition to the geometry that is relevant the design intent or design solution
5.2.1	Requirements	Specification of design form, fit, function and constraints (e.g. cost, weight, material)
5.2.2	Interface control specification	Boundary conditions between systems, subsystems and or components
5.2.3	Technical standards	Design standards and constraints, including prescribed design and manufacturing practices
5.2.4	Simulation, analysis & test results	Results from modeling behaviors and evaluating performance
5.2.5	Bill of material	Product structure, configurations, and attributes
5.2.6	Planning information	Main milestones, deliverables approvals and commercial information exchange

Table 1 – PLM Global Collaboration Taxonomy (continued)

6.	Collaboration Process & Technical Capabilities (How)	Actions performed to facilitate collaboration, and capabilities used during collaboration
6.1	Processes	Actions performed by the OEM to facilitate collaboration
6.1.1	Collaboration environment set up	Configure hardware and software environment
6.1.2	Security administration	Administer security permissions and invitations, assuring IP protection and export control
6.1.3	Information preparation	Locate, collect, modify and assemble geometry and ancillary data into a collaboration package
6.1.4	Information send or post and notify	Send collaboration package to recipient or load in repository and send notification to recipient
6.1.5	Inquiry & response	Resolve issues or questions raised by recipient; locate and provide additional data as required; maintain transaction log of each
6.1.6	Information receive	Receive information package or notification from sender and retrieve
6.1.7	Information QA & remediation	Examine and validate received data; raise issues and request additional data as required; maintain transaction log of each interaction
6.1.8	Information post and notify internally	Log final approved data, post to internal repository and issue internal notifications

APPENDIX B: COMPARISON OF PHASE 1 AND PHASE 2 RESEARCH RESULTS

As noted and discussed in the *Importance, Performance & Improvement Priorities* section of this report, results from this Phase 2 research are not consistent with the results from Phase 1. A comparison of Improvement Potential (Importance Rating Minus Performance Rating) results from Phase 1 and Phase 2 is presented in Tables 5 and 6. A comparison of other results from Phase 1 and Phase 2 is presented in Tables 1 through 4 below.

Table 1 – Collaboration Importance Self-Assessment (Importance ~ Volume)

Phase 1 Group Members' Response Summary						Phase 2 OEMs' View					
Collaboration Entity	Collaboration Purpose					Collaboration Entity	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change		Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change
OEM Remote Site (Internal)	4.0	4.5	4.6	4.6	4.1	OEM	4.0	3.2	4.2	4.4	4.4
Design & Build Partner	4.3	4.4	3.8	4.6	4.3	Design & Build Partner	4.1	3.8	4.4	4.0	4.2
Equip't & System Supplier	3.0	3.0	2.3	3.0	3.0	Equip't & System Supplier	3.5	3.2	3.4	3.0	3.5
Design Supplier	3.8	3.8	3.4	3.7	4.2	Design Supplier	3.6	3.5	3.9	3.6	3.5

Table 2 – Collaboration Performance Self-Assessment (Performance = Effectiveness)

Phase 1 Group Members' Response Summary						Phase 2 OEMs' View					
Collaboration Entity	Collaboration Purpose					Collaboration Entity	Collaboration Purpose				
	Work assignment & des'n delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change		Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change
OEM Remote Site (Internal)	3.6	3.8	3.8	3.9	4.2	OEM	4.2	3.8	4.0	4.0	4.2
Design & Build Partner	2.2	2.3	2.8	2.8	3.1	Design & Build Partner	3.8	3.3	3.3	3.2	3.4
Equipment & System Supplier	1.3	1.3	1.7	1.7	2.0	Equip't & System Supplier	3.3	2.5	2.8	2.7	3.1
Design Supplier	2.4	2.5	2.6	2.8	3.3	Design Supplier	3.8	3.4	3.5	3.1	3.7

Table 3 – Collaboration Environments and Volume of Collaboration for Various Collaboration Purposes

Phase 1 Group Members' Response Summary						Phase 2 OEMs' View					
Collaboration Purpose	Collaboration Purpose					Collaboration Environment	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering change		Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change
Joint Session (inside firewall)	1.6	3.2	4.0	2.8	1.8	Joint Session (inside firewall)	2.8	3.6	2.6	3.9	3.0
Joint Project Repository (inside firewall)	2.6	4.4	4.6	3.1	3.3	Joint Project Repository (inside firewall)	3.6	2.6	3.0	3.1	3.8
Joint Sharing Repository (outside firewall)	1.4	3.0	3.5	1.5	2.4	Joint Sharing Repository (outside firewall)	2.2	3.3	3.2	3.8	2.0
Send/Receive Files (outside firewall)	4.1	2.7	1.8	1.4	1.9	Send/Receive Files (outside firewall)	2.7	2.9	3.8	3.0	3.1

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Table 4 – Types and Volume of Geometric Content Shared for Various Collaboration Purposes

Phase 1 Group Members' Response Summary

Collaboration Content	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering change
Complete native 3D model	4.2	5.0	4.3	3.3	3.8
Simplified native 3D model	2.8	2.6	2.8	3.0	2.1
Standard format 3D model (STEP, IGES, other)	2.2	1.8	1.0	1.1	1.5
Visualization model (JT, 3D PDF...)	1.1	1.5	1.6	2.2	1.9
2D models (images, drawings...)	2.3	2.3	1.5	3.4	1.8

Phase 2 OEMs' View

Collaboration Content	Collaboration Purpose				
	Work assignment & design delivery	Simultaneous design & evaluation	DMU Baselineing	Design review & approval	Engineering Change
Complete Native 3D CAD Model	3.7	2.2	1.9	2.8	3.1
Simplified Native 3D CAD Model	3.8	2.3	1.9	2.5	2.1
Standard Format 3D Model (STEP, IGES, etc.)	4.3	3.1	2.4	2.1	2.4
Visualization Model (JT, 3D PDF, etc.)	4.0	2.8	1.9	2.4	3.0
2D Models (images, drawings, etc.)	4.0	2.4	1.8	2.3	3.1

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