



## Cyber Physical System based Proactive Collaborative Maintenance

### D1.2 Consolidated State-of-the-Art of Sensor-based Proactive Maintenance

#### Appendix 3:

#### Interoperability and properties of existing systems

Work Package	WP1 - Service platform architecture requirement definition. Scenarios and use cases descriptions
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## Document Revisions & Quality Assurance

Revisions:

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0.1	27/08/2015	Tom Maris	First Draft
0.2	11/09/2015	Tom Maris	Added abstract, introduction and conclusions
0.3	05/10/2015	Riku Salokangas	Added formatting issues
1.0	02/06/2015	Mikel Muxika (MGEP)	Format correction Deliverable info update

## Abstract

This appendix describes a number of existing standards and frameworks for interoperability.

PLCS describes a data-model standard for Product Life-Cycle Support. It could be considered as solution for interoperability between different (generations of) CAD, PLM, ERM, CMM tools used within a network of organizations that contribute to a cloud based proactive collaborative maintenance system.

PMML has a similar ambition to be a solution for interoperability by defining a standard for exchange of predictive models between different tools of different vendors.

IEEE Standards Coordinating Committee 20, Diagnostic and Maintenance Control Subcommittee is responsible for two standards that might be of interest. Artificial Intelligence Exchange (AI-ESTATE) and Software Interface to Maintenance Information Collection and Analysis (SIMICA).

Finally, we present a standard from the military on the Generic Vehicle Architecture. As interoperability is an important requirement within the military, this standard deals with many aspects of a vehicle's architecture. The chapter on the Health and Usage Monitoring System is of particular interest, as it describes what data needs to be collected at a minimum for exchange with a CMMS.

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# 1 Introduction

The systems landscape in the domain of cloud-based proactive collaborative maintenance is very diverse. There are the different elements that all contribute to this capability. Data-acquisition, transmission, storage, analysis, etc. Each of these elements are addressed by different vendors that offer technology with different levels of maturity. This diversity generates a real requirement for interoperability between all these different components.

In this document we attempt to collect standards, frameworks and tools that are known state-of-the-art and that might be reusable or provide a headstart in this context.

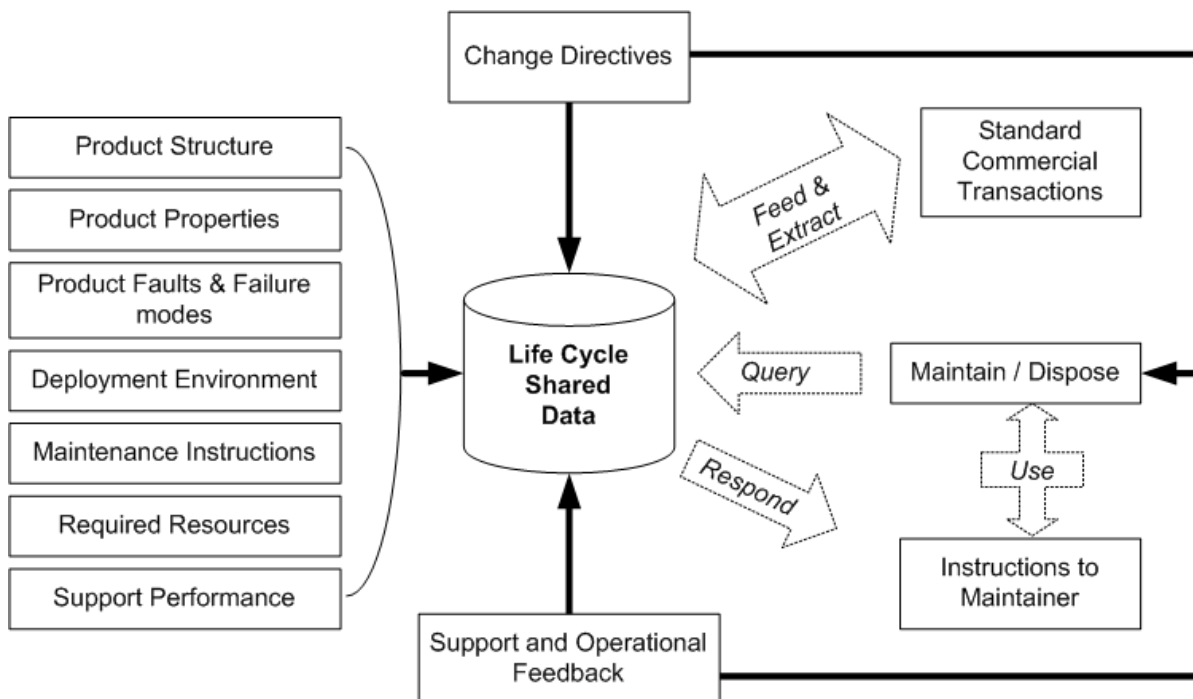
## 2 ISO 10303-239, Product Life Cycle Support (PLCS)



Companies engaged in managing complex assets through time face several information management challenges:

- Much of the data needed to deliver successful support derives from the product design and manufacturing processes, where support information requirements are rarely a primary focus
- Support activities cross many system and organizational boundaries, making it difficult to impose a "single application" solution for data collection and consolidation
- Obsolescence, upgrades and changes to the operational context can create major problems in maintaining alignment between the configuration of actual assets and that of the technical data which specifies necessary support
- Optimization of support delivery, and the operation of performance management depend crucially on the capture of adequate feedback from the in-service domain
- The significance of such feedback is often dependent on context, yet many of the relationships which provide such context - for example, the nature of the mission just completed, or the precise configuration of the asset in question - are lost when feedback is captured

The goal of PLCS was to create an internationally accepted information model - likely to remain valid for several decades - to enable open information exchanges, and necessary data consolidation to address the issues above. This goal is summarized by the figure below.



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### 3 Predictive Model Markup Language (PMML)



The **Predictive Model Markup Language (PMML)** is an XML-based file format developed by the Data Mining Group to provide a way for applications to describe and exchange models produced by data mining and machine learning algorithms.

It is the leading standard for statistical and data mining models and supported by over 20 vendors and organizations. With PMML, it is easy to develop a model on one system using one application and deploy the model on another system using another application. It supports common models such as logistic regression and feedforward neural networks.

Since PMML is an XML-based standard, the specification comes in the form of an XML schema.



## 4 AI-ESTATE and SIMICA



Also the IEEE (Institute of Electrical and Electronics Engineers) community is working on exploring standards for the Test and Diagnosis for Electronic Systems; therefore they established the **IEEE Standards Coordinating Committee 20** (IEEE-SCC20).

The Diagnostic and Maintenance Control Subcommittee responsible for the Artificial Intelligence Exchange and Service Tie to All Test Environments (AI-ESTATE) standard, the Testability and Diagnosability Characteristics and Metrics standard, and the Software Interface to Maintenance Information Collection and Analysis (SIMICA).

The common theme through all of the DMC standards is to provide formal specifications to support exchange and analysis of information in system test and diagnosis.

## 5 DEF-STD 2309, Generic Vehicle Architectur (GVA)

**Defence Standard 23-09, Generic Vehicle Architecture (GVA)** describes and defines the GVA Approach and technical design rules and standards to be applied but is not a system architecture or design in itself. It does not mandate a specific design as the system implementation will vary according to the requirements of the platform and its role.

The Def Stan does explicitly provide requirements that constrain the design of a vehicle platform. It specifies the mandatory standards to be used in the design and implementation of Land platform electronic and power infrastructures, mechanical interfaces, HMI and Health & Usage Monitoring System (HUMS), together with requirements for Interface Control Documents (ICDs) and Verification and Validation (V&V).

Sub systems are integrated into a platform through the GVA based electronic infrastructure which consists of an electronic data infrastructure and a power infrastructure, together with a set of specified mechanical mountings and connectors, and common HMI requirements. This enables data interoperability of sub systems and crew stations, and the rapid re-rolling and upgrading of vehicle platforms.

## 6 Conclusion

We have not been able to identify many standard, frameworks or tools that are considered as state-of-the-art and that might provide to be useful in this context.

Further research will be needed to determine whether this is due to the fact that there are effectively no existing solutions for interoperability, or whether this is due to the fact that they are not commonly known within the diverse but focused community of the MANTIS consortium.

## References

- [1 Mondragon University, "Wireframes Web App," 2015. [Online]. Available:  
] [http://teamsite.youris.com/sites/cityfied/WP2/WP2%20Tasks/Task%202.2/ST%202.2.2/DesignSolutionReport%20\(Spanish\).pdf](http://teamsite.youris.com/sites/cityfied/WP2/WP2%20Tasks/Task%202.2/ST%202.2.2/DesignSolutionReport%20(Spanish).pdf).
- [2 Mondragon University, "Design Solution Report," 2015. [Online]. Available:  
] <http://www.mondragon.edu>.