

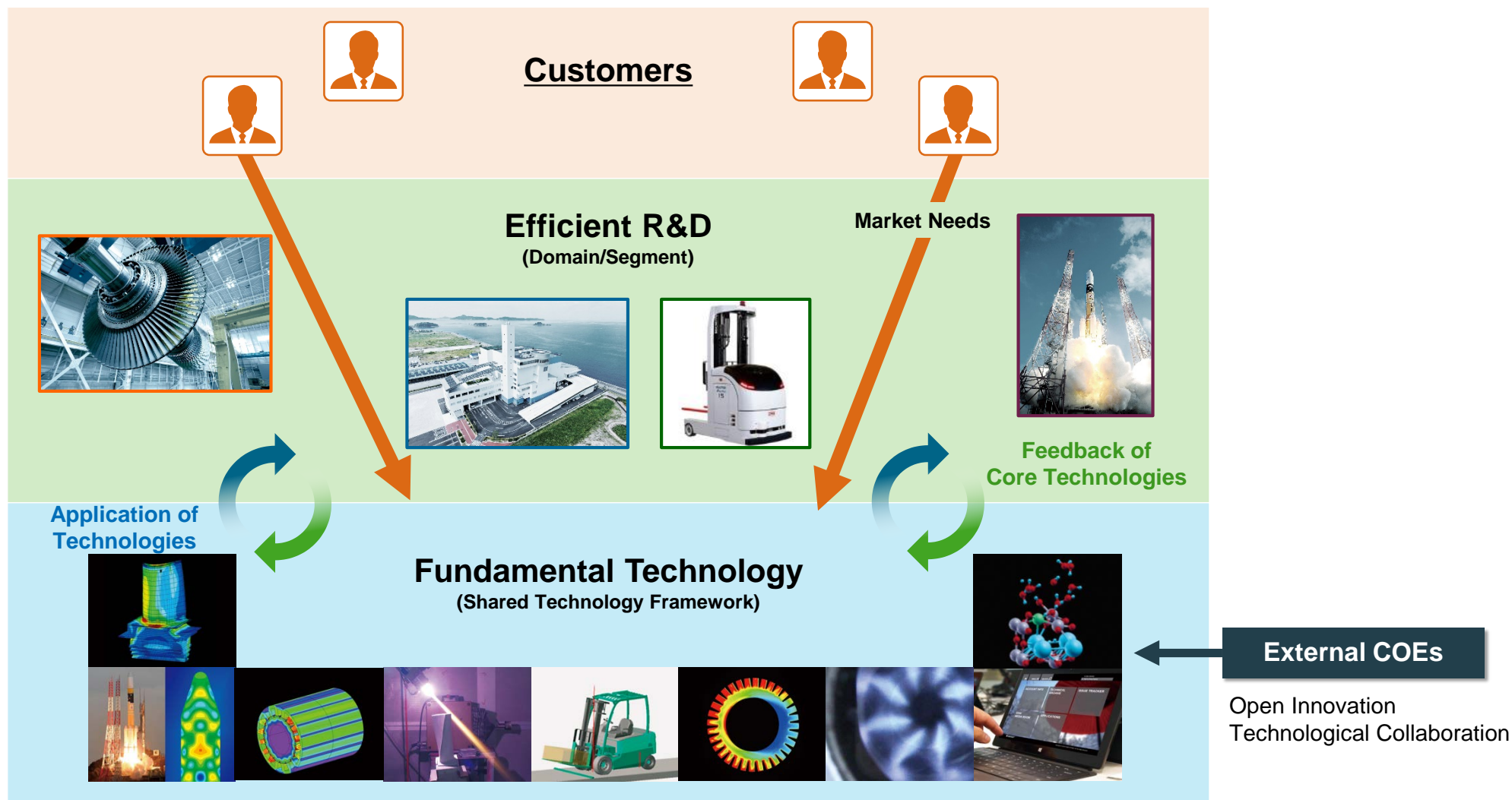
Fundamental Technology Supporting the Energy Transition

Eisaku Ito

Executive Vice President

Chief Technology Officer

Sharing of Varied Technologies Across MHI Group



COE: Center of Excellence, including external research organizations, etc.

Difficulty in Handling Hydrogen

- ✓ High Combustibility
- ✓ Cryogenic Temperature
- ✓ Metal Embrittlement



LOX/LH2 Engine

Most Experienced Player in Japan



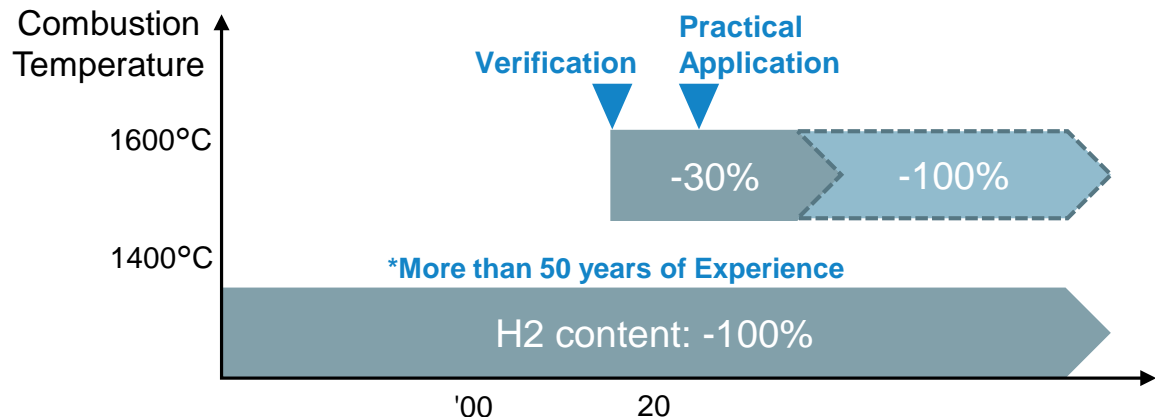
Hydrogen Co-firing Gas Turbine

#1 Global Share

Ref: MHI Technical Review Vol.48 No.3 (2011),
"Development of the Leading Technology of Low BTU Gas Firing Gas Turbine Combined Cycle Plant for Steel Works"

Difficulty of High-Temperature Combustion

- ✓ Flashback Phenomenon
- ✓ Combustion Vibrations
- ✓ NOx Generation

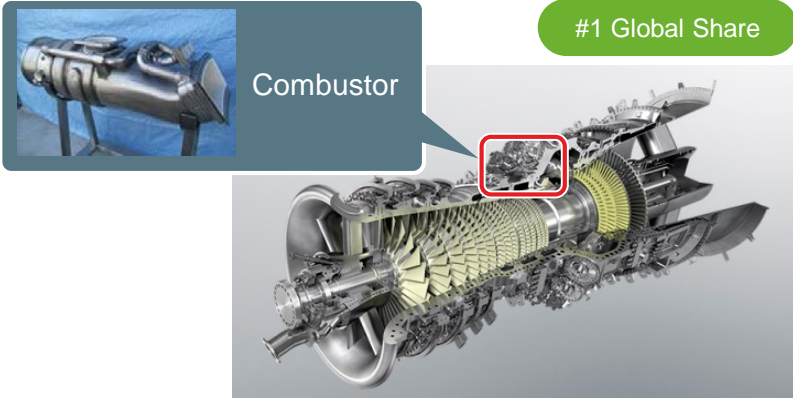


Experience and Real-world Track Record in Hydrogen Gas Turbines

LOX: Liquid Oxygen; LH2: Liquid Hydrogen; NOx: Nitrogen Oxides

Stable Combustion at Ultra-High Temperatures

Joint Development with
Global COEs


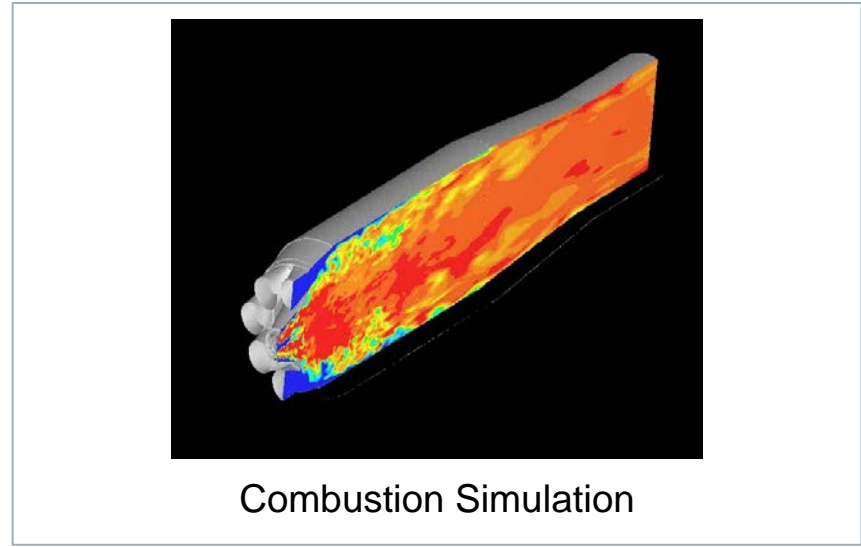


Combustor

#1 Global Share

(1700°C class)

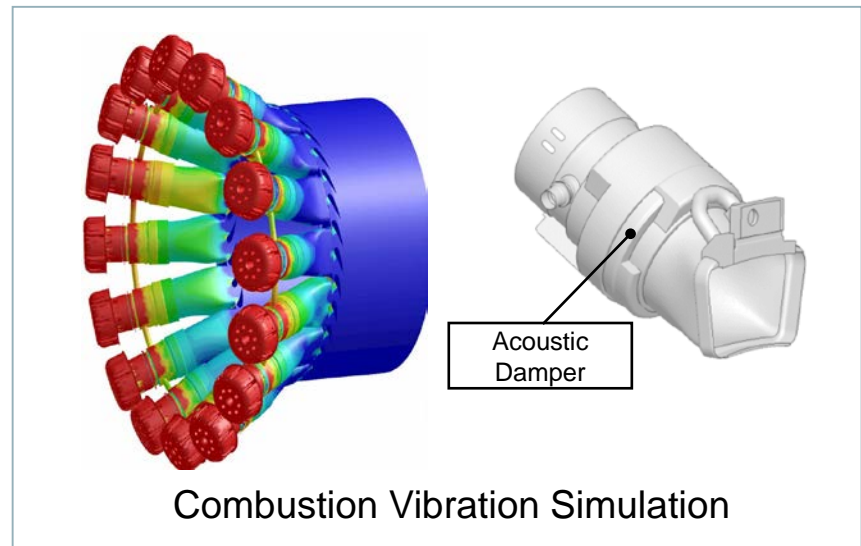
High Efficiency Gas Turbine



#1 Japan Share

(3000°C class)

Rocket Engine



Verification Process of Consistent Development from Concept to Practical Application

Only MHI Can Do This

Elemental Verification



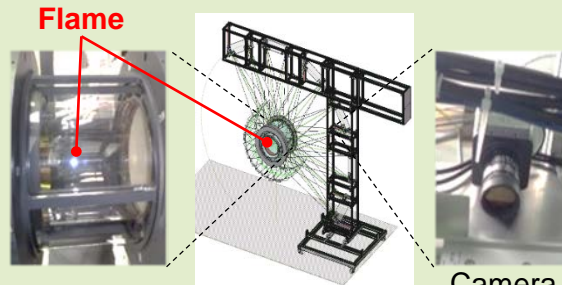
Laboratory Test

Component Verification CT identifies unstable areas

The First in the World



Flame



Combustion CT Measurement



High-Pressure Combustion Test Facility

Verification of Actual Machine 3,000 sensors to understand the phenomenon

Only MHI Can Do This



Demonstration Facility
(2020 Operation)

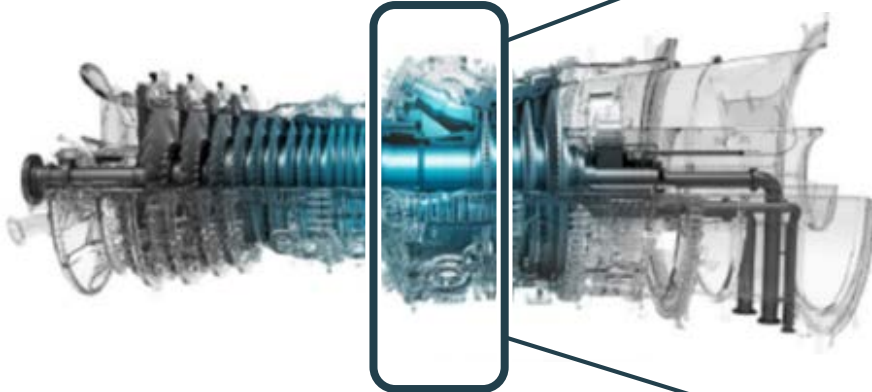
Creation of New Concepts through Simulation

Data Analytics

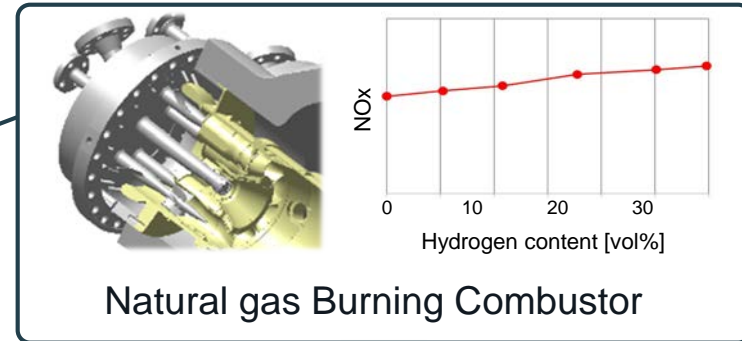
CT: Computed Tomography

Maximizing Conversion Efficiency from Hydrogen to Electricity through Ultra-High Temperature Combustion

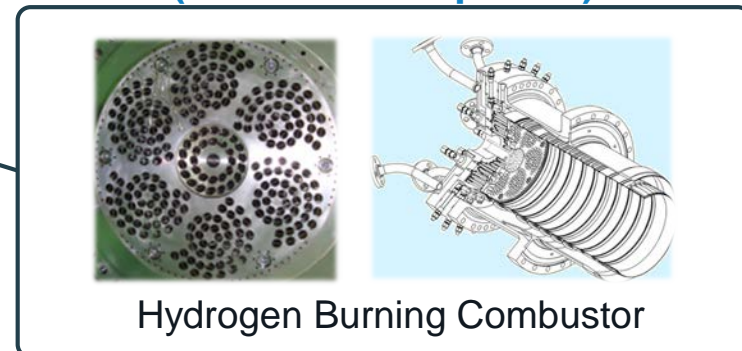
Mixed/Pure Hydrogen Combustion Gas Turbine



Stable Combustion with 30% Hydrogen (Commercialized)



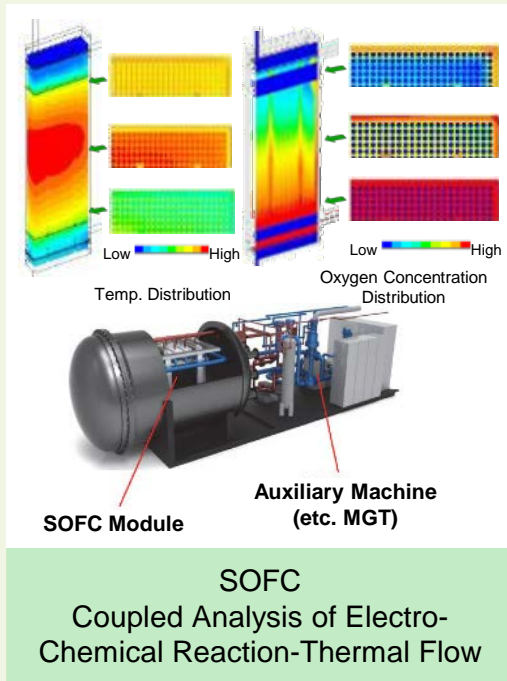
Stable Combustion with 100% Hydrogen (under Development)



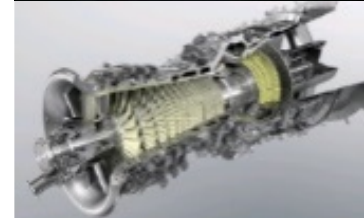
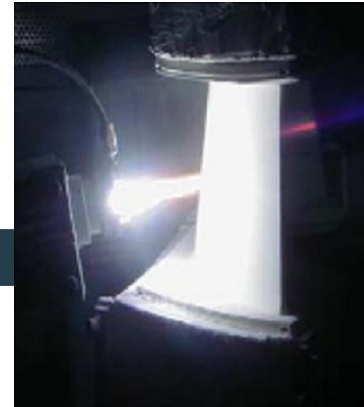
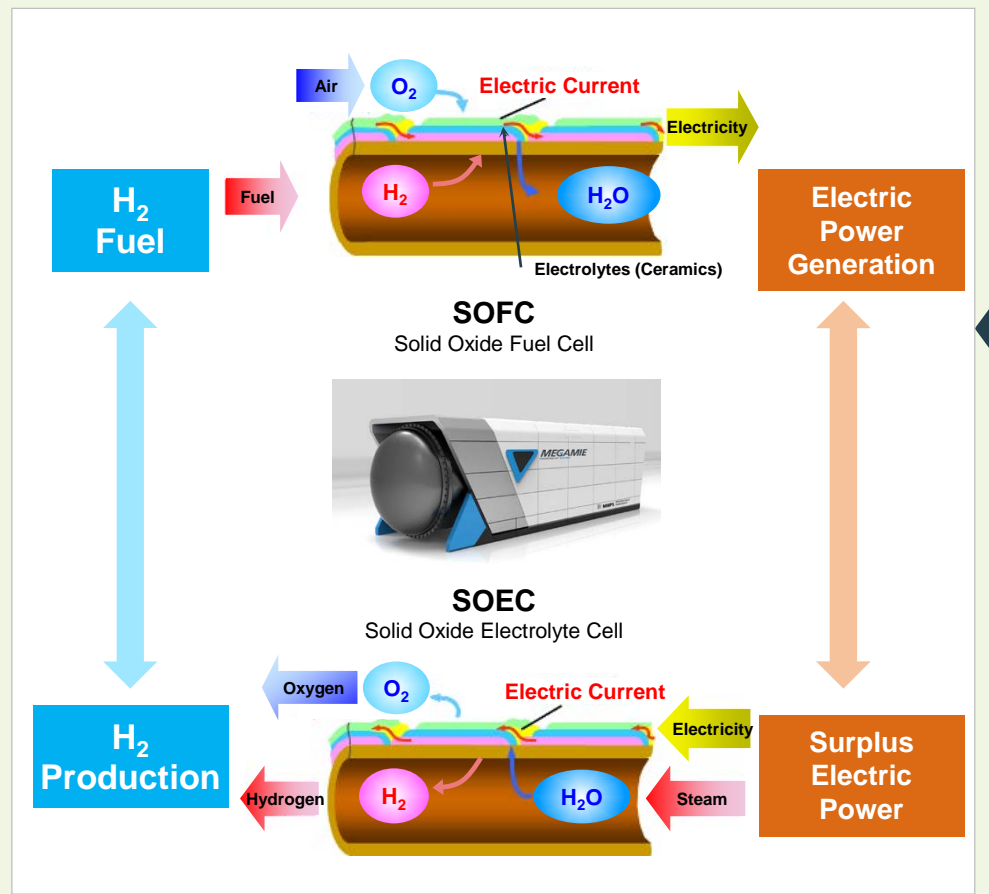
Nox: Nitrogen Oxides

Combining Hydrogen Production & Utilization into One System

Utilize Gas Turbine Ceramics Technology to Achieve Hydrogen Production/Utilization in a Single Piece of Equipment



Use of Surplus Power



Same Material with TBC of Gas Turbine

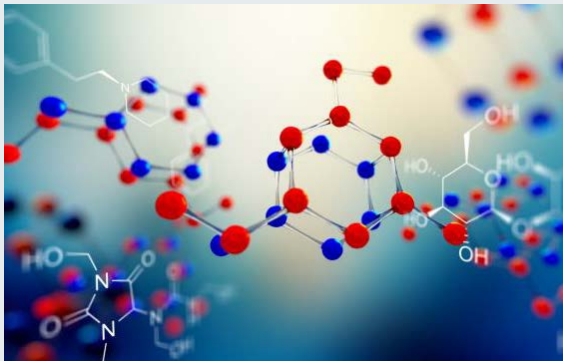
#1 Global Share

SOEC: Solid Oxide Water Electrolysis; SOFC: Solid Oxide Fuel Cell; MGT: Micro Gas Turbine; TBC: Thermal Barrier Coating

Innovative Idea Creation and Rapid Hypothesis Testing

MHI Innovation Accelerator

Development of Leading-Edge Technologies to Overturn Conventional Assumptions



2018-

YHH Yokohama Hardtech Hub

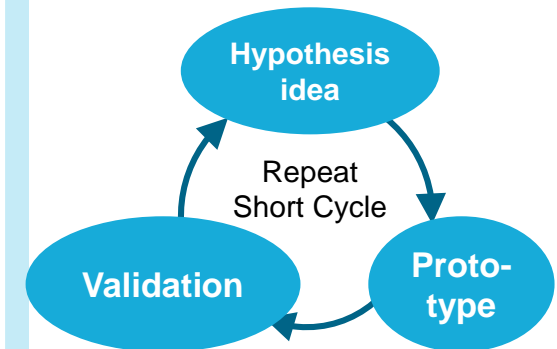
Co-creation Hub with Start-ups



2020-

Introduction of Pivot Development

Address Technical Issues, Develop Faster than Start-ups



2020-

Accelerate Energy Transitions

Fuel Conversion that Minimizes Cost

Wide Range of Product Experience

Leading-Edge Technology

MHI Innovation Accelerator
Yokohama Hardtech Hub
Pivot Development

Fundamental Technology

Sensing

Digital Twin

Data Security

Data Science

Coupled 3D Simulation

Robotics

Sensor Network

IoT/AI

Production and Use of Hydrogen

Catalysis

AM Utilization

Elemental Transformation

Automation

Intellectualization

AM: Additive Manufacturing

MOVE THE WORLD FORWARD

**MITSUBISHI
HEAVY
INDUSTRIES
GROUP**