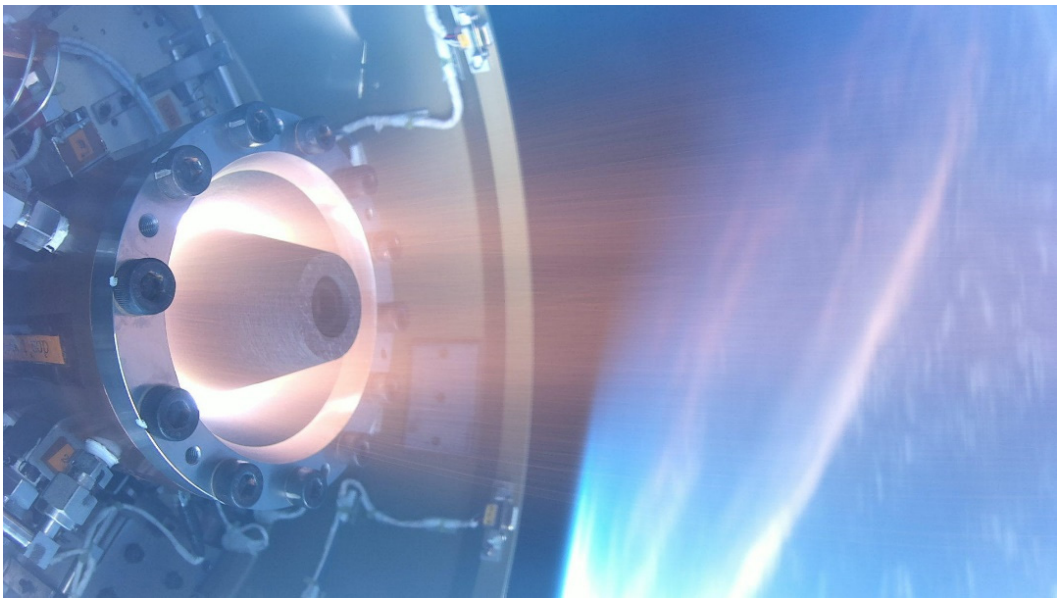


World First! Successful Space Flight Demonstration of Detonation Engines for Deep Space Exploration

A research group at the Institute of Materials and Systems for Sustainability, Nagoya University and the Graduate School of Engineering, Nagoya University, in collaboration with Keio University, Institute of Space and Astronautical Science (ISAS) of the Japan Aerospace Exploration Agency (JAXA), and the Muroran Institute of Technology, has successfully demonstrated a detonation engine in space flight. This is the world's first successful demonstration of a detonation engine in space flight.

The detonation engine system developed in this study was loaded onto the mission section of the sounding rocket S-520-31 and launched from the JAXA Uchinoura Space Center at 5:30 a.m. on July 27, 2021. After the separation of the first stage rocket, the rotating detonation engine and pulse detonation engine were successfully operated in space, and photo images, pressure, temperature, vibration, position, and attitude data were acquired by telemetry and RATS (Reentry and Recovery Module with Deployable Aeroshell Technology for Sounding Rocket Experiment). The fuel is methane and the oxidizer is oxygen.

The detonation engine generates detonation and compression waves at extremely high frequencies (1–100 kHz) to drastically increase reaction speed, leading to radical reduction of rocket engine weights and high performance by easy generation of thrust. The success of this space flight demonstration will bring the detonation engine much closer to practical use as a kick motor for deep space exploration, and as a first and second stage engine for rockets.

The results of this research will be published in academic journals after detailed analysis of the flight data. The development of the detonation engine system was carried out in cooperation with Nets Co., Ltd., and Meiji Electric Industries Co., Ltd.

This research was supported by the Strategic Development Research (Engineering) of the Advisory Committee for Space Engineering, Institute of Space and Astronautical Science, JAXA, from 2014–2021, the NEDO Feasibility Study Program on Energy and New Environmental Technology from 2014–2016, and the JSPS Grant-in-Aid for Specially Promoted Research from 2019–2023.

Major points

1. We present the world's first successful space flight demonstration of detonation engines.
2. The rotating detonation engine (RDE) and pulse detonation engine (PDE) were successfully operated in space under the flight environment, and the operating data of these engines were successfully acquired.
3. The results of this study show that the detonation engine is very close to practical use as an aerospace engine, such as a kick motor for deep space exploration.

Research background and content

The detonation engine generates detonation and compression waves at extremely high frequencies (1–100 kHz) to dramatically increase reaction speed, thereby enabling radical reduction of the weight of rocket engines and increasing their performance by enabling easy generation of thrust. At present, research is actively underway in Japan, North America, Europe, Asia, and Australia with a view to commercialization of a high-performance engine for space use.

This joint research group succeeded in achieving the world's first space flight demonstration of a detonation engine. The detonation engine system developed in this study was loaded onto the mission section of the sounding rocket S-520-31, and launched at 5:30 a.m. on July 27, 2021 from the JAXA Uchinoura Space Center (USC). After the separation of the first stage rocket, the RDE (6-sec operation, 500-N thrust) and PDE (2-sec operation x 3 times) operated normally in space, and images, pressure, temperature, vibration, position, and attitude data were acquired by telemetry and recovery module RATS. The fuel is methane and the oxidizer is oxygen.

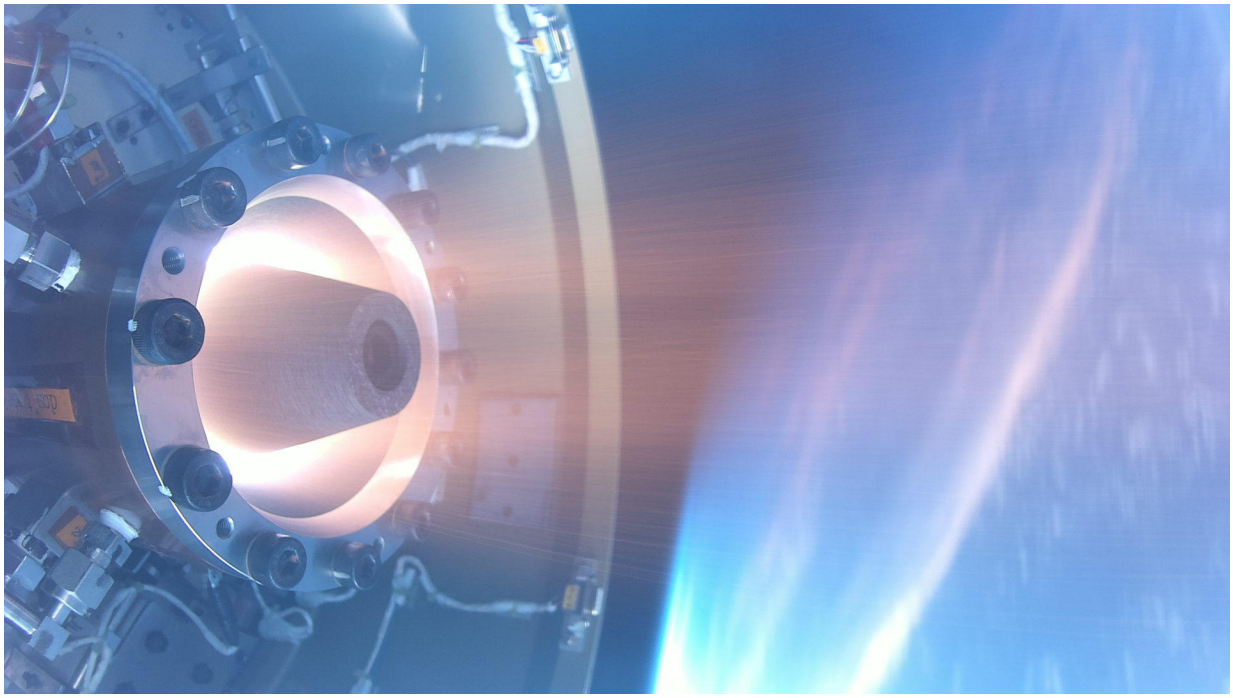


Fig. 1 The moment the world's first rotating detonation engine (RDE) began operations in space. The elliptical luminous area (left) is the combustor of the double-cylinder rotating detonation engine. On the right is an image of the Earth taken from space. Image data was recovered by RATS. [Credit: Nagoya University, JAXA]

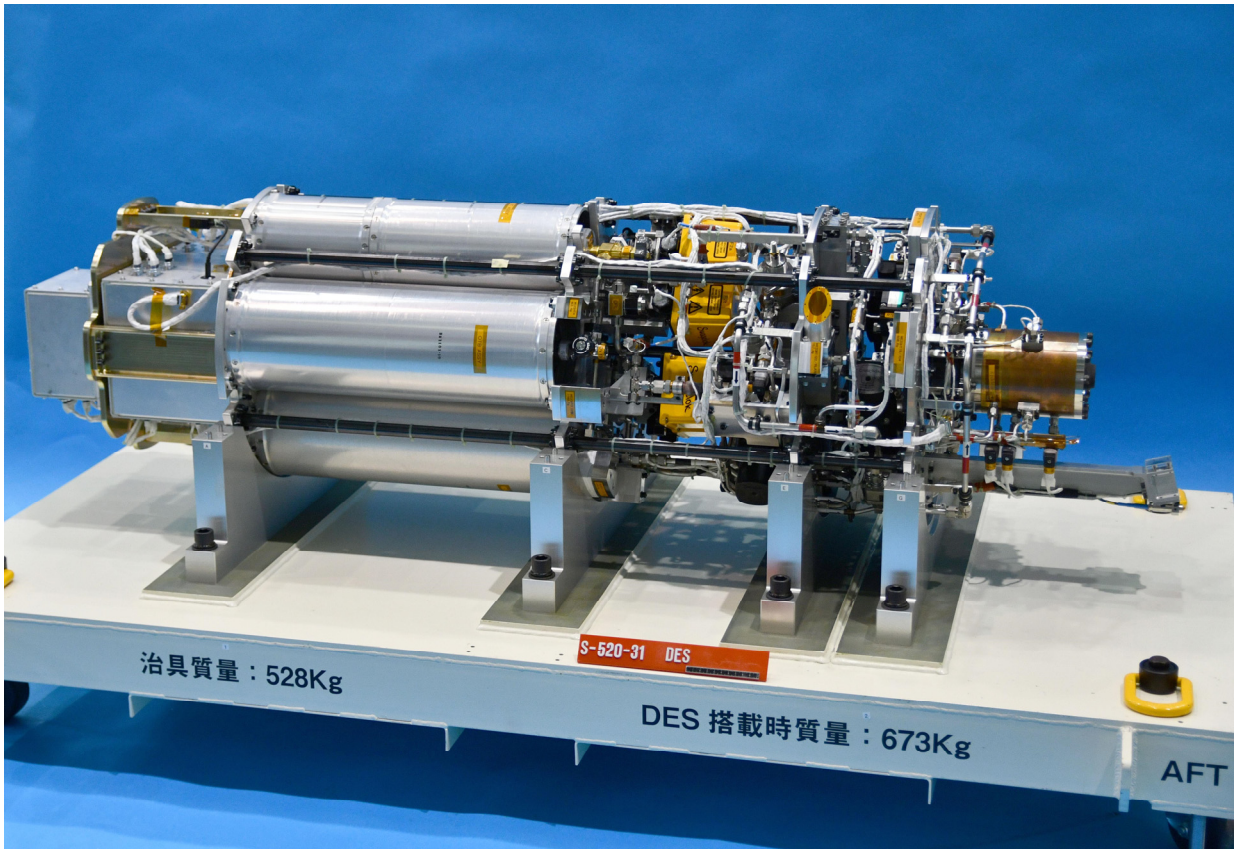
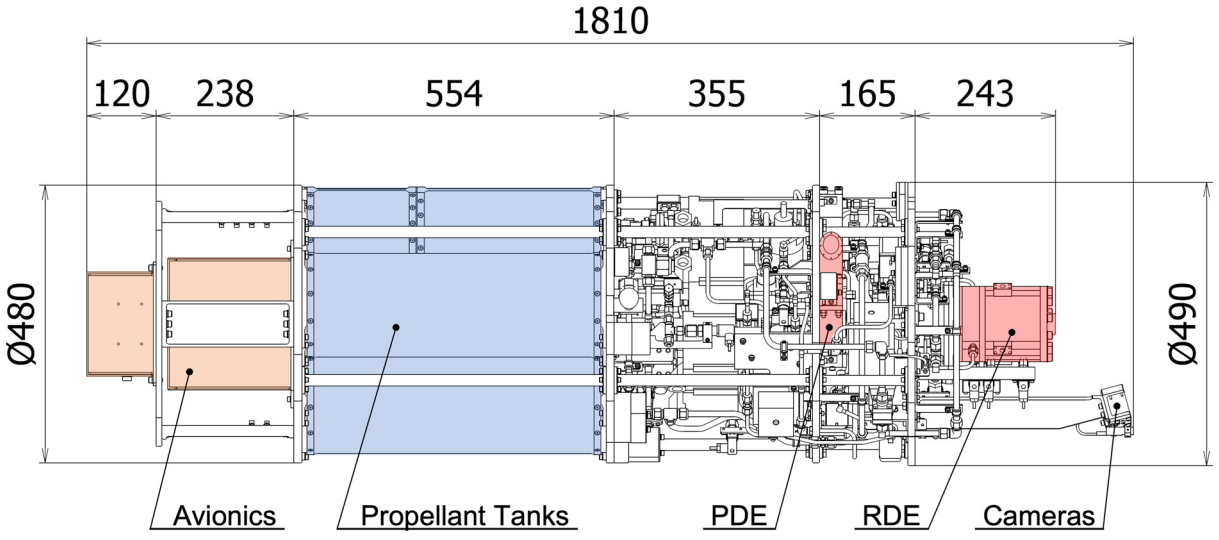


Fig. 2 Photograph of the Detonation Engine System (DES). [Credit: Nagoya University]



Unit: mm
Note: Dimensions are approximate values.

Fig. 3 Schematic diagram of the DES. From left to right: DES avionics (DES-PDU, DES-MCU, PI-BAT-L), methane, oxygen and nitrogen gas tanks (propellant tanks), gas supply system, PDE, RDE, DES cameras and Ku-TV antenna. [Credit: Nagoya University]

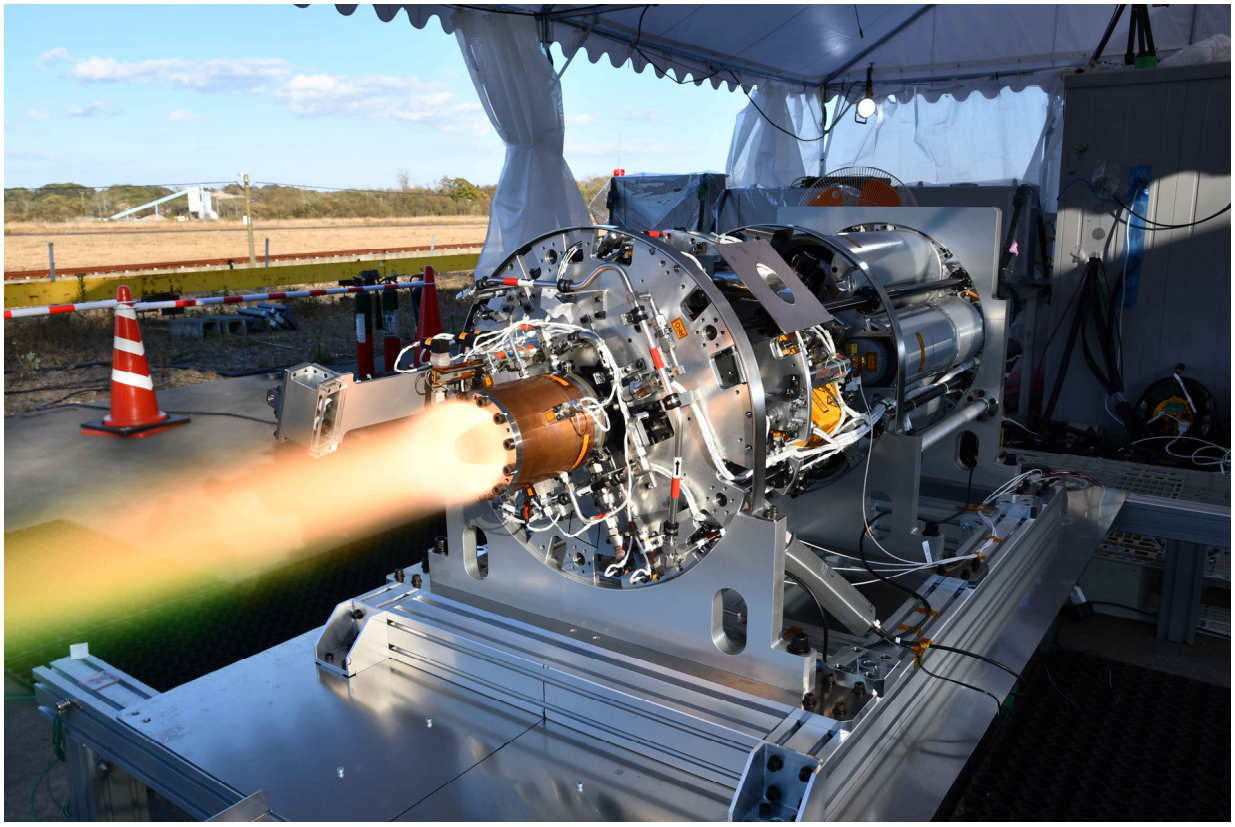


Fig. 4 Ground-based combustion test of the DES at the Shiraoi test site of Muroran Institute of Technology. [Credit: Nagoya University].

Significance of the results

The success of this space flight demonstration will bring the detonation engine much closer to practical use as a kick motor for deep space exploration, and as a first and second stage engine for rockets.

Existing rocket engines will be replaced by detonation engines, because detonation engines are lighter and have higher performance. In other words, the results of this research will be a catalyst for major changes in aerospace engines and systems.

Researcher Contact Information

Nagoya University
Institute of Materials and Systems for Sustainability
Jiro Kasahara, Professor
TEL: +81-52-789-4404
E-mail: kasahara@nuae.nagoya-u.ac.jp

Nagoya University team members researching detonation engine system (DES) part

Jiro Kasahara, Professor
Koichi Matsuyama, Designated Professor
Ken Matsuoka, Associate Professor

Akira Kawasaki, Assistant Professor
Hiroaki Watanabe, Assistant Professor
Noboru Itouyama, Designated Assistant Professor
Keisuke Goto, Designated Assistant Professor
Kazuki Ishihara, Graduate Student
Valentin Buyakofu, Graduate Student
Tomoyuki Noda, Graduate Student
Yuki Akimoto, Graduate Student
Koyo Kikuchi, Graduate Student

Related information

Article on ISAS/JAXA web site (in Japanese)
https://www.isas.jaxa.jp/topics/002693.html
Propulsion and Energy Systems Engineering Research Group, Nagoya University
http://www.prop.nuae.nagoya-u.ac.jp/index.html

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