Foreword

Dedicated to Creating New Value by Integrating Cyber and Physical Technologies

Corporate Vice President
ISHII Hideaki

First, I would like to offer my heartfelt prayers for the repose of the departed souls of the victims of COVID-19 and my deepest condolences to all of those affected. As the outbreak of COVID-19 has grown into a global pandemic, the Toshiba Group has responded to the rapidly changing situation so as to protect the safety of customers, local residents, employees, and their families while ensuring business continuity. We have devoted the utmost efforts to taking the best possible measures to lessen the risks of infection and prevent interruptions to our social infrastructure and other businesses and services that are essential to sustain the activities of society.

We are pursuing the Toshiba Next Plan to combine our experience and expertise in the physical realm cultivated through our achievements in manufacturing with our strengths in cybertechnology, with the aim of transforming ourselves into one of the world's leading cyber-physical systems (CPS) technology enterprises. At the FY2019 Technology Strategy Briefing held in November 2019, we articulated three basic policies for R&D: (1) differentiating competitive components and enhancing their capabilities as edge devices, (2) reinforcing artificial intelligence (AI)-based digital technologies, and (3) deploying our Internet of Things (IoT) reference architecture (the Toshiba IoT Reference Architecture (TIRA)) and services. The enhancement of edge capabilities entails the fusion and interaction of key competitive physical components with cybertechnology by means of AI and IoT, with the goal of offering unique new values and services. In order to enhance our capability to resolve customers' issues related to manufacturing, maintenance, and other processes, we will leverage our first-hand experience and expertise in AI accumulated over many years to advance the sophistication of analysis of customers' data while promoting the deployment of TIRA-based services both internally and externally.

The following provides snapshots of some of our initiatives spearheaded to transform into a CPS technology enterprise as well as major technological innovations achieved as of March 2020 in each business domain of the Toshiba Group.

In the R&D domain, Toshiba Corporation has been developing a charging curve analysis (CCA) technology for estimation and diagnosis of the internal state of battery energy storage systems composed of SCiB™ rechargeable lithium-ion batteries, and confirmed the effectiveness of this technology using actual systems. Toshiba Corporation has also leveraged AI and digital technologies to develop a photovoltaic power generation forecasting technology using various data obtained from its unique weather forecast system, as well as a CPS edge tool that allows a variety of equipment to be retrofitted with sensors to provide connectivity with IoT networks. In the field of cutting-edge technologies, Toshiba Digital Solutions Corporation has developed a simulated bifurcation machine (SBM) capable of finding the best solution to large-scale combinatorial optimization problems at high speed. Toshiba Corporation has succeeded in the demonstration of quantum key distribution (QKD) in collaboration with an external customer with the aim of achieving practical application of quantum cryptography transmission at an early stage. Toshiba Corporation has also developed a technology to detect cancer with a simple blood test based on the amount of micro-ribonucleic acids (microRNAs).

In the digital solutions business domain, Toshiba Corporation has been developing HABANEROTS, an IoT platform service, as one of the implementations of TIRA. Toshiba Digital Solutions Corporation has developed a distributed co-simulation platform for the development of vehicle control systems. It has also utilized one of the features of the SATLYS Toshiba Analytics AI service to develop technologies to provide users with grounds for the results inferred by AI to support their decision-making. In addition, Toshiba Digital Solutions Corporation has launched a new service for RECAIUS Toshiba Communication AI to facilitate workstyle reform and enrich people's lives.

In the energy business domain, the Toshiba Group has been making efforts to establish CPS businesses. For example, Toshiba Energy Systems & Solutions Corporation has applied an IoT platform for energy systems to the Mikawa Power Plant. It is also working on large-scale refurbishment of hydroelectric power plants in the United States and Japan. In the field of geothermal power generation, Toshiba Energy Systems & Solutions Corporation undertook its first engineering, procurement, and construction (EPC) project in Japan to supply a variety of equipment to the Wasabizawa Geothermal Power Plant of Yuzawa Geothermal Power Generation Corporation, contributing to the commencement of its commercial operation. In addition, Toshiba Energy Systems & Solutions Corporation has investigated the condition of the deposits inside the primary containment vessel (PCV) of Fukushima Daiichi Nuclear Power Station Unit 2 as part of the efforts to remove fuel debris, and has added the SARRY (Simplified Active Water Retrieval and Recovery System) II facility to complete the treatment of the remaining contaminated water. In the field of power transmission and distribution, Toshiba Energy Systems & Solutions Corporation has contributed to the commencement of commercial operation of the New Hokkaido-Honshu High-Voltage DC (HVDC) Link of Hokkaido Electric

Power Co., Inc., the first HVDC link in Japan equipped with voltage-source converters (VSCs). Furthermore, Toshiba Energy Systems & Solutions Corporation has developed and expanded the applications of a liquid helium-free superconducting magnet, cultivated a market for fuel cell systems, and commenced the demonstration operation of a turbine and a combustor at a pilot supercritical carbon dioxide (CO_2) power plant in Texas, United States.

In the social infrastructure business domain, Toshiba Infrastructure Systems & Solutions Corporation and Central Japan Railway Company ("JR Central") have jointly developed the world's first battery-based self-traction system for high-speed railway vehicles, targeted at the validation test vehicles for the N700S Shinkansen trains of JR Central. In the field of automation systems, Toshiba Infrastructure Systems & Solutions Corporation has developed a robot for logistics centers capable of unloading packages of mixed sizes, shapes, and weights, which incorporates an intelligent edge capability. In the field of industrial systems, Toshiba Infrastructure Systems & Solutions Corporation has released a small embedded industrial computer that provides the high computational performance, durability, and extensibility required for edge computing. In addition, it has been developing synchronous reluctance motors without permanent magnets to achieve both energy and resource savings.

In the electronic devices and storage business domain, Toshiba Electronic Devices & Storage Corporation has developed system-on-chip (SoC) technologies suitable for realizing advanced driver assistance systems (ADAS) and automated driving functions, including the Visconti5 series of image recognition AI processors incorporating deep-neural-network (DNN) hardware intellectual property (IP) that employs AI in edge components. In the field of power semiconductor devices, it has also commercialized an all-silicon carbide (SiC) module for application to small inverters used in electric railway traction control systems. In the field of small-signal semiconductor devices, Toshiba Electronic Devices & Storage Corporation has developed a small package with high power dissipation for diodes used for electrical rectification and circuit protection that has approximately half the on-resistance of the conventional package.

The Toshiba Next Plan has entered Phase 2. The Toshiba Group is determined to develop differentiating CPS technologies that will support a society in which CPS systems will be widely used. As part of these efforts, we will concurrently implement open co-creation with contenders and closed in-house technological development in competition with contenders, making a shift in development style from a closed/closed to an open/closed paradigm. In the spirit of uncompromising commitment to people and to the future, we are dedicated to creating exceptional value by leveraging CPS technologies in order to open up a new future. We hope that you will read through *TOSHIBA REVIEW Science and Technology Highlights 2020*, and would appreciate your feedback, suggestions, and comments.