ACTIVITIES 2

Create Building Spaces that Enhance QoL

Use of Digital Technologies and the Future of Smart Buildings

Buildings have evolved in parallel with economic growth and urbanization, providing living and working spaces, and venues for consumption and entertainment. Given estimates that around 70% of the world's population will be living in cities in 2050, demand for escalators, elevators, and other building systems is also expected to increase in the future. Meanwhile, the world is also confronting new societal challenges that include climate change, aging populations accompanied by a low birthrate, and more recently the coronavirus pandemic. Amid all these changes in people's values and in the nature of societies and companies, the question arises as to what the buildings of the future will be like and how they will deliver value to global society. For this article, *Hitachi Review* used online videoconferencing to talk to key people engaged in operations and R&D on the future of building systems.

How to Deliver New Value to People, Buildings, and Society

——The environment around buildings is changing along with the emergence of a variety of societal challenges such as climate change. How will Hitachi's Building Systems Business Unit respond to these changes?

Koga: In its 2021 Mid-term Management Plan, Hitachi committed to resolving challenges facing society through its business operations with the aim of enhancing social, environmental, and economic value for customers. Based on our mission of helping achieve a sustainable society by delivering new value to people, buildings, and society, the Building Systems Business Unit seeks to help overcome the challenges facing the world with a focus on goals 7, 8,

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and 11 of the Sustainable Development Goals (SDGs)[*1].

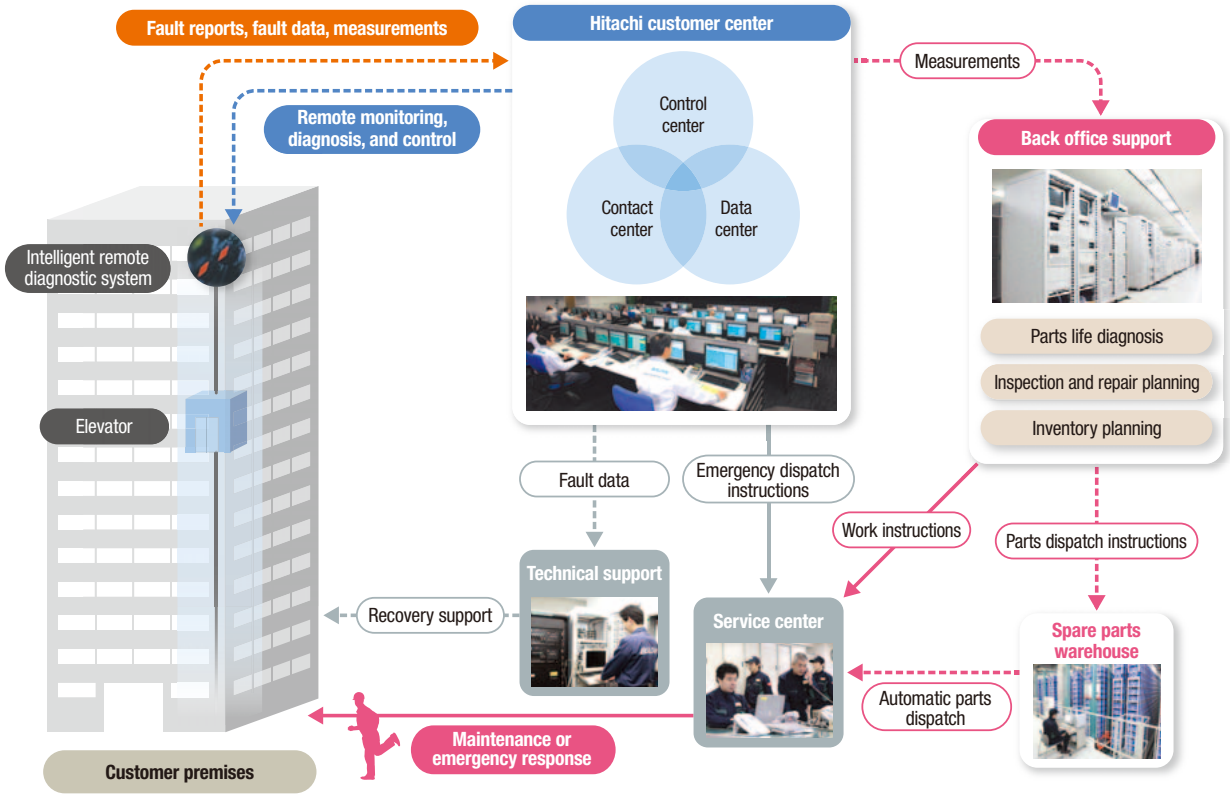
Helped along by the trend toward urbanization, we have grown our business primarily in the area of elevators and escalators. We are recognized as a leading supplier in both Japan and China in particular and we also have many devoted customers in the market for building facilities services. Given the rapidly changing societal challenges and the business environment, however, we cannot rest on our past successes and instead, based on our mission of contributing to society, we need to create new value by combining our products and services with the latest digital technologies and the technical expertise we have built up over time in areas like the Internet of Things (IoT) and artificial intelligence (AI).

*1 Goal 7 (Affordable and clean energy), Goal 8 (Decent work and economic growth), and Goal 11 (Sustainable cities and communities)

What we hope to become at the Building Systems Business Unit is an IoT service provider that is inclusive of all building users. In 1987, 33 years ago, Hitachi developed a system for the remote acquisition of fault signals from elevators and escalators. This was followed in 1994 by the development of the remote intelligent diagnostic system for collecting operational data (see Figure 1). This remote monitoring and the use of data for predictive and routine maintenance can be thought of as a forerunner of the IoT.

Given the progress of digital technology and the infrastructure now in place for service delivery, Hitachi is working to integrate its accumulated skills and expertise into these services. For example, our Business Unit is working in partnership with Research & Development Group (R&D) on technologies such as the analysis of video from surveillance cameras inside buildings, techniques for analyzing

Figure 1 | Service Flowchart of Hitachi Remote Monitoring System



and predicting the internal movement of people, robotics to provide support for the elderly and to help address labor shortages. Our aim is to supply stakeholders with smart building services that utilize digital technology, especially in relation to elevators and escalators.

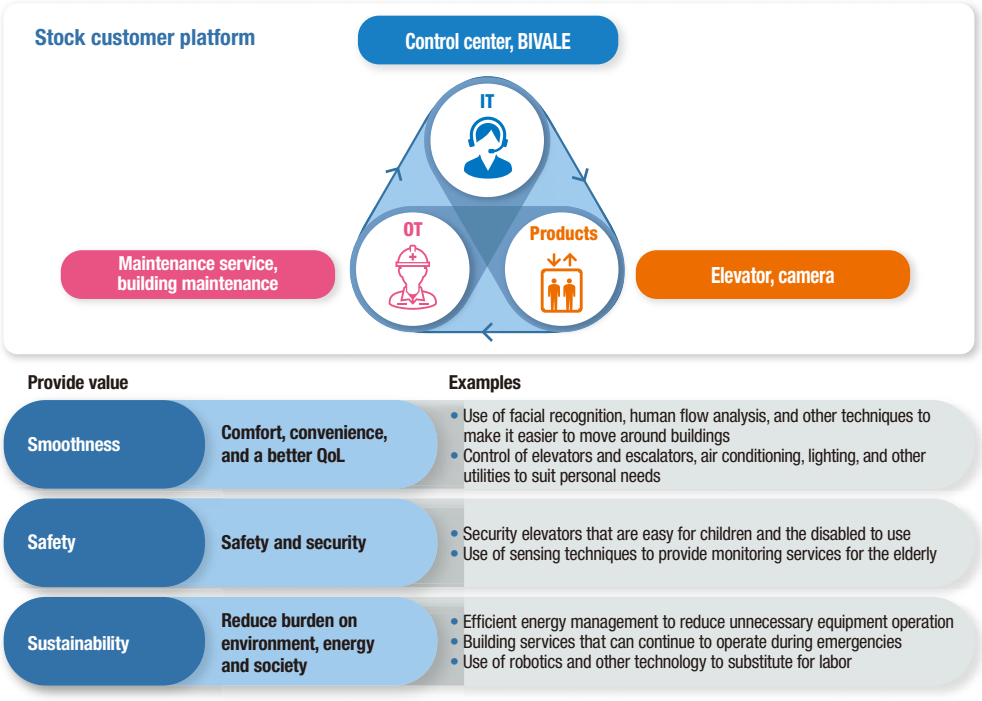
Value Creation through IT, OT, and Products

——Can you go into more detail about these smart building services?

Koga: It is anticipated that remote working will become more common in Japan as our population shrinks and working practices are reformed, not to mention helping prevent the spread of coronavirus. Rather than an increase in the number of new buildings based on the past practice of scrap and rebuild, the focus in the future is likely to be on finding ways to maintain and enhance value that make use of existing buildings. In other words, Japan will begin in earnest transforming the nature of our society from a "flow-based" to a "stock-based" society.

To date, we have supplied approximately 200,000 elevators and escalators in Japan along with the installation of 25,000 camera systems and have provided building maintenance services to 22,000 sites. Technical progress has led to greater use of digital technology in elevators along with advances in information processing such as edge computing. Given these circumstances, what we are seeking to do with our smart building services is to adapt them to suit this "stock-based" society by combining our elevators and their digital technology with building solutions based around the BIVALE integrated facilities management solution together with IT, such as the IoT and AI, and operational technologies (OT) that encompass maintenance services. By integrating and mixing IT, OT, and products in this way, we aim to deliver value in the form of "smoothness" (convenience), safety, and sustainability (see Figure 2).

Figure 2 | **Key Competencies of Hitachi's Building Systems Business Unit**



One of the distinguishing characteristics of buildings is the wide variety of stakeholders they involve, including the building owner, the people who work in or visit the building, the property management company, and the surrounding neighborhood including other nearby buildings. Our role is to deliver value across all of these stakeholders. To achieve this, we recognize that we need to equip our smart building services with the flexibility to add or update services in response to a changing social environment and, rather than being limited to Hitachi products, to design open systems that can interconnect with third-party applications.

Integrated Analysis of Building Facilities and the Movement of People

——What is happening with regard to building services at the Center for Technology Innovation where development work is done?

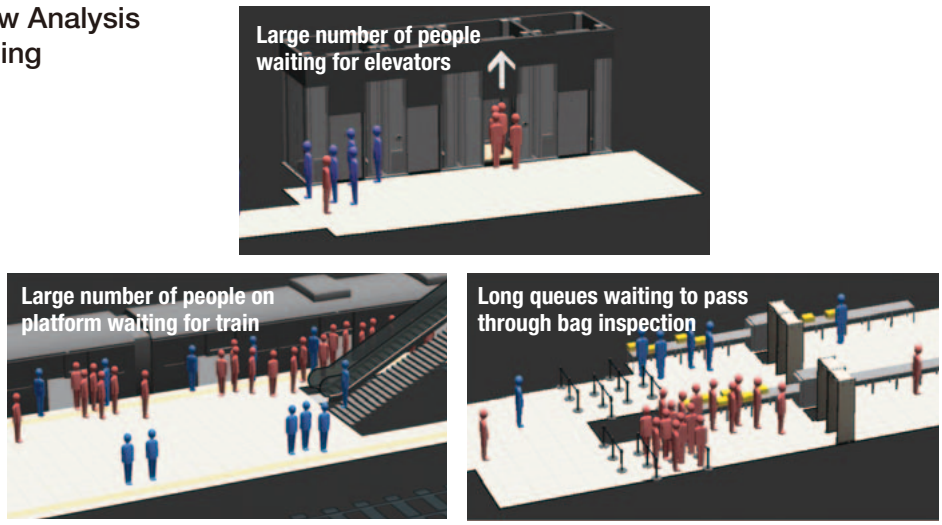
Noguchi: With the aim of contributing to enhancing the three forms of value targeted by Hitachi, the focus at the Center for Technology Innovation is on the value creation cycle of collaborative creation (co-creation), development, and consolidation. With regard to the creation of value through a combination of IT, OT, and products, we are using the Lumada as a basis around which to work with customers on the co-creation of digital solutions. Examples of such from the building services sector include the use of image analysis to track the movement of people, maintenance efficiency improvements, and logistics solutions.

As an organization devoted to developing technologies of direct relevance to products and services, the Center for Technology Innovation sees its mission within the Research & Development Group as including the value-based creation of global No. 1 technology. Taking value for customers and wider society as our starting point, we are developing core technologies that are distinctively Hitachi while also working with partners such as overseas research institutions, companies, and startups rather than trying to do everything ourselves. Examples include AI, image analysis, 5th generation (5G) telecommunications, sensing, robotics, electrification, and security, all of which have a deep affinity with building systems.

——Can you give me any specific examples of this work?

Noguchi: One example is the use of an integrated simulation of the movement of people in a building to optimize its modalities and facilities. The simulation combines the expertise in elevator operation and control that Hitachi

Figure 3 | How Human Flow Analysis Works in a Building



has built up over many years with the use of a cellular automaton*2 (a technique for modeling complex systems) to simulate people's behaviors and predict these movements in time increments of seconds or minutes (see Figure 3). We have accumulated large amounts of data on elevator use, including on car allocation and on people's use of elevator hall buttons to request a ride. We analyzed this data by AI and incorporated an algorithm for predicting the inflow of people in each time period.

The current trend for large buildings is toward multifunctionality, with an increasing number of multipurpose buildings that combine event venues, offices, housing, hotels, and more. Given the wide variety of purposes for which people use these buildings and their diversity in terms of age group and other characteristics, it is important to create safe spaces that enhance the quality of life (QoL) of everyone. It is also likely that minimizing the unnecessary movement of people will be another important consideration in the future to help prevent the spread of coronavirus. I am also convinced that the integrated analysis of data on users and facilities will become a valuable tool in consultations with building stakeholders about what facilities to provide in order to achieve this. By predicting the movement of people in a way that takes account of interactions between facilities and users, we should be able to alleviate crowding and make it easy for people to move from place to place.

*2 An automatic mechanism (automaton) comprised of a spatial lattice of cells, where the state of each cell changes over time thorough interaction with adjacent cells

Safe and Secure Apartment Buildings

——Looking beyond office blocks and multipurpose buildings, what are you doing in relation to residential apartment buildings?

Noguchi: The increasing numbers of high-rise residential buildings mean that elevators and escalators have become an essential service, such that of the three different forms of value, it is safety that is of particular importance. One major concern is that we need to do all we can to shorten the length of time these facilities remain out of service following an earthquake. The ability to restore services remotely or automatically can be provided by installing electronic devices in place of certain safety mechanisms that in the past have been mechanical.

Koga: The loss of electric power to residential buildings during disasters is a major problem. To prevent people from being trapped when a power outage occurs, elevators are equipped with a function that switches to internal battery power and moves to the nearest floor. Unfortunately, this function cannot deal with extended power cuts. Greater use of batteries is seen as a potential solution to this. We are currently trialing the use of batteries from electric vehicles and other commercial applications to power critical equipment including elevators and escalators.

Noguchi: The key to achieving a better relationship between people and buildings, whether they be office or residential, is the use of data on facilities operation and people's behaviors, with the former numbering in the thousands. By making use of data in ways that do not compromise security and privacy, our aim is not only to help people move about more efficiently, but also to facilitate logistical operations such as receiving delivery items. Based on the concept of building management being underpinned by users, we are looking for things we can do to encourage residents to help one another or to facilitate the sharing of information within the building or neighborhood.

Extending Scope of Design to Behavioral Change among Users

——What is the Global Center for Social Innovation doing to develop smart building services?

Uegaki: The Global Center for Social Innovation uses service design methodologies as a basis for undertaking global co-creation with customers in order to accelerate

the development of Hitachi's Social Innovation Business. My own Service Design Department is researching design methodologies that combine data with experience value with the aim of developing services that both enhance people's QoL and improve value for society and customers, in other words, businesses that have value for society as a whole, not just service users and providers.

What prompted us to embark on this work was our experience with services that had lower-than-expected uptake despite being designed to help society and make people's lives better. Even when solution ideas are both valuable and socially reasonable and devised using data from a variety of sources, such that users shown these solutions can appreciate their worth, those users will still not necessarily act accordingly. We realized that was one of the difficulties of human nature, and that unless designs also consider how to encourage self-directed changes in behavior, their true value to users may remain unrealized.

To use the example of a service intended to alleviate congestion inside buildings, analyzing data to show the extent of crowding or when use of facilities is low will not change anything unless people pay attention and change their behavior accordingly. Such a service would become more useful and be more widely adopted if accompanied by measures to spread the timing of people's movements more widely.

What are the Prerequisites for Improving QoL?

——What sort of services can improve QoL?

Uegaki: QoL is a subjective and relative value that varies from person to person and it has been suggested that it can be improved by reducing the disparities we notice when comparing ourselves to others around us. To reduce disparities, it is first necessary to determine what the disparities are between ourselves and others and between our present and past. To do this, we need to collect data that sheds light on people's circumstances and actions. In terms of services, data is also needed that can measure how they are used and the benefits they deliver. As smart buildings can use the IoT to collect a wide variety of data, the hope is that this can be utilized to develop services that improve QoL.

Figure 4 | **Service Ideation Workshop Organized by Global Center for Social Innovation**

In a study of services for apartment buildings conducted in FY2019, we came up with the idea of a service for encouraging residents to be more considerate of others with regard to things like noise and the putting out of garbage based on the assumption that reducing problems of this nature was important for adding value to living in the building. We believed that, by reducing such problems as a means of satisfying safety and societal expectations, people would be able to enjoy a life with high QoL, looking outward and aspiring to self-realization.

One of our findings when we surveyed people about these issues was that tolerance for noise and other disturbances varied depending on the makeup of a building's residents. If people's standards are different, it is likely that their skills and the way they go about preventing difficulties or promoting communication will also be different. No doubt what is needed to find optimal solutions under such circumstances is a mix of data and experience. I believe that one of the requirements of smart services will be the ability to change what they deliver in step with the changes in people's standards that come about from resident turnover (see Figure 4).

Updating Solutions to Reflect Changing Values

——A matter of considerable public concern right now is what will constitute the new normal after the pandemic subsides. What role will technology play in maintaining QoL amid changes in society and in how people live?

Noguchi: Technology will play a large part in the post-corona world. There will be a need for the use of 5G and security measures to facilitate telework and other working style reforms, encouragement for non-touch practices, and both physical and system measures for preventing "three Cs" (closed spaces, crowding, and close contact). In my own area of work, we are putting a lot of effort into touchless means of travel, ways of operating elevators and escalators that avoid contact, and use of robotics to reduce close contact between people. If, rather than being restricted to logistics and manufacturing, robots in the future are called on to move among people inside buildings, then those robots will need to modify their behaviors to be compatible with people. To this end, we intend to step up research that seeks to better understand human beings.

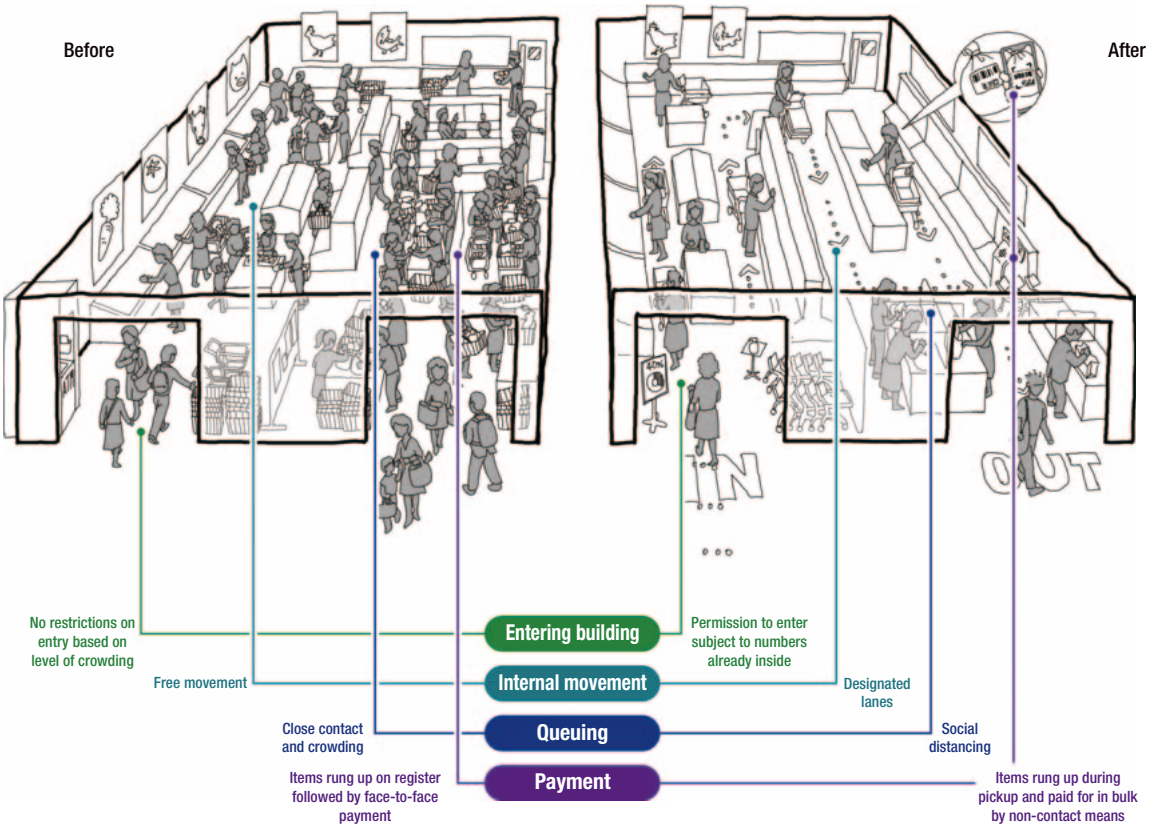
To use value as a starting point for technology development, it is important that we routinely consider how to contribute to society and engage in activities where researchers from a variety of fields contribute their knowledge and ideas. We also work with the Global Center for Social Innovation to discuss technologies that can demonstrate value in societal challenges and ways of overcoming them.

Uegaki: Rather than technology itself, the Global Center for Social Innovation considers service ideas and user interfaces from the perspectives of the people who use this technology. Moreover, we are conscious of rapid and widespread changes in values and behaviors following on from the coronavirus pandemic. One example is how bringing people together and encouraging vibrancy and mingling used to be a major consideration with buildings, whereas now it is finding ways to prevent such mingling that is important (see Figure 5). As some of these changes in values and behaviors will be temporary whereas others will become the norm, we are collecting information from a variety of perspectives and sharing it with the Center for Technology Innovation.

Koga: Energy efficiency is another example that has been an absolute value in the past and, for that reason, we used to keep the ventilation of air to a minimum to improve air conditioning efficiency. However, what we are seeing now that ventilation has become recognized as important for infection control is that the relative value of energy efficiency has fallen.

As in this example, it may be that things we used to take for granted will no longer be the case in the post-corona world. For this reason, I see it becoming more important than ever that solutions be designed in ways that allow them to be updated when changes in societal values are identified.

Figure 5 | Changes in Values Prompted by Coronavirus Pandemic



Developing Technology in Ways that Draw on Japanese Corporate Strengths

——However, it has also been noted that Japanese companies have been slow to develop and deploy digital technologies in the coronavirus pandemic.

Noguchi: I believe there are areas where we are lagging behind what is happening overseas in terms of digital transformation. What matters, however, is not that we catch up on these delays, but that we reassess and build on our own strengths. Japanese companies have an edge in product finish, a sense of balance, and fastidious service that goes into meticulous detail. Even now in the digital era, our intention is to get actively involved in honing these services through repeated practical testing.

One example is the view that AI cannot be used in applications such as infrastructure control that demand high levels of reliability because AIs cannot explain the reasons for their decisions. However, in cases such as when seeking the cause of abnormal data (is it due to human error, to the situation being outside the scope of the system, or to parts at the end of their usable life?), we are able to improve reliability and increase the chances of finding an explanation if we can draw on our accumulated knowledge.

Advances in techniques such as visual simultaneous localization and mapping (SLAM) are bringing a world in which robots will be able to move around on their own. Along with developing rules of behavior, these robots will also need to be equipped with a degree of autonomy if they are to move around safely and efficiently in the real world. Our work includes looking at how to use deep learning to provide this autonomy.

Figure 6 | **EMIEW Humanoid Robot Used for Greeting (Left) and at an Aged Care Facility (Right)**

Protecting Universal Values in an Age of Uncertainty

——Finally, can you tell me about what you see for the future?

Koga: I anticipate that robots fulfilling a variety of roles in which they work and coexist alongside people will be a feature of the post-corona world. The Building Systems Business Unit also believes that robots will be an important factor in future building services and, in collaboration with the Research & Development Group, we intend to deploy the EMIEW humanoid robot with a view to such applications (see Figure 6). If robots are to create new value, it is likely that platform technologies will be needed that enable different robots to operate safely and efficiently alongside one another. Our intention is to combine products such as elevators and escalators that are an important means of movement inside buildings with the associated control techniques to create a world in which people and robots coexist.

Moreover, the very fact that we live in an age of uncertainty where changes can occur unexpectedly on a variety of fronts, as exemplified by the coronavirus, means that universal values are critical. Our aim is to supply smart building services that enhance QoL by utilizing Lumada to engage in co-creation with customers based around the universal values of smoothness, safety, and sustainability that are shared globally.

Noguchi: While technologies such as robotics are making amazing progress, there is a shift underway from functionality to value with regard to what matters most in differentiating building services. I hope that R&D, too, can maintain a focus on universal values and contribute to their realization.

Uegaki: While I expect new technologies and services such as robots will become part of people's lives in the post-corona era, our role is to design these services in such a way that they are accepted, utilized, and become firmly established. It may be, in this time of uncertainty, that our concept of the future will keep changing. My hope is to deliver building services that have the flexibility to respond to these changes and that offer new value to the public in a way that derives from people.