Model-based Integration and Verification of Air-borne System

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Abstract. With the development of aerospace science and technology, the functions of air-borne systems are integrated into a smaller chip. To integrate and verify the air-borne system design, Model-Based System Engineering (MBSE) is a kind of numerous methods. To effectively support the design and development of complicated air-borne system. The advantages of MBSE applying to the integration and verification of air-borne system are analysed, and some advises are given.

1. Introduction
Model-Based System Engineering (MBSE) refers to using models to support the actions as follows: capture of requirements, design, analysis, verification and validation. These actions begin from the phase of conceptual design, to the phase of development, even to the whole life cycle. MBSE is widely used in integrated air-borne system, especially in the integration and verification of the air-borne system.

This paper introduces advantages of MBSE and proposes work methods, hoping to provide more reference and help for the design and development of complex systems.

2. Background of MBSE
MBSE is first proposed at the international conference of the International Council on Systems Engineering (INCOSE) in 2007. MBSE is a kind of system engineering based on models, including two parts, one is technological processes, the other is managing processes.

Technological processes follow the systematic thought of decomposition-integration and step-by-step developing processing. Managing processes involve technological management and project management. Combined with the development of complicated engineering system, the processes of establishing engineering system model include the construction, analysis, optimization, verification of system model in technological perspectives. In management perspectives, the processes of establishing engineering system model include the planning, organizing, directing and controlling of system modelling. Comparing with the traditional system engineering based on text, MBSE can realize the technological communication using the model, is subversive and have many advantages.

3. The advantages of MBSE in the integration and verification of air-borne system

3.1. No ambiguity in model description
On the processes of integration and verification of model-based air-borne system, as to the complicated system engineering, more and more air-borne systems are integrated in a small
chip. Using the model-based constructing air-borne system method, the model has been used to simulate requirements, structures, functions, actions, and parameters. The model has also been used to transmit requirements, structures, actions and parameters etc. dynamic information. This helps all the members in the work-group can understand the system and give the system an exact description, ensuring consistence and accuracy of information transmission in the whole processes. At the same time, ambiguity caused by a large amount of words descriptions and document is avoided.

3.2. Applicable to the management of highly complicated and more comprehensive system
On the processes of the integration and verification of model-based air-borne system, after the modulated design of air-borne system, according to the modulated management of air-borne system, the text system description has been changed, and a lot of inconsistency and repeat is decreased and cooperation between different disciples becomes easier. The system model can also be examine closely form different perspectives and analyse all the effects caused by the changes.

3.3. Can be verified and validated in the pro-phase of project
On the integration and verification of model-based air-borne system, according to the model of air-borne system in the pro-phase of project, such as the protocol design and integration between the systems, the requirements of the product and design can be evaluated effectively and consistence and correctness of requirements can be evaluated. In the pro-phase of project, the product can be verified and validated, reducing the developing risk of air-borne system, time for development and the cost of developing a new product, and improving the qualities of the products.

3.4. Ensuring the design sustainable and all-in-one
On the integration and verification of model-based air-borne system, model-based air-borne system engineering can be compatible to different models, can be compatible to the third-party description, and can be operated for several persons and several platforms. MBSE ensures the traceability of different models and different data. Air-borne system models can be changeable with COTS products.

3.5. Easy to maintain
On the integration and verification of model-based air-borne system, model-driven methods are used to capture information, enhancing the completeness and accuracy of information capture, reducing the cost caused by the change of design. In other words, using the standard input/output format, this method makes the data easily exchangeable and transmitted.

3.6. Easy to parallel design and fast iteration
On the integration and verification of model-based air-borne system, system model can be easy to iterate and develop. According to the model, fast analysis and fast iteration can be achieved. Standardized model can be easily copied and changed. Different models can also be easily used to parallel design process.

3.7. Facilitate system integration and evolution
On the integration and verification of model-based air-borne system, based on the consistency of the model, system can be implemented hierarchically in the later integration process to simplify the system deployment and evolution.

4. Model-based integration and verification methods of air-borne system
The development of complicated systems involve multi-disciples, including systems, sub-systems, modules, electronic hardware, software, mechanical engineering etc. This is a complicated system engineering. MBSE stresses the center of the model, and the model drives system analyzing design, software analyzing design. According to the model, the design and analysis abilities of
engineers for the complicated systems are improved. It can also connect all the works of different classes and different disciples and improve the qualities and efficiency.

The specific methods are as follows.

Firstly, capture all the requirements of air-borne systems, forming the list of functions of air-borne systems, doing the air-borne framework design, using the requirements, functions, framework to form system model boxes and making the integration design of air-borne system/sub-system and its relating systems.

Secondly, using the technology of MBSE, connecting all the air-borne systems and on the basis, clarifying requirement specifications, interface instructions and design requirements, making a balance between systems and the whole size.

Thirdly, in the pro-phase of the project, testing can be introduced in MBSE and at the same time, verifying and validating system-system integration, simulating the properties of validating system, and making the optimization.

Finally, combined the existing tool software or numerical model with MBSE, forming system engineering integrating developing and verifying processes.

The development process of complex system based on MBSE is shown in the figure below.

![Figure 1 Development process of system based on MBSE](image)

5. Conclusion
MBSE technology integrates all the air-borne systems, constructing standard model specifications. Based on the MBSE integrating and verifying processing, the whole team can easily use the outcomes of models and software from different disciples, and as early as possible to achieve the benefit and values derived from the use of MBSE. Though MBSE improves efficiency and quality of the project, in the future it will have a wide application in industry.

MBSE technology should be widely used in complex scientific fields, which can promote and develop complex products.

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