IBF/25

INTERNATIONAL ITER BUSINESS FORUM

# Hot Cell Facility: status and perspectives


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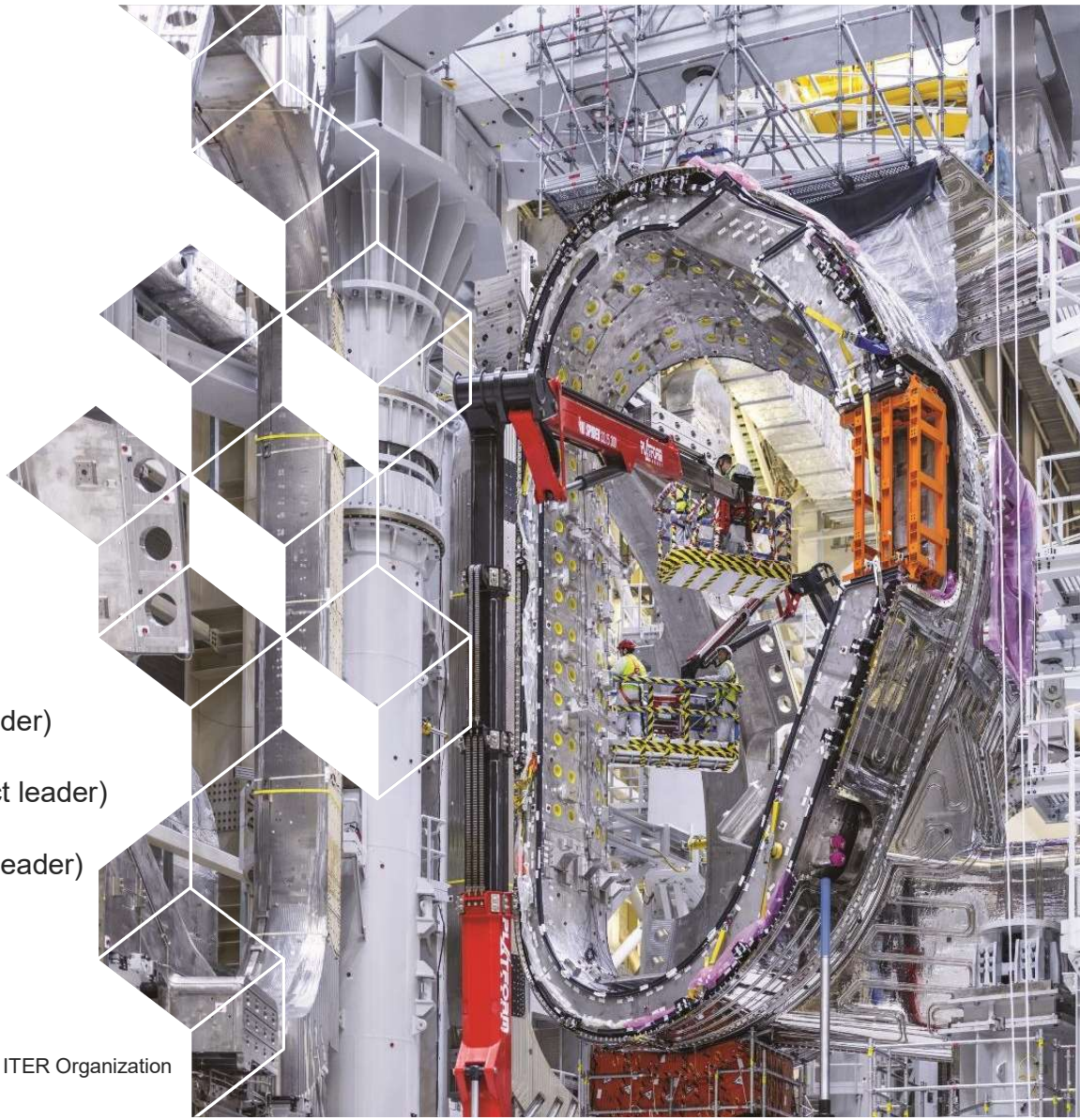


**THURSDAY APRIL 24th**

# Hot Cell Facility: status and perspectives

1. High-level functions
2. HCF history & pre-concept
3. HCF scope and interfaces
4. Perspectives

# 1. High Level functions

Of the Hot Cell Facility

# Why do we need a Nuclear Maintenance Facility?

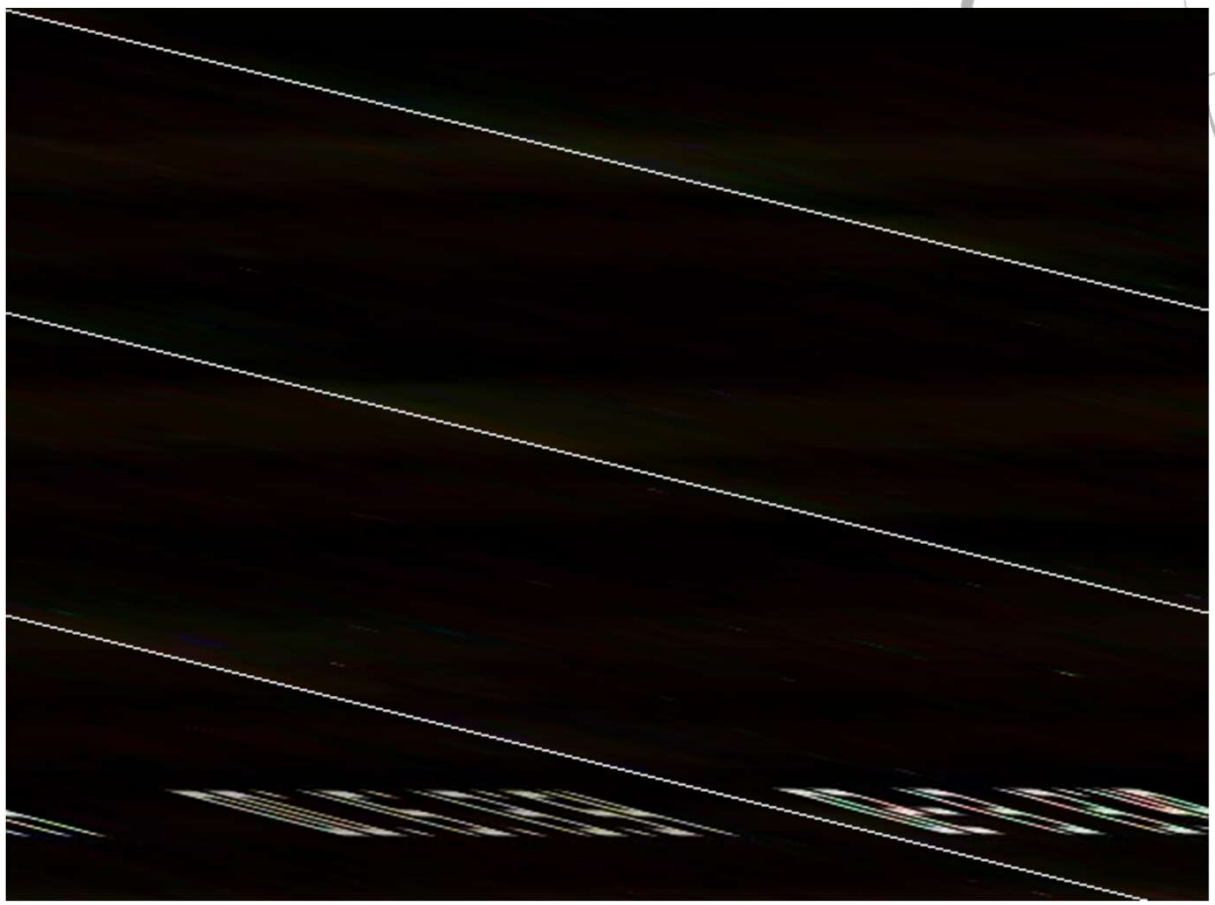
FUSION PLASMA

NEUTRON FLUX

Activation

EROSION

Dust contamination

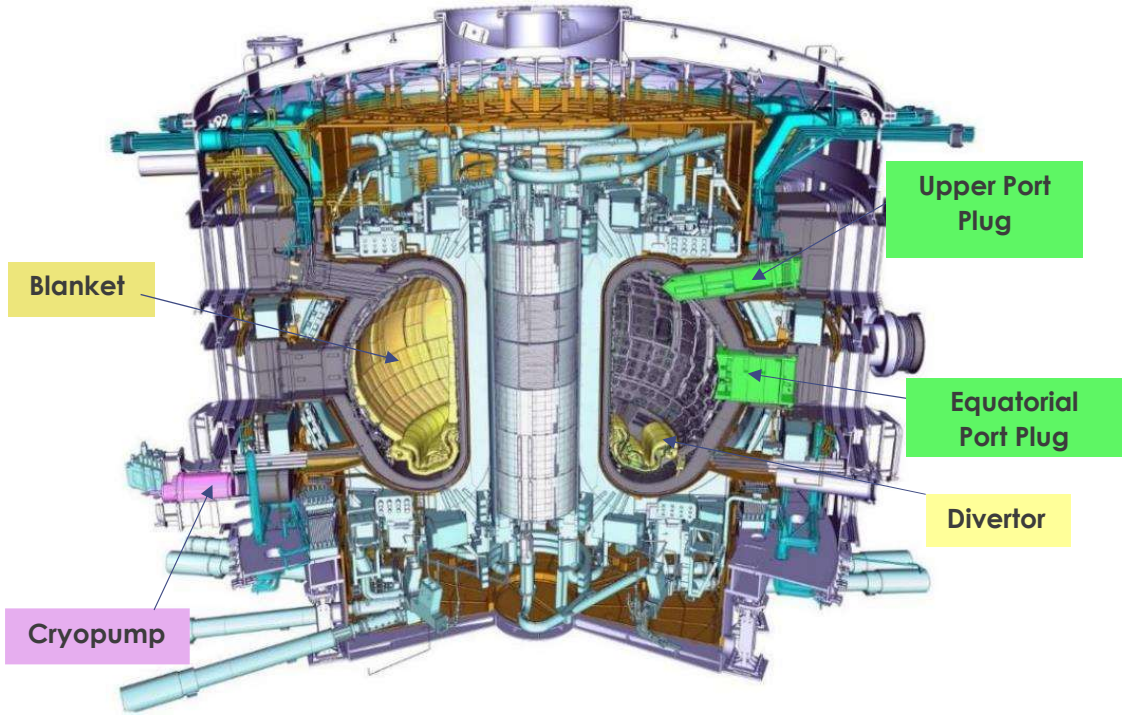


*Plasma in West Tokamak - CEA*

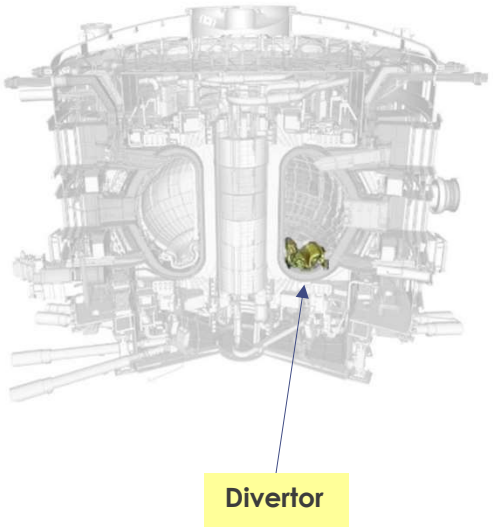
# Why do we need a Nuclear Maintenance Facility?

## 1 – Small repair or replacement of In Vessel Components (IVC)

- **In Vessel Components** may **fail** or be **damaged**
- IVC are **activated** and **contaminated** (dust and Tritium)
- Handling of IVC shall be **remote**
- **Buffer storage** and **small repair** in **Red Zone**

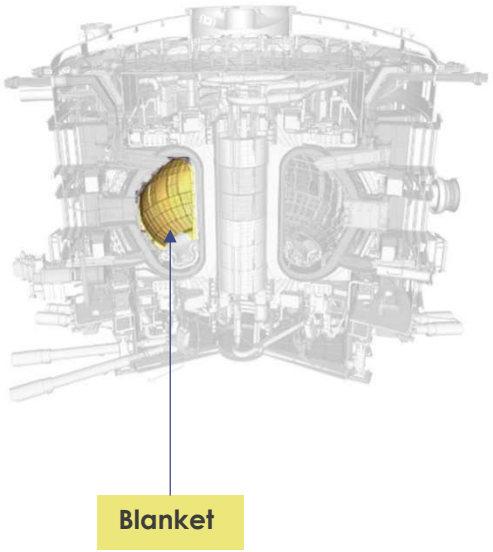


# Illustration of Divertor

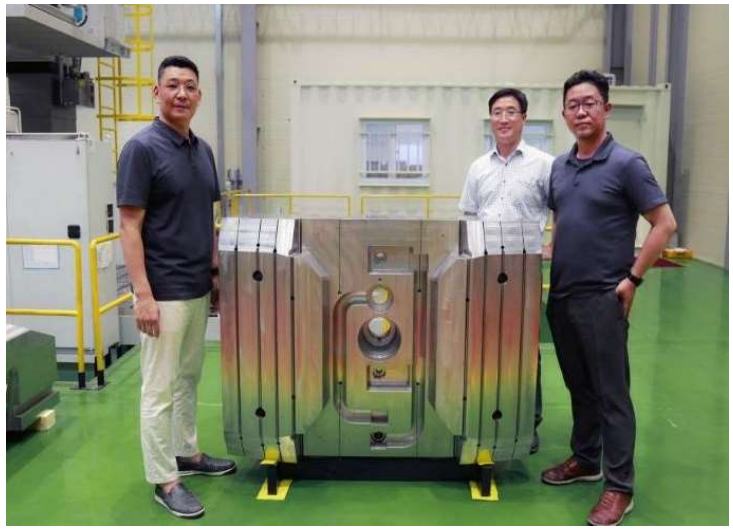



Cassette Body ~ 4.6 tons

# Illustration of Blanket




First Wall - Full size prototype – Atmostat-Alsyom for F4E

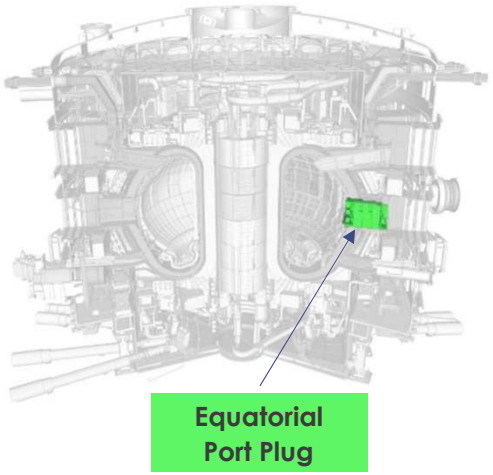


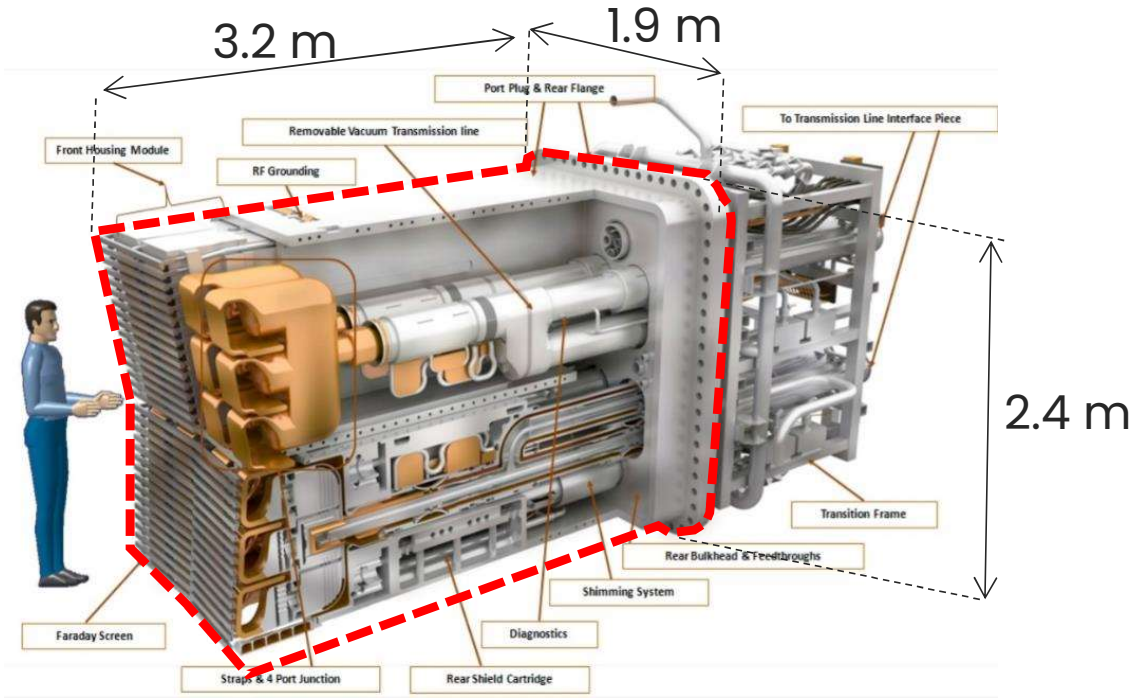
Shield Block – full size prototype

Blanket First Wall Panel (FWP) between 600 and 800 kg

Blanket Shield Block (SB) between 2 and 3 tons

# Illustration of ICH Port Plug




ICH Equatorial Port Plug

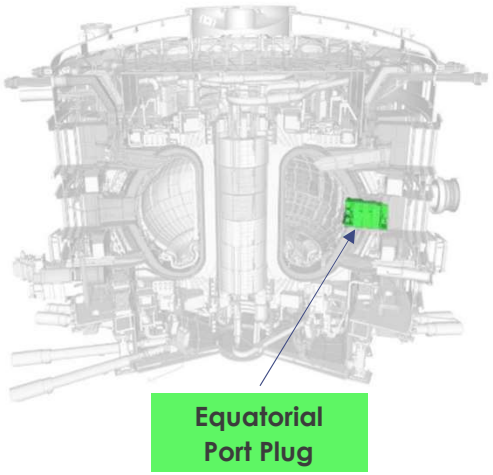
EPP: Equatorial Port Plug
ICH: Ion Cyclotron Heating

Max weight Equatorial Port Plugs (EPP) ~ 50 tons

# Illustration of TBM Port Plug

Remote operations HC:

- TBM Set to be **extracted**
- TBM part to be **removed and exported**



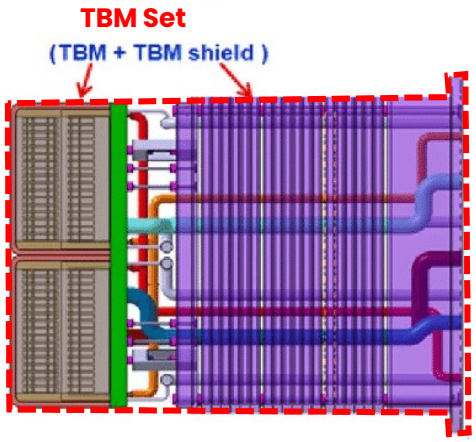




Illustration from Thermal-Hydraulic Analysis for Conceptual Design of Korean HCCR TBM Set Dong Won Lee - IEEE Transactions on Plasma Science · April 2016

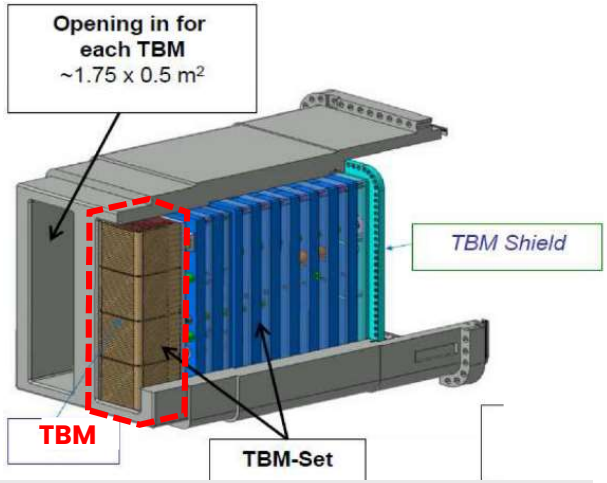



Illustration from ITER Test Blanket Module - ALARA Investigations for Port Cell Pipe Forest Replacement - Jean Pierre Friconneau SOFT 2022

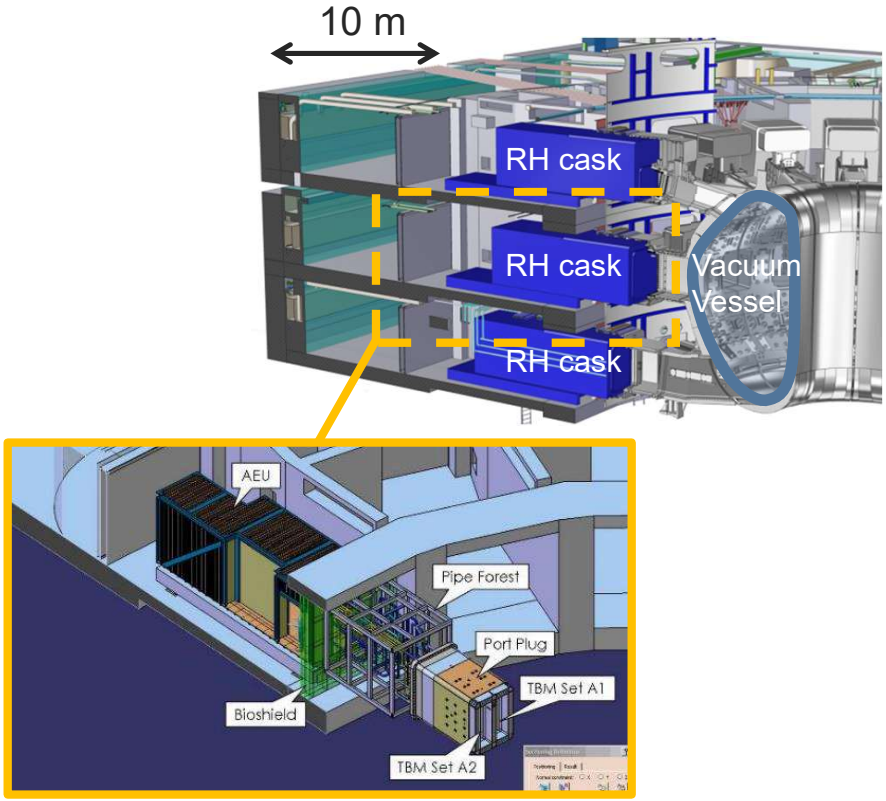
EPP: Equatorial Port Plug

Max weight Equatorial Port Plugs (EPP) ~ 50 tons
Capabilities developed to perform “TBM operations” will be used to perform “Small repair”

# Why do we need a Nuclear Maintenance Facility?

## 2 - Maintenance of EVE (Ex-Vessel-Equipment)

- EVE are **large and heavy**
- **Contamination and activation is limited** but Tritium Source term is not negligeable
- **Maintenance and handling** of EVE can be done **Hands On or assisted.**



# Why do we need a Nuclear Maintenance Facility?

## 3 – Decontamination of Remote Handling System

Example of RH Systems:

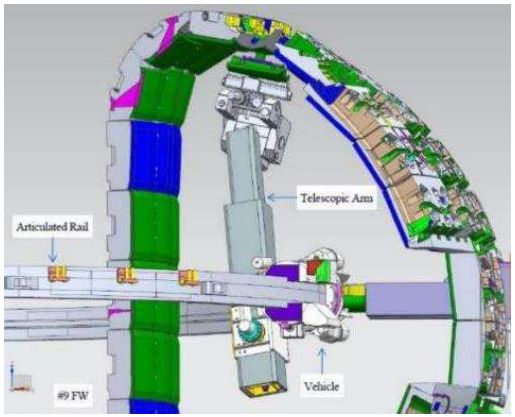
- **Blanket Remote Handling System**

=>handle blankets First Wall and Shield Block

- **Divertor Remote Handling System**

=>handle Divertors

**Decontamination of IRMS in the Hot Cell Facility, before export to another facility for maintenance and test**





*Mock-up Blanket RH System IVT – JA DA*

# Why do we need a Nuclear Maintenance Facility?

## 4 – Radioactive waste (RW) management

Different type of waste:

- **TFA** (very low-level waste) (1)
- **Type A** (low-level waste) (2)
- **Liquid Radwaste**

RW contaminated with Tritium:

- **Treatment of Solid RW**, except IVC which are buffer stored
- **Treatment of Liquid RW Effluents**

(1) TFA: "Très Faible Activité" in French
(2) Type A: "FMA-VC Faible et moyenne activité à vie courte" in French
(3) ANDRA: French Final Radwaste repository

Housekeeping TFA radwaste – ANDRA (3)

TFA radwaste at ANDRA (repository)

Type A radwaste – ANDRA

Transfer of Radioactive Liquid radwaste

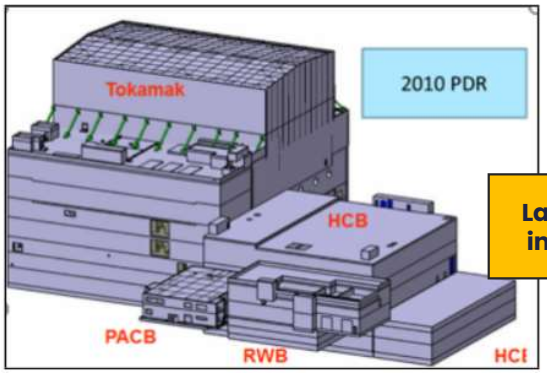
# 2. History & Pre-concept

Of the Hot Cell Facility

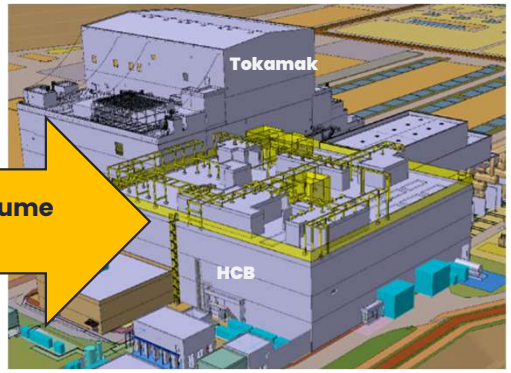
# Hot Cell history, New ITER Research Plan

Different configurations have been developed since 15 years

2010 | 2021 | 2024

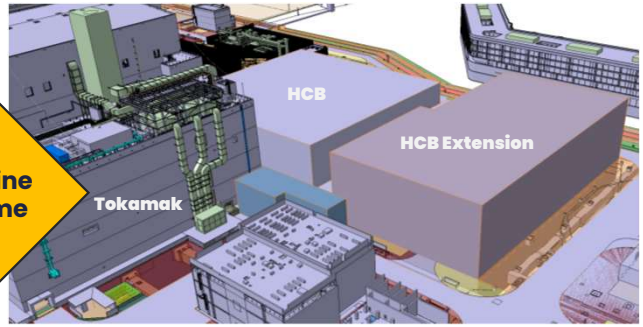



Large Volume increase




Addressing all the nuclear phase

New Baseline New Scheme




Staged construction
HCB addressing DT-1 phase

# Hot Cell history, New ITER Research Plan

Value analysis performed during the past years to **rationalize requirements** and to **define design principles**, aiming to **reduce investment cost** for Deuterium Tritium phase 1 (DT-1) configuration.

Many **opportunities** appeared and could be materialized with the new ITER Research Program [1], for instance:

- **Staged approach of the ITER Research Program** (Start of Research Operation / Deuterium Tritium phase 1 / Deuterium Tritium phase 2)
- Beryllium First Wall replaced by **Tungsten First Wall**
- Revision of maintenance strategy of Port Plugs
- **No change of full set Divertors or First Wall Panels during DT-1**
- **Reduced dose rates, reduced contamination levels**

(1) See https://www.iter.org/node/20687/new-baseline-prioritize-robust-start-exploitation

# Hot Cell history, New ITER Research Plan

**Main changes** of the Hot Cell Facility requirements DT-1 :

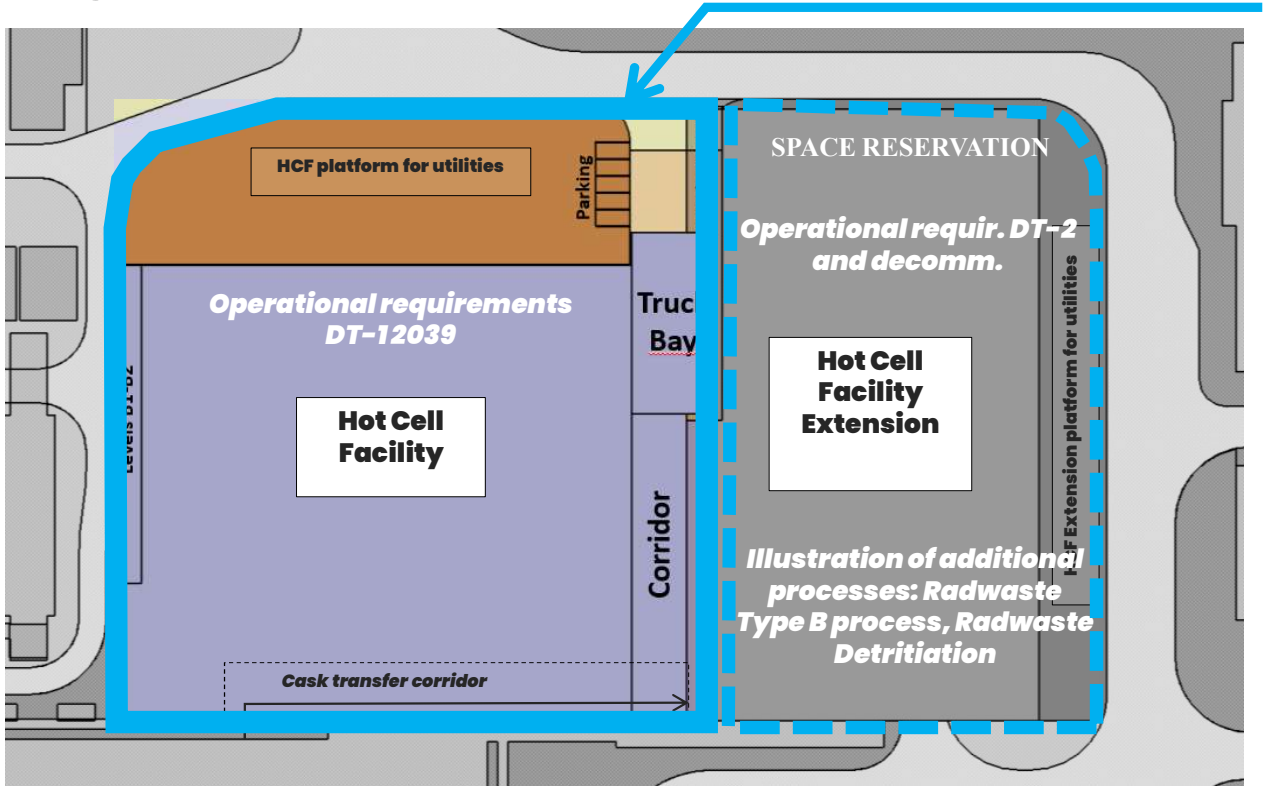
- **Reduced requirements for In-Vessel-Components**: no more complex and challenging remote repair and remote Test of Port Plugs
- **No Beryllium risk for hands-on operations**
- **No need to buffer store a full set of Divertor Cassettes**
- **No need to change First Wall Panels**
- **No Radwaste Detritiation process**
- **Limited number of discarded components during DT-1 phase**, no need to design and build a complex "Radwaste Type B" (1) process / facility
- **Limited functions** implemented in the Hot Cell Facility
- **Reduced Radwaste inventory**

→ Cost reduction 

(1) Radwaste type B = Medium Activity Long Lived Radwaste ("MAVL Moyenne Activité Vie Longue" in French)

# Implementation of the Staged approach

Staged construction of the Hot Cell Facility (HCF)

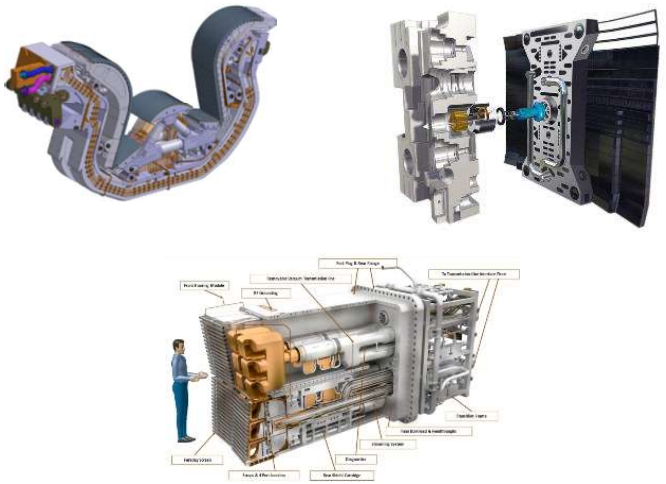



- Space reservation is allocated for a **HCF extension**
- Extension **postponed to the next phases**, it would be a **separate building**

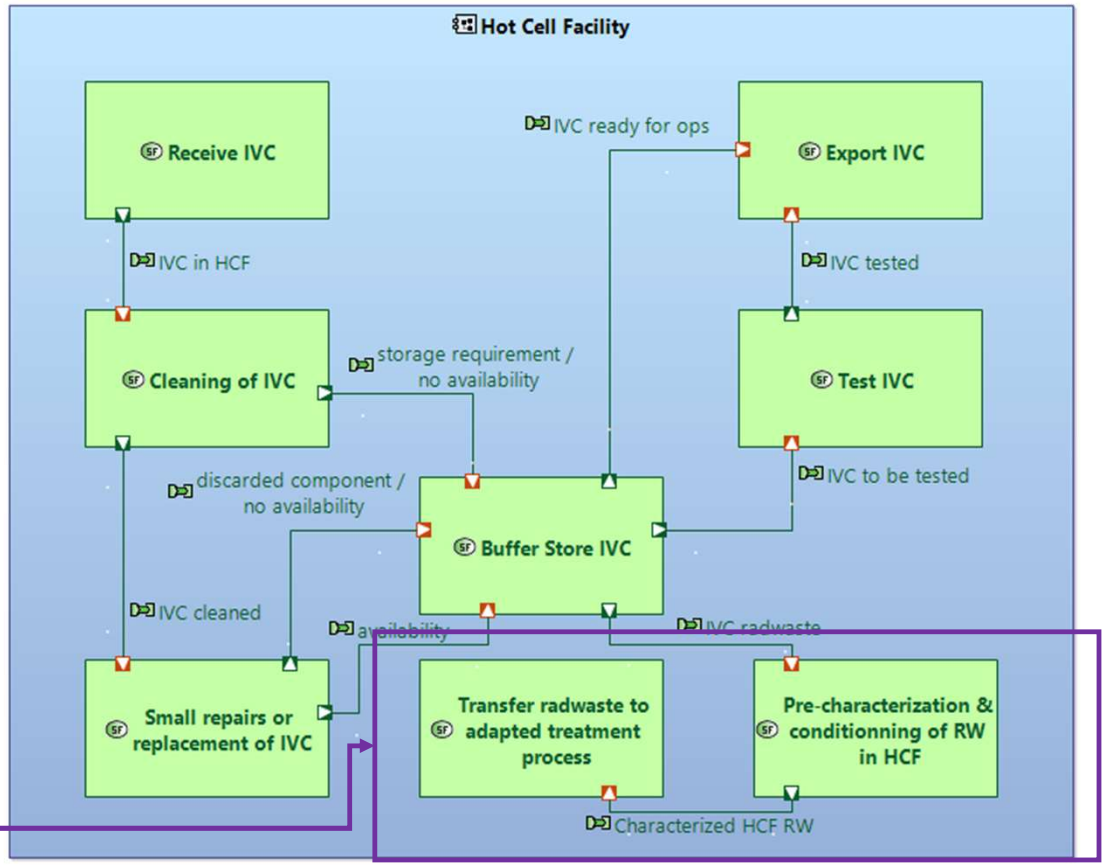
Hot Cell Facility = Hot Cell Building + processes + services

# Functional breakdown

## In-Vessel-Components maintenance

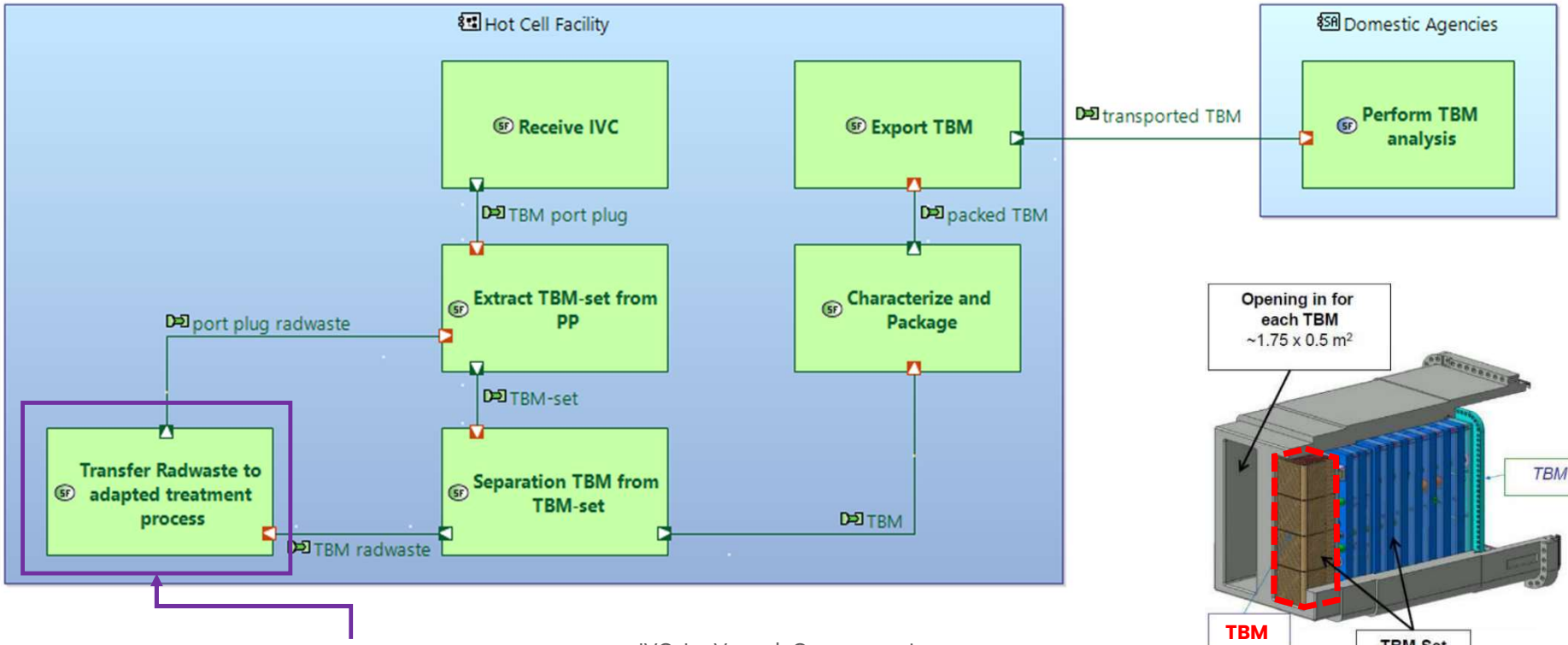


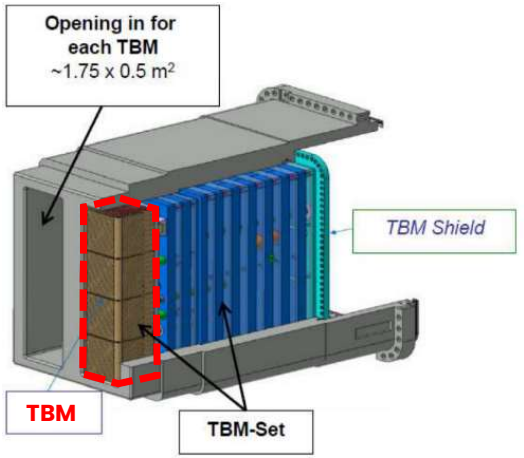
IVC: In-Vessel-Component
HCF: Hot Cell Facility
RW: Radwaste



# Functional breakdown

## In-Vessel-Components maintenance: Focus Test Blanket Module (TBM) → Design driver for the IVC maintenance process



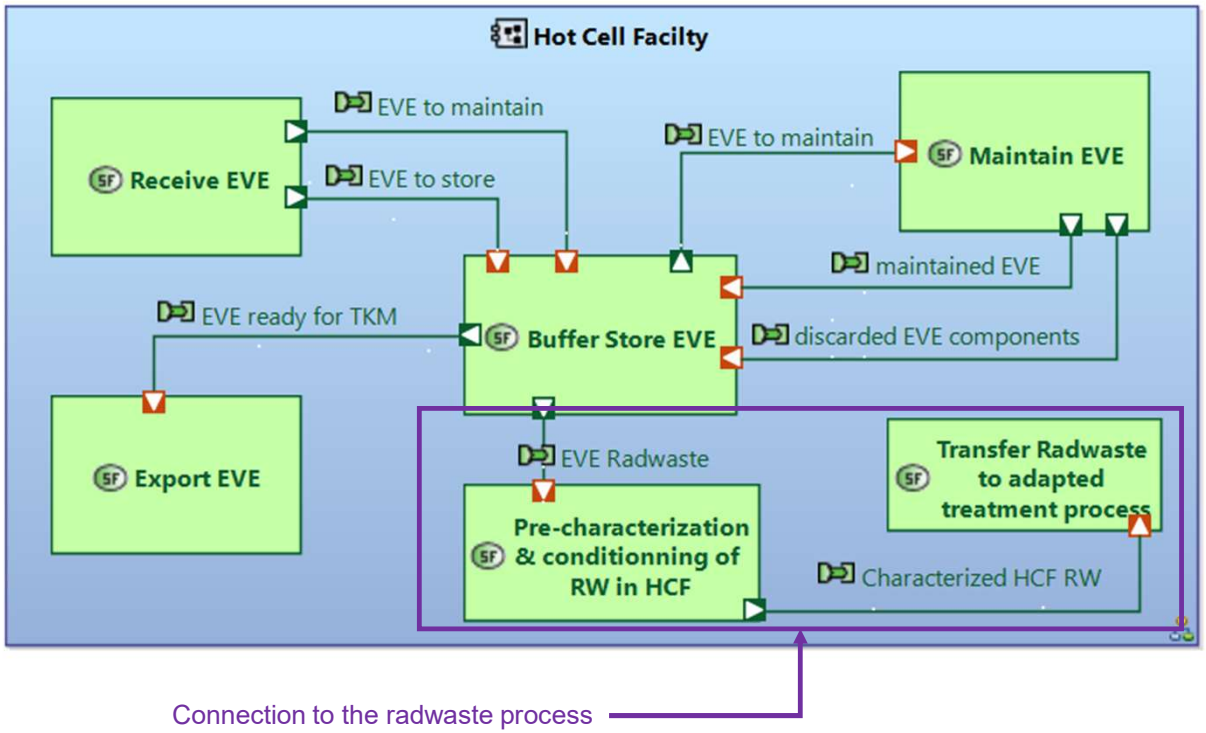



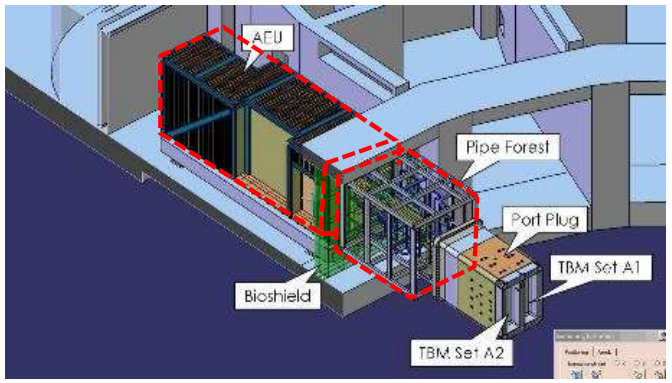

IVC: In-Vessel-Component
HCF: Hot Cell Facility
PP: Port Plug

# Functional breakdown

## Ex-Vessel-Equipment

EVE: Ex-Vessel-Equipment
HCF: Hot Cell Facility
RW: Radwaste

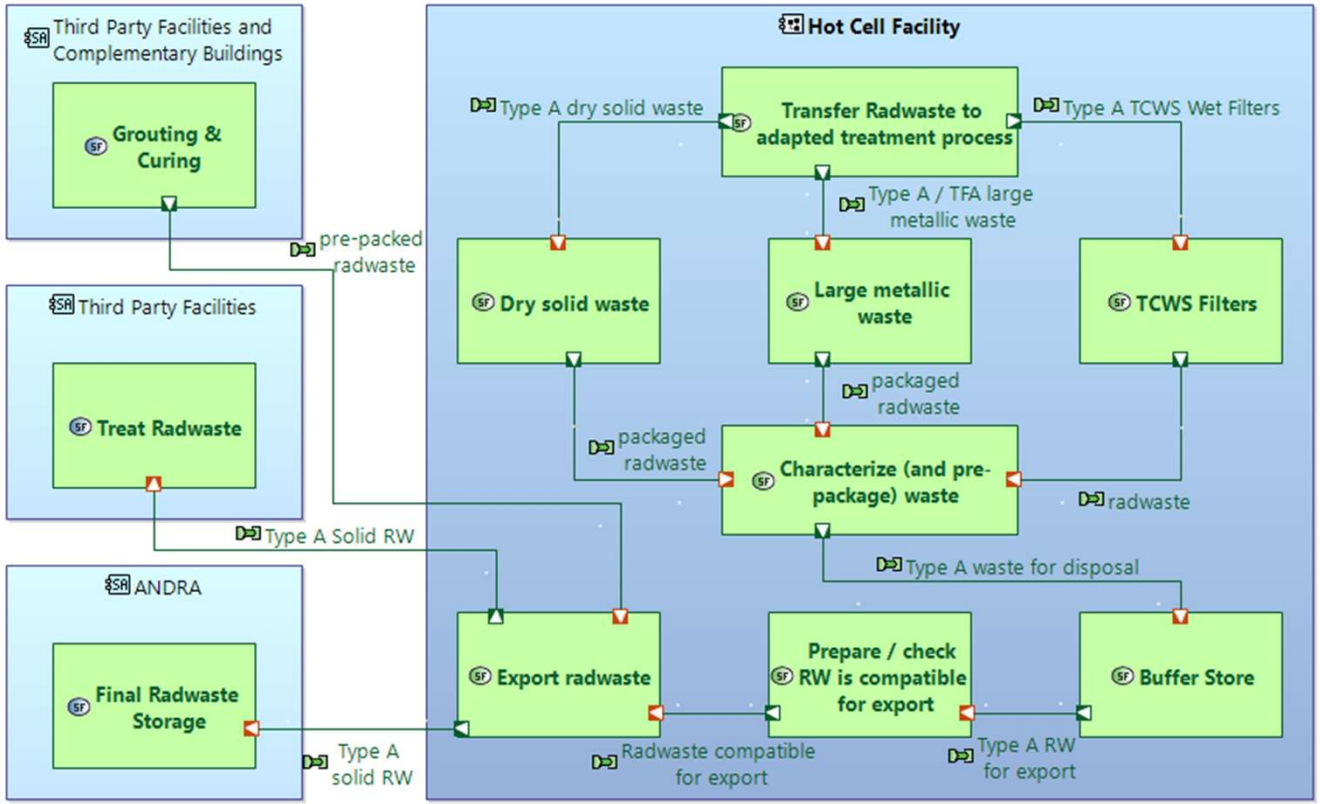


# Functional breakdown

## Type A solid Radwaste (RW)

ANDRA: French Final Radwaste repository
RW: Radwaste
TCWS: Tokamak Cooling Water System
Type A RW: Low level waste (FMAVC in French)



# Hot Cell Facility General Arrangement

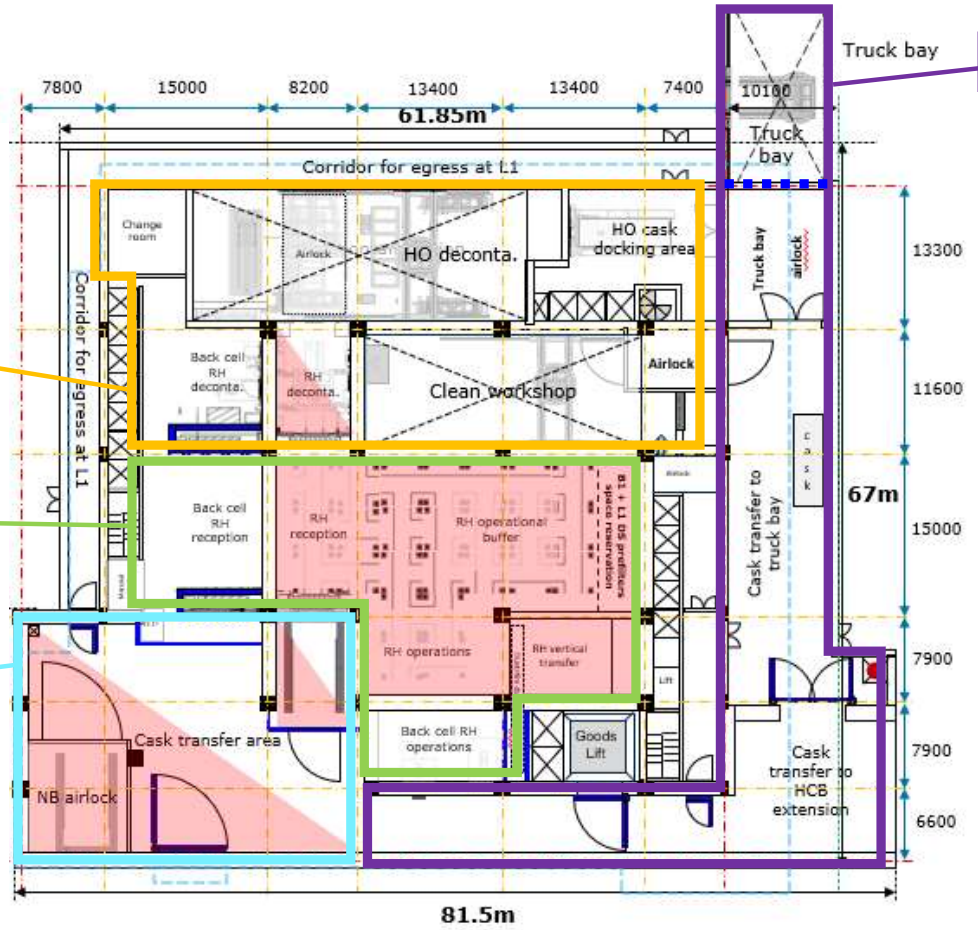
- **Level L1:**

Pre-concept

**IRMS workshop decontamination / reconfiguration**

**Hot Cell Remote Handling areas**

**Cask transfer area** (*)




**Import / Export and transfer**

1x10m scale

North

Shaft

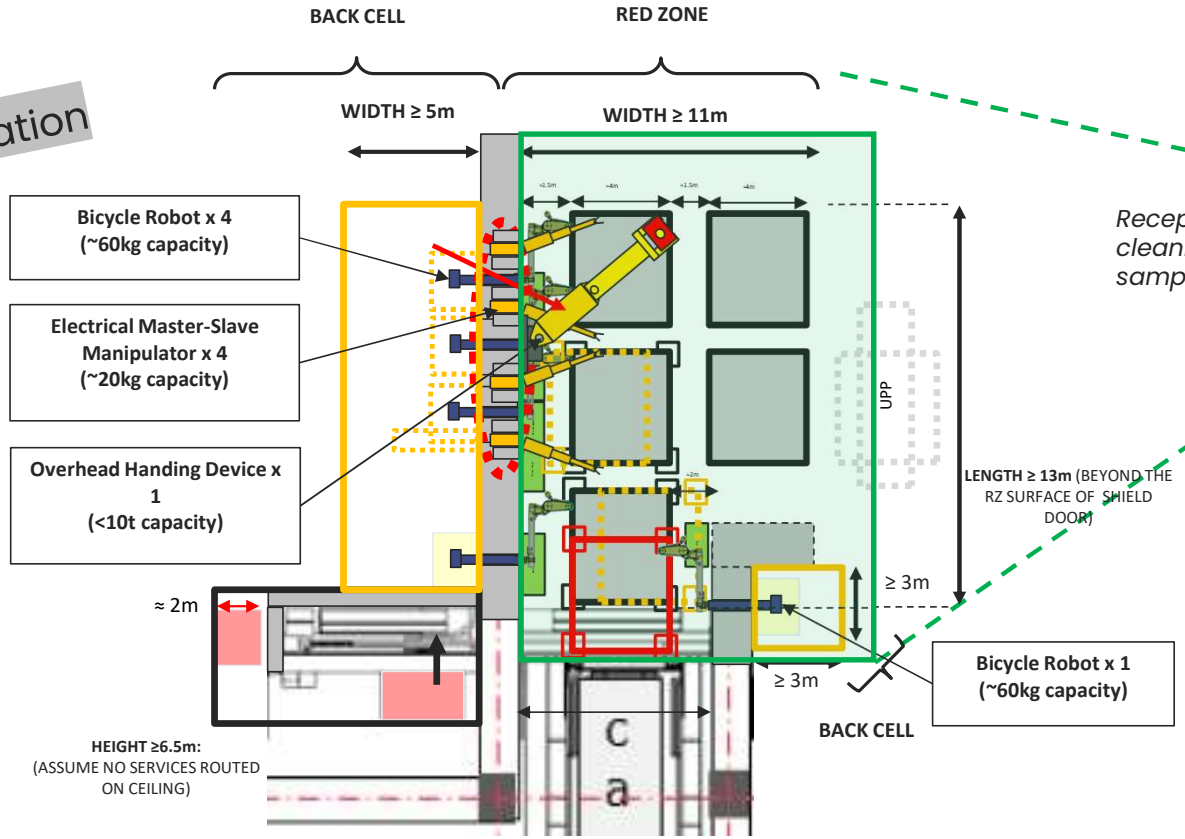
Double height (e.g. for crane)

Excavation limits

(*) Remote Handling Cask = Existing Procurement Arrangement

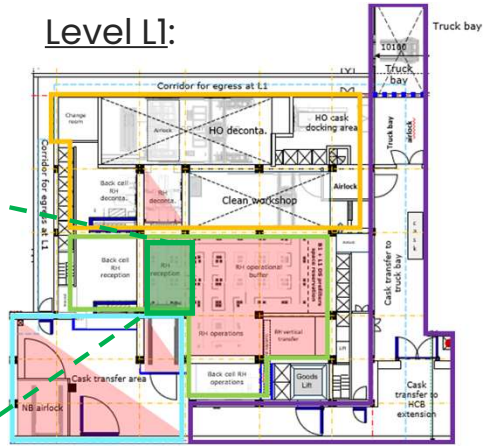
# RH Operation area on Port Plugs – red zone

Illustration




*Reception, cleaning, sampling*

Level L1:

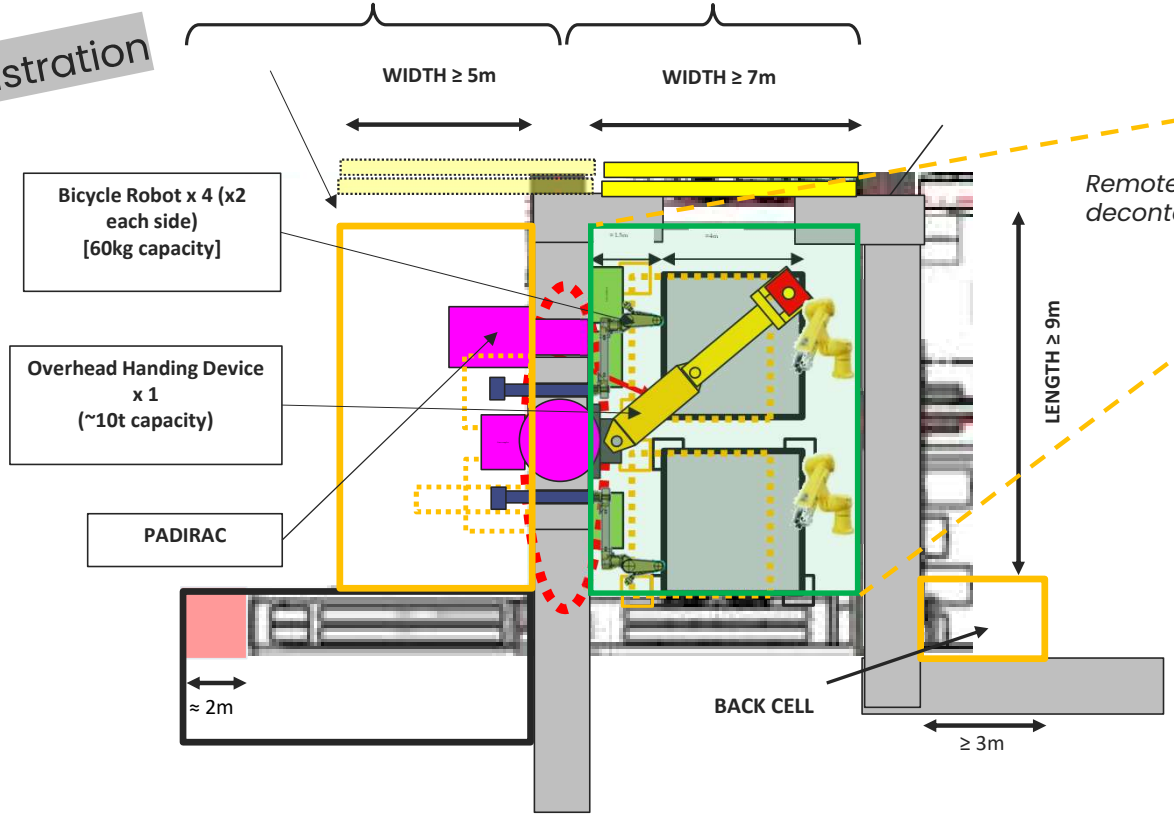



**Primary functions:**

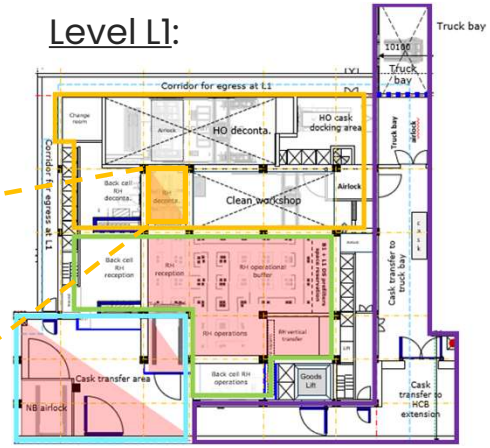
- Reception (from cask) and loading (to cask) of all IVCs / IRMS, the radiological hazard associated with which necessitates full remote handling.
- Cleaning, sampling
- Exchange / configuration of IRMS end-effectors

# RH decontamination area – red zone

Illustration




*Remote decontamination*




**Primary Functions include:**

- Import of tools, end effectors, new IVCs, frames, adapters, flasks, canisters etc.
- Remote decontamination
- Export of PIE samples
- TBM loading in Nuclear Shipping Flask

# Hands-on decontamination area

Illustration

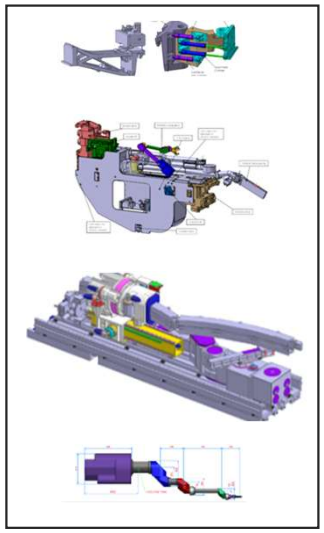
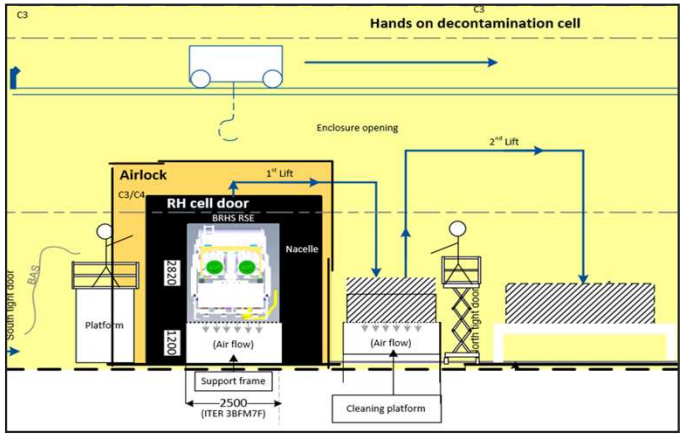
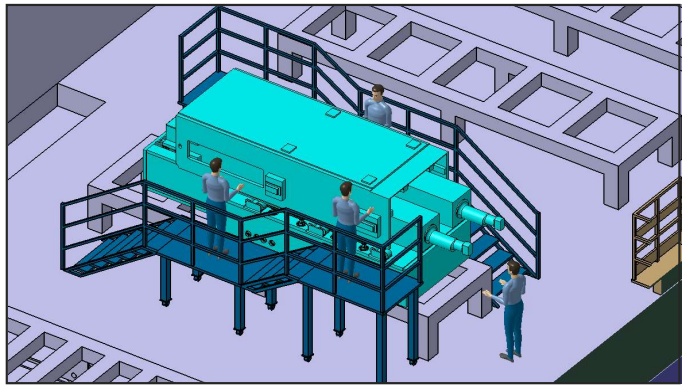


*Illustration of IRMS*



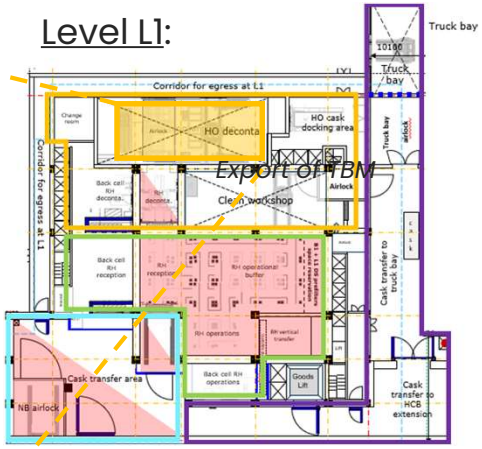

*Hot workshop*



*Accessibility to IRMS*

*Hands-on decontamination of ITER Remote Handling System (IRMS)*

Level L1:



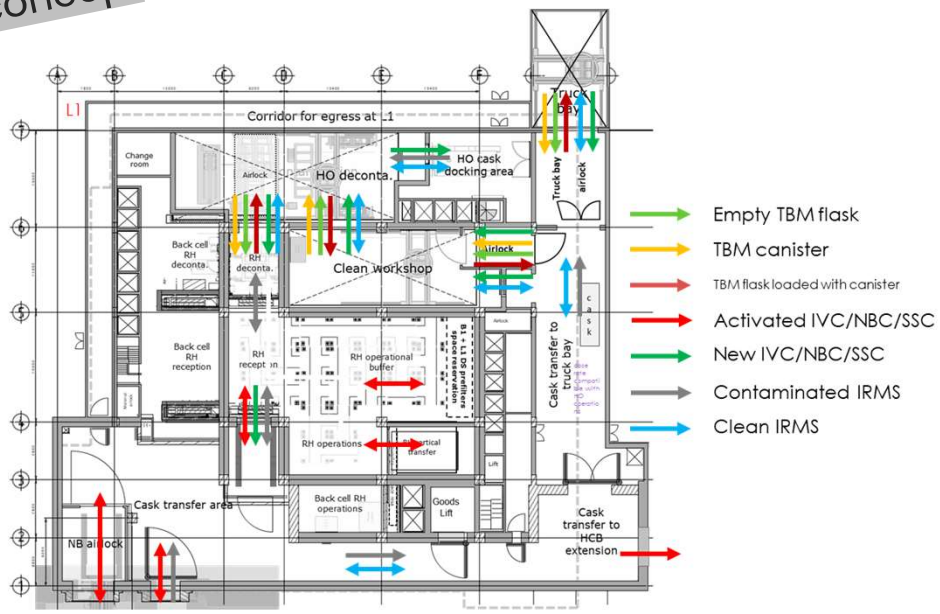

**Primary Functions include:**

- Hands-on decontamination
- Export of IRMS
- Export of TBM Nuclear Shipping Flask

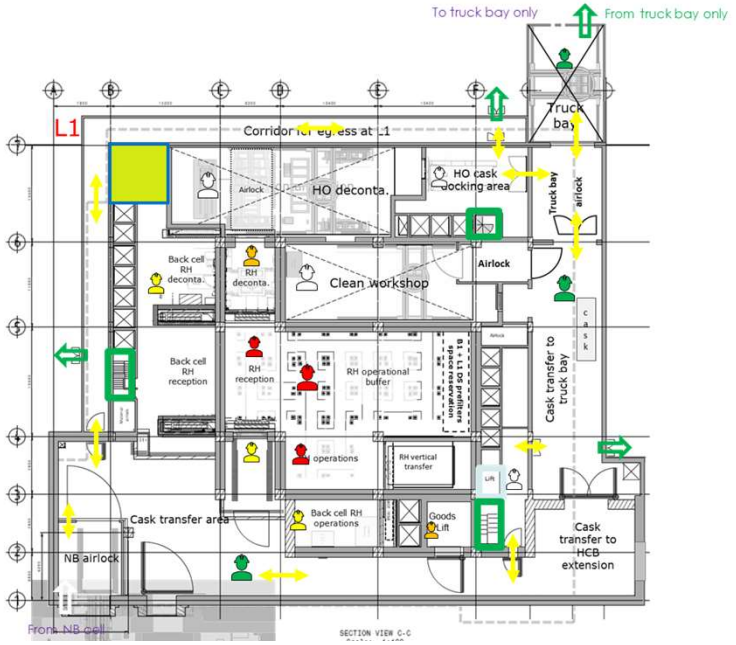
# Equipment pathway / Man access

Illustration at Level L1:

Pre-concept




*Equipment pathway*




*Man access*

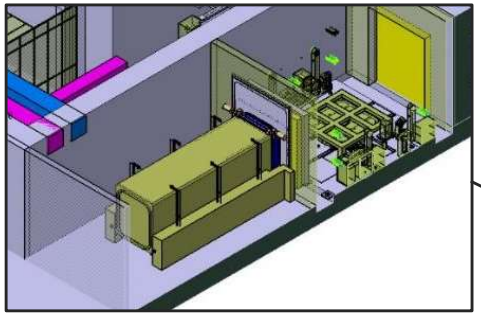
# Import / Export

Illustration

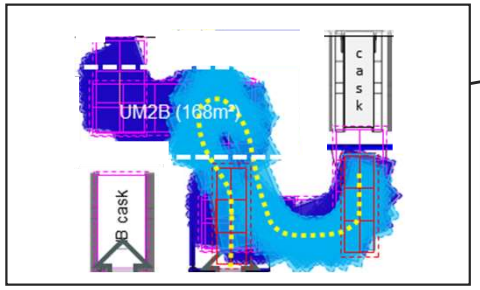
Padirac type transfer

Transport

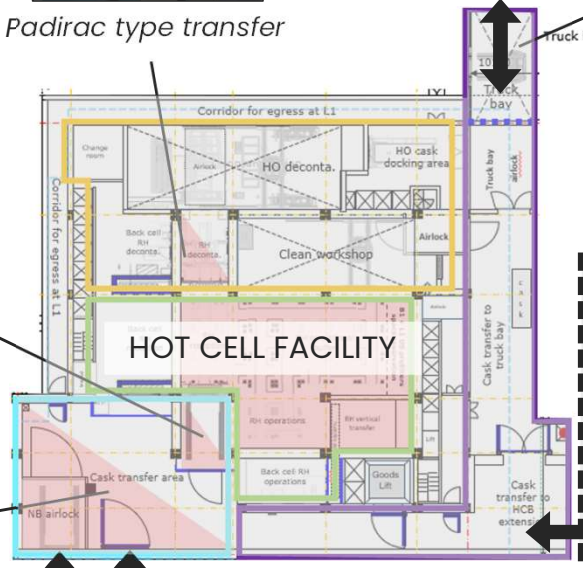
Illustration of Import / Export area



RH Cask docking




RH Cask (*) trajectories




HOT CELL FACILITY

Space reservation for potential EXTENSION HOT CELL FACILITY

Link to Space reservation HCB Extension

Link to Tokamak NB Cell

Link to Tokamak Cargo Lift

TOKAMAK COMPLEX

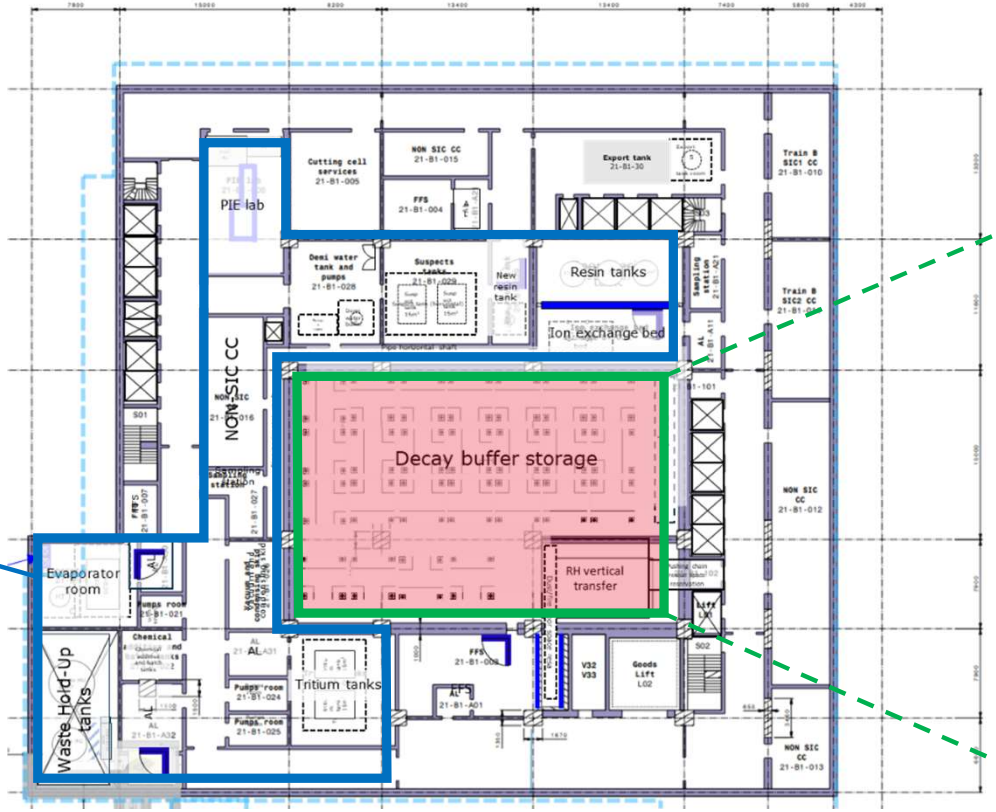
(*) Remote Handling Cask = Existing Procurement Arrangement

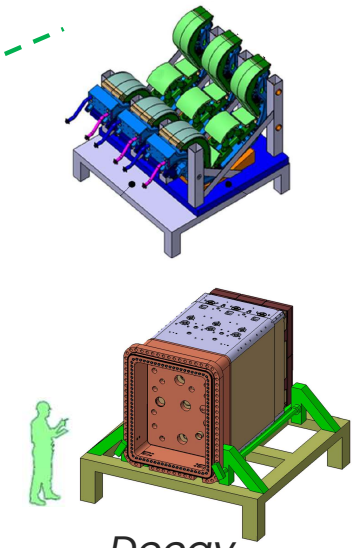
# Hot Cell Facility General Arrangement

- **Level B1:**

Pre-concept

Liquid Radwaste process (B1 level)



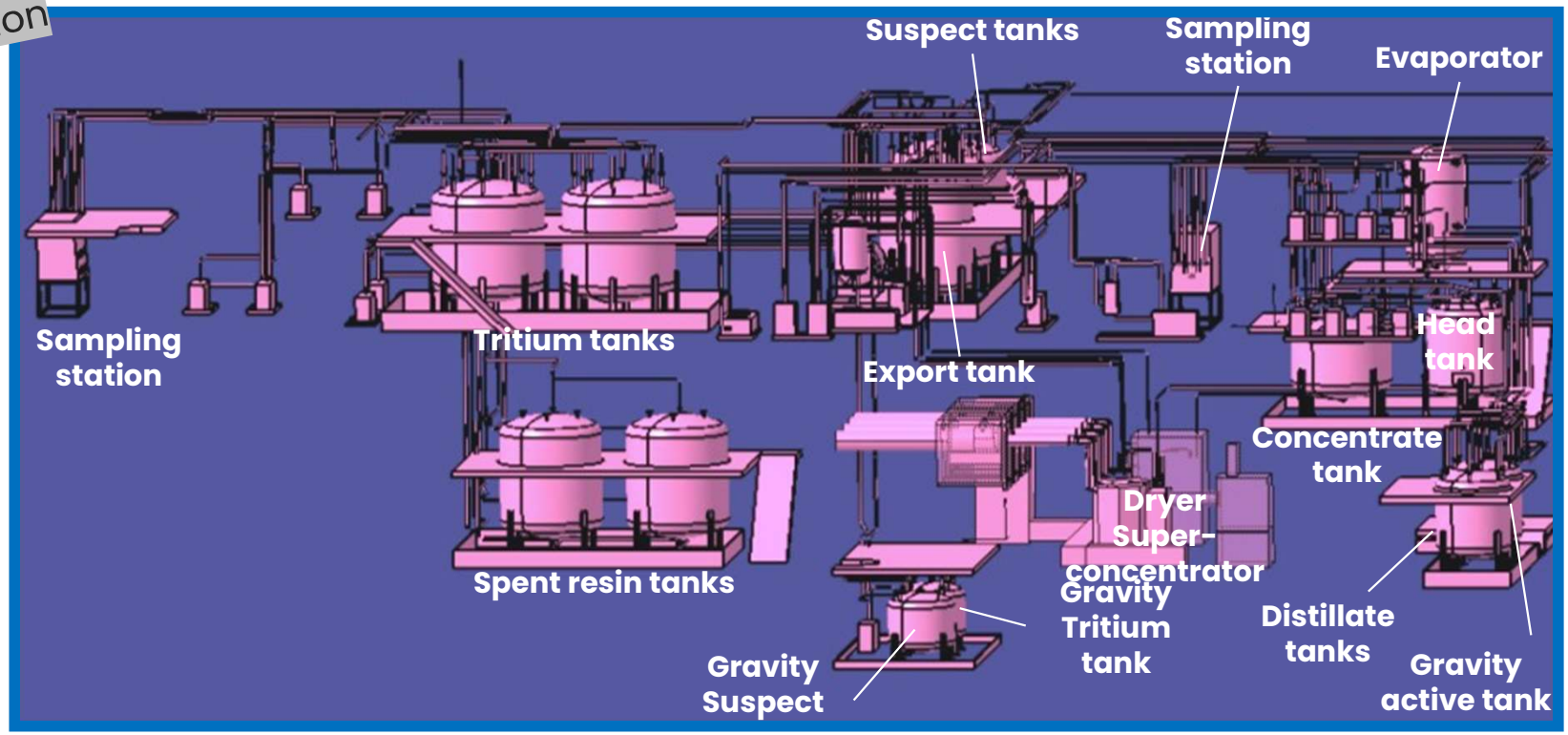



*Decay buffer storage*

# Liquid Radwaste process

Liquid radwaste coming from Tokamak Cooling Water System, Local Air Coolers, Resins, etc to be buffer stored / treated / exported

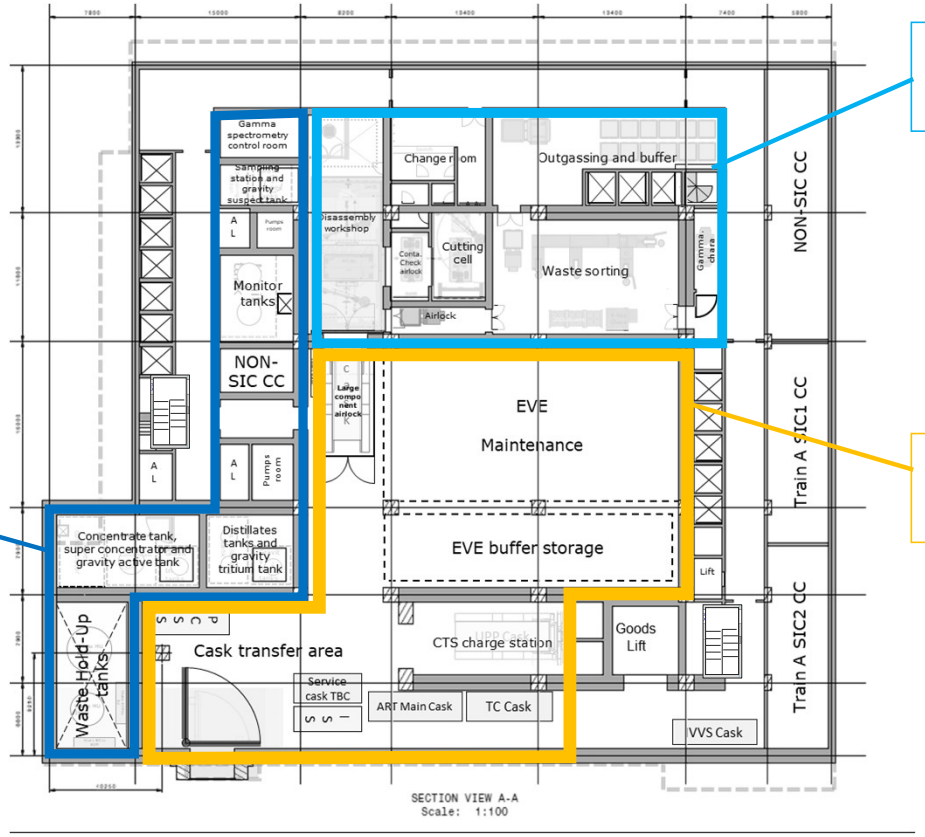
Illustration



# Hot Cell Facility General Arrangement

- **Level B2:**

Pre-concept




Solid Radwaste management

Liquid Radwaste process (B2 level)

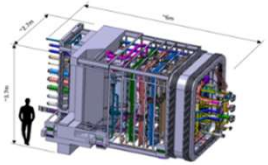
Maintenance Port Cell Equipment

# Solid Radwaste management

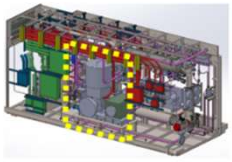
Illustration

Torus Cryopump maintenance

Pipe Forest radwaste pre-disassembly



PIS Cask - Mikuni Pump replacement



VVPSS RDA/BVA radwaste treatment

Disassembly Workshop:

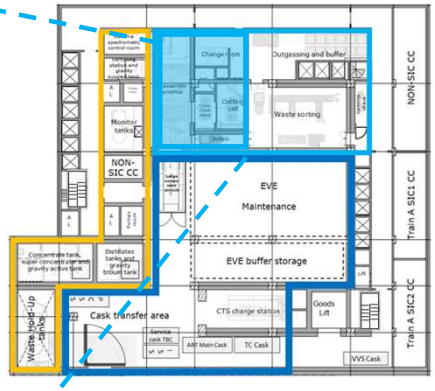
- Local Detritiation System extraction
- Flexible handling devices
- Tight headroom for Pipe Forest

Cutting Cell:

- Radwaste compatible with 5m3 containers
- 5m3 container filling optimization
- Flexible handling means
- Use of dustless, local, flexible cutting tools
- Semi-remote cutting for operator dose reduction

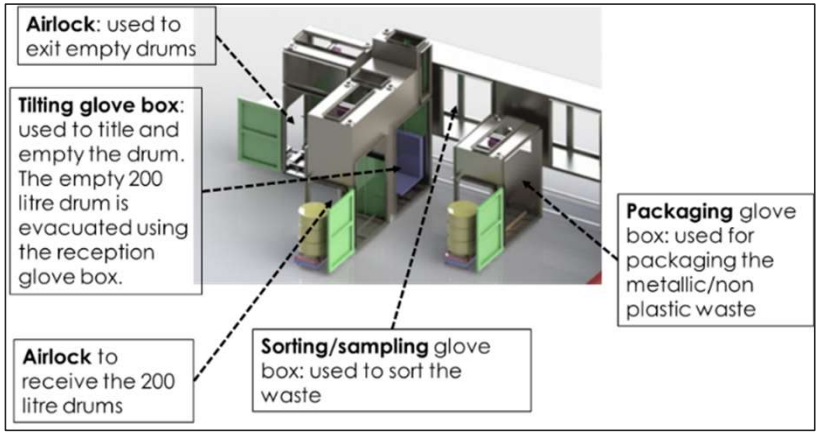

Level B2:

*Large cutting unit*



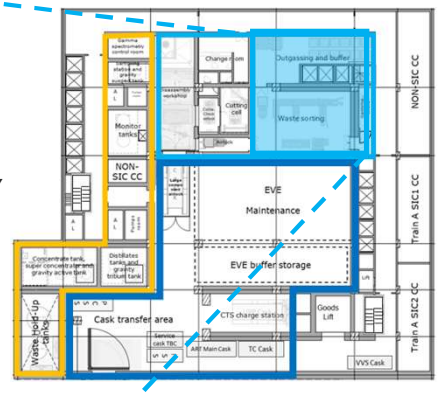
# Solid Radwaste management

Illustration



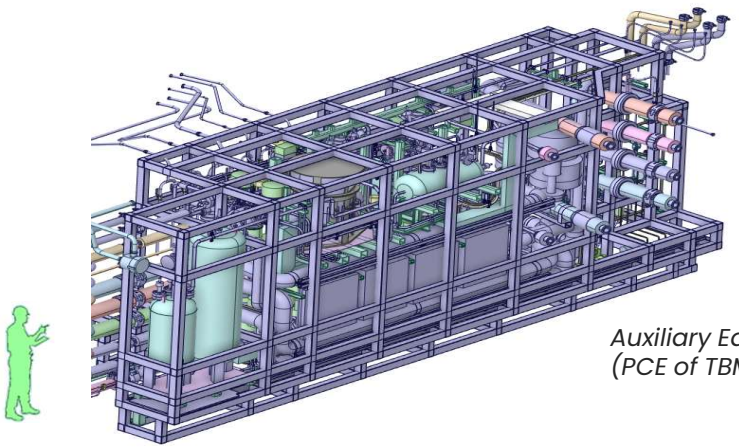

Level B2:

*Solid Radwaste Sorting, packaging, buffer storage, Tritium outgassing measurement*

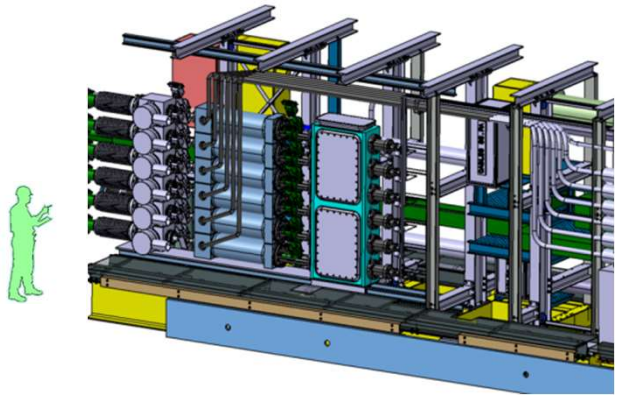


# Maintenance Port Cell Equipment

Illustration

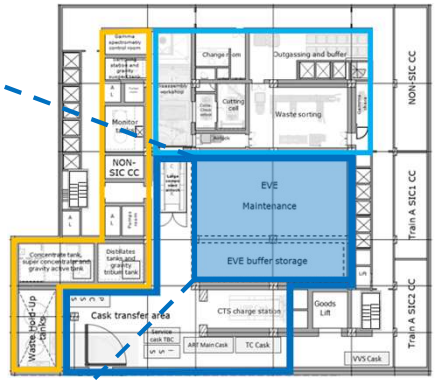


*Auxiliary Equipment Unit (PCE of TBM System)*



*Interspace Support Structure Diagnostic*

Level B2:

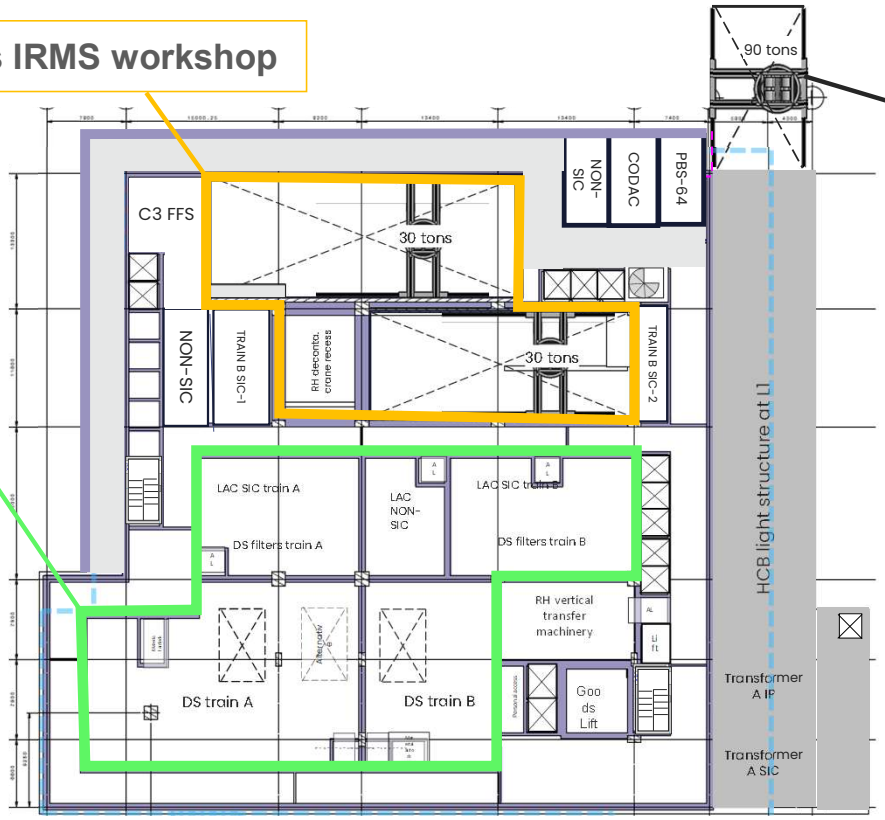


# Hot Cell Facility General Arrangement

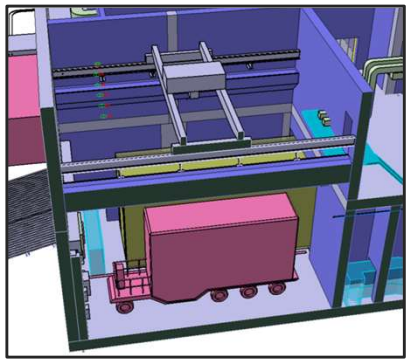
- **Level L2:**

Pre-concept

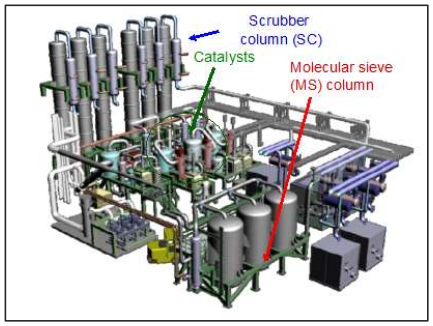
Cranes IRMS workshop




Crane Truck Bay



Local Air Coolers Air Detritiation System (*)



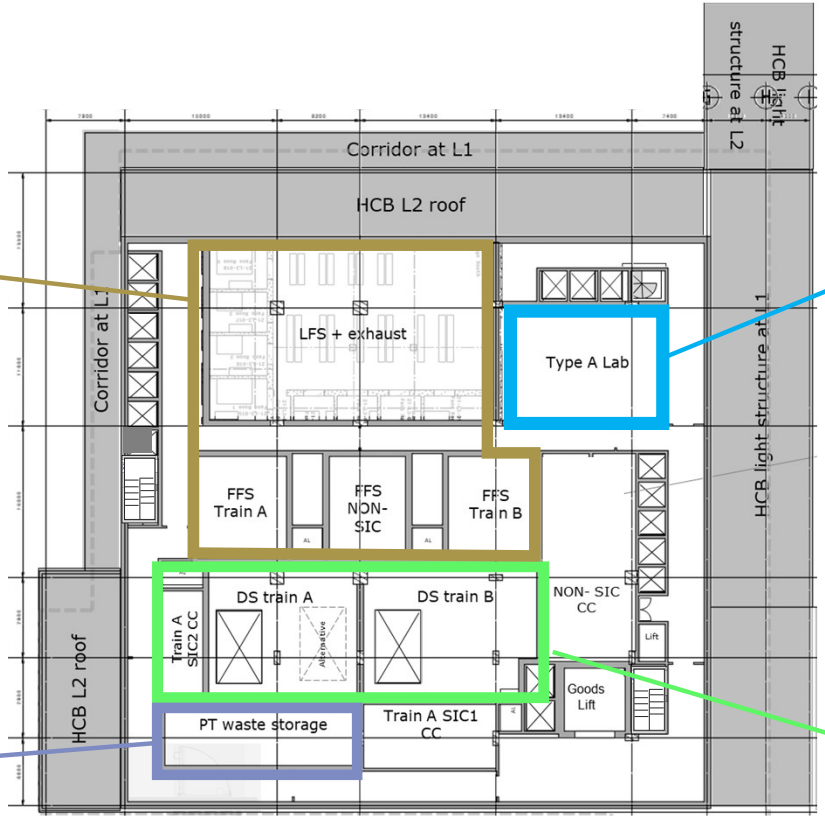

(*) Air detritiation System = Existing Procurement Arrangement

# Hot Cell Facility General Arrangement

- **Level L3:**

Pre-concept

HVAC System




Radwaste laboratory

Storage of Tritiated Radwaste

Local Air Coolers Air Detritiation System (*)

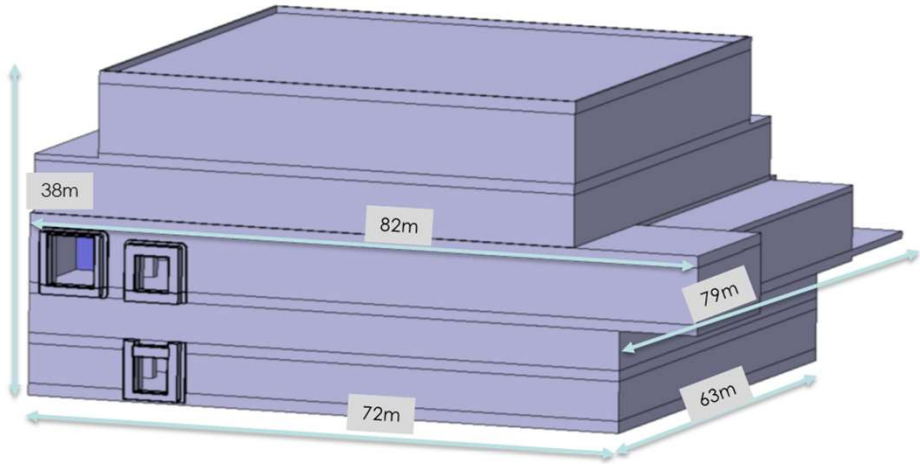
(*) Air detritiation System = Existing Procurement Arrangement

# 3. Scope and interfaces

Of the Hot Cell Facility

# Few figures of the HCF pre-concept

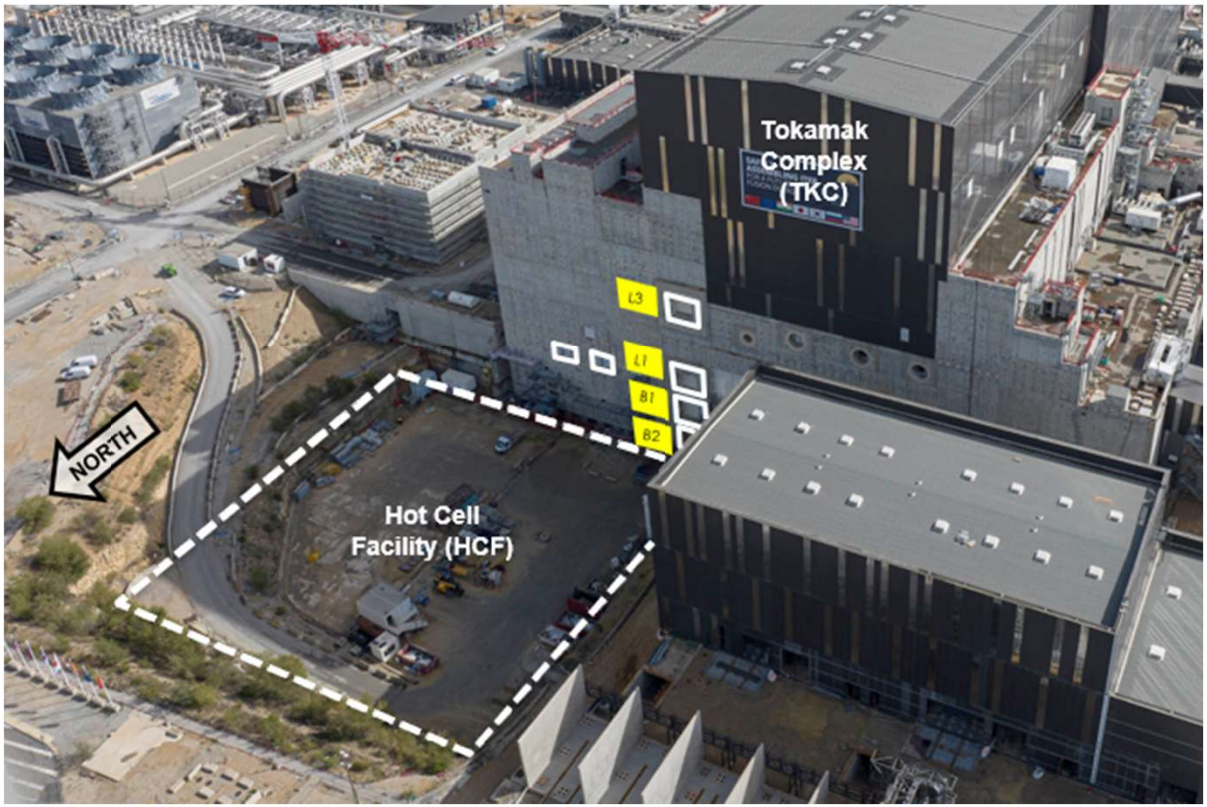
- Total Net **Surface 16,000 m²**
  (including 1,600 m² C4 Red Zone)
- Building Total Net **Volume 100,000 m³**
- Total **Concrete Volume 40,000 m³**
- Total **Stainless Steel Liner Surface 4,500 m²**
- **90t crane** in the import/export
- **Two 30t crane** in the decontamination workshop
- Trolley for **60t load transfer** in red zones
- **14 Large Nuclear Doors** (between 5 and 18m² each)



Pre-concept

# Site interface

- **Tokamak Cargo Lift** (B2, B1, L1 and L3)
- **NB Cell access** (L1)
- **Drain tank room connection** (B2/B1)
- **DS connection** (B1)
- Utilities – Ex:
  - **Road L1** (import/export)
  - **Liquid and Gas** (Underground galleries)
  - **Electrical galleries**
  - **Effluents**

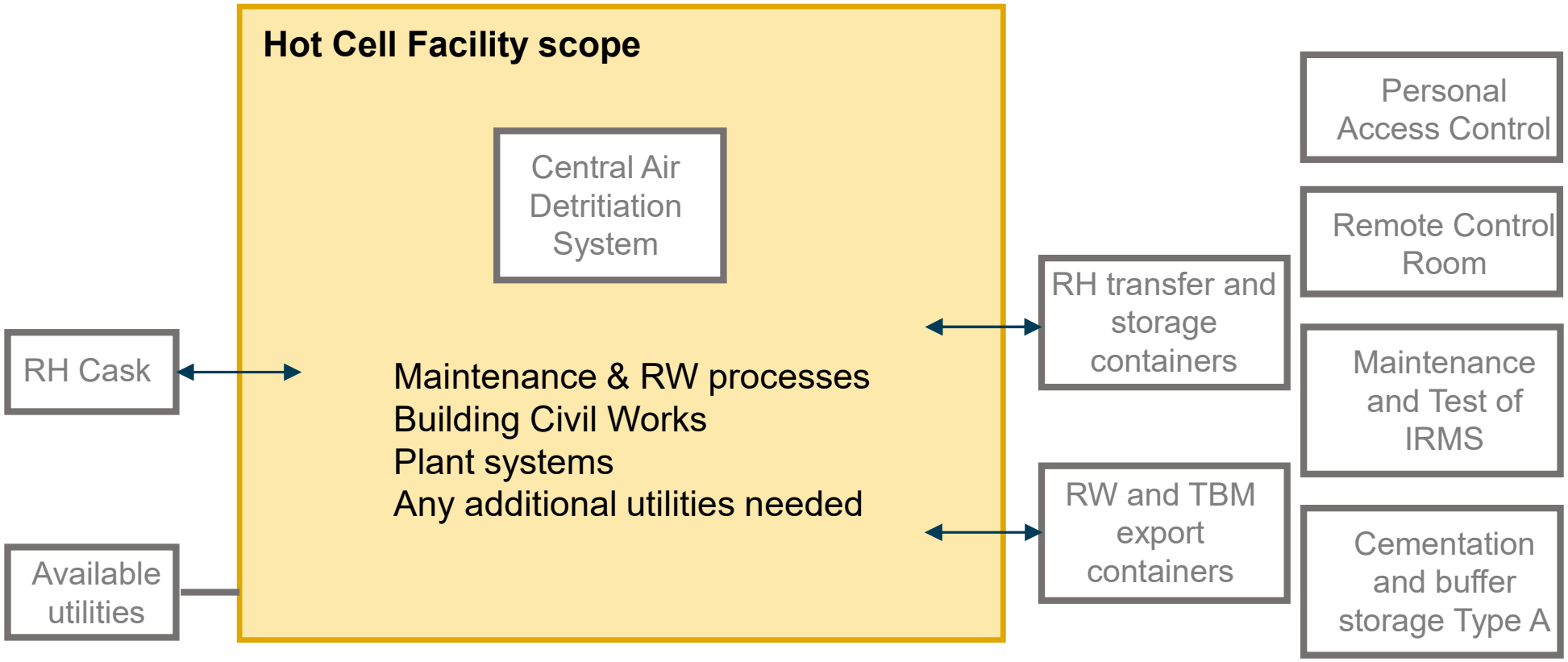


# Hot Cell Facility scope & main interfaces

## High-level visual of the HCF scope

*In grey = out of scope*

RH: Remote Handling
RW: Radwaste
TBM: Test Blanket Module



# Hot Cell Facility scope & main interfaces

## High-level HCF scope

### HCF

| | |
|---|---|
| Processes (maintenance, radwaste) | For the processes:<br>- Remote handling maintenance (PBS 23.06):<br>• In-Vessel-Components maintenance (*except for the control room which is out of scope*)<br>• IRMS: decontamination processes (*IRMS maintenance and control room are out of scope*)<br>- Integration of Ex-Vessel-Equipment maintenance (PBS 62)<br>- Radwaste management (PBS 66)<br>• Type A solid RW: treatment (*except for the cementation and buffer storage before export out of ITER site out of scope*)<br>• Liquid RW treatment and storage<br>• TFA: only reception, characterization and export (*treatment and storage out of scope*) |
| Building (civil works & mechanical systems) | Building 21 and associated platform:<br>- Hot Cell Building (HCB) civil works (PBS 62.21)<br>- Hot Cell Building mechanical systems (doors, handling and lifting means, liner…) (PBS 62.21)<br>- Site integration (PBS 61) |

*Note: the transport containers/flasks are out of scope*

# Hot Cell Facility scope & main interfaces

## High-level HCF scope

**HCF**

HCF Support Systems (cooling water, I&C, Electrical, LGAS, HVAC & LAC)

For the support systems:

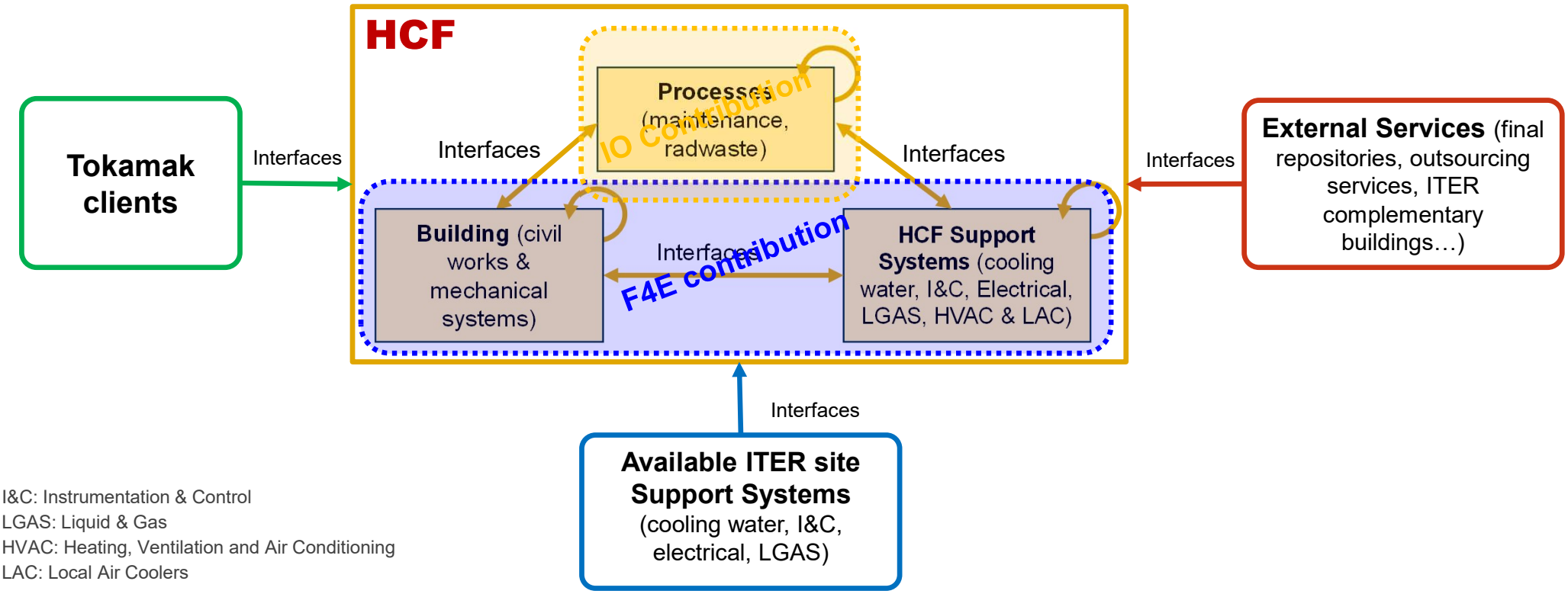
- HVAC & LAC, Drainage, Electrical distribution, Instrumentation & Control (I&C), Fire detection & suppression systems within the HCF (PBS 62)
- Air Detritiation System (ADS): *central unit systems out of scope* but major interface. Network distribution of ADS within HCF in the scope (PBS 32)
- Cask & Plug Remote Handling System (CPRHS): *out of scope* but major interface (PBS 23.03)
- Liquid & Gas (LGAS), Power Supply: network distribution within HCF in the scope and major interface with ITER site production units (PBS 65, PBS 43)
- Chilled Water System (CHWS) H1 and H2: in scope including the distribution within HCF (PBS 26)
- Cable Trays including the cables routing and pulling/termination for all systems is in the scope (PBS 44)
- CODAC, Central Interlock System & Central Safety System: integration of the common network architecture up to the cubicles in HCF. Cubicles and network from the cubicles up to the HCF systems in the scope (PBS 45, PBS 46 & PBS 48)
- Access Control: Doors, Camera, sensors, security access in scope and major interface (PBS 69)

CODAC: Control, Data Access and Communication
HVAC: Heating, Ventilation and Air Conditioning
LAC: Local Air Coolers

# 4. Perspectives

# Hot Cell Facility contract scope

- Overview of the Hot Cell Facility (HCF) and its main external and internal interfaces
- HCF is an integration of IO contribution & F4E contribution




I&C: Instrumentation & Control
LGAS: Liquid & Gas
HVAC: Heating, Ventilation and Air Conditioning
LAC: Local Air Coolers

# Procurement strategy

- **One procurement procedure for all trades, from early design phases.**

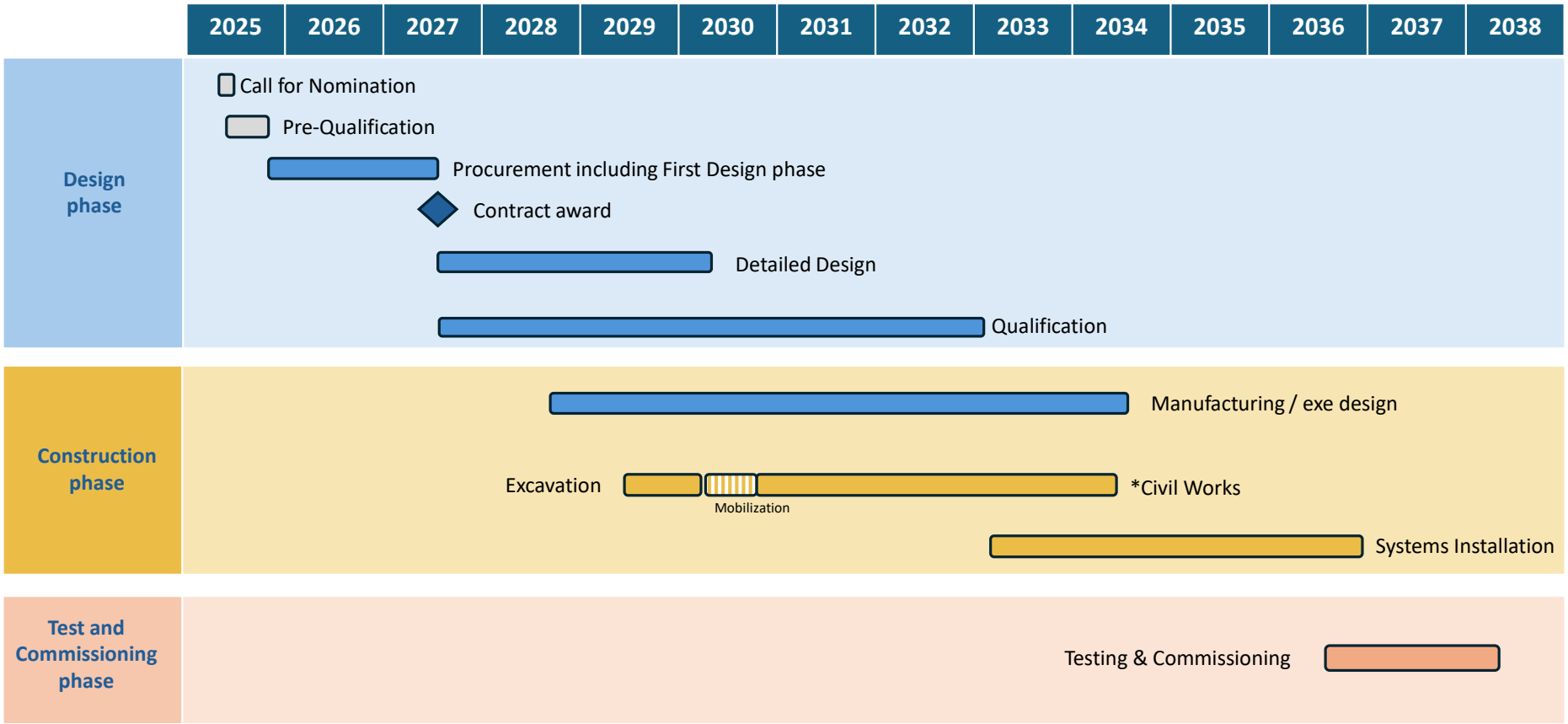
Drivers:

- ✓ To get the early involvement of industry stakeholders,
  Benefit of construction companies' constructability and feasibility feedback in design phases.
- ✓ To select industry stakeholders through a gradual selection among several competitors,
  Technical and commercial competition.
- ✓ To implement a design to cost approach,
  Respecting a cap cost objective.

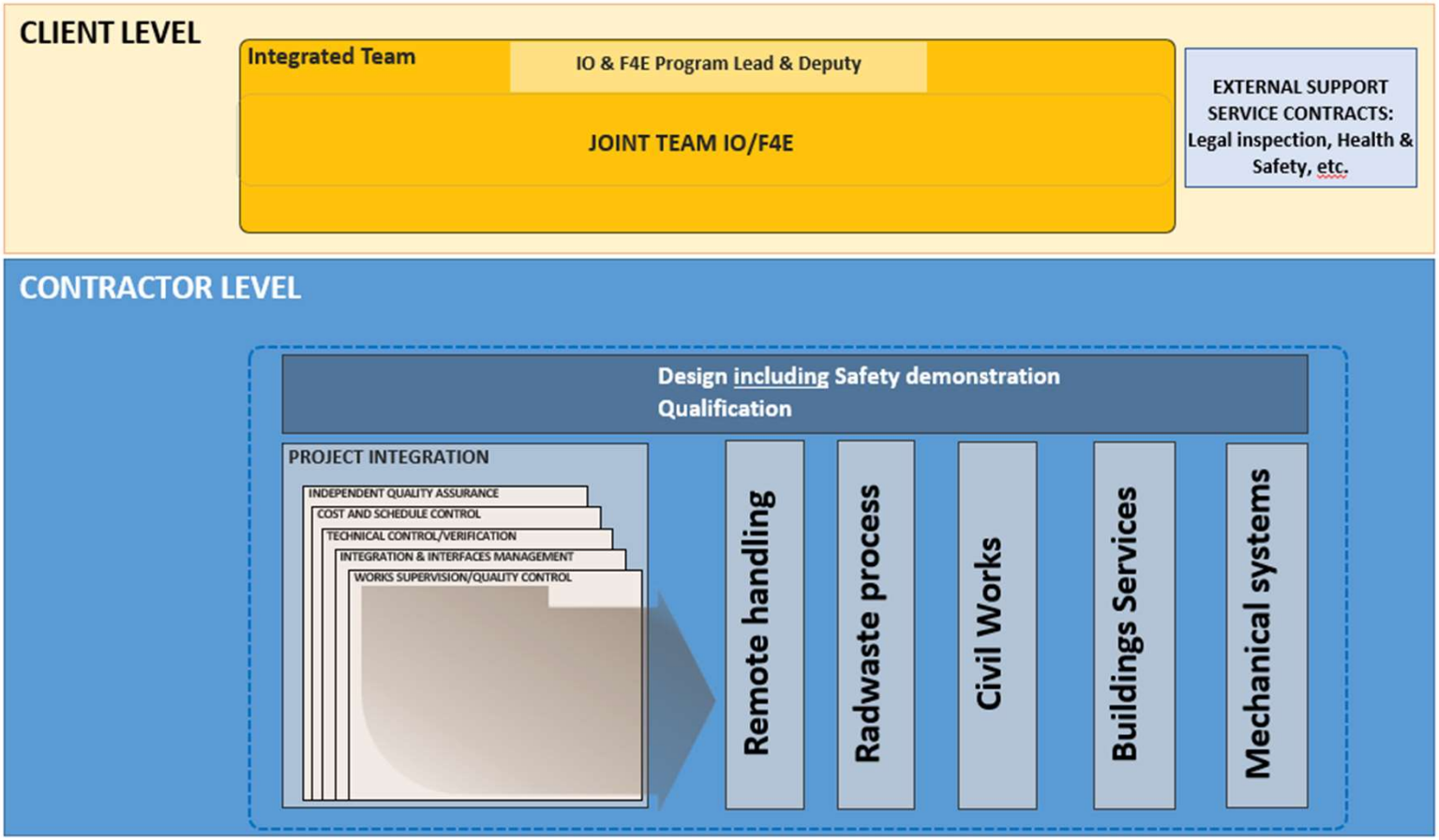
# Lessons Learnt have been considered

- Facility approach
- Rationalized requirements
- Frozen input data
- Cost effective engineering process, Concurrent engineering for process systems and buildings
- Integrated team IO/F4E managing jointly the scope with a “facility approach”

# HCF high level schedule



# Organization



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# THANKS

**TO BE PART** OF THE WORLDWIDE **FUSION** NETWORK

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