The Test and Launch Control Technology for Launch Vehicles

Zhengyu Song

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國防工業出版社
National Defense Industry Press

Springer

Zhengyu Song
China Academy of Launch Vehicle
Technology
Beijing
China

ISBN 978-981-10-8711-0 ISBN 978-981-10-8712-7 (eBook)
https://doi.org/10.1007/978-981-10-8712-7

Jointly published with National Defense Industry Press, Beijing

The print edition is not for sale in China Mainland. Customers from China Mainland please order the print book from: National Defense Industry Press, Beijing

Library of Congress Control Number: 2018934445

Printed on acid-free paper

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
part of Springer Nature
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

The main function of a rocket is to fly reliably and stably and deliver the payload into orbit accurately. Although this should be achieved by the excellent performance of onboard systems (OBSs), ground test and launch control systems (TLCSs) also play vital roles to ensure success. On the one hand, the TLCS provides comprehensive checks and verification for the rocket's function and performance, minimizing technological risks in advance; on the other hand, the TLCS itself is an important part of the prelaunch facilities, critical to completing the task reliably, and particularly for launch site safety. To cope with the increasing competition in the launch service market, many countries have recognized TLCS contributions. With the intensive launch activities nowadays, it is widely accepted that improving efficiency, reducing costs, and getting into and out of space responsively, while still ensuring high reliability and safety, have become the major competitiveness factors in the aerospace industry.

This book is written in the context explained above. It is divided into seven chapters, focusing on the design of the launch vehicle ground test and launch control system, giving consideration to the equipment level tests and the simulation tests, and conducting a special discussion on the responsive test and launch control technology. The book comprehensively reflects China's achievement and the latest progress in these fields.

The first chapter introduces TLCS' development worldwide and the status of related technologies in China. The corresponding technologies of the NASA-led project, ESA Ariane 5 launcher, and JAXA Epsilon rocket are introduced as key points of the present situation of the US, Europe, and Japan. Among them, the responsive test and launch control is alleged as the main innovation of Epsilon, the Japanese newly developed small solid rocket. At the end of this chapter, the Chinese TLCS development is briefly reviewed and prospected.

The second chapter introduces the launch vehicle's electrical system testing technology in general. First of all, it sorts out the current testing technologies from various viewpoints and then proposes different corresponding classification methods. The chapter then presents a brief introduction from four aspects of test activities: Equipment level, system level, launch site, and software testing.

Subsequently, test system design is also introduced in terms of the test requirements, including basic test system development processes, design for test (DFT) technology, typical testing equipment with various bus technologies, etc. At the end of this chapter, the future testing technology development is discussed.

The third chapter introduces the equipment level test technology, which incorporates functional/ performance and reliability testing. Considering the features and complexity of the control system equipment functional test, it introduces two equipment categories: Controllers, including the OBC, and inertial devices, including the IMU and other devices composed of accelerometers and rate gyros. It also considers reliability testing, including reliability growth and enhancement tests. At the end of this chapter, some cautions on the product verification (acceptance) tests are analyzed and explained.

The fourth chapter introduces the system level test technology, which incorporates the subsystem and the system level test. The former test is a functional static test where the notion of "subsystem" is relative. In general, the control system itself is a subsystem but the "subsystem" here refers to a small system composed of multiple devices. The subsystem test must cover the functional inspection of all the onboard products under the system connection state, and the test items should be adapted to the implementations on the launch site. The system level test is the flight simulation with a complete LV electrical system, mainly referred as the general check in China and is performed hierarchically. Through the test, the LV avionics performances, the coordination between the OBS and the TLCS, along with the electromagnetic compatibility between the rocket and the ground system, are being assessed. For the newly developed rocket, the engine and propellant system tests are very necessary and are also introduced as system level test.

The fifth chapter discusses the simulation test technology, which is another kind of system level test. It first reviews the simulation technology in the aerospace industry, with particular attention to LVs, and then discusses the simulation testing for LV control systems along with the basic simulation testing principles. Subsequently, it briefly introduces the modeling, simulation process, and the boundary conditions commonly applied for the LV simulation analysis. The modeling relates to the model design of the control system avionics and the LV motion, including the small deviation motion and 6DOF simulation model. The boundary simulation conditions reflect the evaluation criteria on the system performance.

The sixth chapter introduces the launch control technology, taking the widely used remote launch control technology as the basis. The launch control process, the front-end and back-end facilities, and the network systems are being discussed. Because of the importance of the launch control technology, the safety levels of launch control related software are higher than other ground test software. So under this background, the chapter introduces the ground TLCS software system, including software reliability design, and the corresponding technologies unique to the ground TLCS software.

The seventh chapter introduces the responsive test and launch control technology, focusing on the means to improve testing efficiency, simplify operations, and adopt intelligent data analysis to reduce on-site technical support personnel. It reflects the latest research results in this field, and the experience gained in the practical use of other countries' launch vehicles is also supplemented in this chapter.

Due to the space limitation, this book cannot include all aspects of launch vehicle TLCS. It starts with the discussion from the traditional launch and control system, taking into account the electrical equipment level test, engine and propellant system test, as well as the simulation test. The book does not give detailed and specific hardware or software design, but it expatiates mainly from the aspects of testing principle, purpose, process, etc., and lets the readers grasp the nature of test and launch control technologies.

The compilation of this book has been helped by many colleagues, especially Mr. Li Xinming. The intended audiences of this book are engineers of launch vehicle TLCS and avionics system, and operation staffs on the launch sites.

Beijing, China Zhengyu Song
January 2018

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Brief Introduction

This book sums up systematically the author's research work in launch vehicle test and launch control system (TLCS), and the book is divided into seven chapters, where the overall electrical system test, equipment level test, system level test, simulation test, and launch control technology are introduced. In the end of the book, the author discussed special subject for responsive test and launch control, which are essential to the increasing demands for responsive, reliable, and economical to and from the space. There are many best practices in the book, which are benefit for better understanding of these technologies.

This book can serve as references to designers of TlCS, overall and avionics system, and operators in launch site. It also has certain reference value to the test engineers, and other spacecraft designers.