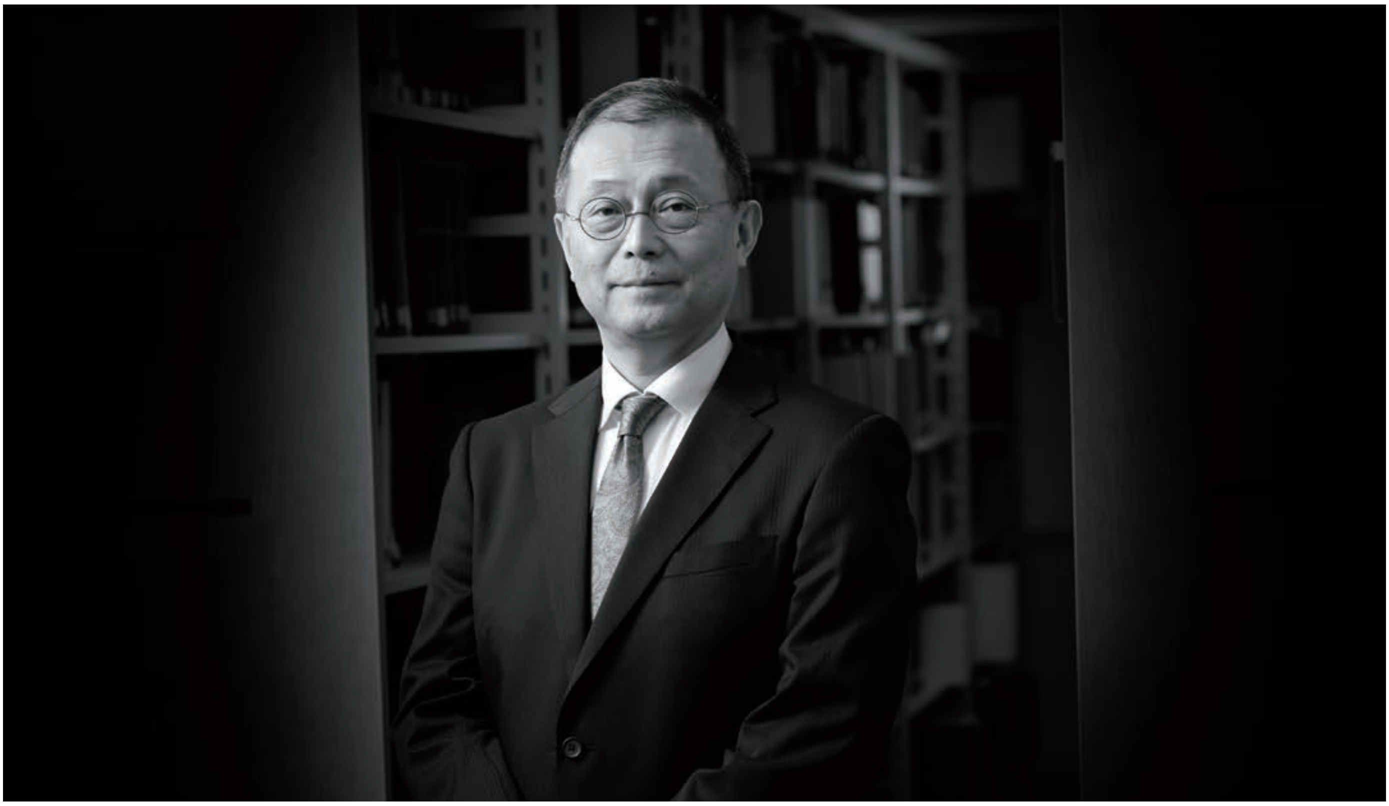
Institute of Fluid Science
Tohoku University

2024

We contribute to society with world-class fluid research and education.

Director Kaoru Maruta



The Institute of Fluid Science, Tohoku University is a state of the art research center of fluid science.

Our History: It all began with cavitation research

The history of the Institute of Fluid Science dates back to the Institute of High-Speed Mechanics, which was established in 1943. The Institute was established to research cavitation, which occurs in the flow of liquids around wings, with the aim of increasing the speeds of naval vessels. The Institute's findings also contributed to the development of Japan's first jet aircraft, the Kikka. After World War II, the Institute provided research support for advances in the performance of industrial fluid machinery such as power plant waterwheels and turbines, ship propellers, and airplane engines. It contributed to the nation's rapid growth. In the 1980s, the Institute's research areas expanded and diversified, from industrial machinery-related fluid flows to fluid flow under extreme conditions, such as high temperatures, high pressures, and high speed, fluid flows at the molecular level, fluid flows accompanying chemical reactions, the flow of fluids through the organisms' bodies, and more.

Reorganization and incorporation as the Institute of Fluid Science

As the Institute's research became more varied, it was reorganized and renamed the Institute of Fluid Science (IFS) in 1989. In 1998, it was further reorganized into the Shock Wave Research Center and four research divisions: Advanced Flow, Intelligent Fluid System, Non-continuum and Heat Transfer, and Complex Flow. In 2003, the Shock Wave Research Center was reorganized into the Transdisciplinary Fluid Integration Research Center. In 2013, the IFS was reorganized into three research divisions and the Innovative Energy Research Center to further stimulate interdisciplinary research collaboration and to help solve energy problems. In 2015, the Collaborative Research Division was established. Internally, the IFS also created the Advanced Fluid Information Research Center (AFI) in 1999, the Advanced Flow Experimental Research Center (AFX) in 2013, the Global Collaborative Research and Education Center (GCORE) in 2015, and the Aircraft Computational Science Center (ACS) in 2017. Since roughly 2004, when Tohoku University incorporated as a national university corporation, the IFS has been promoting research and education activities aggressively as a world-class advanced fluid science research center, and has been selected for the COE Formation, 21st Century COE, and Global COE Programs. In 2010, the IFS was certified as a Joint Usage/Research Center in the fluid science field, and this was renewed in 2016 and 2022. It engages in joint research and development activities in Japan and overseas.

Becoming a state-of-the-art fluid science research institute with a supercomputer and world-class experimental facilities:

In 2018, the IFS established the Lyon Center (Integration Research Center for Materials and Fluid Sciences) and became an even more international organization. Its Collaborative Research Division continued to operate and it launched the new Fundamental Research of Advanced Vehicle Technology (KEIHIN) II project. The supercomputer operated by the AFI was updated in 2018, and is now being used to perform large-scale fluid flow simulations, measurement integrated simulations, and state-of-the-art research regarding visualization technologies and more. AFX is carrying out research using its world-class experimental equipment such as a low-turbulence wind tunnel, a magnetically supported balance, and shock wave experimental equipment. The ACS provides powerful academic support to the Japanese aviation industry through collaboration with the Division for the Establishment of Frontier Sciences, Multi-Physics Design Laboratory. The IFS has established a collaborative research structure using its supercomputer, which is comparable to a numerical wind tunnel, and its world-class experimental facilities.

Becoming a world-class fluid science center that draws together researchers from around the globe:

In October 2022, the Innovative Energy Research Center was reorganized and relaunched as the Global Collaborative Research and Education Center for Integrated Flow Science. This is an international center for flow and material integrated research that fuses and strengthens the international coordination support of the former Global Collaborative Research and Education Center with the activities of the Lyon Center, which has produced tremendous results through organizational collaboration between Japan and France. The IFS is taking advantage of this opportunity to advocate the concept of "integrated flow science," based on the academic foundation of fluid science, which covers a lange scales of time and space and which the IFS has refined through the years, and applied research, which visibly contributes to the solving of the issues faced by society. It will create alliances with prominent overseas research organizations in order to conduct international flow and material integration research.
In October 2022, the IFS became a fluid science research institute with the four research divisions of the Creative Flow Research Division, the Complex Flow Research Division, the Nanoscale Flow Research Division, and the Collaborative Research Division; five centers, including the new Global Collaborative Research and Education Center for Integrated Flow Science and the Lyon Center; and 31 research laboratories. The Collaborative Research Division conducts fundamental research regarding advanced vehicle technology with Hitachi Astemo, Ltd. The new center is continuing to contribute to the international symposiums that have been held by the IFS every year since 2001. In conjunction with the amendment of VISION2030 in 2021, IFS now has reorganized into four research clusters: "environment and energy," "nano-micro," "health, welfare, and medical care (life science)," and "aerospace." Furthermore, it has created a Social Issue Solutions Task Force, a research team that tackles pressing social issues. Using this new organizational structure and the foundation created by the research, technology, and international networks IFS has developed through the years, the Institute will become a global fluid science center that attracts researchers from around the world by 2030. In addition to carrying on and further developing the academic fundamentals of fluid science and thermal-fluid measurement and analysis technologies, the IFS will promote the inter-organizational use of international fluid and material integrated research, as well as the results of leading research activities, to create a safer, more secure, and healthier society. By responding to the demands of society and nurturing humankind's development, the IFS will breathe new life into the science of fluid flow through integrated flow science.

Organization Chart (Research Divisions and Laboratories)

【Creative Flow Research Division】

The Creative Flow Research Division was established to create and to apply novel functions in flows in fluid systems. The development of fluid science and the creation of innovative engineering are pursued through elucidation of flows and creation of novel functions in electromagnetic fluids, living body flows, and flows in aerospace conditions.

- Creation of novel flow functions using an electromagnetic field
- Development of next-generation intelligent fluid control devices and systems
- Development of advanced medical devices based on measurement-integrated simulation
- Clarification of flow dynamics in a living body
- Innovation, safety, and manufacturing of aerospace systems
- Creation of innovative thermal and fluids control systems for next generation spacecraft
- Designing complex systems that harmonize people, nature, and science and technology

【Complex Flow Research Division】

The Complex Flow Research Division was established to explore and to apply complex flow phenomena related to various physical and chemical processes that constitute the foundation of fluid science. Development of fluid science and the creation of innovative technologies are pursued through investigation of heat and mass transfers in complex systems, cavitation, shock waves, turbulent flows and universal principles of heat and material flow phenomena, as well as construction of mathematical models.

- Spatiotemporal multi-scale heat and mass transfer in complicated systems
- Clarification of complex flow with cavitation or boiling and advancement of fluid machinery systems
- Study on elucidation of complex propagation phenomena in gas-liquid-solid three-phase and its interdisciplinary application
- Theoretical modeling for universal and specific complex flow phenomena

【Nanoscale Flow Research Division】

The Nanoscale Flow Research Division was established to advance basic science and to explore new R&D areas related to nano/microscale thermal and fluid phenomena and thermophysical properties. Creation of novel medical technologies and development of innovative nanoscale thermal and fluid devices are pursued through the progress and deepening of science, as well as investigation of mass–momentum–energy transfer mechanisms on scales of electrons–molecules and new discoveries of nanoscale flow characteristics in living bodies and nano-devices.

- Physical and transport phenomena in non-equilibrium gas flow and their applications
- Nanoscale flow and interfacial phenomena governing macroscopic thermal and fluid properties
- Physical mechanism of the quantum effect of fluid molecules on flow dynamics
- Reactions, thermal flow dynamics of plasma flow and their application for medical engineering
- Transport phenomena in large-scale composite systems governed by molecular physics and their applications
- Elucidation of biomolecular nanoflow phenomena and their application to artificial molecular systems
- Development of novel flow devices utilizing unique nanoscale flow and interfacial phenomena

【Collaborative Research Division】

The Institute of Fluid Science, Tohoku University, and Hitachi Astemo, Ltd. have established a joint research department and have been able to obtain results in the first and second phases. In the third phase, as "Fundamental research of advanced vehicle technology (Hitachi Astemo)Ⅲ", the next-generation inverter that drives the motor will be ultra-compact, lightweight, and high-performance for future vehicle electrification toward the realization of a low-carbon society. We will promote the fundamental research to realize those kinds of basic technologies. The research conducted by the Collaborative research division is related mostly to the enhancement and the application of the simulation technology based on computational fluid dynamics and experimental verification. By conducting collaborative research between Hitachi Astemo, Ltd. and Institute of Fluid Science, Tohoku University, aims to create new value directly connected to development of appealing products with excellent environmental performance based on the research of such next-generation technology.

- New cooling system construction and element technology research for next-generation inverter
- Numerical elucidation of laser fusion bonding technology
- Elucidation of solder void generation prediction technology
- Construction of an optimization method for new cooling technology and laser melting technology

【Global Collaborative Research and Education Center for Integrated Flow Science (IFS-GCORE)】

The Global Collaborative Research and Education Center for Integrated Flow Science (IFS-GCORE) will conduct research on the academic foundation of integrated flow science for its deployment in diverse application fields, including green nanotechnology and fuel ammonia. We will promote international joint research and education with overseas centers in France, Taiwan, Saudi Arabia, and the U.S., and aim to become an alliance-type international base that creates social impact.

- Advanced green nanodevices based on atomic layer control processes
- Combustion phenomena in aerospace propulsion systems and energy apparatuses
- Development of greater depth subsurface system for the resolution of environmental and energy issues
- Development of advanced combustion technologies and reaction models for future carbon-free fuels
- Development of integrated multiscale multiphase flow energy system
- Theory and algorithm development for computational analysis of multiphysics problems in aeroscience
- Theoretical design of innovative batteries based on the analysis and control of nanoscale flow
- Integrated flow science and technology to contribute to the solution of societal issues
- Advanced integrated flow science

【Lyon Center (LyC) — Integration Research Center for Materials and Fluid Sciences】

The Lyon Center (LyC) was established to promote international joint research activities which the IFS faculty members and graduate students staying at Université de Lyon (INSA Lyon, École Centrale de Lyon, Université Claude-Bernard Lyon 1) carry out. Especially, we explore interdisciplinary science based on materials science and fluid science to answer current social challenges in the fields of transportation, energy and engineering for health.

- Intelligent sensing and evaluation of mechanical systems
- Design of smart materials and fluids system
- Spatiotemporal multiscale clarification of flow dynamics

【Advanced Flow Experimental Research Center (AFX)】

Specially Appointed Associate Professor Kiyonobu Ohtani
Senior Fellow Yasufumi Konishi

【Aircraft Computational Science Center (ACS)】

【Advanced Fluid Information Research Center (AFI)】

【IHI × Tohoku University Co-creation Research Center of Ammonia Value Chain for Carbon Neutrality】

＊ Concurrent
＊＊ Cross-Appointment

Laboratory	(Professor)	(Associate Professor)	(Assistant Professor)
【Electromagnetic Functional Flow Dynamics Laboratory】	Hidemasa Takana		Yutaka Kaneko
【Intelligent Fluid Control Systems Laboratory】	Kaoru Maruta*		
【Integrated Simulation Biomedical Engineering Laboratory】	Makoto Ohta*	Kenichi Funamoto	
【Biomedical Flow Dynamics Laboratory】	Makoto Ohta	Hiroyuki Kosukegawa**	Hitomi Anzai Jing Liao
【Aerospace Fluid Engineering Laboratory】	Shigeru Obayashi		Aiko Yakeno
【Spacecraft Thermal and Fluids Systems Laboratory】	Hiroki Nagai		Tsubasa Ikami
【Design of Structure and Flow in the Earth Laboratory】	Kaoru Maruta*	Anna Suzuki	
【Heat Transfer Control Laboratory】	Atsuki Komiya		Yuki Kanda
【Advanced Fluid Machinery Systems Laboratory】	Yuka Iga	Junnosuke Okajima	
【Complex Shock Wave Laboratory】	Hiroki Nagai*	Kiyonobu Ohtani*	
【Computational Fluid Physics Laboratory】	Yuji Hattori	Makoto Hirota	
【Non-Equilibrium Molecular Gas Flow Laboratory】	Taku Ohara*		
【Molecular Heat Transfer Laboratory】	Taku Ohara		Donatas SURBLYS
【Quantum Nanoscale Flow Systems Laboratory】	Takashi Tokumasu		Naoya Uene
【Biological Nanoscale Reactive Flow Laboratory】	Takehiko Sato		Siwei Liu
【Molecular Composite Flow Laboratory】	Taku Ohara*	Gota Kikugawa	
【Biomolecular Flow Systems Laboratory】	Takashi Tokumasu*	Takuya Mabuchi	
【Nanoscale Flow Application Laboratory】	(Visiting Professor)		
【Fundamental Research of Advanced Vehicle Technology(Hitachi Astemo)Ⅲ】	Jun Ishimoto*		
【Green Nanotechnology Laboratory】	Kazuhiko Endo		Daisuke Ohori
【High Speed Reacting Flow Laboratory】	Hideaki Kobayashi*	Akihiro Hayakawa	Yu Xia Yi-Rong Chen
【Energy Resources Geomechanics Laboratory】	Takatoshi Ito		Yusuke Mukuhira Lu Wang
【Energy Dynamics Laboratory】	Kaoru Maruta	Hisashi Nakamura	Youhi Morii Yuji Saito*
【Multiphase Flow Energy Laboratory】	Jun Ishimoto		Ippei Oshima
【Multi-Physics Design Laboratory】	Shigeru Obayashi* Tomonaga Okabe*	Yoshiaki Abe	
【Mechanical Systems Evaluation Laboratory】	Tetsuya Uchimoto		
【Advanced Materials and Fluids Design Laboratory】	Tetsuya Uchimoto* Jean-Yves Cavaillé (Visiting Prof.)	Kaori Yuse** Lucile Joly-Pottuz** Carole Frindel**	
【Flow Dynamics Laboratory】	Makoto Ohta* Atsuki Komiya* Hidemasa Takana*		Aiko Yakeno*
【Novel Battery Nanoscale Flow Concurrent Laboratory】	Takashi Tokumasu*		
【Integrated Flow Science and Technology Laboratory】	(Visiting Professor)		
【Advanced Integrated Flow Science Laboratory】	(Foreign Visiting Professor)		

The Mission of the Research Cluster

In September 2021, the Institute of Fluid Science amended its VISION2030 to reflect the tumultuous changes in social conditions in recent years. Under this new vision, it has reorganized into four research clusters, which are unique interdisciplinary research groups in the fields of “environment and energy,” “nano-micro,” “health, welfare, and medical cares (life science),” and “aerospace.” From now on, the work of these clusters will form and advance a new academic foundation of integrated flow science, to contribute to the building of a comfortable and affluent society.

Action 01

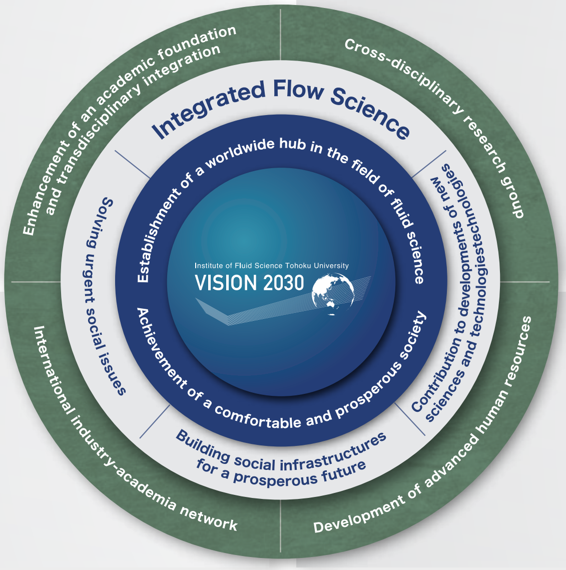
Enhancement of an academic foundation and transdisciplinary integration

Creation of a new field of study by the transdisciplinary integration of different research fields in fluid science while enhancing the academic foundation of fluid science research.

Action 02

Cross-disciplinary research group

Contribution to society and industry through organizational studies by the construction of four research clusters including “environment and energy”, “nano-micro”, “health, welfare, and medical cares”, and “aerospace” and one research team as an “IFS task force for urgent social issues”.



Action 03

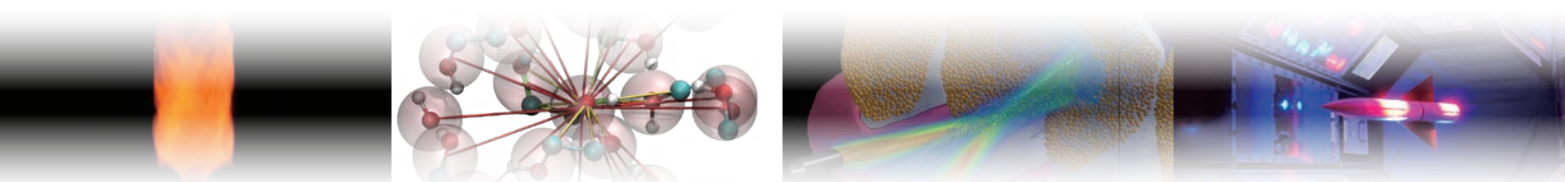
International industry-academia network

Establishment of a hub of international collaborative research by actively transmitting research results both within Japan and overseas through an international industry-academia network.

Action 04

Development of advanced human resources

Creation of an attractive environment and research and education system, and development of advanced human resources that can play active roles in domestic and international research institutions and industries.



Environment and energy

We aim to develop integrated flow science to realize a decarbonized society and create a new energy system

The COP26 "Glasgow Climate Pact" reaffirmed the need for the entire world to tackle global warming issues with specific numerical goals, and the need to control greenhouse gas emissions and create new energy sources have become urgent issues. In order to solve these urgent issues while maintaining and improving industrial activities and quality of life, to weave together the creation of knowledge from entrance to exit are required, along with an awareness of green growth strategies. It is essential to secure new sources of energy with low environmental impact, promote the introduction of self-sufficient renewable energy, further develop energy-saving technologies, and so on. With the environment and energy cluster, we will rethink the conversion and creation of energy, which is essential for human activities and sustainable development, and promote a wide range of research and development, from basic to applied technologies, to solve environmental and energy problems in a wide range of time and space.

Health, welfare and medical cares

We aim to realize a healthy and comfortable society through integrated flow science

The social environment is changing drastically due to the rapidly aging society and declining birthrate. The creation of advanced health, welfare, and medical technologies is necessary in order to realize and keep a healthy, secure, and affluent life. This cluster aims to construct new theories of integrated fluid science by clarifying transport phenomena in living organisms and interaction phenomena between living organisms and physical stimuli. Specifically, we aim to develop methods for diagnosis, prediction, measurement, and modeling related to humans; data-driven prediction and conservation related to the living environment and health; recovery and addition of human functions; application to the treatment of stroke and heart disease through the development of biomodels; prevention, treatment, diagnosis, and prediction related to infectious diseases and cancer; plasma medicine; and regenerative medicine. We are also working on the development of protein and cell processing technologies.

Nano-micro

We aim to build an integrated flow science in which we analyze the phenomena that arise on a nano-micro scale and apply them to technological development in all fields

Recent developments in science and technology have made it possible to design and manufacture equipment with nano and micro-scale structures. Moreover, owing to the increased precision and miniaturization of the processing technology, new types of devices which apply functions which arise on these scales are being built actively in all fields. The purpose of nano-micro cluster is to analyze such nano-micro scale phenomena using supercomputers and large-scale experimental facilities, and to build an academic field that comprehensively understands them from the perspective of fluid science. We will also develop innovative devices and processing technologies that utilize these phenomena to improve the function and performance of equipment in various industrial fields.

Aerospace

We aim to contribute to the development of the aerospace field by clarifying the phenomena in the flow field related to spacecrafts and aircrafts through integrated flow science

The development of innovative spacecrafts and aircrafts for the next generation requires an understanding of a wide variety of flow fields, including flows in extreme environments such as high-temperature, high-pressure, cryogenic temperature, and rarefied atmosphere, multi-phase flow with phase change and plasmas/combustion flow with chemical reactions, and nano/micro/macroscale spatiotemporal flow. In addition, the development of highly efficient airframes and engines is necessary for green growth strategies to achieve a carbon-neutral international society, and the flow fields associated with spacecrafts and aircrafts must be controlled with high precision. Aerospace cluster aims to establish an academic field that comprehensively understands the phenomena from the viewpoint of integrated flow science, including flow field analysis using wind tunnels and supercomputers and mathematical and data science approaches.

Number of Full-time Staffs (2023.5.1)

Professors	Associate Professors	Assistant Professors	Specially Appointed Professors	Specially Appointed Associate Professors	Specially Appointed Assistant Professors	Specially Appointed Research Fellow	Administrative Staffs	Technical Staffs	Limited Regular Employees	Total
16(1)	10(4)	12(2)	1(0)	2(0)	5(1)	3(0)	9(2)	13(0)	12(11)	83(21)

※Numbers in parenthesis represent the number of females, and are included in the totals

Number of Students (2023.5.1)

B3	B4	M1	M2	D1	D2	D3	Total
1(0)	33(1)	57(3)	63(10)	12(1)	12(2)	20(3)	198(20)

※Numbers in parenthesis represent the number of females, and are included in the totals

Expenses (FY2022)

(Units: Million yen)

Operational Grants 1,705		External funding 1,093					
Personnel Expenses	Operation Expenses	Grants-in-Aid for Scientific Research	Sponsored Research Fund	Joint Research Fund	Sponsored Project Fund	Grants	Scholarship Donations
644	1,061	232	560	205	27	56	13

Academic presentations (2022)

Journal papers (International)	Journal papers (Domestic)	Presentation in international conferences	Presentation in domestic conferences	Total
172	10	329	283	794

Building

Total building area 13,167m²

TOHOKU UNIVERSITY

Institute of Fluid Science Tohoku University IFS

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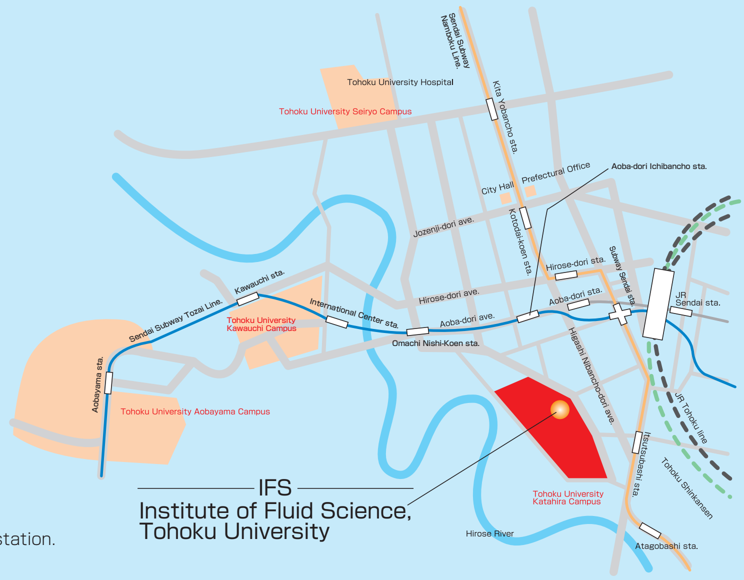

25 mins. by train from Sendai airport to Sendai station.
20 mins. walk from Sendai station to IFS.

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