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Interactive System Modeling for Designing a New Concept Launch Vehicle

Masashi Miura†* and *Yuki Sakamoto**
** Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency*
3-1-1, Yoshinodai, Chuo-ku, Sagamihara-city, Kanagawa-pref., JAPAN
miura.masashi@jaxa.jp
† Corresponding Author

Abstract
Interactive System Modeling is a process in which participants interact and collaborate to build system models. Using this method, stakeholders and project members can obtain common understandings and a consensus for the system effectively. This paper introduces the concept of interactive system modeling and the specialized tools for this purpose. The paper also presents an example of upstream design of a new concept launch vehicle using this method.

1. Introduction

In the upstream design phase of systems engineering, stakeholder analysis, requirements analysis, and system definition are conducted[1]. In this phase, it is very important to obtain a common understanding and consensus for the system among stakeholders and project members. However, when designing new concept systems (rather than updating existing systems), it could be difficult to reach a common understanding and consensus. Then we proposed a method called “Interactive System Modeling” and applied it to the design of a new concept launch vehicle. This method allows stakeholders and project members to reach a common understanding and agreement on the system very effectively. In this section, the concept of interactive system modeling and a dedicated tool for this method.

1.1 Interactive System Modeling

Interactive System Modeling is a process in which participants interact and collaborate to build system models. A system model is a network-like diagram in which the elements of the system are represented by nodes and the relationships between system elements are represented by links. Representing the system in a system model can reduce cognitive discrepancies and facilitate common understanding. In interactive system modeling, participants look at the same system models and discuss it, updating the model in real time. This process enables for them to find a point of agreement for upstream design. Figure 1 shows the conceptual image of interactive system modeling.

Figure 1: Interactive System Modeling

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We have been practicing interactive system modeling using a tool called "Balus[2]". Balus is a cloud-based modeling tool that enable multiple people to view and update system models remotely and simultaneously. Balus allows you to build and update system models with simple operations, making it suitable for interactive processes. Moreover, Balus has the function to represent views and view models described in the following section. These features make Balus an ideal tool for interactive system modeling[3]. The figures in the next chapter (Figures 4-7) are screenshots of the Balus.

1.2 View & View Model

View and view model are important concepts in constructing system models. A view is a frame that cuts out an aspect of the system and is the perspective from which the system model is drawn. A model is a representation of the system as seen from a certain view, and a model cannot be drawn without defining the view. Figure 2 shows the concept of view.

View model is a meta-model that defines the relationships between views. View model represents views as nodes, and related views are connected by links as shown in Figure 3. To successfully practice interactive system modeling, it is necessary to set up the appropriate view model.

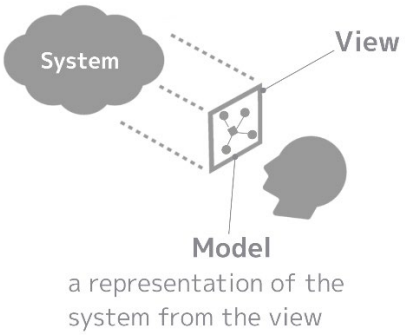

Figure 2: View

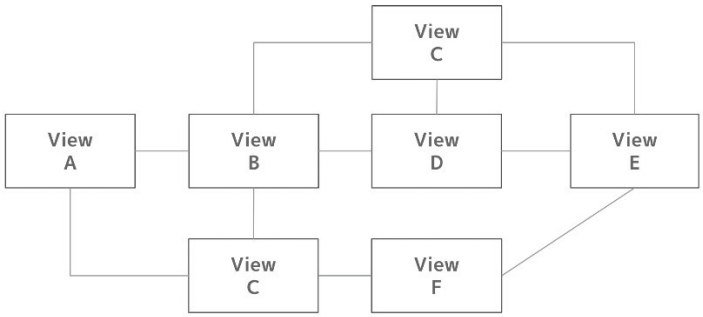

Figure 3: View Model

2. Modeling Practices

This chapter presents practical examples of interactive system modeling. The first section provides a brief introduction to the rocket development project that was the subject of the practice. In the second and following sections, the views used in interactive system modeling and modeling results are shown.

2.1 ATRIUM Project

The practical examples in this paper are activities in the ATRIUM (Air Turbo Rocket for Innovative Unmanned Mission) project[4] led by JAXA/ISAS. The launch vehicle developed in the ATRIUM project is a new concept system which has both the air-turbo engine and the rocket-engine. Currently, we are developing the sub-scale FTB (Flying Test Bed) to demonstrate the various technologies required for this new type of rocket[5]. The FTB will fly within the next two or three years. Interactive modeling with Balus is practiced in the system design for the sub-scale FTB.

2.2 Context

The context view is used to identify external elements and stakeholders that interact with the system of interest[6]. Stakeholders and external elements identified in the context model are the source of requirements. Figure 4 shows the results of the modeling in the context view.

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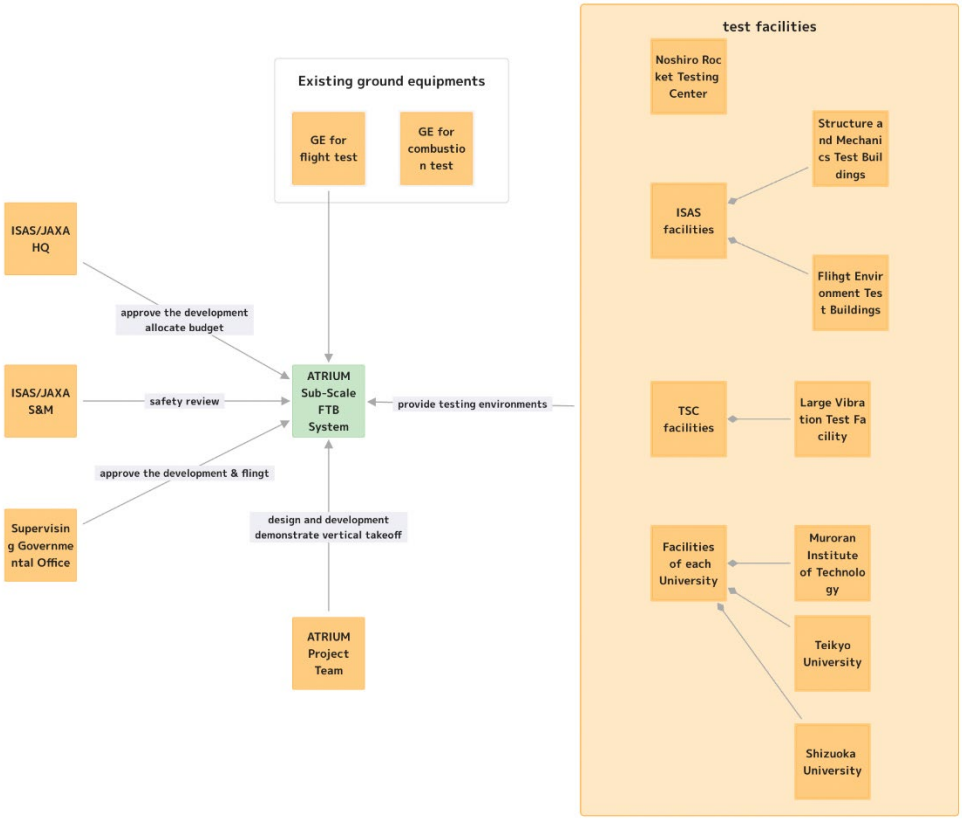

Figure 4: Context Model

2.2 Requirements

In the Requirement view, the upper-level requirements are divided and specified to derive the lower-level requirements. In this view, functions and behaviours required for the system are agreed upon. Figure 5 shows the results of the modeling in the requirement view.

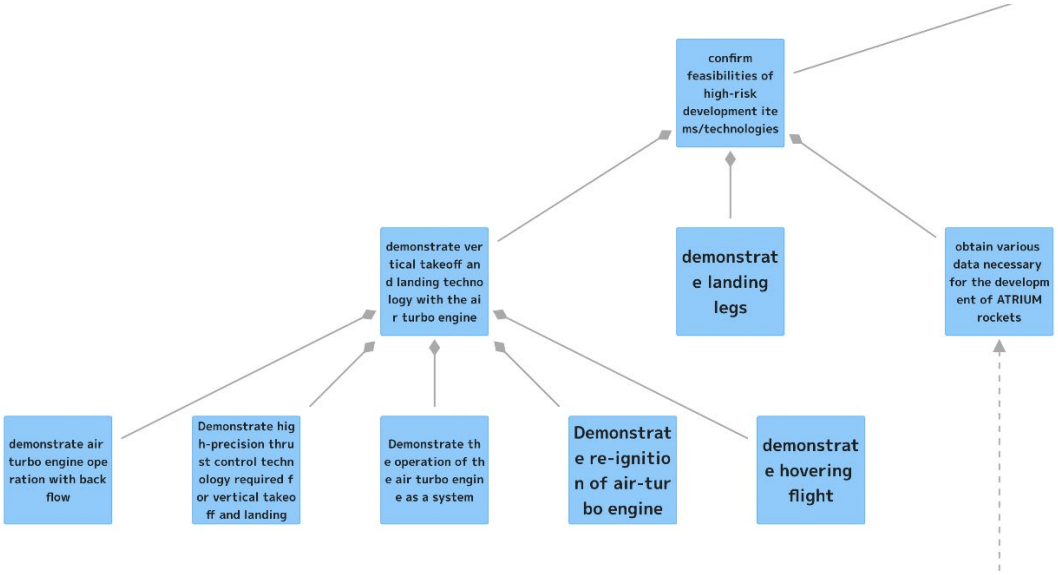

Figure 5: Requirement Model

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2.3 System Structure and Interfaces

After defining the functions and behaviours of the system, it is necessary to think about the configuration of the system. Figure 6 is a model I constructed to discuss how to divide the system into subsystems and what components to have.

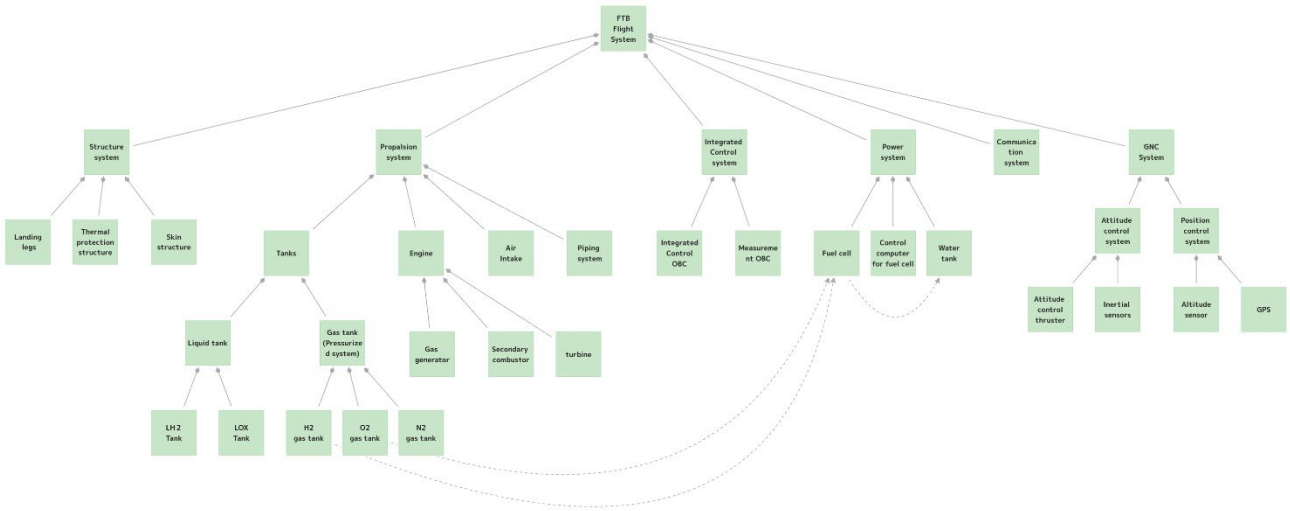

Figure 6: System Structure Model

After subsystems and components are defined, the interfaces between them must also be recognized. Interactive system modeling is also useful for identifying and discussing interfaces. Figure 7 shows an example of the results of such a discussion.

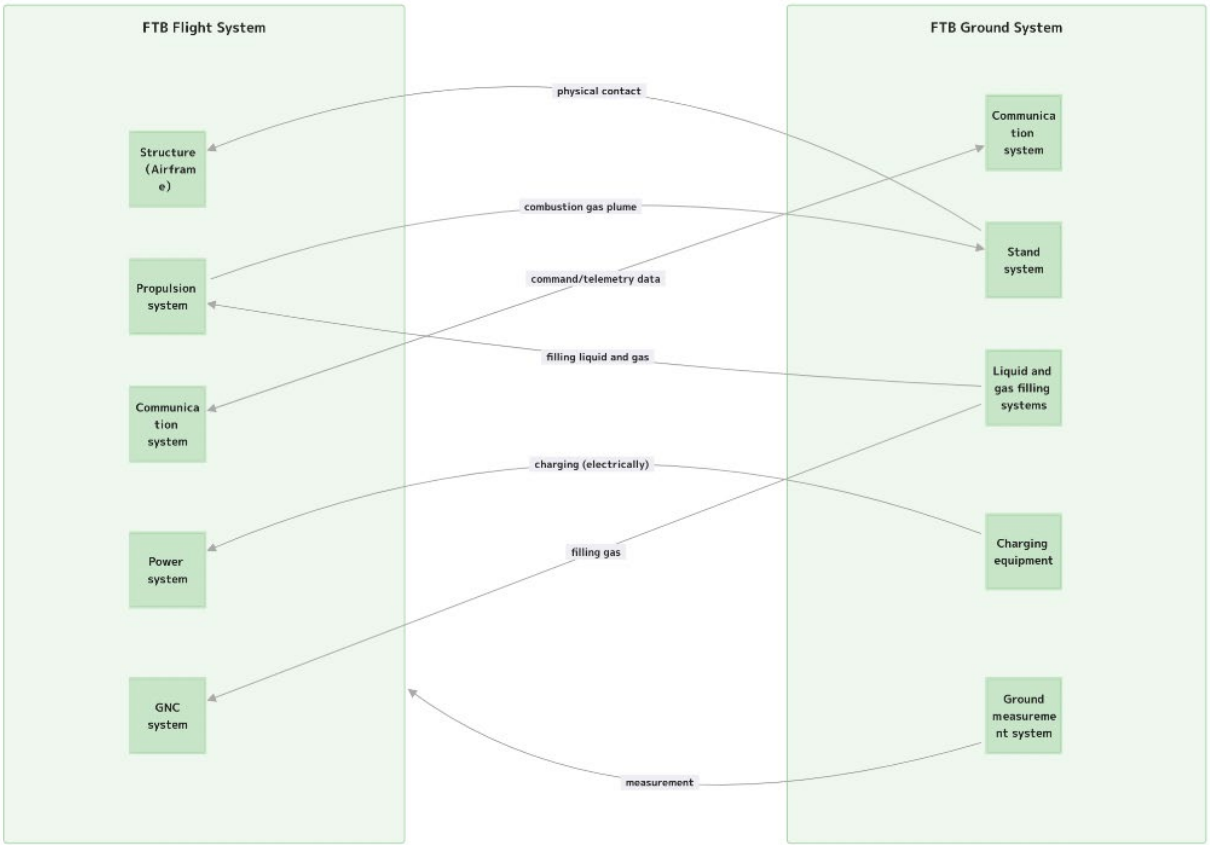

Figure 7: Interfaces of Flight System / Ground System

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3. Summary

When designing a new concept system, it is often difficult for stakeholders and project members to have a common understanding of the system, and consensus building is often inefficient. The same challenges were faced when designing a new concept launch vehicle. Therefore, we attempted to make consensus building more effective by interactive system modeling using Balus. In the development of sub-scale FTB for the ATRIUM project, interactive system modeling using Balus was practiced based on the view model shown in Figure 8. This allowed us to achieve effective consensus building and upstream design.

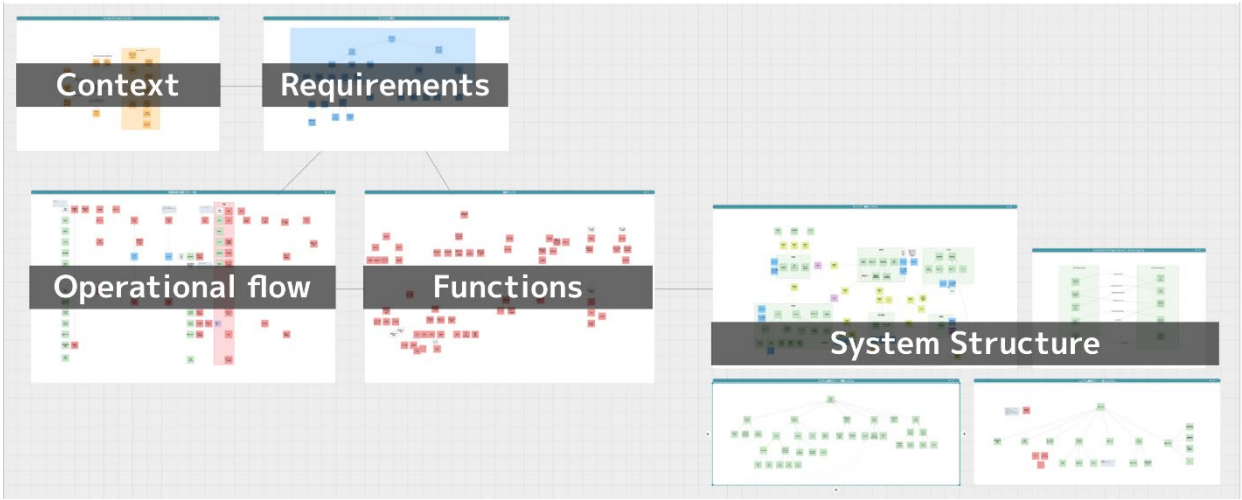

Figure 8: View model used in interactive system modeling for ATRIUM FTB design

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