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Ontology and Model-based Systems Engineering

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Abstract

The subject of this paper is a framework that represents a new approach of information technology in the area of Systems Engineering. This framework enables us to specify, design, engineer, produce and maintain complex capital facilities, e.g. ships and infrastructure in an explicit and consistent way. The framework supports the needs of Systems Engineering according to ISO 15288 for unambiguous and explicit communication about such a facility between project participants, stakeholders, disciplines etc. during all life cycles by introducing an ontology for Systems Engineering. This ontology, derived from the data integration standard ISO 15926, facilitates interoperability, increases efficiency and reduces failure cost. The ontology in this paper enables model-based Systems Engineering and specifically describes a model-based approach of system breakdown structures on process level and on physical level by means of process functions, the Functional Object paradigm and a new approach of interface management by means of the port-interaction theory.
The work presented in this paper is part of ongoing PhD-work by the author carried out at Delft University of Technology in the Netherlands.

Keywords: Ontology, ISO 15926, model-based Systems Engineering, Gellish, RDF

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1. Introduction

Many experiences of the author with a number of large-scale infrastructure projects in the Netherlands show that acquirers struggle with writing an adequate project specification in such a way that it describes the needs of the client and stakeholders in an explicit, consistent and sufficiently "solution-free" way. Due to the highly fragmented nature of the industry [1] the main contractor is usually represented by a consortium formed for the occasion, existing of a combination of contractors and/or suppliers. These kinds of consortiums show a lack of enterprise interoperability which proves to be one of the major reasons for the inability to accomplish these major infrastructure projects in an adequate manner [1]. The reason for this can be traced back to the fact that in general several consortium partners are responsible for the design process, but each of them is on a different maturity level concerning data, service and processes [10], which leads to inadequate information exchange and communication. In general the total failure cost that comes with projects in the capital facility industry is approx. 15% of the capital expenditure [1]. The specification issue mentioned before, in combination with the lack of interoperability is responsible for approx. 30% of these failure costs [14]. A way to achieve more interoperability and therefore less failure costs would be to have an agreement on a common and shared set of terms and their meaning between all parties involved, including the client and stakeholders. In practice, however, each enterprise has its own "languages" and methods for processing information during e.g. design of the system. Wittgenstein has already shown us that natural language and intention are inseparable (which leads to human communication errors). He stated: "***Without a common frame of reference*** as an anchor, ***verbal chaos is a certainty*** without intellectual means to peacefully resolve conflicting differences." [12] This statement of Wittgenstein pinpoints exactly the source of the failure costs of the mentioned infrastructure projects. A common frame of reference for a certain domain or context these days is known as an ontology. ISO 15926 defines an ontology as: "A formal representation of a set of concepts within a domain and the relationships between those concepts" [5]. ISO 15288 (System life cycle processes) [4] describes "by means of a natural language on a high abstraction level a set of processes which are applicable in a wide range of applications and needs in general tailoring for a specific domain and or project." To enable the usage of the ISO 15288 in a proper way there is an urgent need to transform this standard into consistent, explicit and unambiguous process descriptions by means of a specific ontology. This is the only way to let involved parties communicate about Systems Engineering in an explicit way and will allow different ISO 15288 implementations to become interoperable and reusable.

2. Ontology for Systems Engineering

Wittgenstein said: "The world consists of a totality of interconnected atomic facts"[12]. Internet technologies like RDF [15] are also based on the principle that in the real world everything can be described by means of facts. A fact in this context always follows the same pattern: Object-Relation-Object (e.g. MyCar *is a whole for* left front wheel; MyCar *has property* length; MyCar *is owned by* Leo Jansen). A fact is: 'that which is the case', independent of language. The concept 'fact' can be used to classify things as 'being the case'. By using facts each sentence or specification can be broken down into basic statements with the consistent and simple pattern mentioned before. A fact must be accompanied