


## Detonation Engine Physics Elucidation: International Joint Research on Space Flight Demonstration

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	Project Information	Project Number : 23K20036 Project Period (FY) : 2023-2029 Keywords : Detonation Engine, Propulsion, Aerospace, Sounding Rocket

### Purpose and Significance of the Research

#### ● Novel detonation engine element, system, and flight research

On July 27, 2021, using the S-520-31 sounding rocket of JAXA's Institute of Space and Astronautical Science (ISAS), this research group succeeded in the world's first space flight demonstration of a detonation engine system (Fig. 1). This research group is one of the world leaders in the field of detonation engine research. This research group needs to develop more innovative research and foster young, ambitious researchers through strong international collaboration with the United States (Purdue University: leading PGC gas turbine research) and Europe (Technical University of Berlin: leading PGC analysis research).

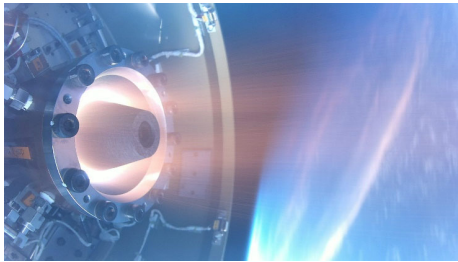


Fig. 1 The world's first detonation engine in operation in space (JAXA sounding rocket S-520-31 experiment)

This research will investigate the key issues of rotating detonation engines (dynamic rotating detonation engines, liquid propellant rotating detonation engines, system integration, and space flight demonstrations) and elucidate the key physics of these issues.

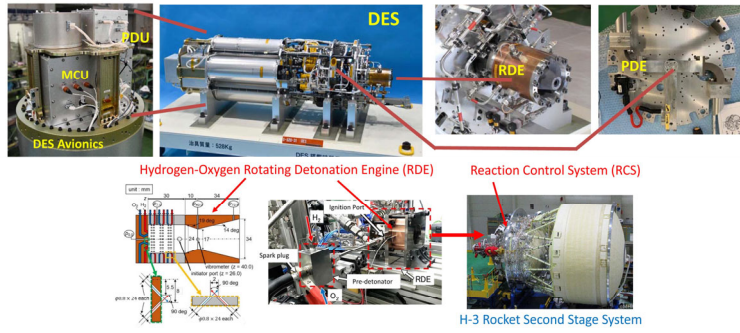


Fig. 2 System integration into a sounding rocket (top) and space flight demonstration on H3 (bottom)

### Organization of the Project Team

#### ● The international network of detonation engines built over the past 20 years

The rotating detonation engine has been actively studied in Japan, Europe, U.S., and Asia with a view to its commercialization as a high-performance engine for space applications. Pressure Gain Combustion (PGC) Technical Committee within AIAA, which has been actively conducting research since 2015. The results of this research group have been published as experimental photos representing the PGC Technical Committee in the Year in Review 2016, 2017, 2019, and 2021 of the AIAA (Fig. 3). On July 27, 2021, using the S-520-31 sounding rocket of JAXA's Institute of Space and Astronautical Science, this research group (Fig. 4) conducted the world's first space flight demonstration test of the detonation engine system, and was presented with five academic international awards, and gave eight international invited lectures.



Fig. 3 Aerospace America's Year in Review

#### Research Organization

(1) Physics of Detonation Combustor Experiment Nagoya Univ. Kasahara, Matsuoka, Kawasaki Numerical Analysis Keio Univ. Matsuo Postdoctoral Fellow Graduate students	(2) Physics of Detonation Turbine Experiment Nagoya Univ. Kasahara, Matsuoka, Kawasaki Purdue Univ. Paniagua Postdoctoral Fellow Graduate students	(3) Combustor and Turbine Integration Experiment Nagoya Univ. Kasahara, Matsuoka, Kawasaki Purdue Univ. Paniagua Postdoctoral Fellow Graduate students	(4) Flight Experiment on Earth Orbit Experiment Nagoya Univ. Kasahara, Matsuoka, Kawasaki JAXA/ISAS MURoran Institute of Tech. Postdoctoral Fellow Graduate students
Joint research and workshops (every six months)		S-520 Sounding Rocket Flight Experiment Meeting	
MH/III   Catech   JAXA Research Division	Detonation Kick Motor Sounding Rocket Orbit Injection Demonstration WG (Japan 2018-18-2)		
Collaborative Research Catech: Prof. Shephard JAXA: Dr. Kojima, Dr. Kawashima, Dr. Ianno MH: Mr. Sato IHI: Dr. Nagao, Dr. Ito PGC Committee Workshop NASA: Dr. Pearson GE: Dr. Tangirala Aerjet Rocketdome: Dr. Cefin University of Poitiers: Prof. Ziboun, MBDA: Dr. Falempin Pusan National University: Prof. Choi University of Texas: Prof. Lu	Detonation Kick Motor Sounding Rocket Orbit Injection Demonstration WG (Japan 2018-18-2) Nagoya University: Prof. Kasahara Prof. Matsuoka, Prof. Kawasaki Keio University: Prof. Matsuo JAXA/ISAS: Prof. Furuaki, Prof. Habu, MURoran Institute of Tech.: Prof. Nakata, Prof. Utsumi Hiroshima University: Prof. Endo Yokohama National University: Prof. Isha Kyushu Institute of Tech.: Prof. Kitagawa Satama Institute of Tech.: Prof. Fukuchi		

Fig. 4 The project team collaboration

### Plan for Fostering Early-career Researchers

#### ● Fostering a young professional community of Japan, USA and Germany

During the entire period, 36 young researchers (3 designated assistant professors, 3 post-doctoral fellows, 10 doctoral course students, and 20 master course students) will be trained. They will be sent to Nagoya University, Keio University, JAXA, Muroran Institute of Technology, Purdue University (Fig. 5), and Technical University of Berlin (Fig. 6). The following (1)-(8) will be implemented to lead the community. To join (1) AIAA Short Course (Pressure Gain Combustion), (2) AIAA SciTech, (3) IWDP/ICVDCW, (4) Marie Curie Innovative Training Network Interact with young researchers at INSPIRE. (5) the Detonation Young Researcher Forum, (6) the Japanese Detonation Research Society Young Researchers Summer School, (7) ICDERS, (8) the International Symposium on Combustion.

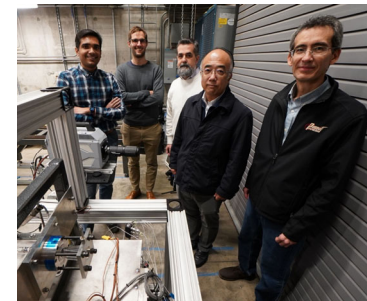


Fig.5 Collaborative research at Purdue University



Fig. 6 IWDP/ICVDCW2022 at Technical University of Berlin