MHI's Theory of Service Evolution
“MHI Group's Services Maximizing Customer Value”

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Sharing the world’s aspiration to transform itself into a carbon neutral society, Mitsubishi Heavy Industries, Ltd. (MHI) Group has declared “MISSION NET ZERO” for achieving net-zero CO_2 emissions by 2040.

Our approaches for realizing decarbonization and energy-saving features in our products/systems are based on not only developing new technologies and creating ecosystems through energy transition, but also making the products and social infrastructures smarter. In this special edition featuring the service technologies, our initiatives are presented in terms of how to introduce smart social infrastructures under the circumstances in which products are getting more and more advanced/complicated. Specifically, these include: practice of customer-oriented and solutions-based services throughout the product life cycle, which helps us to shift our trading focus from products to services; maximization of customer value with services in which AI (Artificial Intelligence) and digital technologies are made use of; and examples of improvement of service technologies.

1. Introduction

As a provider of a wide range of energy and social infrastructure systems, MHI Group declared “MISSION NET ZERO” in 2021. With this declaration, we have set ourselves to achieve net-zero CO_2 emissions from our group itself as well as from our products being operated by the customers by 2040.

What we are required to do towards a carbon-neutral society is not limited to developing new technologies and creating ecosystems through energy transition. The contribution to decarbonization and energy conservation need to be made by improving the performance of our products/systems and operating them in an optimal manner.

On the other hand, now that the internet and digital technologies are ubiquitous, it is possible to find various types of services, information and digital content online. With the commonly used e-commerce, customers can easily get anything anytime. Seamless support for product troubleshooting or repair is also becoming available with the use of digital technologies.

Such development has allowed customers to have advanced support and user experience in their daily lives. This in turn is raising the level of service quality that customers expect to be provided.

Adapting to such a new trend of the times, MHI Group has stopped focusing only on selling products, and has instead combined them with services as a package in order to realize “customer-oriented and solutions-based services” and assist customers throughout the product life cycle.

The examples of such support services, which are provided accurately and continuously throughout the product life cycle to maximize the value for customers in use of our products, include: real-time monitoring of operating conditions utilizing digital technologies and our expertise/experience; detection of early signs of failure to minimize the downtime based on the analysis results of such operational data; proposal of maintenance necessary for the optimal operation of equipment; and improvement of performance and machine intelligence for enhanced

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value of the equipment in use.

This report presents our technology development and projects related to the following three points, which are being undertaken to realize “customer-oriented and solutions-based services” from a technological point of view.

The first is the realization of solutions-based services in which we assist customers through the product life cycle. Specifically, this means the establishment of a commercial platform based on the long-term maintenance contract, and the creation of a technical service platform that enables us to understand the operating conditions through remote monitoring, periodic inspection, maintenance, etc., and keep in contact with the customer. As other initiatives, timely and accurate proposals will be made for optimal services in the long run with the aim of enhancing customer value. Efficient training is also conducted via remote sessions, AI or VR (Virtual Reality)-based education programs and such, ensuring long-term retaining of human capital.

The next initiative is to maximize service value by making use of AI and digital technologies. The use of ΣSynX® enables us to intelligently connect customers’ equipment and our products, making their mechanical systems more intelligent. In addition to providing value through operation of our products, we can allow a wide variety of mechanical products to be linked and controlled to achieve advanced operation, and help customers to accumulate know-how through machine learning.

The last initiative pertains to development of service technologies that help our trading focus to shift from products to services. As products are becoming more sophisticated and complex, we particularly emphasize the importance of developing the technologies that can facilitate customer support and improve user experience, as well as elemental technologies to support more sophisticated services.

2. Realization of solutions-based services to assist customers through life cycle

To maximize customer value, we need to provide services that keep maximizing customer value over a long period of time through the product life cycle. Therefore, customers should be able to receive solutions-based services such as high-value-added performance improvement, in addition to continuous, timely and accurate support and services that are optimized from a long-term perspective. The solutions-based services are considered to play a key role in shifting our focus from supplying products to offering solutions. To allow us to offer solutions meeting a customer’s needs or based on how the product is operated, it is necessary to accurately understand the product’s operating conditions and maintain smooth communication with the customer. In other words, MHI Group continuously listens to the customers’ opinions and requests like a family doctor for our delivered products. The use of operational data, long-term maintenance records and other variables enables us to provide services such as inspection, maintenance and remote monitoring according to the product’s operating conditions. We can also offer a service menu of high-value-added proposals such as performance improvement. Bringing more value for customers will become increasingly critical in the years to come.

These services have already been made available to customers as part of the long-term maintenance contract since around 2000 for some of our products including GTCCs (Gas Turbine Combined Cycles). By helping customers to make their long-term maintenance plans and secure necessary parts/resources in the long run, we assist in achieving stable operation of the products. The services that enhance customer value, such as performance improvement, are also proposed. Going forward, it is expected that these services will become applicable to more products. More customers will also choose a long-term contract considering the optimization of services through the product life cycle. To ensure stable operation, which is a prerequisite for long-term contracts, remote-monitoring technologies in addition to periodic maintenance are used to detect early signs of failure or assess the operating conditions while the product is in operation. Evaluating and analyzing the obtained data against the maintenance and inspection records enable the creation of medium to long-term maintenance plans and use the results as feedback for the next inspection. This leads to the provision of timely and accurate maintenance services.

Such remote monitoring services serve as a platform to not only understand the operating

conditions but also communicate with the customer on a daily basis. This platform, therefore, is the foundation for our capability of providing customer-oriented services that enable us to meet a customer's needs and proposing high-value-added services. It is also essential as an effective communication tool, when services are provided through the product life cycle. Along with the advanced inspection technologies, the centralized management of maintenance data and the digitalization of on-site data entry are considered to increase their importance as advanced service tools.

On the other hand, maintaining the quality of our services in the long run necessitates not only retaining the quality of parts and upgrading the tools, but also keeping/improving the level of technical service staff throughout the product life cycle. The challenges that we have always faced against the backdrop of ageing technical field advisors are handing down of their knowledge/techniques and the efficient development of next-generation human capital. There are also technological issues about hardware such as communication with remote areas. However, services such as remotely providing instructions are becoming available, as technology advances. While remote areas receive efficient instructions by skilled technical advisors, AI or VR-based training programs are developed to efficiently train technical service staff. In this way, we will deal with the problems of human resources and realize long-term provision of maintenance/services throughout the product life cycle.

As such, with the aim of realizing solutions-based services in which we assist customers through the product life cycle for maximum customer value, MHI Group has established two platforms. One is a commercial platform mainly based on the long-term maintenance contract. The other is a technical service platform enabling us to understand the operating conditions through remote monitoring and periodic inspection/maintenance and keep in contact with the customer. Depending on the customer needs, the architectures of commercial and technical service platforms may change. However, we have committed ourselves to continue to provide the services that are optimized with timely and accurate proposals for enhanced customer value. Efficient training is also conducted through remotely providing instructions, AI/VR-based education programs and such, ensuring long-term retaining of human capital.

3. Maximization of service value by making use of AI/digital technologies

The advancement of digital technologies such as AI has been rapidly evolving over the past few years, and is revolutionizing our daily life and business activities. Looking back, the widespread use of personal computers and the internet after the 1990s improved productivity. This was followed by the development of mobile devices, which innovated our communication methods. Others include high-speed networks, and large-capacity storage resulting in advanced technologies such as cloud services and big data analysis. As sensor technologies are getting downsized, more energy-saving and lower-priced, the use of IoT (Internet of Things) is rapidly expanding. Having been used mainly to control large industrial machines, IoT is now being introduced to smaller, niche fields as well. How to use the data obtained by these applications is becoming important. Another dramatic development is the evolution of AI technology, as mentioned at the beginning of this section. Both deep learning AI and big data AI to use for data analysis are evolving every single day. Thus, it can be said that IoT for data transmission and AI to assist data utilization are the key players in the ongoing technological revolution.

Now let us consider how these digital technologies are utilized in the business world or are applied to services. In recent years, IoT has been incorporated into TVs, air conditioners and cars. Moreover, coming to think how often we see people using a smart watch for health monitoring etc., everyone would agree that these technologies are increasingly in use for our everyday devices and are ubiquitous. Their applications are not only limited to devices for consumers, but can also be seen in industries expanding beyond the established boundaries. As in the case with consumer devices, industrial applications are found in the details of various mechanized facilities and their maintenance tools. On-site workers also utilize IoT. The data regarding the work by humans and that by machines are continuously collected in real time, which allows us to have unprecedentedly large amounts of data input from various perspectives. These data are utilized as big data, and their high-speed analysis has become possible through the advent of AI. Such analytics has started to be

utilized to provide advanced services or create added value in businesses.

MHI Group is also undertaking various projects to utilize these digital technologies for maximizing customer value, and has launched its own brand for intelligence called ΣSynX®. Differentiating itself from the counterparts of software companies, ΣSynX® brings an integrated control system of multiple machine groups (hardware) to create new added value. A unique approach is thus taken for service creation. MHI Group's strengths lie in a wide-ranging portfolio and control capabilities. By coupling them with big data obtained by IoT, etc., and AI to utilize big data for decision making, we provide an integrated control system along a series of processes from the upstream to the downstream stage. The result is sophisticated cooperation that cannot be realized by simply combining individual components. Our services, therefore, can deal with complicated problems. Besides ΣSynX®, MHI Group also utilizes various types of digital technologies for advanced services. The examples include the improvement of operation efficiency by combining remote monitoring with AI, the creation of a centralized big data database, the provision of a long-term maintenance plan made by combining the operational data with maintenance data of each piece of equipment, and sharing of such information with the customer through the customer portal. These services have already been made available in many businesses. This service framework is mutually beneficial in terms of enhancing the customer's usability and improving our productivity. Unsurprising it may be, but high-quality output brought by the advance of AI enables us to create a sophisticated service that could not be realized before. As a first step towards digital service, the use of this framework is also being facilitated among our group companies. As part of our effort to expand services, more IoT and/or AI-based services will be introduced in the years to come.

We are continuously developing new original services by taking advantage of our strengths in machine control technology, together with the utilization of latest digital technologies. MHI Group is pursuing maximization of service value to build a sustainable relationship with customers.

4. Technologies supporting shift of our trading focus from products to service

In today's market, MHI Group focuses not only on making individual products more advanced or complex to promote their sales, but also on maximizing customer value through service provision. The technologies and services, which MHI Group is working on for maximum customer value, are presented below.

Smooth customer support is indispensable for maximizing the value that MHI Group can offer to customers through its products and services. To provide prompt but fine-tuned services, we listen to the voices of customers, make every effort to solve problems, and build a specialized customer support system to ensure that customers can feel a sense of security and trust.

Let us give the remote monitoring by TOMONI® as an example. Having been introduced to GTCCs, it functions as a tool to detect early signs of failure by constantly monitoring the facility, and assists operational work and maintenance planning. This not only leads to stable operation of the facility, but also helps enhance cybersecurity and reduce manpower requirements for monitoring/maintenance. MHI Group is expanding the application of this remote-monitoring technology in GTCCs to other products as well. Such use of remote monitoring will enable us to offer the above-mentioned customer value for the whole product portfolio.

As a technology enabling smooth customer support and enhancing user experience, a customer portal is built to allow customers to check our delivered equipment's operating conditions/inspection records or consult the user manuals online. This has markedly improved the accessibility to the information related to their equipment. Others include e-commerce to get a quote for replacement parts via the internet, which not only enables us to respond promptly to the quotation request, but also indirectly helps reduce the time spent by the customer (i.e., those in charge of parts order or facility maintenance). Moreover, tools such as wearable cameras are actively utilized for facility inspection, periodic repair work and maintenance, to make it possible for MHI Group's engineers to assist remotely. In this way, we can efficiently support our domestic/overseas customers in a detailed manner.

Furthermore, to make our services more sophisticated, we are also working to improve the

quality of products and services through the introduction of new technologies and continuous research and development. Some of the projects are presented in this special edition. One example is an examination technology, in which ultrasonic or eddy currents are used to measure a defect in a product and its location can be determined in a short time with higher accuracy than ever. Another is robotics for inspection, in which an autonomous robot was developed to enable safe inspection of piping systems at otherwise dangerous places at heights or confined areas in a short time at low cost. There is also shortened inspection lead time, in which the inspection record data are accumulated and analyzed to formulate the optimal inspection procedure and enable quick decision-making.

As described so far, in making our products more advanced and complex, we emphasize the importance of not only selling products, but also maximizing customer value by providing customer-oriented and solutions-based services. While smooth customer support and enhanced user experience will be continuously improved, even more advanced technologies and services will be realized in order to enable us to always provide products/services of value to our customers. MHI Group will pursue an innovative approach, responding to the voice of customers.

5. Conclusion

Besides the technological projects presented so far, MHI Group makes sure, as a conglomerate, that best practices conducted by all its businesses in all fields in which it is engaged are shared by group companies. It is recommended that their success factors, knowledge, know-how and necessary infrastructures should be generalized for use and disseminated to other businesses in the group.

Specifically, generalization is conducted in terms of the following four domains: “utilization of remote monitoring”, “advancement of parts supply chains”, “strengthening of service networks” and “centralized data management”. By promoting the adoption of this approach in a way suitable to each business project or model, we aim for early realization of “customer-oriented and solutions-based services” in all our group’s products and services (**Figure 1**).

Figure 1 Key domains for implementing services with tailored proposals

MHI Group is working towards a sustainable, secure, safe and comfortable society by promoting from the following two points of view: decarbonization by way of carbon neutrality through energy transition on the energy supply side, and energy conservation, reduced manpower requirements and decarbonization on the energy demand side by making social infrastructures smart.

As described in this report, we are undertaking the projects for early realization of such smart social infrastructures. These pertain to: the development of a remote monitoring platform enabling us to assist customers through a product’s life cycle; the development of ΣSynX® in which AI and digital technologies are used to intelligently connect customers’ equipment and our products, making their mechanical systems more intelligent; and the development of elemental technologies for various services.

As a provider of a variety of energy and social infrastructure systems, MHI Group will continue to strive to achieve a carbon neutral society by promoting customer-oriented and solutions-based services throughout the product life cycle, with the aim of making social infrastructures smart and maximizing customer value.