YOKOGAWA

Co-innovating tomorrow™

The 44th Virtual UNISEC-Global Meeting

YOKOGAWA's Contribution to Lunar Exploration and Industrialization

Satoru Kurosu (Cross)

Executive Mentor, Space Business Development Office
Yokogawa Electric Corporation

CEO, Cross Space & Sustainability, LLC

2024 5 18

Introduction

Satoru Kurosu (Cross)

- **Founder and Executive Mentor, Space Business Development Office, Yokogawa Electric Corporation**
  - Advisory Board Member, UNISEC-Global
    - Past presentations to UNISEC
      - “How can UNISEC Contribute to the Sustainability of the Earth?” in July 2023
      - “Space & SDGs” in July 2022
      - “Introduction to Yokogawa’s Space Business” in July 2020
  - Supporter, CROSS U (Open Innovation Platform for the Space Business)
  - Director, Japan Marketing Academy
- **CEO, Cross Space & Sustainability, LLC**

Yokogawa Electric Corporation at a glance

Founded	September 1, 1915
Paid-in Capital	43.4 billion yen
Business domain	Measurement, Control & information （No.1 process automation company in Japan and in the LNG industry）
Sales	540.2 billion yen (Approx.70% is from outside Japan)
Net income	61.7 billion yen
R&D Investment	6% of sales
No. of Employees	17,084(FY2022)
Capital Ratio	64.9%

(Results of FY2023)

Recent awards


Yokogawa Selected as MAC for Construction of Europe's Largest Renewable Hydrogen Plant

Tokyo, Japan - September 26, 2022

Yokogawa Electric Corporation (TOKYO: 6841) announced today that it has been selected by Shell Plc to be the main automation contractor (MAC) for the construction of its Holland Hydrogen I plant in the Dutch port of Rotterdam.

The Holland Hydrogen I plant will produce renewable hydrogen by using electricity from an offshore wind farm and will be Europe's largest renewable hydrogen plant once operational in 2025. In its role as MAC, Yokogawa will optimize operations at the plant by closely integrating its systems and equipment.

Illustration of the proposed Holland Hydrogen I site. Source: Shell


Yokogawa to Provide Integrated Control System for Australian Green Hydrogen Project

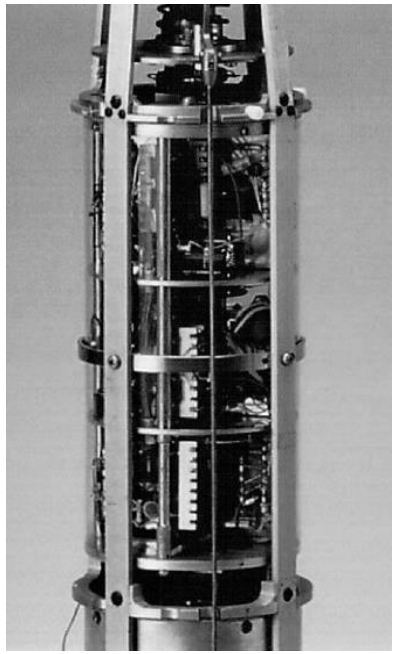
First ever use in Australia of green hydrogen as feedstock for ammonia production

Tokyo, Japan - November 30, 2022

Yokogawa Electric Corporation (TOKYO: 6841) announces that its subsidiary Yokogawa Australia has been selected by Technip Energies to provide the integrated control system for the initial phase (Phase 0) of the YURI Green Hydrogen Project (hereafter 'YURI'), which will construct the largest of its kind industrial-scale renewable hydrogen production facilities in Australia.

Conceptual drawing showing the YURI project facilities at the completion of phase 0. The existing YPF ammonia plant is in the foreground (Source: Engie S.A.)

Yokogawa started Space business in 1961



Yokogawa Ionosphere Sensor launched in 1961 with Kappa 8 rocket of a former JAXA organization

NASA's Nike Cajun rocket launched from Wallops Island with the Yokogawa sensor in 1962

The actual sensor was exhibited at SPACETIDE, the biggest Space industry conference in Japan, in Jul. 2022. It was kept in a warehouse for more than 60 years, and still in good condition without rust.

1961- 2020
Project-based response

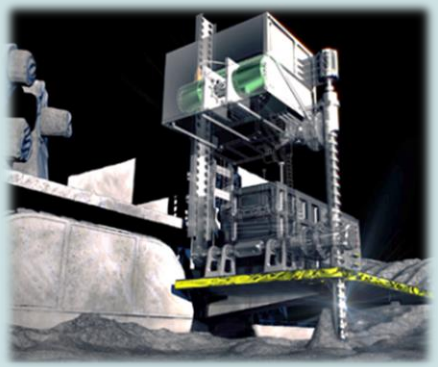
→

July 2021
Established the dedicated Space organization, "Space Business Development Office".

Recent Developments for Space

Moon Exploration

A probe vehicle development for Lunar water exploration by using a very sensitive and robust gas senser



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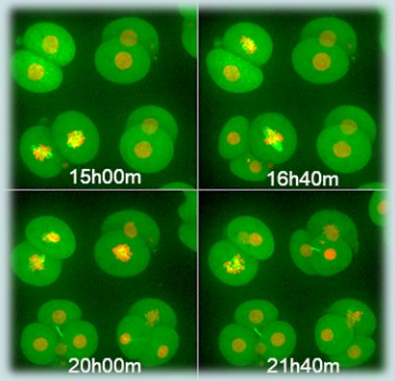
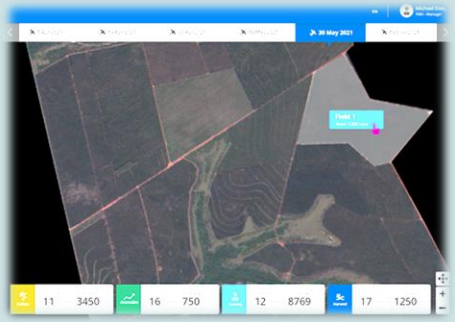
Space Station

A confocal microscope widely used for stereoscopic observation of cell tissues working in ISS



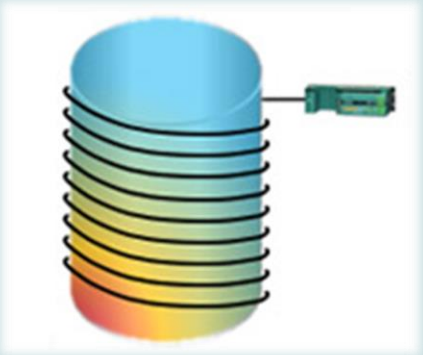
Earth Observation

Digital Transformation by using satellites for Land displacement detection and Forest monitoring doing PoC with industry arena



Spacecraft

A near real-time measurement fiber sensing technology for structure health monitoring co-researching with JAXA



Semiconductor for Space

A semiconductor fab suitable for high-mix and low-volume manufacturing that is also used by JAXA

Why Moon?

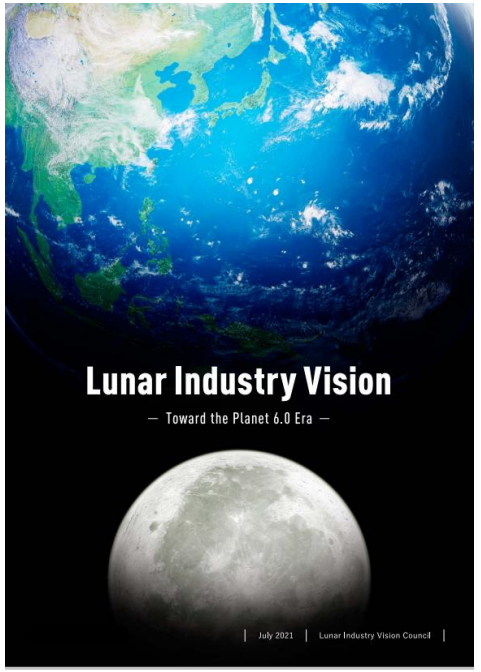
- **The closest potential industrial location to the Earth in Space**
  - Moon is the closest celestial body with lands for industries.
  - Yokogawa can contribute to the Lunar industries, leveraging our strength in Measurement, Control and Information Technologies which have long track record in the terrestrial industries.
- **Emerging Lunar industries**
  - Discovery of water on the moon made sustainable industry development possible.
  - Artemis program started involving industry players as well as Japanese government.
  - **More than 50 Japanese private companies, such as the members of Lunar Industry Vision Council, are enthusiastic to work together to create Lunar industries.**
- **Lunar enabled technologies and solutions to solve issues on the Earth (SDGs)**
  - Hydrogen-base supply chain for Net-zero Emissions
  - Circular Economy System with ultimate recycle and reuse technologies
  - Overview effect to change our mindset to protect the Earth

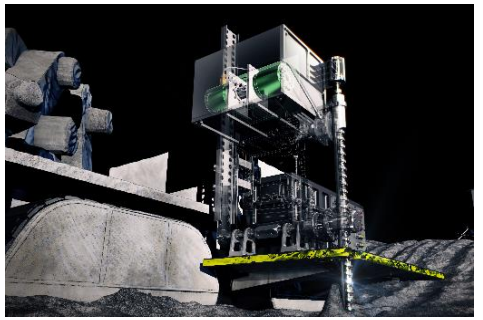
Credit: NASA

SUSTAINABLE DEVELOPMENT GOALS

Yokogawa's history for the Moon

Jul. 2019	Participated in Business Consortium for Space Frontier for Lunar developments
Apr. 2021	**Participated in Lunar Industry Vision Council (LIVC)**
Jul.	Submitted the Lunar Industry Vision to the Minister of Space Policy by LIVC
Dec.	**Started the study for Ministry of Economy Trade and Industry's hydrogen-base energy related technologies on the Moon**
Jan. 2022	**Yokogawa, Chiyoda Co., ispace, Inc. and Lunar experts from the University of Tokyo and Ibaraki University started industry-academia collaboration meetings for Lunar Water Analysis**
Jun.	**Joined ispace's HAKUTO-R Commercial Lunar Exploration Program as a Supporting Company**
Aug.	Participated in the panel "Collaboration and Co-creation in Future Industry-Academia Partnership Aimed on the Moon" at the 1st Lunar Industry Vision Conference
Jul. 2023	Participated in the panel "Proceeding Cislunar Architecture Formation and Sustainability" at SPACETIDE2023
Aug.	Participated in the panel "Collaboration and Co-creation with Science for Lunar Economic Zone" at the 2nd Lunar Industry Vision Conference
Nov.	**Press release for the joint development with JGC Co. for the Lunar Plant Control System that will support ultra-remote communications**
Dec.	Presented "Control Systems for Plants on the Moon" at the 7th Moon Village Workshop and Symposium in Kurashiki, Japan
Mar. 2024	**Yokogawa Joined EURO2MOON, a European Initiative Dedicated to Sustainable Lunar and Space Exploration**





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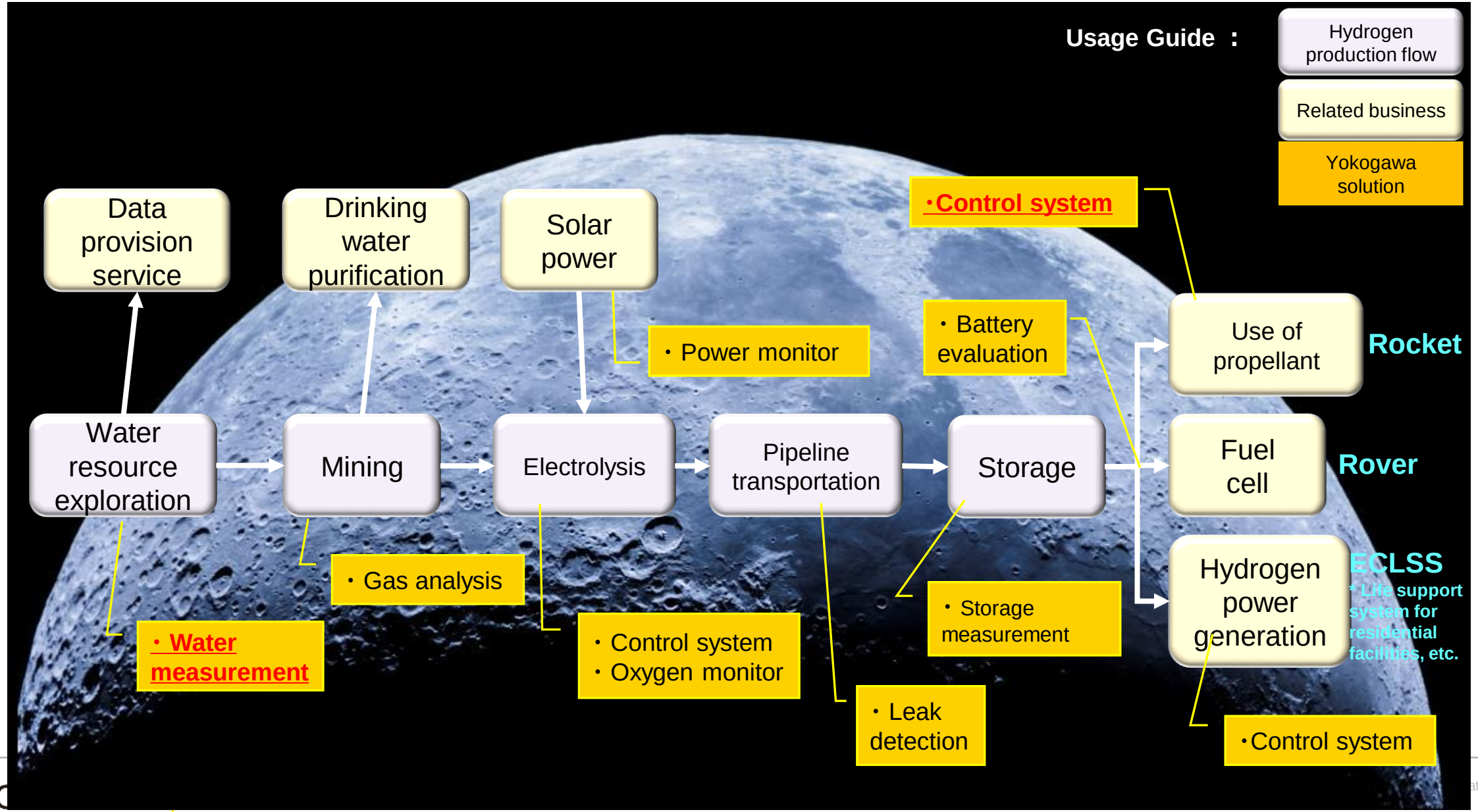
Yokogawa's contribution to the lunar hydrogen supply chain

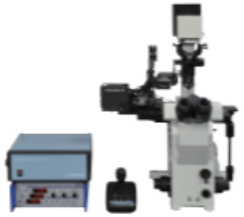


Yokogawa Product Lineup

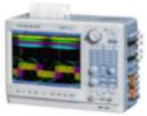
Life Science

CellVoyager CV8000
High-Throughput System

CSU-W1 SoRa
Confocal Scanner Unit



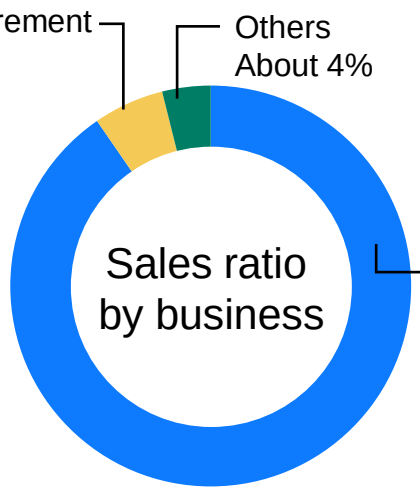
Single Cellome™ Unit SU10
Single-Cell Analysis Solution



DL850E
Scope Corder

WT5000
Precision
Power Analyzer

AQ6370D
Optical
Spectrum Analyzer



Control System

CENTUM VP
Distributed Control System (DCS)

FAST/TOOLS
SCADA Software

ProSafe-RS
Safety Instrumented
System (SIS)

FA-M3V
Programmable Logic Controller (PLC)
e-RT3 Plus
Embedded Controllers／
Industrial AI platform

Test & Measurement

TDLS8000
In-Situ Gas Analyzer

Field Wireless
Wireless Differential Pressure/
Pressure Transmitters, Sushi Sensor

DPharp EJX
Pressure Transmitters

DTSX
Distributed Temperature Sensor

GC8000
Process Gas Chromatograph

Yokogawa Product Lineup for Space

Life Science

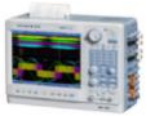
Cell experiments on the ISS

CSU-W1 SoRa
Confocal Scanner Unit

CellVoyager CV8000
High-Throughput System

Single Cellome™ U
Single-Cell Analysis Solutio

Satellite development



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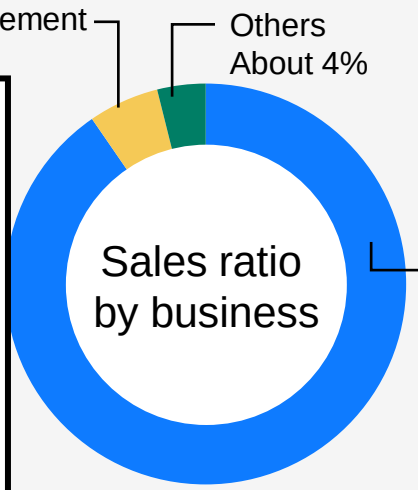

Control System

Space development

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Lunar water resources exploration

TDLS8000
In-Situ Gas Analyzer

Space development related products

DPharp EJX
Pressure Transmitters

GC8000
Process Gas Chromatograph

Test & Measurement

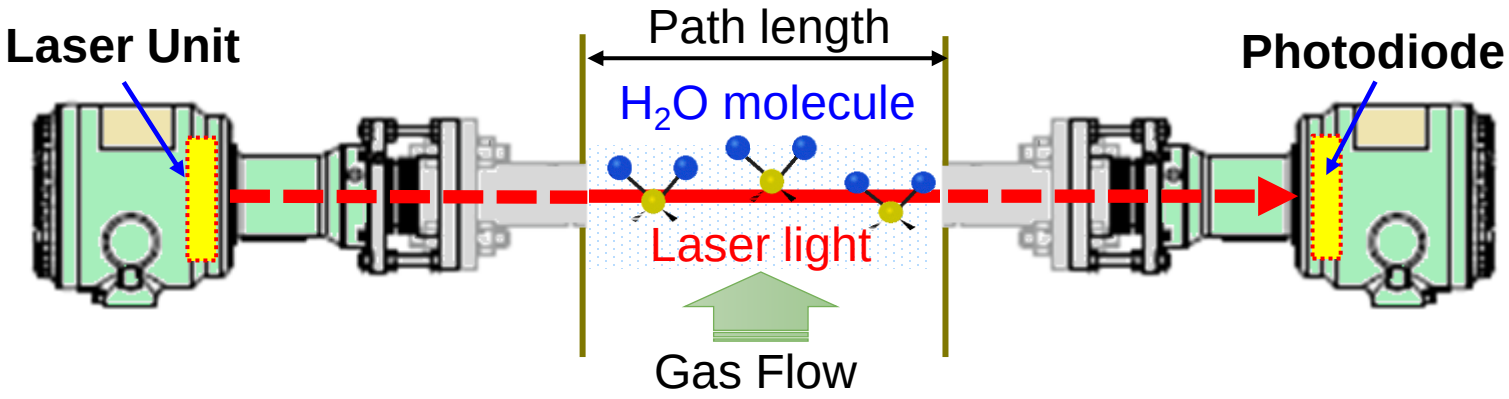
JAXA Innovation Hub Joint Research

DTSX
Distributed Temperature Sensor

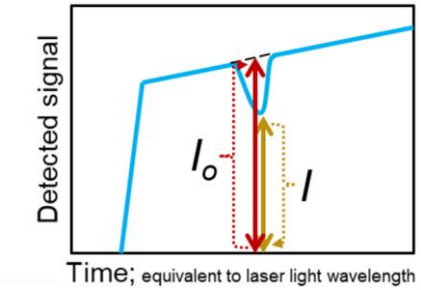
Field Wireless
Wireless Differential Pressure
Pressure Transmitters, Sushi Sensor

Core Analytical Technology: TDLS

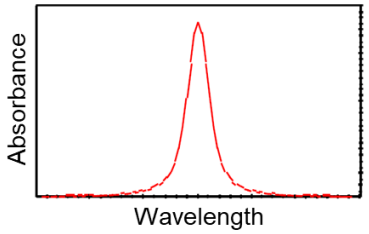
1) Overall configuration of the spectrometer



2) Photodiode raw signal



3) Calculated absorption spectrum (measured)



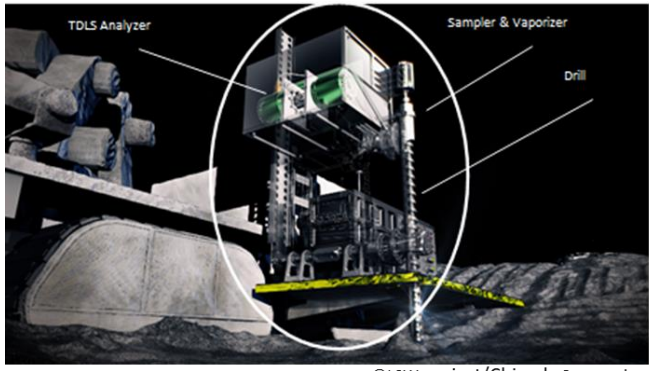
Absorbance = -log I / I_o∝ gas concentration, path length

◆ Tunable Diode Laser Spectrometer (TDLS)/ Yokogawa Electric Corporation

- Industrial analyzer capable of robust and accurate measurement of trace H_2O vapor gas; aiming for diversion as a space utility.
- This analyzer can also measure other components, for instance, O2, CO, CO2, CH4, NH3, H2S and HCl.

Water Analysis Module on the Moon

Yokogawa is developing Water Analysis Module with Chiyoda Co., supported by ispace, Inc., the Univ. of Tokyo and Ibaraki Univ.



©LSW project/Chiyoda Corporation

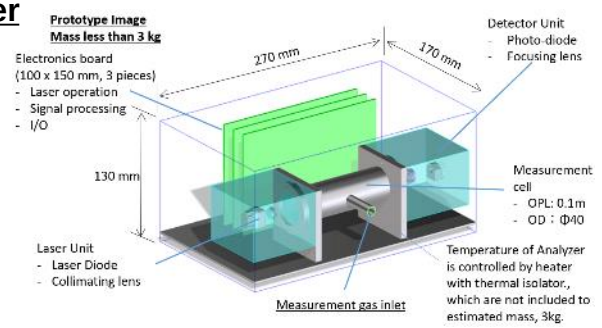
- **Our goal**: **Create lunar water-resource utilization plant** in the 2030s to utilize hydrogen as energy and propellant.
- **What we need**: **Information of distribution & properties of lunar water and geometric characteristic of the moon** in the 2020s.
- **We are working on**: Developing Water Analysis Module and combining data from remote sensing satellite for creating precise lunar water-resource map.

【Specifications】
- Module size:600mm×300mmx300mm
- Module weight：10kg
- Drilling depth：50cm
- Measurable substance：H2O (0.01wt%～10.00wt%), other
- Other：movement, electricity, communication depends on carrier machine

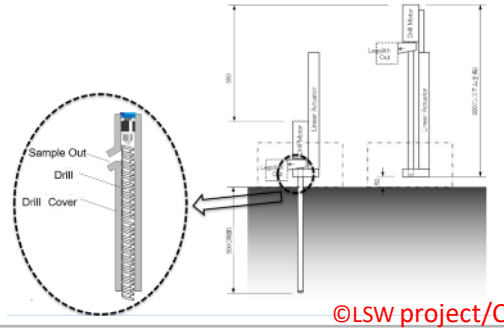
【TDLS(Diode Laser Spectroscopy) Analyzer】
- Developed by Yokogawa Electric Corporation
- Measure the optical absorption spectrum and calculate specific gas components concentration

【Drilling & Sampling】
- Under design phase
- Utilizing motor-driven drill and take sample accurately under lunar environment

Analyzer

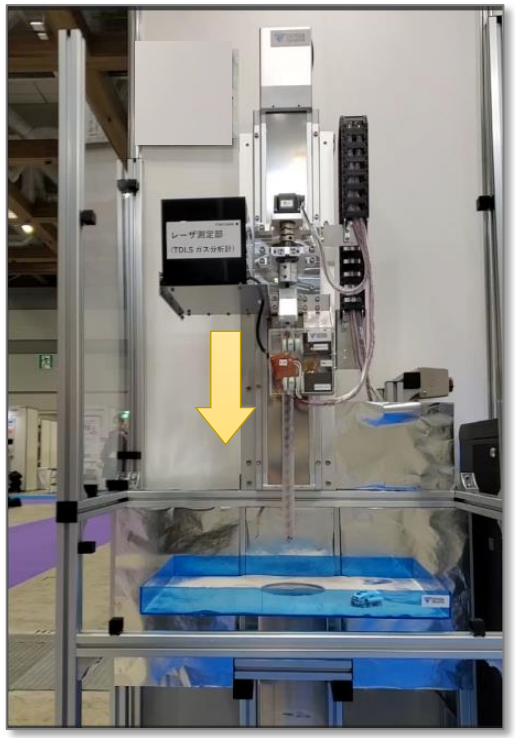


Drilling

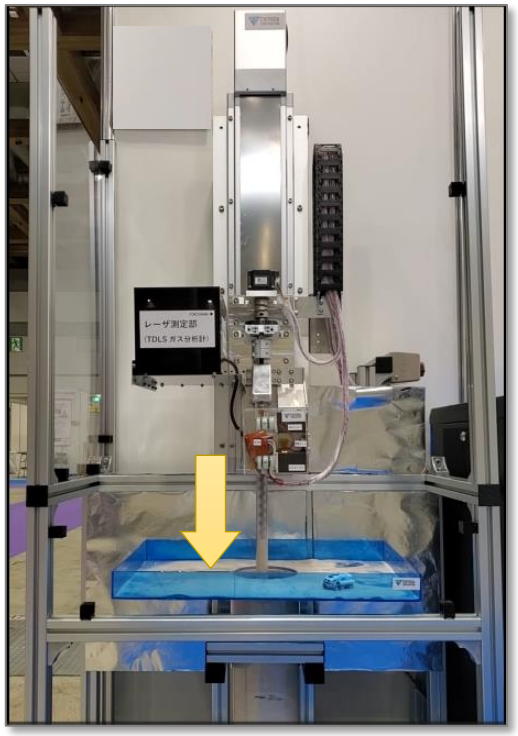


©LSW project/Chiyoda Corporation

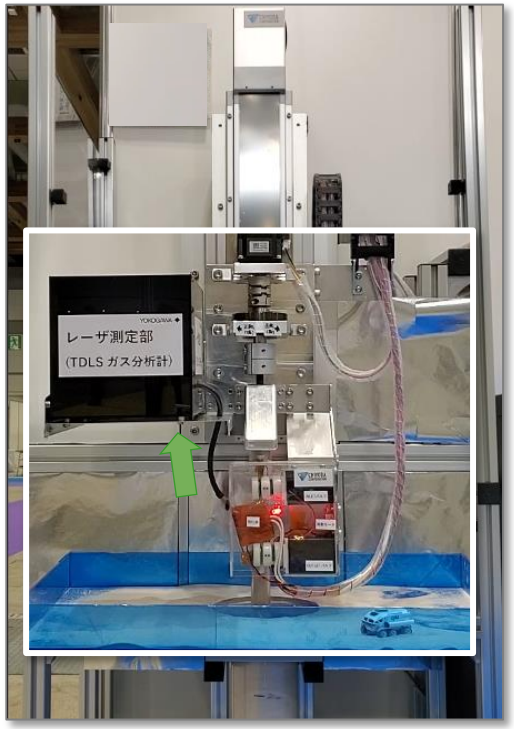
Water Analysis Module Demonstration Unit



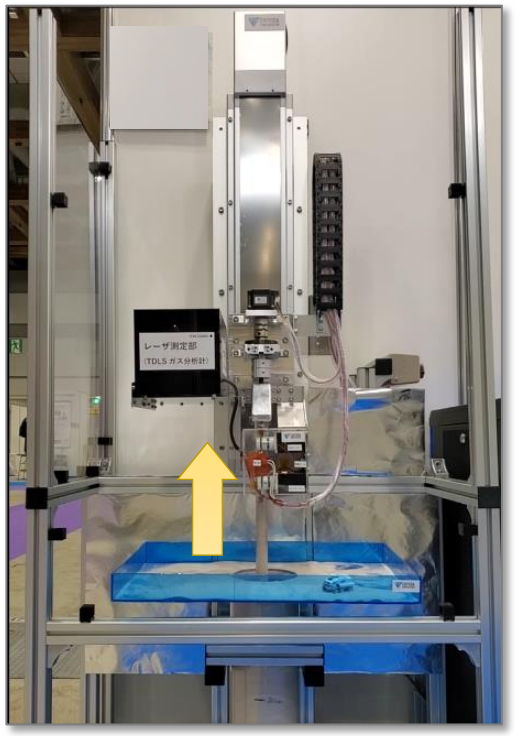
① The drill descends towards the regolith.



② Commence regolith excavation and simultaneous regolith collection.



③ Heat the regolith (red lamp), direct the water vapor to the TDLS (green arrow).

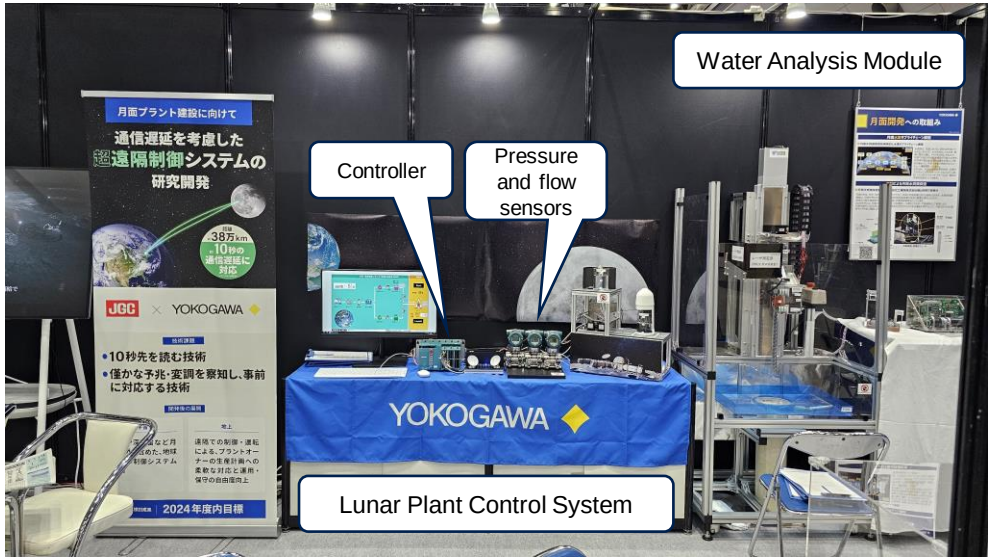


④ End the exploration and move the drill back to its original position.

Lunar Plant Control System

JGC and Yokogawa Team up to Develop Lunar Plant Control System That Will Support Ultra-remote Communications

- **Leverage the technology and experience in terrestrial plant operation, remote monitoring, and control to research and develop the core underlying technology for a control system that will support communications at extreme distances.**
  - JGC: Know-how of energy plant control/operations and knowledge gained through the conduct of lunar plant studies
  - Yokogawa: Remote monitoring and control technology

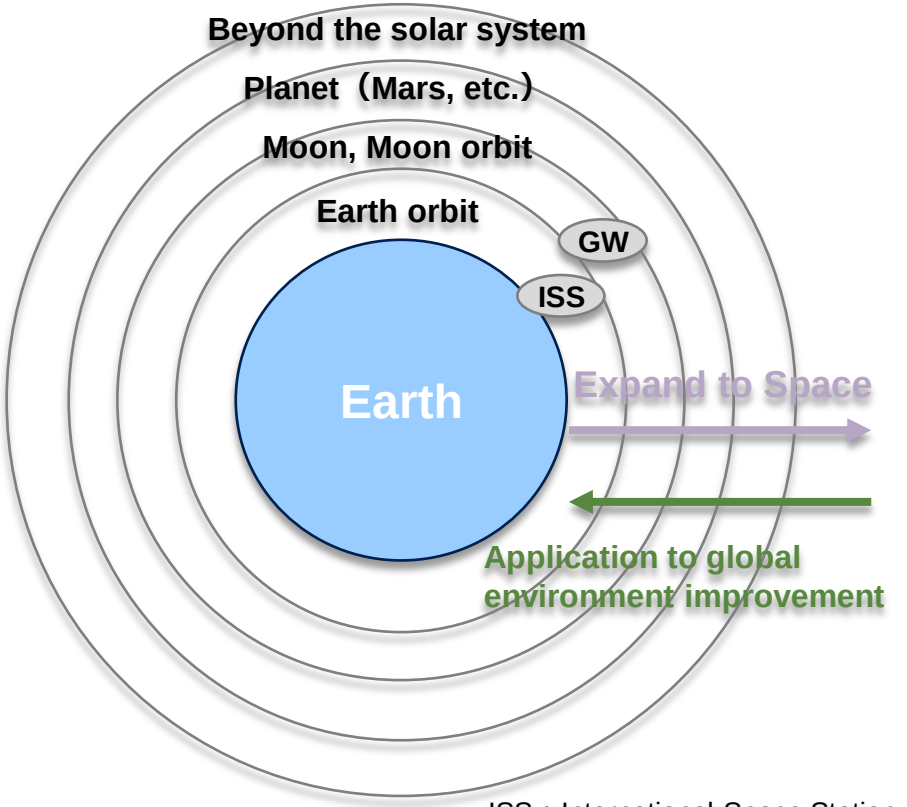


Demonstration at the 3rd International Space Industry Exhibition in Feb. 2024

Co-innovate tomorrow together

- **Yokogawa contributes to create Lunar Industries, leveraging our strength in Measurement, Control and Information Technologies.**

- **And utilize Lunar-born technologies and solutions to solve terrestrial issues, too.**



ISS：International Space Station
GW：Gate Way

YOKOGAWA

Co-innovating tomorrow™

https://www.yokogawa.com/