Research and Development Aimed at Creating New Value and Solving Social Issues

Along with developing new business fields by applying core competence management, we aim to create new value and solve social issues by promoting technology development.

Canon's Approach to R&D

As society changes dramatically under digital transformation (DX), which has itself been accelerated by the COVID-19 pandemic and the shift to a new normal, Canon is also approaching a major turning point. Not only is the camera market contracting, but our other core markets in office multifunction devices and printers are also undergoing significant change. In response, Canon is likewise embracing the challenge of transformation, aiming for the next stage of growth.

R&D in the industrial age and the information age was invention-focused, creating seeds of technology that flowered into a wealth of new discoveries. Groundbreaking products were launched one after the other, enriching lives, improving convenience and changing the world. However, advancing globalization has brought with it a range of environmental and other social issues, which technology must now turn its attention to addressing. Indeed, we have now reached a reversed situation in which technology development is driven by social issues. It is no longer enough to gradually nurture the seeds of "invention-focused" R&D. What we increasingly require is "innovation-focused" R&D that can speedily address social issues.

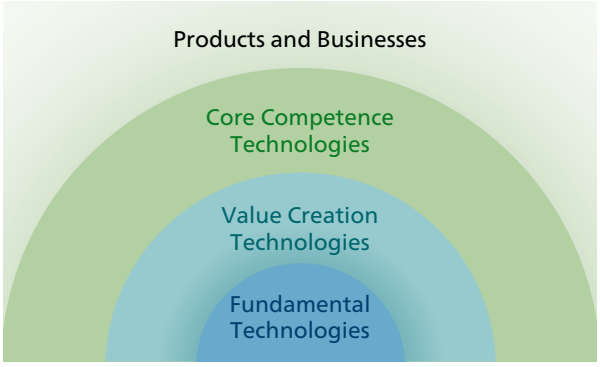
Seizing the momentum brought about by these changes, Canon will proceed with invention-focused R&D through open innovation and industry-academia partnerships, while its innovation-focused R&D will seek to address social issues by refining proprietary technologies and creating new value through corporate mergers, acquisitions, and alliances.

Lens development using CAE

Core Competence Management

Since its founding, Canon has pursued diversification of its business through core competence management, combining in various ways the core competence technologies (hereinafter "core technologies") that drive the creation of its industry-leading core products with fundamental technologies that form the base for its accumulated technologies and value creation technologies that form the base for its commercialized technologies. Our product lineup—cameras, office multifunction devices, inkjet printers, laser printers, and semiconductor lithography equipment—is no exception. Likewise, we are building competitiveness by incorporating fundamental technologies accumulated over the years into the core technologies of products in businesses that have recently become part of the Canon Group, such as medical systems, network cameras, commercial printing, and industrial equipment.

We have transformed several of these core technologies into fundamental technologies through repeated R&D efforts. Toner, drums, and other advanced materials, for example, were once core technologies used in copying machines. Now, they are fundamental organic synthesis technologies which are being used to develop competitive products in other areas and businesses. In the field of imaging, our lenses, image sensors, and image processing—our overwhelmingly superior core technologies—are making Canon cameras more competitive. These are now fundamental technologies—optical, electronic device and sensor, and video image processing technologies—that are used in other



Creating businesses through multiple combinations of our core technologies, value creation technologies, and fundamental technologies

businesses. Specifically, the core technology behind Canon camera person detection has been further developed as a fundamental technology for AI and data statistical analysis, and is now being incorporated into healthcare IT systems helping to drive diversification in our medical business and strengthen this business.

The value creation technologies supporting quality, cost, and on-time delivery, which Canon has accumulated during its growth, underpin the launch of new products and businesses. Robust value creation technologies focusing on analytical simulation, intellectual property, quality, design, value engineering, field engineering, and environmental technologies, are one of Canon's greatest strengths for swiftly growing a business.

R&D System

With Canon's current diversification, each product division is moving forward with product development based on plans unique to that division. At the same time, our R&D Headquarters carries out leading-edge trend research and the resulting advanced technology development. This system allows individual business groups and headquarters to engage in multiple R&D projects while strengthening existing businesses and fostering new businesses by means of close coordination.

R&D Strategy for Phase VI

Canon embarked in 2021 on phase VI of the Excellent Global Corporation Plan, which focuses on strengthening R&D along the following three trajectories.

First, we will further strengthen fundamental technologies and value creation technologies. In this way we will drive forward the key strategies of Phase VI of the Excellent Global Corporation Plan, which call for the Group to thoroughly enhance competitiveness in the Printing, Imaging, Medical, and Industrial industry-oriented business groups.

Second, we will generate the seeds of our next ventures based on robust core technologies and fundamental technologies. In terms of physical research and development, for example, we will develop materials with new functionality leveraging material technology based on ink and toner materials, while also developing devices utilizing other specialized materials, then we will foster next-generation technologies as the seeds of new business. At the same time, through technological diversification, we will pioneer new business fields.

Third, we will strengthen innovation-focused technology development that meets the needs of this era. While recognizing trends such as DX and carbon-neutral solutions, we will continue driving technology development that leads to higher corporate value. In particular, Canon is focusing on a cyber-physical system that effectively integrates cyberspace, which allows us to merge various services, and physical space where people connect with one another. We are drawing on world-class core technologies in the physical domain and advanced cyber technologies through our various alliances, while expanding and developing technologies to develop cyber and physical business models and products that are one step ahead and generating a range of innovation.

Human Resources to Support Future R&D

Human resources are the cornerstone of these new measures. Through its core competence management, Canon has created a database that includes technologies worked on and the divisions and number of people involved as well as engineer profiles. We have established a framework that enables personnel to take an active role from a company-wide perspective, working with world-class core technologies in commercial business development and cutting-edge fundamental technologies in the R&D Headquarters. For new technical areas needing to be reinforced, we offer training opportunities for personnel to acquire technologies, and develop human resources, positioning the Group to adapt its R&D framework to changing needs. Core competence management in the various product divisions and at the R&D Headquarters is providing young employees with opportunities to exercise their talents and cultivating professionals who are adept in both the business and technological fields that are indispensable to innovation. These human resources will lead the Group into challenging new fields and support the Group in the next generation.

Development of SPAD sensor with 3.2 megapixels for color photography

Examples of R&D to Create New Value and Address Social Issues

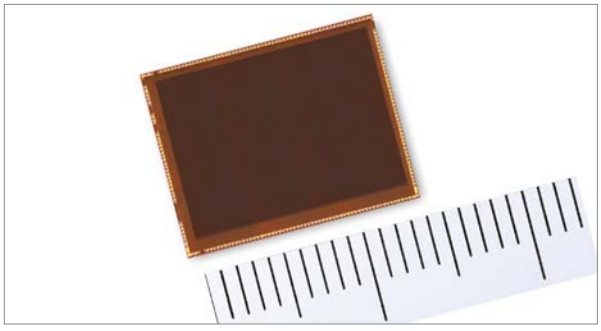
Through core competence management leading to multiple combinations of our core technologies, fundamental technologies, and value creation technologies, Canon is generating new businesses that will create new value and help solve social issues.

Successful Development of a Key Device of the Future SPAD Sensor with World-first 3.2 Megapixel Count

Canon has developed a single photon avalanche diode (SPAD) sensor that enables color photography at 3.2 megapixels—higher than the 2.07 megapixels of full HD—even in dark environments. SPAD sensors multiply a single light particle (photon) when it reaches a pixel—as if creating an 'avalanche'—, amplifying it in a 'snowball' effect to produce a single large electrical pulse. CMOS sensors measure the volume of light present in a pixel. As the accumulated light is picked up as an electrical signal, associated 'noise' can impair picture quality. SPAD sensors, by contrast, count individual photons digitally, making it possible to measure very small amounts of light even under low-light conditions without electronic noise, making it possible to capture clear images even in dark environments.

The new SPAD sensor developed by Canon uses an approach that includes a unique pixel structure to refract photons within the pixel, enabling photons to be efficiently detected across the entire range of the effective pixels. As a result, even if the pixels are made smaller and rendered at higher resolution (3.2 megapixels), it is possible to capture video even in conditions darker than a starless night sky.

Moreover, as the SPAD sensor is capable of extremely high information processing speeds on the level of 100 picoseconds (one trillionth of a second) it is able to capture very fast-moving objects such as light particles. In addition to its high-sensitivity performance, the sensor's unique rapid response functionality brings great expectation for a wide range of applications including automated vehicles, diagnostic imaging equipment and chemical measurement devices.



SPAD sensor prototype

Social Infrastructure Inspection Services Detecting Cracks with AI Technology

To address the issue of deteriorating and support the maintenance of aging social infrastructure, Canon has developed a service offering inspection of bridges, tunnels and other concrete structures. The condition of concrete depends on design criteria, materials and the environment. If the conditions are bad, concrete is generally considered to start deteriorating after 40 to 50 years, and the need for structural inspection has now reached high levels worldwide.

One of the most important points in assessing the soundness of concrete structures is whether cracks are present. Traditionally, the main inspection method for concrete structures has been based on a graphical sketch of the cracks in the structure made through visual inspection by an inspection engineer with specialized knowledge. In recent years, however, image-based inspections using a camera to take photographs to identify cracks and other locations needing attention at the inspection site are increasingly becoming the standard. Although this method has the advantage of enabling fine cracks to be confirmed by increasing the resolution of the image, it also requires a lot of time for inspection engineers to check the image at their desks.

Canon, which has been developing image-related AI for many years, has used AI to detect even thin cracks as wide as 0.2 mm and, depending on the quality of the image, even hair cracks as wide as 0.05 mm, from inspection images taken with high-resolution cameras. It has also significantly lightened the growing workload

Using AI to detect cracks in concrete structures

of inspection engineers. As one example, it has been reported that the twelve hours it used to take an inspection engineer to assemble the inspection data has been taking just one hour and a half.

Offering a Realistic Viewing Experience Volumetric Video System

Canon's Volumetric Video System delivers a new visual experience in a wide range of spectator settings, from sports to entertainment, allowing the action to be viewed from any position or any angle in the stadium or auditorium. When watching sports for instance, free viewpoint selection enables viewing from the perspective of a player on the field or from any number of alternative angles, as well as showing reruns in slow motion while simultaneously changing the viewpoint. In this way, the new system offers complete freedom to choose the viewing angle and the speed of playback. It is also possible to generate three-dimensional camera work and images from places where a camera cannot be placed in real life. In TV program recording, it is possible to realize realistic images as if a person is in a forest or in the sea.

The system uses a network of high-resolution cameras installed at many points around the recording scene to capture visual data, which are then converted via a unique image processing technique into 3D data and stored on servers. When the user sets or moves the position of the virtual camera, the corresponding image is generated from the 3D data to show video footage from the selected camera angle.

The Volumetric Video System was made possible by a sophisticated combination of Canon's accumulated optical and imaging technologies with other technologies developed within the Canon Group in areas such as network transmission and user interface. Canon will continue to develop the Volumetric Video System as a technology that breaks down the barriers of location and time while also reducing the amount of materials needed for studio sets in line with the aims of the SDGs.

Canon's Volumetric Video System will dramatically change how people watch sports

Exploring the Final Frontier: Outer Space Satellite Development

The space business is seen as a highly promising future growth area offering business opportunities ranging from the development, production and launch of satellites to the provision of services such as telecommunications, image transmission and location-based services. Our Group member Canon Electronics already has the technological foundation essential to making a micro satellite—motor technology for attitude control of the satellite, macro to zoom lens technology, and miniaturization technology to eliminate waste. It will additionally be able to access Canon Group technologies in electronics, mechanics, optics, materials and other areas for the development and production of its satellite from parts.

Micro-satellite development involves a range of issues associated with the very different operating conditions of the space environment, such as system failure due to radiation, the risk of operational error, and the heat generated under vacuum conditions. Canon Electronics has overcome these issues by using radiation-resistant commercial parts and by developing a metal-based radiative cooling method. By devising solutions in this way, it has successfully launched two satellites so far. These satellites were fitted with Canon cameras and ultra-sensitive camera. The resulting imaging system can provide wide-angle shots within a 740 km x 560 km frame from a 500 km orbit, giving an image quality that enables individual vehicles to be identified and shooting nighttime images with only moonlight. The image data are transmitted to ground control daily.

Additionally, Canon Electronics and three other companies have established SPACE ONE Co., Ltd., to operate a rocket launch service. The company plans to construct Japan's first private-sector rocket launch station at Kushimoto in Wakayama Prefecture in order to develop a comprehensive space business with activities ranging from satellite development and production through to launch.

A micro satellite now in orbit around the earth