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Space Propulsion Development for the 21st Century

NOW, in 1998, we are approaching the dawn of the 21st century. Let us recall that the first launch of a German V-2 rocket in 1942 laid the foundation for modern launch vehicle technology. The launch of the first satellite by the Soviet Union in October 1957 showed that mankind had the ability to access space, and since then, great achievements have been made in space technology. Satellite-transmitted global communication, radio, and television signals are received in private homes; weather forecasts, exploration of the Earth's resources, navigation, and global positioning via satellites have made great contributions to the development of the world economy. Man landing on the moon and the exploration of other planets and deep space by unmanned craft have opened a new route for the development of space science. Considerable progress has been made in medicine production and material processing in microgravity environments. The establishment of the International Space Station will offer a common orbital infrastructure for space research in the next century. It is the responsibility of space scientists to chart a course for development of space technology in the 21st century.

Launch-vehicle and satellite technologies are the core space technologies. The performance of rocket propulsion systems is a dominant factor in determining the payload capability of launch vehicles. Let us consider the history of rocket propulsion. The V-2 rocket engine generated 267 kN of thrust at a chamber pressure of 1.47 MPa, had a specific impulse at sea level of 218 s, and used a gas-generator system with LOX and an aqueous ethanol solution as the propellants. But the RD-170 currently used in Russia's Zenit rocket has a thrust of 7250 kN, chamber pressure of 24.5 MPa, specific impulse at sea level of 309 s, and uses a staged-combustion system with LOX and kerosene as the propellants. Other propellants, such as N_2O_4-UDMH, and LOX-liquid hydrogen have been successfully used in other modern rocket propulsion systems.

This example shows how the performance and payload capacity of launch vehicles have improved with the progress of technology. Developments in electronic components, automatic control technology, and computer technologies have led to great improvements in the performance, mass reduction, and reliability of rocket control systems. But even so, the basic layout, contents, and functions of the subsystems of current launch vehicles, including the United States' Space Shuttle and Russia's Energia, are fundamentally similar to those of the V-2.

It obviously takes a long time—weeks, even months—to prepare a launch at a launch site. It often happens that the launch date is delayed for one reason or another on the launch pad. The launch pad and tracking station facilities are huge and complex. The results are high launch costs and restriction of the progress of space activities.

For a commercial launch of a GTO satellite, if we assume a satellite mass of 2.5 tons, the launch cost is between $55 and $60 million. The commercial development of space has significantly raised requirements for launch vehicles. That is, space launchers must be as safe and reliable as other transportation systems, and turnaround, checkout, and launch processes must be faster and more punctual.

To ensure that the performance of launch vehicles will meet the requirements for the further development of space exploration, the first thing to be done is to develop new rocket propulsion systems, especially new engines. The United States has made the decision to develop a single-stage-to-orbit reusable launch vehicle, and has set up the X-33/X-34 project to demonstrate key technologies for a next-generation space transportation system, which is planned to be operational in the early 21st century. It is expected that the launch cost can be reduced by an order of magnitude. From my personal point of view, I would like to express my admiration of their courage and insight, and appreciation of this decision.

In this special issue, experts in propulsion systems from the space-faring nations have gathered to discuss the development of propulsion systems for the 21st century. It is my belief that this issue will make important contributions to the development of the world's future propulsion systems.

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