Accelerating
Transformation:

Lockheed Martin's Model-Based Enterprise Playbook for Suppliers

LOCKHEED MARTIN

Table of Contents

Welcome to Lockheed Martin's Model-Based Enterprise Supply Chain Playbook!

Lockheed Martin's adoption of the Model-Based Enterprise (MBE) represents an organizational approach that seamlessly connects and consumes product data while eliminating functional and systems silos. By leveraging data-rich models, MBE realizes an end-to-end digital vision throughout the Design, Buy, Build, and Sustain value chains. **– Dan Heller, VP of Corporate Engineering**

Our transition to a Model-Based Enterprise enables real-time data sharing amongst Lockheed Martin and our Supply Chain, enabling us to accelerate design, reduce total cycle time, and improve quality. A Model-Based Enterprise will accelerate our transformation capabilities, driving our industry competitiveness and improving Supplier collaboration. **- David Tatro, VP of Operations Transformation**

As a corporation, Lockheed Martin (LM) is moving to a Model-Based Enterprise (MBE). But what does that mean for you, an LM supplier? How does it change how you engage with LM or perform on LM subcontracts? This playbook aims to explain that.

MBE will be evolving over time. For now, it means 3D models are the new norm and suppliers will start receiving a 3D model from LM instead of a 2D drawing. In other areas, it may still be evolving - for instance, collaboration on Model-Based Systems Engineering (MBSE) design work. As a result, this will be a living document that changes as LM's overall MBE maturity evolves.

These playbooks are designed to raise awareness of the Model-Based Enterprise (MBE) organization and Model-Based Definition (MBD) practices throughout our Supply Chain community. The goal is to raise the overall level of MBE acumen throughout the Supply Chain community to prepare us all for procurements that involve MBE elements.

This playbook will provide basic knowledge about the fundamental characteristics of an MBE and how LM is incorporating it into business processes, with sections on the following topics:

- Lessons Learned & Implementation Timelines
- MBE Terms & Concepts
- New MBE tools that will be used to facilitate the processes
- MBE Foundational Knowledge and a Comparison of Legacy vs MBE Procurement
- Impacts to Suppliers

Each topic will be covered at a general level in this playbook, and additional industry resources will be linked for those interested in learning more about a specific topic. In addition, FAQ & Answers are provided based on real questions from you, our suppliers. Today, these MBE practices are generally based upon Mechanical parts as the most mature segment. However, as a living document, this Playbook will evolve as other part segments mature.

What is MBE?

Per the National Institute of Standards and Technology (NIST), a Model-Based Enterprise (MBE) is "an organization that applies modeling and simulation technologies to integrate and manage its technical and business processes related to production and product lifecycle support."

Lockheed Martin's vision of our MBE steers away from 2D drawings, linear handoffs, and long engineering cycle times, instead moving toward system models, concurrent engineering, flexible and agile design through Concurrent Engineering, and an integrated Digital Thread. LM suppliers and the components they provide are a critical part of this vision.

Why MBE?

At LM, the environment is changing and is moving toward an MBE to react and predict customer needs with speed and agility. Highly specialized functions and disciplines are transforming from disconnected silos into a coherent and integrated MBE. This transformation is not only technical, it is cultural and organizational, requiring a One Lockheed Martin (OneLM) strategic approach. The outcome of this transformation changes the way the corporation interacts with customers and suppliers and the way it executes programs internally. This rapid transformation shifts LM collectively from being drawing based and siloed with transactional enterprise systems toward a data-rich and digitally connected enterprise.

Playbook Intent

Mission	The goal of this Playbook is to raise the baseline level of Model-Based Enterprise (MBE) awareness and understanding across the LM Supply Chain. Using this Playbook, the reader should come away with a better sense of what is changing as Lockheed Martin transitions to an MBE, including foundational terms and concepts as well as impacts to Lockheed Martin subcontracts.

Who should use this Playbook

- Program Managers
- Engineering Leads
- Contracts Managers
- Quality Engineering Managers
- Procurement Engineers
- Other team members who engage with Lockheed Martin

When to use this playbook:

- During an LM solicitation of a model-based part
- When exchanging model-based tech data to support a procurement
- When supporting LM and supplier collaborations on MBE programs
- When looking to educate team members new to MBE
- When supporting a new program that is implementing MBE practices
- When reviewing a Statement of Work (SOW) for a Model-Based part procurement

Why is LM transitioning toward MBE? Why should Suppliers Embrace MBE?

In the coming years, LM and its suppliers will be faced with a choice - embrace MBE or continue to operate using legacy tools and processes. While there may be near-term challenges as associated with any learning curve, MBE and MBD show incredible potential to produce quality products faster and more affordably. This evolution is larger than just Lockheed Martin - MBE is being referred to as "Industry 4.0" or "the Fourth Industrial Revolution." Several of the benefits of embracing MBE are described below.

Efficiency in Design

By enabling tools like automation and design reuse, MBE allows for efficiency in the design phase by reducing the amount of design work required by our engineers. This extends to our Supply Chain by providing 3D models to our suppliers, who historically have often needed to use their own engineering labor to create models from our 2D drawings. It is estimated that MBE practices may allow for 2-3x faster design and engineering work, while the automation opportunities presented by using models throughout the supply chain have shown to reduce certain machine and inspection programming spans by up to 90%. Furthermore, MBE offers the opportunity to use design tools that have evolved to incorporate Design for Manufacturing principles which enable designs to take advantage of new manufacturing capabilities.

Improved Collaboration Throughout the Supply Chain

Establishing an MBE that encompasses our supply chain not only allows us to share models with our suppliers in a traditional "built to print" scenario, but it also allows us to integrate supplier-generated data back into our models and reduces the turnaround time for technical support. With our Design Partners, we can even take the model of a supplier's design and integrate it into the model of the higher LM-produced assembly or product. This ingestion of supplier data back into the model helps us establish the **Digital Thread.**

Enablement of the Digital Thread and Digital Twins

Implementing MBE requirements on procurements and production will support the maintenance of the Digital Thread for a part, assembly, and end-product throughout its lifecycle. The Digital Thread allows us to capture a myriad of As-Built, As-Processed, and As-Tested data that today often gets left behind on a machine or computer. Finally, the Digital Thread allows us to know exactly how the As-Built part compares to the As-Designed model.

Customer Demand

Our customers recognize the potential value in the MBE and has embraced MBE and Digital Engineering practices. More and more frequently, we are seeing Next-Generation programs with MBE and digital collaboration requirements. The Department of Defense has even outlined **"Digital Engineering and Modeling Practices"** in its own handbook, MIL-HDBK-539. These actions indicate to us that OEMs and Suppliers who want to remain competitive in the coming years and decades will need to embrace MBE concepts to continue to secure work on future USG DOD programs. We must transform to remain competitive!

What are the implications of not embracing MBE?

If a supplier decides **not** to embrace MBE, they will still be able to compete for LM business. However, over time the portfolio of non-MBE parts will become smaller as legacy programs wind down and are replaced by new programs that levy MBE practices. As those non-MBE parts become fewer, competition will grow, and margins may shrink. Furthermore, legacy suppliers may struggle to compete with their competitors who have realized efficiencies in their organization as a result of implementing MBE.

Lessons Learned - Why the need for a Playbook?

Lockheed Martin (LM) has received valuable insight from suppliers through surveys and pilot projects about best practices and process improvements that can be implemented as the MBE Procurement process is further defined and understood by LM. What is clear is that today, across the corporation and our supply chain, we have various levels of understanding when it comes to MBE practices and applications. That variation exists across supply chain segments, business areas, and between individual suppliers. For example, our interactions to date indicate that, in general, machining and design authority suppliers are more prepared to embrace MBE concepts than other suppliers. The intent of this Playbook is to "level the playing field" and provide a consistent message to suppliers about the direction LM is going as it transforms toward an MBE.

What is 1LMX?

The Game is Changing....

LM's journey toward becoming a Model-Based Enterprise is one portion of a larger OneLM Transformation. It is recognized that today's way of working is drastically changing due to workforce transitions, advances in technology, and new challenges on the horizon. Industry must embrace these challenges to drive innovation and opportunity. To overcome these challenges, LM is undergoing a multi-year transformation to re-engineer processes and procedures to operate as OneLM – this transformation is known as "1LMX."

LM's 1LMX Mission:

- Re-Engineer Business Processes and Re-Engine the Company
- Empower LM Team Members to Connect and Innovate with Speed and Agility

MBE Implementation Timeline

Like 1LMX, Lockheed Martin's transition to a Model-Based Enterprise is incredibly complex with multiple moving pieces. This multi-year program is already underway, with a planned completion by 2028 for the entire transition. Along the way, there are numerous "Accelerator" efforts (including this Playbook) that will bring some of the benefits of MBE to the LM enterprise and supply base as they become available.

Introduction to the Digital Thread

As LM evolves from 2D drawings to 3D models with metadata, the opportunity exists to support those models with data generated throughout the Buy-Build-Sustain lifecycle. This data is known as the Digital Thread, and when combined with 3D and System Models, provides the opportunity to generate Digital Twins. Digital Thread data includes data generated by LM suppliers, including production settings and telemetry, inspection settings and results, material, and environmental information, and more. This data is known as "As-Built," "As-Processed," and "As-Tested" data.
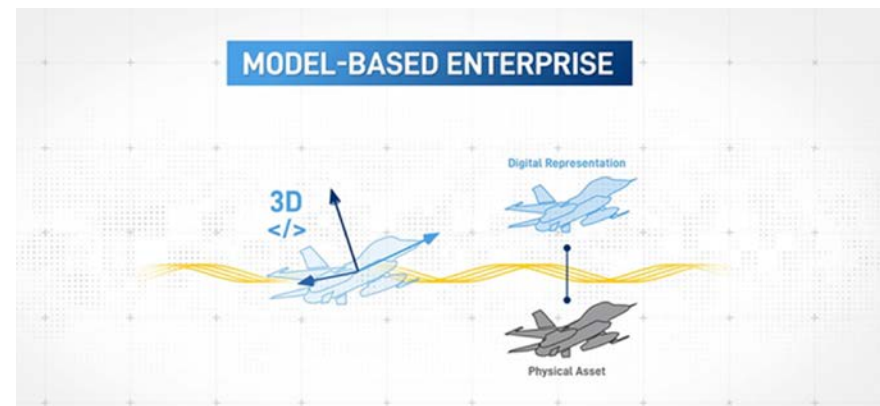
Preserving the Digital Thread is the impetus for why LM must begin working from models throughout the Supply Chain. Any translation from a model to 2D drawings or other formats presents an opportunity to break the Digital Thread.

As-Built Data:

Types of data include Bills of Material (BOM), Serialized Components List, etc.

As-Processed Data: How was the part made?

- Types of data include production telemetry data, environmental conditions, toolpaths, etc.
- Preferred data format is MTConnect.
  - MTConnect can record data against STEP Persistent IDs, which ties the data back to the original feature on the model.

As-Tested Data: How does the part perform to requirements?

- Types of data include: CMM results, simulation results, environmental screening test results, serialized inspection scans, etc.
- Preferred data format is QIF-Results
  - QIF-Results can record data against STEP Persistent IDs, which ties the data back to the original feature on the model.

The graphic below provides a glimpse of the future state MBE enabled by the Digital Thread. It holds significant potential and LM's supply base is a key element.
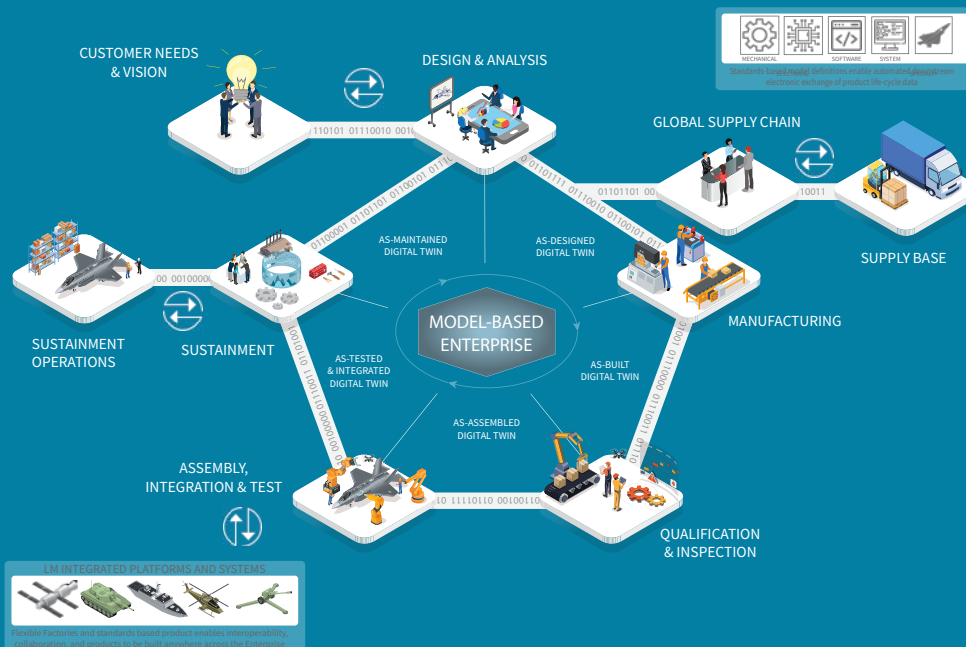
Finally, the Digital Thread enables the creation of Digital Twins, a digital representation of a physical part. DoD defines Digital Twins as "an integrated multiphysics, multiscale, probabilistic simulation of an as-built system, enabled by Digital Thread, that uses the best available models, sensor information, and input data to mirror and predict activities/performance over the life of its corresponding physical twin." Digital Twins allow companies to simulate and validate products without ever needing to manipulate the physical part.

MBE Foundational Knowledge

This section contains the foundational "building blocks" of the Model-Based Enterprise (MBE) and Model-Based Definition (MBD). It aims to educate the reader's understanding of and appreciation on both the basics of the MBE and process differences explained elsewhere in the Playbook.

- MBE Terms & Concepts - basic terminology and concepts referenced frequently when discussing MBE.
- MBE Tools - Tools used when working with MBD.
- Supplier MBE Readiness – Overview & Background - efforts to date to assess LM suppliers' MBE readiness.
  - Supplier Process Verification by BA - processes used by BAs today to rate their suppliers' MBE readiness.
- Cyber Security Impacts - considerations to Cyber Security as MBE matures.

MBE Terms & Concepts

Data Set Ratings (DSR)

What is a Data Set?

ASME Y14.41 describes a data set as a "collection of data that discloses (directly or by reference) the elements needed to completely define a product, by means of textual or graphic presentation, or combinations of both." The Data Set may include 3D models (i.e., models with annotations, product manufacturing information and material designations) or additional data objects such as Parts Lists or model representations (e.g., visualization files, STEP files, or 3D PDF files) which are configuration managed along with the models.

What is a Lockheed Martin Data Set Rating?

Data Set Ratings are applied to communicate 3D model fidelity within a data set and to clearly identify whether the 3D model or 2D drawing takes precedence in the event of duplicated or conflicting information. In general, a higher Data Set Rating indicates a greater capability to support MBE practices. Data Set Ratings

range from 0-6. The highest data set rating of 6 does not include a drawing, only a model and related supplemental data. All LM Model-Based parts will have a Data Set Rating on the technical data.

Technical Data Overview

What does the term "model" mean?

In a Model-Based Enterprise, the model is not just a digital depiction of the 3D shape but rather "a combination of design model, annotations, and attributes that describes a product." (ASME Y14.41)

Model-Based Definition (MBD)

The term MBD refers to the technical data used in the MBE. It includes digital 3D model files and their supporting digital artifacts, as well as system models and their attributes.

Model Files - Native vs Neutral Format:

It is important to understand the difference between "Native" and "Neutral" file types.   Native files are formats created by the PLM or CAD tool that was used to create the design (3DX, Catia, Creo, etc.) and generally work best when opened in the same software that created them. Neutral files are flexible formats that are intended to be opened by most model viewers and software available on the market. The most common neutral formats are STEP AP242 and 3D PDF. LM is driving toward using "neutral" formats that can be interchanged business wide, both internally and externally.

STEP AP242

- STEP, the Standard for the Exchange of Product Model Data, is a comprehensive ISO standard (ISO 10303) that describes how to represent and exchange digital product information. The current AP242 format is the preferred standard for CAD import/export. STEP is a neutral (non-proprietary) format intended to be "machine readable."
- STEP files are one example of a "neutral" format that can generally be used by most engineering tools, which makes them the frequent choice for sharing across the supply chain. STEP is LM's format of choice for machined parts and cable/harness components.

3Di/3D PDF

- 3-Dimensional intelligent (3Di) technical data is a 3-dimensional (3D) viewable computer-aided design (CAD) representation that details the complete technical description of the required design configuration of an item in a widely available software format (e.g., ISO 32000-1 portable document format [PDF]), as specified in MIL-STD-31000. The most common 3Di software format, and the one used by LM, is a 3D PDF. This Playbook will therefore use the term "3D PDF" throughout.

- 3D PDFs are a lightweight format that can be used to share a model with other parties and primarily serve to be "human readable" reference documents. 3D PDFs utilize the ubiquitous Adobe Reader as the viewing tool for all use cases.

  - Note: Some third-party tools may not properly work with 3D PDFs. LM recommends using the standard Adobe toolset when working with 3D PDFs.

- By not requiring expensive software licenses, 3D PDFs allow LM and its suppliers to transition to more engineering rich content without adding cost to the supply chain.
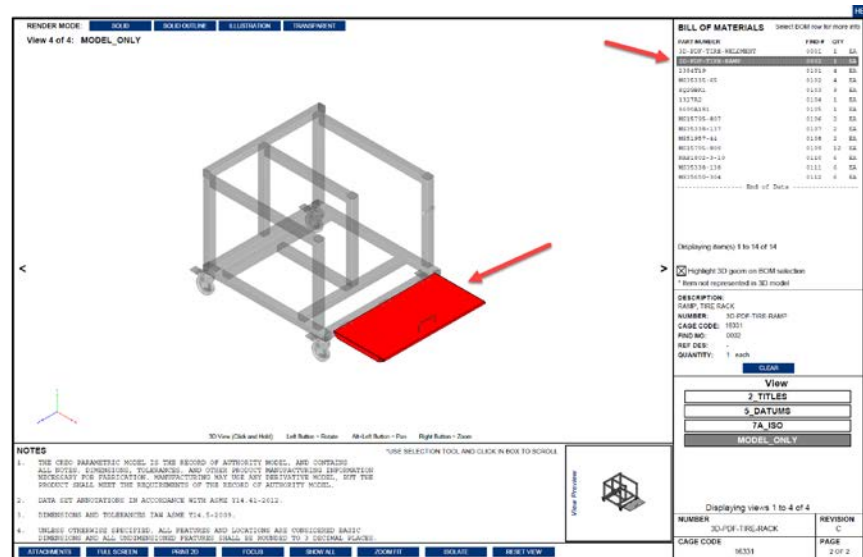
Example of LM 3D PDF from 3D PDF training materials

Quality Information Framework (QIF) – LM's Preferred format for As-Tested data

- ANSI QIF 3.0 / ISO 23952:2020, known casually as "QIF," is a standard format for tagging Model-Based features and enabling consumption and re-use to downstream systems and stakeholders. QIF also allows for rapid programming of Coordinate-Measuring Machines (CMMs) and has the potential for automation and labor savings throughout the supply chain.

- The "QIF-Results" format allows inspection data to be recorded back to the features of the model. As a result, after inspection the CMM measurements can be overlaid back onto the design model, giving us the "twin" of how the part was produced vs the design.

- LM expects to begin requiring QIF deliverables beginning in late 2024 into 2025 for select programs.

MTConnect - preferred format for "As-Processed" data. Also supports and exports QIF.

- MTConnect is the preferred format for As-Processed Digital Thread deliverables from LM's Supply Base.

- MTConnect provides the machine telemetry needed in a standardized data format for ingesting back into models for the most critical subset of components, i.e., safety of flight.

- Expect to see MTConnect requirements on critical parts more frequently in the next 3-5 years. It is estimated <10% of LM parts will require MTConnect data deliverables.

Preparing for Build to Model – Supplier Call-to-Action: LM is working with industry to expand the proliferation of QIF and MTConnect standards in new equipment and software. LM encourages suppliers to do the same when having future capital planning conversations with software and **equipment providers. As the demand for these standards increases over** time, there will be greater compatibility in new equipment and software across the industry. We are asking suppliers to:

- **Evaluate** – Is your equipment and/or software compatible with emerging standards like QIF and MTConnect?

- **Engage** - Ask software and equipment providers what their plans are to support data standards like QIF and MTConnect in current and future product releases. Express interest in having these capabilities in your equipment.

- **Consider** - including these features on your next equipment/software capital procurements so you are ready for these future requirements.

Several teams within LM have prepared excellent training packages for learning about Data Set Ratings, STEP and 3D PDF, and QIF file types. Contact your Buyer or Subcontract Program Manager for a copy of this training material.
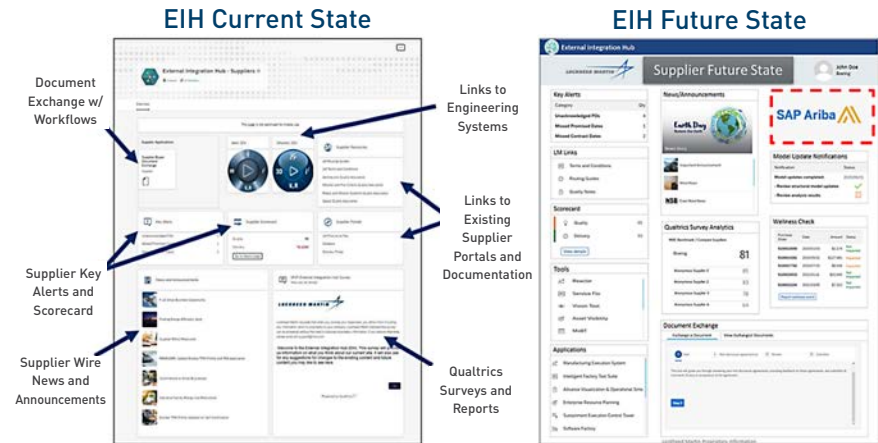
MBE Tools for Suppliers

- [External Integration Hub](#) (EIH)

- [File Transfer Tools](#)

- [MBE Supplier Statement of Work](#)

- [Quality Tools](#)

LM External Integration Hub (EIH) - 1LMX Accelerated Capability

- The External Integration Hub (EIH) is a web-based "front door" that provides a centralized platform, secure integration, and common user experience for all external users needing to collaborate with LM. For suppliers, EIH serves as a central landing page to securely access a wide variety of tools including links to LM Supplier Portals, key alerts and scorecard info, as well as supplier news and announcements. Additional capabilities are in development and continuously being added. The supplier population is being incrementally onboarded to EIH as development continues.

- To support MBE, EIH will offer suppliers their central landing page with role-based access to any Program collaboration tools they need to use, along with file transfer tools that will allow for the inbound and outbound exchange of tech data.

EIH Current State / EIH Future State

LM File Transfer Tools

Note the tools described below may be used in different scenarios depending on the nature of a subcontract. If you are a "Build-to-Model" supplier who is primarily consuming LM data, you will likely use one of the file transfer tools described below. If you are a "Design Authority" supplier that owns a design or is contributing to an LM design, you may use one of these transfer tools to send system and/or design models, or you may be asked to work directly in the LM PLM system. All these tools are planned to be accessible via the External Integration Hub (EIH) in the near future. Above all, LM remains committed to the security of LM, suppliers', and customers' digital data.

[DocPak](#) and [MoveIT](#) – file transfer tool specific to the RMS Sikorsky line of business. MoveIT is in the process of being migrated to be an enterprise tool as part of 1LMX.
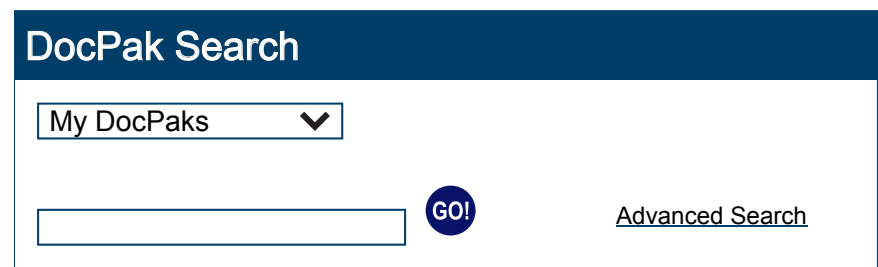
[Secure Information Exchange (SIE)](#) – file transfer tool used outside of RMS-Sikorsky. *SIE is accessed through an easy-to-use web interface and can securely transfer large files (up to 20GB) to LM recipients.*

To	[_____] [+]
Subject	[_____]
Message	[_____]

[Add Files] [Send]

Native-PLM Supplier Collaboration Capabilities - *F*rom time to time the LM program may need to have suppliers on the same network and platform to support design/build activities. This may be more common for Classified programs and/or Suppliers who have Design Authority where close collaboration is required to support program and customer needs. The ability to relate data, use workflows, and build a stronger Digital Thread are the primary reasons for why LM might have a subset of suppliers using the Native - PLM tools for collaboration purposes. Your Buyer or Subcontract Program Manager will inform you if this is a requirement and assist you with gaining access.

Industry Available MBE Tools

In an MBE, there are numerous opportunities to make Aerospace and Defense (A&D) quality processes more efficient by leveraging new tools and technologies that work in conjunction with Native CAD and build on the robust quality processes our industry maintains today. Examples of processes that can be automated include derivative CAD validation, revision comparison and measurement uncertainty simulation. In addition, these tools can often:

- Publish into 3D PDF (3Di) and include derivative formats for downstream usage, including First Article Inspection or Production Part Approval Process (FAI or PPAP) document generation.

- Perform model quality checks for Product and Manufacturing Information (PMI) consumption.

- Perform model comparisons. This can identify common issues including:
  - Derivative file geometric errors thru exportation from native format generators into derivative formats.
  - Errors associated with using different versions of a Native CAD software.
  - Translation errors between file types.

- Generate and ingest QIF files with associated inspection data and statistical process capabilities.

- Generate an AS9102 First Article Inspection report template with pre-populated model features. Suppliers are encouraged to explore this functionality as it offers significant time savings when preparing First Article Inspection documents.

LM has selected MBDVidia as its QIF publishing and packaging tool. Suppliers are free to evaluate the tool that works best for their needs. The state of **Connecticut Center for Advanced Technology (CCAT)** has an excellent video depicting these types of capabilities using MBDVidia as an example tool.

CCAT - Automated First Article Inspection Overview Video

LM would also like suppliers to be aware of a robust, managed, and **continuously improving** [STEP file analyzer and viewer](#) tool provided at no charge by the National Institute of Standards and Technology (NIST). This can provide suppliers with a no-cost option to increase their means of viewing STEP files throughout their operations without purchasing additional CAD/PLM licenses. The tool supports all common formats of STEP file formats including AP242, AP203, and AP214.

Supplier MBE Readiness - Overview & Background

As Lockheed Martin transitions to a Model-Based Enterprise, there have been several efforts to assess suppliers' readiness for such a transition.

A variety of Business Area and Enterprise-level efforts have been conducted to understand the MBE knowledge and capabilities in LM's internal and external supply chain. Each method has served a purpose in the overall communication and implementation strategy for becoming a Model-Based Enterprise by illuminating areas where there are gaps in the internal & external abilities to support a Model-Based Enterprise.

The **Supplier MBE readiness survey** provided a general understanding of how knowledgeable suppliers were about principles related to engineering, operations, and quality.

- -

MBE Pilots have allowed Lockheed Martin to work directly with a supplier to understand, improve, and define the Model-Based Procurement process by going through the procurement steps and getting direct feedback from the supplier about the experience.

- -

Each Business Area has a Supplier Process Verification method to assess a suppliers› readiness to perform a Model-Based procurement.

MBE Supplier Surveys

Approximately 600 LM suppliers participated in surveys designed to assess the current state of the supply chain in terms of their understanding of MBE and their capability to produce and consume data formats that will enable LM to move to a Model-Based Enterprise.

Each of the five (5) supplier segments listed below received a tailored survey with questions based on their support type.

Machining	Design Authority	Cable Harness	Printed Wiring Board Circuit Card Assembly	Optics

Major takeaways from these surveys include:

- The multi-CAD landscape of LM and its supply chain will require a standards-based solution.
- MBE utilization within the Design Authority and Machining category is more mature than other segments.
- The lack of equipment, software, or training limits the use of models on suppliers' production floor.
- Many suppliers will still create 2D drawings for manufacturing or inspection from a model.
- Segments where Coordinate-Measuring Machine (CMM) inspection is prevalent have higher potential for MBE automation.
- There was no distinction between small and large businesses with regard to MBE readiness.
- The understanding and implementation of Quality Information Framework (QIF) was limited across all supplier segments.

LM has refined the supplier MBE survey for continued data collection. There are currently no plans for widespread survey activity, however, limited surveys may be sent out to specific suppliers in the future.

MBE Pilots

LM has conducted several pilot efforts with suppliers at the enterprise and BA level. The intent of these pilots was to try to practically apply concepts to obtain real world feedback and insights into suppliers' ability to ingest model-based data and generate the requested Digital Thread artifacts back to LM.

Benefits:

- Able to inform and validate requirements for MBE Statement of Work (SOW) requirements.
- Assess suppliers' ability to consume 3D models throughout the product lifecycle.
- Assess suppliers' familiarity with Digital Thread elements.
- Capture these insights across different segments of the supply chain (i.e., machining vs electrical)

Insights:

- Many suppliers are not prepared to use models throughout the entire production process and still rely on 2D drawings at times.
- Suppliers require education on Digital Thread artifacts and up-and-coming data formats like QIF and MTConnect
- There are labor savings to be gained in areas like CNC and CMM programming if suppliers can leverage LM models.

As more production procurements are implementing Model-Based requirements, there have been less need for Pilot efforts. Any future MBE Pilots will be focused on implementing specific requirements, such as QIF or MTConnect.

Supplier MBE Process Verification Overview

Each Business Area (BA) has their own methodology for assessing suppliers' readiness for MBE procurements. These methods may involve surveys and/or assessments:

- As a first method, some of the BAs refer to the MBE Supplier Survey activities described previously. A limited number of representative suppliers were targeted for input to assess the levels of MBE acumen across the LM supply base. Reviewing the survey responses provides insight to a Suppliers' MBE readiness.
- Some BAs have developed an assessment that gauges suppliers' MBE processes. These assessments review suppliers' ability to translate 3D model data and review content stored in 3D PDFs. The results of this type of assessment are stored in LM procurement and quality management systems like other special processes.
- Lastly, some BAs have suppliers perform self-assessments of their process while providing objective evidence. This content will be distilled into categories based on design authority and how closely integrated to LM business processes the supplier will be.

For more questions regarding supplier MBE process verification, please reach out to your Buyers and/or the Supplier Quality Engineers who manage your procurements. While each BA has their own process today, LM is striving to have a common Supplier Digital Maturity Assessment by the end of 2024.

What has LM learned from Supply Chain MBE so far?

Through close engagement with suppliers, LM has learned that:

- While suppliers vary dramatically in their understanding and implementation of MBE, most are looking to embrace MBE and desire help to guide them on their MBE journey.

- Different segments of suppliers are more mature than others.

- Some suppliers are more mature because they have been a part of other A&D Prime's supply base already implementing MBE.

- Software compatibility will be a challenge if LM does not embrace and help shape industry standard neutral formats like ISO 10303-242 STEP AP242, aka "STEP," QIF, SysML, and others.

- The hardest challenge to overcome may simply be traditional change management obstacles. Many of LM's suppliers' current processes are the result of decades of application of traditional engineering practices, and embracing MBE may be daunting.

To address the variances in MBE knowledge, LM has created this playbook that is specifically written for suppliers. Additionally, LM has started offering webinars to further inform suppliers about LM's MBE journey, and we are working in partnership with industry and government entities to generate resources for supplier MBE readiness.

Successes

File formats have been identified for the Machining, Printed Wiring Board-Circuit Card Assembly (PWB-CCA), and Cable/Harness supplier segments. Compatible file formats are:

- Machining: STEP AP242
- PWB-CCA: ODB++ / IPC-2581
- Cable/Harness: STEP AP242

3D PDF was seen as a valuable neutral file format and has been selected as a key component of LM's future Technical Data Packages

Models have proven beneficial to CNC and CMM programmers in reducing the setup time required to operate the machines. By ingesting a model rather than a human programming a machine manually from a drawing, there have been instances of labor reductions upwards of ~75-90%.

Automatically generating First Article AS9102 forms using tools like MBDVidia has saved suppliers' Quality teams significant labor who would normally need to create these documents manually.

Challenges

As with any change of this magnitude, there will continue to be learning curves and challenges along the way. LM is asking its supply chain partners to maintain a growth mindset on this journey as the industry continues to embrace and mature this new technology.

MBE software is still maturing:

- Support of standards like QIF within inspection software (ex: Zeiss Calypso, Hexagon PC-DMIS, InnovMetric Polyworks) is still in its infancy. Essential capabilities are still in development and not yet fully supported.

- Suppliers have experienced translation issues when working with STEP242, ODB++, and Zuken files including:

  – Text, Annotations and Product Manufacturing Information (PMI) did not transfer with the geometry.

  – Predefined attributes showing up incorrectly in Model.

  – Some features required corrections or manual changes.

- While there has been some success in automatically generating AS9102 First Article Forms, there is still manual input required to complete certain aspects and most suppliers are unable to generate results automatically.

Many Suppliers' internal processes are not yet optimized for MBE:

- There is a wide variety in suppliers' internal processes for ingesting and managing MBE data.

- Some suppliers' internal processes require them to create 2D drawings from Models as they are not yet able to fully implement use of digital models of the production floor.

  - Creating 2D drawings from 3D models can introduce risk with data translation and break the Digital Thread.

- Discrepancies have been found between MBE capabilities claimed in supplier survey responses versus practical demonstrations of capabilities.

Implementation Challenges Experienced in MBE Procurements to Date:

Some Suppliers are Unable to "Consume" Models or have Paper-Based Processes:

- Suppliers should be prepared to consume machine readable neutral format models like STEP.

- Additionally, the supplier should be prepared to open and interpret a 3D PDF. The recommended viewer for 3D PDF is Adobe Reader.

  - Suppliers must have a working knowledge of 3D PDFs. Different views of the 3D PDF will contain a variety of information. When bidding, manufacturing, building, and delivering the supplier must ensure they are reading all views and adhering to all applicable notes.

- As the models become the record of authority, LM will migrate to the use of the model throughout the life cycle. This will especially be true of those suppliers who have Design Authority. Those suppliers may have to submit As-Designed and As-Built models in the form of an SDRL contract requirement.

- What if the supplier needs to use 2D Drawings in their process for work instructions or other purposes?

  - Suppliers will be able to create their own 2D Drawings from models if needed. However, LM encourages suppliers to develop the ability to work with models in order to realize the efficiencies offered and maintain the Digital Thread.

What changes can Suppliers expect?

Lockheed Martin Technical Data

- Technical Data Package (TDP) provided by LM:

  - TDPs, also referred to as the Model-Based Definition (MBD) refers to the technical data used in the MBE. It includes digital 3D model files and their supporting digital artifacts. Example formats include "Neutral" (STEP, 3D PDF) and "Native" (Catia, Creo, Solidworks, etc.).

  - TDPs may vary in content by Business Area but will contain some combination of a 3D STEP model and supporting artifacts.

New Types of Model Files

- LM plans to provide the following file types to suppliers of mechanical parts.

  - **STEP Model** - these are flexible formats that are intended to be opened by most model viewers and software available on the market.

  - **Native Model** - these are formats created by the PLM or CAD tool that was used to create the design. They may be provided in some cases where there is known commonality between LM and Supplier tools.

  - **3D PDF** - a lightweight format that can be used to share a model with other parties and primarily serve to be "human readable" reference documents.

  - **QIF Model** - Quality Information Framework - standard format for tagging Model-Based features and enabling consumption and re-use to downstream systems and stakeholders.

- The files provided for other part types is still being finalized. This Playbook will be updated as each part type is matured.

Inspection and First Article Impacts

- First Article Inspections will still be a requirement as they are today. However, MBE enables certain efficiencies within the quality and inspection realm. One of the **automations enabled by MBE is the ability to generate pre-populated First Article Inspection reports** with the model features that require inspection.

  – This saves suppliers time by not needing to populate the entire form, but rather focus just on populating the measured results.

- Another efficiency is that Suppliers' inspection tools like CMMs can be programmed directly from the model data, saving the inspection programmers' time.

MBE Technical Data Example

LM encourages a new MBE approach to deliver quality, speed and agility using data-driven intelligence and promotes a collaborative exchange of end-to-end information to leverage and maintain an unbroken digital thread.

It is recommended that suppliers work closely with LM Supply Chain and Program professionals to document like information for individual materials across various stages of development through procurement.

Following is a typical example of data input/output sources acceptable by LM for Mechanical Products:

Mechanical Use Case:	Information Being Conveyed	Record of Authority	Source of info for Review		Source of info for Manufacturing		Source of info for Assy & Test		Source of info for Inspection		Source of info for Sustainment	
			Human in the loop	Machine readable	Human in the loop	Machine readable	Human in the loop	Machine readable	Human in the loop	Machine readable	Human in the loop	Machine readable
Machined Part	Geometry and CAD structure	Native model	3Di	Native model	3Di	Native model or STEP242 model	3Di	Native model or STEP242 model	3Di	Native model, STEP242 model, or QIF	3Di	Native model or STEP242 model
Machined Part w/ Inseparable Hardware	Dimensions	Native model	3Di	Native model	3Di	Native model or STEP242 model	3Di	Native model or STEP242 model	3Di	Native model, STEP242 model, or QIF	3Di	Native model or STEP242 model
Sheet Metal Part	Tolerances	Native model	3Di	Native model	3Di	Native model or STEP242 model	3Di	Native model or STEP242 model	3Di	Native model, STEP242 model, or QIF	3Di	Native model or STEP242 model
Additive Part	Metadata	Native model	3Di	Native model	3Di	Native model or STEP242 model	3Di	Native model or STEP242 model	3Di	Native model, STEP242 model, or QIF	3Di	Native model or STEP242 model
Composite Trimmed Part Definition (TPD)	Notes[2]	Native model	3Di	Native model	3Di	Native model or STEP242 model	3Di	Native model or STEP242 model	3Di	Native model, STEP242 model, or QIF	3Di	Native model or STEP242 model
Mechanical Separable Assembly	Parts List	Native PLM	3Di	eBOM	3Di	eBOM	3Di	eBOM	3Di	eBOM	3Di	eBOM
Composite Panel Assembly (with Inseparable Hardware) Installation	Attached Documents, Requirements, Standards[3]	Native PLM	3Di	eBOM	3Di	eBOM	3Di	eBOM	3Di	eBOM	3Di	eBOM
Casting[1] Forging[1]	Visualization	Native model	3Di	Native model	3Di	Native model or STEP242 model	3Di	Native model or STEP242 model	3Di	Native model, STEP242 model, or QIF	3Di	Native model or STEP242 model

Notes

1. Ensure that the derivative file contains all of the manufacturing data needed

2. Can be separate note objects in the PLM or PDM.

3. STEP 242 model (or other applicable derivatives), LM Applicable Standards, Requirement Docs (linked to eBOM - collected by 3Di).

Example – Mechanical Products Consolidated Part Types

LM MBE Supplier Statement of Work Template

The Model-Based Enterprise Supplier Statement of Work (MBE SOW) template was developed by the 1LMX Supply Chain team and creates a starting point that enables a program to initiate a SOW-based procurement. The standardized SOW language and format allows the program to rapidly tailor it for their own Model-Based efforts based on specific program/part requirements. The SOW contains a standard set of requirements, standards, and definitions that can be altered as needed by the program. The intent of this common language is to provide suppliers with a consistent experience when receiving model-based requirements. Suppliers may see this SOW language embedded in their program SOW, or as an addendum to a larger program SOW.

Item	Title	Due Date
A01	Inspection Plan	Prior to Manufacturing
A02	Manufacturing Plan	Prior to Manufacturing
A03	Part Number and Description, Qty	As specified in PO
A04	Completed Inspection Report and/or FAI Documentation	As specified in PO
A05	Serialized Components List	At time of Part Delivery
A06	As-Tested Data Artifacts set	At time of Part Delivery
A07	As-Processed Data artifacts set	At time of Part Delivery
A08	Model(s) or STEP file(s) associated with required part integration	At time of Part Delivery

Example of SOW SDRL List Depicting Digital Thread Deliverables as Subcontract Requirements

How will LM and Suppliers collaborate?

Which Categories, Programs, or Suppliers are Transitioning to MBE?

- The transition to Model-Based Enterprise has already begun. Certain LM programs have released DSR 4/6 TDPs for suppliers to start manufacturing. As this becomes a standard practice, the volume of DSR 4/6 TDPs will increase over time making it imperative that suppliers are prepared to digest MBD and deliver Model-Based parts.

- Today in 2023, most MBE work is taking place in the mechanical category as those tools and processes are most mature.

- New programs with MBE requirements are also driving LM to begin collaborating with Design Partners on supplier generated MBD, including how to ingest that MBD into LM's own Models for higher assemblies.

- MBE is expected to continue spreading across additional material categories over the coming years as LM migrates to a Model-Based Enterprise. It will primarily be found on new part designs, however, legacy part conversion to MBD will be handled on a case-by-case basis.

- If a part revision is required, it will be evaluated if it is the right time to convert it to MBD as well.

- Some BAs may desire that a digital maturity assessment be performed prior to awarding Model-Based procurements. Like other qualifications, this assessment will evaluate People, Processes, and Technology for categories such as, but not limited to, MBE/MBD Literacy, training, Collaboration, Process Monitoring, Analytics Simulation, Tooling, Fidelity, and others. While each BA has their own process today, LM is striving to have a common **Supplier Digital Maturity Assessment** by the end of 2024.

Suppliers MBE collaboration experience may vary by the part type contracted:

"Build-to-Model" (formerly "Build to Print") Parts:

- Minimal design input, TDP largely developed by LM and provided to supplier.
- File exchange tools like SIE, DocPak, MoveIT, will be used for collaboration.
  - It is important LM SCM works closely with Configuration Management to ensure the Supplier is getting the appropriate TDP.
- Can leverage LM-provided Models to program CNC and CMM machines, reducing labor required.

Parts of Supplier Design:

- Parts featuring extensive supplier design input, including where the supplier may own the design.
- File transfer tools may not be collaborative enough. Suppliers may need to collaborate directly within LM PLM systems. These collaborations can be facilitated through tools like the External Integration Hub (EIH) or BA/Program specific Integrated Design Environments (IDE) using tools like Anark.
- LM will need to be able to ingest suppliers' models into LM MBD for higher assemblies that LM produces. These models may then be made available to a customer, or even integrated into a customer's data model.
- LM may require system models in addition to 3D CAD models to support MBSE deliverables to the end-user. See MBSE section of this Playbook

Cyber Security Impacts

Soon our Model-Based Enterprise (MBE) will require many suppliers to provide more digital content along with the physical part itself. This will especially be true for those suppliers who have design authority and manufacture the product itself. In the future these suppliers will likely be required to include a digital model of the engineering and manufacturing product. This will be in addition to providing the "As-Built" data set that often comes in the form of a Subcontract Data Requirements List (SDRL). The security of this data will be of upmost importance, so it will be critical that suppliers maintain a robust Cyber Security process and capability to protect the data sent from LM and to LM. **Suppliers with poor Cyber Security ratings may not be able to compete for Model-Based part subcontracts.**

The policies governing Cyber Security remain in place regarding Sensitive Information as well as Controlled Unclassified Information (CUI) and its derivatives, Covered Defense Information (CDI) and Controlled Technical Information (CTI):

Suppliers handling Sensitive Information shall require LM approval if they do not maintain a Green Cyber Risk Rating

Suppliers handling CDI must be compliant with DFARS 252.204-7012 and DFARS 252.204-7020

The expectation is that while LM policies and procedures surrounding Cyber Security are not changing during the transition to MBE, LM suppliers may be impacted by these requirements when asked for additional data from the Supply Chain. In the future, Cyber Security requirements may become more stringent depending on what is being procured (design services, hardware, or software) as well as the type of data set supporting the procurement.

Supplier Call-to-Action: Review your current LM Cyber Security Ratings and, if appropriate, take steps to improve your current rating.

Digital Intellectual Property (IP) and Data Rights

Suppliers who own the design of a part or subsystem may find themselves requested to deliver a system model with certain attributes for inclusion in a higher system model. In addition, LM customers are also requiring the appropriate level of Data Rights to utilize these system models. Any Data Rights required as part of a subcontract will be conveyed in the Statement of Work.
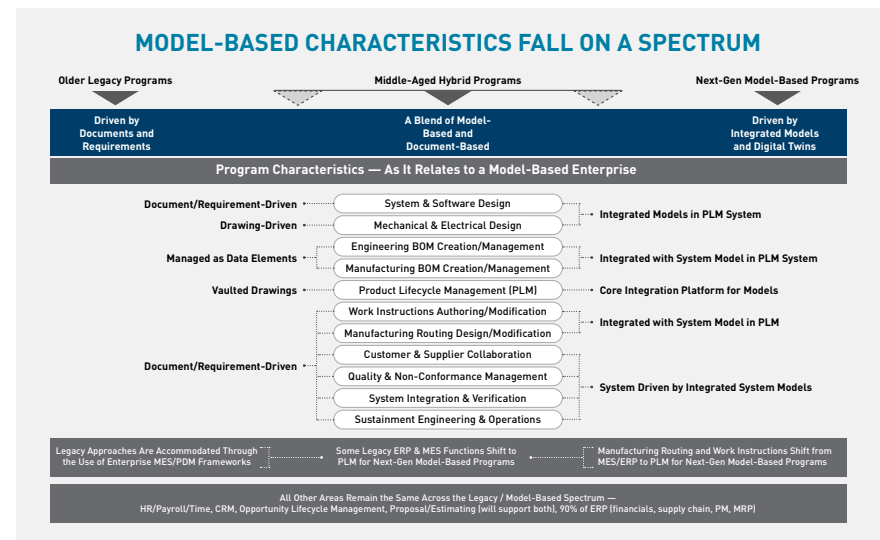
How is LM mitigating concerns with the sharing of Data Rights and Digital IP?

Attribute Specificity:
Rather than requiring a Supplier's entire Technical Data Package, LM requires the only the attributes needed to provide a compliant model deliverable to the customer.

- -

Access Restrictions:
Through techniques like Role-Based Access Control (RBAC), access will be limited to those with a program need to see Suppliers' data.

Comparison: Legacy vs MBE Procurement

It's important to understand that **implementation of the MBE will fall on a spectrum**. LM has a wide variety of programs - ranging from cutting-edge next generation programs to legacy programs with decades of production. As LM transitions to an MBE, many legacy programs may continue to operate with legacy practices, or partial MBE implementations.

MODEL-BASED CHARACTERISTICS FALL ON A SPECTRUM

Older Legacy Programs	Middle-Aged Hybrid Programs	Next-Gen Model-Based Programs
Driven by Documents and Requirements	A Blend of Model-Based and Document-Based	Driven by Integrated Models and Digital Twins

Program Characteristics — As It Relates to a Model-Based Enterprise

Document/Requirement-Driven	System & Software Design	Integrated Models in PLM System
Drawing-Driven	Mechanical & Electrical Design	
	Engineering BOM Creation/Management	
Managed as Data Elements	Manufacturing BOM Creation/Management	Integrated with System Model in PLM System
Vaulted Drawings	Product Lifecycle Management (PLM)	Core Integration Platform for Models
	Work Instructions Authoring/Modification	Integrated with System Model in PLM
	Manufacturing Routing Design/Modification	
	Customer & Supplier Collaboration	
Document/Requirement-Driven	Quality & Non-Conformance Management	System Driven by Integrated System Models
	System Integration & Verification	
	Sustainment Engineering & Operations	

Legacy Approaches Are Accommodated Through the Use of Enterprise MES/PDM Frameworks	Some Legacy ERP & MES Functions Shift to PLM for Next-Gen Model-Based Programs	Manufacturing Routing and Work Instructions Shift from MES/ERP to PLM for Next-Gen Model-Based Programs

All Other Areas Remain the Same Across the Legacy / Model-Based Spectrum —
HR/Payroll/Time, CRM, Opportunity Lifecycle Management, Proposal/Estimating (will support both), 90% of ERP (financials, supply chain, PM, MRP)

Opportunities for legacy programs to implement limited MBE:

- Engineering Change Proposals (ECPs)
- Upgrades
- Modifications, Repairs, Overhaul contracts
- Obsolescence/DMS mitigation retrofits

These situations may lead to new design work associated with these efforts. A program may choose at that time (or a customer may mandate) to perform the design and build applying MBE concepts and generating MBD technical data.

To Recap:

- Not all programs/procurements will fully transition to MBE format. Some will continue using legacy processes and many will adopt a hybrid form of the Legacy/MBE state.
- MBE impacts to specific stages of the subcontracting lifecycle will be detailed in dedicated pages in this Playbook.

Sample Example of Legacy vs MBE Procurement. Note this is intended to be a set of examples and not an exhaustive list. As noted, individual procurements may differ.

Procurement Artifacts/Categories	Traditional/Legacy procurement	Model-Based Enterprise Procurement
TDP items provided to Supplier. (Build-to-Print or Build-to-Model procurements)* *Individual procurements may differ*	- 2D Drawings - Bill of Material - Material Spec documents - Process Spec documents - Primarily "paper-based" and human readable - Necessary Quality requirements - FAI/GSI requirements - standard (blank) AS9102 forms - Traditional/modified Ts&Cs	- **Model** of P/N in Native file format - **Model of P/N in derivative AP STEP-242 Edition 2 file format** - **Model of P/N in derivative Quality Information Framework (QIF)** - P/N **3D PDF** Reference Documentation - P/N **Auto-FAI Documentation** in 3D PDF or Excel - As-Built PMI data 3D PDF Reference Documentation and/or XML as applicable - Human and Machine-Readable artifacts
Data Deliverables to be received from Supplier* *Individual procurements may differ*	- Inspection Plan - Manufacturing Plan - Completed Inspection Report and/or FAI Documentation - Process KPI Data (As inspected) - Serialized Components List - 2D Drawings (if Supplier is design authority)	- Model-Based Inspection Plan - Model-Based Manufacturing Plan - Completed Inspection Report and/or FAI Documentation - auto-generated in some cases. - As-Built Data, including Serialized Components List - As-Tested Data Artifacts set. - As-Processed Data artifacts set. - Model(s) and/or STEP file(s) associated with design and/or required part integration (Scan Data, Point clouds, etc.) - System Models (SysML) - Other artifacts such as Discrete Event Simulation process models

File Transfer Process/Tools:	- Secure Information Exchange (SIE)
	- DocPak
	- MoveIT
		- Secure Information Exchange (SIE)
		- MoveIT
		- DocPak
		- Native PLM Collaboration functionality
		- Program-specific Integrated Design Environments (IDE)
		  – Enabled in concert with External Integration Hub
		  – Leveraging collaboration tools like Anark

2D Drawing	- **Created at LM** & shared as needed with suppliers. - **Serves as record of authority**	**Generated by Supplier** from LM model using various tools such as 3D PDF or any CAD/CAM software. Serve as supporting artifacts to the 3D Model but is not the Record of Authority
3D Model	- **Created by LM, not always shared with supplier.** - **Re-created from LM drawing by supplier** to support CNC or CMM processes	- Primary file format containing part dimensions & technical specifications, shared with supplier. - **Serves as Record of Authority for part design.** - Tied into downstream consumption - Procurement, Manufacturing, Sustainment systems

Our customers' perspective:

[MIL-HDBK-539](#) was published in 2022 by the USG DOD and contains an excellent artifact describing differences across the product life cycle when transitioning from traditional to MBE principles:

Phase	Traditional Enterprise	Model-based Enterprise
Product Development	Design requirements established early in the design process make changes tedious and present challenges in keeping them updated.	Design requirements modeled and constantly reviewed and adjusted throughout the design process
	Design tradeoffs not well understood or considered	Design tradeoffs well understood, modeled, simulated, and constantly re-examined
	Design Process DESIGN → PROTOTYPE → TEST FIX → BUILD	Design Process DESIGN → MODAL → SIMULATE FIX → BUILD AND DESIGN → PROTOTYPE → TEST FIX → BUILD
	Static design, development, production, and support processes	Constantly improving MBx capabilities and integration between MBx capabilities
Product Definition	Paper-based	Digital
	2D drawings represent the authoritative definition of the product	3D models authoritative definition of the product
	Focus on human-readable product data only	Focus on human- and machine-readable product data
	Engineering changes are slow and inefficient	Engineering changes are fast and efficient, and tailored to the context of the change
	Product definition changes done with hanging engineering changes that require the user of the data to have drawing and hanging changes in order to have the most up-to-date product definition	Product definition information is online, on-demand, and always up to date (i.e., changes are quickly incorporated into the product definition and no longer have hanging changes)
Project Information	Information travels as email attachments or hand carried hardcopies	Established digital workflows for standard processes
	Multiple copies of information and is difficult to version control	Information exists as a single authoritative master accessible by all authorized users and is easy to version control
	Information recreated and reentered for downstream applications	Information created once and accessed/linked by downstream applications
	Significant time spent looking for project information	Eight-second rule applies. Eight-second rule requires that all key product and project information (e.g., requirements, test plans, budget information, drawings/models) can be accessed within 8 seconds of the realization that it is needed
	Key project and product information cannot be relied on to be accurate or up to date. Local copies of key information are stored because official repositories are slow or unreliable	Key project and product information managed to ensure data visible, accessible, understandable, linked, trustworthy, interoperable, and secured (VAULTIS) in accordance with DoD data strategy (i.e., the data is accurate, people know it to be accurate and updated, and the information is traceable and controlled over its lifecycle).
Build Information	Design information separate from manufacturing information	Seamless flow from design to manufacturing
	Additive and advanced manufacturing built into the design process	Additive and advanced manufacturing an afterthought after design
	M-BOM created separately from E-BOM	M-BOM generated from and connected to E-BOM
Operations & Sustainment	Logistics and sustainment information separate from design	MBD information seamlessly flows into sustainment and logistics information
	P-BOM created and maintained independently	P-BOM generated from and connected to E-BOM
	Little feedback from the field on deficiencies or needed design improvements	Established and robust processes to obtain field feedback on product deficiencies and possible design improvements
	Product operational information (e.g., operator manuals and technical manuals/orders) consists of paper documents and black line art	Product operational information is digital, constantly up-to-date, and contains dynamic, interactive 3D models, how-to videos, and other multimedia presentations

Special Considerations – Design Authority Suppliers

Overview:

The Technical Data Package (TDP) delivered with a system often contains all the engineering data and descriptive documentation required throughout its lifecycle. The information in the TDP is initially used to produce and inspect the product. It then can support the operation of the system, including provisioning, logistics, training, and maintenance. For maintenance operations, interactive technical manuals can often be produced directly from the product definition data. Later in the system life, the TDP is useful for support, repair, retrofit, and upgrades to the system. The TDP provides the basis for re-procurement of system components. A "traditional" technical data package includes applicable engineering data such as models, drawings, associated lists, specifications, standards, quality assurance, performance, and operational requirements. TDP completeness varies with each system procurement. Many major defense system support contracts are unique. Some systems have been delivered with comprehensive TDPs, while others have been delivered with very little technical data.

In the cases where insufficient technical data is delivered, the government must rely on the system prime manufacturer for support. This is often not cost effective and decreases operational tempo. Supporting advanced defense systems with little or no access to technical data adds significant costs and reduces system availability. Over 70% of the lifecycle cost of a system is incurred during the maintenance and support of a system.

LM is collaborating with Government and industry partners on the technical approach to future acquisition that uses models and other digital artifacts as the primary means of information exchange, rather than document-based information exchange. With this future approach, a Systems Architecture Model (SAM), sometimes referred to as a Total System Model (TSM), provides a "hub" for data integration and decision making across the product lifecycle. This will provide the ability to link analysis through the systems model to provide insight into architectural and system level decisions. Supplier models will be an important link in achieving this objective. Therefore, a major MBE focus area for LM and its customers is integration of "Design Authority" Suppliers and partners into the rapidly expanding model-based environment.

Design Authority Suppliers in this context are suppliers **that develop the design of a part or assembly.** These suppliers often produce and deliver the first product to LM. These are generally considered the "Major Subs" on a given program and are encouraged to work closely with LMs SPM and/or Engineering team as needed for handling Model-Based requirements on these subcontracts. The specifics of things like change management and collaboration will be determined during subcontract award with LM Supply Chain and Program Management professionals.

Model Integration:

Many of the procurements in this category are subassemblies or major subsystems of an end-item or Next Higher Assembly (NHA). Therefore, to develop a complete Model-Based Technical Data Package (TDP), the Design Authority Supplier must develop and deliver product definition models. Depending on the contract requirements, LM may then either deliver the entire* End-Item model to the Prime Contract customer as part of the TDP or integrate it into a larger Government-Furnished Model.

The model LM requires from a Design Authority Supplier will likely vary based on part/assembly type. For example, for a straightforward part like a bracket, a supplier may only need to provide size, shape, annotations, and material attributes. More complex parts/assemblies may require more information in the model.

Entire = the required elements as stated in the contract

Digital Intellectual Property (IP) and Data Rights:

Suppliers who develop the design of a part, assembly or subsystem may be required to share elements of the design with the LM. Along with Model-Based acquisition, LM customers have begun requiring corresponding Data Rights to enable the integration of the technical data package.

The specifics of IP and Data Rights will be determined during the RFP, Negotiation, and subcontract award phases with LM Supply Chain and Program Management professionals.

Supplier Call-to-Action – learn more about how design models will be incorporated in the future:
- Get involved in working groups or industry groups.
- Familiarize with integration of systems models.
- Network with other local A&D subcontractors and/or local industrial groups to share best practices around preparing for MBE.

MBE Procurement Process Plays

This section of the Playbook will describe high-level and/or step-by-step processes that can be applied to a Model-Based procurement.

- It's worth emphasizing that LM's transition to MBE does not change any formal policies in place today when it comes to procurement processes.

- This Playbook is intended to be an enterprise-level guide. Individual Business Areas, Lines of Business, and Programs may have specific guidance on Model-Based Enterprise implementation.

The process is broken down into three major phases of the supply chain process:

1. RFx/Solicitations

2. Negotiations

3. Post Award through Delivery

Each of these phases is explained in detail on their corresponding page of this section with specific "Plays," and additional resources are linked throughout the pages to provide guidance and background information for each step.

The procurement process that governs how LM engages with suppliers will remain much the same. Some of the tools may change as the 1LMX and MBE journey continues in the future. For example, the solicitation process may migrate from LMP2P and Email to a single online portal like Ariba. The technical packages the suppliers receive may be in a different format (Model-Based vs 2D Drawing). The goal of these transitions is to make the process more efficient for all parties involved.

Play: RFx/Solicitation

Overall Impact to Solicitation Process

In general, there is little expected impact to the overall solicitation process as LM transitions to MBE. The process will still follow the same policies and overall sequence used today, however, on certain steps there are activities that may be impacted by a suppliers' MBE readiness or new technical data formats. There may be additional changes to the solicitation process as MBE processes evolve.

Three main distinctions come to the LM solicitation process when procuring a Model-Based part:

1. **Source selection**: Currently, each Business Area has their own process for tracking which suppliers are ready to produce parts in a Model-Based fashion. Some Business Areas assess suppliers ahead of time, others will assess when a related Model-Based procurement comes along.

   - There is a plan to harmonize and release a single Readiness Assessment for this process in 2024.

2. **Technical Data**: 3D PDFs, Models, and other artifacts that make up the MBD may accompany the solicitation and be delivered through the data exchange tools described.

3. **Data Deliverables**: As described throughout this Playbook, MBE procurements may levy additional Data Deliverables in the form of SDRLs to enable the Digital Thread. These requirements will be identified in the Statement of Work or Purchase Order terms.

Item	Title	Due Date
A01	Inspection Plan	Prior to Manufacturing
A02	Manufacturing Plan	Prior to Manufacturing
A03	Part Number and Description, Qty	As specified in PO
A04	Completed Inspection Report and/or FAI Documentation	As specified in PO
A05	Serialized Components List	At time of Part Delivery
A06	As-Tested Data Artifacts set	At time of Part Delivery
A07	As-Processed Data artifacts set	At time of Part Delivery
A08	Model(s) or STEP file(s) associated with required part integration	At time of Part Delivery

Example of SOW SDRL List Depicting Digital Thread Deliverables as Subcontract Requirements

MBE Solicitation Instructions:

Some organizations throughout LM use Solicitation Instructions to educate suppliers on what to expect when responding to an RFx from LM. As LM transitions toward more Model-Based procurements, suppliers may begin to see Solicitation Instructions such as the paragraph below:

Model-Based Technical Data:

Model-Based technical data packages or components, commonly referred to as "Model-Based Definition" or MBD, is incorporated herein in support of Lockheed Martin's progression to a Model-Based Enterprise. MBD data may consist of one or more of the following: 3D PDFs*, 3D Models (AP 242 STEP and/or Native CAD/CAM files), Quality documents including a Quality Information Framework (QIF) file, as well as other supporting artifacts. Solicitation supporting documents are delivered using LM collaboration tools such as Secure Information Exchange (SIE), DocPak, MoveIT, or secure email.

*3D PDFs are best viewed using the free Adobe Reader (www.adobe.com)

Supplier Call-to-Action: It is important to fully read and understand any Request for Proposal documents and supporting artifacts to ensure your firm can deliver a compliant and competitive proposal. In some cases, the supporting data and model deliverables may be just as important as the physical end-item itself. Ask questions as needed to ensure you are interpreting the requirements accurately. Ensure you request any Government Furnished models or artifacts that can be made available. Delineate how you will meet the requirements by detailing your approach and/or previous experience in working in the Model-Based environment.

Play: Negotiations

This section is intended to prepare the reader for scenarios that may arise during the negotiation of a Model-Based part subcontract. It contains a series of "Plays" based on various scenarios encountered to date.

Play: What accommodations will LM make for suppliers who have challenges working with LM-provided MBD?

- During negotiation of a Model-Based part, LM recognizes a supplier may have requests based on their level of MBE Maturity such as:
  – Can LM provide 2D views of this model?
  – Can LM provide a different format of this 3D model? (i.e., Creo, 3DX, etc.)
- **In general, LM will not accommodate requests from suppliers** to modify the MBD or tech data. LM would prefer that suppliers expand their capabilities to be able to work with the 3D MBD directly without need for conversion. LM is moving forward with neutral formats in order to limit the amount of file types of suppliers must use.
- There are numerous benefits to be gained by developing the ability to utilize MBD:
  – Reduces risk for creation of errors in translation of the models between formats.
  – Eliminates the labor to create models from 2D drawings, which allows suppliers to start taking advantage of the efficiencies offered by MBD, like faster machine and CMM programming.
  – Positions suppliers to be prepared for the customer requirements associated with the latest DoD programs.

- Requests for accommodation will be evaluated on a **case-by-case** scenario. LM Supply Chain and Engineering may choose to assist a supplier with their request by performing certain translations and/or validations. However, these accommodations require resources, which drives costs and impacts LM's competitiveness. As LM transitions to an MBE, models are to be the single source of truth throughout LM and our supply chain.

- Procurements that are sole-source or only have a few possible sources are more likely to be accommodated. In this case, there may only be one or two qualified suppliers for the part. It may be prudent for LM to support the supplier rather than risk a no-bid and delay getting the material on order.

Note: 1LMX has taken strides to standardize what the requirements should be for a DSR 6 part in various categories. These have been approved at a high level but may not have made it to BA engineering practices, particularly on existing programs.

Play: Modifying Data Deliverable Requirements

- During negotiations of a Model-Based part, LM recognizes a supplier may have requests based on their level of MBE Maturity:

- In general, these requirements are part of the solicitation due to a customer requirement or to establish the program Digital Thread. Requests for removing these requirements will be evaluated on a case-by-case basis but will be evaluated against the driving requirement:
  – Is it a Customer Requirement / Prime Contract flowdown?
  – Is it stemming from an LM engineering classification such as a Critical or Major feature?

- If stemming from a customer/prime contract requirement, it is very unlikely that LM will waive the requirement. To have the most competitive proposal, suppliers should strive to meet all the requirements.

- If it is not a customer driven requirement, then LM may choose to evaluate the impact of accommodating the request and assess the impact of not receiving the Data Deliverable.

- In the near term (2023-2024), LM expects suppliers may not be ready to deliver some of the data deliverables we would like to have to support the Digital Thread. It is the goal of artifacts like this Playbook and industry resources to prepare LM suppliers to meet these requirements in the coming years.
  – 2025 and beyond is when LM expects new deliverables like QIF-Results to become a firm requirement, as one example.

Play: MBE Requirements are Driving Significant Subcontract Cost

- As a supplier competing for a Model-Based subcontract, it is important to recognize if Model-Based requirements are driving significant cost.

- If this is the case, contact your LM Buyer, Subcontract Manager, or Subcontract Program Manager. Explain the cost drivers, identifying specific requirements. Your LM POC may be able to help ascertain if affordability is more important than a data deliverable for the part.

- Long term, LM expects to see suppliers realize efficiencies in their Production and Quality processes as the benefits of working in an MBE mature.

Play: Competitive Model-Based Solicitations

- Competitive solicitations will continue to be performed in a fair and equitable manner as they are today.

- The weighting of any Model-Based requirements on the proposal evaluations will be disclosed where appropriate in the solicitation as with any other competition evaluation criteria.

- If Model-Based requirements are part of the weighting, LM Engineering will review bidders' compliance as part of their Technical Evaluation.

- In solicitations where there are no discrete Model-Based requirements, suppliers who have implemented and realized the benefits of MBE practices may find their prices are more competitive because of efficiencies gained by embracing MBE.

Play: Submitting a Proposal for Model-Based Part as a Design Authority

- As a supplier responsible for the design of a part, LM will likely require that the design model, or associated data, be provided as a data deliverable for incorporation to the end item model. These requirements may be a part of **Model-Based Systems Engineering (MBSE.)**

- If these requirements apply to you, it is important to understand the proposal and its attachments/exhibits carefully:
  - Some programs may ask for data attributes only and LM will populate the system model, while other programs may require the supplier to prepare and deliver a model that can be ingested, usually in the form of SysML format.
  - There may be Government- or Customer-furnished models, modeling guides, or other artifacts available to aid in your understanding of the scope. Ensure these are requested if not provided up front.
  - Ensure your proposal addresses any specific interface or formats highlighted in the RFx.
  - Delineate how you will meet the requirements by detailing your approach and/or previous experience as a Model-Based supplier.
    - Identify any Non-Recurring conversions of existing technical data to Model-Based artifacts.

Play: PO Award through Delivery

This section is intended to prepare the reader for scenarios or questions that may arise after a Purchase Order has been placed, up to and including part delivery. It contains a series of "Plays" based on various scenarios that have encountered to date.

Play: How does First Article Inspection (FAI) start to look different under an MBE procurement? (Mechanical Parts)

- **Today**: Key features are identified on the AS9102 form - the supplier populates the features and measurements. This can take a Quality Engineer quite some time to identify the various features and set up the FAI form, before inspection can even begin.

- **MBE**: Tools like MBDVidia allow LM and suppliers to leverage automation to create the pre-populated AS9102 FAI form(s), also with the requirement characteristics graphically identified ("ballooned"). This allows suppliers to only have to populate the inspection measurements, which **generates significant labor savings.**
  - Distinction here is that LM has the capability to provide pre-populated AS9102 forms to suppliers. If the supplier has organic capability, they can generate their own AS9102 forms from the model.

- In addition to the automated creation of the FAI forms, the QIF and MBD can also be used to program the inspection software. Since the programming is stemming from the same model, linked to the unique identified characteristics, the inspection results can then be automatically populated in the FAI data sheet.

- Combined, these automations stemming from use of the model can result in **up to ~90% reductions** in the time it takes a supplier to perform an FAI!

Play: Recurring Mechanical Inspection (Non-FAI)

- With MBD, suppliers can use Models and QIF files to program CMMs and other inspection devices automatically.
  - This can yield significant supplier labor savings compared to the traditional method of a Quality Engineer or Inspector programming an inspection machine manually. It also unlocks other inspection techniques, such as 3D scanning.
  - Inspection scans can then be imported back into the model using the MBD to ensure the part is acceptable. In pilot efforts, this combination has seen **~75% reductions** in the time it takes a supplier to perform an inspection!

- Like many areas of MBE, these processes will continue to quickly evolve and mature.
  - Models and QIF present additional opportunities to leverage automation for part acceptance and additional specialty inspection forms such Flight Safety Dimensions. As these areas mature, this Playbook will be updated.

The State of Connecticut has developed excellent training videos showing suppliers how to perform automated FAIs and recurring inspections, leverage QIF, and work with MBD. The videos include excellent step-by-step computer walkthroughs. They can be used as a general guide to gain an understanding of the processes, but specific steps might differ based on software suppliers ultimately use.
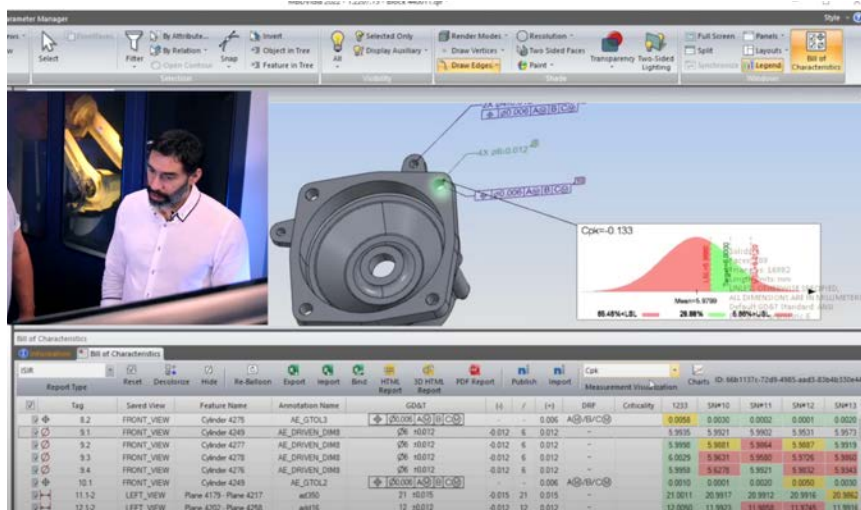
CCAT - Automated First Article Inspection Overview Video

Play: Part Shipment/Receiving -

- In the near term there are no impacts to shipping or receiving a part produced using MBE practices, however, the future state contains opportunity for using MBE data - for instance:
  - Performing source inspection using QIF to compare "As-Built" to "As-Designed."
  - Doing a simulated build using the "As-Built" data could identify a nonconformance at the Next-Higher Assembly before the part leaves the supplier's facility.

- This playbook will be updated as this area matures.

Play: Impact of MBE on SDRLs/Data Deliverable submittals

- In general, the number of SDRLs is expected to increase compared to legacy programs due to the additional collection of As-Built, As-Processed, and As-Tested data to maintain the Digital Thread.

- Whether MBE SDRLs are required will vary by part type and complexity, as well as type of supplier and program requirements:
  - Part Type and Complexity:
    - As of 2023, machined parts are the most common part type found in Model-Based procurements.

    - Part Complexity is broken into 5 categories as delineated in LM Cross Function Procedure, CRX-106, Managing Major Subcontracts. Types 3-5 will most frequently have Model-Based requirements, either as a «Build to Model» or a part where the supplier is the Design Authority. Complexity types 1-2 are less likely to have MBE requirements given their nature.

  - Supplier Types:
    - "Build to Model:" Would provide As-Built, As-Tested, and As-Processed artifact sets that can be used to keep the design model and Digital Thread updated.
    - For example, a supplier requests a Material Review Board disposition on a defect to use a part that differs from the spec in some fashion. The As-Built artifacts would allow LM to keep the Digital Thread intact by updating the model for that unit to depict the deviation, so it is not unexpected in the field.

  - Design Authority: Would be expected to provide a model with each part delivered and would reflect As-Built configuration, As-Processed, As-Tested.
    - These models would be integrated into LM's larger assembly model.
    - Note: this may have Digital Intellectual Property ("Digital IP") implications. Handling of Digital IP in the Model Based Enterprise is being evaluated and this Playbook will be updated as that guidance evolves.

  - Program Requirements:
    - Due to customer flow downs or the nature of the delivered system, certain programs may have unique requirements that result in a wider range of parts that require MBE SDRLs.
      - E.g., a requirement for a full digital twin

- Your Supplier SOW should indicate which SDRLs are required for a given subcontract.

The mindset of when a PO is "Done" may need to change.

- In an MBE, it is expected that more POs will have SDRL requirements to maintain the Digital Thread on each part delivered, versus traditional SDRLs that can be more "programmatic" in nature and submitted in accordance with a predetermined calendar.
  - The "Contract Closeout" process will continue to identify the closure of our procurement activity and isn't expected to change because of transitioning to the MBE. Closeout will continue to occur when the delivery, payment, rates, tooling, and other tasks as governed by LMAP and local policy are complete.

In Closing

This Playbook has provided an outline of what is changing as Lockheed Martin transitions to a Model-Based Enterprise. From foundational terms and concepts, new collaboration tools and techniques, as well as specific changes to Supply Chain processes, there is an opportunity to significantly advance the way business is done in the A&D industry. LM is asking Supply Chain Partners to embrace this journey to deliver better value for all customers in the long-term.

Final Takeaways:

1. Review the Industry Resources, Call-to-Action Checklist, and FAQs enclosed to see what actions suppliers can begin to take to prepare for MBE.
2. Keep an eye out for upcoming LM-hosted webinars to learn more about MBE, as well as other industry learning opportunities.
3. Consider joining industry working groups to shape the future of standards, architectures, etc. used in Model-Based design.
4. Watch for future releases to the LM MBE Playbook for Supply Chain. As MBE continues to evolve and mature, this Playbook will be released with updated content.

Understanding MBE	Quality Information Framework (QIF)	STEP AP242 File Format (.STP)	Digital Thread
Connecticut Center for Advanced Technology MBE Resources *(10-minute video)*	**Home - qifstandards.org** *DMSC website on QIF*	**What is an STP File?** *Spatial Corp responds to FAQs*	**NIST Summary of Digital Thread** **PTC Blog on What is a Digital Thread**
MBE Dictionary – Action Engineering *Defines many MBD terms and industry standards*	**QIF: 2021 Definitive Guide** *Guide & videos from Capvidia*	**What are STEP files and how do you open them?	Adobe**	
MIL-HDBK-539 *US DOD Digital Engineering & MBE Military Handbook*	**ISO 23952:2020** *Automation systems and integration — Quality information framework (QIF) — An integrated model for manufacturing quality information*	**STEP AP242 (ISO 10303-242)**	

Supplier Call-to-Action Checklist

Category	Action
Prepare for Build to Model	• **Evaluate** – Is your equipment and/or software compatible with emerging standards like QIF and MTConnect? • **Engage** - Ask software and equipment providers what their plans are to support data standards like QIF and MTConnect in current and future product releases. Express interest in having these capabilities in your equipment. • **Consider** - including these features on your next equipment/software capital procurements so you are ready for these future requirements.
Cyber	• Review your current LM Cyber Security Ratings and, if appropriate, take steps to improve your current rating.
Design Models	Learn more about how design models will be incorporated in the future: • Get involved in working groups or industry groups • Familiarize your firm with integration of systems models • Network with other local A&D subcontractors and/or local industrial groups to share best practices around preparing for MBE
Proposals	• Fully read and understand any Request for Proposal documents and supporting artifacts • Ask questions as needed to ensure you are interpreting the requirements accurately. • Request any Government Furnished models or artifacts that can be made available. • Delineate how you will meet the requirements by detailing your approach and/or previous experience in working in the Model-Based environment.

Frequently Asked Questions

The questions on this page have been consolidated from LM MBE Surveys and other engagements with Suppliers. They are provided to address common topics that arise regarding LM's transition to an MBE and fall into the following categories:

- Implementation Timeline
- Training & Support provided by Lockheed Martin
- New Standards with MBE
- Technical Specifications & File Formats
- Quality & Inspection
- Miscellaneous

Implementation Timeline

Supplier Question	Lockheed Martin Answer
Can Lockheed Martin provide us with an implementation timeline, and current progress along timeline? • When will Lockheed Martin start to implement MBE from RFQ, PO Issuance on EXOSTAR and QC reporting to Shipping?	Lockheed Martin's transition to a Model-Based Enterprise is incredibly complex with multiple moving pieces. The entire transition is expected to complete by 2028, with "Accelerator" efforts that will bring some of the benefits of MBE to the Lockheed Martin enterprise earlier. Some Lockheed Martin Business Areas already selectively issue POs leveraging MBD Technical Data Packages to meet customer requirements. Lockheed Martin will increasingly ramp up MBE procurements from RFQ through part acceptance over the next 5 years.
Is the MBD process requirement relevant to all manufacturers? • As a supplier of Tool Designs to LM, what will our requirements look like? • Is this applicable to a Job Shop Machine Shop? • Do you think this is important for a small business that provides single components?	The end-goal for Model-Based procurements is that all data in the 3D model is directly usable for manufacturing to fabricate, assemble, install, or inspect parts or tools. All sizes of manufacturers can benefit from Model-Based data which will enable higher levels of automation between process steps. Over the coming years, Lockheed Martin expects most of the Supply Chain to be impacted by both Lockheed Martin's and the overall industry's transition to MBE. As a result, LM is preparing the Supply Chain for this transition now.
Are there certain groups/programs/functions being prioritized, or will require MBD sooner? • If approaching MBD in a staged implementation which data items would Lockheed Martin prioritize. • Will this be standardized across all Lockheed Martin programs?	New programs will have a higher percentage of MBD parts as LM works with more new designs and begins to see the requirement more frequently from customers. Mechanical parts and assemblies make up most MBD at Lockheed Martin today, as well as some electrical and cable/harness parts. Legacy programs may not see a full conversion to MBD but may see come capabilities added over time via mods, retrofits, or block upgrades. In time, MBD will comprise much of the LM portfolio.
How will MBD requirements apply to legacy programs and existing parts? Will updates be needed to covert legacy designs to MBD?	Legacy part conversion to MBD will be handled on a case-by-case basis. If a part revision is required, it will be evaluated if it is the right time to convert it to MBD as well.
When do you think this will be a requirement for doing business with Lockheed Martin? Will this become a contract requirement in coming months/years?	At this time, we are encouraging but not requiring suppliers to use Model-Based practices. Some Lockheed Martin Business Areas already selectively issue POs leveraging MBD Technical Data Packages to meet customer requirements. Lockheed Martin will increasingly ramp up MBE procurements from RFQ through part acceptance over the next 5 years.
What level of commitment is Lockheed Martin giving to this program?	Lockheed Martin's transition to a Model-Based Enterprise is a key transformation imperative, part of our overall "**1LMX Transformation**." These transformations are considered key strategic initiatives and have the full support of Lockheed Martin's Executive Leadership Team and Board of Directors.

Training & Support provided by Lockheed Martin

Supplier Question	Lockheed Martin Answer
Will Lockheed Martin provide additional training for how to onboard with MBD? • What level of communication & support will Lockheed Martin provide for us transitioning into MBD processes?	Lockheed Martin's *MBE Playbook for Supply Chain* describes what to expect in our MBE transition. In addition, there are numerous industry resources for training that can be leveraged, such as those developed by the [Connecticut Center for Advanced Technology](#).
We would like more information on what an integrated PLM platform would look like and what the implications would be for our internal business process and security policies in order to assess if this would be a viable approach.	Lockheed Martin is evaluating multiple vectors of collaboration with external parties inside a PLM system. At the heart of any future solution will be the Lockheed Martin External Integration Hub (EIH), the launchpad for all suppliers' interactions with Lockheed Martin.
How do you or will you deal with suppliers that do not have the financial means to support MBD? • Is Lockheed Martin prepared to burden some of the initial setup costs for small businesses?	From the use of neutral formats that don't require expensive software solutions to supplier resources like our MBE Playbooks for Supply Chain and Small Business-focused engagements, Lockheed Martin is implementing multiple strategies to minimize any impact of transitioning to MBE on suppliers. In addition, there may be grants available at the local, state, or Federal level to incentivize MBE adoption. Engage with your local government-industry liaison organizations for more details.
What should I do If my manufacturing/inspection processes prevent me from being able to use MBD or 3D Files? • Why would you need to eliminate 2D drawings? • Will I be permitted to create a 2D drawing from a model? • My sub-tier cannot work from a model, what do I do?	Lockheed Martin understands many legacy processes are in place throughout the Supply Chain and that a transition to MBE won't happen overnight. Consider evaluating MBE/Industry 4.0 practices to see where your business may be able to modernize its processes and benefit from MBE enablers. If 2D drawings are required to support current state processes, suppliers will be empowered to create them from the provided models. Ensure you have a rigorous process in place to validate the data after translating from the model to 2D. Suppliers and their sub-tiers may need to work together to create the necessary drawings needed for that sub-tier's scope of work.

New Standards with MBE

Supplier Question	Lockheed Martin Answer
What are Lockheed Martin's "standard" MBE tools, software & file types? Are those compatible with the Suppliers' existing tools? • What SysML tools will Lockheed Martin use? • What is Lockheed Martin native CAD system? • what software do you use? • What are Lockheed Martin's intentions for electronic and systems/software management /change?	Lockheed Martin uses a variety of engineering tools across the corporation, and as a result, is driving toward a neutral format and standards-based MBE approach. Formats like STEP and 3D PDF should be compatible with a wide variety of tools already in place in the Supply Chain. Newer technologies supporting the Digital Thread are also intended to be standards-based, including QIF and MTConnect.
Will a certain software/version be required to continue business with Lockheed Martin? • Are you planning to use multiple neutral files to allow use of different software packages? • Will you be mandating a company have a certain software to participate in this effort or will this effort be based on an industry standard format? • Are you working with Siemens NX, Mastercam and Verisurf to see if your MBD can be passed on to these other systems? • What versions of software do you currently use?	Currently, Lockheed Martin is not dictating specific software solutions, rather, the approach is to utilize neutral formats like STEP, 3D PDF, and QIF. Lockheed Martin is participating in industry committees and working groups to continue to shape and steer these evolving standards.
Are there opportunities for supplier's existing systems to be evaluated for equivalence?	Lockheed Martin is developing various resources for suppliers to validate their existing systems will be compatible with MBE.

Technical Specifications & File Formats

Supplier Question	Lockheed Martin Answer
What level data package per MIL-STD-31000 are you expecting to work to?	Lockheed Martin is adopting MIL-STD-31000 in varying levels throughout the corporation. As LM continues to move toward an MBE, LM will harmonize, across Business Areas, around implementation of MIL-STD-31000.
If a 3D PDF is supplied with the model - would that PDF be "certified" to the model?	For Build-To-Model procurements, Lockheed Martin will validate the neutral (STEP) and viewable (3D PDF PRC) before providing to our suppliers.
If at all possible, can you please add material type to the model so the weight can be utilized for the verification process.	Lockheed Martin is currently evaluating what attributes should be included to generate a comprehensive model. Material type has been recommended as an attribute for new releases of Model-Based parts.
As far as annotations and Model-Based parts, will Lockheed Martin still use CATIA models for MBD/DPD to Suppliers?	As not all BAs use Catia, Lockheed Martin plans to provide neutral STEP models and 3D PDF files to our Suppliers.
Does Lockheed Martin have process standards for digital product definition that could be shared with Suppliers? Boeing has provided their standard.	Yes, Lockheed Martin has established internal definitions known as Data Set Ratings to be used for Digital Product Definition. These Data Set Rating definitions and interpretations apply to all business areas and are outlined in this playbook. Lockheed Martin also follows The American Society of Mechanical Engineers (ASME) Y14 standards for product development through delivery. This includes the Digital Product Definition standards ASME Y14.37, ASME Y14.41, ASME Y14.46 and ASME Y14.47. Lockheed Martin is currently supporting ASME activities with the objective of developing new rules, guidance, and examples for the creation, use and reuse of Model-Based datasets, data models, and related topics within a Model-Based Enterprise (MBE).
Is there a timeline in which DSR6 compliance is required?	Not at this time, and not all parts will transition to MBD. However, newer programs will have the most Model-Based content, and over time, the broader Lockheed Martin portfolio will transition to where MBD is the norm. This will result in fewer opportunities for suppliers who choose not to embrace MBD.
Is it possible to send the .STP files for the model with all RFP's? Is it possible for us to get models in a format friendly with Solid Works? It would be much easier than the 3DX viewer we are currently using with Sikorsky MBD parts.	To provide the most flexibility throughout the Supply Chain, Lockheed Martin intends to provide STEP files and 3D PDFs as the basis for our TDPs as we transition to MBE.
Can you provide BOTH native data and STEP with a 3D PDF? We can validate all here but have used this method to make sure all data translates correctly into our Solidworks dataset for local distribution.	To provide the most flexibility throughout the Supply Chain, Lockheed Martin intends to provide STEP files and 3D PDFs as the basis for our TDPs as we transition to MBE. On a case-by-case basis, a program may choose to provide the native file if requested. Note that a variety of PLM and CAD tools are used across Lockheed Martin, so the native file types will differ.

Quality & Inspection

Supplier Question	Lockheed Martin Answer
How will AS9102 inspection data be submitted to Lockheed Martin using MBD?	Long term, Lockheed Martin is looking to leverage the QIF data format for capturing inspection data. In the near term, LM is using existing formats while looking for opportunities to bring more automation to the process.
What type of Automated inspection is being used, CMM, Surface Mapping, Traditional FAI techniques?	Lockheed Martin is transitioning to Model-Based datasets that will enable QIF inspection and facilitate supplier automation. However, for Build-To-Model parts Lockheed Martin provides the MBD but does not dictate the inspection methodology.
What if I do not have the ability to do Model-Based inspection?	Suppliers can use "traditional" techniques to program their inspection tools if they do not have the capability to ingest the model itself. By learning to work with the model directly, they can potentially save significant labor when it comes to programming certain inspection tools like CMMs.
As a supplier can I add additional content to the AS9102 First Article Inspection (FAI) form?	Yes. While tools like MBDVidia do a good job of identifying the features that require an inspection value, you may identify additional data points required for the FAI that are not pre-populated, such as material specification certificates, lot codes, etc. If provided a pre-populated AS9102 FAI form by Lockheed Martin, suppliers may add to the proper sheet as needed in order to provide necessary detail for a compliant FAI.
The views in the AS9102 First Article Inspection (FAI) document appear to be mirrored, how do we fix this?	It is a known issue with our tool that sometimes causes the views in the auto-generated AS9102 FAI forms to be mirrored. Lockheed Martin is working with the software OEM to resolve. This does not affect the "ballooning" and the other model files (3D PDF, STEP or Native) will be accurately depicted. The AS9102 forms 1-3 for recording inspection results are still applicable and can save suppliers significant time by not needing to build the FAI forms from scratch.

Miscellaneous

Supplier Question	Lockheed Martin Answer
How can we get additional exposure to LM procurement to communicate we have MBE capabilities in place? Would it mean more work for our company if we had the ability to produce parts based on MBD?	Communicate your MBE capabilities and/or desires to your Lockheed Martin Subcontract Manager, Supplier Quality POC, and any Engineering POCs currently managing your contract. New programs will have the most Model-Based content, and over time, the broader Lockheed Martin portfolio will transition to where MBD is the norm. Suppliers who have not embraced MBE will find fewer opportunities to meet subcontract requirements in the future.
What percentage of Lockheed Martin parts fabricated outside of Lockheed Martin currently use MBD?	While MBD is the minority today, as new programs come online with MBD, and legacy programs wind down the Lockheed Martin portfolio will transition to where MBD is the norm.
Would you be willing to work with your competitors to develop standard submittal expectations for MBD files?	Yes, in fact Lockheed Martin is engaged in various industry working groups and committees to drive toward standardization as Model-Based practices evolve.
With our current design capabilities in 3D modeling, but limited manufacturing and inspection MBD capabilities, what would be the key requests from Lockheed Martin for immediate development to support Lockheed Martin products?	Lockheed Martin is asking suppliers to embrace MBE concepts and consider embarking on their own MBE journey. Evaluate what steps you could take to begin to work with neutral formats like STEP, 3D PDF, and QIF models throughout your processes. LM is also asking suppliers to request support for emerging standards like QIF and MTConnect from their capital equipment and software Suppliers. Demands for support of these emerging standards will help accelerate their proliferation throughout industry.
Is MBE able to support efforts surrounding In-Service Support activities and focusing on predictive maintenance rather than preventive maintenance?	Yes - MBE enables concepts like the Digital Thread and Digital Twins - two very powerful concepts that can change the way we sustain our products!
Are there special requirements to be certified as an MBE Supplier?	Some Lockheed Martin Business Areas require that Model-Based Suppliers pass an assessment and a process demonstration. The assessment consists of questions regarding procedures, audit plans, sub-tier supplier control etc. The process demonstration aspect requires the supplier to process a STEP file and verify values regarding the center of mass positioning, volume, and surface area for both the STEP and machine files. (RMS-CAM)

FAQs will be added over time as they are gathered from the supply base. If you have a question about LM's transition to MBE not listed here, please contact your Buyer, Subcontract Manager, or Subcontract Program Manager. They can engage the LM MBE Supply Chain Strategy Team as needed.