

# 2023 Complex Systems Design & Management (CSD&M) Conference—Contributed Talks

## CSD&M 2023 Program Day 1

		Contributed Talks, Track 1 (Room 6) 报告题目
13:30	13:45	An Architectural Design and Architectural Transformation Method Based on the Complex Real-time Embedded Systems (Hongxin JI) 基于复杂嵌入式实时系统的架构设计和架构转换方法
13:45	14:00	The Research on the Task Scheduling and Optimization Technology for Flight Tests (Gang XIAO) 飞行试验任务调度与优化技术研究
14:00	14:15	A Systems Engineering Framework that Integrates Aircraft Final Assembly Design Activities (Tao LI) 整合飞机总装设计活动的系统工程框架
14:15	14:45	Study of MBSE Development Framework for Flying Cars (Lei ZHANG) 飞行汽车 MBSE 开发框架研究
14:45	15:00	Model Compression Method Based on Knowledge Distilling and Adversarial Learning (Ming DU) 基于知识提炼和对抗学习的模型压缩方法
00:00	16:15	Model Based Analysis and Verification Method for Helicopter System Performance Requirements (Ji XIN) 基于模型的直升机系统性能要求分析与验证方法

16:15	16:30	Design of Ground Integrated Testing Equipment based on MBSE (Delong CUI) 基于 MBSE 的地面综合测试设备设计
16:30	16:45	The Virtual Twin Experience – Shaping the Future of Systems Engineering (Gan WANG) 虚拟孪生—塑造系统工程未来
16:45	17:00	An Adaptive Assembly Process Modeling Approach for Aircraft Manufacturing: Distinguishing Between Product-specific Constraints and Optimal Assembly Sequences (Lei HE) 区分特定产品约束和最佳装配顺序——飞机制造的自适应装配过程建模方法

### List of Abstracts

## Day 1, Track 1 (Room 6)

### **An Architectural Design and Architectural Transformation Method Based on the Complex Real-time Embedded Systems**

**Abstract.** The architectural design and architectural transformation method proposed in this paper is aimed at the architecture design and analysis of the complex real-time embedded systems based on the models. The architecture models, as the authoritative data source, provide data for the work of other perspectives in the whole system design process. The functional architectures of the complex real-time embedded systems are described by SysML. SysML and extended FACE Profile are used to describe the logical architecture. Describe the physical architecture through SysML and extended MARTE Profile. Based on the created functional architectures, logical architectures and physical architectures of the complex real-time embedded systems, the method is implemented through model transformation to convert SysML functional architectures, SysML and FACE Profile logical architectures, SysML and MARTE Profile physical architectures into corresponding AADL architectural models automatically, which improves the efficiency and accuracy of subsequent complex real-time embedded system architecture analysis.

### **The Research on the Task Scheduling and Optimization Technology for Flight Tests**

**Abstract.** The flight test plays an important role in aircraft development. For flight tests, the flight test schedule directly determines the flight test duration (FTD) and flight test cost. To generate an effective flight task schedule, the task scheduling problem for flight tests, which refers to searching for the optimal arrangement solution for a given flight test task requirement,

is proposed and studied in this paper. First, a description and classification of the task scheduling problem for flight tests are presented. Based above, the mathematical model for the basic problem is established. Then, the solving algorithms including the exact and approximate methods are reviewed. Finally, numerical experiments on the task instances of different scales are conducted.

## **A Systems Engineering Framework that Integrates Aircraft Final Assembly**

### **Design Activities**

**Abstract.** A modern large-scaled aircraft consists of numerous structural and system components. Many of those components are installed and tested in the final assembly stage. To design the aircraft final assembly processes, engineers are required to have a comprehensive understanding of the interdependences and interactions between all the aircraft components, and the following influence to manufacturing operations. This work is difficult and challenging due to final assembly design activities lie in both product design and operations management fields. Final assembly processes link to product and operations constraints, thus a process-oriented method is required. Aircraft as a typical system of systems, systems engineering framework, for instance the V model, is used to understand the product complexities and guide the product design activities. However, there is no such a framework for final assembly line (FAL) process. This research investigates the activities of aircraft integrations at final assembly stage, then introduces a framework following Systems Engineering (SE) principles for integrating FAL design activities.

## **Study of MBSE Development Framework for Flying Cars**

**Abstract.** As a new type of flying car with both land and flight functions, flying car require a complete and scientific development framework to analyze and design its functions and architecture in detail. Based on the MBSE methodology, define the stakeholders and usage scenarios of the flying car from the perspective of the human-machine-context, and use the modeling approach to develop the requirements, functions and architecture of the flying car at the concept stage. The flying car MBSE development framework combs and defines is completed by using model-in-the-loop simulation and human-in-the loop test environment according to the system of system architecture design thinking, which verified the requirements, functions, interactions, and performance of the concept stage of the vehicle.

## **Model Compression Method Based on Knowledge Distilling and**

### **Adversarial Learning**

**Abstract.** For airborne computing platform, fault diagnosis model is a very important part of Prognostics and Health Management System. Because of the lack of labels, unsupervised learning is commonly used in fault diagnosis model. However, unsupervised learning method requires too much computing power and storage, so it's hard to be deployed to airborne computing platform with limited computing power and storage. In this paper, we proposed a model compression method named Optimized Adversarial Distilling Model Compression (OADMC) that combines Knowledge Distilling and Adversarial Learning to solve this problem. In our method, we trained an Artificial Neural Network (ANN) model to imitate the unsupervised model, and use Simulated Annealing (SA) method to find the difference between them. OADMC can made required computing power reduced to less than 25% and required storage reduced to less than 5% and the accuracy is higher than 95%, whose performance is better than traditional model compression such as pruning algorithm.

## **Model Based Analysis and Verification Method for Helicopter System Performance Requirements**

**Abstract.** Model Based System Engineering (MBSE) methodology still exists shortcomings on quantitative requirements. There is no rigorous analysis process. Indexes are loosely connected with other system requirements and the determination of indexes is over-reliance on designer subjective decision. The aims of this article is to study the method for defining performance indexes so that the indexes can link with functional requirements and system general design data can be added into MBSE model to support the analysis. The decomposition process of multi-level indexes is proposed. The requirements of quantitative indexes are verified in MBSE simulation by means of scaling up CPU time of some actions to make the simulation logic and integrating the subject design models into MBSE operational logical model. The feasibility of new analysis and modeling methodology are demonstrated on the MagicDraw software with helicopter system.

## **Design of Ground Integrated Testing Equipment based on MBSE**

**Abstract.** With the increasing complexity of onboard systems, aircraft ground testing equipment is becoming increasingly complex, which provides fresh challenges for both system and domain engineers. Traditional design methods are inefficiency to ensure the functional completeness and structural rationality of the equipment. To solve the problems of inadequate requirement expression, weak traceability, and insufficient early validation in traditional document-based design methods, model-based systems engineering (MBSE) method was proposed to guide the design processes in the development of ground integrated testing equipment for an aircraft, and Rhapsody modeling tool, SysML language and Harmony-SE methodology were utilized to ease the whole process. The design method based on MBSE fully guaranteed the close integration of requirements, functions, and architectures, and constructed an optional design workflow for aircraft integrated testing equipment oriented to meet the needs of stakeholders. It greatly improved the design efficiency, guaranteed the quality of the equipment, shortened the development cycle, and reduced the cost and risk as well.

## **The Virtual Twin Experience – Shaping the Future of Systems Engineering**

**Abstract.** Powered by the rapid expansion of digital technologies and driven by the need for greater efficiency and sustainability, the digital twin technology creates a new paradigm for synthesizing virtual and physical worlds and connecting cyber-physical systems in the field directly to their designers and builders. One phenomenon brings all this to a new level. The Virtual Twin Experience creates a highly immersive and interactive environment, by combing massive amount of data from a variety of sources with modeling and simulation (M&S) techniques. It focuses on human experience in a connected virtual and physical world. It allows stakeholders to understand complex systems and their behaviors in the virtual world long before the physical implementation and to explore real world, what-if scenarios collaboratively and in real time.

This presentation provides an overview of the technology and applications. It defines the basic virtual twin architecture and different variants as applied to product design, digital manufacturing, supply chain, and operations and support services. With a use case on the modernization of airport operations, it demonstrates how the virtual twin experience, as an integrated system-of-systems approach, explores new and expanded trade spaces by applying extensive, multi-domain M&S tools and techniques. Through illustrative examples, the presentation shows that, as a natural evolution of the digital engineering transformation, the virtual twin experiences will shape the future of product design and manufacturing and change the way in which stakeholders collaborate in complex system-of-systems operations.

## An Adaptive Assembly Process Modeling Approach for Aircraft Manufacturing: Distinguishing Between Product-specific Constraints and Optimal Assembly Sequences

**Abstract.** Traditional assembly process modeling methods often exhibit limited adaptability to changes in the production environment, leading to inflexibility when confronted with material shortages, equipment failures, and other production disturbances. In this paper, we introduce a novel adaptive assembly process modeling approach specifically tailored for aircraft manufacturing. Our method differentiates between product-specific assembly constraints and optimal assembly sequences derived from process expertise. This distinction enables the dynamic determination of subsequent assembly stages during actual production while accounting for production disruptions, such as material shortages and equipment malfunctions. By ensuring that product-specific assembly constraints are satisfied, the proposed method permits a controlled degradation of optimal assembly sequences to accommodate fluctuations arising from production disturbances. The efficacy and adaptability of our approach are demonstrated through its successful implementation in real-world aircraft manufacturing scenarios, yielding enhanced flexibility and resilience of the assembly process in the face of unpredictable production conditions.

### CSD&M 2023 Program Day 1

		Contributed Talks, Track 2 (Room 7) 报告题目
13:30	13:45	Research on Hardware-in-the-loop Simulation for Aircraft Electric Power System (Danyang WANG) 飞机电力系统硬件在环仿真研究
13:45	14:00	An Assumption of R&D Method Driven by Model and Data (Wenming SONG) 模型和数据驱动的研发方法假设
14:00	14:15	Research on the Model-Based Process and Method for Aviation Equipment Requirement Demonstration (Siyang TAN) 基于模型的航空设备需求论证过程和方法研究
14:15	14:45	Model-based Embedded Radar System Software Development and Verification (Yue TAN) 基于模型的嵌入式雷达系统软件开发与验证

14:45	15:00	Model-based Design Method and Practice of Avionics System Architecture in Civil Aircraft (Xinyi TANG) 基于模型的民用飞机航空电子系统结构设计方法与实践
00:00	16:15	Applying Systems Thinking and Architectural Thinking to Improve Model-Based Systems Engineering Practice: Concepts and Methodology (Zhe WANG) 应用系统思维和架构思维改进基于模型的系统工程实践的概念与方法
16:15	16:30	Top-Down Military System-of-systems Design using MBSE based on UAF: A Case Study (Naihao LIU) 基于 UAF 的 MBSE 正向军事系统设计案例研究
16:30	16:45	Risk Assessment Method of Aircraft Engine Product Supply Chain Based on AHP Analysis (Jian-Hua YU) 基于 AHP 分析的飞机发动机产品供应链风险评估方法
16:45	17:00	A SysML-based Architecture Framework for Helicopter (Le WANG) 基于 SysML 的直升机架构框架

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## Day 1, Track 2 (Room 7)

### Research on Hardware-in-the-loop Simulation for Aircraft Electric Power System

**Abstract.** As more electric aircraft power systems grow in complexity and power rating, the design, evaluation and testing of such systems become quite challenging tasks, while real-time simulator based hardware-in-the-loop (HIL) technique is considered a cost/time-effective solution. This paper establishes the simulation model of aircraft electric power system (EPS) through combining the functional model with the circuit ones. The principle of state space node (SSN) algorithm is applied to the simulation system with hardware Bus Power Control Unit (BPCU) in the loop. The control method for EPS network based on the Finite State Machine (FSM) structure and the power supply priority has been used to realize the system reconfiguration operation. The experiment results are presented to validate the effectiveness of the simulation model as well as the operation of BPCU in the loop.

## **An Assumption of R&D Method Driven by Model and Data**

**Abstract.** The model-based systems engineering is gradually applied to the development of complex systems, it has the advantages of accurate transmission of design output, rapid response to design changes, and undemanding reuse of design achievements. In this paper, MBSE is evaluated from three perspectives, including the theoretical system of model-driven research and development (R&D), the requirements of product R&D as well as the requirements of complex system R&D, and the shortcomings of MBSE are sorted out. On this basis, this paper proposes the R&D process of complex system hybrid-driven by model and data, and analyzes the key technologies to be solved.

## **Research on the Model-Based Process and Method for Aviation Equipment Requirement Demonstration**

**Abstract:** In response to the increasing complexity of aviation equipment systems, the increasing urgency of the equipment pre-research process and the urgent need for rapid iterative optimization during the aircraft development process, this paper proposed a kind of model-based process for aviation equipment requirement demonstration. Starting from the operational concept, the requirement demonstration process for aircraft equipment is established from system of system layer to equipment layer, then to system layer, then to subsystem layer by modelling and simulation based on MBSE theory. The methods for each layer are proposed to support the agile requirement generation of aviation equipment from mission and task requirements to performance indicators. Through concept confirmation, logic verification and principle verification, the forward design of aircraft equipment complex system is practiced. Finally, this paper verifies the rationality of this method through a case, so as to provide a reference of requirement demonstration for aviation equipment in other scenarios.

## **Model-based Embedded Radar System Software Development and Verification**

**Abstract.** This paper introduces the model-based embedded software development and verification method. Taking radar system software as an example, the development process of model-based embedded software is introduced, and the use of models formed in different stages in the development process and its related verification methods are discussed. Model-based embedded software development can make full use of the advantages of model simulation and verification, analyze the correctness of the model intuitively and comprehensively, realize virtual design verification, and promote the deepening of design optimization. Not only can the requirements and design defects be discovered as early as possible, but also the correctness of the design can be guaranteed under the premise of satisfying the requirements.

## **Model-based Design Method and Practice of Avionics System Architecture in Civil Aircraft**

**Abstract.** The traditional avionics system architecture design process of civil aircraft has encountered many problems, such as inconsistent design process, poor traceability, and difficult interface matching. Based on the design characteristics of avionics system and the system engineering design ideas of COMAC, this paper designs a method suitable for civil aircraft avionics systems, and develops an avionics system modeling tool that conforms to this method. The results of model practice

indicate that this method can achieve collaborative modeling between systems, real-time interface synchronization, and automation of avionics network design. The modeling results meet the requirements of model design.

## **Applying Systems Thinking and Architectural Thinking to Improve Model-Based Systems Engineering Practice: Concepts and Methodology**

**Abstract.** Effective practice of Model-Based Systems Engineering (MBSE) in domain-specific contexts requires right way of thinking. In this paper, we study systems thinking and architectural thinking regarding their core concepts and respective values in improving MBSE practices. First, the core concepts of systems thinking and architectural thinking are discussed. A conceptual model is then proposed that depicts the relationships between systems thinking and architectural thinking. Finally, guided by systems thinking and architectural thinking and their relationships, a six-step approach is developed that provides a trans-domain methodology for effective practice of MBSE, which could be further adapted according to domain-specific context.

## **Top-Down Military System-of-systems Design using MBSE based on UAF: A Case Study**

**Abstract.** The development of the system architecture study, especially using the Model-Based System Engineering (MBSE), provides an opportunity of a better modeling and analysis of a system-of-systems (SoS). The Unified Architecture Framework (UAF), developed from the UPDM and the NAF, is a framework which is designed for the modeling of a system-of-systems (or an enterprise). The present study focuses on the application of Model-Based System-of-Systems Engineering (MBSOSE) in a typical military system-of-systems engineering based on the UAF domain meta-model (DMM), in order to solve a typical problem in the military domain. Four major layers are analyzed and modeled: the strategic layer, the operational layer, the services layer and the resources layer. Using the model-based method, the study provides a top-down design of the military system-of-systems, which is an available and flexible solution for the typical military problem, and which leads to the inputs of the system level design.

## **Risk Assessment Method of Aircraft Engine Product Supply Chain Based on AHP Analysis.**

**Abstract.** The risk problem of aero-engine product supply chain is complex and there are many variable factors. In recent years, various enterprises have invested a lot of money in the intelligent construction of supply chain. Based on the concept of system engineering, a V-shaped model of aero-engine supply chain is established in this paper, and then a panoramic information base of product supply chain is formed. Then the analytic hierarchy process (AHP) is used to establish the evaluation model of aero-engine product supply chain, and the risks sorted out in the panorama information database are systematically analyzed, and the related algorithm models are introduced, which provide the basis for intelligent risk evaluation and operation decision of supply chain.

## **A SysML-based Architecture Framework for Helicopter**

**Abstract.** A multi-level system architecture framework has been devised due to the absence of an architecture framework suitable for helicopter development. The proposed architecture framework is tool-agnostic and can accommodate a wide



range of SysML modeling tools. It uses three viewpoints (conceptual, logical, and physical) to transform stakeholder requirements into final products. The framework facilitates the development of helicopters at five system levels. The logical viewpoint is the focal point of this framework, corresponding to three levels of system hierarchy. The principles of functional integrity and three-level function integration are proposed for developing a logical viewpoint. The principle of functional integrity is used to decompose a function into a subfunction. The principle of functional integration is used to decompose functionality downward. This approach emphasizes the expression of system architecture, defines the representation of system elements, establishes rules for expressing relationships through different views, and identifies views applicable to various viewpoints. Finally, this framework's concrete application is demonstrated using the helicopter brake function.

## CSD&M 2023 Program Day 2

		<b>Contributed Talks, Track 1 (Room 6)</b> 报告题目
09:00	09:15	Design Method of Task Meta-model of Avionics System Architecture Based on DM2 (Cong CHEN) 基于 DM2 的航空电子系统结构任务元模型设计方法
09:15	09:30	Research and Application of Decoupling Method for Fuel System Testing in the Final Assembly Stage of Aircraft Complex Systems (Bo YE) 飞机复杂系统总装阶段燃料系统测试解耦方法的研究与应用
09:30	09:45	Research on the Concept of MAV/UAV Cooperative Combat Based on UAF (Shuang ZHANG) 基于 UAF 的 MAV/UAV 协同作战概念研究
09:45	10:00	A Method for Generating Radar System Logical Architecture Models Based on Domain Ontology (Chang LI) 基于领域本体的雷达系统逻辑架构模型生成方法
10:00	10:15	A Novel MBSE-based Design Method for Search and Rescue Humanoid Robots (Mengyue WANG) 一个基于 MBSE 的搜索救援仿人机器人设计方法

10:15	10:30	Design and Modeling of Nuclear Power Inspection Robot Based on MBSE (Jia ZHANG) 基于 MBSE 的核电站检测机器人设计与建模
10:30	10:45	PRODEC-based Task Analysis for the Design of Semi-automated Trains(Yang SUN) 基于 PRODEC 的半自动列车任务分析
10:45	11:00	A systematic approach to conducting FHA (Jian WANG) 功能危害分析的系统性方法

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## Day 2, Track 1 (Room 6)

### Design Method of Task Meta-model of Avionics System Architecture Based on DM2

**Abstract.** Architecture design based on meta-model is a hot research topic in the field of architecture. In this paper, a design method of task meta-model for avionics system based on DM2 is proposed. It expresses the requirements, structure, behavior and parameter elements of the mission architecture design by constructing standard, specification and unified task meta-model data. This method can promote the standardization of avionics architecture data, promote the sharing and reuse of design data, and effectively improve the efficiency of avionics system architecture design.

### Research and Application of Decoupling Method for Fuel System Testing in the Final Assembly Stage of Aircraft Complex Systems

**Abstract.** As modern aircraft systems become increasingly integrated, they exhibit a high level of fusion and interconnection between systems, requiring multiple systems to work together to effectively achieve the functionality of a single system. This presents a challenge for validating product functionality in ground tests during the aircraft integration phase. In the face of highly integrated and complex aircraft systems, decoupling the inter-level interconnections within the aircraft is critical to establishing effective product functionality validation. This study draws on principles and tools from Systems Engineering (SE) to establish an inherent inheritance relationship between aircraft product design and aircraft process design of ground tests. This enables effective recognition and decoupling of internal interconnections within the product, and establishes a connection between the Hardware-In-the-Loop requirements and ground tests hardware during the aircraft integration, forming a general method framework for the decoupling "V" model of the aircraft system tests. In the application of ground tests on aircraft for aircraft fuel system, this method effectively analyses the requirements of system test simulation and, combined with the test environment characteristics of the Aircraft Final Assembly Stage, forms a corresponding fuel system test facility.

## **Research on the concept of MAV/UAV Cooperative Combat based on UAF**

**Abstract.** Aiming at the concept of MAV/UAV coordinated combat, this paper proposes the UAF architecture based on the capability-oriented approach and designs a typical combat scenario of MAV/UAV air-ground coordinated combat. According to the UAF methodology, the architecture analysis and design of MAV/UAV cooperative combat capabilities and tasks are completed from the Operational viewpoint and Resource viewpoint. Through the UAF model, the text document is transformed into an executable model to clearly express the combat concept. First, from the functional requirements of the Operational concept, The Operational High Level Concept diagram, Operational Internal connectivity diagram, and Operational Process Flow diagram under the Operational viewpoint are established. Then the functional nodes of the Operational viewpoint are corresponded to each system equipment in the combat system, and the timing relationship and information transfer between the combat activities and combat states of each combat equipment in the whole combat concept are analyzed. Based on the UAF description, the MAV/UAV combat coordinated conceptual model can provide a reference for subsequent combat conceptualization, combat effectiveness assessment and equipment development.

## **A Method for Generating Radar System Logical Architecture Models Based on Domain Ontology**

**Abstract.** This paper presents a method for generating a domain ontology based model of the logical architecture of a radar system in the context of MBSE. The method consists of constructing a domain ontology for the logical architecture of the system and using it as a framework for a Model Knowledge Base, and then devising a method based on this to automatically generate a radar system logical architecture model from an existing radar system functional architecture model. The method aims to store and reuse domain knowledge of the logical architecture model of a radar system in the form of an ontology and to use radar domain expert knowledge to assist the user in the decision making process during the logical architecture model generation. This approach could improve the efficiency of modeling, speed up the design process of the radar system logical architecture model and assists the designer in trade-off exploration during the model generation process to find a better solution.

## **A Novel MBSE-based Design Method for Search and Rescue Humanoid Robots**

**Abstract.** The current system design approaches for humanoid robots are mostly platform-based, making it difficult to consider the operational scenarios comprehensively. This leads to challenging modifications to the complex humanoid robot before meeting real-world task requirements. To boost the effectiveness and efficiency of task-oriented humanoid robot design, a novel robot design method based on Model-Based Systems Engineering (MBSE) is proposed. Firstly, a top down model-based humanoid robot development method is presented, which integrates the development process and model to design and describe the requirements, functions, the logical architecture and the physical architecture of the humanoid robot. Then, the development of the search and rescue humanoid robot is taken as an example to illustrate the effectiveness of the method.

## **Design and Modeling of Nuclear Power Inspection Robot Based on MBSE**

**Abstract.** Model-based System Engineering (MBSE) is a hot research topic and has yielded notable achievements in several industrial fields. Introduction of MBSE on the R&D of nuclear power products for demand-oriented forward design is able to improve design efficiency and innovation competence. In this article, a specific executable modeling process based on MBSE for nuclear power products was proposed by using CESAMES Systems Architecting Method (CESAM), and the system design and modeling of nuclear power inspection robot was also carried out. The results indicate that MBSE can ensure the consistency and completeness of design information and better support complex engineering activities. This study can provide reference for the future implementation and promotion of MBSE in the nuclear field.

## PRODEC-based Task Analysis for the Design of Semi-automated Trains

**Abstract.** The deployment of high-speed automated trains is a worldwide objective for railway stakeholders. The French railway operator SNCF has conducted several safety-oriented analyses and studies to better understand Automated Train Operation (ATO) impact. But none of them really is supported by humans in the loop simulation (HITLS). In PRODEC, AS-IS scenarios based on existing declarative configurations can help to project TO-BE scenarios based on new declarative configurations of the system to be designed. This paper is dedicated to the task analysis of the scenarios selected and constructed by safety analysis. The comparison between the train driver's task in AS-IS scenarios at Grade of Automation 1 (GoA1) for manual driving and the train driver's task in TO-BE scenarios at Grade of Automation 2 (GoA2) for teaming with ATO and ETCS enables to discover design gap and tasks evolutions to project potential functions and infrastructures.

## A systematic approach to conducting FHA

**Abstract.** To develop a complex, safety-critical system, it is of great importance to identify the safety requirements at the earlier stage of system development. Functional Hazard Assessment technique is commonly used in order to identify top-level safety requirements based on the system functions. In this article, we present a systematic approach to conducting FHA starting from the list of system function, based on which the functional Failure Conditions are identified, then each Failure Condition is classified based on its Failure Effect. Different Failure Effects are categorised to different level of Severity, to which a safety goal is associated. By studying the chain from Failure Condition to Failure Effect, to Severity, and to the associated safety goal, the safety requirements for each Failure Condition can be determined at the end of Functional Hazard Assessment.

## CSD&M 2023 Program Day 2

		Contributed Talks, Track 2 (Room 7) 报告题目
09:00	09:15	Modeling the Impact of Interdependency among Capabilities in System of Systems Context Using Unified Architecture Framework and Choquet Integral(Xusheng REN) 基于统一架构框架和 Choquet 积分的体系能力相互依赖性影响建模

CSD&M 2023 Contributed Talks

09:15	09:30	<p>Building A Unified Model-based SoSE and SE Tool-Chain Framework Economically Based on Data Exchange Mechanisms (Yuqiang GUO)                      基于数据交换机制的基于模型的体系和系统工程统一、经济的工具链框架</p>
09:30	09:45	<p>Research and Application of Model-based Aircraft Complex Function Analysis Method (Liu MENG)                      基于模型的飞机复杂函数分析方法的研究与应用</p>
09:45	10:00	<p>Enterprise Modeling for Architecture-Centric Production Systems Planning (Jiaheng SUN)                      以架构为中心的生产系统规划企业建模</p>
10:00	10:15	<p>A Unified SoS and System Architecture Modeling Framework Based on Grid-type MBSE Methodology (Yuqiang GUO)                      基于网格类 MBSE 方法论的体系和系统统一架构建模框架</p>
10:15	10:30	<p>Investigation of a Model-Based approach to a Grid Fin System Design (Wenfeng ZHANG)                      基于模型的网格鳍片系统设计方法研究</p>
10:30	10:45	<p>Architecture Design of Model-Based Land Combat Equipment System (Qiang LIU)                      基于模型的陆地战斗装备系统架构设计</p>
10:45	11:00	<p>A Generalized Reuse Framework for Systems Engineering (Gan WANG)                      系统工程通用可复用框架</p>
11:00	11:15	<p>An Effective Approach for Model-Based Radar System Architecting (Jiaheng SUN)                      基于模型的雷达系统架构有效方法</p>

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### Day 2, Track 2 (Room 7)

#### **Modeling the Impact of Interdependency among Capabilities in System of Systems Context Using Unified Architecture Framework and Choquet Integral**

**Abstract.** In order to model interdependency among capabilities more accurately in the process of forming the capabilities of System of Systems (SoS), we propose a methodology that combines Unified Architecture Framework (UAF) views and Choquet integral to represent the capabilities and the corresponding interdependencies. A conceptual analysis model was constructed by the simplified extraction of the strategic viewpoint, operational viewpoint and resource viewpoint in UAF, which emphasizes the construction of qualitative interdependencies. Then, the Choquet integral preference model with improved solving method was established to tackle the interdependency by quantifying the individual capability and all the sets of capabilities. At last, a modified aircraft carrier combat SoS as an illustrative example was used to verify the effectiveness of the proposed model.

#### **Investigation of a Model-Based Approach to a Grid Fin System Design**

**Abstract.** The SysML language has demonstrated significant utility in the system engineering field as well as aerospace system design. This paper investigates the limitations of document-based methods encountered in design of a grid fin system and correspondent model solutions. The paper first introduces the fundamental architecture of the grid fin system. Subsequently, it identifies two principal problems encountered during the design process: the difficulty in managing primary components, and the problem of supporting control loop design. The paper proposes a viable solution to these challenges in the grid fin design with model based method and SysML language. This research contributes to a better understanding to SysML language models on aerospace design in and provides practical insights into addressing the challenges encountered in the design of similar complex systems.

#### **Research and Application of Model-based Aircraft Complex Function**

##### **Analysis Method**

**Abstract.** At present, the overall design of aircraft is facing with the problems of increasingly complex functions and close cross-interconnection of systems. Aiming at the characteristics of complex function, such as multiple discrete events, strong dynamics, high degree of coupling and difficult modeling expression, this paper proposes an analysis method based on the combination of model and data definition is proposed to realize the decoupling design of aircraft complex functions. Through functional logic model and data modeling, this method realizes the architecture design of related systems, completes the iterative mapping from logical interface to physical interface, and ensures that the related system interfaces of complex functions are clear and the module division is reasonable to the greatest extent, so as to improve the efficiency of system design and verification.

## **Enterprise Modeling for Architecture-Centric Production Systems**

### **Planning**

**Abstract.** The planning of modern production systems faces unprecedented complexity challenges in terms of diverse stakeholder expectations, value chain integration, and the adoption of new technologies. Existing studies have shown that formal modeling of production systems at enterprise level has potential to alleviate such difficulties by enhancing stakeholder understanding and improving planning rigor. This paper proposes a domain metamodel for the production system architecture framework to enable formal architecture-centric production system planning. A domain-specific modeling language is further implemented through the SysML profiling mechanism to facilitate and formalize planning processes. The proposed modeling language is further validated using an exemplary aircraft production system.

## **A Unified SoS and System Architecture Modeling Framework Based on**

### **Grid-type MBSE Methodology**

**Abstract.** There is dense and heterogeneous information exchange between the SoS, System architecture model, and it is meaningful to build a unified SoS and system architecture modeling framework to bridge the gap between the two different architecture level modeling. The paper studied the grid-type SoS/system architecture modeling methods and the two different unified architecture framework building approaches. A unified SoS and system architecture modeling framework that aligns with ISO 15288 is proposed. The modeling framework takes full advantage of MBSOSE and MBSE to save time and cost in the engineering practice.

## **Building A Unified Model-based SoSE and SE Tool- Chain Framework**

### **Economically Based on Data Exchange Mechanisms**

**Abstract.** A unified Model-based SoSE and SE Tool-Chain is significant and necessary for the dense and heterogeneous information exchange between the SoS, System, and domain engineering models. This paper studies data exchange mechanisms between the SoS architecture tool, System architecture tool, and other engineering tools. A unified Model-based SoSE and SE Tool-Chain framework is given for reference. Compared with other frameworks, this solution uses the SoS and System architecture tool as a hub in the center. It is flexible and fully utilizes the existing modeling tools, which will save costs and time significantly. Ultimately, a helicopter system model as a case study demonstrates the proposal's feasibility.

## **Architecture Design of Model-based Land Combat Equipment System**

**Abstract.** Given the large scale, diverse element categories, and complex interactions of the land domain equipment system, in order to establish a more systematic and comprehensive land domain combat conceptual model with better model reusability, this article, based on the design concept and description method of DoDAF 2.0, depicts the capability requirements, combat activities, and system functions of the land domain combat equipment system from three aspects: static description, relationship mapping, and dynamic verification, this provides a theoretical reference for modeling the architecture of land combat equipment systems in the future, and lays a solid foundation for the development and planning of the system. The results indicate that the execution status of the proposed combat system is consistent with the expected combat process, the architecture design is reasonable, and the definitions of various combat nodes and information architecture descriptions within the system are consistent and coordinated.

## A Generalized Reuse Framework for Systems Engineering

**Abstract.** Reuse in system development is a prevalent phenomenon. However, how reuse is applied varies widely. The Generalized Reuse Framework is a strategic reuse model for systems engineering management in product development that addresses both investment and leverage of reuse through two interrelated and interacting processes: Development with Reuse (DWR) and Development for Reuse (DFR). This chapter summarizes the latest development of this framework by providing the taxonomic definition of DWR and DFR and analyzing the decision processes for reuse as applied to incremental development and product line engineering. It also describes how the framework is applied to the revision of the Constructive Systems Engineering Cost Model (COSYSMO), a parametric cost estimating model for systems engineering. With use case scenarios, it illustrates the approach to apply the framework and to quantify the economic impact of reuse vis-à-vis investment strategies.

## An Effective Approach for Model-Based Radar System Architecting

**Abstract.** This paper proposes an effective approach for applying Model-Based Systems Engineering (MBSE) to radar system design. Specifically, a cross-domain system ontology model is first developed to capture radar design domain knowledge, enabling a common understanding between system engineers and radar designers. Furthermore, a domain-specific architecture framework is defined to provide a big picture view of radar system design (including operational analysis, system analysis, logical/physical architecture definition) and meanwhile organize model-based radar system architecting processes accordingly.