



E-Standards For Mass Properties Engineering

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Abstract

A proposal is put forth to promote the concept of a Society of Allied Weight Engineers developed voluntary consensus standard for mass properties engineering. This standard would be an e-standard, and would encompass data, data manipulation, and reporting functionality. The standard would be implemented via an open-source SAWE distribution site with full SAWE member body access. Engineering societies and global standards initiatives are progressing toward modern engineering standards, which become functioning deliverable data sets. These data sets, if properly standardized, will integrate easily between supplier and customer enabling technically precise mass properties data exchange. The concepts of object-oriented programming support all of these requirements, and the use of a Java™ based open-source development initiative is proposed. Results are reported for activity sponsored by the NASA Langley Research Center Innovation Institute to scope out requirements for developing a mass properties engineering e-standard. An initial software distribution is proposed. Upon completion, an open-source application programming interface will be available to SAWE members for the development of more specific programming requirements that are tailored to company and project requirements. A fully functioning application programming interface will permit code extension via company proprietary techniques, as well as through continued open-source initiatives.

Abbreviations

| | |
|------|---------------------------------------|
| AIA | Aerospace Industries Association |
| ANSI | American National Standards Institute |
| API | Application Programming Interface |
| CAD | Computer Aided Design |
| CAE | Computer Aided Engineering |
| MPE | Mass Properties Engineering |
| MPEX | Mass Properties data EXchange |
| NIST | National Institute of STandards |
| OMB | Office of Management and Budget |
| OOP | Object-Oriented programming |
| RP | Recommended Practice |
| SAWE | Society of Allied Weight Engineers |

SMC Space and Missile systems Center, U.S. Air Force
VCS Voluntary Consensus Standard

Introduction

Standards are required for quality certification and efficient development of engineered products. In the current global aerospace transportation sector, efficient global standards are required so that companies, such as those that manufacture large commercial aircraft, can utilize a highly distributed supplier base yet still obtain certified quality components for their final integration and product distribution tasks. The more efficient these communications are, at a highly technical level, the less rework and redefinition of tasking is required to arrive at the agreed-upon solicited component.

Several factors that are related to standards development, Society of Allied Weight Engineers (SAWE) recommended practice development, and greater technical content control in transportation system acquisition have, in the author's opinion, converged and formed the backbone for this paper. In the United States, acquisition processes for large government product development programs were greatly modified by the National Technology Transfer and Advancement Act of 1995 and its implementation through the Office of Management and Budget circular, OMB A-119. Finkleman [1] explains this history and notes how the opportunity and burden for developing standards is left to voluntary consensus standards (VCS) organizations, such as professional engineering societies. Cerro and Fleck [2] describe impacts of acquisition reform on SAWE and mass properties engineering (MPE). This impact has been discussed at International Meetings of the SAWE's Government/Industry Committee since the mid 1990's. The SAWE was given control of U.S. Military mass-properties related specification/standard/ handbook documents in the ground, marine, and aerospace transportation sectors and has since maintained these documents as SAWE recommended practices. The SAWE has also successfully created new MPE recommended practices, particularly for marine and aerospace systems [3]. The process is slow and not without significant investment of a society member's personal time due to the placing of unfunded goals on employing organizations that struggle to devote dollars and personnel time to the task [4]. It is the purpose of this paper to further document the goals of developing a mass properties engineering e-standard as introduced in [2]. Through open-source software-development practices, promotion of this project may encourage greater industry and government-funded participation by providing a useful product for the management and control of mass properties information throughout a products entire lifecycle.

In regards to SAWE recommended practice development efforts that have followed acquisition reform, Table 1 shows a proposed document hierarchy that is currently being discussed by the SAWE Government/Industry committee. Of primary importance to note here is the hierarchical document structure. The top level recommended practice discusses mass properties control and management and describes document content flow

down to lower tier documents. There is a second tier for each transportation sector — marine, aerospace, and ground. Organizations of product and process requirements are shown within the hierarchy. If a document is created with content meant to apply to all military aircraft, it would logically be created under the Aerospace-Military Aircraft (A-MA) hierarchical level. Complications will undoubtedly occur within this simplistic document structure, but on the whole such a structure adequately defines the areas of SAWE recommended practice activities and their interdependence. This hierarchical document relationship, the commonality of data, and the inheritance of information from a higher level to form the basis of extended information at a child level is analogous a primary concept of object-oriented programming (OOP). Object instantiation and extensibility are the basic concepts that enable code sharing and reusability. The purpose of this paper is to provide a possible path, through open-source software-development activities, which SAWE members may implement and extend to suit their particular requirements.

Greater technical content control in government acquisition programs is noted in [5] as a requirement for future products that are developed by the U.S. Air Force Space and Missile systems Center (SMC). Many SAWE members contributed to a task intended to reinvigorate the technical rigor of MPE, that is the re-establishment of best practices for MPE. Aerospace Corporation [6] and the American Institute for Aeronautics and Astronautics [7] led document development efforts associated with this task. The SAWE Journal article [2] concerning e-standards for MPE data is intended to supplement initiatives of this nature by proposing a detailed technical data format, extending its utility through the VCS development process, and adding data manipulation functionality [8]. Reinforcement and extension to the ideas introduced in [2] are provided in this paper.

In addition to the three converging forces already mentioned—VCS standards development initiatives, SAWE Recommended Practice developments, and goals for greater technical content control for product-development programs, a fourth initiative will be discussed in this paper. This initiative is the application of a NASA Langley Research Center activity to stimulate innovative ideas for the development of an open-source e-standard for MPE.

Table 1 Proposed SAWE recommended practice document hierarchy

| Document Hierarchy | Description |
|---------------------------|--|
| FRP 1.0 | SAWE Functional Recommended Practice “Mass Properties Control and Management for Commercial & Military Vehicle Systems“ |
| Category A | Aerospace Vehicle mass properties engineering |
| RP 1 | Requirements for Aircraft On-Board Weight and Balance System |
| RP 6 | Standard Coordinate Systems for Reporting the Mass Properties of Flight Vehicles |
| RP 11 | Mass Properties Control for Space Vehicles |
| RP 16 | Measurement of Missile and Spacecraft Mass Properties |
| Category A-MA | Military Aircraft |
| RP 7 | Mass Properties Management and Control For Military Aircraft |
| RP 8 | Weight and Balance Data Reporting Forms for Aircraft (including Rotorcraft) |
| RP A-MA-1 | example of a new RP |
| Category A-CA | Civilian Transport Aircraft |
| Category A-GA | General Aviation Aircraft |
| RP A-GA-1 | example of a new RP |
| Category A-RA | Rotary Wing Aircraft |
| Category A-ML | Missiles and Launch Vehicles |
| RP 9 | Weight and Balance Control System for Guided Missiles and Space Launch Vehicles |
| RP 10 | Weight and Balance Data Reporting Forms for Guided Missiles and Space Launch Vehicles |
| Category A-SV | Space Vehicles |
| Category M | Marine Vehicle mass properties engineering |
| RP 13 | Standard Coordinate System for Reporting Mass Properties of Surface Ships and Submarines |
| RP 14 | Weight Estimating and Margin Manual For Marine Vehicles |
| RP 15 | Vendor Weight Control for the Marine Industry |
| Category M-SUR | Surface Ship mass properties engineering |
| RP 12 | Weight Control Technical Requirements For Surface Ships |
| RP M-SUR-1 | example of a new RP |
| Category M-SUB | for Submarine mass properties engineering |
| RP M-SUB-1 | example of a new RP |
| Category G | Ground Vehicle mass properties engineering |
| RP-5 | Mass Properties Control System for Wheeled and Tracked Vehicles |

Innovation Institute Initiatives

The Aerospace Industries Association (AIA) [9], and the International Council on Systems Engineering (INCOSE) [10], have taken strong positions on the future need for representing data as e-standards in the growing global product-development environment.

This author has chosen to combine the goals of SAWE with the goals of an activity sponsored by the NASA Langley Research Center to promote e-standards for SAWE. Standards work collaboration between industry and the U.S. government is supported generically through U.S. Government encouragement of employees to work with industry and professional societies to create voluntary consensus standards through guidance provided under OMB Circular A-119, “Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities.” This paper will serve as an additional call to the community of mass properties engineers to assist in the development of e-standards for SAWE.

In February of 2007 the NASA Langley Research Center Innovation Institute solicited employees to propose innovative solutions to current aerospace product-development problems. Funded solicitations provided for 5 percent of an employees time, and \$5000 in acquisition money, to encourage development of a proposed idea. This funding mechanism complements NASA’s goals in working with professional societies and provides resources that are not available through typical project funding mechanisms. Industry based project funding limitations for standards activities are also noted in [4].

Existing Resources

The field of MPE is well developed and has a good history of data and process requirements from which to work. The current government acquisition environment and modern additional best practices in areas such as total quality and lean manufacturing require that existing practices be efficient and, to the extent possible, quantifiable. Existing SAWE products and processes can be incorporated into an e-standard to support these evolving goals of cost-, schedule-, and quality-conscious program management.

Commercial software tool vendors and analysis service providers already participate in SAWE standards initiatives. In 1996 Fleck [11] defined an open format ASCII file standard called MPEX. Current documentation is provided in Reference [12]. That proposal is encouraged by this paper where MPEX, is taken herein to represent all MPE data which must be defined and processed by an MPE e-standard. Later it will be noted that other stakeholders of the mass properties discipline may wish to push back on this choice. That is why a well defined standard was chosen, so that an initial standard to push back against is provided.

After the format for data storage is defined, data processing is the second major defining capability for an e-standard. The most basic set of data manipulation operations performed on mass properties data are well defined in [8]. Nakai [8] also went as far as to develop a Java application, called MassCalc, to perform the MPE data processing. MassCalc is a Lockheed Martin proprietary product and is distributable in executable form only and to U.S. citizens only. For an open-source e-standard to be developed, a more transparent development environment is required. The major goal of this paper is to define an open-source mechanism that can be used to unite the capabilities of MassCalc

and MPEX into an evolving SAWE MPE e-standard. The data processing that is defined in [8] and performed by MassCalc is targeted for duplication in this open software environment. The developed software must also be extensible to allow continuing contributions by parties of multiple product sectors, and by specialists at different phases of product life-cycle development. The major MPE data manipulation operations implemented by Nakai listed in Table 2 identify baseline functionality that should be incorporated into an e-standard. Readers are encouraged to review [8] to investigate the full capabilities of MassCalc, which includes Java objects for user interface and data containment as well as the computational object classes. If MassCalc and MPEX are combined into an extensible set of Java Classes, the integration becomes the basis for an Application Programming Interface (API) for mass properties engineering.

Table 2 - Computational Object Class descriptions from [8]

| Computational Object Class | Description |
|-----------------------------|--|
| CMassProp | Used to contain and manipulate mass properties data. |
| CVector | Used to model points or vectors, and supports interpretation in rectangular, cylindrical, or spherical coordinates. It also supports all vector operations. |
| CIertia | A compact inertia class, which contains six scalar elements Ixx, Iyy, Izz, Ixy, Iyz, and Izx. |
| CTensor | Defines a 3-by-3 tensor object suitable for holding inertia or other 3 by 3 tensor data and performing coordinate transformations, principal inertia computations, and principal axis determination |
| CComplex | A general-purpose complex number class, which goes beyond most standard complex number implementations in that, it accommodates tracking of branch cuts and the Riemann plane on which its numbers reside. |
| CCoordSystem | Used to hold fundamental coordinate system definitions. |
| CCoordTransform | Used to hold coordinate transformations from one coordinate system to another. |
| COrientSpecCoordinateSystem | Derived from the CCoordSystem class to store added attributes, which are not needed for the basic coordinate system definition, but reflect the input parameters used to create the coordinate system definition |
| CPart | Models a detailed part (indivisible part). |
| CAssembly | Derived from the CPart class, and is designed to model assemblies of other parts and subassemblies. |

Another feature of a useful MPE API is the ability to present mass properties data as necessary to meet program reporting requirements. The SAWE recommended practices 5,

8, 10, and 12 define traditional reporting formats [3]. Additional MPE product definition covering the full program life-cycle is given by Belt [13]. The reader is referred to Appendix A of [13] for a matrix summary view of tasks and deliverables which can occur throughout all phases of a product lifecycle in the discipline of mass properties. All of these products could be supported through functionality to be defined as part of an MPE e-standard. Less general functions, reports, and company proprietary methods can be developed from child classes or abstract class instantiation of the more general parent classes. It is hoped that by utilizing an open-source code development methodology an SAWE e-standard will evolve to support a large number of products, vendors and customers across the three transportation sectors. Code reusability and object inheritance are expected to add great utility to this development.

More should be said about the choice of MPEX and Java as the tools proposed for an e-standard activity. Designers and engineers are familiar with the STEP¹ neutral file data exchange format and may think it would be an appropriate framework for MPE data. The U.S. National Institute of Standards and Technology (NIST), has for many years been a promoter of procedures to enable concurrent engineering and efficient engineering practices, linking process and data activities in engineering. NIST reference document, “STEP the Grand Experience” [14] states:

NIST has taken a lead position in developing STEP because of its historical mission to promote U.S. economic growth. NIST has done its best by working with industry to develop and apply technology, measurements, and standards. Specifically in the last few years, the NIST laboratories have increased their efforts to address the 2 infrastructural needs of the information technology and manufacturing industries. STEP is an ideal example of a set of standards that integrates both industries. NIST recognizes that developing standards such as STEP must be accomplished in the international arena because of the ever-increasing worldwide economic dependencies.

Reference [14] also promotes utilization of the Java programming language

“The future of STEP on the Internet depends on our ability to define an effective integration of STEP and Java ... Java is a key to the popularization of STEP. There are currently over 400,000 practicing Java programmers who are

¹ STEP is a synonym for all aspects of the international project developing: the technology of product data representation, the methodology for creating the standards for information models, and the standards themselves. Some authors use STEP as an acronym for STandard for the Exchange of Product data, but the purpose of the standard is to provide information models for the representation of product data. The exchange of data is only one of the uses for a standardized representation.

producing new Internet applications at an amazing rate. The Java programming environment promises to provide even greater programming productivity.”

As a result of the existing work detailed in [8] and the strong endorsement in the area of product data management for Java by NIST in [14] the decision was made to use Java as the programming language for integrating the work of [11],[8]and [13] into this initial e-standard. Following conversations with Kemmerer [14], Deputy Chief of the Manufacturing Systems Integration Division at NIST, and NASA/STEP office representative S. C. Waterbury (NASA Goddard Space Flight Center) it was determined that STEP itself does not support the broader data requirements as currently defined in MPEX. The NASA/STEP office could assist in programming efforts with this e-standard activity provided they were funded to do so. That initiative if kicked off would focus on e-standard support for AIAA S-120-2006 “Mass Properties Control for Space Systems”. NASA/STEP office programming support was sought for mapping data between STEP and MPEX, but no such support could be provided in the short term. It was estimated that six man months of effort would be required to complete initial data mapping capabilities. The data set features specific to MPEX are listed in Table 3 - MPEX Data Set Descriptions as excerpted from [12].

Table 3 - MPEX Data Set Descriptions

| MPEX Data Set | Description | Initial Java Class Created ? |
|----------------------|---|-------------------------------------|
| Description | describes the source of the data, providing its description and the path and catalog file for the source database | yes |
| Units | used to specify the units of mass, length and/or delta time | yes |
| Change Case | used to specify whether the MPEX translator should change the case of the text given in the data file | no |
| Weight Status | used to compute a weight margin based on the defined factor. It is the field used for weight maturity reporting. | yes |
| Uncertainties | provides a list of uncertainty factors uniquely identified by their description. The uncertainty values can be assigned to the lowest level entries (parts) by the associated description. The link status indicates whether the uncertainty values are linked to the corresponding weight status with the same description | yes |
| Materials | used to define the material types and their associated densities | yes |
| Add Fields | used to add fields to those that are predefined by any particular data set | yes |
| Class Categories | used to give extended descriptions for the categories in the case where the original data given in the | yes |

| | | |
|----------------------------------|---|-----|
| | referencing data set (e.g. ENTRIES) uses cryptic abbreviations. This feature was implemented to support converting flat file data that references numeric codes or abbreviations to identify specific categories of information to relational databases | |
| Factors | The MPEX format supports factor fields through the use of the ADD FIELDS data set. Each factor field is uniquely identified by its description. Each factor field has independently defined factors | no |
| Standard Parts | used to specify entries that are standard parts | no |
| Assemblies Coordinate Systems | used for defining drawing tree type assembly breakdowns when entry mass properties are given in different coordinate systems | yes |
| Entries | The ENTRIES is the primary data set that defines the bulk of the data. In many cases, it may be the only data set in a MPEX file. This data set brings together all the data typically defined for a mass properties database. It supports hierarchical relationships being defined for the entries with indentation as the default relationship method | yes |
| Items | The ITEMS data set uses the group relationship support of the MPEX format to define the details that make up a part. | yes |
| Weight Changes | uses the group relationship support of the MPEX format to define the weight change history for a given part | no |
| Notes | uses the standard MPEX format to describe the notes associated with a given entry record. | no |

Innovation Institute Focused Work

Initial work under the Innovation Institute activity included defining the necessary integrations of, and soliciting support from the principal parties involved in [8] and [11]. With these necessary resources a best-in-class set of products could be integrated into a functional API. The NASA supplied \$5000 procurement funding was used as a small enticement to inspire industry toward providing support. Larger than the immediate financial incentive is the fact that a great deal of influence on the functionality of the e-standard could be provided by responsible vendors. The desire to use this process in an American National Standards Institute (ANSI) “Open Standards” development environment also inspired the notion of soliciting support through an international outlet for mass

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Funding for E-Standards - Seed Project Bucks available

[view](#) [edit](#)

Submitted by [Jeffrey Cerro](#) on Wed, 2007-03-14 21:17.

The NASA Langley Research Center Innovative Institute has awarded small grants to NASA researchers for development of, guess what... Innovations. If you are interested in pursuing the concept of combining Object Oriented Programming, E-Standards, and Mass Properties simulation objects please [email here](#) to find out more. Several grants on the order of \$1000 to \$2000 each are available. Please respond by 4/16/2007.

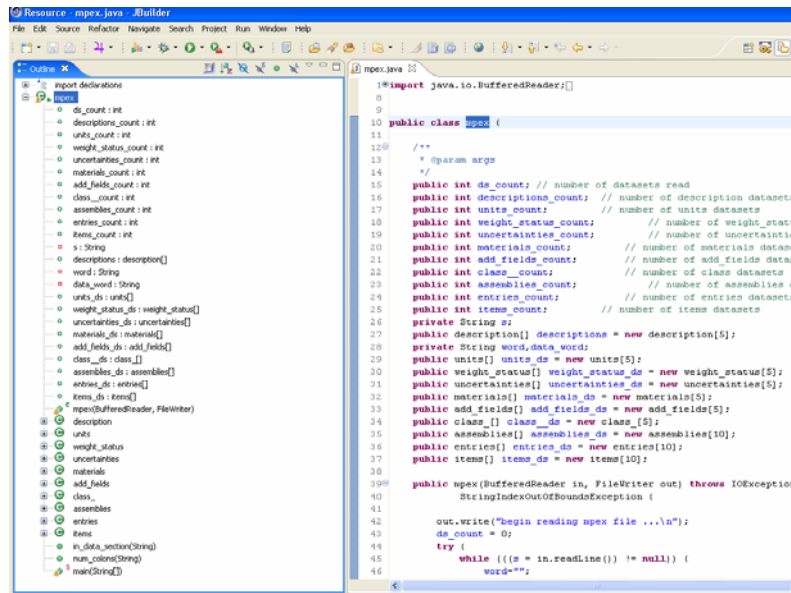
Figure 1 SAWE e-standards Solicitation for Support

properties engineering activities, the SAWE website, www.sawe.org. Figure 1 shows a

posting placed on the SAWE web site to solicit for national and international participation from governments, industry, service companies, and academia. Additional exposure of this solicitation at the SAWE 66th International Conference held in Madrid, Spain, in May of 2007 also sparked some supplier interest. One German analysis software and services provider (IndustrieHansa Consulting and Engineering) was interested in helping, and one U.S. American Aerospace Manufacturer (Northrop Grumman) showed initial interest.

In coordination with NASA Langley Research Center procurement regulations, the services of these and other companies were formally sought. Because of the amount of money involved, the selection had to be bid. Sole-source justification was not necessary or even appropriate for implementation of an open process. Appendix 1 is a copy of the Statement of Work that was used to solicit industry input to the creation a mass properties e-standard and to scope out requirements for a Java based API. IndustrieHansa Consulting and Engineering GmbH was eventually awarded the contract and currently is in the process of fulfilling deliverable requirements. As this is a small amount of money it was used only to formally determine industry opinion on the utility of creating this e-standard, the applicability of MPEX in association with Java, and also to provide a mechanism for vendors to present their own techniques to NASA and the SAWE. A final report from IndustrieHansa is expected prior to this year's SAWE International Convention, May 2008.

A small amount of initial Java coding was performed using the remainder of the Innovation Institute's 5 percent allocated non-project-funded hours. This coding involved the creation of a Java MPEX Class, and of a program to parse an MPEX file and store the information in the MPEX Class Hierarchy. Table 3 indicates those MPEX data sets that have been incorporated into the class structure. Program variables are shown in Figure 2.



```
1 import java.io.BufferedReader;
2
3
4
5
6
7
8
9
10 public class mpeX {
11
12     /**
13      * @param args
14      */
15     public int ds_count; // number of datasets read
16     public int descriptions_count; // number of description datasets
17     public int units_count; // number of units datasets
18     public int weight_status_count; // number of weight_status
19     public int uncertainty_count; // number of uncertainties
20     public int materials_count; // number of materials dataset
21     public int add_fields_count; // number of add_fields dataset
22     public int class_count; // number of class datasets
23     public int assemblies_count; // number of assemblies ds
24     public int entries_count; // number of entries datasets
25     public int items_count; // number of items datasets
26
27     private String s;
28     public description[] descriptions = new description[5];
29     private String word,data,word;
30     public units[] units_ds = new units[5];
31     public weight_status[] weight_status_ds = new weight_status[5];
32     public uncertainty[] uncertainty_ds = new uncertainty[5];
33     public materials[] materials_ds = new materials[5];
34     public add_fields[] add_fields_ds = new add_fields[5];
35     public class[] class_ds = new class[5];
36     public assemblies[] assemblies_ds = new assemblies[10];
37     public entries[] entries_ds = new entries[10];
38     public items[] items_ds = new items[10];
39
40     public mpeX(BufferedReader in, FileWriter out) throws IOException,
41         StringIndexOutOfBoundsException {
42
43         out.write("begin reading mpeX file ... \n");
44         ds_count = 0;
45         try {
46             while ((s = in.readLine()) != null) {
47                 word="";
```

Figure 2 Code view of the MPEX Java class

After reading MPEX data into this class structure the data are fully available to functional manipulation as described in reference [8]. This class behaviour can be inherited by additional Java classes which would then perform reporting functions as required by SAWE recommended practices, [13], or specific project requirements. Approximately 1400 lines of code were created in this first step, and approximately 80 percent of MPEX functionality is covered. This programming effort was quite small and requires enhancement and collaboration with existing mass properties engineers and software developers to truly become practical in a commercial manufacturing organization. Note again that MPEX and thus this Java code includes items which may not be detailed in CAD, CAE, and STEP data files such as paint, fittings, wire bundles and so forth. It is meant to define product life cycle data for the mass properties engineer. An appropriate next coding step would be to add data manipulation, data interrogation and data reporting functions. Insufficient time was available to pursue these tasks under the Innovation Institute’s resource constraints. To continue development efforts, Innovative Institute reports, the results of industry participation, and the developed code should be made available for open-source collaborative development. It is proposed that further work in this area should be carried out under SAWE Government/Industry distribution control with access to data limited to the SAWE member body. NASA’s distribution requirements have been met and the initial software disclosure was made under the NASA “eNTRe” program [15]. Upon completion of the New Technology Reporting process additional information will be available from the NASA TechFinder website [16].

Summary

The suitability of creating an MPE e-standard based upon the MPEX file format and the Java programming language is investigated. The approach is current with respect to NIST and NASA/STEP goals in its objective to integrate engineering and information technology features and exploit modern product data management CAD/CAE data standardizations. The features of e-standards are discussed and an approach to implement these for an MPE e-standard is presented. The final e-standard will provide data packaging, manipulation, interrogation, and reporting. The MPE e-standard would provide a consistent data package to enable a high degree of technical content control for projects ranging from small organization internal projects, to large external acquisition programs. Participation in e-standards development will position users to efficiently integrate increasingly complex data into their own product lifecycle management environment and so support modern automated system engineering processes that are linked to computer based architecture framework implementations and simulation analyses.

The NASA Langley Research Center's Innovation Institute Initiative "Investigate and Develop E-Product Standards for Application to DDT&E Program Acquisition and Program Operational Phase Practices with Application to the Field Of Mass Properties Engineering" produced the following products:

- Initial development of an MPEX Java Class
- Exposure of the MPE e-standard initiative to an international audience:
 - at SAWE International Conference, Madrid, Spain
 - via Publication of an e-standard article in the SAWE Weight Engineering Journal
- Discussion with industry on how to support e-standard initiatives
- An awarded solicitation obtaining industry opinion on the utility of an SAWE e-standard for MPE, specifically addressing MPEX as a proposed neutral file format
- Internal NASA discussion regarding e-standards and mass properties engineering
 - with representatives of the NASA Office of the Chief Engineer and
 - the director of the NASA Standards Office, Marshall Space Flight Center

It is noted how the U.S.'s standards activity has suffered since acquisition reform and needs to be re-established. The NASA Langley Research Center's Innovation Institute provided a funding vehicle such that NASA engineers could once again support standards initiatives with direct charge accountability. Expanding this type of funding can ensure that the U.S. Government is provided an appropriate voice in the definition of newly developing international aerospace product standards.

It is proposed that the products that resulted from the Innovation Institute task be placed on an SAWE web site for further membership-based collaborative development.

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Appendix 1 - Industry Solicitation Statement of Work

Statement of Work for:
LaRC Innovation Institute Project
E-Standards for Mass Properties Engineering

Abbreviations:

| | |
|------|--|
| ANSI | American National Standards Institute |
| CAE | Computer Aided Engineering |
| ISO | International Standards Organization |
| PLM | Product Lifecycle Management |
| AIA | Aerospace Industries Association |
| SAWE | Society of Allied Weight Engineers |
| IGES | Initial Graphics Exchange Specification |
| LaRC | National Aeronautics and Space Administration, Langley Research Center |
| MPE | mass properties engineering |
| OMB | Office of Management and Budget |
| OOP | object-oriented programming |
| RP | Recommended Practice |
| STEP | STEP is a synonym for all of the aspects of the international project that is developing: the technology of product data representation, the methodology for creating the standards for information models and the standards themselves. Some authors use STEP as an acronym for STandard for the Exchange of Product data but the purpose of the standard is to provide information models for the representation of product data. The exchange of data is one of the uses for a standardized representation, but it is not the only use. |
| U.S. | United States |

Scope: This procurement is for consulting services on an LaRC Innovation Institute Project Titled: “Investigate and Develop E-Product Standards for Application to DDT&E program acquisition and program operational phase practices with application to the field of mass properties engineering”

The provider should be experienced in the fields of mass properties engineering, and object-oriented programming in Java. The contractor will be required to provide an Industry viewpoint consultation on the best ways in which NASA could implement e-standards for mass properties engineering (MPE). Knowledge of CAE/PLM/IGES capabilities can assist with providing informed guidance.

Background: SAWE, ANSI, ISO, AIA and similar global standards organizations are making the press for utilization of electronic product standards that can be applied on acquisition contracts to clarify and speed delivery of detailed engineering data. NASA as

part of the aerospace infrastructure and as a United States governmental agency participating the creation of Voluntary Consensus Standards has an interest in assuring that it has efficient processes for utilization of such electronic standards. The above societies have expressed the future need for electronic standards and their implementation on a global basis.

This procurement will be used to obtain consulting services in the fields of mass properties engineering and Java programming to study the utility of providing an Object Oriented electronic standards product to define mass properties data and processes for engineering and acquisition purposes. This moves standards from the text based mode into the virtual product definition and modeling&simulation, world. Product data as well as product functionality are defined buy such a standard. Commercial vendor activities will be supported in the spirit of satisfying U.S. OMB circular A-119 and the creation of Voluntary Consensus Standards. The process can also be made open and could be promoted through a professional engineering society as an ANSI open process standard suitable for U.S. standards and eventually ISO acceptance.

References

- [1] MPEX – E standards, Draft Article for SAWE Journal ([update](#))
- [2] G.W. Fleck: “Mass Properties Exchange Format Recommendations for a Standard”, SAWE Paper No. 2311, May 1996
- [3] G.W. Fleck; “Mass Properties Exchange Format Standardization Forum (<http://i-e-Solutions.com/mpex/>).
- [4] “STEP Overview.” [http://www.tc184-sc4.org/SC4_Open/SC4%20Legacy%20Products%20\(2001-08\)/STEP_\(10303\)/](http://www.tc184-sc4.org/SC4_Open/SC4%20Legacy%20Products%20(2001-08)/STEP_(10303)/)
- [5] “Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities”, Office of Management and Budget, CIRCULAR NO. A-119, Revised February 10, 1998.
- [6] ”United States Standards Strategy”, American National Standards Institute, 25 West 43rd Street — Fourth Floor New York, New York 10036 (<http://ansi.org/>)
- [7] “The Future of Aerospace Standardization”, Aerospace Industries Association of America, Inc. January, 2005 (http://www.aia-aerospace.org/library/reports/aerospace_standardization0105.pdf)
- [8] R. Boynton; J. Nakai, K. Wiener; G. Strom: “Standard” SAWE Mass Properties Calculation Software and Algorithms”, SAWE Paper No. 3156, May 2001.
- [9] R. Belt: “The value of mass properties engineering” (ie: data product definition throughout a projects life cycle) SAWE Paper No.3300
- [10] Jeff Cerro - Partially written Java code for MPEX processing (distribution to contract awardees only)

Objectives:

- 1) This task will provide to NASA an Industry viewpoint on the scope, data, and process requirements which should be included in creating an OOP based e-standard for MPE. Consideration will be given to SAWE's viewpoint, [1]
- 2) The MPEX data format will be reviewed and discussed in terms of how suitable it is as a neutral file exchange format. [2][3]
- 3) The provided MPEX Java software will be reviewed for comment on applicability to the overall MPE e-standard goal. [10]
- 4) Additional insight may be provided which is based upon the providers industry perspective, as well as their MPE and OOP skills.

Contractor Tasks: The focus of this procurement is to obtain industry consultation on the best way in which NASA should implement e-standards for mass properties engineering (MPE).

The Contractor Shall:

- 5) collaborate with contract technical monitor Mr. Jeffrey A. Cerro, to determine **requirements** of an MPE e-standard based upon the above 4 stated objectives.
- 6) suggest **implementation methodologies** of such a standard which would if fully developed:
 - o implements MPEX as the “universal file format” for MPE data exchange
 - o provides a Java API for
 - accessing MPEX data
 - manipulating MPE data
 - supporting MPE processes/reports etc as specified by SAWE RP's and SAWE paper 3300 [9]
 - o supports linkage to established Product Data Management, Product Lifecycle Management systems via support of STEP protocols [4].
- 7) Define possible deviations from 6) which maybe felt by the contractor to be necessary to make the proposed MPE e-standard more capable or more acceptable to the full aerospace MPE community.

Electronic (web meetings) and phone conversations may be requested at any time with the NASA POC, No travel is anticipated for this task work.

Contractor End Items:

Required deliverable: The Contractor Shall Deliver a whitepaper which describes his resolution of Contractor Tasks 5) 6) & 7). The contractor shall include in this whitepaper:

- How Java Abstraction may be utilized to create an application programming interface(API) for MPE
- An Industry viewpoint, how industry might desire to participate in creation of this “open standard”
- Review and consultation on

- how the computer code concepts and actual code defined in [8] & [10] may be improved/extended
- how the MPE manipulations defined in [8] may be made into part of this Java API,
 - i. cost estimate for stated amount of work which would be required.
- how the acquisition process and MPE products defined by SAWE RP's such as RP 8, 11, 12 or Ref. [9] could be supported by implementation of the proposed e-standard.

Optional Deliverable, The contractor may deliver:

- Example Java API class Abstraction definition if it is felt by the consultant to be prudent at this time
- Java code which performs the functions prescribed in [8].
- Java code implementation supporting an example MPE report with data drawn from an MPEX data file.

Period of Performance: Task will terminate 90 days from Authority to Proceed Date. All deliverables are due on that date.