Project Planning Document
Call for White Papers

DMDII-15-11
Completing the Model-Based Definition

Project Call Release Date: 21 October 2015

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1 Record of Change

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<td>Ver 1.1</td>
<td>21-Oct-2015</td>
<td>2.2 &amp; 2.3</td>
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2 Summary

2.1 Purpose
Digital Manufacturing and Design Innovation Institute (DMDII) Project Calls are issued to address research and development needs in digital design and manufacturing technology that are aligned with the technical objectives of the DMDII (also referred to as the Institute). This Project Planning Document (PPD) is a description of a specific technology objective. A separate document, the Proposal Preparation Kit (PPK), offers detailed instructions on the White Paper and Cost Proposal organization, format and submission instructions. The PPK can be found at [http://dmdii.org](http://dmdii.org).

2.2 Key Dates

<table>
<thead>
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<tr>
<td>Call for White Papers released</td>
<td>16-Jul-2015</td>
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<tr>
<td>Workshop</td>
<td>10-Sep-2015</td>
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<td>White Papers due</td>
<td>28-Oct-2015</td>
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<tr>
<td>Selection / Cost Proposal solicitations released</td>
<td>12-Nov-2015</td>
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<td>Cost Proposals due</td>
<td>Est. 17-Dec-2015</td>
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<td>Project kickoff meetings</td>
<td>Est. 17-Feb-2016</td>
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2.3 Submission Information
White Paper submissions in response to Project Call DMDII-15-11 are due no later than 12:00PM Central Time, October 28, 2015. Submissions should be made electronically to [DMDII@uilabs.org](mailto:DMDII@uilabs.org). Please include the Project Call designation (e.g., “DMDII-15-<xx> – <Project Call Title> - <Offeror Name> - WP”) in the subject line of the email.

2.4 Project Summary
Current industrial implementations of Model-Based Definition (MBD) primarily deal with product geometry, and limited metadata. The use of MBD in manufacturing has been limited compared to its use in design. Moreover, MBD is inherently dependent upon the software application that authors use to create the model. These software applications may or may not be accessible/affordable by small/medium enterprises. All three of these issues need to be addressed in order to support a seamless digital thread throughout the entire product life cycle.

In order to enable additional consumers of information among the stakeholders in the product life cycle,
the MBD must address not only shape information, but behavior and life cycle context information as well. This includes such information related to requirements, materials, analysis, manufacturing processes, and operations. MBD should also include process data and the variable as-built data created during the manufacturing life cycle. MBD used throughout the product lifecycle has the potential to reduce cost, increase quality, and enable better (and more accurate) communication within the supply chain and during operation/maintenance efforts. Inclusion of semantic Product Manufacturing Information (PMI), i.e. “smart” PMI, will allow for the extension of an unbroken digital thread from function requirements through the as-built record. Model-Based Definition is fundamental to the digital thread, a critical communication conduit for the product life cycle.

Companies spend billions of dollars dealing with inadequate data exchange and interoperability. Too much time and money is spent on non-value added cost avoidance, mitigation activities (i.e., repairing data), translators, and other human-in-the-loop tasks. The lost opportunity costs are staggering. There is significant need for software application independent product model definition for defining assemblies, parts, attributes, and manufacturing information (e.g. PMI) that is ingestible by various software (in a heterogeneous software environment) for CAD design, analysis, fabrication, assembly, test, sustainment, i.e., the whole product life cycle.

3 Requirements

3.1 General Requirements

DMDII’s primary goal is to apply digital manufacturing technologies to solve business problems. To this end, successful proposers must demonstrate an understanding of both the business needs as well as the technology solutions. White Papers should provide a crystal clear explanation of the problems that are to be solved, and how the project success will benefit the manufacturing organizations.

DMDII is interested in supporting projects that offer a significant advancement over state-of-the-art. Successful White Papers will clearly explain the present state of the technology as well as the desired future state of the technology. This technology advance must create a clear business benefit. White Papers should explain the business benefit that is being created in the project. They should also explain the metrics to be used – both technical and business – that can measure project success.

If the proposed project were to be successful and eventually implemented at scale, it should have the potential to impact the manufacturing competitiveness of the United States. Projects that demonstrate benefits to small manufacturing businesses are particularly encouraged.

Each White Paper is evaluated by a specific set of criteria. The PPK defines a general list of project call evaluation criteria, all of which are applicable to this project call.
<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
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<tr>
<td>Problem Statement and DMDII Relevance</td>
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<td>Methodology</td>
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<td>Innovation</td>
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<td>Program Management Plan</td>
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<td>Technology Transition and Impact to Industrial Base</td>
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<td>Workforce Development and Education</td>
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<td>Cost Factors</td>
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<td>Total Points Possible</td>
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### 3.2 Problem Background

There has been a near continuous attempt to accomplish true interoperability for industries from a variety of application domains for nearly 30 years. It started with the definition of an IGES subset for specific applications, continued into the development of STEP application protocols for product/system structures, plant configurations, molded forms, and arrangements. The efforts for MBD standards development have mostly been limited to objects that define mechanical parts and assemblies and are used during a narrow part of the life cycle. Further, these past efforts have not led to a universally adopted standard for parts for mechanical CAD models. A taxonomy and framework is also needed, including schemas for various levels of complexity (i.e., mechanical vs. electrical, and from components/subassembly/system levels) and various life cycle stages. Metadata formats and linkages to other data systems to reuse and repurpose the product data are critical for long-term archival and retrieval.

This situation has emerged primarily due to choices made when capturing the geometric definition of the object. Most companies today use some form of 3D CAD tools, which have their own proprietary data formats. While these proprietary formats do well at capturing shape definition, once a user has encoded their part model into that format, it is nearly impossible to disseminate that model to others who may use a different CAD tool to try to import the model and use it with confidence that no data was lost. As such, much time is spent, and many errors are propagated when trying to overcome data format incompatibilities.

Neutral format standards have been under development to handle this type of data for four decades, yet implementation remains limited to geometry and predominately mechanical component applications. Proposing new standards will not solve the problem, but enhancing current standards with manufacturing information and propagating them through the software throughout the life cycle could be part of the overall solution.

Standardization of the digital product definition has been difficult to achieve through open market collaboration and is a critical first step that can be built on top of some existing frameworks; however, completing the Model-Based Definition requires more than accurate and transferable geometry. Including other functional characteristics into the MBD can provide a technical data set that allows for more
complete documentation of the component design DNA. This may include specific design calculations that confirm a factor of safety for static or cyclic loading, and may also include development testing requirements that were applied to the final design to confirm compliance with a critical functional requirement. A technical data package (TDP) is needed to provide detail on specific design activities that are undertaken to insure that designed components meet requirements. This provides more transparency to upstream engineers to confirm the design as well as to estimate the impacts of the actual as-designed (not just as-specified) component on system performance.

For long-life systems, the design intent that is embedded in components is often lost. When manufacturing capabilities change, or materials or processes become obsolete, it is very difficult to reverse engineer the complete original intent of the design. This is exacerbated by the fact that many of the original flow down requirements generated by the systems engineering process are also lost. Embedding the functional requirements as well as the design compliance measures is a critical element for the MBD. The other aspects of the data elements not within scope of the TDP including product manufacturing information (PMI), analysis data, operation/maintenance, and logistic data would also be beneficial to providing MBD for long life products. Insertion of semantic PMI into the MBD would extend the digital thread through manufacturing as it should be at the assembly and installation level and not just for GD&T at the component level. PMI should be consumed into the Bill of Process with all PMI fully accounted for and should be able to be used to automatically generate standard manufacturing plans and be passed through to shop floor equipment and then collection of the as-built data from the equipment and storage into the PLM. This automation would reduce errors and aid in cost and schedule. This would be applicable across multiple industry sectors given that nearly every complex system such as, automobiles, aircraft, ships, and most other vehicle or energy systems requires shape, behavioral, and contextual definitions to create, produce and support it. Identifying and connecting data along the stages of the life cycle will create efficiencies, especially when connected via the Digital Manufacturing Commons (DMC). While engineering drawings have traditionally contained the product manufacturing and inspection information, robust digital product definition is needed to facilitate rapid prototyping, reduce overall product development time and reduce cost. Optimizing the digital thread will enable additive manufacturing (3D printing) to be used not only for prototyping but for delivering products which are sustainable.

In summary, product life cycle stages requiring attention are quite broad, but include at a minimum: 1. Detail Design; 2. Analysis for Producibility and Affordability; and 3. Manufacturing and Assembly Integration. There is also a need to expand focus beyond mechanical systems into electrical systems, routed systems and other functional systems. In addition to new products, there is also need to address older products that do not have 3D CAD models and the approaches that will mitigate this problem. This will require reverse engineering CAD products and adding MBD functionality. Future project calls will address the broad scope of MBD to the total product lifecycle requirements and integration concerns from piece parts to assembly to full product.

### 3.3 Specific Requirements

DMDII is seeking project White Papers to demonstrate Model-Based Definition (MBD) as the key to gathering, organizing and managing product/process data within the Digital Thread. The Offeror should
demonstrate information flow along the Digital Thread including one or more life cycle stages such as, design to manufacturing. This project call will focus on seamless flow of the MBD information characterized by a heterogeneous software application environment and sufficient information content to accomplish life cycle activities. Potential life cycle activities for this project call should focus on enabling the Digital Thread in these areas:

- MBD for Detail Design
- Manufacturability & Affordability Analysis
- Design to Manufacturing

White Papers should describe one or more industry scenario or opportunities that can be addressed through the use of product data for the various lifecycle activities described above. White Papers should describe a specific product(s), process(es) or system(s) that can impact one or more lifecycle stages and demonstrate improvement through the development of the proposed technology.

**Example Scenario:** Seamless flow of MBD information from design to manufacturability analysis with feedback for design changes to optimize manufacturing operations in a tool agnostic/heterogeneous application environment.

The proposed technology should be demonstrated on at least one scenario that has the potential for a broad-based impact to industry. The demonstration must be realized in an industry-relevant in a virtual and or physical test bed and quantitatively assessed using both technical and business criteria.

DMDII expects that successful projects will create knowledge and specific technical products that can be used broadly by the members of DMDII. This knowledge and specific technical products should create a business benefit for the broad membership of DMDII. White Papers should clearly explain what knowledge is being created, the specific technical products to be delivered, and what is the corresponding business benefit that will accrue to the members of DMDII.

DMDII encourages the participation of small manufacturing businesses on project teams, and especially encourages the development of technologies that can benefit these small manufacturing businesses. Small businesses can provide an excellent test bed for digital manufacturing technologies. Furthermore, technical solutions that can be disseminated across many small businesses have the potential for broad-based impact for the DMDII membership as well as the United States industrial base.

DMDII is interested in projects that significantly exceed current state-of-the-art solutions and capabilities, as assessed on a global-scale, with the long-range prospect of developing and maintaining U.S. leadership in the field. Proposed projects that describe incremental advances will be considered nonresponsive.

Offerors shall identify the project deliverables. White Papers should also explain how the deliverables will benefit the DMDII Membership and how those benefits will be realized.

**Travel:** At a minimum, White Papers should include funding for two trips per year for two people. These trips may be for travel to UI LABS or to another location at the request of DMDII (e.g. a conference, workshop,
4 Period of Performance
The Period of Performance may range between 12-24 months.

5 Award Information
The DMDII anticipates awarding up to $2,000,000 total to fund two to four projects under Project Call DMDII-15-11. This $2,000,000 is a target total award amount for this Project Call not inclusive of expected cost share commitments. Final award amounts will be adjusted accordingly based on White Papers received and subsequent evaluations. This project requires a minimum 1-to-1 Cost Share in aggregate by each Offeror team.

6 Team Composition
The proposing teams may be led by either industry or academia. DMDII strongly encourages the participation of small businesses. Regardless of the specific team composition, the proposed project must have meaningful participation from industry. Additionally, the requirement of at least 1-to-1 Cost Share does not need to match the individual contributions of each team member. Only the aggregate cost share value across the entire proposal team needs to meet or surpass the requested funding amount from DMDII.

To facilitate the formation of project teams, DMDII encourages manufacturing businesses, manufacturing services providers, and academic institutions to register their capabilities and interests on an online survey at https://www.surveymonkey.com/r/FGM5ZXD. This survey is also accessible from the DMDII Projects website page. Interested parties are requested to complete this survey by August 8, 2015. DMDII will provide a summary of the collected information via email one week after the requested completion date to all individuals who provide input. Survey completion is not required to submit a proposal to this project call.

Please note that answers to questions submitted to DMDII@uilabs.org will be posted on the DMDII webpage. Individuals interested in received updates related to this project call (e.g., PPD amendments, PPK amendments, Q&A postings, etc.) should submit their email address on the DMDII Projects webpage. Additional information regarding DMDII can be found at http://dmdii.org.

7 Workshop
In order to facilitate a common understanding of this technology and digital manufacturing in general, the DMDII will host a Project Call workshop in Chicago, IL on September 10, 2015. This event will allow participants to familiarize themselves with the DMDII mission, gather information on current state of the technology, and prepare for teaming arrangements. Attendees will hear from the DMDII leadership about our mission, vision, and goals, as well as how to do business with the Institute.

Attendees will have the opportunity to interact with the members of the Advanced Manufacturing Enterprise (AME) technology thrust team and learn more about the project objectives and requirements. There will also be opportunity for Offerors to discuss their technology development ideas, their suitability
for the project, and partnering arrangements. Membership in the DMDII consortium is not required to attend this workshop. Information on workshop attendance is available at http://dmdii.org.