



# Exploration technology in a wide range of unexplored areas

## Objective

To implement coordinated and distributed functionality using multiple, rather than a single, small probes to achieve high-density, arduous surveys over wide unexplored areas, providing a new and innovative exploration strategy.

## Research Topic

Development of small, light-weight advanced probes based on biomimetic robotics, and to construct a self-organization mechanism for a coordinated and distributed system.

## Approach

The required technologies for activities on lunar or Martian surfaces share commonalities with those required on Earth. Therefore, we develop new technologies for lunar and planetary surface exploration through innovations in software, hardware, and system integration achieved here on Earth.



Image of advanced exploration by multiple biomimetic robots

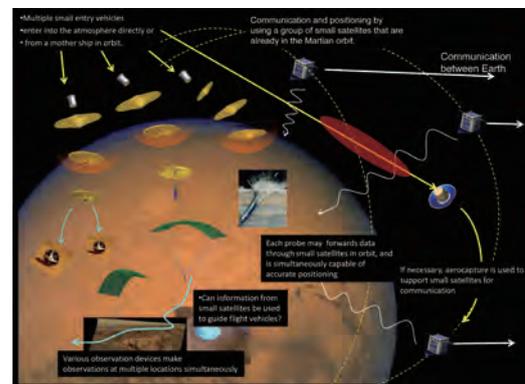


Image of cooperative exploration with multi-landers

## Solution Creating Research

- ▶ Projects with a clear technological target
- ▶ Conduct research over approximately three years, and maximum five years, with a total budget of 100–300 million yen

Project title	Institutions
<b>1st Request for Proposal : Research projects</b>	
Development of the small actuator with the best power density in the world	ShinMaywa Industries, Ltd., OITA UNIVERSITY, Ibaraki University, NIPPON BUNRI UNIVERSITY and Shizuoka University
Development of super small high accuracy absolute angular sensor modulated wave resolver for next generation actuator	EXTCOM Inc.
Development of Small and High-Torque Actuator for Medical and Welfare field	YASKAWA Electric Corporation
Development of innovative soft actuator system and its application technology	MEIJI RUBBER & CHEMICAL CO.,LTD. and Chuo University
Study of water/dust proof multi-stator electromagnetic motor	Adamant Namiki Precision Jewel Co., Ltd.

# Exploration technology in a wide range of unexplored areas

## 2nd Request for Proposal : Research projects

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## 3rd Request for Proposal : Research projects

Development of advanced element of MHz band driven DC-DC converter for compactness and light weight

ICIKAWA ELECTRIC CO., LTD.,  
Shinshu University and Osaka University

## 4th Request for Proposal : Research projects

Multiple Robot System with Stochastic Exploration Area Navigation

TAKENAKA CORPORATION  
CHUO UNIVERSITY

Development of a Material Supply System in Manufacturing Factory with Distributed Cooperative Swarm Robots

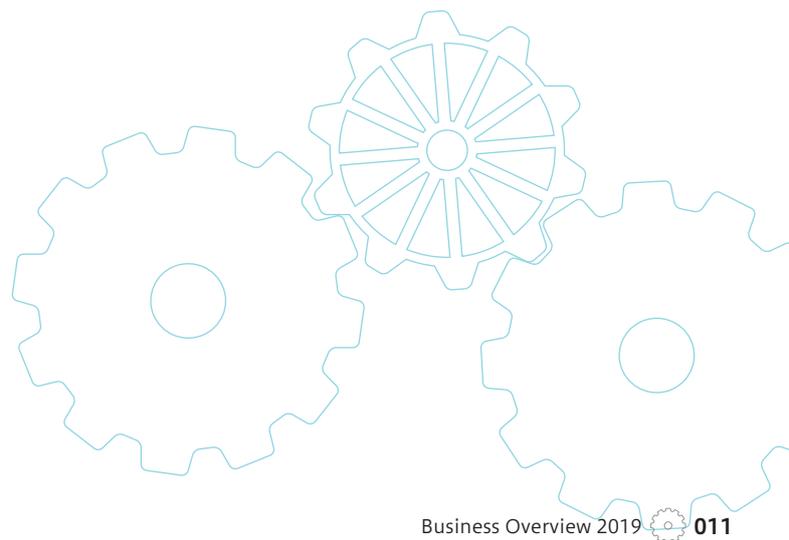
JOHNAN CORPORATION  
KYOTO UNIVERSITY

Development of Automated Guided Vehicle using Collective Movement Control Method For Swarm Robots

Koganei Corporation  
Tokyo Denki University

Development of Peristaltic Mixingpump for Slurry by using Artificial Muscle Actuator

Solaris inc.  
Chuo university  
Bridgestone Corporation  
Hosei University



## Ideas Incubating research

- ▶ Project implemented to discover new technologies and ideas
- ▶ Conduct research over approximately one year with a total budget of 1-5 million yen.

Project title	Institutions
<b>1st Request for Proposal : Research projects</b>	
Insect type small mobile robots for underground and ground surface exploration	PROGRESS TECHNOLOGIES, Inc. and Chuo University
Prototype Development of an Insect-like Robot for Walking/Jumping Exploration	ispace, inc. and Tohoku University
Toy Technology Robotics (Small size, Low energy, Low cost)	TOMY Company, Ltd.
High-efficiency and low-cost wide-area surveillance based on formation control of multiple passive vehicles	Tohoku University
Triangulation-based Simultaneous Localization and Mapping for Massively Distributed Robots	The University of Aizu
Environment-adaptive robotic vehicle for construction site	Takenaka Corporation and Takenaka Civil Engineering & Construction Co., Ltd.
Research and Development on Environment Recognition based Mobility Intelligence of Deformation Mobile Robots with RT Solution Technology	The University of Tokyo and THK CO., LTD.
<b>2nd Request for Proposal : Research projects</b>	
A study on a compact multi-rotor mechanism with high efficiency	Yanmar Co., Ltd., Osaka Prefecture university, Osaka University and Nagoya University
<b>3rd Request for Proposal : Research projects</b>	
Monitoring and Exploration System with Ultra-Low Energy Consumption by Using Field Energy	Tohoku University and Nihon University
System and technology of Stochastic Exploration Area Navigation with Behavior Control of Multiple Mobile Agents	Chuo University and PROGRESS TECHNOLOGIES, Inc.
Research of the high-value added vSLAM technology utilizing ultra-sensitive multi-camera system and deep learning method	Intelligent Vision & Image Systems and ViewPLUS Inc.
Robust Visual SLAM for Textureless Scenes	Qoncept, Inc. and Morpho, Inc.

# Exploration technology in a wide range of unexplored areas

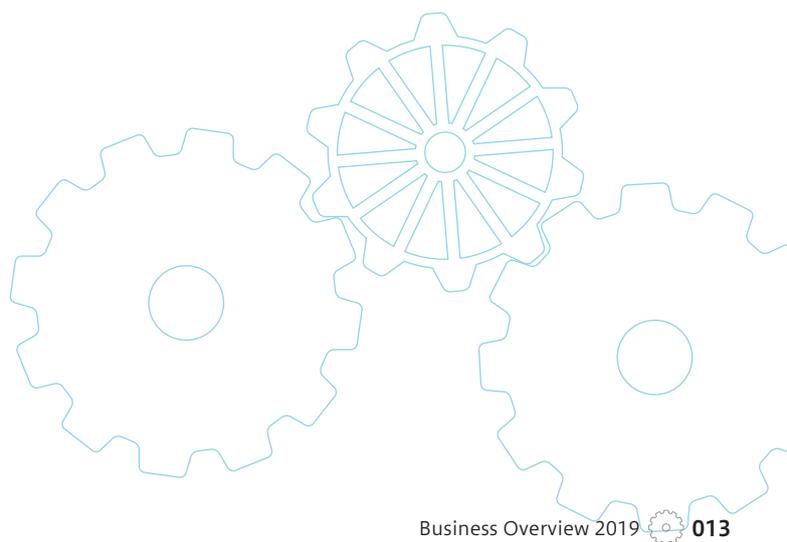
## 4th Request for Proposal : Research projects

Conceptual system design of a deployable inflatable structure

Shimizu Corporation  
Taiyo Kogyo Corporation  
Setsunan University

Research on extremely thin and extremely lightweight inflatable structure by utilizing polyimide films

Saitama University  
Seidensha Electronic Co., Ltd.





# Automatic and autonomous exploration technology

## Objective

Develop "automated/autonomous" exploration technologies to step away from earth-based commanding to realize future unmanned construction of a manned lunar base.

## Research Topic

Bring innovation to space technology by applying Japan's world-class automobile and construction technologies to space, keeping the same-scale but reducing the weight.

## Approach

Focus on critical technologies in space application, such as weight reduction, power consumption, or environment resistance, based on the existing unmanned or automated operation technologies on the ground, not starting from the scratch. Verify the technologies in simulated fields and analog sites, and ultimately aim for demonstration in space.



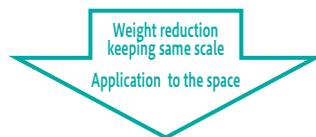
Autonomous Dump Truck  
(image from Komatsu website)



Computerized Construction  
(image from Hitachi Construction Machinery website)



Automated Driving  
(image from Toyota website)



## Solution Creating Research

- ▶ Projects with a clear technological target
- ▶ Conduct research over approximately three years, and maximum five years, with a total budget of 100–300 million yen

Project title	Institutions
<b>1st Request for Proposal : Research projects</b>	
Development and evaluation of the innovative remote construction system by cooperation of remote control and automatic control	Kajima Corporation, Shibaura Institute of Technology, Kyoto University and The University of Electro-Communications
Development and field verification of ultra-light attachment and boom and stick	TAGUCHI Industrial Co., Ltd. and Tokyo University of Agriculture and Technology

# Automatic and autonomous exploration technology

## 2nd Request for Proposal : Research projects

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## 3rd Request for Proposal : Research projects

Development and field verification of remote operation of excavators and lightweight construction system capable of automatically mounting and removing attachments

TAGUCHI Industrial Co., Ltd. and Tokyo University of Agriculture and Technology

Construction of a sustainable new housing system

Misawa Homes Co., Ltd. and Misawa Homes Institute of Research and Development Co., Ltd.  
National Institute of Polar Research

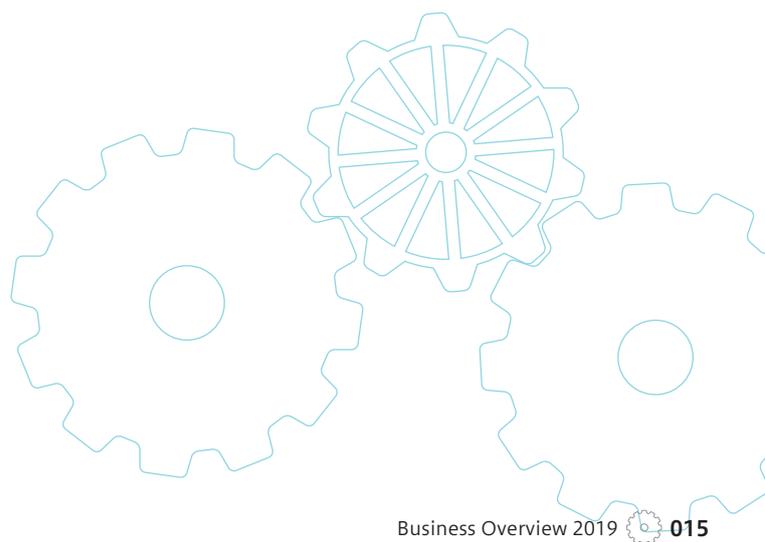
Investigation on systematization of estimation method for ground properties based on mechanical data during earthauger drilling

NITTO CONSTRUCTION CO., LTD.  
and Ritsumeikan University

## 4th Request for Proposal : Research projects

Research on labor saving by automating forestry machine system (Operation on the lunar surface of forestry machine system)

KUMAGAI GUMI CO.,LTD.  
SUMITOMO FORESTRY CO.,LTD.  
KYC Machine Industry Co.,Ltd.  
KATO WORKS CO.,LTD.

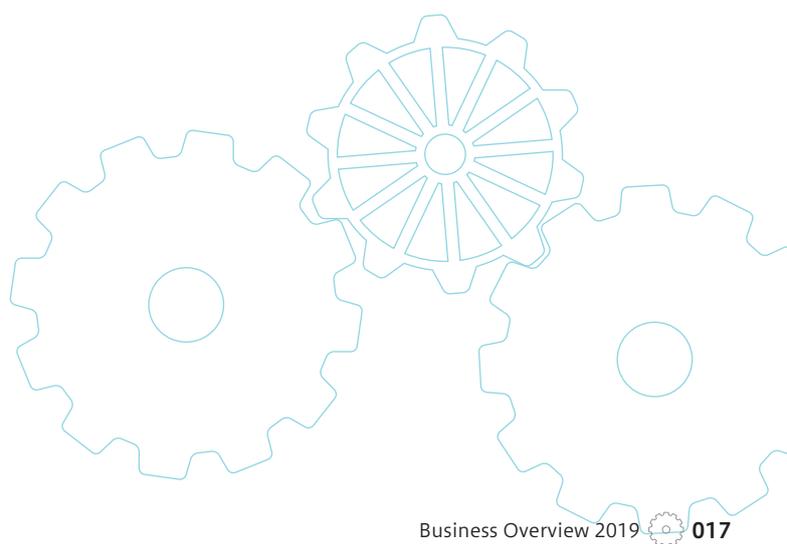


## Ideas Incubating research

- ▶ Project implemented to discover new technologies and ideas
- ▶ Conduct research over approximately one year with a total budget of 1-5 million yen.

Project title	Institutions
<b>1st Request for Proposal : Research projects</b>	
Application of Screw Driving Sounding technique to lunar soil mechanics investigation	Tokyo City University JAPAN HOME SHIELD CORPORATION, NITTO SEIKO CO., LTD. and TOKYU CONSTRUCTION CO., LTD.
Estimation of soil-strength parameters based on construction information during ground excavation by earth auger	Ritsumeikan University and NITTO CONSTRUCTION CO.,LTD.
Research for effective vibration compaction method on hard-to-compact materials and achieved trafficability	SAKAI HEAVY INDUSTRIES, LTD.
<b>2nd Request for Proposal : Research projects</b>	
Preliminary system design for teleoperated building construction	SHIMIZU CORPORATION
<b>3rd Request for Proposal : Research projects</b>	
Development of Physical Model to Estimate the Ground Strength by using Resistive Forces Acting on the Bucket	Tohoku University and SHIMIZU CORPORATION
<b>4th Request for Proposal : Research projects</b>	
The Control method study using AI, IoT technology to realize autonomous motion of excavating machine (Road Header)	Mitsui Miike Machinery Co., Ltd
Visualization of subsurface distribution of electrical property based on ultra wide-band measurement of electromagnetic wave	UNIVERSITY OF HYOGO Kyoto University Nagoya University Kawasaki Geological Engineering Co. Ltd.

# Automatic and autonomous exploration technology





# In-situ resource utilization (ISRU) technology

## Objective

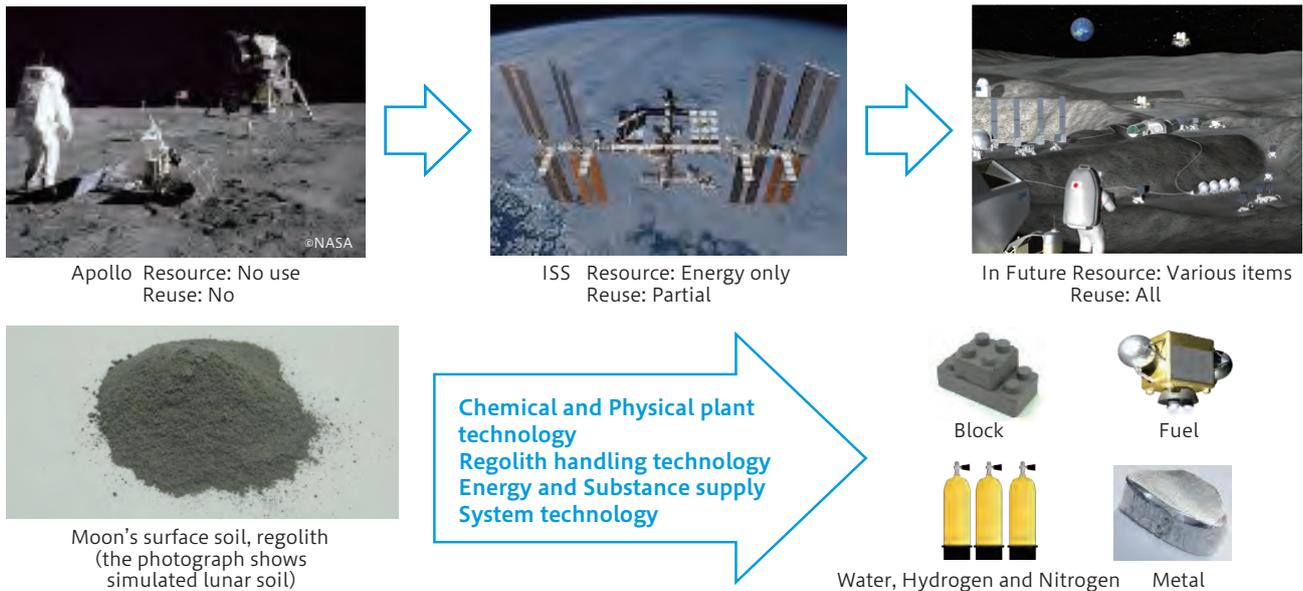
Enable sustainable exploration with minimum transportation from the Earth by a paradigm shift from “shipping all” to “producing necessities on site” and “reuse”.

## Research Topic

We aim to develop a system, in which Japan’s strengths in energy conservation, reuse, recycling technology and resource purification technology, are applied to produce necessities more efficiently on an unmanned basis.

## Approach

First, we will verify the technology in simulated test facilities and analog sites, and ultimately aim for demonstration in space.



## Solution Creating Research

- ▶ Projects with a clear technological target
- ▶ Conduct research over approximately three years, and maximum five years, with a total budget of 100–300 million yen

Project title	Institutions
<b>1st Request for Proposal : Research projects</b>	
Study on ice/water sensing technology by development of the small Imaging Spectrometer	Sentencia Corporation and Osaka University
Study on in-situ production technology of liquid-free construction materials	TOKYU CONSTRUCTION CO., LTD., Tokyo City University and NITTO SEIMO CO., LTD.
Production system of construction materials from in-situ resources	Mitsubishi Materials Corporation, Hokkaido University, Yamaguchi University, Obayashi Corporation, Japan Manned Space Systems Corporation, IHI Corporation and IHI AEROSPACE CO., LTD.
<b>2nd Request for Proposal : Research projects</b>	
Development of compact and robust analyzer for trace moisture in gas samples	SHINYEI Technology Co., LTD., National Institute of Advanced Industrial Science and Technology, Osaka University, Ibaraki University and Kagoshima University
Microwave freeze drying process	Microwave Chemical Co., Ltd. and Tokyo Institute of Technology

# In-situ resource utilization (ISRU) technology

3rd Request for Proposal : Research projects

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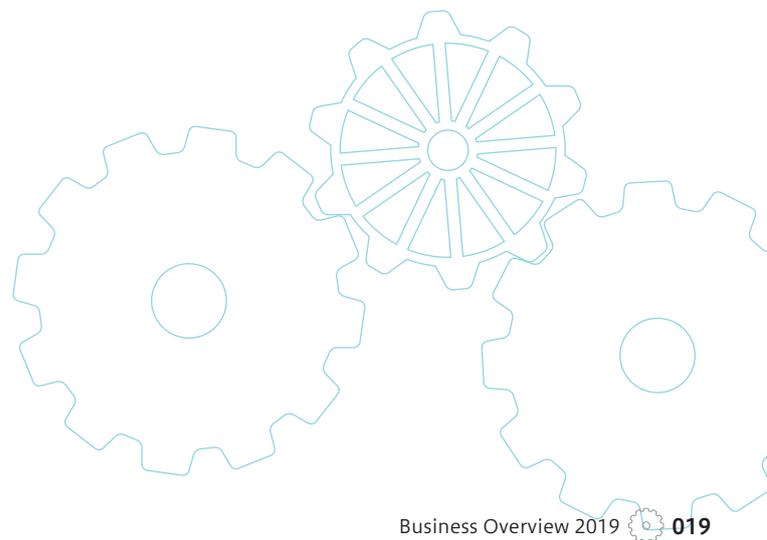


4th Request for Proposal : Research projects

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## Ideas Incubating research

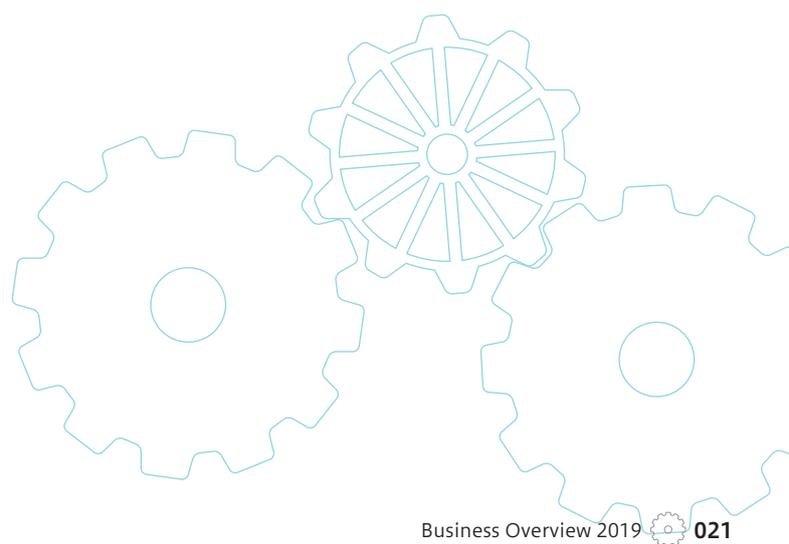
- ▶ Project implemented to discover new technologies and ideas
- ▶ Conduct research over approximately one year with a total budget of 1-5 million yen.

Project title	Institutions
<b>1st Request for Proposal : Research projects</b>	
Study on sand and volcanic ash solidification technology	MORUTARU MAGIC Co.,Ltd.
Manufacturing of construction materials from soil materials mainly composed of igneous rock or clay mineral	Obayashi Corporation
Hydrogen reduction system of lunar soil -Industrial utilization of low-grade materials-	Kyushu University, The Wakasa Wan Energy Research Center and HIROSE UNIENCE Co., Ltd.
Development of plasma/catalytic-nanoparticle hybrid field for converting CO <sub>2</sub> to resources	Kyushu University
<b>2nd Request for Proposal : Research projects</b>	
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<b>3rd Request for Proposal : Research projects</b>	
Development of high-performance material made of engineered protein for use as a fertilizer for plant cultivation	Spiber Inc.
Research on a farm system free from pathogens and insects and capable of backing up in emergency	Takenaka Corporation, Kirin Company, Limited, Chiba University and Tokyo University of Science
Development of high-throughput plasma irradiation to seeds for crop yield improvement	Kyushu University and Kenix Co. Ltd.
The feasibility study of the cultivation system for high calorie plant in lunar farm	Chiyoda Corporation and Mebiol Inc.
A study on the plant cultivation system using hydroponics with artificial light for the production of eatable potatoes	Tamagawa University and Panasonic Corporation Life Solutions Company

# In-situ resource utilization (ISRU) technology

## 4th Request for Proposal : Research projects

Functional Materials Production from Irreducible Oxides by Hydrogen Reduction System	Kyushu University H4 Co., Ltd. Nano-Science Laboratory Corporation
Research and Development on Pavement Construction and Repair Using AM Technology	NICHIREKI CO.,LTD
Development of indoor dry fog cultivation system with enhanced water use efficiency	H. IKEUCHI & CO., LTD. Osaka Prefecture University
Development of a small scale and efficient protein production platform utilizing edible microalga, Spirulina	Chitose Laboratory Corp. Tavelmout Corp. IHI Aerospace Co., Ltd. Fujimori Kogyo Co.,LTD.





# Common Technology

## Objective

To develop technologies commonly required for space exploration activities, such as electrical power, communication, sensor technology, and can be used for terrestrial applications.

### Solution Creating Research

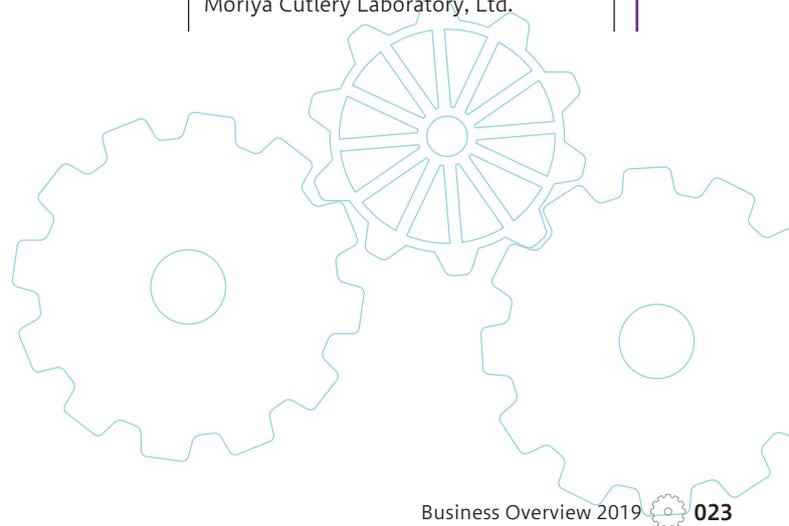
- ▶ Projects with a clear technological target
- ▶ Conduct research over approximately three years, and maximum five years, with a total budget of 100–300 million yen

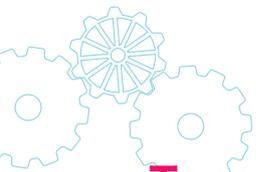
Project title	Institutions
<b>1st Request for Proposal : Research projects</b>	
Manufacturing Technology of Lightweight Composite High-Pressure Gas Vessel for Fuel Cell Vehicles	CHUGOKU KOGYO CO., LTD, Kyushu Institute of Technology and National Institute of Advanced Industrial Science and Technology
Development of all-solid-state lithium-ion secondary batteries	Hitachi Zosen Corporation
Development of Solid-State Marine Radar	Koden Electronics Co., Ltd. and Toyo Tech Industry Inc.
Fundamental and feasibility studies on long-distance communication system with free-space laser link technologies	Sony Corporation
<b>2nd Request for Proposal : Research projects</b>	
Development of multipoint high sensitive photon sensor for simultaneous ranging	Hamamatsu Photonics K.K.
<b>3rd Request for Proposal : Research projects</b>	
Durability enhancement of high efficiency, low cost, and lightweight perovskite thin film solar cells	Toin University of Yokohama, Hyogo Prefectural Univeristy, Peccell Technologies, Inc., Ricoh Co., Ltd. and Kishu Giken Kogyo, Co. Ltd.
<b>4th Request for Proposal : Research projects</b>	
Development of High Performance Marine Radar	Koden Electronics Co., Ltd
Development of a scalable regenerative fuel cell system as a completely isolated power supply	Mitsubishi Heavy Industries, Ltd. Japan Agency for Marine-Earth Science and Technology

## Ideas Incubating research

- ▶ Project implemented to discover new technologies and ideas
- ▶ Conduct research over approximately one year with a total budget of 1-5 million yen.

Project title	Institutions
<b>1st Request for Proposal : Research projects</b>	
Design of omnidirectional crawler platform for multipurpose	Topy Industries, Ltd., University of Fukui Japan Manned Space Systems Corporation and Tohoku University
<b>2nd Request for Proposal : Research projects</b>	
Investigation of designable shock absorption metals with multiscale structure	Institute for Lotus Materials Research Co., Ltd.
Development of ultra-light shock-absorbing material by designing cell morphology of porous aluminum	Nagoya University
Development of Lightweight Thermal Insulation Materials using Carbon Nanotube/ Porous Silica Composite Materials	Nagoya University, LIXIL Corporation and MEIJO NANO CARBON Co., Ltd.
Development of high performance and lightweight vacuum thermal insulation for cryogenic region	ORBITAL Engineering Inc.
<b>3rd Request for Proposal : Research projects</b>	
Development of High-Sensitivity Radiation Detection device using photoelectric conversion material	Toin University of Yokohama and Peccell Technologies, Inc.
<b>4th Request for Proposal : Research projects</b>	
Development of reliable and compact Stirling cooler	TWINBIRD CORPORATION Kokushikan University Meisei University
Development of Wavelength Conversion Material for Photovoltaic Cell	Panasonic Corporation
Research of Super-compact Harness-free Sensor Systems for Wireless Health Monitoring to Equipment in a Space Craft	Kagoshima university Toyo Tech Industry Inc. Beacon Technologies Inc.
Basic research on thermal harvester using Seebeck element.	Actronics Co.,Ltd. Sensor Controls Co.,Ltd. Moriya Cutlery Laboratory, Ltd.





## TansaX Challenging Research

Project title	Institutions
<b>4th Request for Proposal : Research projects</b>	
Development of "the scent linked to the environment (Kankyo kou)" that reduce psychological stress in daily life	SHISEIDO CO.,LTD.
Sustainable food/protein production by symbiotic recycling culture system combining algae and animal cells	Tokyo Women's Medical University Integriculture Inc.

