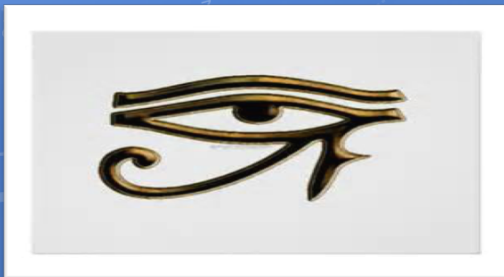


# 'NEEDS AND EMERGENCY TECHNOLOGIES FOR DECOMMISSIONING'

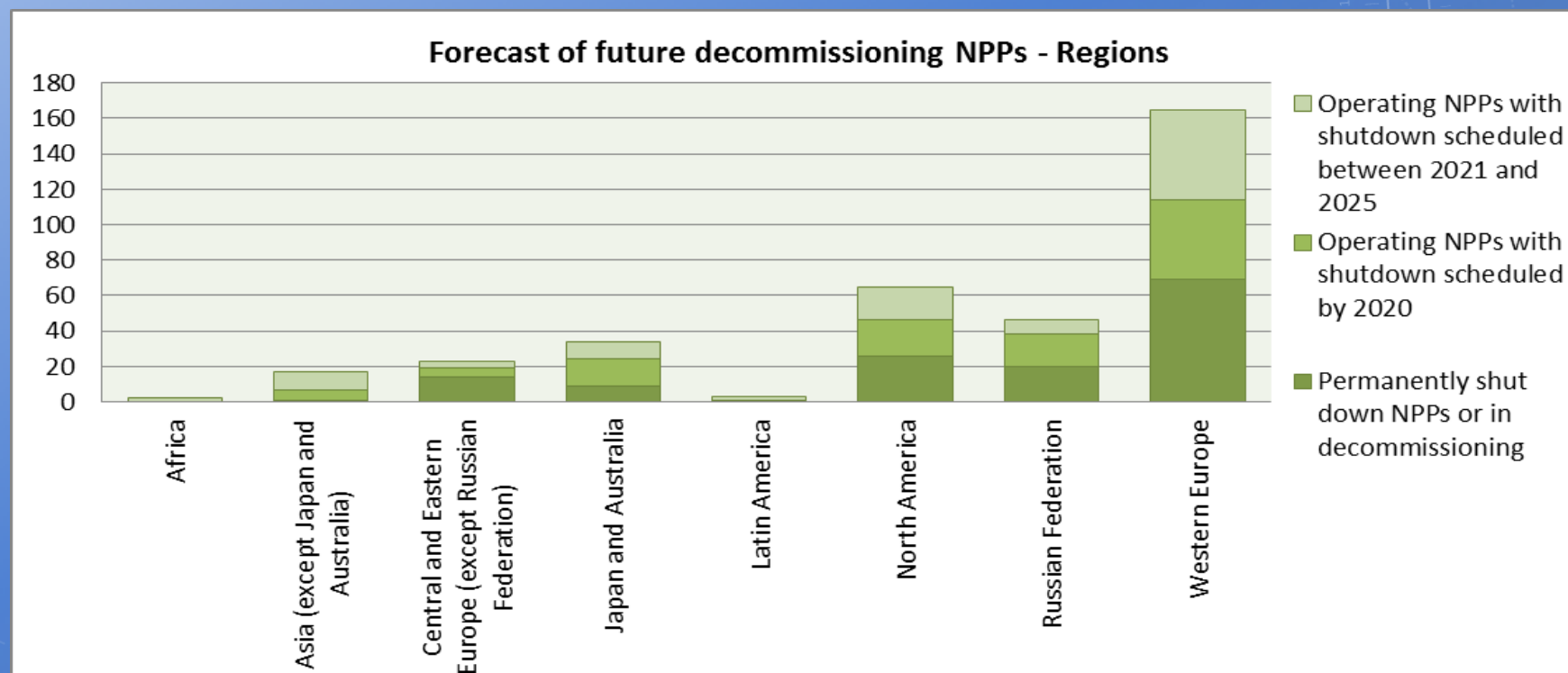
## SESSION 3

GÉRARD LAURENT - IN SOLUTIONS



Current and Emerging Methods for  
Optimising Safety and Efficiency in Nuclear  
Decommissioning'  
7th-9th February 2017, Norway

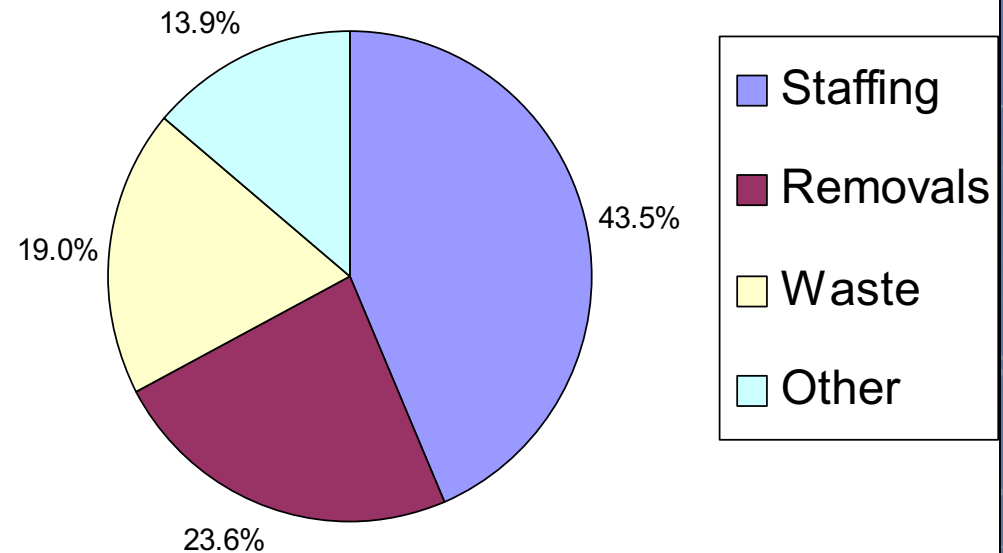
# FUTURE DECOMMISSIONING NPPs



# ORIGINS OF D&D COSTS

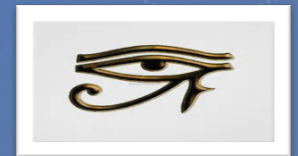
- In front of this huge market with feeds already existing (at least partially) :
- May be an '*El Dorado*'?
- Seems very important to manage safety, time, environment and money

**Cost Categories as a % of Total Cost**



# STATUS OF D&D TECHNOLOGIES NATIONAL ACADEMY OF SCIENCE

- *D&D : 'yes we can' BUT...*
- Current technologies are :
  - labor intensive and time consuming,
  - require hands-on contact by workers while wearing bulky protective clothing,
  - operate powerful equipment (e.g. plasma torches, saws, and lifting devices)
- The facilities present hazards to workers :
  - penetrating irradiative areas, airborne contamination,
  - toxic chemicals, and other industrial hazards. (NRC, 2001)
- Main goal for R&D: **save time and increase safety**





# FOCUS, MEANS

## FOCUS

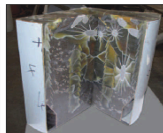
- analysis of R&D needs for decommissioning,
- assign broad priorities,
- define relevant R&D projects for international and jointly funded basis.

## SUPPORT

- Membership : EDF, US NRC, NDA, CEA, Studsvik AB, ENRESA, SOGIN, US DOE, JAPC,
- identify examples of current research program (ie DOE, CEA, NDA etc...) and prioritise future R&D.

Radioactive Waste Management  
2014

## **R&D and Innovation Needs for Decommissioning Nuclear Facilities**



A report of 300 pages  
and more than 700  
references

# THE R&D NEEDS REPORT

- R&D tasks subdivided into five themes :
  - characterisation and survey prior to dismantling,
  - technologies for segmentation and dismantling,
  - technologies for decontamination and remediation,
  - materials and waste management,
  - site characterisation and environmental monitoring.

# SOME UPDATE TO THIS REPORT

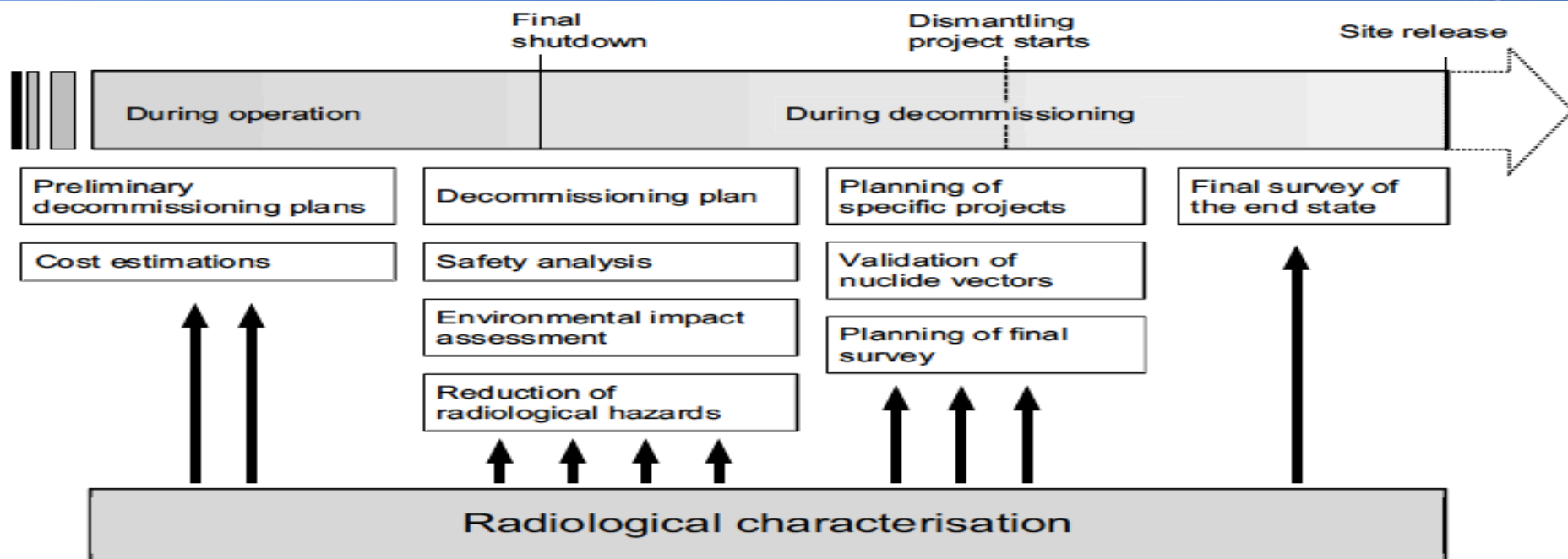
- Japan TEPCO: *'Mid and long term roadmap for Fukushima'*,
- And some others...
  - Norway: *'Decommissioning R&D within the OECD reactor Halden project (Institute for Energy Technology)'*,
  - Japan: *'Technology under development for decommissioning in JAEA'*,
  - Korea: *'Current status of R&D activities on DD&R in KAERI'*
  - *Etc...*
- Update of the R&D program for DOE, CEA, NDA etc...
- Try to identify: **'7 challenges' with '2 tags'**
  - *Needs for normal D&D versus FD quite similar*
  - *Existing technologies from non nuclear areas*

## THE 'SEVEN CHALLENGES'

- (1) Predemo characterisation,
- (2) Use of remote sensing and satellite,
- (3) Use of robotics,
- (4) Modeling mobile nuclides,
- (5) statistical modelling and sampling
- (6) prioritisation on waste management,
- (7) site remediation,

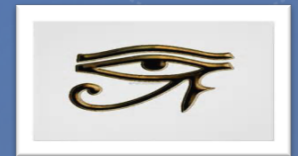
# CHALLENGE (1) : PREDEMO CHARACTERISATION 'THE KEY STONE'

- Objective
  - identify physical properties of system, structure, component (SSC)
  - identify radiological hazards of SSC: combination of historical informations and surveys,
  - material sampling and analysis.
- *Needs for normal D&D versus FD quite similar*



# RADIOLOGICAL CHARACTERISATION

- Modelling concrete characterisation at depth
  - Develop imaging technologies in concrete cracks and at depth
  - Detecting and imaging beta gamma and alpha by secondary emission and coupled with imaging to 'see' distributions in 3 dimensions (inc depth)
- Hard to detect RN (alpha pure beta) in solids with no dissolution
  - Using primary or secondary particles or photons emissions (ex PET for CL36)
  - Deploy and test mass spectrometry based systems to support D&D characterisation,





## Challenge (2) : Use remote sensing and satellite technologies

- in-situ deployable sensors for monitoring,
- wireless communications, 3D CAD, Pattern Recognition, and Data Sharing Technologies,
- network with autonomus and monitoring capabilities,
- field deployable platform with equipment and power supply,
- *Needs normal D&D versus FD quite similar*
- Existing technologies from non nuclear areas





## CHALLENGE (3) : USE OF ROBOTICS

- For works
  - re-usable, multi-fonctionnal and highly adaptable robots for various size/designs
  - integrate automated equipment and processes
- For samplings
  - for high radiation or hasardous environment
  - autonomus for awareness, navigation and sample collection
  - ex-situ and in-situ analysis
- Adapt existing technologies from non nuclear areas
- *Needs normal D&D versus FD quite similar*



# CHALLENGE (4) : MODELLING MOBILE NUCLIDES BEHAVIOUR ON SUBSTRATES



Set of measurements and mathematical interpretations to modelise RN interaction with waste forms

Evaluate chemical and physical mechanisms that influence RN behaviour,

Correlate with field measurements,

Understand basis of RN behaviour to support new development of

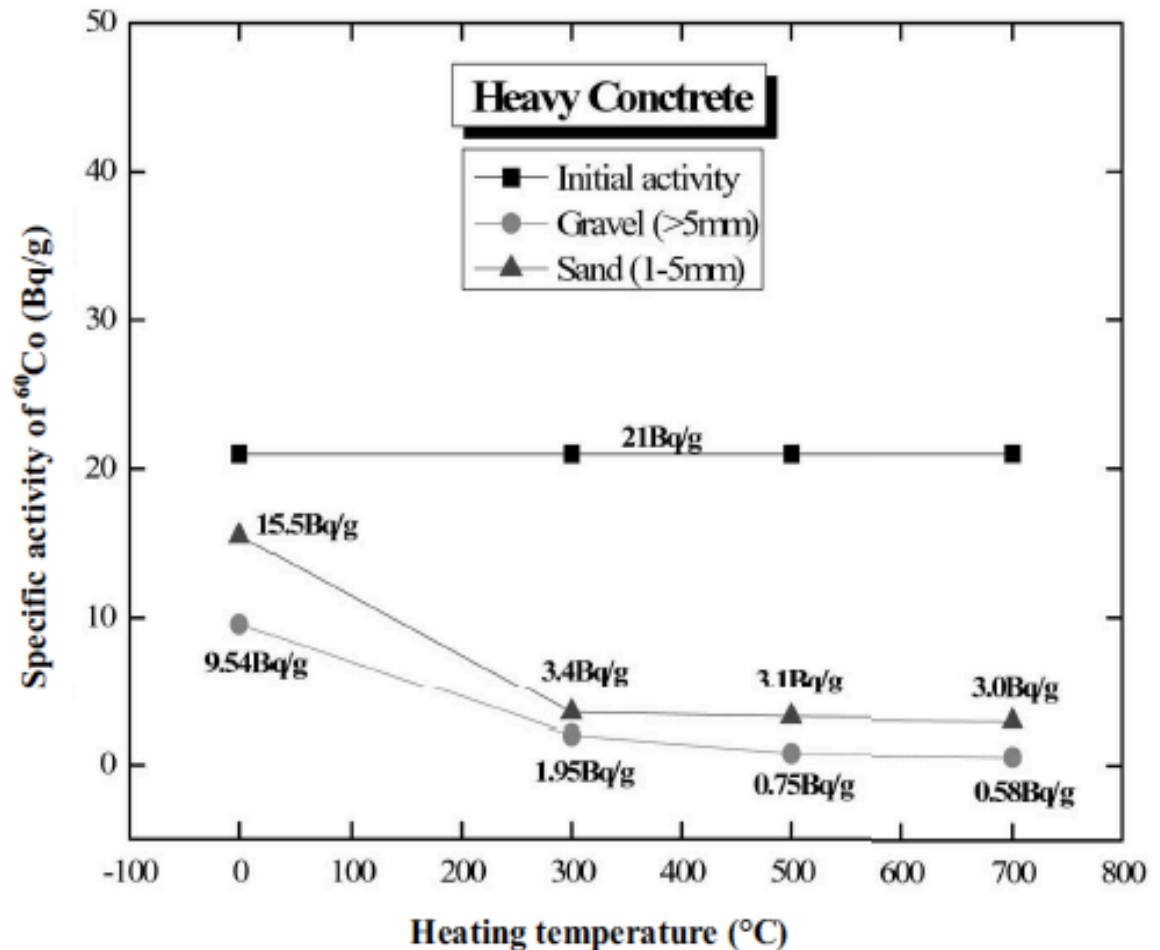
- new kind of decontamination,
- new approach for containment during interim storage or during disposal stay

# DECONTAMINATION

- Basic Research :
  - Chemical and physical interactions
    - contaminants vs primary materials (concrete, stainless steel, paints, strippable coatings)
    - Describe interactions, Improve decontamination
  - Biotechnological means : same items
- New physical and chemical processes for decontamination
  - Concrete, Graphite, Large components
- Surface treatment and removal of contamination
  - Using gels and foams
  - Washing and pressure techniques
  - Supercritical fluids
  - Laser process
  - Heels and residues
  - Fuel element debris (FED) dissolution

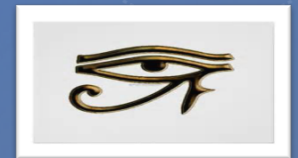
# CONCRETE REMEDATION

- Removal of surface, contaminated coating and embedded contamination
- Chemical washing, strippable coating couple with electrokinesis
- De-planting process : laser scabbling and nitrojetting



## CHALLENGE (5) : STATISTICAL MODELLING AND SAMPLING

- Develop geostatistical models to optimise characterisation of SSC, environment and activated materials
- Develop use of statistical models for survey and sampling protocols for land, materials, and buildings
- Reach good certainty with the least amount of scanning and sampling
- Adapt existing technologies from non nuclear areas

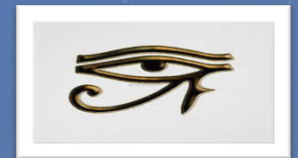


# CHALLENGE (6) : PRIORITISATION ON WASTE MANAGEMENT

- Management of problematic wastes – chemical (PCB, asbestos, etc.) and mixed waste
- Treatment of organic materials (bituminised waste, resins, oils, nitrates)
- Treatment of reactive metals (high-temperature processes, melting) and managing gas generation
- Development of dynamic chemo-toxic inventories from chemical reactions during storage
- Management of depleted uranium
- Improved segregation of waste (separation of long-lived components from LLW); segregation of VLLW
- Clearance and recycling of low contaminated materials

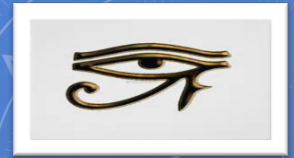
# CHALLENGE (6) : PRIORITISATION ON WASTE MANAGEMENT

- Treatment of materials with hard-to-measure nuclides
- Monitoring and long-term management (traceability) of waste package data
- Handling and treatment of degraded waste packages
- Conditioning of waste (grouts, foam concrete, etc., improving waste incorporation)
- Avoiding radiolysis inside casks (beta/gamma emitters and water)
- Long-term monitoring of entombed facilities including avoidance of voids
- Long-term performance of waste forms (e.g. concrete, impact of super-plasticisers on radionuclide migration)





## CHALLENGE (7) : SITE REMEDIATION



- Adequacy of characterisation and compliance for release (challenge5), definition of the grid density,
- Acceptance of residual activity (vertical and horizontal)
- Means to convert doses to concentration (pathway and scenarios)
- Remote detection equipment (long time and hard to reach areas)
- Environmental impact of soil decontamination and transport
- Detection limits (mobile nuclides like H3, Sr, Cs)
- 3d modelling of subsurface soil and groundwater (benchmark and simulation)

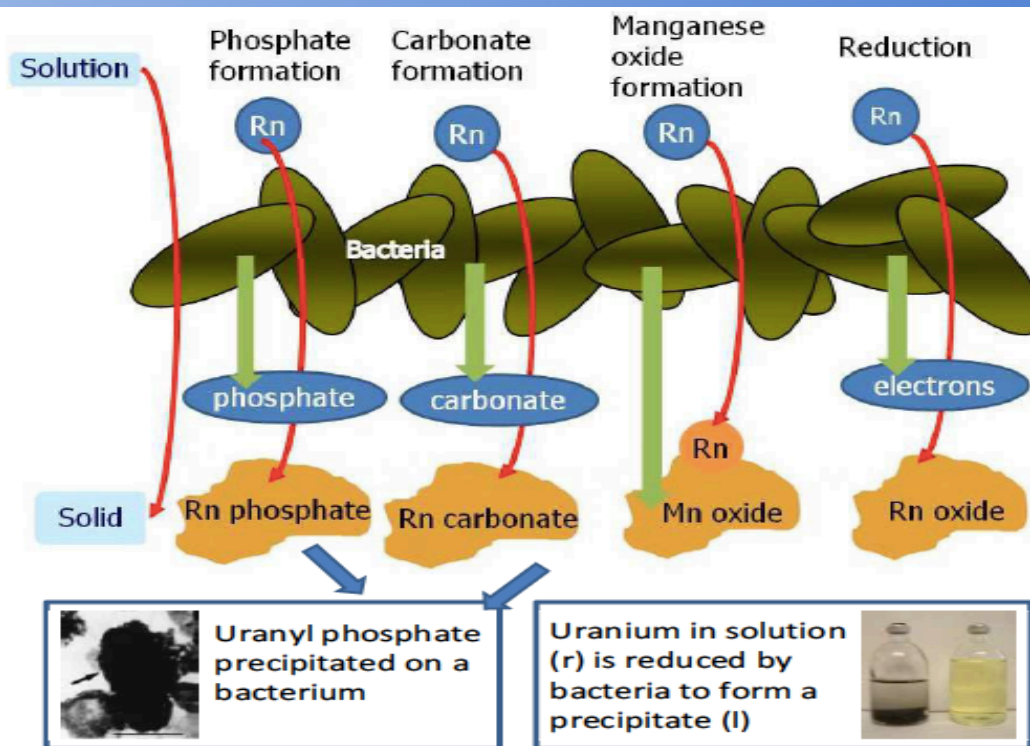


# BULK SOIL REMEDIATION (INC. BIOREMEDIATION)

- Develop new ex situ and in situ methods:
  - Phytoremediation,
  - Bacteriological remediation,
  - Physical/chemical treatments (inc. extraction) with nanotechnology development.
- Minimisation of waste generated, 'auto remediation' with time.
- Need of field tested new technologies
- *Needs normal D&D versus FD quite similar*



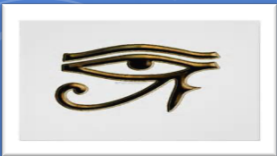
# FIXING CONTAMINATION USE OF ENGINEERED BARRIERS



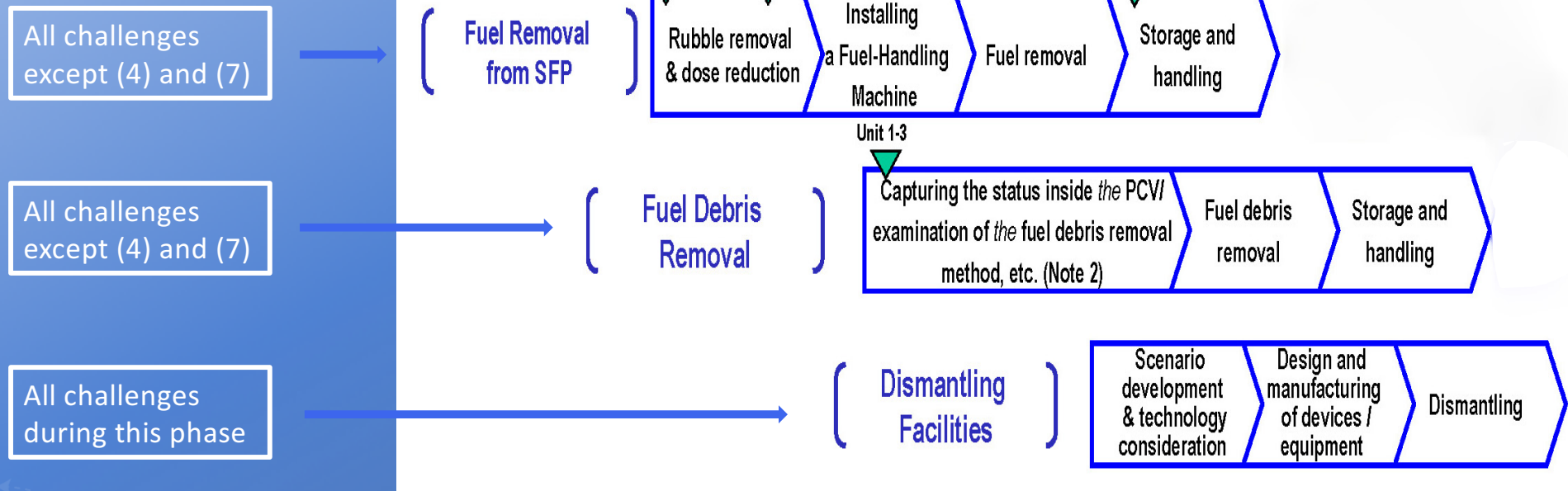
- Prevent airborne dispersion to ground water
- Develop soil contamination fixation
- Methods for long term containment for contaminants (various soil types and environmental conditions)

## COMPARISON OF DOSE MODELLING WITH STUDIED CASES

- Benchmark software tools used to modelise
- International standards to assess risks and doses basis for man and env. : grid, norms ...
- International consensus on input parameters to underpin the models
- Common risk-based for releases (at the desired statistical confidence level) for human and non human.
- *Needs normal D&D versus FD quite similar*

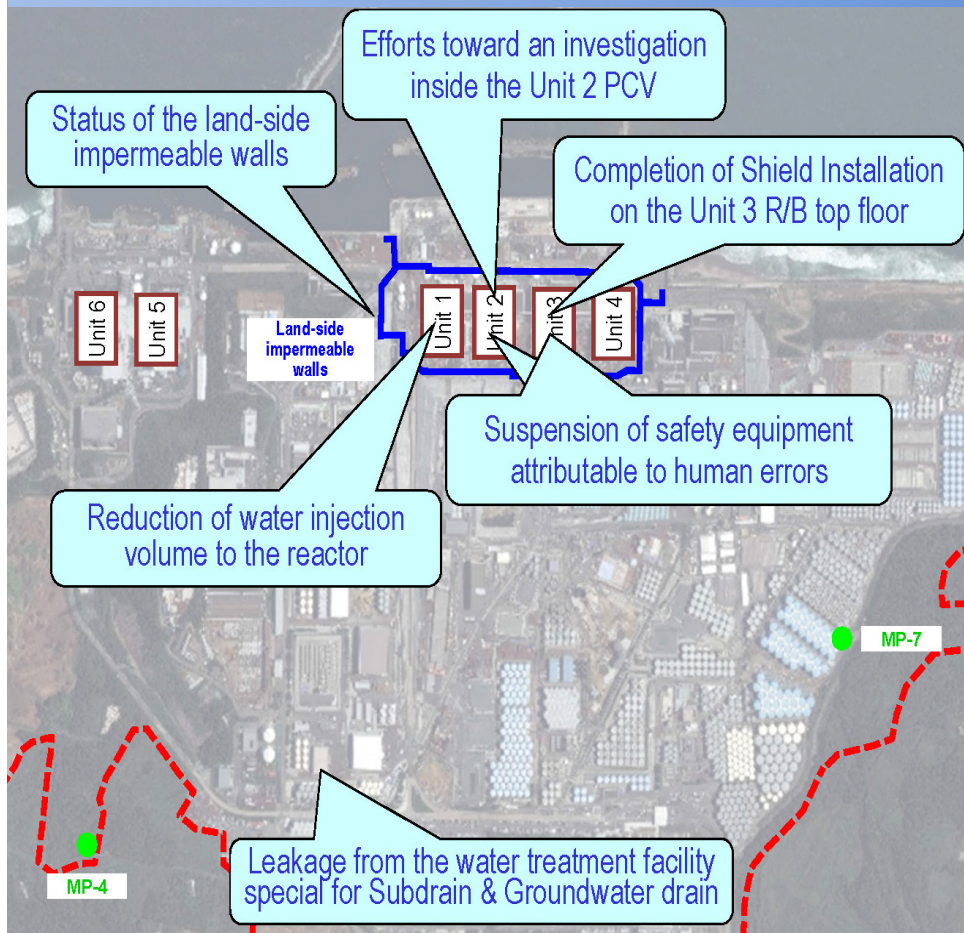


# CHALLENGES AVAILABLE FOR FUKUSHIMA DAICHI D&D



## AN EXAMPLE: DECONTAMINATION OF LARGE VOLUME OF WATER

- Collect new insight for large volume treatment (Japan, UK, USA):
  - Mesoporous materials,
  - Carbon nanotubes
- Use of nanotechnologies to fix and remove contamination
- Detritiation
- *Needs normal D&D versus FD quite similar*







## AS A CONCLUSION ...

- Why is it so difficult to start international cooperation on main challenges :
  - common standards (site remediation, statistical sampling),
  - pilot plant (waste reduction, incineration, graphite management and treatment)
- Huge interest to share cost, time and efforts to find a solution to a worldwide challenge?
- **Could be great for IAEA and OECD to identify and support them!**