

Research and
DevelopmentManagement
Approach**Material Issues and Our Approach**

To ensure sustainable improvement in the enterprise value of the Kawasaki Group, the internal companies, business divisions and Corporate Technology Division work as a cohesive unit, concentrating technologies available within the Group and utilizing technological synergies to develop new products and new businesses with a competitive edge.

We also strive for balanced R&D through new product and new business development as well as activities geared toward such development in the future in each internal company in addition to nurturing and reinforcing basic technologies needed to realize these new products and new businesses.

Engineers from the internal companies and business divisions and specialists in the Corporate Technology Division, who have expertise in various fields, form project teams to share issues and work together to develop new products and new businesses, seeking always to achieve the overall optimization of management resources. The Corporate Technology Division acts as an intermediary, facilitating access to the technological core competences of each internal company so that they can be applied to products in other internal companies. This promotes the multifaceted expansion of technology and realizes major synergistic effects.

We will utilize this type of matrix-based operation to create technological synergies throughout the Kawasaki Group and further raise enterprise value.

Focus Activities and Medium-term Targets**● Goals for the MTBP 2019**

- Reinforce the competitiveness of existing products and businesses.
- Build a platform that will support groundbreaking innovation that creates new value in response to rapid changes in society.
- Achieve process reforms by such means as strengthening system design and *monozukuri* manufacturing capabilities.
- Establish intellectual property action plans as part of business strategy and build a framework to allocate IP rights where needed or keep such property confidential in the form of internal expertise.
- Build a framework for carrying out IP rights infringement prevention checks through design reviews and other precautions taken at specific development stages.

Progress, Results and Challenges

- We are working to create new products and business that leverage digital innovation. In particular, we are focusing efforts on service businesses that utilize ICT/IoT.
- We are working to build a supply chain for hydrogen, a form of clean energy.
- We are working toward process innovation using digital technologies.
- We are acquiring strategic intellectual property, mainly in robotics.
- Before commencing R&D, we carry out comprehensive examinations of preceding patents to avoid infringement.

KPI**● Progress**

	(FY)	2014	2015	2016	2017	2018
R&D expenditures	Billion yen	41.6	43.6	43.6	45.4	48.7

Structure

The internal companies carry out R&D in areas specific to their businesses, while the Corporate Technology Division handles forward-looking R&D on a Company-wide basis. In addition, the internal companies and Corporate Technology Division work together closely on projects.

The Corporate Technology Division comprises the Technical Institute, System Technology Development Center, Hydrogen Project Development Center, Manufacturing Improvement Center and IT Strategy Planning Center. All of these collaborate to advance R&D.

● Responsible Officer

Hiroshi Nakatani, Managing Executive Officer, General Manager of Corporate Technology Division

● Responsible Executive Organ and Committee

The internal companies and the Corporate Technology division meet regularly to share information about the market environment and business strategy and form consensus regarding development themes.

They also regularly take steps to concentrate technologies from across the Group to plan and follow up on important Group-wide R&D, facilitate the horizontal exchange and sharing of technologies, and promote synergy.

Research and Development

R&D Expenditures

		(FY)	2014	2015	2016	2017	2018
Total		Billion yen	41.6	43.6	43.6	45.4	48.7
Breakdown by segment	Ship & Offshore Structure		1.0	0.8	0.8	0.8	1.1
	Rolling Stock		1.1	1.2	0.8	0.8	0.8
	Aerospace Systems		4.3	4.3	3.8	4.0	6.1
	Gas Turbine & Machinery		4.2	4.1	3.9	3.8	–
	Energy System & Plant Engineering		0.9	1.1	1.3	1.4	3.9
	Motor Cycle & Engine		12.9	13.3	14.3	15.8	15.6
	Precision Machinery & Robot		5.6	6.1	5.3	5.4	6.2
	Head Office, other		11.2	12.4	13.0	13.0	14.6
Percentage of sales	%	2.8	2.8	2.9	2.9	3.1	
Number of employees engaged in R&D	Persons		1,766	1,791	1,868	1,888	1,941
	Scope		cg	cg	cg	cg	cg

Note: In April 2018, the former Aerospace Company and the jet engine business of the former Gas Turbine & Machinery Company were integrated into the newly established Aerospace Systems Company. The former Plant & Infrastructure Company and the energy and marine-related businesses of the former Gas Turbine & Machinery Company were integrated into the newly established Energy System & Plant Engineering Company. In addition, the former Precision Machinery Company was renamed to the Precision Machinery & Robot Company.

Open Innovation

Open Innovation Policy

In addition to leveraging the technological synergies that come from bringing our technologies together, we also work with outsourcers to introduce state-of-the-art technologies in an efficient manner. By making use of outside resources, not simply sticking to in-house innovation, we are able to provide solutions to social issues as well as create value that we would not be able to offer singlehandedly or at least not without overly large expenditures of cost and time.

Example of Open Innovation

Building a CO₂-Free Hydrogen Supply Chain

Four companies—Kawasaki, Iwatani Corporation, Shell Japan Ltd., and Electric Power Development Co., Ltd. (J-POWER)—have come together to form the CO₂-free Hydrogen Energy Supply-chain Technology Research Association (HySTRA) to promote the building of a CO₂-free hydrogen supply chain and have launched a full-fledged demonstration project.

● Effects on Business and Impact on Society

Working under the HySTRA umbrella, these four companies are bringing together their strengths to efficiently advance R&D and demonstration projects. The HySTRA demonstration projects consist of two technical components: brown coal gasification technology and technologies for the long-range mass transportation and cargo handling of liquefied hydrogen. The organization's goal is to demonstrate the technologies and identify challenges to commercialization for each of the two components by fiscal 2020.

An inexpensive and reliable supply of CO₂-free hydrogen is critical to the future integration of hydrogen energy into society. To realize such a hydrogen supply chain, Kawasaki led a collaboration with Iwatani and J-POWER to propose a demonstration project that was accepted by NEDO (New Energy and Industrial Technology Development Organization) in June 2015 as the Demonstration Project for Establishment of Supply Chain for Mass Marine Transportation of Hydrogen and Gasification of Brown Coal. Shell Japan has since joined the three companies to form HySTRA, which is working toward realizing an international commercial liquefied hydrogen chain.

J-POWER, which is currently developing an integrated coal gasification combined cycle (IGCC) system in Japan, is primarily responsible for the demonstration of brown coal gasification technology leveraging its accumulated wealth of gasification technologies. Kawasaki, a supplier of cryogenic equipment that has built LNG storage tanks and receiving terminals as well as equipment for the rocket launching complex on Tanegashima Island, Iwatani Corporation, the only producer and supplier

of liquefied hydrogen in Japan, and Shell Japan, the Japanese subsidiary of Royal Dutch Shell, which has a strong track record in LNG supply chains and carrier operation, are working together to demonstrate technologies for the long-range mass transportation and cargo handling of liquefied hydrogen.

In future societies, hydrogen gas turbines will play a key role in establishing environmentally friendly, hydrogen-fueled energy supply systems.



Kawasaki Hydrogen Road
<https://global.kawasaki.com/en/hydrogen/>

New Product and Business Development

New products and businesses that were in development or for which development was completed in fiscal 2018 are as follows.

● Aerospace Systems

- H145//BK117 D-3
 - Training center for H145//BK117 helicopters
 - HTV* (space station cargo transporter) small re-entry capsule
- * HTV: H-II Transfer Vehicle

● Energy System & Plant Engineering

- Loading arm for the ship-to-shore transfer of liquid hydrogen
- Stoker incinerator equipped with Smart-ACC*
 - * Smart-ACC: Proprietary, sophisticated combustion control technology designed to achieve more efficient and reliable power generation than conventional waste treatment facilities
- The CK Mill, a high-efficiency roller mill that achieves the highest production capacity of Kawasaki mills
- The world's highest gross output cement plant waste heat recovery power generation system
- A cogeneration system powered by a M5A gas turbine boasting the world's highest efficiency in the 5 MW class

● Precision Machinery & Robot

- Successor, a new robot system that enables skills transmission
- duAro2, in the duAro series of collaborative Dual-Arm SCARA Robots
- Medical robots
- A high-pressure hydrogen regulator for Daimler AG

● Transportation

- SOPass ship operation and performance analysis support system
- New Panamax LNG carrier
- LPG carrier equipped with sulfur oxide (SOx) scrubbers to remove SOx from exhaust gas
- LNG carrier with twin engines and twin shafts
- EEDI-compliant* large LNG-fueled bulk carrier
 - * EEDI: Energy Efficiency Design Index
- Autonomous underwater vehicle (AUV) equipped with a robotic subsea pipeline inspection system
- LNG floating power plant
- Z400/Z400 SE/Z250 high power, lightweight super naked models
- VERSYS 1000/VERSYS 1000 SE, with advanced electronic control technology
- W800 STREET/W800 CAFE retro models
- Ninja H2 SX SE+ high-grade model
- Ninja ZX-6R ABS/Ninja ZX-6R, featuring improved riding performance
- Ninja H2/Ninja H2 Carbon, with smartphone connectivity
- Ninja H2R, with greater product marketability
- KX450 motocross model

Process Innovation

Kawasaki uses a proprietary production system, the Kawasaki Production System (KPS) for its mass-produced products. The KPS was developed by Kawasaki based on the production system of Toyota Motor Corporation, known as the Toyota Production System (TPS). The system is aimed at thoroughly eliminating waste in production processes.

Using IT to provide detailed instructions for the work of each individual and analyze accumulated performance data, Kawasaki is expanding the scope of the KPS to include custom order products, as well.

Effects of Process Innovation

COGS statistics (indicating cost reduction effects) are calculated on a project by project basis. For example, by applying the KPS to individually ordered products, the Energy System & Plant Engineering Company reduced costs of turbine assembly by more than 20%.

Environmental Innovation


At Kawasaki, we have defined a set of in-house criteria to improve the environmental performance of our products through energy and resource conservation and to reduce our environmental footprint by reducing the amount of industrial waste produced and chemical substances used in our production processes. Products that meet these criteria are registered as Kawasaki-brand Green Products.

Kawasaki-brand Green Products are marked with an environmental label that shows the product's environmental advantages as one way to communicate our efforts in this area to our customers and other stakeholders. In 2018, nine products were newly registered, and the registrations of products for which the three-year registration limit expired were renewed, bringing the total number of registered Kawasaki-brand Green Products to 50.

Effects of Environmental Innovation

	(FY)	2014	2015	2016	2017	2018
Reduction in environmental footprint (CO ₂ emissions) due to product-based contributions	kt	513	745	898	22,924	29,129

*The calculation method was revised in fiscal 2017 to one which uses a flow-based method where the expected life of a product launched during this fiscal year is used as the evaluation period for calculating the difference in CO₂ emissions between our products and standard grade products in the industry over this period of usage.


Kawasaki-brand Green Products
https://global.kawasaki.com/en/corp/sustainability/green_products/index.html

Intellectual Property Management

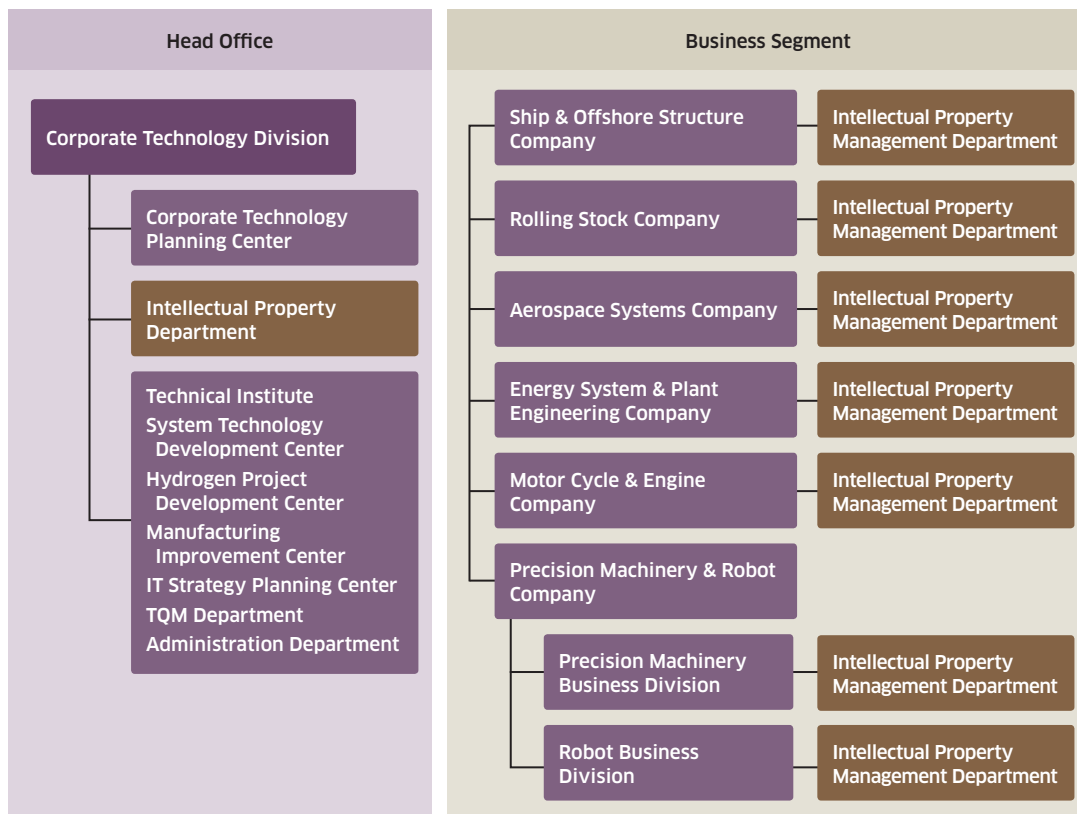
Principles of Intellectual Property Management

To survive amid intense global competition, we must raise enterprise value by developing business pursuits that leverage our core competence. Toward this end, we rely on intellectual property, which is a vital management resource, and the key to securing and successfully applying this corporate asset is to undertake activities from a three-point perspective that adds intellectual property to business and R&D as a third component of our core competence.

Structure

To promote strategic intellectual property activities, we maintain a structure whereby the Intellectual Property Department in the Corporate Technology Division drafts and implements corporate measures and works with the intellectual property management departments of the internal companies and business divisions to provide support in line with each segment's business activities.

Organizational Chart of Intellectual Property Protection Structure



● **Responsible Officer**

Sukeyuki Namiki, Representative Director, Vice President and Senior Executive Officer (in charge of technology)

● **Responsible Executive Organ and Committee**

We periodically formulate operating and basic policies regarding Group-wide intellectual property activities.

Counterfeit Product Countermeasures

To handle counterfeit products that use Kawasaki Group brands and other similar products, we have in place appropriate countermeasures based on trademark and other rights. By further developing such activities, we will protect and further enhance market confidence in our brands.

Invention Reward System

Based on the Patent Law regulation pertaining to inventions by employees, Kawasaki has established a provision in its internal rules regarding inventions by employees to reward employees at specific milestones, such as the filing of a patent application (application reward), patent registration (registration reward), and practical application (performance-based reward).

The Company faithfully adheres to this provision. In addition, the same reward system is applied even when the invention is not made public for strategic reasons. Of note, the performance-based reward is fairly awarded after duly taking into consideration how the Company has benefited from the invention, using an evaluation standard based on comparisons with other companies in the same industry as well as trends in society.

Employee Training

Intellectual property is an important management resource for increasing our business competitiveness. As such, Kawasaki’s basic policy is to secure and effectively utilize its own intellectual property while respecting the valid intellectual property rights of third parties. In line with this policy, we carry out grade-specific activities to foster correct awareness of intellectual property.