Phase One Final Report

Assessment of Supplier Capabilities to Operate in a Model-Based Enterprise Environment

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Prepared by NIST MEP

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This report was prepared by the National Institute of Standards and Technology (NIST), specifically the NIST Manufacturing Extension Partnership (MEP). The report presents the initial results of tasking conducted by NIST MEP for the U.S. Department of Defense, with sponsorship from the U.S. Army Research Laboratory and Amy Manufacturing Technology Program.

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Introduction

With sponsorship from the U.S. Army Research Laboratory and Army Manufacturing Technology (ManTech) Program, the National Institute of Standards and Technology (NIST) Manufacturing Extension Partnership (MEP) and BAE Systems Ground Systems, Pennsylvania (BAE) formed a partnership intent on assessing and developing the capabilities of U.S. manufacturers to operate as part of a Model-Based Enterprise (MBE). Plans are being developed at BAE and other original equipment manufacturers (OEMs) to use MBE as the basis for supply chain operations in the design and production of military vehicles for the U.S Department of Defense (DOD). The initial assessment and development necessary for this supply chain transformation to occur across the DOD supply base has been conducted under the auspices of Army ManTech.

The MBE vision is relatively simple: master models that fully represent the complete design are distributed electronically throughout the entire enterprise. On a more technical level, an MBE environment is a production system that employs concurrent product development with electronic, interoperable engineering tools and methods to optimize design, manufacture and supportability. The 3D models used in MBE are comprehensive and fully annotated. Therefore, the models only need to be created once and do not need to be re-mastered. Every detail of their content can be extracted and seamlessly transitioned to all downstream uses, including: manufacturing; suppliers and subcontractors; quality; procurement; and maintenance, repair, and overhaul.

MBE implementation offers many benefits to OEMs and their suppliers, including:

- Streamlining the design-build process
- Decreasing lead-time to manufacture
- Reducing engineering changes
- Improving first-time quality
- Greatly reducing overall program costs

This Army ManTech supply base project began with the development of a market assessment that was then conducted by NIST MEP as a means for the DOD to build their knowledge and understanding of the domestic military ground vehicle supply base and its capabilities. The results of this market assessment, outlined in this report, will serve as a tool for the DOD, defense OEMs, and other industry stakeholders to use in the development of MBE implementation plans. Furthermore, this project, and the partnerships associated with it, will make MEP resources and assistance available to small manufacturers looking to capitalize on the significant business opportunities presented by MBE. Through MBE implementation, small manufacturers can improve their own operations and maximize their ability to effectively manufacture parts and components for BAE and the DOD.

This Phase One Final Report presents the findings from an MBE capabilities assessment involving nearly one thousand manufacturers who supply piece parts and subassemblies for military ground vehicles

through BAE. NIST MEP, working closely with its nationwide network of MEP Centers, conducted this MBE capabilities assessment of military ground vehicle supplier companies using a two step approach:

1. The onsite assessment of 10 suppliers, selected as a cross-section representation of the military ground vehicle supply base.
2. The online assessment of a broad sweep of nearly 1000 military ground vehicle suppliers, of which 445 companies participated.

The Phase One Final Report includes the following:

- An overview of the processes used to conduct the MBE capability assessments.
- Results and detailed analyses of the MBE capability assessments of the military ground vehicle supply base.
- NIST MEP's observations and conclusions from the assessments.
- NIST MEP's recommendations for the provision of assistance to these companies to improve their MBE capabilities and overall readiness to serve as suppliers to the DOD, operating in an MBE environment.

Methodology

MEP assessed the MBE capabilities of the military ground vehicle supply base using a set of characteristics and attributes that was collaboratively defined by NIST MEP and BAE with input from the Army. During 10 onsite assessments, an MBE capabilities assessment guide was used to direct the discussions. The onsite assessments served as a learning tool for NIST MEP and providing the basis for a refined assessment tool that was used for the online portion of assessment *(See Appendix A)*.

In addition to NIST MEP, two MEP Centers contributed significantly to the MBE assessment process. MANTEC, the MEP Center located in York, PA, was responsible for contacting BAE suppliers to encourage their participation in the assessment and served as a primary resource for companies needing assistance in the completion of the assessment. Catalyst Connection, the MEP Center located in Pittsburgh, PA, developed the technical infrastructure for the online assessment.

BAE, with concurrence from the Army, provided a list of 1020 suppliers, of which MEP was able to gather engineering points of contact for 850 suppliers, who were then contacted by MEP to participate in the online MBE capabilities assessment. A letter of support from the U.S. Army sponsor for this activity was sent to the suppliers to encourage their participation. Of those 850 companies, 445 suppliers submitted an assessment. A small number of suppliers, less than 10, submitted information to MEP regarding their MBE capabilities after the online assessment was closed. This information has been catalogued by MEP, but is not included in the data and analyses provided in this report.

Onsite Assessments

During the onsite MBE assessments, NIST MEP focused the questions and discussions on the engineering capabilities of the companies, how those engineering capabilities are integrated with production and other departments, and how they are utilized in interactions with customers and suppliers. An array of non-technical, business information was also captured. During each assessment, MEP received a tour of the company's manufacturing facilities. These facility tours not only provided clarity and understanding in terms of each company's operations and capabilities, but also helped MEP in developing the right questions and terms in the online assessment to get at the most relevant and accurate supplier information.

Along with NIST MEP assessors, representatives from local MEP Centers also participated in the onsite assessments. For information about both pre-existing and developing relationships between MEP Centers around the nation and BAE supplier companies see *Recommendations & Next* Steps.

It is important to distinguish that these assessments focused on the MBE capabilities of the companies, not the MBE readiness of the companies. This is an important distinction because capabilities and readiness are different. Manufacturer MBE readiness, while heavily dependent on current capabilities, is also tied into broader business-related issues. This distinction is essential to understanding the results of this MBE assessment and is explained further in the *MBE Capabilities Metric* section.

Online Assessment

Catalyst Connection created a secure, password-protected website that hosted the online assessment to which 850 military ground vehicle suppliers were invited. This website was live for approximately four weeks during July and August 2009. MANTEC was able to leverage high-level endorsement from both BAE and the U.S. Army in encouraging the 850 suppliers contacted to participate in the assessment. In the end, 445 companies participated in the assessment. *(See Appendix A to view the online assessment.)*

MBE Capabilities Metric

Based upon learning from the 10 onsite assessments, NIST MEP developed an MBE Capabilities Metric designed to serve as an accessible rating tool, applicable to any manufacturer. This metric provides a quick snapshot of manufacturers' MBE capabilities to operate in an MBE environment from both a technical/engineering perspective, as well as from a company operations perspective. Accordingly, the metric defines MBE capability levels in terms of both engineering system and business system attributes.

The metric presents the obvious distinctions among MBE-related capabilities observed at the 10 manufacturers that were assessed onsite. It has been applied to the 445 participating suppliers and used in the analysis and presentation of the assessment results.

This metric is an MBE *Capabilities* Metric – NOT an MBE *Readiness* Metric. Capabilities and readiness are two distinct attributes. This assessment deals only with manufacturer capabilities. Manufacturer MBE readiness, while heavily dependent on current capabilities, is also tied into broader business-related issues. A higher level of MBE capabilities does not necessarily indicate that a company is ready to advance those capabilities to fully utilize MBE. Conversely, a lower level of MBE capabilities does not indicate the absence of a desire and readiness to advance those capabilities. Only the combination of capabilities and readiness can determine the extent to which a manufacturer is willing, able – and ready – to implement MBE more fully than they currently do.

MBE Capability Level 1	MBE Capability Level 2	MBE Capability Level 3	MBE Capability Level 4	MBE Capability Level 5
Very little computer-driven/automated /CNC ops Most or all ops based upon 2D drawings Receive, send electronic manufacturing files in .pdf or other 2D format Use software to assist certain business/ management functions, but little or no electronic cross-dept integration/ re-use of data	Both CNC, manual ops Can accept 3D models from customers, but convert to 2D drawings to drive manufacturing processes Small amounts of electronic cross-dept integration/ re-use of info exists	Majority of mfg processes are computer-driven/ automated / CNC operations Planning, programming for manufacturing processes is performed using combination of 3D models, 2D models, 2D drawings Cross-dept integration exists via use of MRP system (or "MRP-like" software)	All manufacturing processes are planned/ programmed based upon 3D model info Significant cross-dept integration, re-use of info exists via extensive use of MRP, ERP systems Some use of PDM/PLM systems occurs	All manufacturing processes are planned/ programmed based upon 3D model info All company ops are integrated, driven by the same 3D model info PDM/PLM systems serve as the data integration hub for company ops

The application of an MBE capability rating from this metric is not an exact process. During the onsite assessments MEP was able to tour the manufacturing facilities and ask clarifying questions, resulting in greater accuracy in the metric application and overall assessment. While the online assessment was designed to be user-friendly, not all participating suppliers completed the online assessment comprehensively. Many level 1 ratings were the result of incomplete assessment information.

With this in mind NIST MEP employed several tactics to ensure the validity of the results. The application of an MBE rating based on this metric was performed by a subject matter expert from the NIST MEP project team and was done so blindly, looking at only the information relative to the metric, not distinguishing company information. The rating process was repeated multiple times to ensure accuracy. As an additional process check, the 10 companies that were assessed onsite were also entered into the pool of online assessment companies and rated blindly. All 10 of the ratings that were applied for the online assessments matched the ratings that were given as a result of the onsite assessments.

The metric used in this project does not directly correlate to the detailed metric produced by a team of organizations, including BAE, working in conjunction with the Army Manufacturing Technology (ManTech) Program-sponsored Manufacturing Technology Objective (MTO). The metric used for this assessment is not intended to replace the more comprehensive ManTech metric, but rather to complement it. The ManTech metric is currently being used as the basis for further MBE development and implementation throughout the DoD. For clarity and reference, an approximate correlation between the ManTech metric and this project's MBE metric is provided in the table below:

ManTech MTO MBE Capability Level	MEP Project MBE Capability Level	Correlation and Notes
0: Model-centric drawings for design and manufacture, 2D drawing	**1:** 2D, drawing-based, mainly manual ops	▪ Operational basis is 2D drawings
1: Model-based manufacturing, 2D drawing and neutral CAD model	**2:** Can accept 3D, but 2D drawing oriented, some computer-driven ops	▪ Operational basis is 2D drawings, but have CAD capabilities, which implies 3D capabilities at some level
2: Native CAD based manufacturing, 2D drawing and native CAD model		
3: Model-based definition, 3D annotated model and light weight viewable	**3:** 3D-oriented, still use drawings, mainly computer-driven ops, some electronic data integration across company ops	▪ Operational basis is 3D models ▪ Still likely to see use of 2D data in operations ▪ Software systems assist in management and re-use of 3D model data across company operations
4: Model-based definition with data management, 3D annotated model and light weight viewable via PLM		
5: Model-based definition with automated technical data package, digital product definition package and TDP	**4:** 3D-oriented, no use of drawings, significant electronic data integration across company ops	▪ Operational basis is 3D models ▪ No 2D conversions ▪ Extensive electronic integration of data across company operations, most of which are automated
6: MBD with automated TDP and on-demand enterprise access, digital product definition package and TDP via the web	**5:** All ops based on 3D model, full electronic data integration across company ops based upon PDM/PLM hub	▪ Operational basis is 3D models ▪ Fully integrated company operations for asset visibility up and down the supply chain

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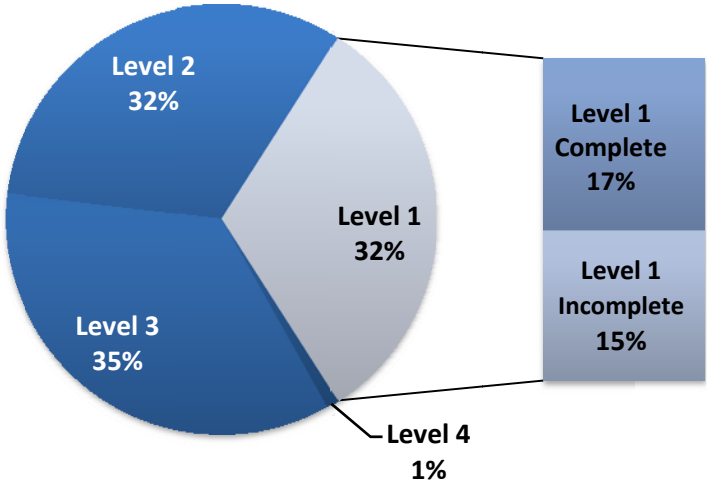
Online Supplier Assessment Results

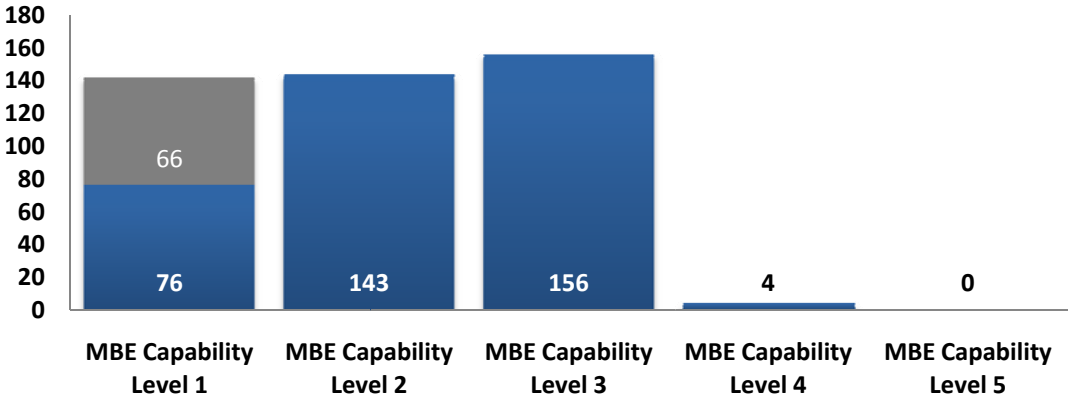
Application of MBE Metric

During the assessment analysis, NIST MEP applied an MBE capability rating to each participating supplier in accordance with the MBE Capability Metric. Companies rated as follows:

- **Level 1:** 142 companies
- **Level 2:** 143 companies
- **Level 3:** 156 companies
- **Level 4:** 4 companies
- **Level 5:** 0 companies



Company assessment information for a level 1 rating showed no signs of using 3D models, very little computer-driven operations, and little or no electronic, cross-department integration and re-use of data. Company assessment information for a level 4 rating showed no indication of the use of 2D, drawing-based information – everything is based upon 3D data. Level 4 companies also indicate significant cross-department, electronic re-use and integration of data with the assistance of software resource planning and data management systems. Ratings at Level 2 and 3 fell in between these two extremes.



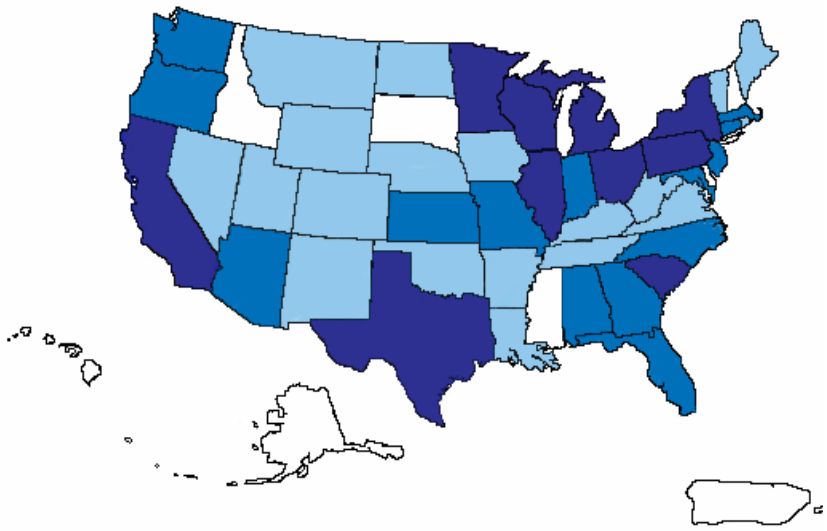
The lowest level at which a company could be considered ready to operate in an MBE environment is level 2, as that is the first level at which 3D data can be received and consumed to some degree. Sixty-six companies rated a level 1 due to incomplete assessment information. Given that no participating supplier rated a level 5, the remaining results address levels 1-4.

Supplier Demographics

I. Supplier Location by State

The map below indicates the number of suppliers in each state that responded to the assessment. As part of this assessment, 850 companies were contacted by MEP. Of that 850, 445 companies completed the online assessment.

A **Dark Blue** state indicates a presence of >10 suppliers; **Medium Blue** indicates from 5 to 9 suppliers; **Light Blue** indicates a presence of <5 suppliers; and a White state indicates no responding suppliers in that state. Five responding suppliers were located in Canadian provinces.



AL:	7	**MD:**	7	**OR:**	6
AR:	1	**ME:**	2	**PA:**	60
AZ:	5	**MI:**	44	**RI:**	1
CA:	85	**MN:**	36	**SC:**	12
CO:	3	**MO:**	5	**SD:**	1
CT:	5	**MT:**	1	**TN:**	2
FL:	9	**NC:**	7	**TX:**	12
GA:	5	**ND:**	1	**UT:**	1
IA:	3	**NE:**	1	**VA:**	2
IL:	11	**NJ:**	10	**VT:**	2
IN:	8	**NM:**	1	**WA:**	10
KS:	5	**NV:**	1	**WI:**	13
KY:	3	**NY:**	22	**WV:**	1
LA:	1	**OH:**	15	**WY:**	1
MA:	9	**OK:**	3	**CNDA:**	5

Physical Locations

Companies were asked in how many locations they operated facilities, according to the responses:

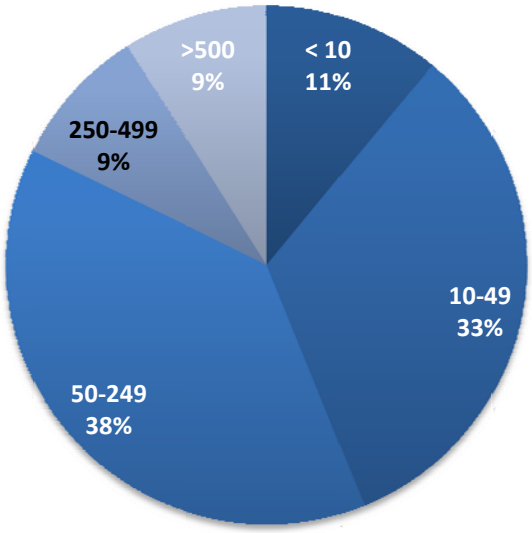
- 2.5% of participating suppliers do not operate manufacturing facilities,
- 58.9% operate out of a single facility,
- 26.3% have 2-4 facilities, and
- 12.4% operate out of 5 or more locations.

# of Facilities	# of Suppliers
0	11
1	262
2	73
3	30
4	14
5-10	36
>10	19

II. Size: by Number of Employees

The majority of participating suppliers are small to medium sized businesses, as defined by the U.S. Small Business Administration as having fewer than 500 employees. Of the suppliers who participated in this MBE capabilities assessment:

- 44% have less than 50 employees
- 71% have 10-249 employees
- 18% have greater than 250 employees
- 9% are considered large companies – defined as having greater than 500 employees



The data does show a correlation between larger companies and more advanced MBE capabilities, however this correlation is not necessarily directly proportional. For example, the table below shows that one of the level 4 companies has less than 10 employees, while several level 1 companies have more than 500 employees:

MBE Rating	# of Employees	# of Suppliers	MBE Rating	# of Employees	# of Suppliers
Level 1	< 10	33	**Level 3**	<10	5
	10-49	56		10-49	53
	50-249	33		50-249	72
	250-499	6		250-499	19
	>500	14		>500	7
Level 2	< 10	10	**Level 4**	<10	1
	10-49	37		10-49	0
	50-249	65		50-249	1
	250-499	14		250-499	0
	>500	17		>500	2

III. Company Set-Aside Categories

The table below indicates the total number of company set-asides that were identified by suppliers who participated in the assessment, as well as the breakdown by MBE capability level. No level 1 company noted any set-asides. Companies were instructed to identify all set aside categories that applied to their business.

Set-Aside	MBE Rating	# of Suppliers	Set-Aside	MBE Rating	# of Suppliers
Hub-Zone	Level 1	0	**Veteran Owned**	Level 1	0
	Level 2	11		Level 2	3
	Level 3	17		Level 3	13
	Level 4	0		Level 4	0
	Total	**28**		**Total**	**16**
Small Disadvantaged	Level 1	0	**Service-Disabled Veteran**	Level 1	0
	Level 2	19		Level 2	1
	Level 3	23		Level 3	4
	Level 4	1		Level 4	0
	Total	**43**		**Total**	**5**
Woman Owned	Level 1	0	**Alaska Native/Indian Tribe**	Level 1	0
	Level 2	4		Level 2	2
	Level 3	1		Level 3	1
	Level 4	0		Level 4	0
	Total	**5**		**Total**	**3**

IV. Company Quality Certifications

Suppliers were asked to list any quality certifications their company has received. This was an open-ended item, and company responses varied widely in terms of specificity. 97 companies provided no response. Twenty-seven of the suppliers included in the ISO category specified that they were "compliant" rather than "certified". Companies were instructed to identify all quality certifications that apply to their business.

The following responses were provided for six of the more prominent quality certifications that were listed by respondents. These six are also highlighted due to their association with the automotive, aerospace, and defense industries:

- ISO = the International Organization for Standardization
- AS = Quality Management System for the Aerospace Industry
- MIL = Military Standard
- TS = ISO Technical Specification for Automotive Quality Management Systems
- QS = Automotive Industry Quality System
- NADCAP = National Aerospace and Defense Contractors Accreditation Program

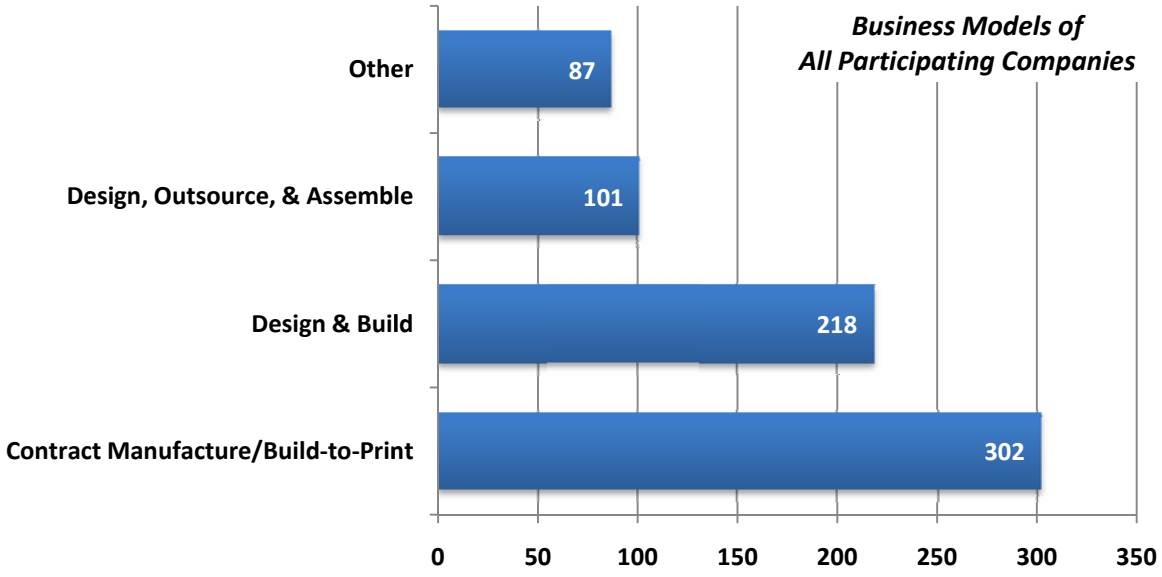
Certification	MBE Rating	# of Suppliers	Certification	MBE Rating	# of Suppliers
ISO	Level 1	53	**TS**	Level 1	2
	Level 2	88		Level 2	7
	Level 3	114		Level 3	24
	Level 4	3		Level 4	1
	Total	**258**		**Total**	**34**
AS	Level 1	16	**QS**	Level 1	1
	Level 2	25		Level 2	0
	Level 3	32		Level 3	1
	Level 4	2		Level 4	0
	Total	**75**		**Total**	**2**
MIL	Level 1	16	**NADCAP**	Level 1	0
	Level 2	12		Level 2	5
	Level 3	12		Level 3	4
	Level 4	0		Level 4	0
	Total	**40**		**Total**	**9**

Business Dynamics

I. Company Business Model

The assessment collected information about the business models used by supplier companies. Based upon knowledge obtained during the 10 initial onsite assessments, four business model options were provided for companies: Contract Manufacturer/Build-to-Print; Design & Build; Design, Outsource, & Assemble; and Other. Companies designated the business models they employ from among these options, several companies use multiple business models.

The charts below show the business model results in aggregate, as well as broken down in terms of level of MBE capability. Of the 87 companies that selected "other", 46% fell into 3 categories: Distributors (33 companies), Engineering/Prototyping firms (4 companies), and Software Development companies (3 companies).



MBE Rating	Contract Manufacturer/Build-to-Print	Design & Build	Design, Outsource, & Assemble
Level 1	6	21	8
Level 2	99	78	38
Level 3	132	85	41
Level 4	4	3	2

II. Defense vs. Commercial

The assessment collected information about the sources of business/customers of the participating suppliers. Companies indicated the percentage of their business fell that into the following categories: Defense/Non-Government; Defense/Government; Government/Non-Defense; Auto-Industry Related; and Commercial.

The following tables display the data results, with each category broken down in terms of level of MBE capability:

Defense/Non-Government

% of Business	Level 1	Level 2	Level 3	Level 4	All Suppliers
< 10	62.7%	67.1%	53.8%	50%	60.9%
11-30	18.4%	14.7%	22.5%	25%	18.7%
31-50	11.9%	7.7%	11.6%	25%	10.6%
51-80	5.6%	5.6%	7.0%	0%	6.0%
> 80	1.4%	4.9%	5.1%	0%	3.8%

Defense/Government

% of Business	Level 1	Level 2	Level 3	Level 4	All Suppliers
< 10	53.5%	52.4%	53.2%	75.0%	53.5%
11-30	20.5%	17.5%	17.9%	0%	18.4%
31-50	9.8%	14.0%	8.3%	0%	10.6%
51-80	9.1%	7.7%	11.6%	25%	9.7%
> 80	7.0%	8.4%	8.9%	0%	8.0%

Government/Non-Defense

% of Business	Level 1	Level 2	Level 3	Level 4	All Suppliers
< 10	91.5%	97.2%	92.9%	100%	93.9%
11-30	6.3%	2.8%	5.7%	0%	5.0%
31-50	2.1%	0%	1.2%	0%	1.1%
51-80	0%	0%	0%	0%	0%
> 80	0%	0%	0%	0%	0%

Auto-Industry Related

% of Business	Level 1	Level 2	Level 3	Level 4	All Suppliers
< 10	90.1%	84.6%	88.5%	50%	**87.4%**
11-30	5.6%	9.8%	5.2%	50%	**7.2%**
31-50	1.4%	2.1%	1.9%	0%	**1.8%**
51-80	2.1%	2.1%	3.1%	0%	**2.5%**
> 80	.7%	1.4%	1.2%	0%	**1.1%**

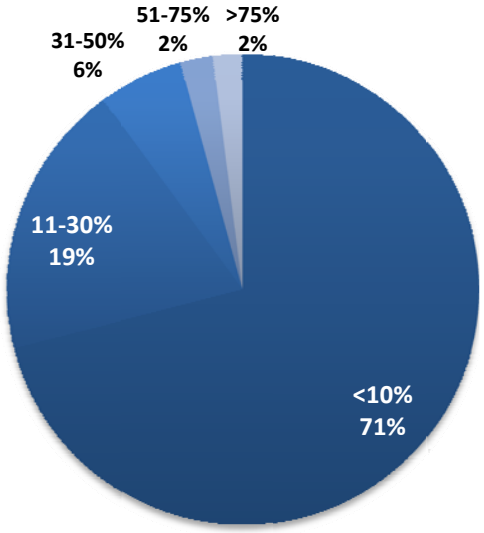
Commercial

% of Business	Level 1	Level 2	Level 3	Level 4	All Suppliers
< 10	29.6%	30.1%	26.9%	0%	**28.5%**
11-30	14.7%	16.6%	16.6%	25%	**14.6%**
31-50	16.9%	11.9%	16.7%	0%	**15.1%**
51-80	22.5%	16.6%	28.1%	50%	**26.1%**
> 80	16.2%	19.6%	11.6%	25%	**15.7%**

III. Business to a Single OEM

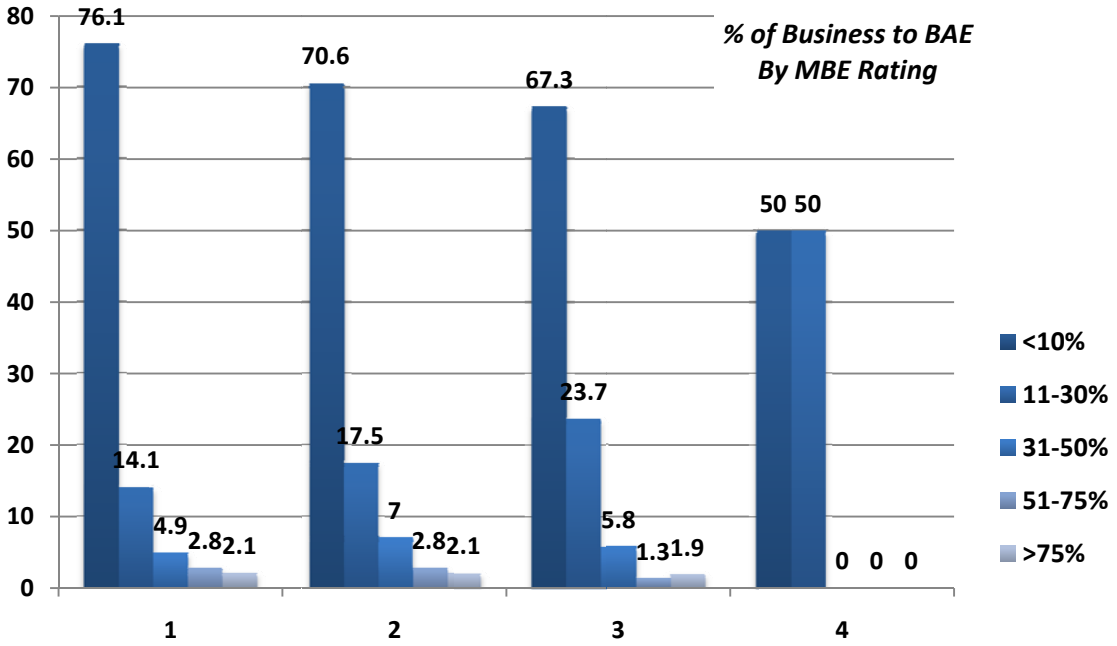
The assessment collected information about the market diversity of participating suppliers. Participants were asked what percentage of their business went to a single OEM/prime, in this case BAE Systems.

In the majority of companies, only a small percentage of their business goes directly to a single OEM.



- In 96% of participating suppliers, BAE business accounts for less than 51% of their overall business.
- In 90%, BAE business accounts for less than 31% of overall business
- 2% of companies reported BAE business accounting for over 75% of their overall business
- BAE business accounts for less than 10% of overall company business in the following percentages of companies, as broken down in terms of levels of MBE capabilities:

Level 1: 76% **Level 3:** 67.3%
Level 2: 70.6% **Level 4:** 50%

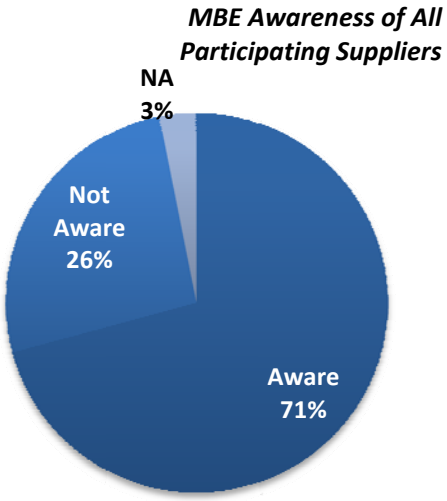


MBE Familiarity/Interest

The assessment collected a series of information designed to gather information regarding the participating suppliers' awareness and interest in MBE. The questions were designed to capture suppliers' awareness of the concepts of MBE, and also of the potential DOD transition to the use of 3D data in procurements. The assessment gauged participant interest in two ways: 1. near the beginning of the assessment companies were given the opportunity to indicate their interest in learning more about MBE, and 2. after largely completing the survey, companies were also given the opportunity to indicate their interest in operating as part of an MBE environment. The results were as follows:

I. MBE Awareness

The chart to the right shows responses for all participating companies regarding whether they are familiar with the concept of a model-based enterprise (MBE), where the prime contractor or OEM creates and consumes all design and product data in a comprehensive, fully annotated 3D master model, rather than 2D drawings, using CAD/CAM/CAE Systems.



The table below shows the breakdown of supplier awareness by level of MBE capability:

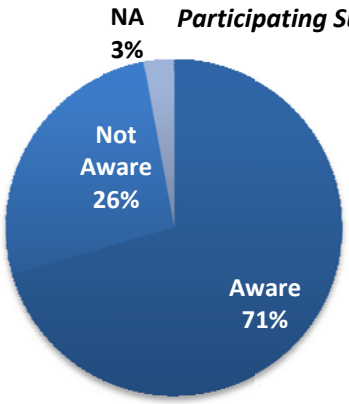
MBE Rating	Aware of Concept of MBE	Not Aware of Concept of MBE	No Answer
Level 1	70	59	13
Level 2	110	32	1
Level 3	142	14	0
Level 4	4	0	0

II. Awareness of DOD Transition to 3D

The chart to the right shows responses for all participating companies regarding whether they are aware that the DOD and its contractors are moving from 2D paper drawings to electronic 3D models as the procurement basis for the design and production of military hardware.

The table below shows the breakdown of supplier awareness by level of MBE capability:

Awareness of DOD Move to 3D Data All Participating Suppliers



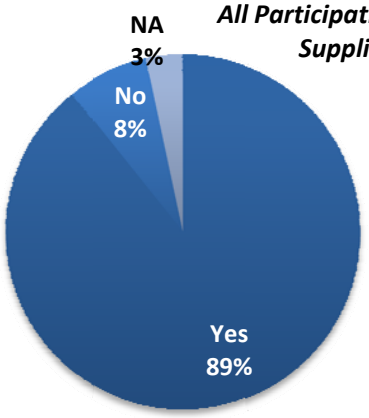
MBE Rating	Aware of DOD Move to 3D Data	Not Aware of DOD Move to 3D Data	No Answer
Level 1	73	57	12
Level 2	105	37	1
Level 3	132	24	0
Level 4	4	0	0

III. Interest in Learning about MBE

The chart to the right shows responses for all participating companies regarding whether they are interested in learning more about MBE and how it works, including how suppliers interact with OEMs/primes to share relevant design and production data in an MBE environment.

The table below shows the breakdown of supplier interest by level of MBE capability:

All Participating Suppliers



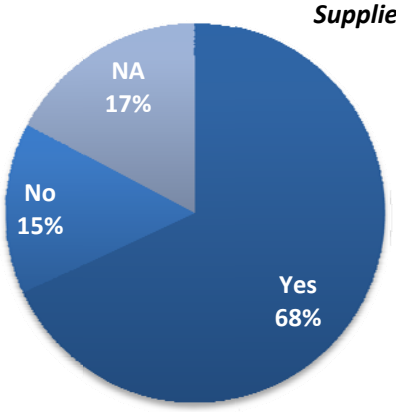
MBE Rating	Interested	Not Interested	No Answer
Level 1	97	32	13
Level 2	140	1	2
Level 3	156	0	0
Level 4	4	0	0

IV. Interest in Operating in an MBE Environment

The chart to the right shows responses for all participating companies regarding whether they would you be willing to operate their production facility or line as an integrated part of an MBE environment, assuming the customer can provide the necessary, fully-annotated 3D models.

The table below shows the breakdown of supplier interest by level of MBE capability:

All Participating Suppliers



MBE Rating	Interested	Not Interested	No Answer
Level 1	52	23	67
Level 2	104	31	8
Level 3	143	11	2
Level 4	4	0	0

Use of 3D Software & Models

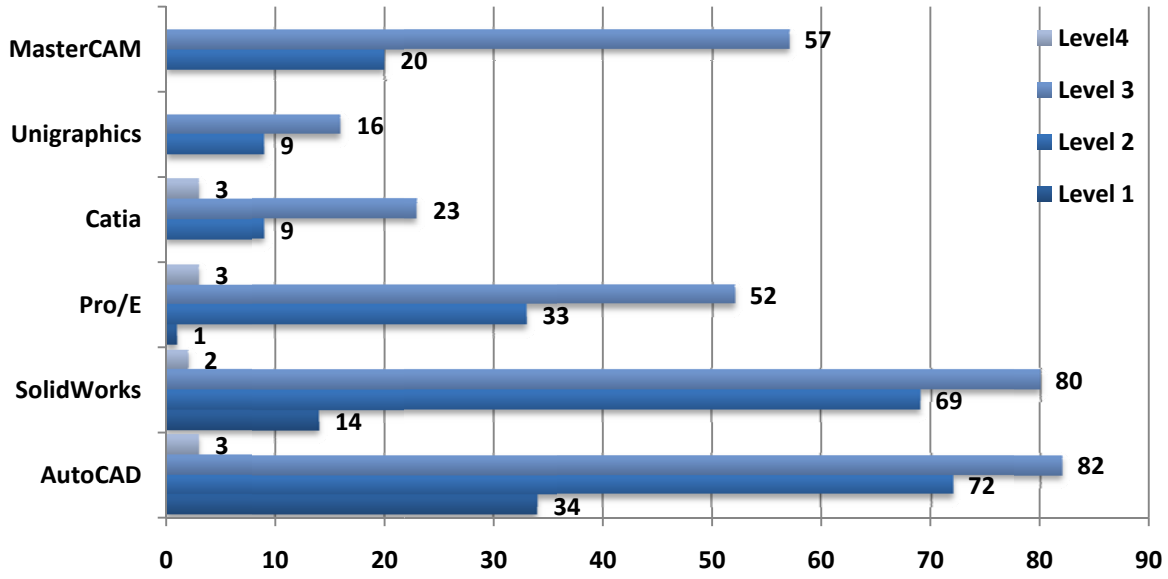
To gain insight into the technical and operational details associated with manufacturers' capabilities to operate in a model-based enterprise, the assessment collected a series of information that focused on specific attributes and facets of MBE. MBE is based upon 3D data and comprehensive models. Specifically, this assessment examined the use of CAD/CAM/CAE systems and software, along with the use of certain data file formats, the use of 3D data in production, the use of 2D prints/drawings, and the integration of 3D data across departments within a company. Assessment results in these areas are presented in the following sections.

I. CAD/CAM/CAE Software Used

Companies were given the opportunity to define the CAD/CAM/CAE software products they use internally. The purpose here was to identify those systems that are commonly used throughout the supply base, as well as to get a sense of how extensively and for what specific purposes these systems were used. Twenty-two companies, all rated as MBE capability level 1, indicated that they did not use any CAD/CAM/CAE software. Sixty-three level 1 companies failed to provide any response.

Participants identified the use of over 100 different software products, the most common of which are provided below:

- **AutoCAD:** 191 suppliers
- **SolidWorks**: 165 suppliers
- **Pro/E:** 89 suppliers
- **MasterCAM:** 77 suppliers
- **Catia:** 35 suppliers
- **Unigraphics:** 25 suppliers



As shown in the graph above, of the four level 4 companies: three use Pro/e; three use Catia; three use AutoCAD; and two use SolidWorks. Companies were able to indicate the use of multiple products, if appropriate. Other software products reported include:

- SurfCAM
- PCDMIS
- CADKey
- BobCAD
- Gibbs
- ADAMS
- Nastran
- Cosmos
- SolidEdge
- SmartCAM
- EdgeCAM
- FabriWIN
- Abaqus
- Espirit
- Merry Mechanization
- FeatureCAM
- PartMaker
- Key Creator

II. Data File Formats

Four data file formats were identified in the assessment: STEP, IGES, PDF, and DXF. Participating suppliers were given the opportunity to indicate which of these formats their company used. Companies could indicate the use of multiple formats if appropriate. All MBE capability level 4 companies utilize all four of these data file formats. 47.8% of MBE capability level 1 companies did not indicate any use of any of these file formats.

MBE Capability Level	Data File Format	% of companies that use format type
Level 1	PDF	48.5%
	DXF	27.4%
	IGES	14%
	STEP	10.5%
Level 2	PDF	90.9%
	DXF	85.3%
	IGES	78.3%
	STEP	75.5%
Level 3	PDF	97.4%
	DXF	94.7%
	IGES	96.0%
	STEP	97.3%
Level 4	PDF	100%
	DXF	100%
	IGES	100%
	STEP	100%
Total	PDF	79.7%
	DXF	69.9%
	IGES	63.8%
	STEP	62.0%

Companies were also given the opportunity to identify which data file format they used most often in the operations. The results follow:

- **PDF:** 23.6%
- **DXF:** 11.5%
- **IGES:** 11.0%
- **STEP:** 25.6%
- **No Preference:** 3.6%
- **No Answer:** 19.8%
- **Other:** 4.9%

  Note that "Other" indicates that the company either responded with a file format not listed or some combination of the four.

Notably, the IGES format was indicated with a slightly higher overall percentage of usage than STEP, however, STEP rated significantly higher than IGES in terms of company use. In fact, IGES rated the lowest of all four data file formats in terms of "used most often".

III. Use of 3D Models in Production

Companies were queried regarding their use of 3D models in production. This first addressed the issue in a very broad sense, then in more detail if a company indicated that they have used 3D models in production.

If a company indicated that they have not used 3D models in production, then the company did not provide further information about how they use 3D models, as included in the remaining items in this section. The number of data points in the remainder of this section reflects this.

MBE Capability Level	Use 3D Models in Production	# of Companies
Level 1	Yes	3
	No	86
	No Answer	53
Level 2	Yes	78
	No	63
	No Answer	2
Level 3	Yes	153
	No	1
	No Answer	2
Level 4	Yes	4
	No	0
	No Answer	0
Total	Yes	238
	No	150
	No Answer	57

IV. Creation of Drawings

A common practice among participating companies is to receive information in one format, then translate it to another format that is aligned with company practices and compatible with company systems. For 3D data, a typical practice involves converting 3D electronic models into 2D drawings or prints for various manufacturing or other company operations. Information was collected regarding the extent to which companies convert to drawings for select operations.

The numbers in the table on the below indicate the numbers of companies that convert 3D models to drawings for the specific operations referenced:

Operation	Level 1	Level 2	Level 3	Level 4	All Suppliers
Create an equivalent drawing for process planning	1	7	10	0	**18**
Create an equivalent drawing for inspection	0	7	12	1	**20**
Create an equivalent drawing for other departments	0	3	7	1	**11**
All of the Above	2	67	122	0	**191**
No Answer	139	59	5	2	**205**

V. Use of 3D Model Information to Directly Drive Production Systems

In addition to companies simply being able to receive, interpret, and send 3D data and models, some companies employ production systems that can be directly driven with this data. Such systems are highly computer-driven and software-assisted, and typically do not use 2D prints or drawings. The assessment collected information from participating companies regarding the extent to which their production systems can be directly driven by 3D models.

A significant number of companies seemed to have difficulty providing meaningful information here - 219 companies provided no information and 21 gave ambiguous information that could not be used to determine whether their production systems can or cannot be directly driven by 3D model data.

Of the 205 companies that provided meaningful, interpretable information, 44.9% (92 companies) indicated that they could use 3D models to directly drive their production systems, and 55.1% (113 companies) indicated that they were currently unable to do so.

VI. Conversion from 3D Models to 2D Drawings at the Machine Level

The assessment specifically examined whether companies convert from 3D models into 2D prints or drawings at the machine level for various operations. A total of 191 suppliers indicated that they do, in fact, convert to 2D drawings at the machine level. 52 companies indicated that they did not perform such conversions; and 202 provided no indication either way.

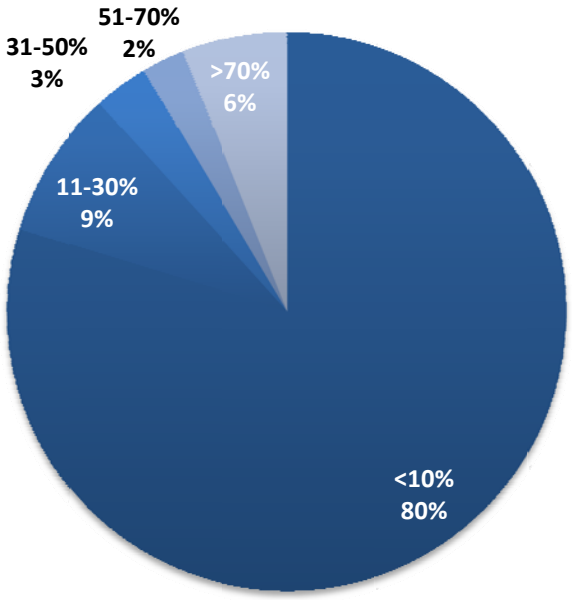
All MBE capability level 1 companies either indicated that they do convert to 2D, or made no indication at all. No level 4 company indicated the conversion of 3D models to 2D drawings at any time during production.

MBE Capability Level	Convert to 2D Drawing at Machine Level	# of companies
Level 1	Yes	4
	No	0
	No Answer	138
Level 2	Yes	67
	No	15
	No Answer	61
Level 3	Yes	120
	No	33
	No Answer	3
Level 4	Yes	0
	No	4
	No Answer	0

VII. Percentage of Parts Produced using 3D Models Only

The assessment collected information about the prevalence of companies producing products using 3D models only, as opposed to 2D data, or some combination of 3D models and 2D data.

While most participating suppliers are producing a small number of parts using only 3D models (<10%), the data shows that a significant number (8%) are producing more than 50% of their products without the use of 2D drawings. In fact, 6% are producing more than 70% using only 3D. These numbers do not capture the numbers of parts produced using some or mostly 3D, which would intuitively be significantly larger.



The table below shows these results broken down by MBE capability level. It's noteworthy for the MBE capability level 4 companies that 75% of these companies only produce 11-30% of their products using 3D models only. The likely reason why these numbers are low is that these companies may have customers who supply them information in 2D, which the companies may then convert to 3D; nonetheless, that would indicate that there is still a mix of parts for which they use some 2D information.

% Parts	Level 1	Level 2	Level 3	Level 4	All Suppliers
< 10	100%	88.1%	55.8%	0%	79.8%
11-30	0%	7.7%	15.4%	75%	8.5%
31-50	0%	0.7%	8.3%	0%	3.1%
51-70	0%	2.1%	5.1%	0%	2.5%
> 70	0%	1.4%	15.4%	25%	6.1%

VIII. Use of 3D Models as Part of Quality Program

The following are the results of the information collected in the assessment about the numbers of participating suppliers that use 3D models as part of their quality program.

- **Level 4**: 100% of companies indicated that they use 3D models in their quality programs.
- **Level 3:** 64.1% (100 companies) indicated that they use 3D models in their quality programs; 32% (50 companies) indicated that they do not; and 3.8% (6 companies) did not indicate either way.
- **Level 2:** 14.7% (21 companies) indicated that they use 3D models in their quality programs; 43.4% (62 companies) indicated that they do not; and 42% (60 companies) did not indicate either way.
- **Level 1:** 2.8% (4 companies) indicated that they do use 3D models in their quality programs; 0 indicated that they do not; and 97.2% (138 companies) did not indicate either way.

IX. Use of 3D models in Virtual Manufacturing Processes

The assessment sought to determine how common the use of 3D models in virtual manufacturing processes within the supply base. This means that software-based engineering or production analyses are conducted to virtually produce parts in the computer domain before actually physically making them, either on machines or with other means such as might be employed during assembly processes.

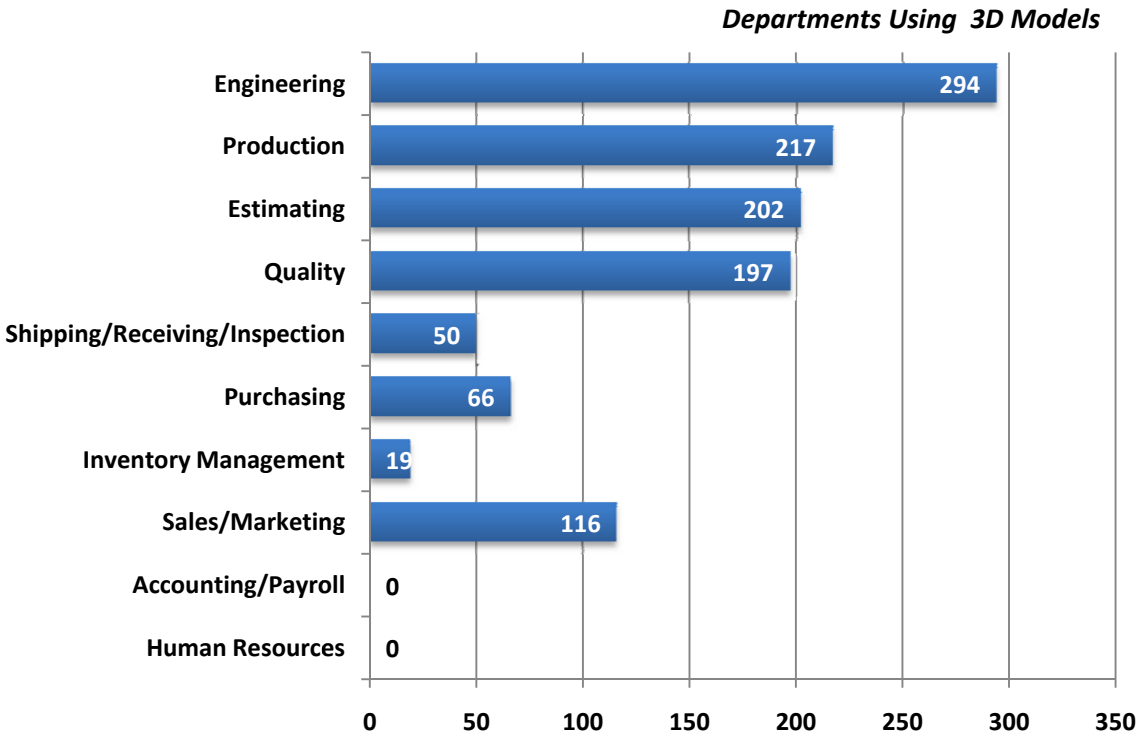
MBE Capability Level	Use 3D in Virtual Mfg	Do Not Use 3D in Virtual Mfg	No Answer
Level 1	1	5	136
Level 2	34	46	63
Level 3	101	52	3
Level 4	3	1	0
All Participating Suppliers	139	104	202

Results are shown in the table above, broken down in terms of level of MBE capability, as well as in aggregate for all participating suppliers.

X. Company use of 3D by departments

The assessment collected information from participating suppliers regarding the departments within their companies that could use 3D models in their operations. This is an important item because the electronic integration and re-use of 3D data across multiple departments is a differentiating characteristic among the various levels of MBE capabilities.

The graph below displays the aggregate data collected here. Note that companies frequently indicated multiple departments that use 3D data.



Below is the breakdown of this information by MBE capability level. Of the 142 MBE capability level 1 companies, only four indicated that they have any departments that have used 3D data in any capacity, as detailed in the chart. S/R/I = Shipping, Receiving, and Inspection.

MBE Level	Engineering	Production	Estimating	Quality	S/R/I	Purchasing	Inventory Mngt.	Sales & Marketing
1	3	0	0	0	0	0	0	1
2	81	50	39	36	7	17	3	30
3	147	128	117	127	39	40	12	69
4	4	4	4	4	1	1	1	2

Estimated Cost & Lead Time Impacts

Participating suppliers were given the opportunity to provide their perspectives on two issues relating to the potential impacts of MBE on their company operations:

- hardware production and delivery/lead time
- cost savings on hardware bid, production, and delivery

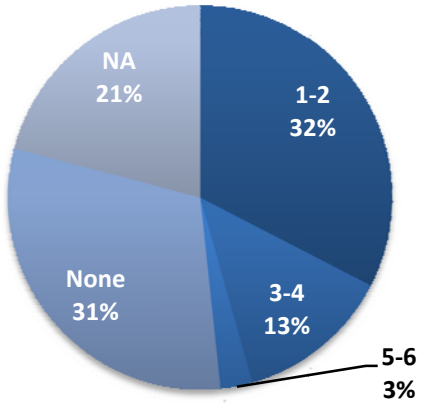
Both of these issues were predicated upon the existence of all necessary information being provided in a fully annotated model. Company perspectives on these issues were intended to not only gather supplier impact estimates, but also to gauge participant understanding of the potential benefits of operating in an MBE environment. Each issue was also divided into three sub-categories: machined parts, assemblies, and COTS items.

I. Lead Time Impact of MBE

When estimating the lead time impact MBE could potentially have, companies were given the following options: 1-2 weeks; 3-4 weeks; 5-6 weeks; and none or increase in delivery time.

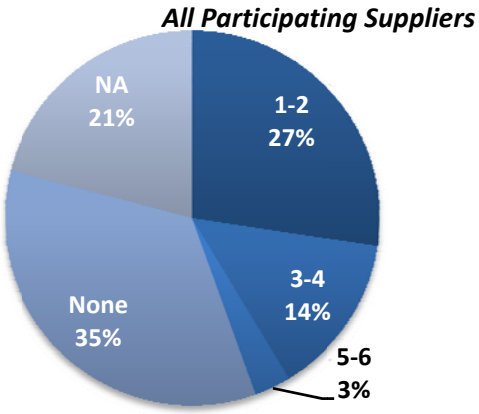
Machined Parts

All Participating Suppliers



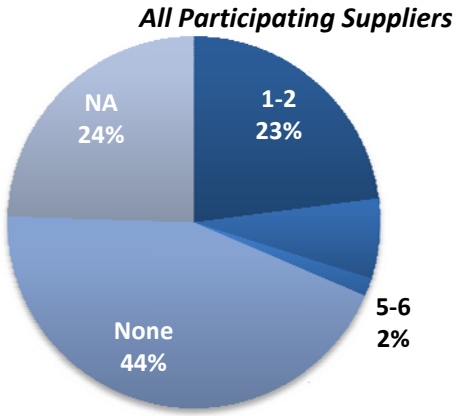
Estimate *in weeks*	Level 1	Level 2	Level 3	Level 4
1-2	9.2%	39.2%	46.2%	100%
3-4	5.6%	11.2%	21.8%	0%
5-6	2.8%	2.8%	2.6%	0%
None	29.6%	39.9%	24.4%	0%
No Answer	52.8%	7.0%	5.1%	0%

Assemblies



Estimate *in weeks*	Level 1	Level 2	Level 3	Level 4
1-2	11.3%	29.4%	39.1%	75.0%
3-4	4.2%	14.7%	21.8%	25.0%
5-6	2.1%	2.1%	5.1%	0%
None	30.3%	46.9%	28.2%	0%
No Answer	52.1%	7.0%	5.8%	0%

COTS Items

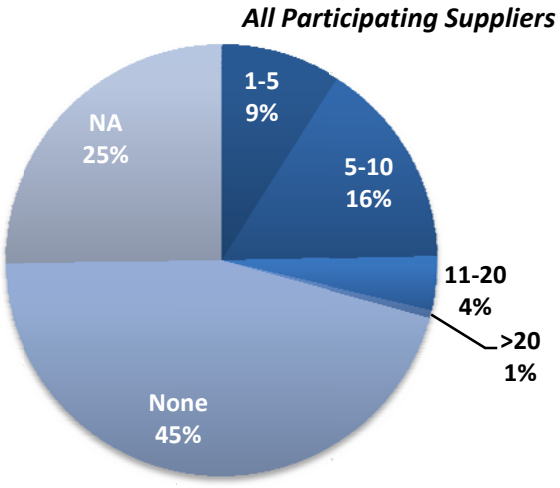


Estimate *in weeks*	Level 1	Level 2	Level 3	Level 4
1-2	7.7%	21.7%	36.5%	75.0%
3-4	4.2%	5.6%	10.9%	0%
5-6	1.4%	1.4%	1.9%	0%
None	31.7%	58.0%	42.9%	25.0%
No Answer	54.9%	13.3%	7.7%	0%

II. Cost Reduction of MBE

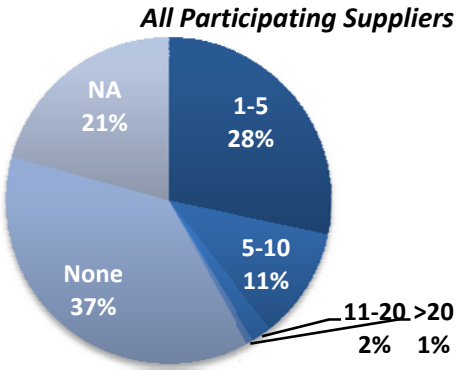
When estimating the cost reduction impact MBE could potentially have, companies were given the following options: 1-5% reduction; 5-10% reduction; 10-20% reduction; >20% reduction; and none or increase in cost.

Machined Parts



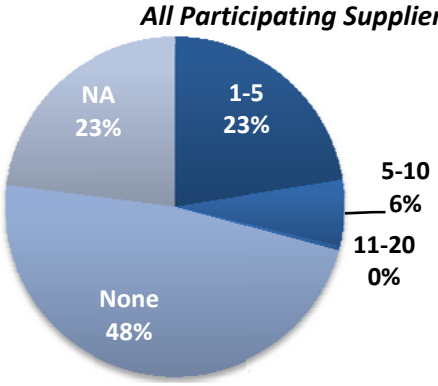
Estimate *in cost %*	Level 1	Level 2	Level 3	Level 4
1-5	15.5%	31.5%	40.4%	25%
5-10	2.1%	11.2%	21.2%	50%
11-20	0%	4.2%	5.1%	0%
>20	0%	.7%	.6%	0%
None	31.7%	49.0%	26.9%	0%
No Answer	50.7%	3.5%	5.8%	25%

Assemblies



Estimate *in cost %*	Level 1	Level 2	Level 3	Level 4
1-5	15.5%	23.1%	44.9%	25.0%
5-10	1.4%	14.0%	15.4%	75.0%
11-20	.7%	1.4%	3.8%	0%
>20	0%	.7%	1.3%	0%
None	28.9%	54.5%	30.1%	0%
No Answer	53.5%	6.3%	4.5%	0%

COTS Items



Estimate *in cost %*	Level 1	Level 2	Level 3	Level 4
1-5	9.9%	18.9%	37.2%	25.0%
5-10	.7%	7.7%	9.0%	50.0%
11-20	0%	1.4%	0%	0%
>20	0%	0%	0%	0%
None	35.2%	60.8%	48.1%	25.0%
No Answer	54.2%	11.2%	5.8%	0%

Obstacles & Challenges

The assessment gathered information on what companies perceive to be their most significant obstacles and challenges in developing their ability to operate in a fully MBE environment. Companies were given an open-ended question in order to allow room for their comments.

Of the 445 participating suppliers in this assessment, 75% (322 companies) responded to this question. Of the 322 responding suppliers, only 16 answered that they believed MBE implementation could not work at their company. In contrast, 46 responded that they believe they either already operate their business in an MBE environment, or they see no obstacles and are ready to do so. The most typical supplier comments fell somewhere in between these extremes.

A significant number of companies identified the cost and investment necessary for their business to participate in a fully MBE environment as the biggest challenge for their company. Specifically, respondents mentioned cost investment, time investment, personnel training, additional staff and expertise, and software/equipment upgrades.

- 69 companies were concerned with the ***capital investment*** required to raise their level of MBE capabilities and 10 companies were specifically concerned with the ***time investment*** associated with becoming MBE ready.
- ***Personnel training*** was mentioned by 65 suppliers, following closely behind, and often associated with, capital investment as a leading concern for companies. Another 12 companies felt they would need to add ***additional staff and expertise*** from outside the company.
- 61 companies responded that the ***software and equipment upgrades*** necessary for their company to operate in an MBE environment would pose a serious challenge.

Other responding suppliers identified concerns that their customers and suppliers would be able to support them in an MBE environment:

- 26 participating suppliers saw ***customer data*** as a significant obstacle. They were not confident that the customer would be able to provide adequate data and true *fully-annotated* 3D models.
- 8 companies were concerned that they would not be able to deliver in, or fully benefit from, an MBE environment without the cooperation of their own sub-contractors. These 8 companies saw ***supplier/subcontractor readiness*** as a barrier for their company.

Still others responded that their biggest challenges were not technical or financial, but rather cultural:

- 15 responding suppliers felt that operating in an MBE environment would require a large ***business culture transformation*** within their company, which would serve as a significant internal obstacle.
- 14 companies identified uncertainty of the MBE ***business case***, and whether it would justify the potential transitional pains that MBE implementation could bring, as a major uncertainty.

Analysis & Conclusions

For a broad-based assessment such as this, with a population sample size of 850 companies, the over 52% participation rate received here is an extraordinary achievement. 445 military ground vehicle suppliers participated in this assessment, representing the acquisition of a substantial base of knowledge for DOD ground vehicle OEMs/primes.

This section provides a summary of several key analyses derived by NIST MEP from the assessment results. These analyses relate to both the processes used to conduct the assessment, as well as the results obtained.

Assessment Process

The onsite assessments yielded a richer body of information and understanding than the online assessment. The onsite assessments gave the assessment team the opportunity for extensive discussions with company engineers and managers. These discussions provided a level of understanding that cannot be gained from impersonal, online interactions. The development of the online assessment, including the selection of the most effective questions and phrasing, was based upon the discussions knowledge gained from the onsite assessments.

The assessment team is confident that the results obtained from the online assessments capture the information necessary for the DOD to move forward with the implementation of MBE throughout its military ground vehicle supply base and recommends that the first step of MBE implementation be to individually contact suppliers for additional discussion to gain a deeper understanding of MBE capabilities and readiness before moving onto tactical MBE implementation.

While the onsite assessments were undoubtedly more comprehensive, making the rating process for these ten companies easier and more accurate, NIST MEP is confident in the accuracy of the ratings applied to the 435 companies based on the data from the online assessment. The following steps were included in the process to ensure this accuracy:

- A random sampling of over 300 companies was rated twice to check consistency of the process. The ratings were repeated at the same level for over 95% of this sampling.
- All ratings were conducted blindly without knowledge of the company name being assessed. This process was followed to remove any rating bias that could exist if the rater was otherwise familiar with the company.
- The companies assessed onsite and rated for MBE capabilities were also included in the blind population of the 445 total companies assessed online. The MBE capabilities ratings that were applied to each of the 10 companies for the online assessments exactly matched the ratings that were applied for the onsite assessments – for 10 out of 10 companies.
- The application of the ratings was led by the subject matter expert and principal investigator for this project from NIST MEP.

Other relevant notes regarding the overall assessment process:

- Several companies that participated in the online assessment did not do so comprehensively. Many provided incomplete information. This was most prevalent among companies rated with an MBE capability of level 1. Of the 142 level 1 companies, 66 received a level 1 rating due to their provision of incomplete assessment information.
- Representatives from local MEP Centers participated in the ten onsite assessments and as a result, several engagements between MEP and these suppliers have occurred. The interaction at the onsite assessments opened up a dialogue between the companies and their local MEP Centers and several of these companies have turned to MEP as a business and technical resource not necessarily connected with MBE. This should be viewed as a positive, spin-off result of these assessments.

Results: Analyses and Conclusions

In general, MBE awareness is high within the assessed DOD military ground vehicle supply base. Approximately 70% of participating companies indicated that they are familiar with concept of MBE, and a similar number (approximately 70%) indicated an awareness of the DOD move to 3D data and models as the basis for DOD procurements.

While awareness is relatively high, understanding is not. Based upon interactions that occurred during the onsite assessments, as well as communications between MEP and certain companies during the course of the online assessment, along with company-provided information relating to obstacles and challenges associated with implementing MBE companies do not have a good understanding of:

- Exactly what MBE means and what it will mean for their relationship with OEMs/primes;
- What it may mean regarding their status as a DOD supplier;
- What benefits stand to be gained from operating in an MBE environment; and
- What is the next step for suppliers in regards to the implementation of MBE and their participation in this MBE capabilities assessment.

Demographically, the military ground vehicle supply base is spread widely across the U.S. – the only states that did not have participating suppliers were Alaska, Delaware, Hawaii, Idaho, Mississippi, New Hampshire, and South Dakota. The states with the highest concentration of participating suppliers were: California (85), Pennsylvania (60), Minnesota (44), Michigan (36), and New York (22).

The assessed military ground vehicle supply chain primarily consists of small-to-medium sized manufacturers with less than 500 employees – 91% of participating companies fell into this category. Company size and MBE capability, however, are not directly proportional. The assessment results show that, in general, the larger the company, the higher the level of MBE capability; however, this is not a uniform distribution. In fact, of the 4 total companies that were rated with an MBE capability level 4, one of those companies had fewer than 10 employees.

Approximately two-thirds of the assessed supply base is capable, at least at a basic level, to operate in an MBE-based environment. Sixty-eight percent, or 303 of the participating companies, were rated with an MBE capability level of 2, 3, or 4. Based upon the MBE capability metric that was developed and applied here, an MBE capability rating of level 2 is the lowest level at which 3D data can be sent, received, and consumed to some degree.

Thirty-two percent, or 142 of the participating companies, were rated with an MBE capability level of 1 – meaning that they are not equipped to handle 3D data. No companies assessed are *fully* MBE-capable. Only 4 companies were rated with an MBE capability level of 4, and 0 companies were rated at MBE capability level 5.

These results are significant because they present an interesting scenario with respect to the implementation of MBE within the DOD supply base. To elaborate, if the only MBE capability that the DOD desires within its supply base is the bilateral communication of 3D data, two-thirds of the suppliers are ready to proceed.

However, if operating in an MBE environment should include a transformed and integrated approach to engineering and production systems, the majority of the supply base will require some degree of capabilities advancement. Specifically, between 65-99% of military ground vehicle suppliers will require a range of MBE capability development. The exact number will depend upon DOD requirements for their suppliers and the MBE readiness of those companies. Companies rated with an MBE capability level 4 and above should likely need little in the way of capability development.

It is important to reiterate that ratings applied as part of this assessment are ratings of MBE *capabilities* – and NOT MBE *readiness*. Each of the manufacturers assessed possesses distinct levels of both MBE capabilities, and MBE readiness. In order to understand manufacturer MBE readiness a series of broader business issues must be considered along with MBE capabilities. This will examine the extent to which a manufacturer is willing, able – and ready – to implement MBE more fully than they currently do.

Information collected during the assessments provides evidence of this difference between capabilities and readiness. For example, the data results show a statistically significant reluctance to transition to MBE, even by higher level companies. Additionally, the assessment results show that company culture and business approaches will present major challenges to MBE implementation, especially given the general lack of understanding of what MBE really means – from both technical and business perspectives – among participating suppliers.

Another significant supplier dynamic that surfaced during the assessment is the existence of diverse markets that many companies serve. Seventy-one percent of participating suppliers reported that less than 10% of their overall business that goes to a single OEM, in this case BAE. In 90% of the suppliers, that single OEM business accounts for 30% or less of overall business, and in 96% of participating suppliers, the single OEM business accounts for 50% or less of their overall business. Only 2% of companies reported the single OEM business accounting for over 75% of their overall business.

These business figures are further evidence that capabilities and readiness are two very different entities. Companies widely reported that the operations of their business, engineering, and production processes are set up to meet the demands of their customers. If business to a specific OEM/prime does not represent a major component of a supplier's overall business portfolio, then a very clear and compelling business case must be evident to motivate suppliers to make any significant transformations.

Furthermore, it is likely that companies will pursue a "path of least resistance" to implement MBE. More specifically meaning:

- If working in an MBE environment improves the means by which these suppliers can do business with their customers, they will comply.
- It is very possible that compliance may mean sending and receiving data to and from their customers in an MBE-based manner prescribed by the DOD, without significantly changing other company operations.
- This means that manufacturers may set up electronic communication systems with their DOD customers to be MBE capable, where they send, receive comprehensive, annotated 3D model data, but still convert internally to approaches and processes they've always used to get their job done.

It will be up to the DOD and military ground vehicle OEMs/primes to determine if this scenario is an acceptable implementation of MBE.

Recommendations & Next Steps

What's Next for Suppliers?

Interactions with suppliers throughout Phase 1 indicate that suppliers are very interested in what's next for them with respect to MBE. NIST MEP recommends that the DOD contact all suppliers targeted for MBE assessment, including those that did not participate, as soon as possible. This communication should inform suppliers that the first phase of these MBE assessments is complete and provide an indication that information will be forthcoming about the planned implementation of MBE within the military ground vehicle supply base.

The creation of a website is also advised. This website should include up-to-date information from OEMs/primes, the Army, and the broader DOD community with respect to MBE implementation. This website would be a place where suppliers could access background information about MBE, as well as updates on MBE status and schedules.

As OEMs/primes plan their implementation of MBE, it is important that their plans be continuously coordinated with the broader Army and DOD community. Such coordination will help to improve the business case for companies to consider moving to MBE by demonstrating that MBE is not just an initiative from one of their customers, but the way of the near future for the DOD at large. Critical points of coordination for the DOD community include the Office of the Secretary of Defense, and its coordination of: the DOD Manufacturing Technology (ManTech) Program; the ManTech community; the U.S. Army Research, Development, and Engineering Command (ARDEC); and U.S. Army Research Laboratory (ARL).

How to Implement MBE

It is imperative that as the MBE implementation path is being developed, both detailed technical and business requirements be defined and communicated to the supply base. Without detailed technical requirements, MBE implementation will become increasingly complex as "MBE Compliance" will have no accepted meaning. Without detailed business requirements, the business case for suppliers will remain unclear and transition to MBE operations will be resisted.

For example, companies must understand what operating in an MBE environment specifically means. Does it mean being able to send and receive STEP files? Does it mean the use of Pro/E CAD systems? Does it mean tying an MRP or PDM system in with their DOD customers? Does it mean that their DOD customers will only accept certain information in certain formats? Does it impact business systems for suppliers? What exactly does this mean for each company? Without detailed technical and business definitions and requirements, MBE cannot be implemented broadly throughout the supply base.

It is recommended here that such requirements be developed by the DOD and communicated to their supply base. Consultation with leading experts in the field, including NIST, is also recommended to ensure technical rigor exists for the requirements.

Addressing the real, abundant cultural issues will also be critical in the approach taken to assist companies in their successful implementation of MBE. Helping companies to fully understand why it makes sense for them to implement MBE within their operations, what the benefits of MBE-based operations are for them and for their customers – and possibly even incentivizing them to implement MBE – will be imperative to the successful implementation of any MBE operating plan .

If appropriate, the MEP Program and the nationwide network of Centers are prepared to provide assistance to supplier companies. A framework for the provision of MBE assistance to suppliers is offered below.

MBE Capability Level	Assistance
All (1-5)	▪ Access to and understanding of MBE development opportunities and connections, especially with respect to potential new business opportunities and/or partnerships with BAE ▪ Business Transformation and Growth Planning ▪ Market Diversification ▪ Access to resources
Advancement from 1-2	▪ CAD/CAM/CAE software training ▪ Automation planning and training
Advancement from 2-3	▪ CAD/CAM/CAE software training ▪ Business Integration software (MRP) training ▪ Automation planning and training
Advancement from 3-4	▪ CAD/CAM/CAE software training ▪ Business Integration software (MRP / ERP) training ▪ Automation planning and training
Advancement from 4-5	▪ Business Integration software (PDM / PLM) training

There are four types of assistance that are recommended for companies operating at every level of MBE capability, from 1-5. Additionally, other assistance is recommended in the table to specifically assist companies in advancing from one level of MBE capability to the next. Every assistance type identified in this table is further explained below.

Explanation of Assistance Opportunities

Business Transformation and Growth Planning: The emphasis here is on assisting the manufacturer in understanding and planning for their opportunities for growing their business, set within whatever context is appropriate for an individual company. Business Transformation is then focused on the definition and implementation of the processes by which manufacturers achieve their growth objectives. This must be the starting point for assistance for manufacturers as the means to assess basic culture and MBE readiness.

Access to and Understanding of MBE Development Opportunities and Connections: This is the first step following the basic understanding that comes from growth planning and business transformation. The emphasis is on helping manufacturers understand what business opportunities exist for them specifically as a result of the advancement of their level of MBE capabilities – then connecting those manufacturers with those opportunities. This includes opportunities associated with supplying to BAE, as well as potentially other customers and markets, as well. This also includes the potential for realizing and operating a completely different business relationship with customers based upon the potential to provide that customer with more integrated, more visible supplier operations relating to engineering, production, and business systems.

Market Diversification: This assistance goes hand-in-hand with the basic understanding associated with growth and business transformation, because it targets assistance to make companies strong by determining the appropriate diversification of the markets they serve. The emphasis here is on assisting the manufacturer in understanding and planning for their business opportunities in markets that are different from the current markets they serve. This can include supplying products in new markets for new customers (for example, automotive suppliers producing parts for defense applications), or it can mean changing the mix of business percentage supplied to existing markets and customers, or any combination therein.

CAD/CAM/CAE Software Training: To advance among levels of MBE capabilities, manufacturers typically need to advance the sophistication of their engineering systems, as well as the integration of engineering systems with production systems and business systems. This often means the need for acquisition and use of new software systems for CAD, CAM, or other CAE purposes, and this requires workforce training to effectively implement. This training can be provided by software vendors and third party organizations. And a critical aspect of software acquisition and use is the process by which the appropriate approaches and/or systems are selected.

Automation Planning and Training: Advances in MBE capabilities produce advances in the extent to which engineering, manufacturing, and business processes are driven by computing systems. MBE advances also can specifically lead to the automation of many manufacturing processes. The focus here is on the identification of opportunities for computer driven improvements in processes, as well as opportunities for automation of production systems. This also includes the requisite workforce training to implement such improvements.

Business Integration Software Training (MRP/ERP, PDM/PLM): As companies advance their MBE capabilities, the extent to which their business systems become electronically integrated with their engineering and production systems – across departments – also increases. The implementation of software tools that serve as MRP, ERP, PDM, and PLM systems represent viable means by which companies achieve such integration. The focus here is on both the workforce training that is required to implement these systems, as well as the processes by which the appropriate approaches and/or systems are selected.

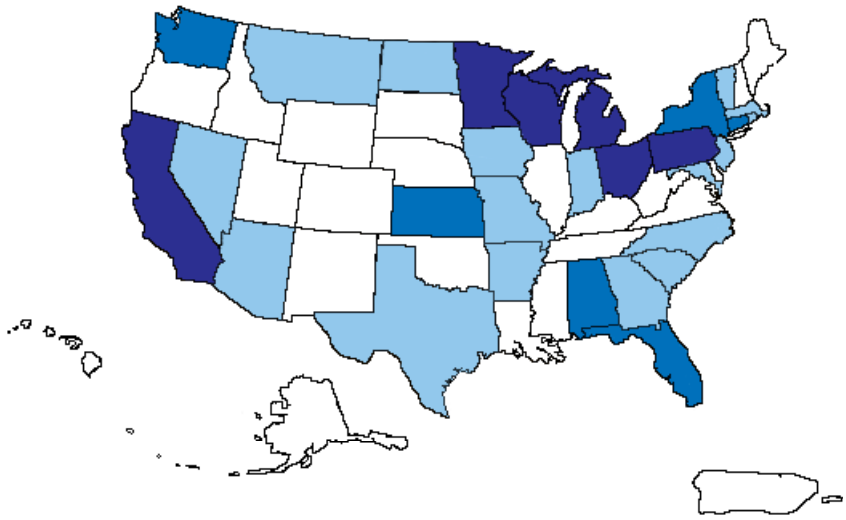
Access to Resources: In many, if not most, instances associated with advancing a manufacturer's level of MBE capabilities, the manufacturer is required to make a resource investment to realize the desired advance. The focus here is on working with the manufacturers to understand the options available to them for finding these resources from multiple sources such as U.S. Department of Defense, Department of Commerce/NIST MEP, and other Federal programs; state and local programs; and even potentially through business relationships with BAE.

Recommendations Moving Forward

NIST MEP views this first phase of MBE capabilities assessments as laying the foundation for a long term business relationship with the DOD and its supplier companies. If desired by the DOD or individual OEMs/primes, these assessment activities will lead to the conduct of a series of supplier development activities that will include the provision of MEP technical and business assistance and training to MBE-capable and MBE-interested suppliers. This first phase of MBE assessments, both onsite and online, indicates that there are extensive assistance opportunities for the DOD's military ground vehicles supply base.

It's also noteworthy that MEP Centers around the nation have existing relationships with 123 military ground vehicle suppliers that participated in this assessment. This means that nearly 30% of participating suppliers have already sought out MEP as a resource for technical assistance and business improvement projects. The distribution of MEP Center relationships with these supplier companies is depicted in the map on the following page.

A **Dark Blue** state indicates a presence of > 5 military ground vehicle suppliers that are already MEP clients; **Medium Blue** indicates from 3 to 5 military ground vehicle suppliers/MEP clients; **Light Blue** indicates a presence of 1 to 2 military ground vehicle suppliers/MEP clients; and a White state indicates no existing relationships in that state. However, this information is based on recorded MEP projects, newer or less formal relationships may not be captured here.



AL:	3	**MA:**	1	**NY:**	5
AR:	1	**MD:**	1	**OH:**	9
AZ:	1	**MI:**	9	**PA:**	29
CA:	11	**MN:**	11	**RI:**	1
CT:	3	**MO:**	2	**SC:**	2
FL:	3	**MT:**	1	**TX:**	2
GA:	2	**NC:**	2	**VT:**	2
IA:	1	**ND:**	1	**WA:**	4
IN:	1	**NJ:**	2	**WI:**	9
KS:	3	**NV:**	1		

As a result of the onsite assessments conducted and the participation of local MEP Center representatives in these assessments, a several follow-up interactions have already begun to occur between MEP Centers and military ground vehicle suppliers. MEP is continuing to maintain and expand a trusted advisor relationship with the DOD supplier base.

Using the framework provided in the MBE Assistance Recommendations, NIST MEP would like to continue its relationship with the DOD in that MEP would serve as the provider of the assistance needed by the military ground vehicle supplier companies. NIST MEP also endorses the conduct of an MBE Production Pilot involving a small subset of appropriate supplier companies. In such a pilot, technical requirements would be defined and tested with respect to companies participating with different levels of MBE capabilities. A critical aspect of the pilot would also include documentation of procedures and processes used, difficulties encountered, and lessons learned for the participating companies. And of course, these companies would need MBE implementation assistance as appropriate to ensure their successful participation in the pilot.

Concurrently, NIST MEP will continue testing methods to scout for new DOD supplier companies. These companies will be manufacturers who do not currently provide parts or subassemblies to the DOD, but who have engineering, production, and business system attributes that are MBE capable and are relevant to the military ground vehicle product mix.

Appendix A: MBE Capabilities Assessment for Suppliers to BAE Systems

June 8, 2009

1) PRODUCT LINE
   Please indicate the line of products you manufacture.

2) BUSINESS MODEL
   Which of the following describes your business model? Please select all that apply.

   a) Contract Manufacture / Build-to-Print
   b) Design and Build
   c) Design, Outsource, and Assemble
   d) Other – please specify.

3) EMPLOYEES
   Please indicate the number of employees at your company.

   a) <10 employees
   b) 10-50 employees
   c) 50-250 employees
   d) 250-500 employees
   e) >500 employees

4) OWNERSHIP
   Please select all that apply for your company.

   a) Small Disadvantaged Business
   b) Woman-Owned Small Business
   c) HUB-Zone Small Business
   d) Veteran-Owned Small Business
   e) Service-Disabled Veteran-Owned Small Business
   f) Alaska Native Corporation and Indian Tribes

5) LOCATIONS
   At how many physical locations does your company operate facilities? Please list addresses that involve manufacturing.

6) DEFENSE VS. COMMERCIAL
   What percentage of your business falls into the following categories?

   a) Defense / Non-Government
   b) Defense / Government
   c) Government / Non-Defense
   d) Auto-Industry Related
   e) Commercial (anything that is not included in the other categories)

7) BAE BUSINESS
What percentage of your business goes to BAE Systems? Please indicate if any of this business goes to BAE indirectly in a Tier 2 relationship – where your company supplies parts to a third party, who then supplies to BAE for ultimate application on a BAE vehicle/product.

a) <10%
b) 11-30%
c) 31-50%
d) 51-75%
e) >75%

8) Are you interested in expanding your business with BAE?
a) Yes
b) No

9) PROCESSES
Please list the manufacturing process capabilities you possess in the following areas:

a) Fabrication & Assembly
b) Machining
c) Welding
d) Testing & Inspection

10) MATERIALS
a) Please list the materials that you process most frequently.
b) Please list other materials that you have the capabilities to handle.

11) SIZE
How large or small are the products you make? Please list the range of dimensions that you have the capability to handle.

12) TOLERANCES
Please list the typical tolerances you produce, as well as the tightest tolerances that you can achieve.

13) QUALITY CERTIFICATIONS
Please list any quality certifications your company possesses.

14) MODEL-BASED ENTERPRISE
Are you familiar with the concept of a model-based enterprise (MBE), where the prime contractor or OEM creates and consumes all design and production data in a comprehensive, fully annotated 3D master model, rather than 2D master drawings, using CAD/CAM/CAE systems?

a) Yes
b) No

15) DOD AND MBE
Are you aware that the U.S. Department of Defense (DOD) and its contractors are moving from two-dimensional (2D) paper drawings to electronic three-dimensional (3D) models as the procurement basis for the design and production of military hardware?

a) Yes
b) No

16) WANT TO LEARN MORE?
Are you interested in learning about MBE and how it works, including how suppliers interact with OEMs/primes to share relevant design and production data in an MBE environment?

a) Yes (CONTINUE with items below)
b) No (STOP - Thank you for your time.)

PROVIDE LINK TO MBE VIDEO

17) CAD/CAM/CAE SOFTWARE USED
Please indicate the CAD/CAM/CAE software product(s) used by your company. Examples include Pro/Engineer, AutoCAD, SolidWorks, Mastercam, Vericut, Nastran FEA, etc. Please list all these types of systems that you use, including versions.

18) APPLICATION OF CAD/CAM/CAE
Please indicate if you use CAD/CAM/CAE software for the following applications. If yes, please describe how.

a) NC programming
b) Work instruction authoring, including tolerancing
c) Mechanical Inspection and/or Testing
d) Other (please describe)

19) DATA FILE FORMATS
Please indicate whether you use the following data file formats.

a) STEP
b) IGES
c) PDF
d) DXF

20) Please indicate which file format you use most often from item #19 and why.

21) USE OF 3D, ELECTRONIC MODELS
Have you used 3D models in production?

a) Yes (Please describe how used.)
b) No (Skip to item #30)

22) If your organization received 3D models only, please indicate if you would:
    a) Create an equivalent drawing for process planning
    b) Create an equivalent drawing for inspection
    c) Create an equivalent drawing for other departments
    d) All of the above

23) Can 3D model information be used to directly drive your production systems? If so, please describe what this means at your company.

24) What types of parts have you produced using 3D models?

25) When you use 3D models in production, do you still convert to 2D drawings at the machine level?

26) What percentage of your parts is produced using 3D models only – rather than 2D drawings?
    a) <10%
    b) 11-30%
    c) 31-50%
    d) 51-70%
    e) >70%

27) Do you use 3D models as part of your quality program?
    a) Yes (Please indicate how.)
    b) No

28) VIRTUAL MANUFACTURING
    Does your company use 3D models in virtual manufacturing processes? This means that software-based engineering or production analyses are used to virtually "produce" parts in the computer domain before actually physically making them on machines.

    a) Yes (Please describe processes used.)
    b) No

29) COMPANY USE OF 3D MODELS
    Please list the departments within your company that can utilize 3D model information as part of your business operations. Please select all that apply.

    a) Engineering
    b) Production
    c) Estimating
    d) Quality
    e) Shipping / Receiving / Inspection
    f) Purchasing
    g) Inventory Management
    h) Sales / Marketing
    i) Accounting / Payroll
    j) Human Resources

30) PDM / PLM / MRP / ERP SOFTWARE
Please list any Product Data Management (PDM), Product Life Cycle Management (PLM), Manufacturing Resource Planning (MRP), or Enterprise Resource Planning (ERP) software used by your company, including versions

31) LEAD TIME IMPACT OF MBE
If all information was provided in a comprehensive, fully annotated 3D model, would you expect hardware production and delivery to be shorter or longer?

a) Machined parts
   i) 1-2 weeks
   ii) 3-4 weeks
   iii) 5-6 weeks
   iv) None or increase in delivery time
b) Assemblies
   i) 1-2 weeks
   ii) 3-4 weeks
   iii) 5-6 weeks
   iv) None or increase in delivery time
c) COTS items purchased
   i) 1-2 weeks
   ii) 3-4 weeks
   iii) 5-6 weeks
   iv) None or increase in delivery time

32) COST IMPACT OF MBE
If all information was provided in a fully-annotated 3D model, would you expect cost savings on hardware bid, production and delivery?

a) Machined parts
   i) 1-5% reduction from traditional bid
   ii) 5-10% reduction from traditional bid
   iii) 10-20% reduction from traditional bid
   iv) >20% reduction from traditional bid
   v) None or increase in cost
b) Assemblies
   i) 1-5% reduction from traditional bid
   ii) 5-10% reduction from traditional bid
   iii) 10-20% reduction from traditional bid
   iv) >20% reduction from traditional bid
   v) None or increase in cost
c) COTS items purchased
   i) 1-5 percent reduction from traditional bid
   ii) 5-10 percent reduction from traditional bid
   iii) 10-20 percent reduction from traditional bid
   iv) >20% reduction from traditional bid
   v) None or increase in cost

33) MBE INTEREST
Assuming the customer can provide you with the necessary, fully-annotated 3D models, would you be willing to operate your production facility or line as an integrated part of an MBE environment?

a) Yes
b) No
c) Why or why not?

34) Please describe the obstacles and challenges that pose the biggest barriers for your company developing its level of MBE readiness and ability to operate fully in an MBE environment.

35) Please list the appropriate contact information for use in relation to MBE developments
a) Company Name
b) Street Address, City, State and Zip Code
c) Contact Name
d) Position
e) Email
f) Phone

Thank you for your interest and participation!

www.model-based-enterprise.org