

NTV

입쿠 붓도  
춘두 범스시 저빙인



# Design and Control of the Hydraulic Dual-Arm Robot, ARMstrong, and its Application to Nuclear Facilities

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# Major Nuclear Accidents



- March 1979
- United States
- **Three Mile Island** nuclear power plant



- April 1986
- Ukraine
- **Chernobyl** No. 4 reactor



- March 11, 2011
- Japan
- **Fukushima Daiichi** nuclear power plant

# DARPA Robotics Challenge vs. Real World

Opening a door



Turning a valve



Removing debris

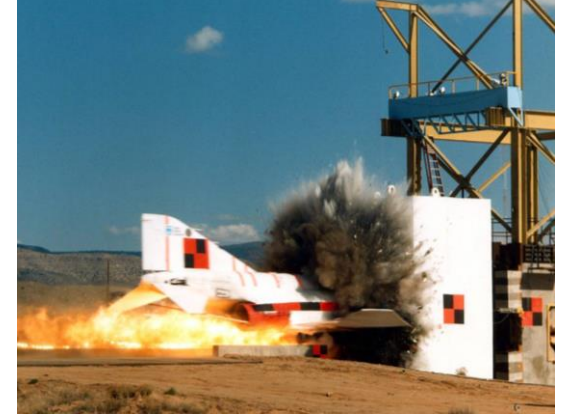


Cutting through a wall



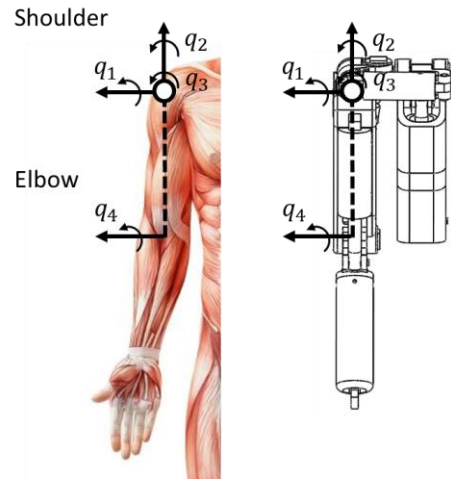
DARPA  
Robotics  
Challenge

Real  
World

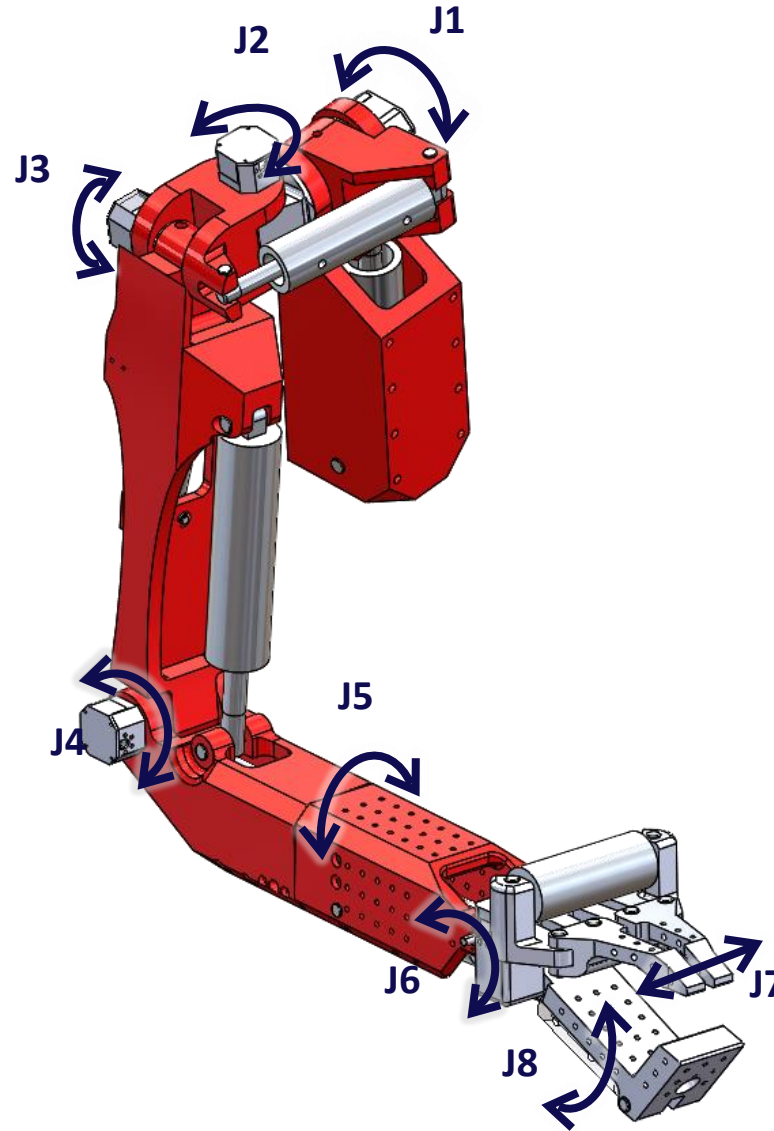
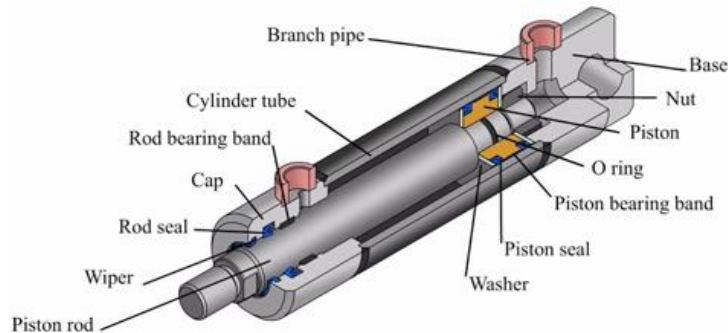


# Manipulator design

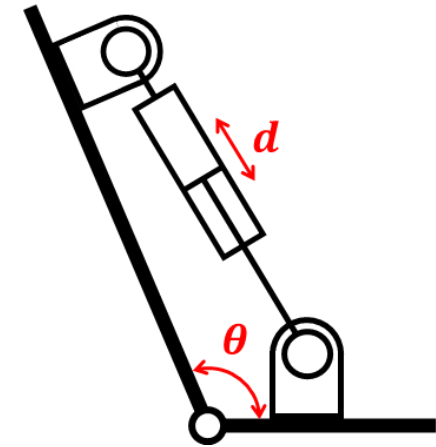
## ❖ Human-arm inspired design



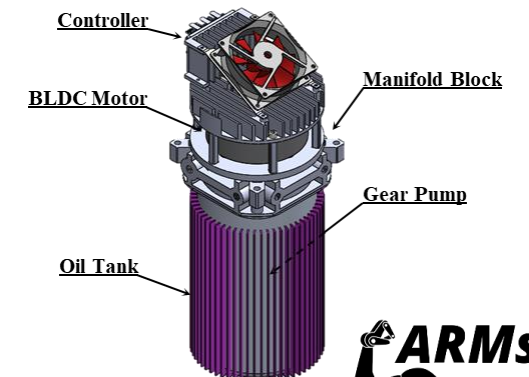
## ❖ Hydraulic actuators



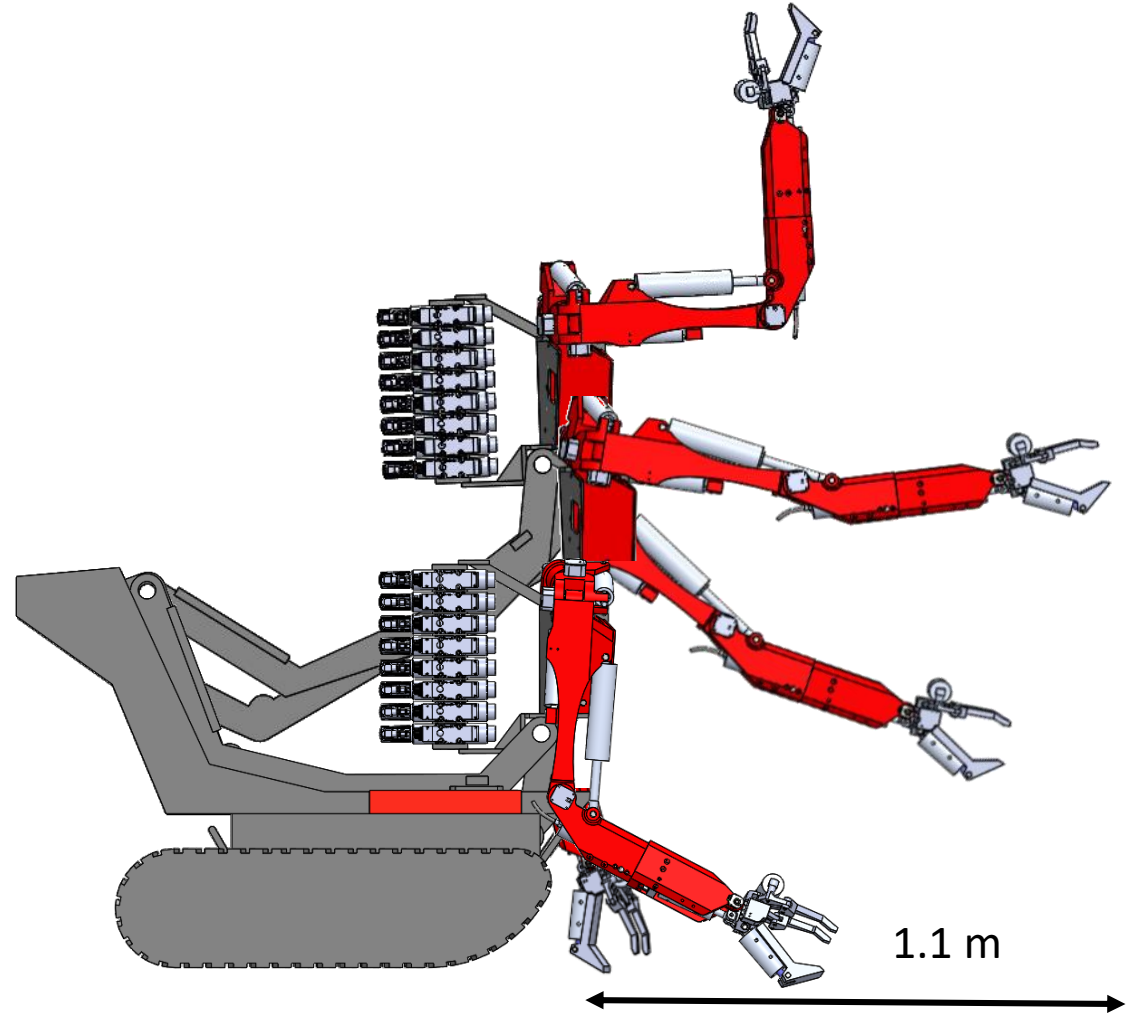
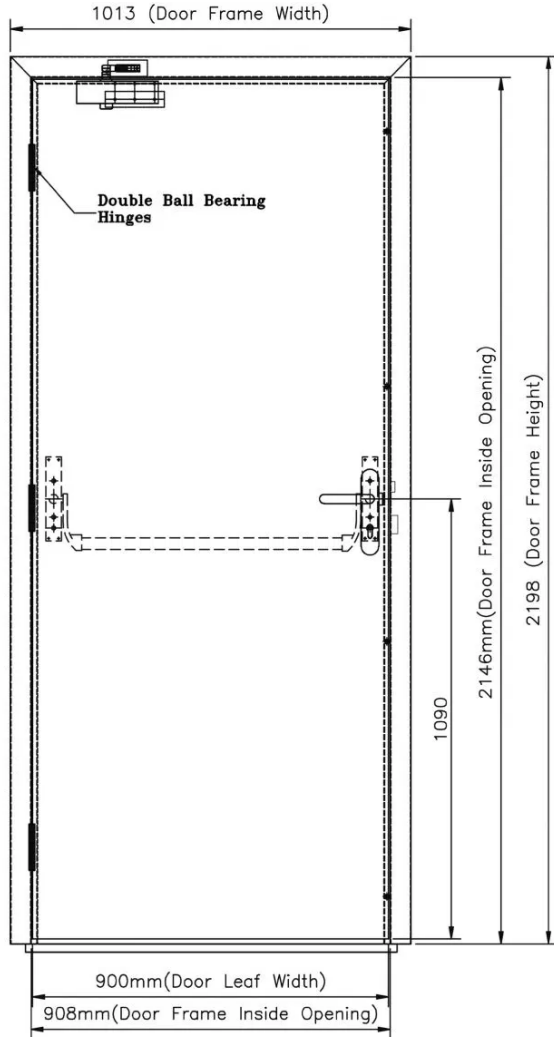
## ❖ Closed linkage mechanism



## ❖ Micro Hydraulic Power Unit



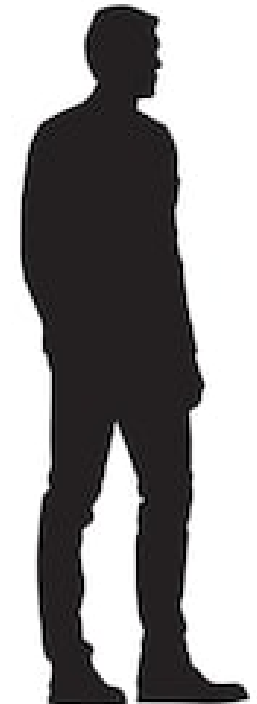
# Size, workspace



2.2 m

1.1 m

Fire door width: < 800 mm



# Micro Hydraulic Power Unit

## [Conventional HPU]

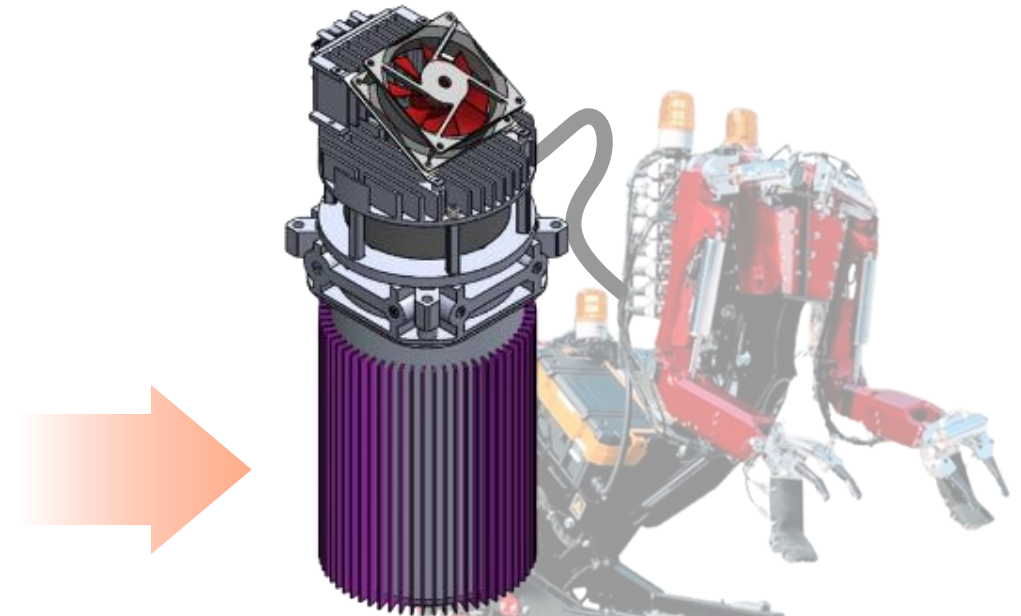


• Noise & Smoke

- Large volume
- Low power density

• Absence of flow controller

## [micro - HPU]



- Electrically driven
- Compact size
- High power density
- Variable flow rate control

# ARMstrong robot



Item	Specification
Size	180 (L) x 70 (W) x 120 (H) cm
Weight	620 kg
Speed	6 km/h
Arm length	110 cm
Workspace	Height: 0~220 cm Width: 260 cm
Payload	200 kg = 100 kg x 2

## Applications

- Valve control
- Connecting hoses
- Hazardous material handling
- Heavy weight lifting
- Assembly (from LAN cable to heavy pipes)
- Fire equipment control
- Construction tool handling
- Stacking bricks
- Debris removal
- Waste disposal
- General door open
- Dismantling
- Logistics

# ARMstrong Robot



**ARMstrong**



# Application to Nuclear Facilities



# Current Radioactive Material Sampling Methods

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- Collecting and analyzing radioactive samples by human inspectors at high radiation area

# Radioactive material sampling

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- Cuboid sample



- Surface swipe sampling



- Surface Soil sampling



- Sampling operation in a radioactive contamination area
- 100 cc of topsoil x 5 samples
- Depth: 5 ~ 10 cm from the ground

- Research project with KINAC (Korea Institute of Nuclear Nonproliferation and Control)

# Prevention of radioactive material leakage using a sealing window

- Date: 20.8.18
- Place: Post Irradiation Examination Facility
- Accident scenario

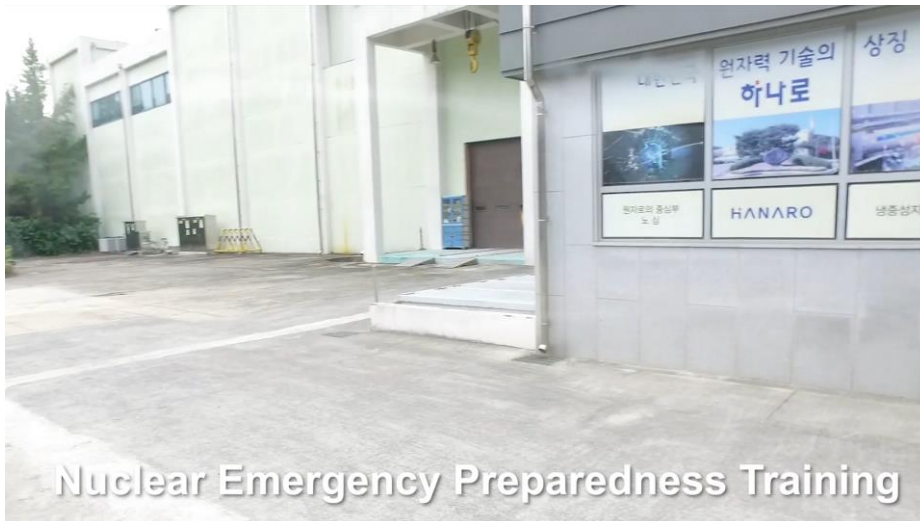


Time	Event
H+00:00	<ul style="list-style-type: none"><li>• Normal operation status of post-irradiation fuel test facility</li><li>• Spent nuclear fuel crash</li></ul>
H+00:10	<ul style="list-style-type: none"><li>• Fire</li><li>• Rapid rise in radiation level in the water tank test area</li></ul>
H+01:30	<ul style="list-style-type: none"><li>• <b>Air leak sealing operation</b></li></ul>
H+02:00	<ul style="list-style-type: none"><li>• Complete sealing of polluted air at the post-irradiation fuel test facility</li></ul>



# Prevention of radioactive material leakage using foam spray

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- Date: 20.10.21
- Place: [Hanaro research reactor](#)
- Accident scenario

Time	Event
H+00:00	• Operating at full power (30MWth) of the reactor
H+04:00	• Damage to the nuclear fuel bundle in the core due to a heavy object fall
H+04:10	• Failure to extinguish the fire in the reactor room
H+04:40	• Establishment of building leakage sealing plan
H+04:50	• <b>Dispatch of a building leak sealing robot</b>
H+06:00	• Completed sealing of leaks in the reactor building

# Fire suppression training

- Date: 21.10.06
- Place: **IMEF**(Irradiated materials examination facility)
- Accident scenario



Time	Event
H+00:00	<ul style="list-style-type: none"><li>• Normal operation</li><li>• Fire alarm</li></ul>
H+00:01	<ul style="list-style-type: none"><li>• Initial fire response failure due to sprinkler malfunction</li></ul>
H+00:10	<ul style="list-style-type: none"><li>• Increase in radioactivity concentration</li><li>• <b>Early fire suppression</b></li><li>• Start of radiation dose detection</li><li>• Rapid increase in radiation concentration</li></ul>
H+00:25	<ul style="list-style-type: none"><li>• Start of radiation dose rate exploration around the facility</li></ul>
H+00:50	<ul style="list-style-type: none"><li>• Fire suppression completed</li></ul>

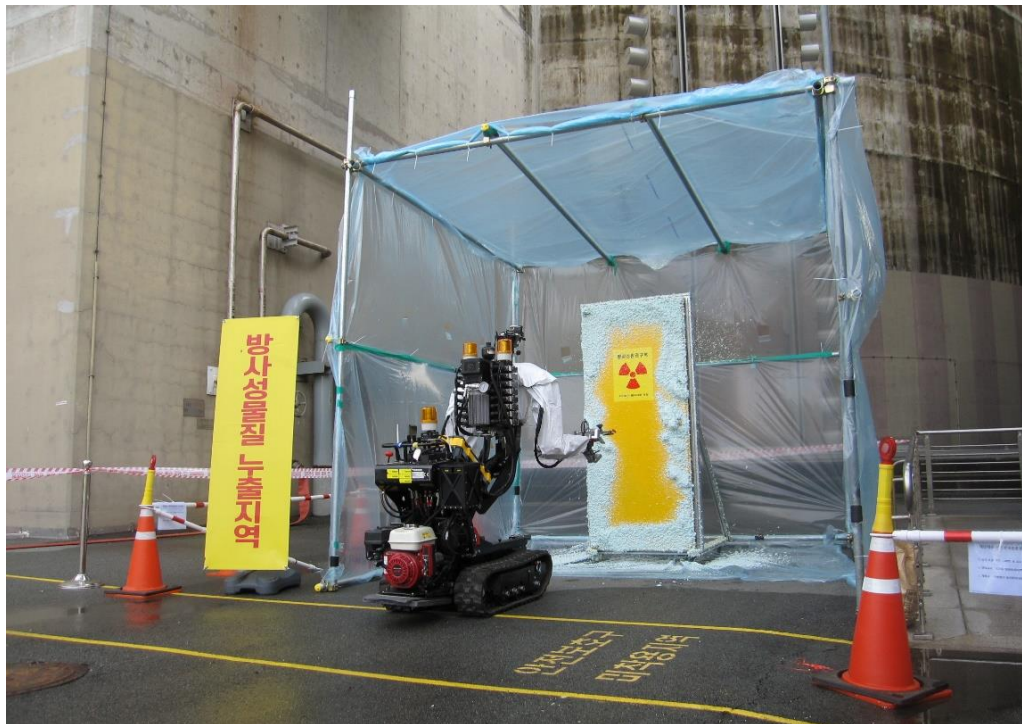


# Radiation disaster preparedness training (**Wolseong** Nuclear Power Plant)

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- Date: 23.8.31
- Place: Wolseong Nuclear Power Plant
- Accident scenario

Prevention of **radioactive gas leakage** through a fire door

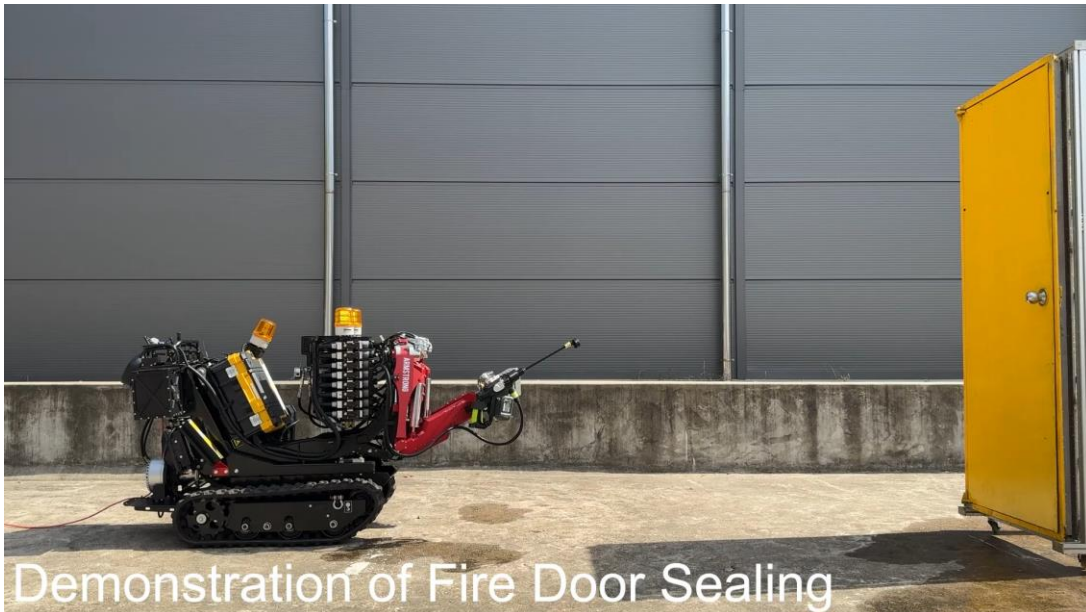


# Radiation disaster preparedness training (**Saewool** Nuclear Power Plant)

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- Date: 24.9.25
- Place: Saewool Nuclear Power Plant
- Accident scenario

Prevention of **radioactive gas leakage** through a fire door



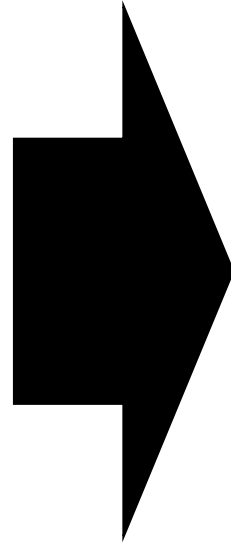
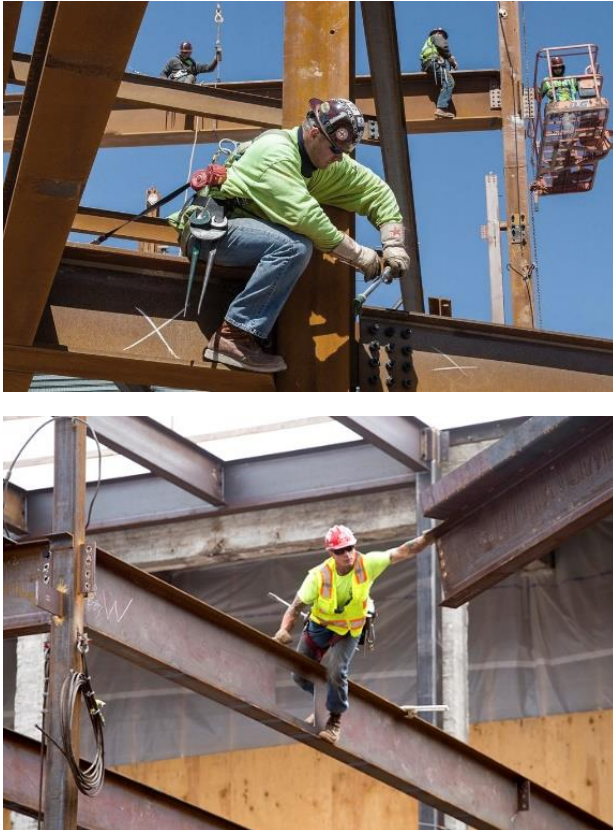


# Spin off

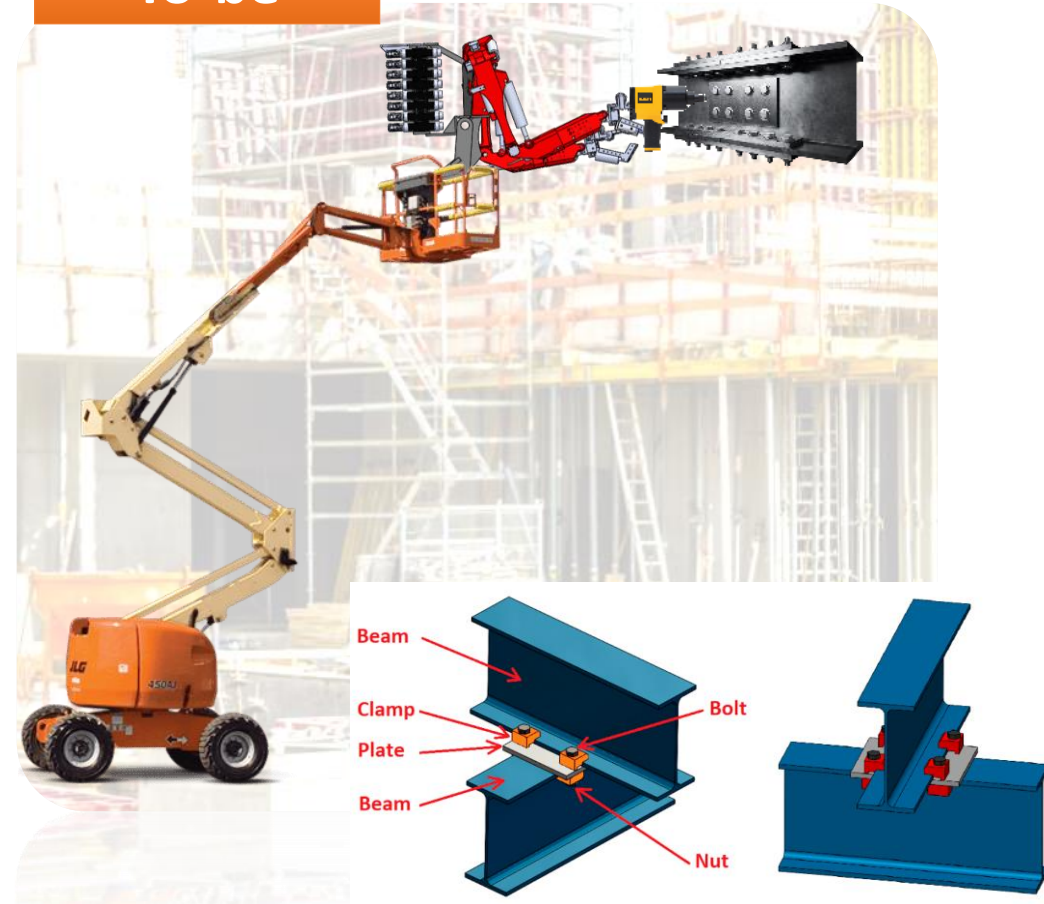


# High-Tension Bolt Tightening Robot

As-is



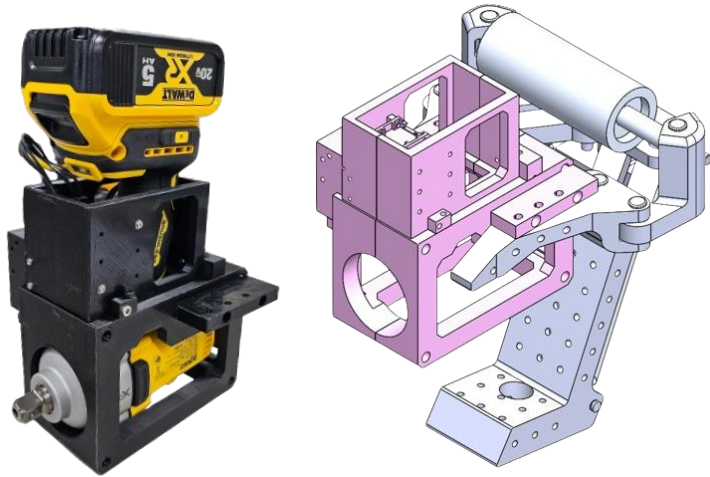
To-be



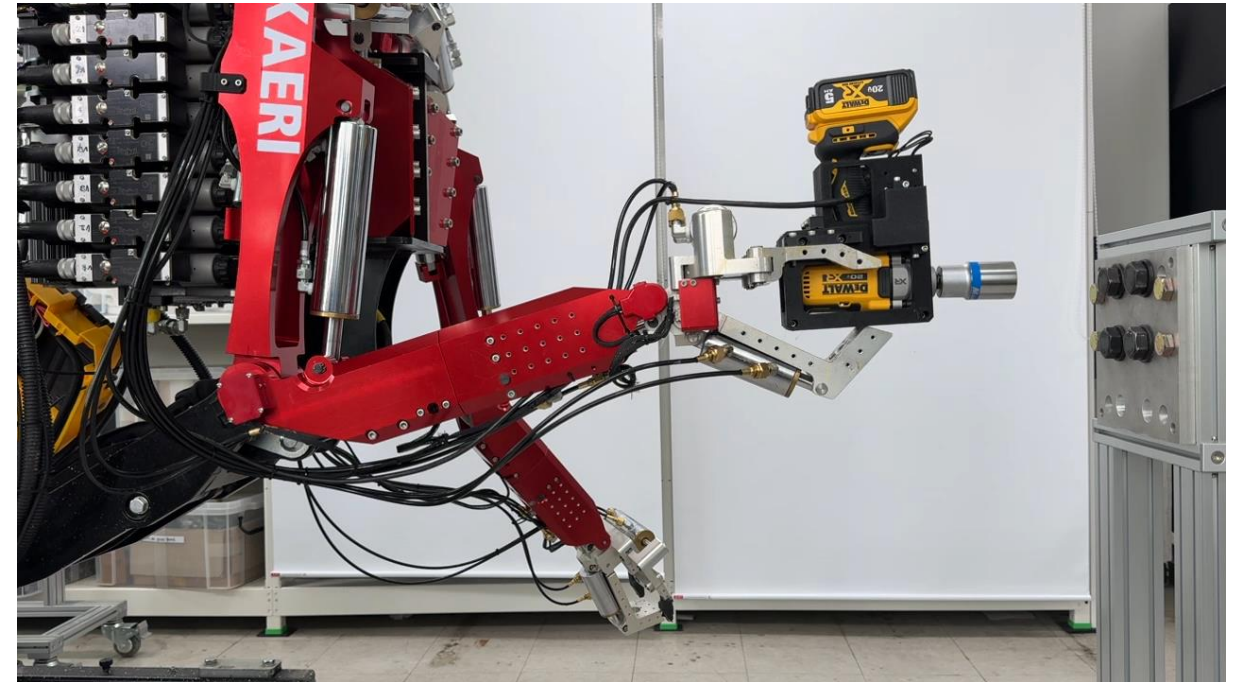
- Development of Technology for Applying Commercial Tools to Dual-Arm Robots for Bolt Tightening in High-Risk Construction Sites

# High-Tension Bolt Tightening Test

## Impact Wrench Mount Design



## Hyundai Engineering & Construction Robot Demo.



- High-tension bolt x4 tightening
- M22 bolt

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# Thank you

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