The Model Engineering for Complex System Simulation

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ABSTRACT

The model is the foundation for simulation, especially for the complex system simulation. To meet the challenges in development and management of the complex system model, this paper proposes the concept of the model engineering, which aims at setting up a systematic, normalized, and quantifiable engineering methodology by exploring basic principles in model construction, management and maintenance to manage the data, processes and organizations/people involved in the full lifecycle of a model to guarantee the credibility of model lifecycle. The meaning and contents of the model engineering are given, a set of key technologies are introduced. A preliminary framework of the body of knowledge of the model engineering is given based on software engineering, system engineering and some other relative disciplines.

Keywords: simulation, model engineering, credibility, complex system, body of knowledge

1. INTRODUCTION

A model is an abstract expression of objects to study and embodies high intelligence of human beings in recognition of the world. With continuous development of science and technologies, the model is becoming more and more important. With a model, the key elements such as semantics and context in the information, system structure, functions and behaviors can be clearly displayed to exchange and share information among different fields, areas and platforms cross the obstacles in the culture, languages and technology level. The model has become one of the key contents in the modern science system. Human being has accumulated a large number of knowledge and experiences on model construction and use during long-term science research and practices, which play important role in the respective science and technology area. With continuous growth of complexity and diversity of objects to study, the models are becoming more complicated and diversified. Research on models is the key to affect science development.

Simulation technology has rapidly grown up and becomes a new interdiscipline with the development of computer technology, and has become one essential research method and means to almost all fields of science and technology (Li and Chai, 2002). Simulation is an activity based on the model, and its main research purpose is to create a system model and carry on the scientific research and experiments. In the simulation field, the research on the model is very representative.

The correct model can guarantee correct simulation results. Verification, Validation and Accreditation (VV&A) is the primary means of the credibility of the research simulation and simulation results (Pace 2004). VV&A for the model is to calibrate or validate the established model in order to determine whether it is credible. This post determination has important implications to discover model problems and defects, but it still cannot solve the problem that how to get a correct model, Especially for complex systems, due to the complexity and uncertainty of the system, the modeling process can be very complicated, which makes VV&A of a model become extremely difficult. Even if the defects are found via VV&A, the amendment of the model will be very difficult and high-cost.

More importantly, for a complex system, to construct a correct model is only the first step since the a complex system model generally experiences a long term of evolution and management. As a result, the key issue for a complex system model is to guarantee the credibility of the full model lifecycle with minimum cost.

In the current research on model, the theories and methods are generally aims at specific objects and are random and lack necessary fundamentals and rules. Most of the research is only for a certain phase and isolated from other phases of a model lifecycle, and seldom systematically consider the full lifecycle of a model as a whole. So it leads to many problems and difficulties in model development and management and cannot guarantee credibility of the model lifecycle. This case is caused due to three main reasons, first, no generic methodology guide for model lifecycle is available; Secondly, no effective process management mechanism for model lifecycle is established; thirdly, no uniform standard and technical support is available. Therefore, it is necessary to establish model-oriented methodology system to restrain, guide and manage the model lifecycle process and guarantee correctness of the established models and credibility of the model lifecycle.

This paper aims to apply the engineering ideas and methods into the lifecycle of complex system model, get a standardized, normalized, quantified and systematic model engineering system by referring to and absorbing ideas and methods in the system engineering and software engineering, exploring, mining and summarizing ubiquitous theories, methods, technologies, standards and tools in the model related activities, serve for the model lifecycle including model construction, management, use, maintenance process, etc, and guarantee credibility of the model lifecycle.

This paper first analyzes the issues and challenges in modeling of the complex systems, then introduces existing research achievements in model development and management, gives concept and key technologies of the model engineering based on them, and proposes the body of knowledge framework of the model engineering for the complex system simulation by analyzing and arranging the software engineering, system engineering and body of knowledge in other related fields.

2. CHALLENGES IN DEVELOPMENT AND MANAGEMENT OF COMPLEX SYSTEM MODELS

No uniform definition for the complex systems is available now. The reference (Dai 1997) thinks that "a complex system features complicated composition relation, complex system mechanism, and complicated interaction relation and energy exchange between the system sub-systems and between system and environment" . Typical complex systems include social systems, complex environment systems, complex engineering systems, complex military systems and complex network systems, etc. (Li and Chai 2012). We can summarize main features of complex system models and challenges in construction and management of models.

1) High system complexity

First, a complex system is characterized by complicated composition, containing a large number of composition elements and very complicated relationship between elements. Secondly, generally a complex system is dynamic and variable and is very uncertain. Above complexities lead to very complicated verification, validation and accreditation (VV&A) of complex system models. Complexity of complex systems leads to complexity of models.

2) Long life cycle of a complex system.

With time elapse, the models should be continuously improved and changed. Different model versions are available. Each version may be applicable to different application phases. Different versions and application phases of multiple models compose complicated network. How to keep consistence and credibility of different parts and versions of the model is the key for model maintenance.

3)Model heterogenicity

A complex system is composed of many heterogeneous component models. Heterogenicity of models generally comes from different development organizations, different platform and architecture, different development languages and databases, etc. Heterogenicity brings big challenges to integration and maintenance of the system models.

4) Complicated evolution of models

Generally a complex system is in continuous evolution, so the models will be continuously adjusted and changed. Changes of different relations are very complicated in evolution due to system complexity, so the model elements and its relation should be completely tracked and managed to guarantee correctness of the model evolution.

5) Difficult model reuse

With growth of complexity of the systems to study, the roles and values of model reuse is very remarkable in model development and use of a complex system (Liu, Tang, and Zheng 2008). Generally a complex system includes multiple combined systems. A huge number of models in past research and development practices have been accumulated. Correct and efficient reuse of the models will reduce model development cost, shorten development time much and effectively improve model credibility. Although some research on model reuse has been conducted, no efficient and practicable model reuse method is available now.

6) Massive processing data

Generally a complex system includes a large number of data to process, including required modeling data, data generated in modeling process, and data generated in model operation. Data processing includes data storage, inquiry, exchange, management, understanding, analysis and mining, which brings many challenges.

7) The multidisciplinary collaborative model development

Collaborative model development is associated with different steps in the whole model lifecycle. Collaboration is required on different phases, e.g. collaborative requirement analysis, collaborative design, and collaborative validation. All work compose a huge engineering and should be supported by management tools or platform.

8) Higher requirements for system performance

Compared to a simple system, a complex system requires higher performance, e.g. higher requirements for reliability, security, credibility, cost and energy saving. To guarantee that these performance requirements are met, special means should be required to analyze and process the models.

3. RELATED WORK

How to build a right model is the core issue in simulation. A large number of research achievements on models have been obtained in the past dozens of years. These achievements are related to different phases in a model lifecycle, e.g. modeling theory and method, model validation and model management.

For modeling theory and methods, as described in the above part, many researchers have developed different modeling methods for different systems. For modeling of complex systems, now issues in two aspects exist: (1) the confliction between model precision and complexity has not been well solved; (2) research on field-associated methodology for modeling process has seldom been conducted. Although many specific modeling methods are available, no enough generic guides and restraints are available for model development. For a complex system model requiring long-term use and maintenance, it is difficult to guarantee the model credibility and the aftermaths are catastrophic.

Research on the model validation, verification and accreditation (VV&A) is a hotspot in simulation field and many research achievements have been obtained (Wang and Lehmann 2007, Balci 1994). Related methods and technologies include model confidence rule, simulation credibility evaluation theory and method, VV&A framework and standard, quantified statistics and test method, data sequence comparison method, similarity method, and validity analysis method of simulation model acknowledge data (Yang and Fang 2011). Although researchers are plentiful, lot of work is required to establish a complete and mature VV&A theory system (Yang 2013, Liu 2007).

Compared to the research on modeling and VV&A of models, research on the model management, especially model lifecycle process management is very limited. Research on model management focuses on simulation model library design and management and model reuse, e.g. web-based simulation model library system framework (Wu, Qiu, and Liu 2006, Fensel and Bussler 2002), multi-model switching based on dynamic model library, object-oriented model library DSS reuse architecture and model library architecture management method. Research on model reuse includes meta-model (Alanen and Porres 2004, Wang and Lei 2007), component (Liang and Zhang 2008), modeling languages for model reuse, standardized modeling for model reuse, model driven architecture (MDA) (Kleppe, Warmer, and Bast 2003), and modeling environment and run environment for simulation model reuse (Jia and Zhang 2007, Brutzman 2002). Some preliminary achievements have been achieved in the fields such as combination of simulation models, model evolution and model configuration (Liu, Liu, and Wang 2012; Martens, Koziolek, and Becker 2010; Dhungana, Grünbacher, and Rabiser 2010), but they are in the initial phase.

The lifecycle concept has not been emphasized enough in the simulation domain, and related research and applications are not sufficient (Balci 2012).. The reference (Fishwick 1989) called the simulation model development process as simulation model engineering to emphasize engineering feature of the model development process, but no special explanation on its meaning was given and no systematic method system was established.

In recent years, the international simulation community is conscious of unfavorable influences of missing foundational theory of M&S on the development of simulation curriculum. As a result, research on the M&S lifecycle management is gradually attracting attention from the academic circle. The reference (Radeski and Parr 2002) proposed the modeling simulation lifecycle model framework, which defined organization mode and structure of the modeling simulation process, work products, quality assurance, project management, and described the features and requirements of the lifecycle phases such as development, use, maintenance and reuse of the modeling simulation system. The reference (Fishwick 1990, AbdouniKhayari 2010) achieved some valuable results in model lifecycle management and developed a model prototype management system, which provided valuable reference to model development for designers.

In a word, current research on models is generally focused on one phase in the model lifecycle and is separate and disperse. Although importance of the engineering idea is gradually recognized in applications of the full model lifecycle, now no complete theory and technology system and philosophy is available.

4. MEANING OF THE MODEL ENGINEERING

4.1. Concepts of The model engineering

Generally a model experiences requirement analysis, model design, model construction, model validation, model application and model maintenance. These processes compose a complete lifecycle of the model.

Based on state-of-the-art research on models, we propose a systematic methodology to cope with challenges in model lifecycle management of a complex system. The model development and management activities change from a spontaneous and random behavior to conscious, systematic, standardized and manageable behavior by constructing a model engineering theory and methodology system in order to guarantee credibility of different model phases.

Model engineering is defined as the general term of theories, methods, technologies, standards and tools relevant to a systematic, standardized, quantifiable engineering methodology that guarantees the credibility of the full lifecycle of a model with the minimum cost.

1) Model engineering is regarded the full lifecycle of a model as its object of study, which studies and establishes a

complete technology system at the methodology level based in order to guide and support the full model lifecycle process such as model construction, model management and model use of complex systems.

2) Model engineering aims to ensure credibility of the full model lifecycle, integrate different theories and methods of models, study and find the basic rules independent of specific fields in the model lifecycle, establish systematic theories, methods and technical systems, and develop corresponding standards and tools.

3) Model engineering manages the data, knowledge, activities, processes and organizations/people involved in the full lifecycle of a model, and takes into account time period, cost, and other metrics of development and maintenance of a model.

4) Here the model credibility is a comprehensive indicator and includes factors such as availability, accuracy, reliability and QoS.

4.2. Key Technologies of The model engineering

As the described in the above part, now the research on the technologies related to the full model lifecycle is preliminary and disperse. For comprehensive and systematic application and implementation of the model engineering, many key technologies should be studied.

1) Body of knowledge of the model engineering

The body of knowledge (BOK) includes the concepts and terminologies involved in a specific research field. This paper gives a preliminary knowledge system framework. The model engineering BOK identifies the research scope of the model engineering and its boundary and relationship with other related subjects. Establishment of systematic and complete BOK requires long-term accumulation and extraction.

2) Model engineering standards

Standards are the basis for the implementation of the model engineering. During the lifecycle process of a model, each activity requires corresponding standards, including model development process, model description, model component interface, model storage, model data exchange, model interoperation, model service, model maintenance, etc.

3) Modeling of model lifecycle process

The lifecycle model of the model engineering aims to identify the structural framework of activities involved in model construction and management (Zeigler, Kim, and Praehofer 2000), which is the methodology to guide the model engineering, and ensure improvement of model quality and development efficiency and reduction of full model lifecycle cost. Proper process models and corresponding implementation methods can be proposed by referring to the existing achievements in the system engineering, software engineering and other relevant fields and combining the model development features of complex systems.

4) Model engineering process management

The data, knowledge, tools, persons/organization and technologies in the full model lifecycle should be effectively managed with the model lifecycle process model as the guide, with standards as the basis, and with the project management methods and means as reference in order to get the dependable model with the minimum cost. The model maturity definition and control, performance management, flow monitoring and optimization, risk control, and cost control are important in the model engineering process management.

5) Acquisition and management of model requirements

Accurate requirement acquisition is the key in modeling. Requirement acquisition and management is very challenging due to uncertainty and ambiguity of complex systems. Requirement acquisition studies to extract, describe, parse and validate requirement via automated or half-automated means. Requirement management studies how to reflect the changing requirements in model construction and maintenance accurately and timely.

6) Model description and modeling language

Complex systems generally contain multiple different systems with different properties, such as quantitative systems, qualitative systems, continuous systems, discrete event systems, deterministic systems, uncertain systems, etc. One of the core issues in model development of complex systems is how to take advantage of effective ways to describe the whole system. Therefore, it is required to study corresponding model description mechanism and structure and develop generic or specific description languagesaccording to the characteristics of the various systems.

7) Quantitative analysis and evaluation of the model engineering

The quantitative analysis is one of main features of the model engineering. To ensure credibility of the full model lifecycle, many steps should be analyzed, evaluated and optimized in a quantitative manner, e.g. complexity analysis and evaluation of model development process, cost and benefit analysis and optimization, risk analysis and control, model availability and reliability analysis, and model service quality analysis.

8) Model validation, verification and accreditation (VV&A)

The model VV&A technology is one important part in the model engineering. Although some rich research achievements have been achieved, they cannot meet the actual requirements of modeling simulation of complex systems. Most research focus on qualitative analysis and quantitative and formalized analysis methods are lack, so VV&A technology, especially VV&A quantitative analysis and formalized analysis technology are still main research content in the model engineering.

9) Model library

The model library is the foundational platform to carry out model management and perform standardized encapsulation, storage and query for the models (Ören and Zeigler 1979). The complicated applications such as model reuse, combination and configuration management can be based on the model library. Traditional database technology, service-oriented technology, and cloud computing technology can support construction and management of the model library.

10) Model composition and reuse

The model composition and reuse technology is an important means to improve model construction and maintenance efficiency and improve model credibility of complex systems. It mainly studies how to use the existing model components to quickly and correctly compose complicated models according to the system requirements and includes standardized encapsulation of model components, intelligent model matching, model relation management, dynamic model composition, model consistency validation and model service.

11) Model reconstruction and configuration management

The requirements for model functions and performances change due to diversified requirements and inside and environmental uncertainty, so the models should be quickly reconstructed or configured. The model reconstruction aims to adjust the internal structure without change of main external functions of models, further optimize the model performance, and ease its understanding, maintenance and transplant of models. Model configuration can adapt different requirements or changes of models in function and performance by adjusting and optimizing internal components and parameters. For complex system model engineering, model reconstruction and configuration management is very important and challenging.

12) Model data and knowledge management

Many complex system models contain many data to process. Some models are constructed based on massive data, even exist in the form ofdata and their relations. Data management aims to effectively organize and use the data, especially massive data, and plays a key role in quantitative analysis of the model engineering.

On the whole, the knowledge is divided into two classes. The class 1 indicates the knowledge in the model, e.g. some qualified models include massive knowledge rules. Another class indicates the knowledge on model development and management and generally includes experiences accumulated and extracted by developers and users in practices. Different knowledge should be managed and use in different manners to improve model quality and intelligence and automation of model construction and maintenance.

13) Visualization of the model engineering

Visualization technology can be used on different phases of the model engineering, can realize transparent model development and management process, facilitate understanding and monitoring, and improve human-machine interaction efficiency. The visualization technology plays an important role in the model engineering.

14) Support environment and tools of the model engineering

Implementation of the model engineering requires an integrated support environment and corresponding support tool to support different activities of the model engineering, e.g. network collaboration, requirement management, process model construction and maintenance, model library management, qualitative and quantitative analysis and evaluation, data integration, knowledge management, model validation and simulation experiment.

5. PRELIMINARY FRAMEWORK OF THE BODY OF KNOWLEDGE

The model engineering is resultants of fusion of many crossing subjects including the software engineering, system engineering, computer science and engineering, mathematics, system modeling and simulation, knowledge engineering, project management, quality management and related application fields. Based on the body of knowledge (BOK) in these disciplines, specific BOK of the model engineering is formed according to the requirements and features of the model engineering.

To establish the model engineering BOK, it is necessary to tease out the involved knowledge in a systematic manner, extract features closely associated with the model-related activities from related fields, and summarize and condense those specific development technologies and management means of the model lifecycle process. Now we give a preliminary BOK framework of the model engineering. Two aspects are mainly considered in this process.

1) Identify the horizontal crossing relations between the model engineering and other closely associated subjects, properly tailor their overlapping parts, and make these overlapping parts reflect specific features of the model engineering.
2) Identify the modules in the model engineering system and vertical hierarchical relations and horizontal interface relations between modules, make the framework compose an organic whole, and serve for the full lifecycle process of the model.

By establishing the model engineering BOK framework, we hope to reach the following targets:

1) Promote consistent opinion of the academic circle on the meaning of model engineering;
2) Identify the research scope of model engineering;
3) Expound the position of model engineering to other subjects such as software engineering, system engineering, computer science and mathematics and set their boundaries.

We give the BOK framework of model engineering (Figure 1) by referring to knowledge system in the fields and subjects such as the software engineering, system engineering, modeling and simulation, project management and quality management (Mittal and Risco-Martín 2013, Feron 2013, Ludewig 2003).

Figure 1 gives the general logic structure of the BOK framework of the model engineering. Based on the full lifecycle process of model requirement, design, construction, VV&A, application and maintenance, the model engineering completes the model lifecycle process via implementation and guarantee means such as the model engineering process management, model engineering quality management and model configuration management. The model engineering tool provides assisted support for implementation of the model engineering. The model engineering standard provides the rules, protocols or specifications which should be complied with in implementation of the model engineering and development of related tools. The model engineering foundation includes the ideas, terms, theories and methods for the model engineering.

The BOK framework of the model engineering is divided into five parts:

Part I - foundation: including the basic concepts and terms, methodology, technology systems, etc. It provides the basic guidance for the implementation of the model engineering, and also is the foundation and guarantee of the model engineering independent of the other subjects.

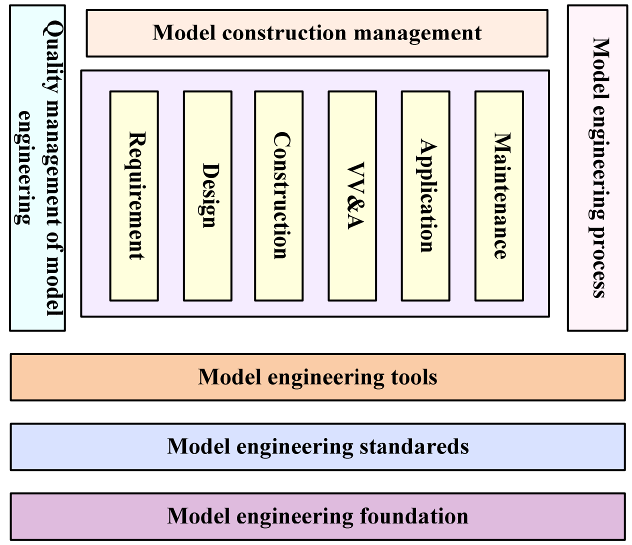

Figure 1: The BOK framework of the model engineering

Part II: model lifecycle: it describes different phases of the full model lifecycle at the technical level. This part is divided into six subjects, namely modeling requirement, model design, model construction, model VV&A, model application and model maintenance.

Part III: implementation and management: it includes the process management and quality management of the model engineering, and model configuration management. All activities in the full model lifecycle are managed and controlled in implementation, process and quality.

Part IV - tools: it provides the necessary software tools for the implementation and application of the full life cycle of the model engineering.

Part V - related standards: it includes rules, protocols or specifications which are necessary for implementation of the model engineering and development of related tools.

The detailed contents of each part are listed in Table 1.

Table 1: Details in the BOK framework of the model engineering

	Theme		Contents
Part I	Foundation of the model engineering	Outlines	The overviews, definition, function, body of knowledge of the model engineering, as well as necessary instructions of the brief introduction of other sections
		Concept of model	the basic contents, function, characteristics and meta-model
		History and status quo of modeling technology	Brief review of emergence and development of modeling technology, and the summary of status quo of the current modeling technology
		Model classification	The model classification is given from the consist, time characteristic, state characteristic, construction means, such as discrete, continuous, deterministic, random, qualitative, quantitative, mathematics, computer, concept, ontology model.
		Application field of model	According to the final application purpose of the model, and the macroscopic classification is given, such as communication,

	Theme		Contents
			education, training, understanding, decision support, entertainment.
		Life cycle of the model	Description of the main work of the model in every main phase from the full life cycle of production to the application, and each stage between join relationship
		Modeling ideas	From the view of the cognitive theory, logic and methodology, to elaborate modeling ideas and its features
Part II	Model requirement	Requirement foundation	Definition of requirements, process quality requirements, the functional and non-functional requirements, qualitative and quantitative requirements, system requirements, hardware and software requirements.
		Requirement acquisition	Requirement source, determination and negotiation technology.
		Requirement analysis	Requirement classification, requirement modeling, framework modeling and management.
		Requirement validation	Requirement assessment, requirement model verification, accreditation and revision.
		Requirement process	Process model, process support and management.
	Model design	Model design foundation	The design conception, model design context, model design process, enabling technologies
		The key issues of model design	Abstraction process, the interaction and performance, meta-model, data persistence
		The quality analysis and evaluation of model design	Quality attributes, quality analysis and evaluation technology, measurement
	Model construction	Modeling foundation	Complexity, related standards for validation and verification of modeling
		Modeling paradigm and modeling language	Modeling based on the graph, modeling based on the modeling language, description modeling, structure modeling, function modeling, relationship modeling, information modeling, process modeling, framework modeling and object-oriented modeling, formalization modeling, modeling based on component
		Modeling process	Modeling levels, refinement steps, implementation criterion
		Complex system modeling (hierarchy modeling)	Meta-model modeling, combined modeling, qualitative modeling, causal modeling, multi-resolution modeling, uncertainty modeling
		Emerging modeling	The multi-body modeling, modeling based on the self-organization theory, comprehensive integrated modeling
		Ontology modeling	ontology classification, candidate ontology, OWL
		Multidisciplinary collaborative modeling	Model with unified expression, model information exchange based on ontology, model abstraction level, model storage
	Model VV&A	VV&A foundation	Related termination of VV&A, key issues, relationship of VV&A and other activities
		VV&A technology	Non-formalization method, formalization method, index, steps
		Relevant measurement of VV&A	Model maturity, evaluation validation model, evaluation verification model, completed VV&A
	Model application	Model deployment	The environment deployment, the model calibration, model sensitivity optimization
		Model Integration	Model consistency, interface matching and transformation
		Model reuse	Model splitting and combination, model integrity

	Theme		Contents
	Model maintenance	Model maintenance foundation	Definition and terminology, the essence, necessity, classification of maintenance
		Key issues of model maintenance	Technical issues, management issues, maintenance cost estimation, model maintenance measurement
		Model maintenance technology	Model meaning, model storage, model retrieval, models version control, the document generation technique based on the model
Part III	Configuration management of the model	Process management of model configuration	Organization context, process scheme constraints and guidelines, plan making, management plan and supervision of model configuration.
		Model configuration identification	Identifying item, model base
		Model configuration control	Model change request, evaluation, approval, and implementation model change
		Model configuration state bookkeeping	Model configuration state information, model configuration status report
		Model Configuration verification	Model function configuration verification, model physical configuration verification, model base verification within the process
	Process management of the model engineering	Definition of the process	The lifecycle model and processes of the model engineering, process definition notation, process revision and automation
		Process evaluation	Process evaluation model and methods
		Process realization and change	Process foundation structure, modeling process management cycle, process realization and change model
		Engineering quality	Measurement establishment and maintenance, measurement process planning, measurement implementation process, measurement evaluation
		Project management	Deliverables products determination, workload estimation, schedule, cost, resource allocation, risk management, quality management, plan management, process monitoring and control
		Assessment and evaluation	Model consistency, the functional and non-functional demand determination, performance assessment and evaluation
		Process and product measurement	Process measurement, model engineering product measurement, measurement results quality, information model, process measurement technology
	Quality management of the model engineering	Model quality foundation	Model engineering culture and ethics, quality value and cost, model and quality characteristics, quality improvement
		Model quality management process	Model quality validation, verification and accreditation and review
		Model quality management technology	Model quality measurement, model comparison
Part IV	Tools of the model engineering		It mainly includes model requirement tools, design tools, construction tools, VV&A tools, maintenance tools, configuration management tools, engineering management tools, engineering process tools, model quality tools, etc.
Part V	Related standards of the model engineering		It mainly includes related existing or intended standards supporting model engineering model, such as terminology standard, model description standard, packaging standard, interface standard, model data exchange standard, interoperability standards, validation, verification and accreditation (VV&A) standard, visualization standard, etc.

6. CONCLUSION

Model engineering (ME) is a systematic solution for the credibility of the full model lifecycle in modeling simulation of complex system based on the research achievements on model development and management in the simulation field. It can improve credibility of the full model lifecycle and reduce the model development and management cost by providing theories, technologies, methods, standards and tools on standardized, systematic and quantified engineering management and control in the model lifecycle.

It is a long-term and complicated work to establish model engineering and should extensively depend on collaboration of the academic circle and industry circle. It is expected that this paper can launch a discussion and provide a reference for final establishment of complete model engineering curriculum and true service for model development and management of complicated simulation systems.

Finally it should be pointed out that although the idea of model engineering is discussed for simulation in this paper, the application scope of model engineering is not limited to the simulation field and is valuable for any fields which requires modeling and model management.

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