

The 5th International Forum on the Decommissioning of the Fukushima Daiichi Nuclear Power Station

Efforts to Ensure Safety in Decommissioning (No.2) Spent Fuel Removal

November 1, 2021

Kenji Shimizu
General Manager of ALPS treated water Program

Fukushima Daiichi Decontamination &
Decommissioning Engineering Company
Tokyo Electric Power Company Holdings, Inc.

Situation of stored fuel assemblies in SFP (at time of 2011 disaster)

Unit 1



Stored fuel assemblies: 392

Unit 2



Stored fuel assemblies: 615

Unit 3



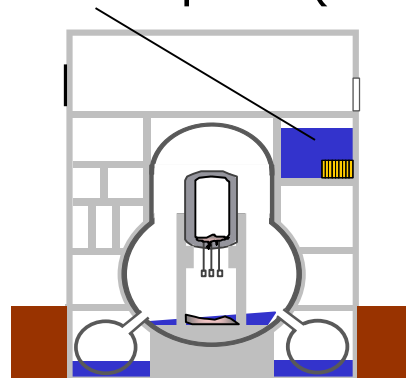
Stored fuel assemblies: 566

Unit 4



Stored fuel assemblies: 1,535

Spent fuel pool (SFP)



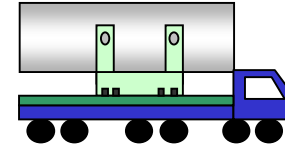
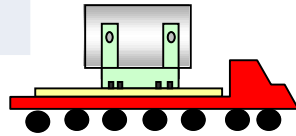
Example Unit 2

	Assemblies stored in pool
Unit 5	1,542
Unit 6	1,704

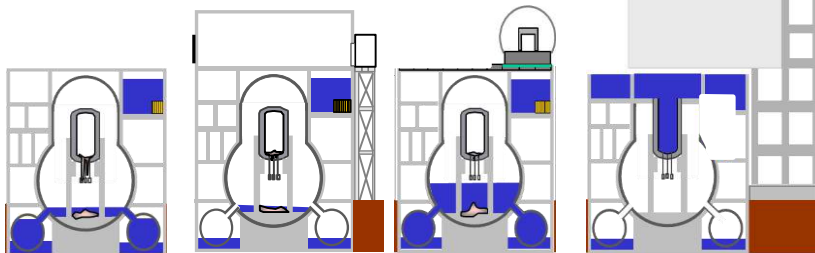
Overview of pool fuel removal

	Assemblies stored in pool
Unit 5	1,542
Unit 6	1,704

Transport/Storage
Multi purpose cask



On-Site transport cask



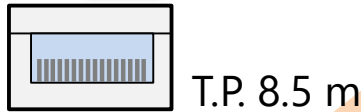
Unit 1 Unit 2 Unit 3 Unit 4

Common pool

Secure the pool
storage capacity



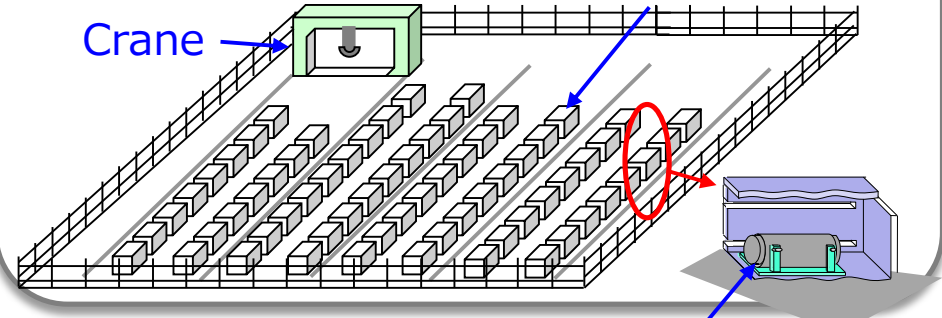
Temporary dry cask
storage facility



Common pool



Temporary dry cask storage facility



Crane

Concrete module

Dry storage cask **TEPCO**

Overall schedule (As of Oct. 2021)



Units 1–3: High dose (when fuel removal roadmap was developed)



Prioritize Unit 4, which has low dose levels and large amounts of SFP-stored fuel

Unit 1: Building cover installed

Unit 2: Building escaped explosion



Prioritize Unit 3 after Unit 4

- Units 1/2: Start with Unit 2 before moving to Unit 1, as work preparation demands
- Units 5/6: Remove within range that has no impact on work of Units 1/2
- **All units: Complete removal by end of 2031 (Goal)**

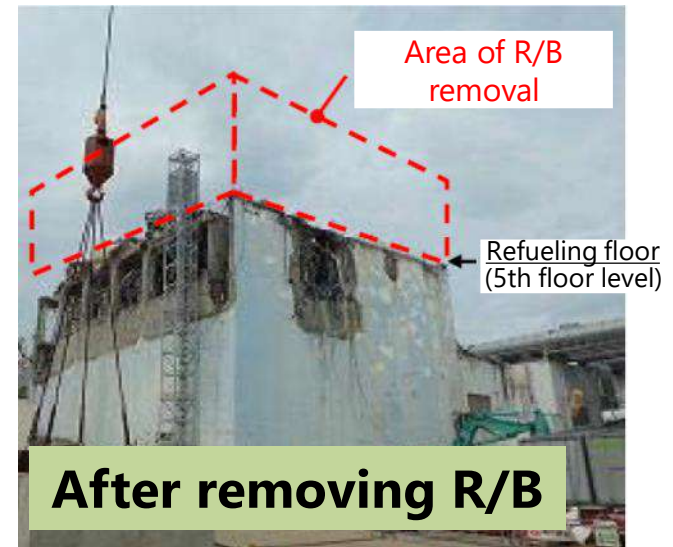
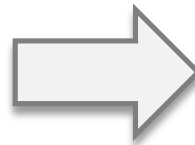
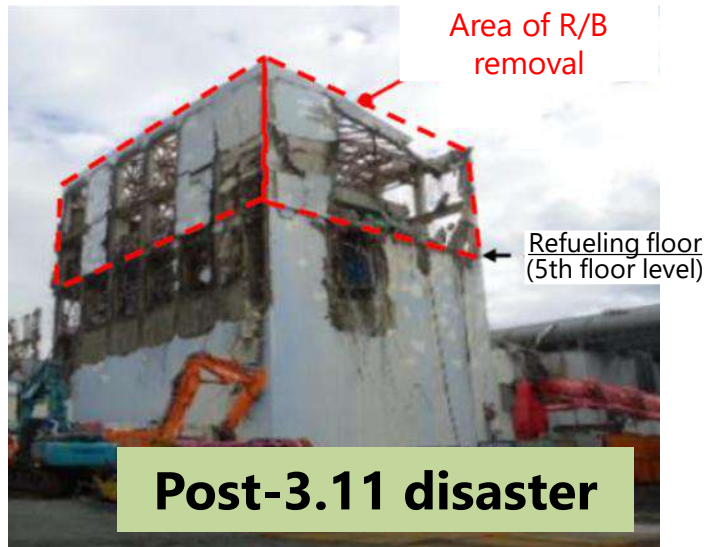
Mid-and-long-term Roadmap (2011): Start removal in 2013

	FY2011	FY2012	FY2013	FY2014
Plan			Start removing fuel	Complete removal
Result	Dismantle upper part of reactor building (R/B)	Install cover	Install FHM	Fuel removal

Fuel removal was completed as per goal (Mid-and-Long-Term Roadmap)

- (1) 7-day/week schedule
- (2) Shortened inspection process for FHM, crane, etc.
- (3) No deficiencies were found in particular
- (4) No rubble galling, which had been a concern, was confirmed

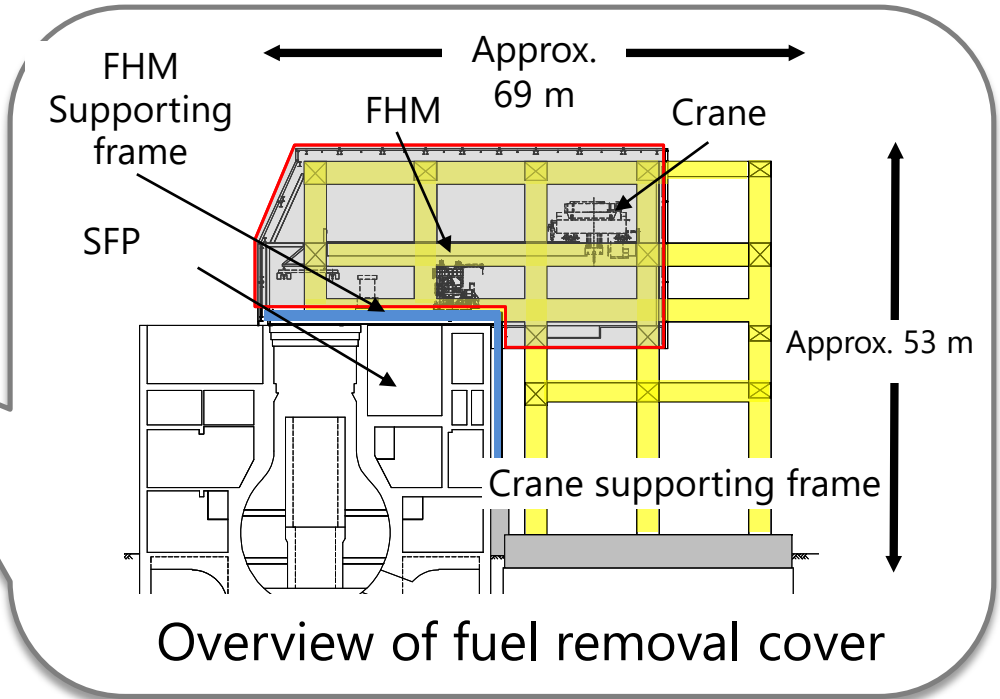
Dismantling upper part of R/B and installing cover (1)



- Despite a hydrogen explosion, Unit 4 had **lower radiation dose levels** than other units
- Materials left at the top floor were **removed by manned operations**, as such operations were possible.
- The explosion damaged the building framework above the uppermost floor. **The upper part of the R/B was dismantled by manned heavy machinery for dismantling.**



After cover installation



- The R/B vicinity has **relatively low dose levels, which allows for using common construction methods.**
- A **cantilever-type** cover was used as the cover for fuel removal **to prevent any load** on the damaged **R/B.**
- The pillars and beams had 3 m x 3 m sizes to **reduce worker exposure.** Elevator equipment and walkways were installed inside the materials.

Removing rubble in the pool and installing FHM

HITACHI



Unit 4

Rubble was retrieved piece by piece, using jigs of various sizes/shapes



Retrieval of large rubble



Rubble suction

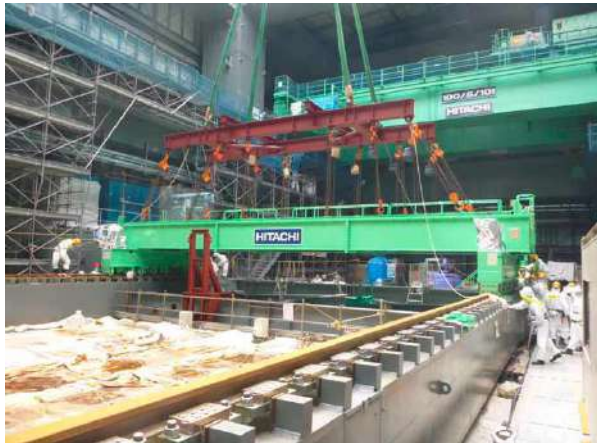


After suction

Rubble retrieval jigs
(21 types in total)

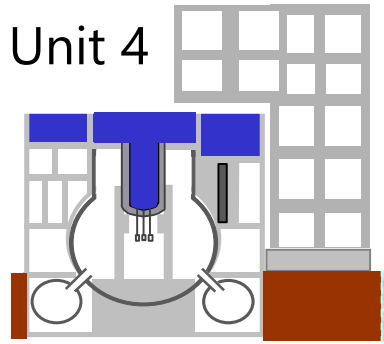


FHM installation



Manned fuel transfer operations





Common pool
(Most of the new fuel was transferred to Unit 6)

Cannot meet Roadmap schedule with original transfer schedule



Shortened schedule

Removal completed in Dec. 2014!

Remarks made later by Unit 4 manager

Unit 4 was able to **achieve the originally scheduled TEPCO's Decommissioning Roadmap**



Key points for achievement

- Relationship of trust is vital to cooperation
- Cooperation creates unity
- With unity, staff can deliver full performance

TEPCO and 4 other companies cooperated



HITACHI



株式会社 宇徳
UTOC UTOC CORPORATION



TEPCO

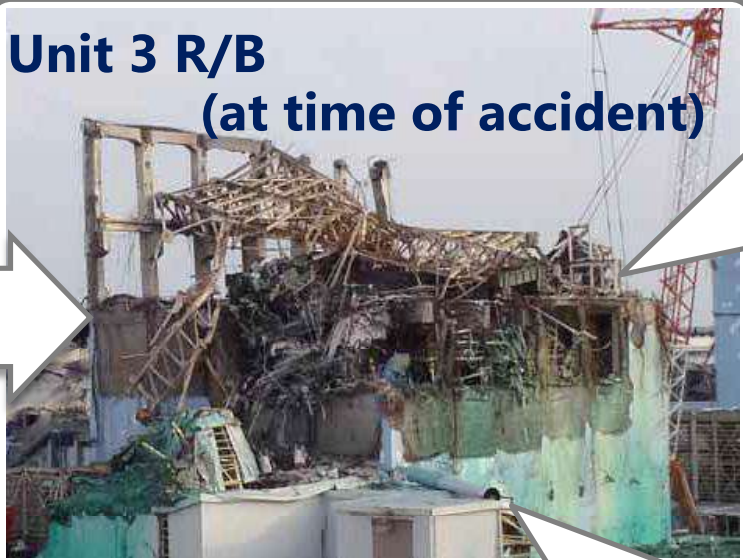


Unit 3 had high dose levels



Mar. 14, 2011
Unit 3 explodes

Unit 3 R/B
(at time of accident)



Dropped roofing



920

mSv/h

Dropped FHM (approx. 20 t)

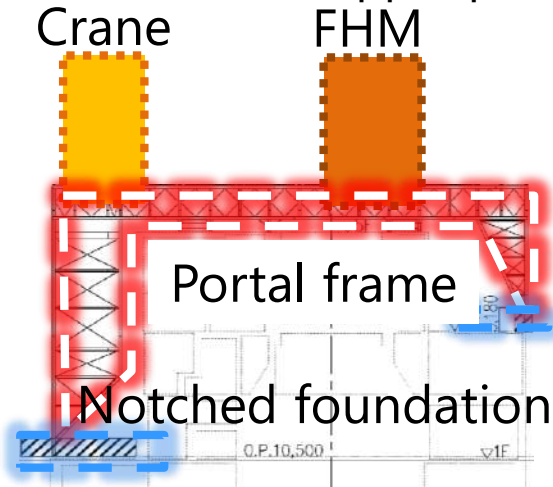


Sediment on fuel

Fuel removal cover

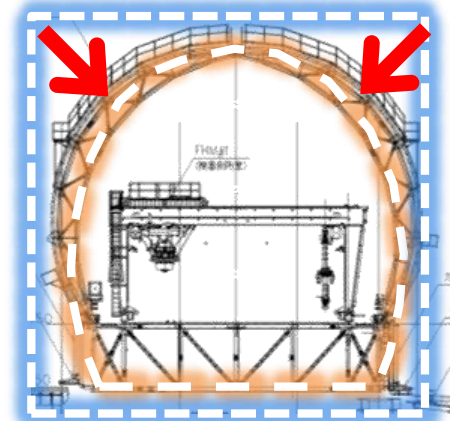
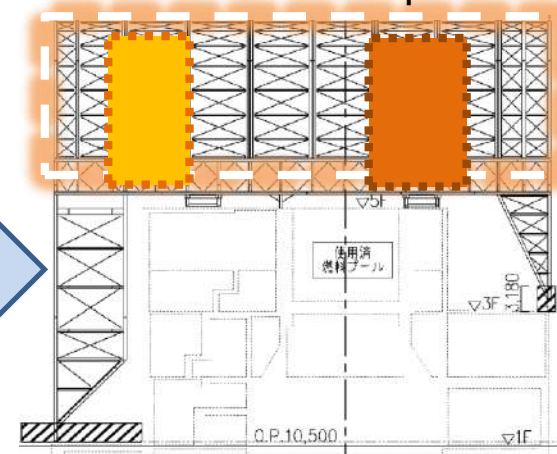
Portal frame and notched foundation adopted

- Reduce load on upper part of R/B



Weight reduction required

Trussed structure and dome roof adopted



Reduced 100 t by remodeling from blue to orange



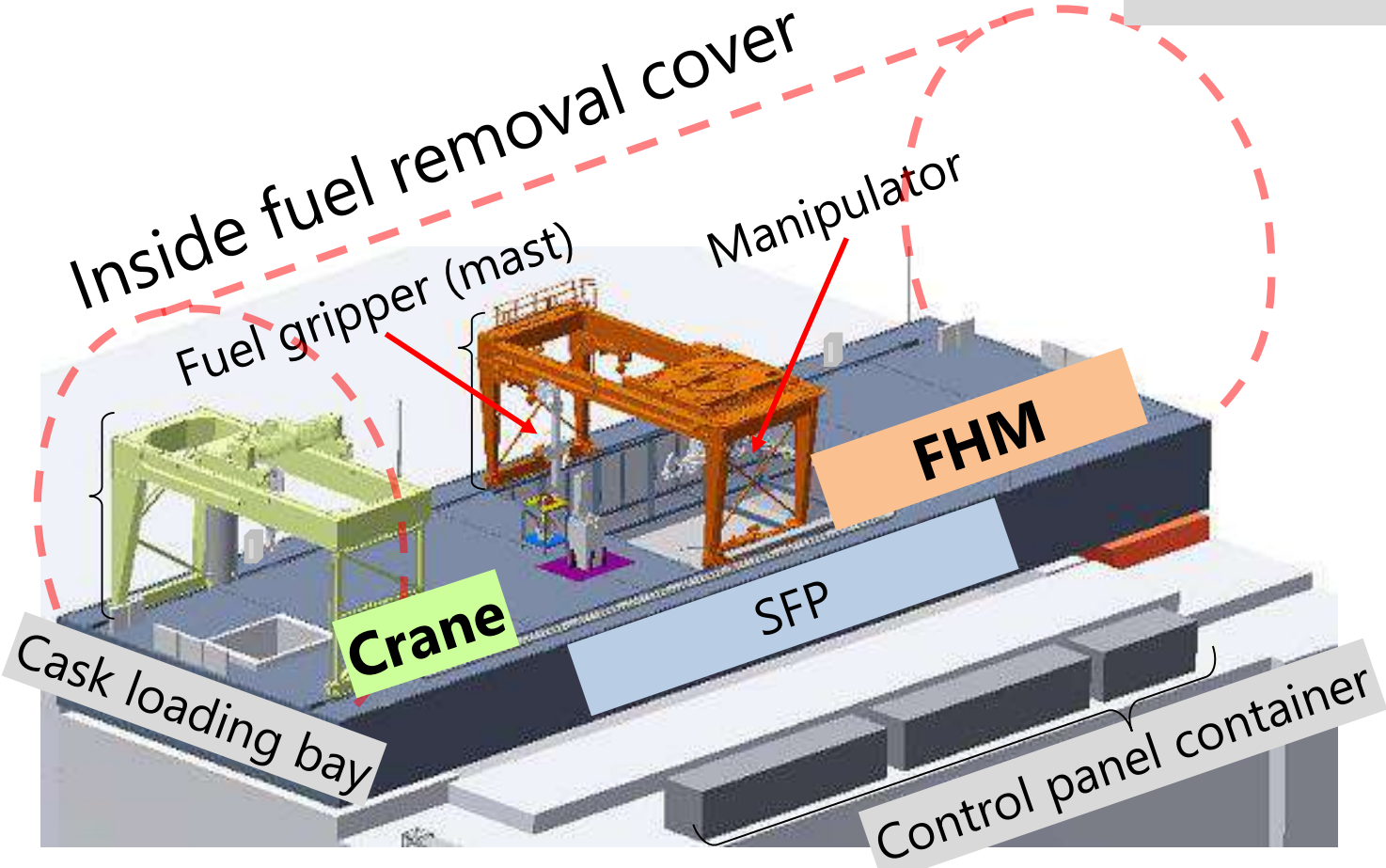
Assembly test (Onahama yard)

Transition of cover installation



Fuel removal system (Entirety)

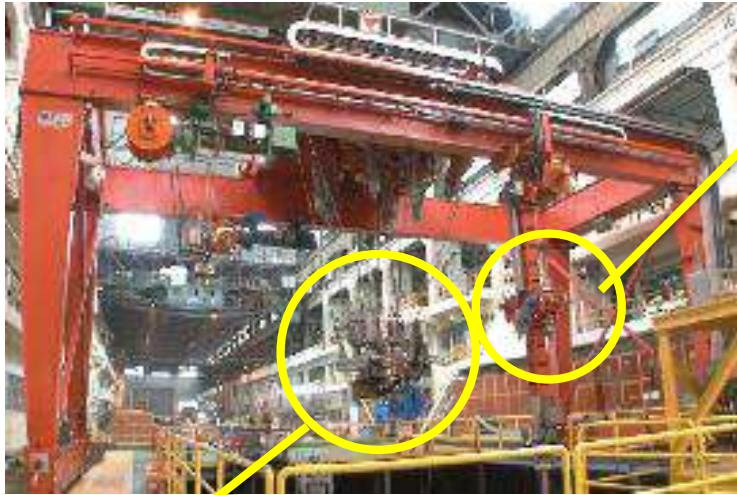
Fully-remote-controlled fuel removal
[First-ever achievement in the world]



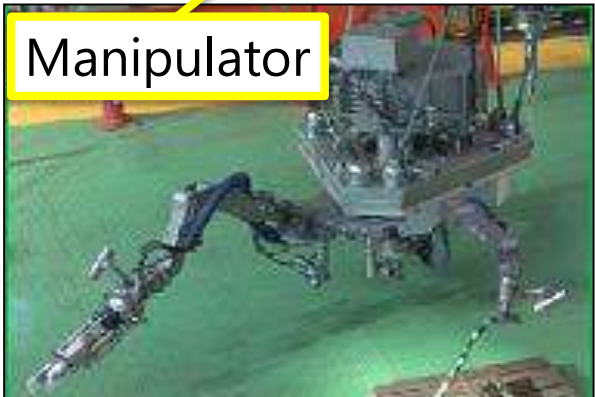
Fuel removal system (FHM, crane)

FHM

- Moves fuel with fuel gripper
- Removes rubble with manipulator



Fuel gripper



Manipulator



Gripper



Cutter

Crane

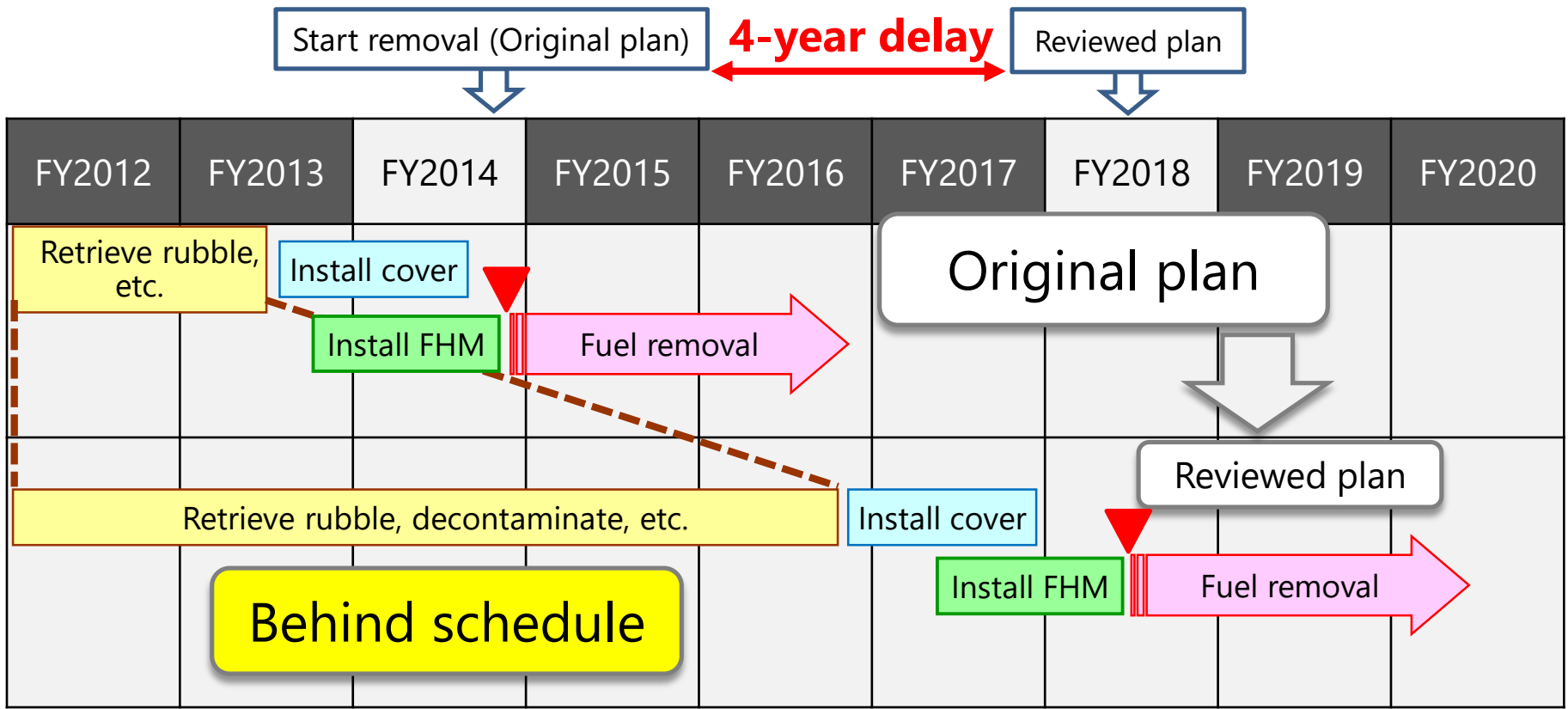
- Tightens transport cask lid
- Lifts transport cask



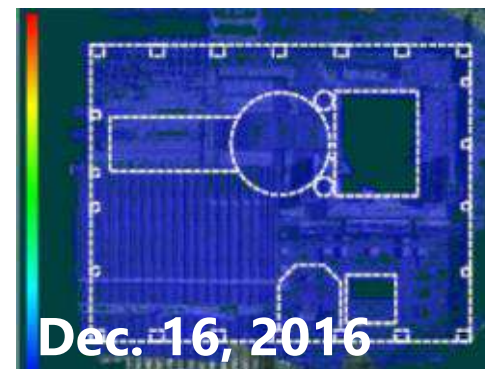
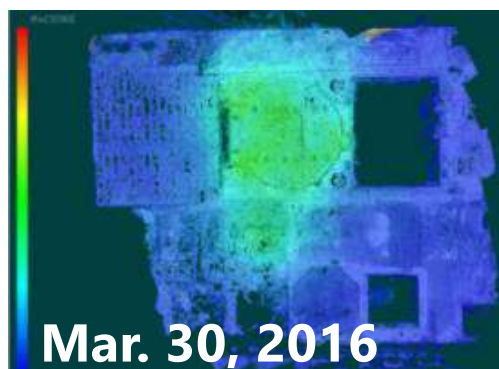
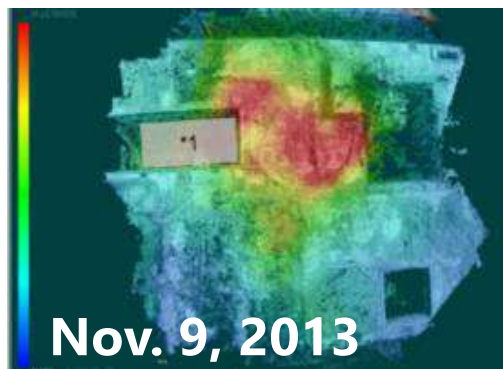
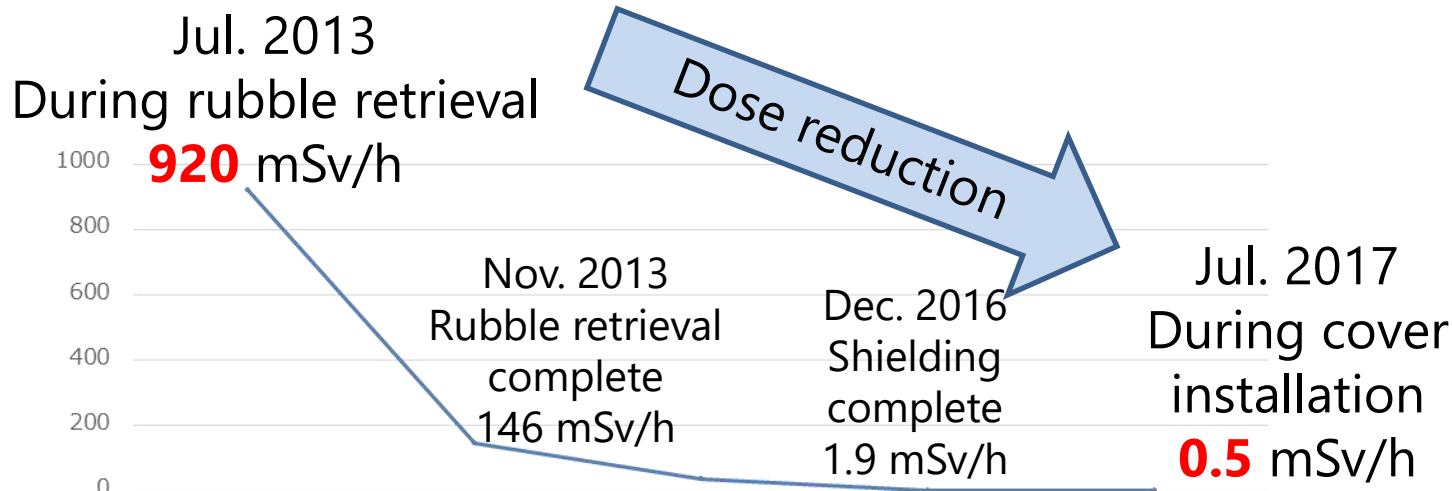
Transport cask lifting accessory



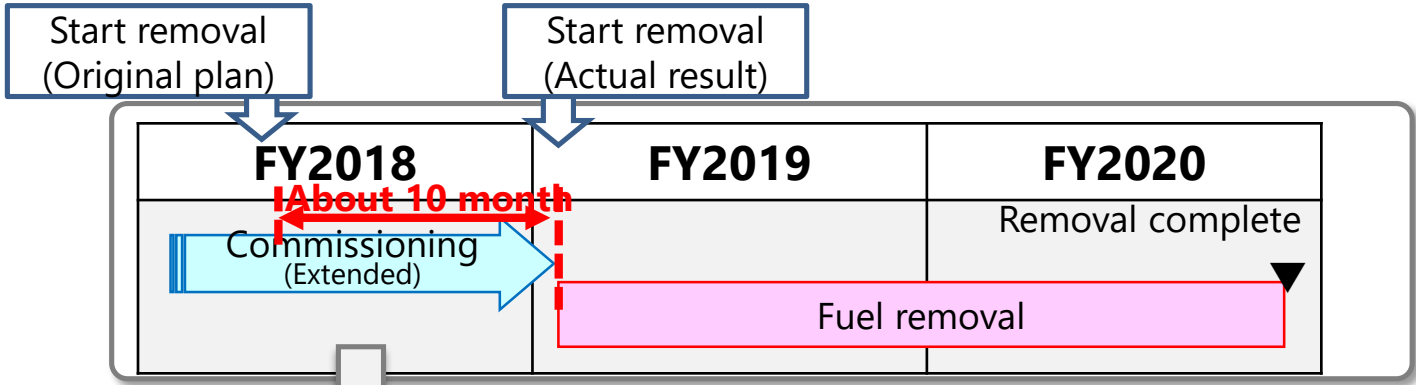
Lid tightener



- The plan was to remove fuel from late FY2014 (in Roadmap announced in 2011)
- Delay in rubble retrieval, decontamination, shielding -> **Fuel removal started 4 years behind schedule**



- Manned work was impossible before rubble removal, because of high dose
- With rubble retrieval, decontamination, and shielding, dose levels dropped from 920 mSv/h to 0.5 mSv/h



Deficiency found in commissioning

Burn

Incorrect voltage setting

Wire snap

Cable quality

Finding from initial removal

Fuel

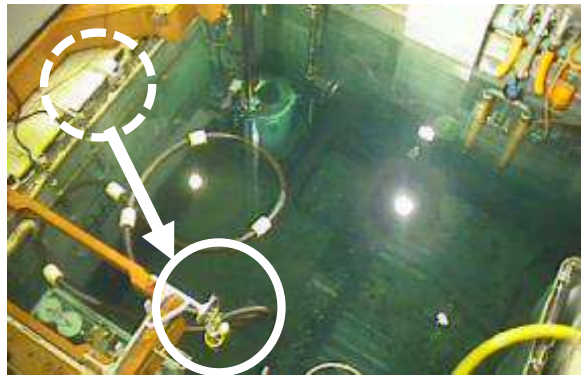
Interferes with cask and consumes time

Jul. 2018–Mar. 2019	Apr. 2019	Apr. 2019–	<p>Removal restarted but with about 10-month delay</p>
<p>Response to deficiency (Voltage setting) (Cable replacement)</p>	<p>Start removal at 1 unit (7 assemblies)</p>	<p>Reflection</p>	

Reflections and KAIZEN (improvement efforts) were made after removing 1 transport fuel unit (7 assemblies)

- (1) Made general inspection of equipment
- (2) Incorporated operational findings into procedures

(2) Moved fixed location of suction hose out of fuel transport route



(2) Moved monitor to a place with better visibility

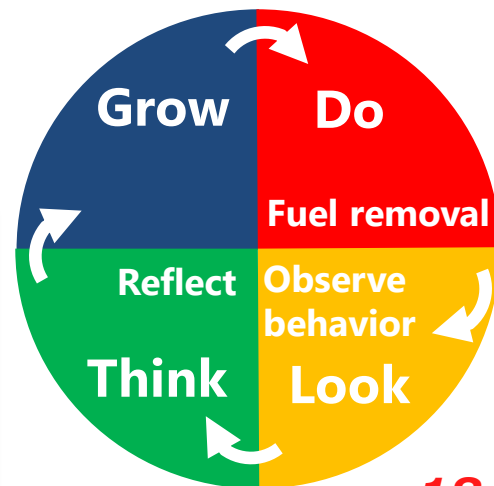


DLTG cycle

Useful in decommissioning work, in which many variables are involved and how things turn out are difficult to expect.

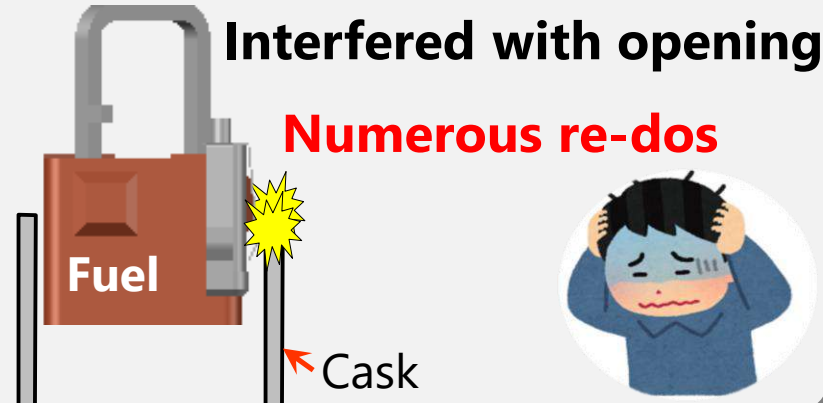
Do, Look, Think, Grow

(Do the work and observe/think for better results next time)



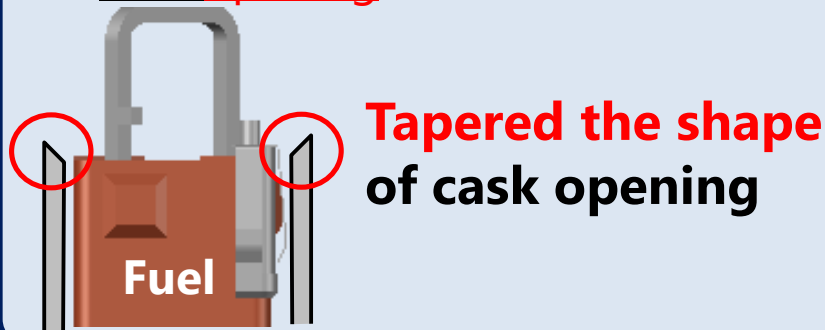
Changed loading steps

Original plan: **Interfered** with cask

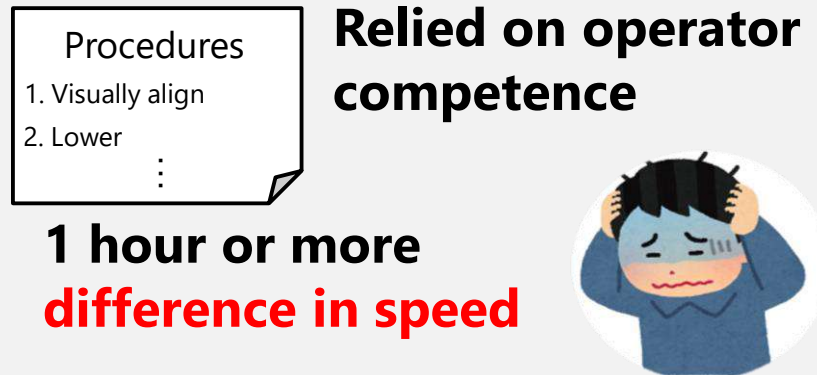


KAIZEN

After review: **Changed shape of cask opening**

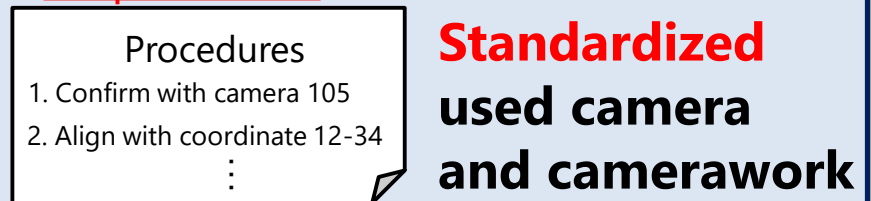


Original plan: **Nonspecific** procedures



KAIZEN

After review: Procedures **do not rely on personnel**



Changed tools

Original plan: Install with manipulator

Free movement

Convenient

Manipulator

Fuel pool

Cask

Flange protector
(Installed location needs adjustment)

After review: Install with auxiliary hoist

Only elevation,
no interference

Plus:
Modified protector
(360° installation
now possible)
No need for
adjusting installed
location

However:

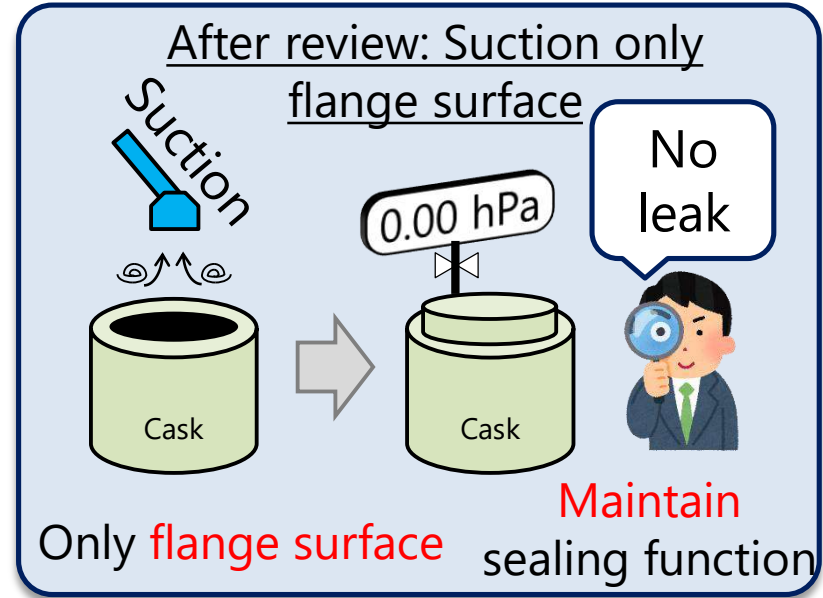
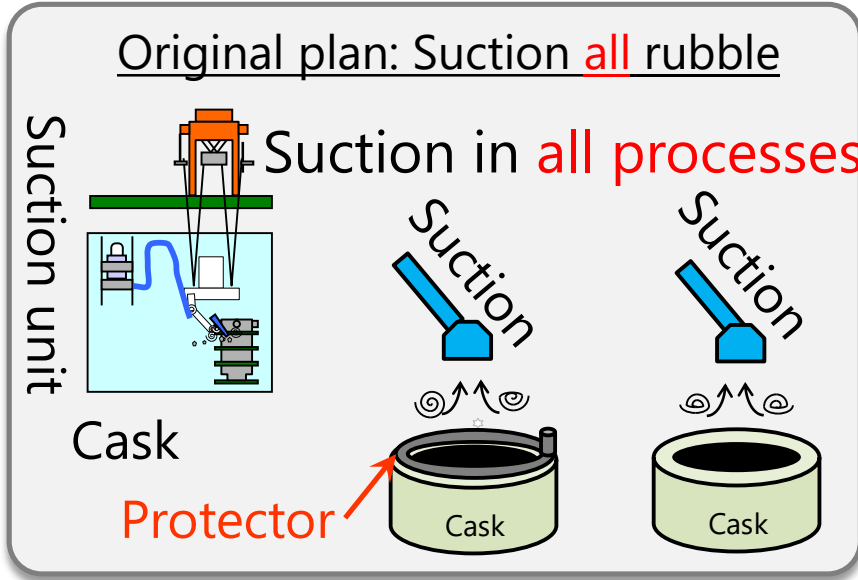
Free movement

More interference/contact

Takes time to check interference

KAIZEN
(Changed tools)

Stopped suction work



Suction: Meant for **sealing function**

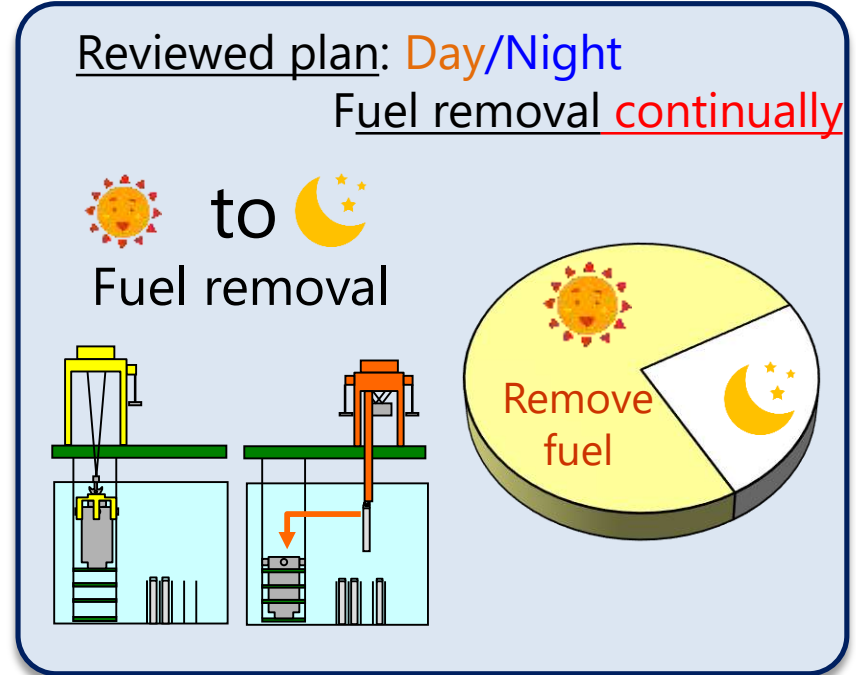
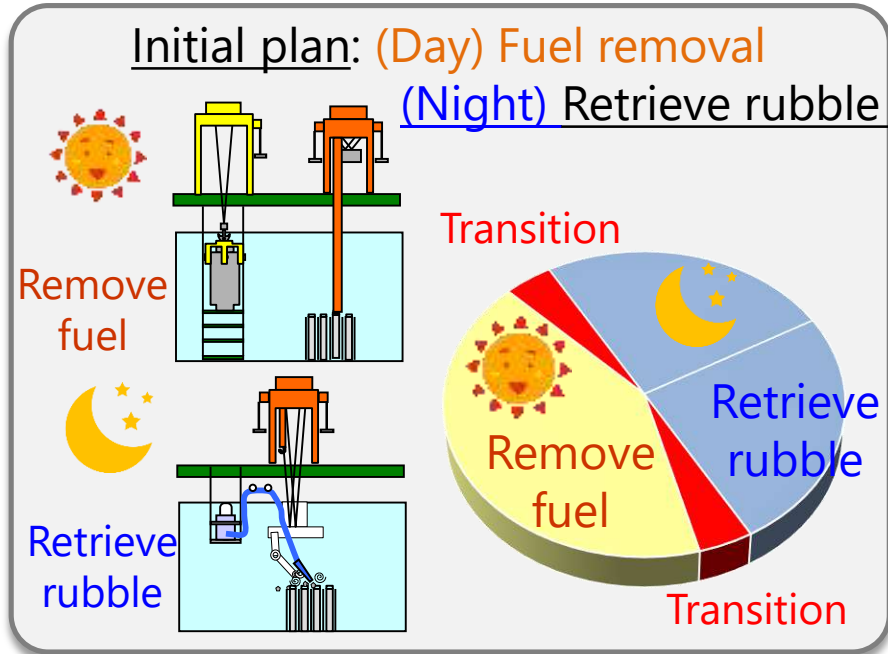
Sealing function: Only **flange surface**

Suction: Unnecessary for **protector surface**

KAIZEN

(Review procedures)

Changed operational transitions



Rubble retrieval: All **completed in advance**
Fuel removal: Done intensively and **continually**

Reduced time taken in operational transitions

KAIZEN
(Changed cycle time)

22

11 fuel assemblies
stuck in racks were
unremovable

rack
Fuel
rubble

Pulling out measures consideration

Measure(1)
Vibration generation
Air injection

Measure(2)
Rack narrow part cutting device

Measure(3)
Rack cutting device

Vibration
Air
Fuel
Narrow part

Insertion of **chisel** between rack and fuel

Chisel

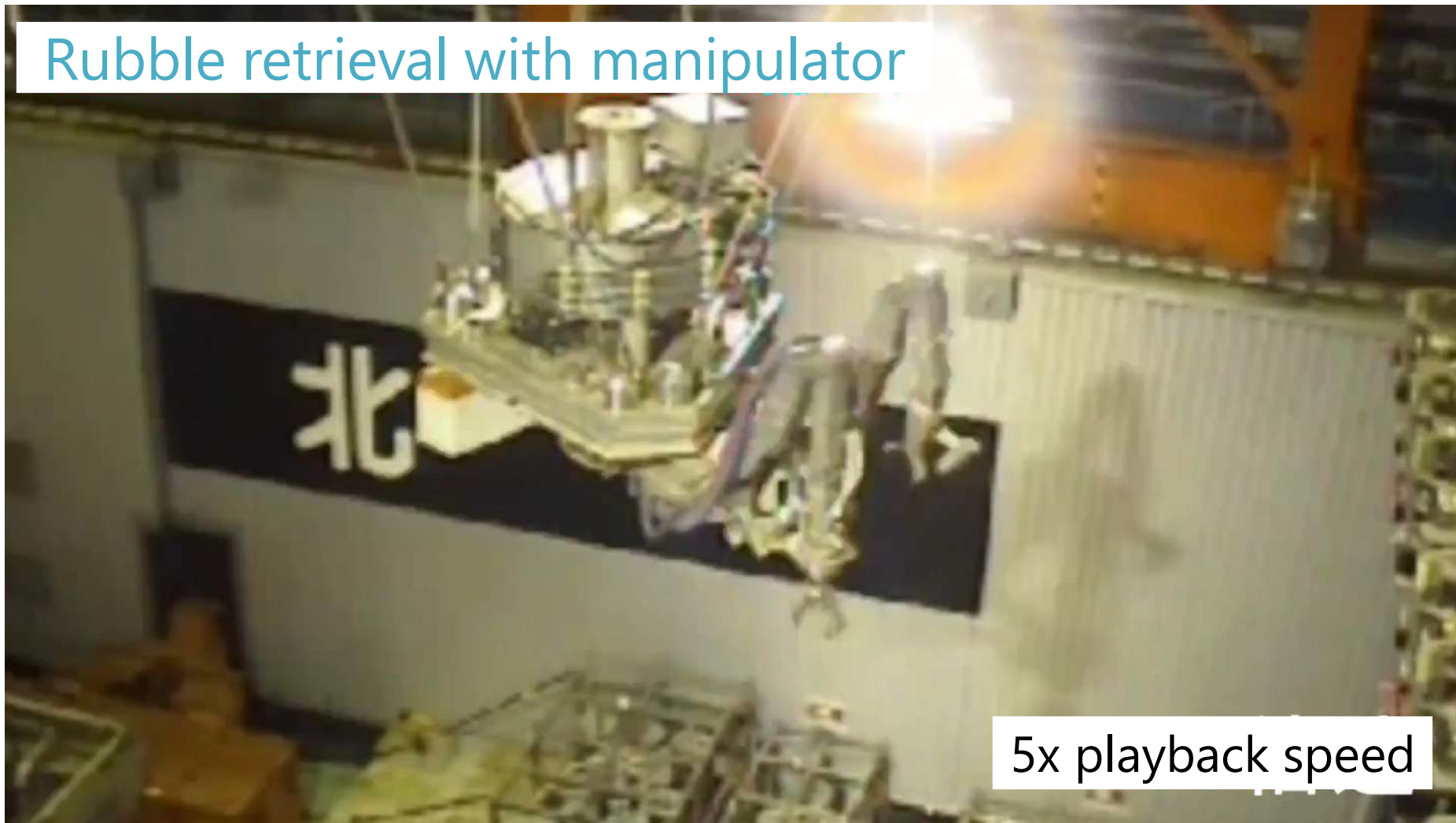
Fuel

Chisel

Recovered 10-month delay

Removal completed in late Feb. 2021

Rubble retrieval with manipulator



5x playback speed

With the collective wisdom of the international community, the first-ever fully-remote-controlled device was developed for Unit 3. Initial deficiencies occurred but were recovered through removal operations.

Key points for achieving the plan

- On-site reflections
(Do, Look, Think, Grow)
- Determination to follow through
- Above all, unity with partner companies



TEPCO



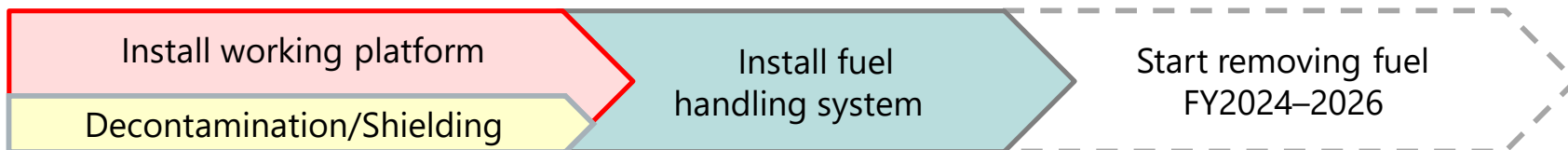
TOSHIBA
Leading Innovation >>>

鹿島
KAJIMA CORPORATION

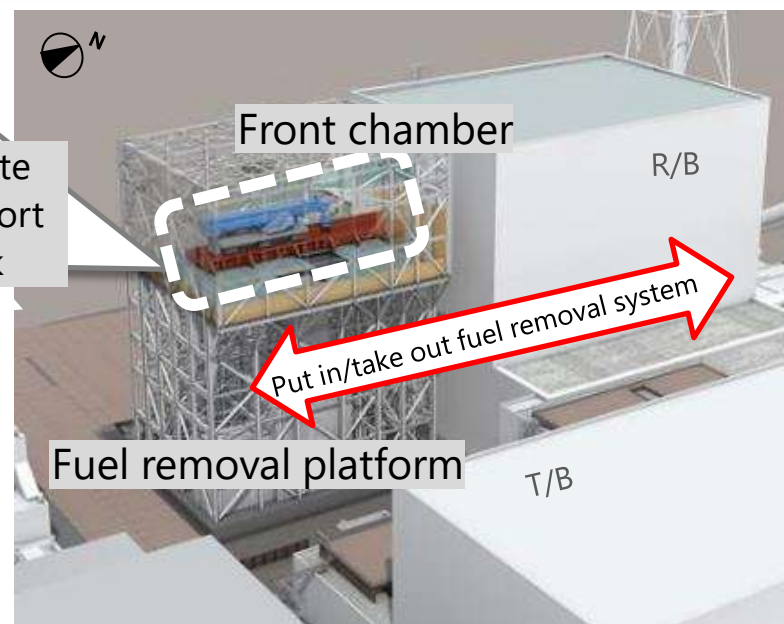
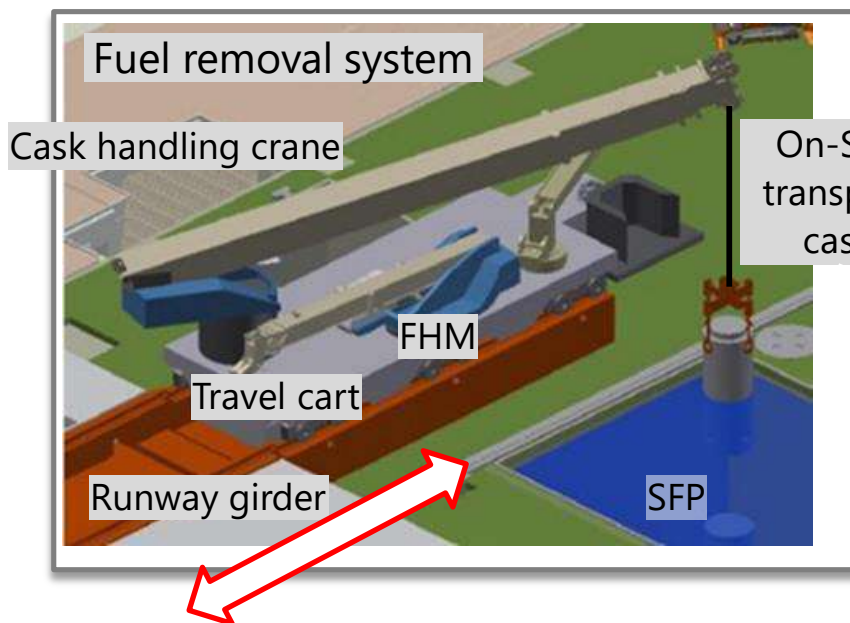
 **株式会社 宇徳**
UTO CORPORATION


東京パワーテクノロジー

Fuel removal strategy for Unit 2



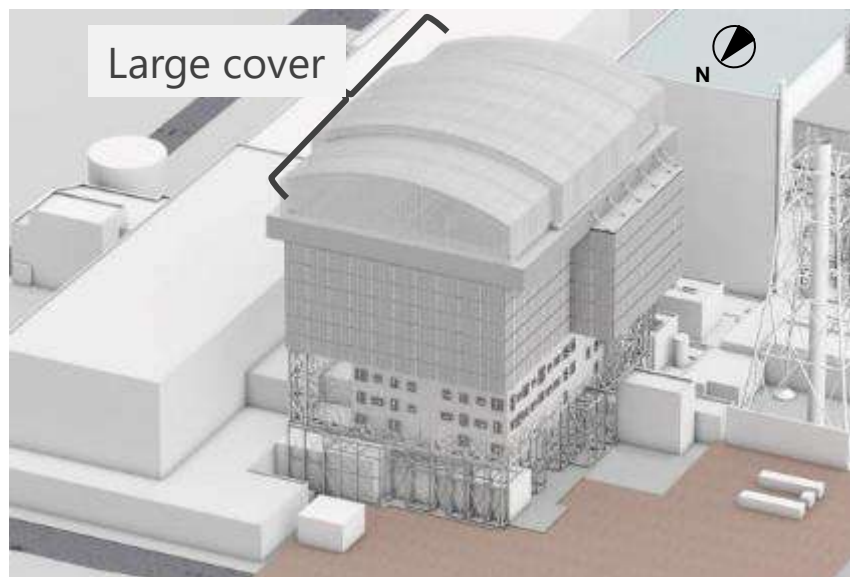
- Capitalize on existing building and install minimal wall opening
Take in/out fuel removal system through wall opening: **Prevent contamination spread**
- Install fuel removal system after decontamination/shielding
Remotely fuel removal: **Reduce exposure**



Fuel removal strategy for Unit 1



- Install large cover for top of R/B: **Prevent contamination spread**
- In order to **reduce exposure**, rubble retrieval and decontamination/shielding before install fuel removal system and fuel removal by local operation
- How to safely remove the fuel is a challenge, because some fuel rods have damage in their cladding tube



Final remarks

- Using insights gained through Units 3 and 4, steady efforts will be made for subsequent fuel removal efforts of Units 1 and 2.
- The fuel removal process will be improved daily while giving top priority to safety.
- TEPCO will follow through on the Roadmap that the company promised with society to achieve.

TEPCO and contractors will engage in the decommissioning work united as a team to keep fulfilling TEPCO's responsibilities to Fukushima.

