Abstract—Adopting the Space launch vehicle virtual test platform as research object, and focusing on the key functional demand of distributed virtual test based on numerical simulation, a new architecture based on the Model Driven Architecture (MDA) and High Level Architecture (HLA) is discussed. In the vertical, it separates the federate members’ logic behavior and code integrated manner, so that the work of developing the platform-independent model and platform specific model can be finished at the same time. In the horizontal, the using of HLA can partially achieve the reusability of the models. So the benefit using MDA and HLA in simulation is the reusability and interoperability of the models in whole lifecycle of the software. Using the Measurement Studio to develop the virtual instruments can improve the real-time performance and the architecture based on the MDA and HLA can meet the demands of the Launch Vehicle Test and Simulation System.

Index Terms—launch vehicle, virtual test, model driven architecture, high level architecture, measurement studio

I. INTRODUCTION

Lack of the real equipments has always been an important issue in daily training in launch center. In the pre-developed rocket digital simulation platform, High Level Architecture (HLA) is proposed in system and the effective integration of numerical simulation and the scene simulation based on HLA is realized. The platform realizes the rocket flight simulation and other functions, greatly reducing the training cost-effective and has a certain innovation [1].

As far as the HLA specified [2], HLA has not contacted closely with other areas of similar middleware technologies, resulting that the application of HLA mainly concentrated in specific military fields. Hence, the existing simulation components’ reusability just limits in the range of HLA. If other distributed simulation technologies want to translate to the HLA, even though the actual simulation of the system behavior does not change much, but just in order to migrate to RTI simulation support environment, the federal members should be re-developed and simulation components need to rewrite their code. So in the field of modeling and simulation, an advanced software engineering technology is needed urgently to solve these problems.

Model Driven Architecture (MDA) is a software development methodology [3], which developed by the Object Management Group (OMG) aimed to increase the productivity of software development and the portability and interoperability, in the whole life cycle of software [4]. Thus using the design models designed by MDA, and combining the idea of HLA to achieve the architecture of the launch vehicle simulation system, not only the technical results of pre-system can be used, but also can meet the needs. Taking into account of the possible new simulation technology in the future, the openness of the system can be improved, as well as the portability in the new simulation platform.

II. APPLICATION REQUIREMENT OF LAUNCH VEHICLE TEST AND SIMULATION SYSTEM

A. The Main Requirement of Launch Vehicle Test and Simulation System

To establish the test and simulation platform in far-controlled manner, the specific requirements are:

1) Using modeling technologies to carry out numerical simulation and scene simulation of the main equipment of the rocket, as well as the establishment of virtual instruments.

2) Subsystems constitute the overall launch vehicle with a form of federation through the HLA-RTI (Run-Time Infrastructure) proposal, and in the HLA common platform, complete the test and simulation of the rocket system.

After the establishment of the system, all the information, like the test theory, the testing process, test parameters and the interpretation of the results, will be showed in visual form. And the system can be used to additional tests, and to achieve real-depth development of rocket test through connecting with the real rocket.

B. Functional Requirement and Constitutes of Launch Vehicle Test and Simulation System

According to analyze the functional demands of Launch Vehicle Test and Simulation System, initially the
system should be constituted by numerical simulation, scene simulation and test simulation module.

1) Numerical simulation module

The numerical models which are of the control systems, telemetry systems, external security systems and power systems should be established primarily and then can be used to simulate the functions requirements.

2) Scene simulation module

Using the virtual scene technology to build the visual simulation model of the rocket with a high degree of details of the model to result in a smooth continuous movement, some visual simulation models need respond to the user's input.

3) Test simulation module

Virtual Instruments are designed in the light of the actual operation of equipment used in Xichang Satellite Launch Center.

III. DESIGN OF ARCHITECTURE FOR LAUNCH VEHICLE TEST AND SIMULATION SYSTEM

The architecture of Launch vehicle test simulation system is designed mainly for the function that focusing on numerical model based on distributed virtual test and must ensure that the system is real-time, taking into account three-dimensional system reusability and interoperability and can be scalability and reliability.

A MDA-based system contains two major parts, which are platform-independent model (PIM) and platform specific model (PSM). Using of MDA in the entire software development life cycle, the first step is to establish the PIM of the system, which is just designed one time. And then selecting the appropriate software platform, through the development of specific mapping rules for model transformation, the PIM will be transformed into PSM, which will be finally converted to program code.

Based on understanding the simulation system functions required to achieve, combined with MDA for the development of thinking, the architecture, in the vertical, includes systems, simulation and software, respectively corresponding to the MDA's PIM, PSM and HLA-related platform, shown in Fig.1.

First, analyzing the actual measurements system of rocket, unit testing, subsystem testing and whole system testing are included. Different systems test different items and require the combination of numerical simulation systems, scene simulation systems, and virtual test systems, which are all belonged to PIM and need the UML to accomplish.

Second, it is the PSM. For each simulation system, respectively, through a variety of modeling techniques to develop different models, including the numerical models, scene models and virtual instruments for testing and at the same time in order to ensure a real-time system, as well as the establishment of a federation in the platform of HLA, the corresponding middleware are needed to develop. Simulation of the test requires a control system in general management, meanwhile, and public databases for the need of completing data backup and saving models.

IV. REALIZATION OF THE ARCHITECTURE OF LAUNCH VEHICLE TEST AND SIMULATION SYSTEM

Launch Vehicle Test and Simulation System realizes the test functions, including the unit equipment, subsystems and the total system test and simulation. When testing, the scene models and test equipment are real-time driven by numerical model. Through displaying critical data, monitoring and analyzing the testing process and results of training, all these provide a good example to the simulation environment.

The overall technical architecture of Launch Vehicle Test Simulation System adopt the MVC mode, which shown in Fig.2.

Figure 2. Functional structure of Launch Vehicle Test and Simulation System.

First, analyzing the actual measurements system of rocket, unit testing, subsystem testing and whole system
A. Measurement Studio for VC++

Measurement Studio for Visual C++ is provided by National Instruments (NI), which is embedded directly into VC++ development environment for software development [5].

Measurement Studio for VC++ and VC++ development environment are similar in use, but just a slightly different in generate framework in using the application wizard. After the generations of the application Framework, the Measurement Studio controls package categories can be seen in the Class View window of the work area. Measurement Studio User Control can be used by visiting and calling these types of member functions and member variables. One of the Test UI with the Measurement Studio is shown in Fig3.

B. Design the platform of HLA

In Launch Vehicle Test and Simulation System, the whole rocket is regarded as a federation, which consists of some interactive federates, Federation Object Model (FOM) and RTI. Fig.4 is the logic frame of the Launch Vehicle Test and Simulation System flat.

The logic structure of Launch Vehicle Test and Simulation System flat is constituted by four components: 1) Central RTI Component (CRC) is an Overall situation course, which manages several different federations and also their establishment and end. Each member of federations is initialized by communicating with CRC and joins in the corresponding federation. CRC offers an interface of graph and order line to manage federations and to dispense tasks among LRCs (Local RTI Component).

2) Federate member mean the one that joins in the federation can be carried out by computer languages such as c++, JAVA and so on.

3) Local RTI Component (LRC): is to take charge the communication between federates and federate members. And LRC itself is constituted by classes and methods, which control the communication with federations.

4) FOM File is an executive file of federation which describes the FOM.

As a development platform of distributed simulation system, the key technologies of HLA that need to be addressed are: the logic of federal executive, the federal synchronous mechanism.

V. CONCLUSION

This paper analyzes the functional demands of Launch Vehicle Test and Simulation System, and then ascertains its basic parts and its development structure including the MDA and HLA and the logical structure of the system. In the realization of the system, the specific technologies are given, like the Measurement Studio for VC++ and HLA. The result of simulation shows: this architecture can satisfy the requirement of Launch Vehicle Test and Simulation System, and broaden the using range of HLA. This paper has the certain reference value to the design of distributional real-time test and simulation system.

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REFERENCES


