

# INTERNATIONAL SAFEGUARDS AT REPROCESSING FACILITIES



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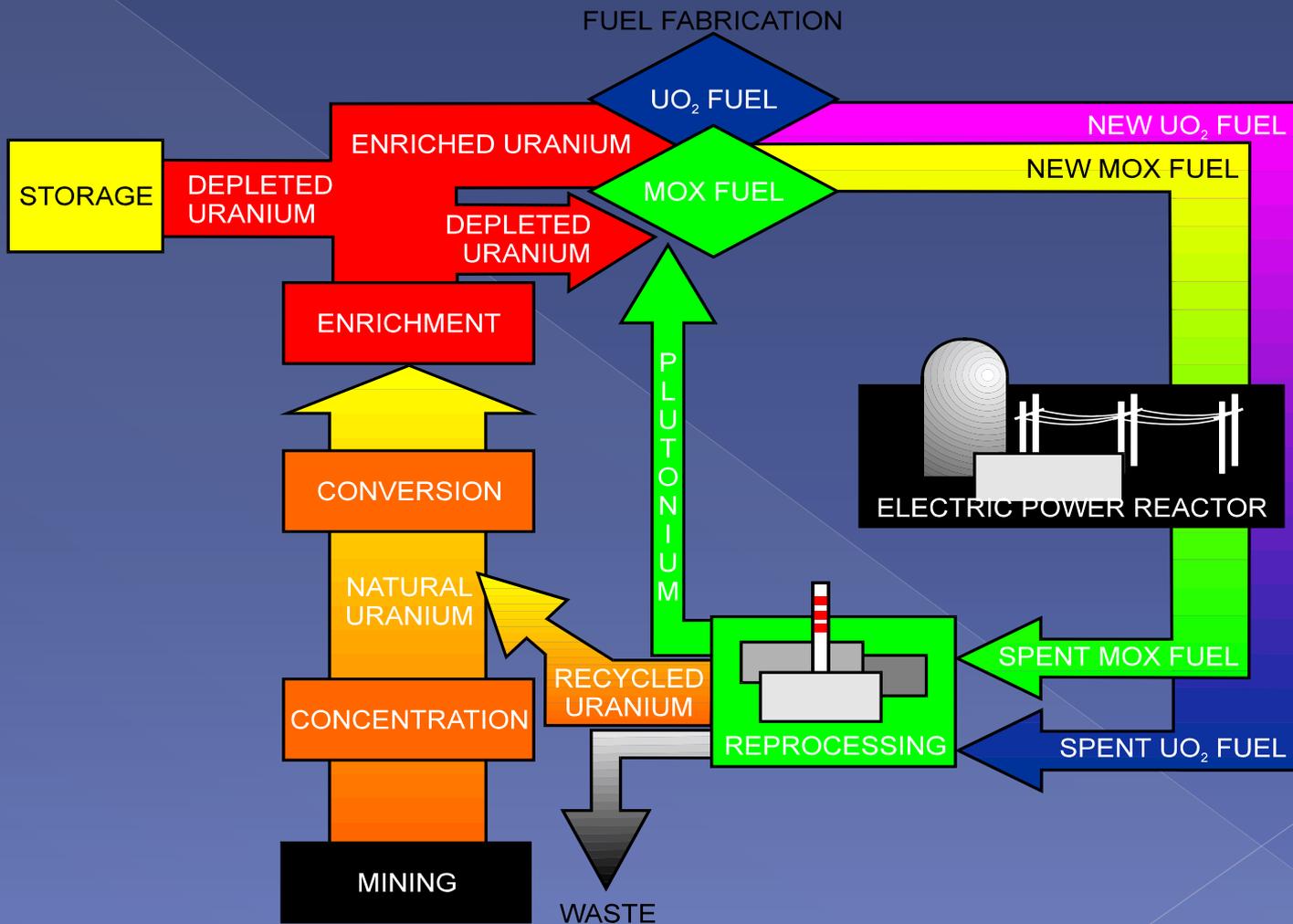
# AN ITEM FACILITY IS A FACILITY WHERE:

- All nuclear material is kept in item form;
- The integrity of the item remains unaltered;
- Such as:
  - > Reactors,
  - > Critical assemblies,
  - > Laboratories, and
  - > Storages.

# A BULK FACILITY IS A FACILITY WHERE:

- Nuclear material is held, processed or used in bulk form, i.e., pellets, powders, liquid, gas.
- Facility may be organized in multiple material balance areas (MBA).
- Such as:
  - > Conversion,
  - > Enrichment,
  - > Fuel fabrication,
  - > Reprocessing, and
  - > Storages.

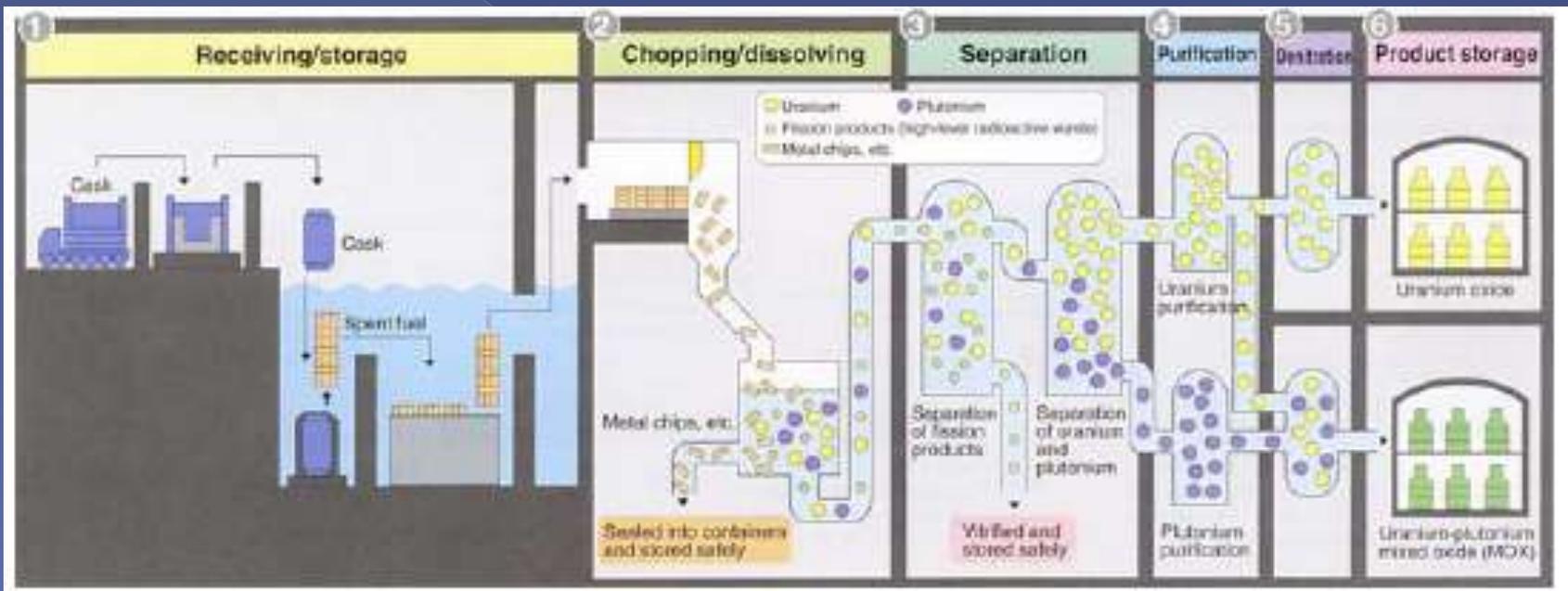
# CLOSED NUCLEAR FUEL CYCLE



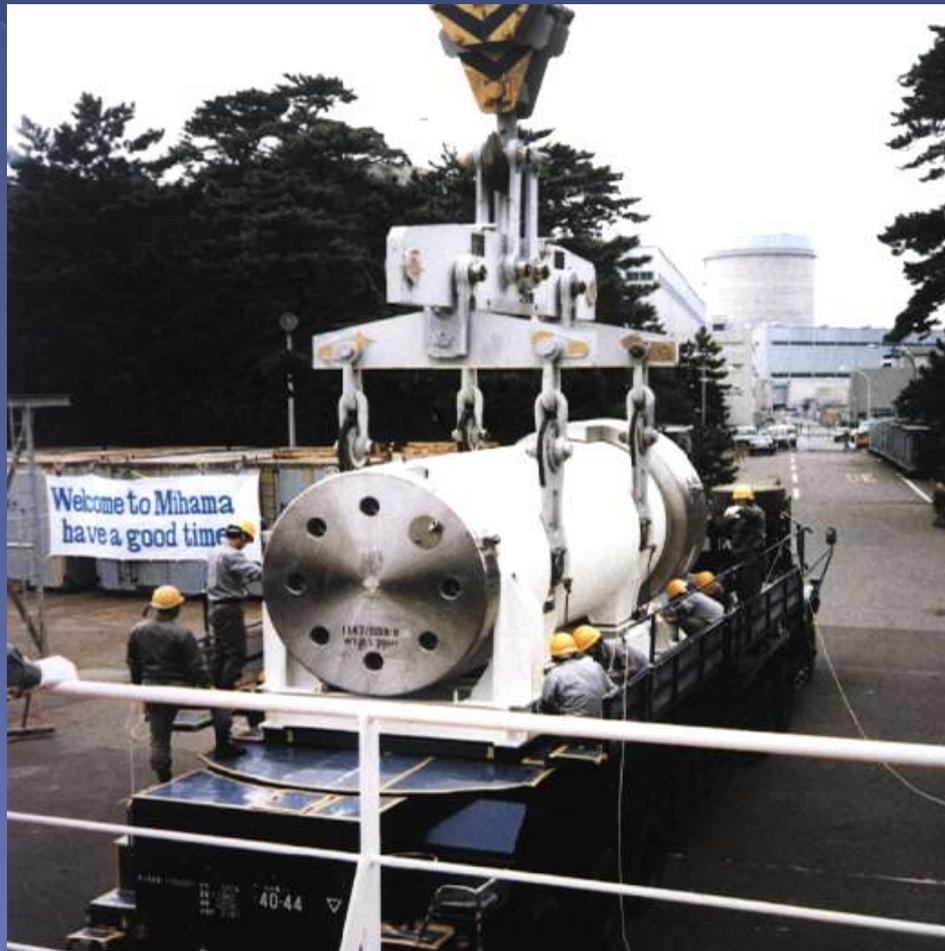
# FEATURES RELEVANT TO SAFEGUARDS

- Throughput is normally larger than the inventory at any given time
- Nuclear material inventory is in constant movement: it changes its locations, physical forms and chemical compositions
- Non-product materials (scrap and waste) are generated in relatively large quantities
- Accumulation of holdups is possible

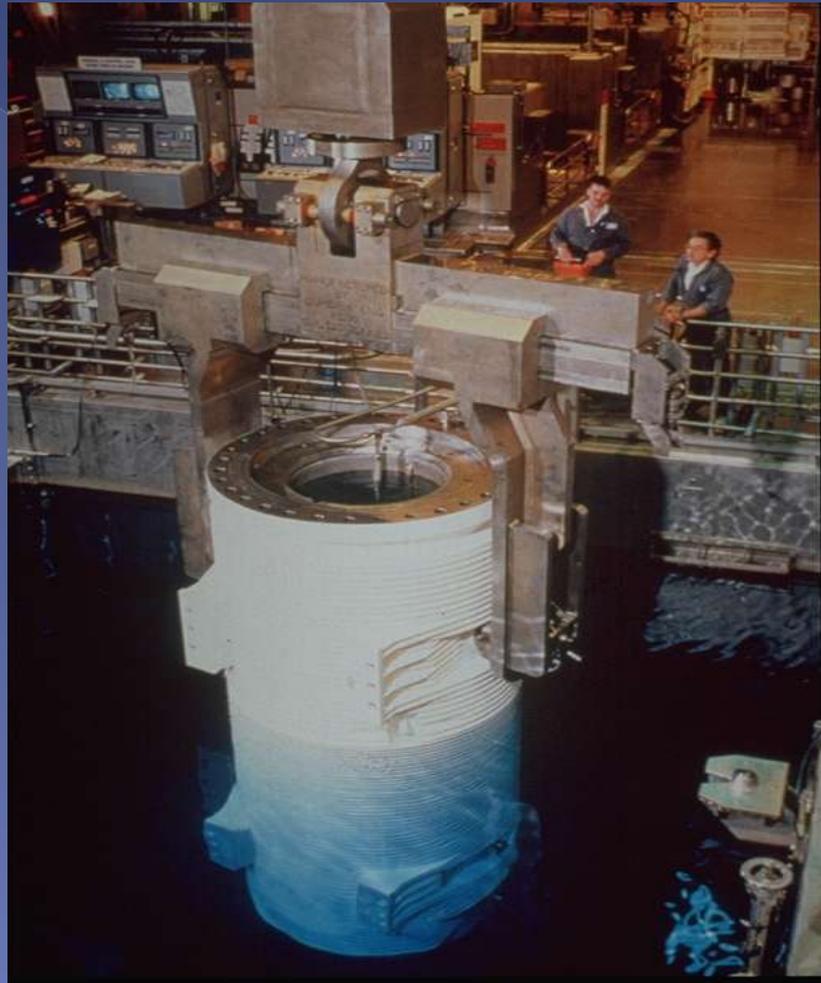
# REPROCESSING PLANT FLOW



# RECEIPT FROM REACTOR (RD)



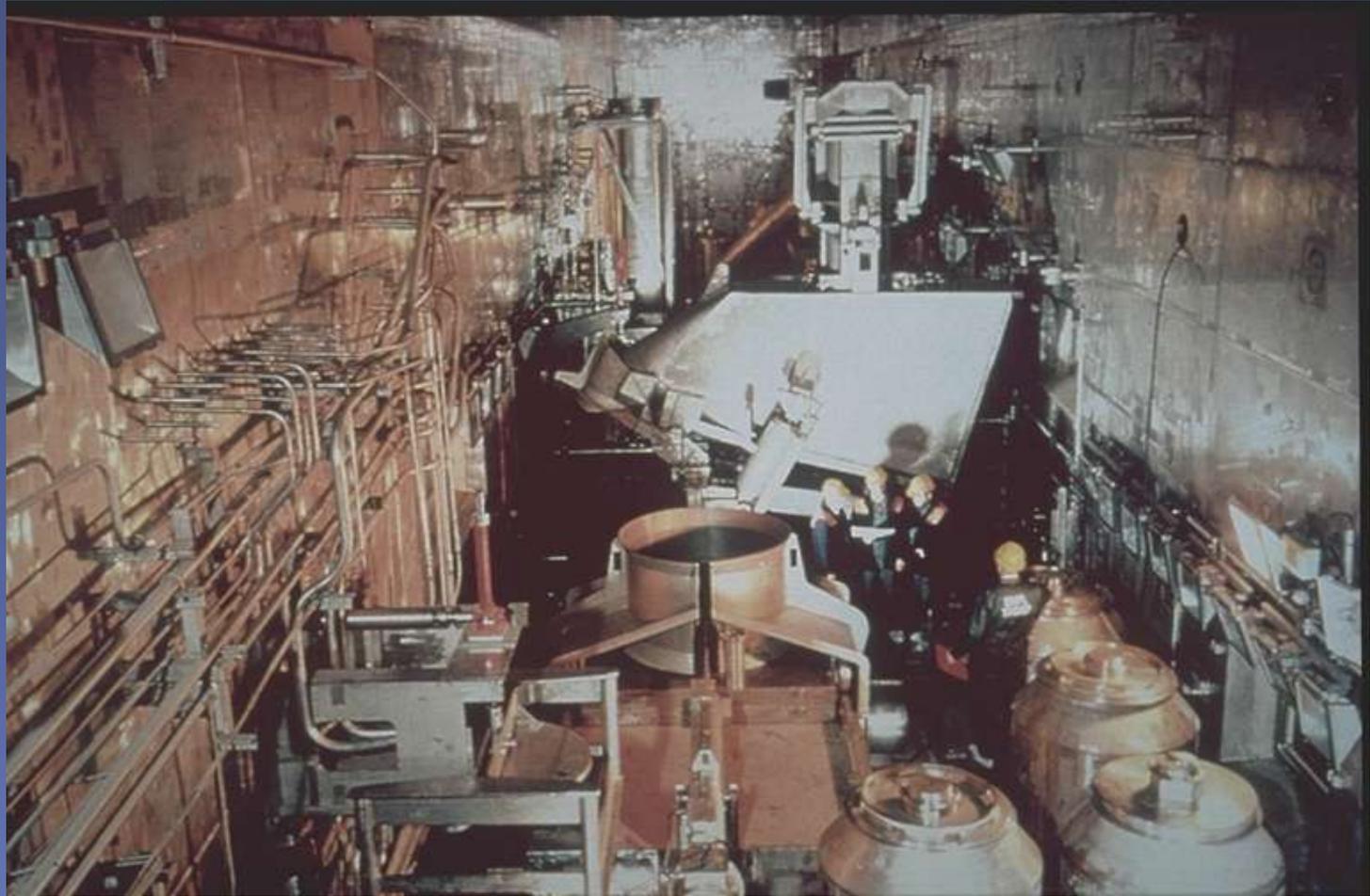
# UNLOADING SHIPPING CASK (OSP)



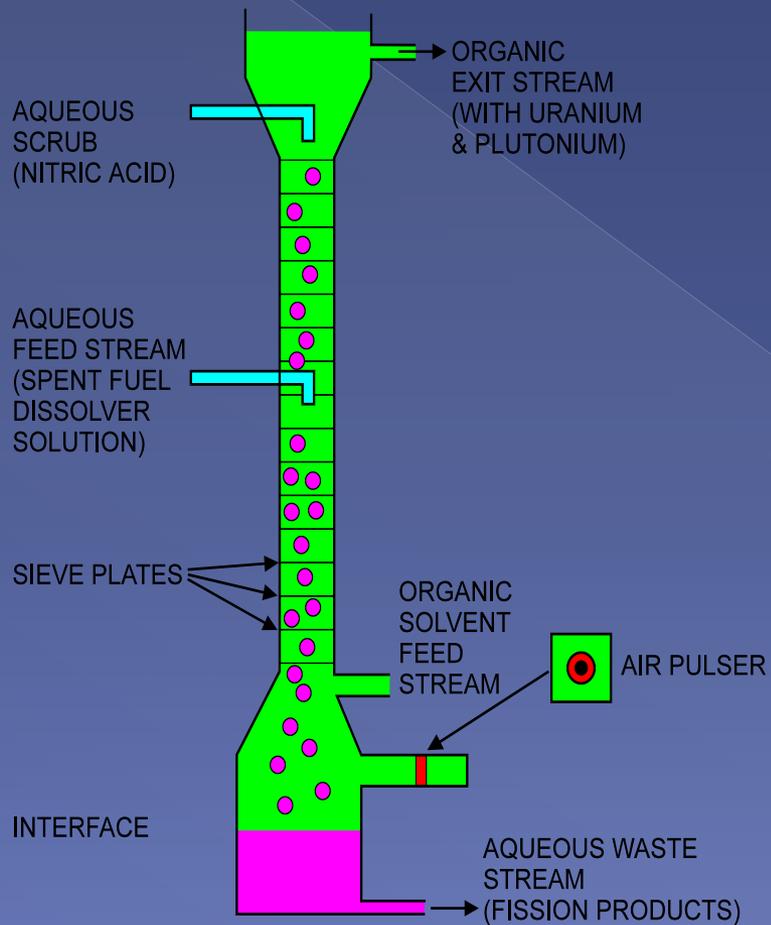
# SPENT FUEL INVENTORY (IIV/PIV)



# MECHANICAL CELL (OSP/IIV)



# SOLUTIONS IN PULSE COLUMNS (IIV/OSP)



# CHEMICAL PROCESS CELL (IIV/OSP)



# SOLUTIONS IN TANKS (IIV/IC/OSP/PIV)



# GLOVEBOX INVENTORY (IIV/PIV/OSP)



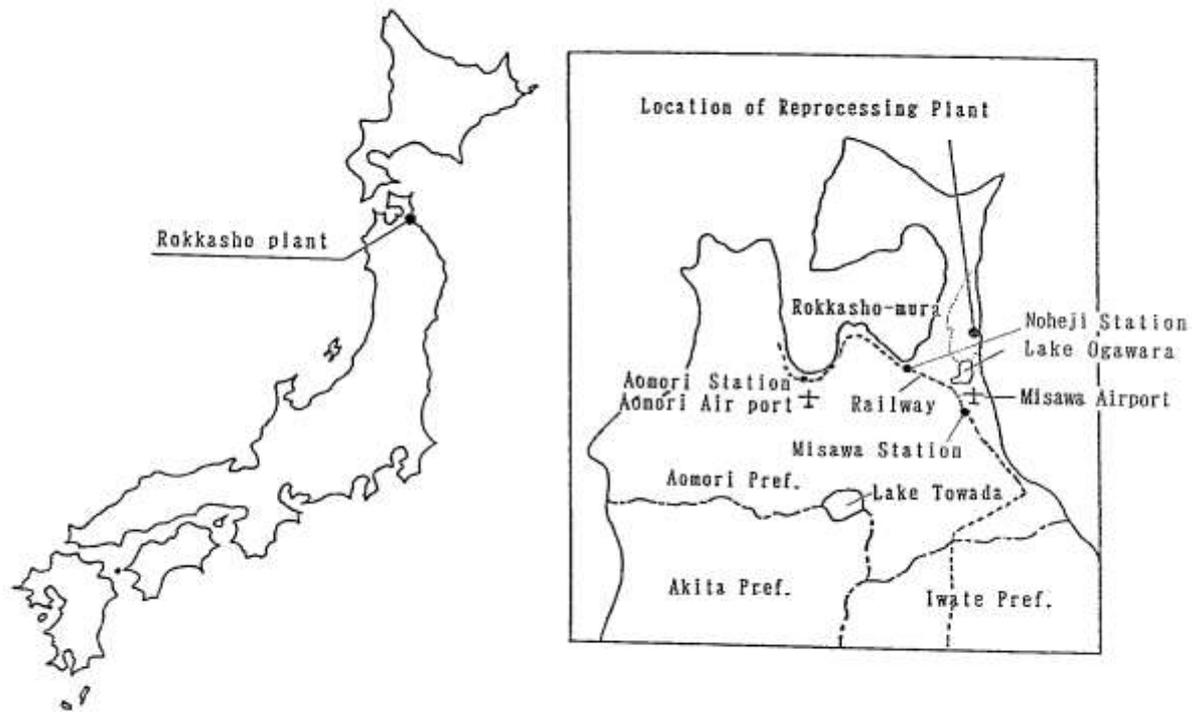
# VITRIFIED WASTE IN CANISTER (LD)



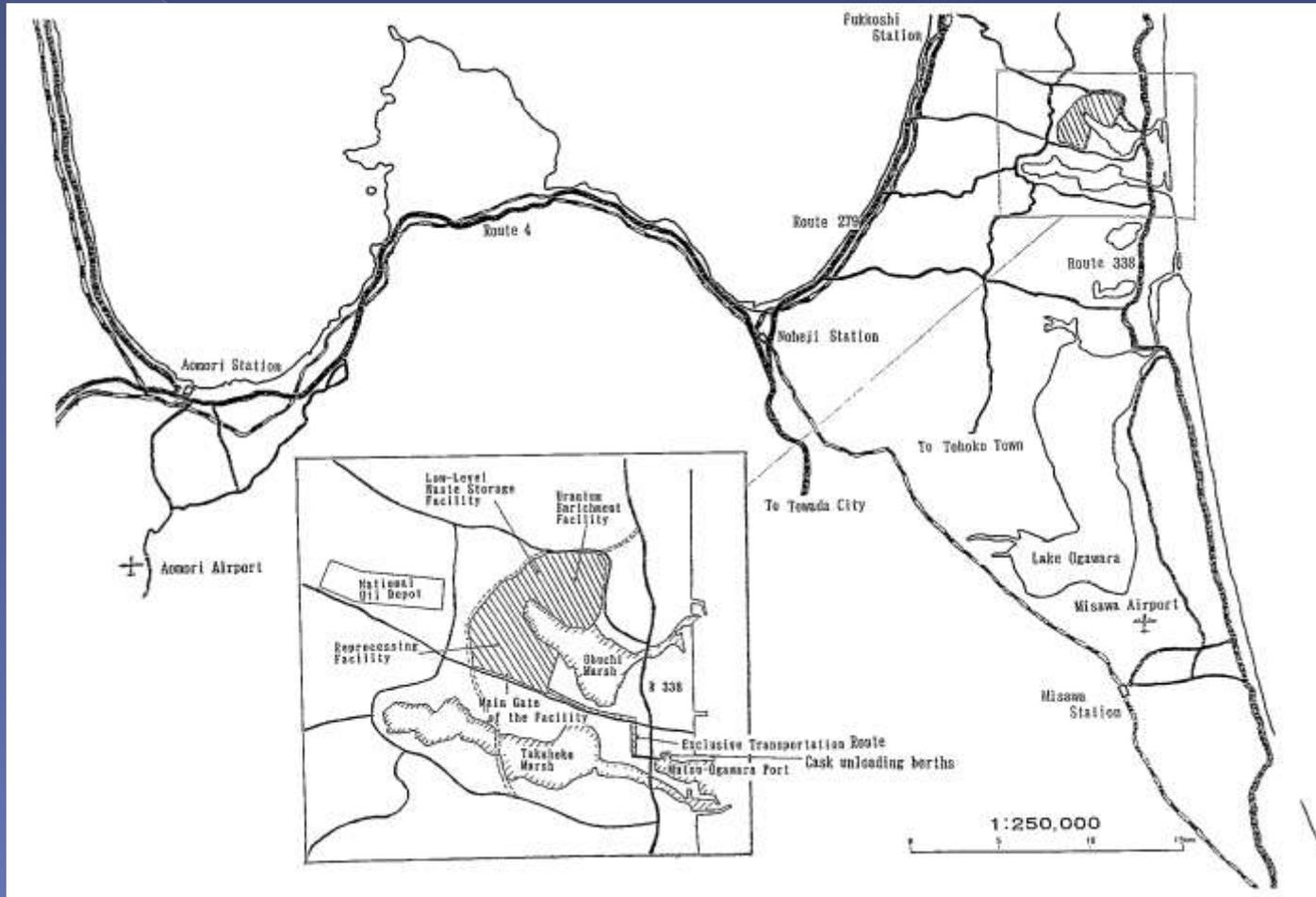
# ROKKASHO REPROCESSING PLANT



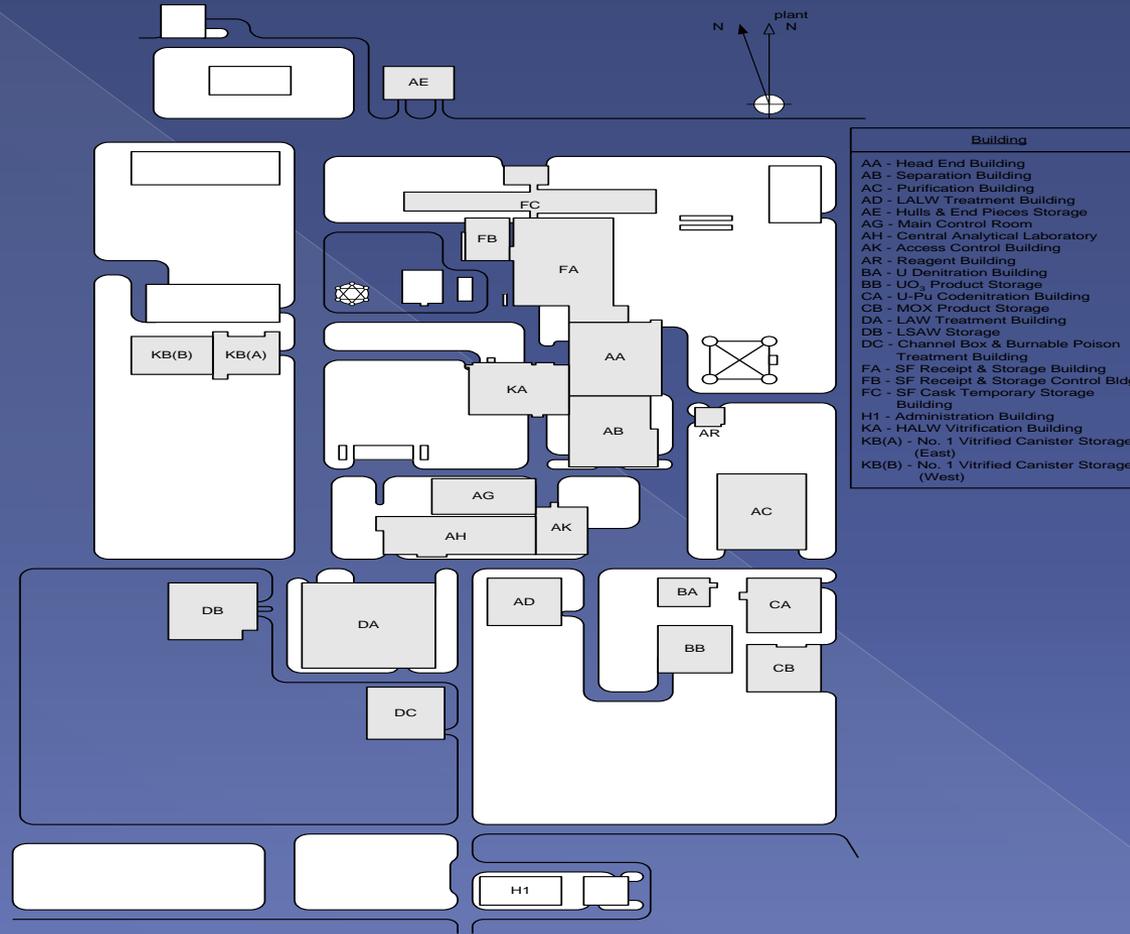
# JAPAN



# ROKKASHO



# ROKKASHO REPROCESSING PLANT



# OVERVIEW OF RRP

- **Location:** Aomori Prefecture, Japan
- **Site Area:** 3,800,000 m<sup>2</sup>
- **Facilities:** 38 buildings (more than 20 process and storage buildings) with 1700 km of pipes (Main Process 700 km).
- **Capacity:**
  - > **Maximum annual throughput:** 800 tons of Uranium or 8 tons of Plutonium.
  - > **Maximum daily throughput:** 4.8 tons of Uranium
  - > **Storage capacity for Plutonium:** 30 tons
  - > **Storage capacity for vitrified canisters:** 1440

# CHALLENGE #1

## Initial and Continuing DIE/DIV

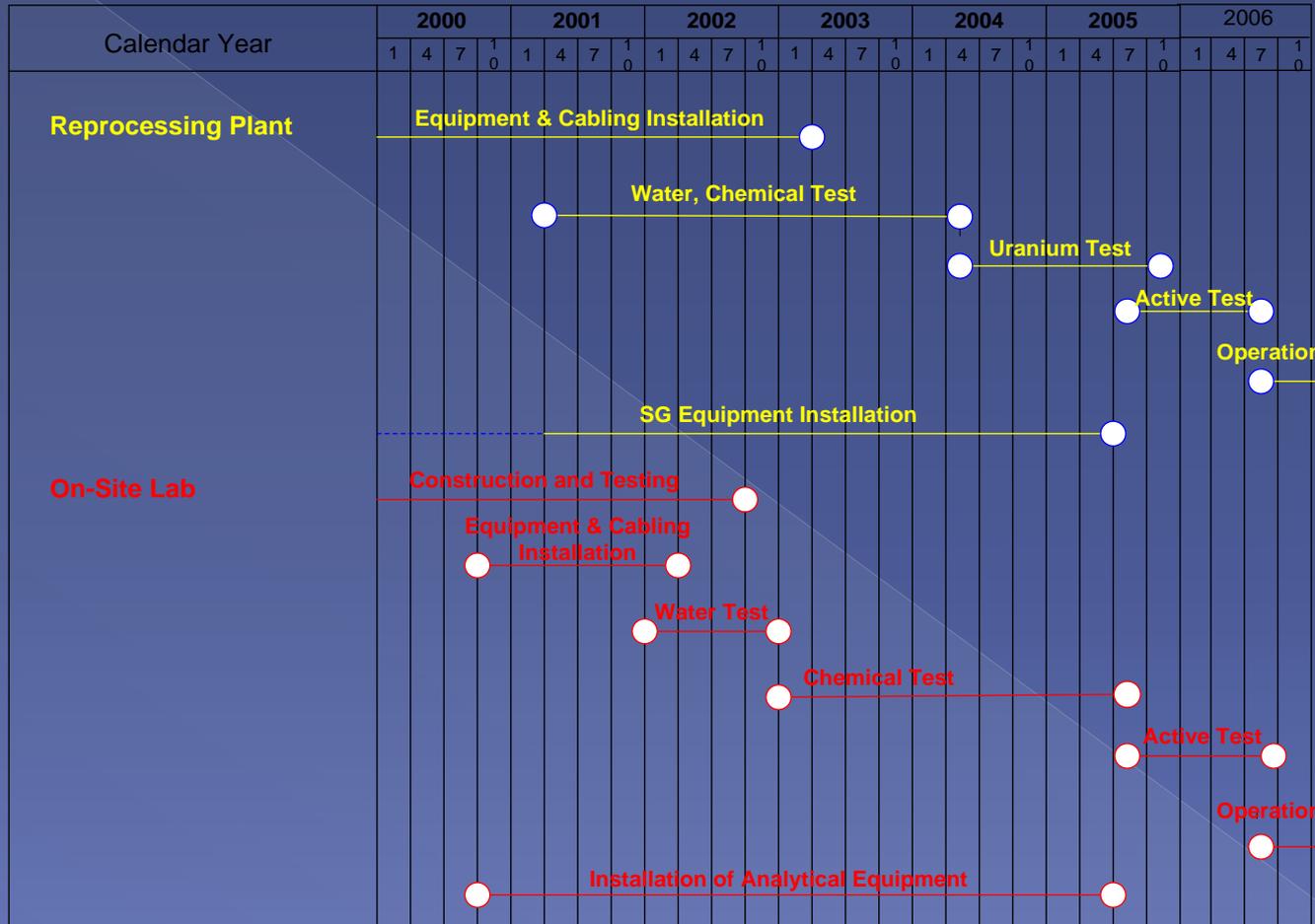
*How to verify the design of more than 30 buildings with hundreds of cells, glove boxes and vessels, and over 1000 km of piping , and maintain that knowledge for future reference?*

# CHALLENGE #1 – DIE/DIV

## Initial and Continuing DIE/DIV

- **Prioritize**
- **Random verification**
- **DIV tools**
  - Endoscopes, laser distance finders, portable electromanometers
- **Continuity of knowledge (CoK)**
  - Digital photography, scanning 3-D laser range finder (LRFD)

# INSTALLATION AND TESTING SCHEDULE



# 3-D Laser Ranger Finder for Design Verification ( LRFD)



Laser Range Scanner

Portable Computer

Tripod

Batteries

Dolly



# Data Processing

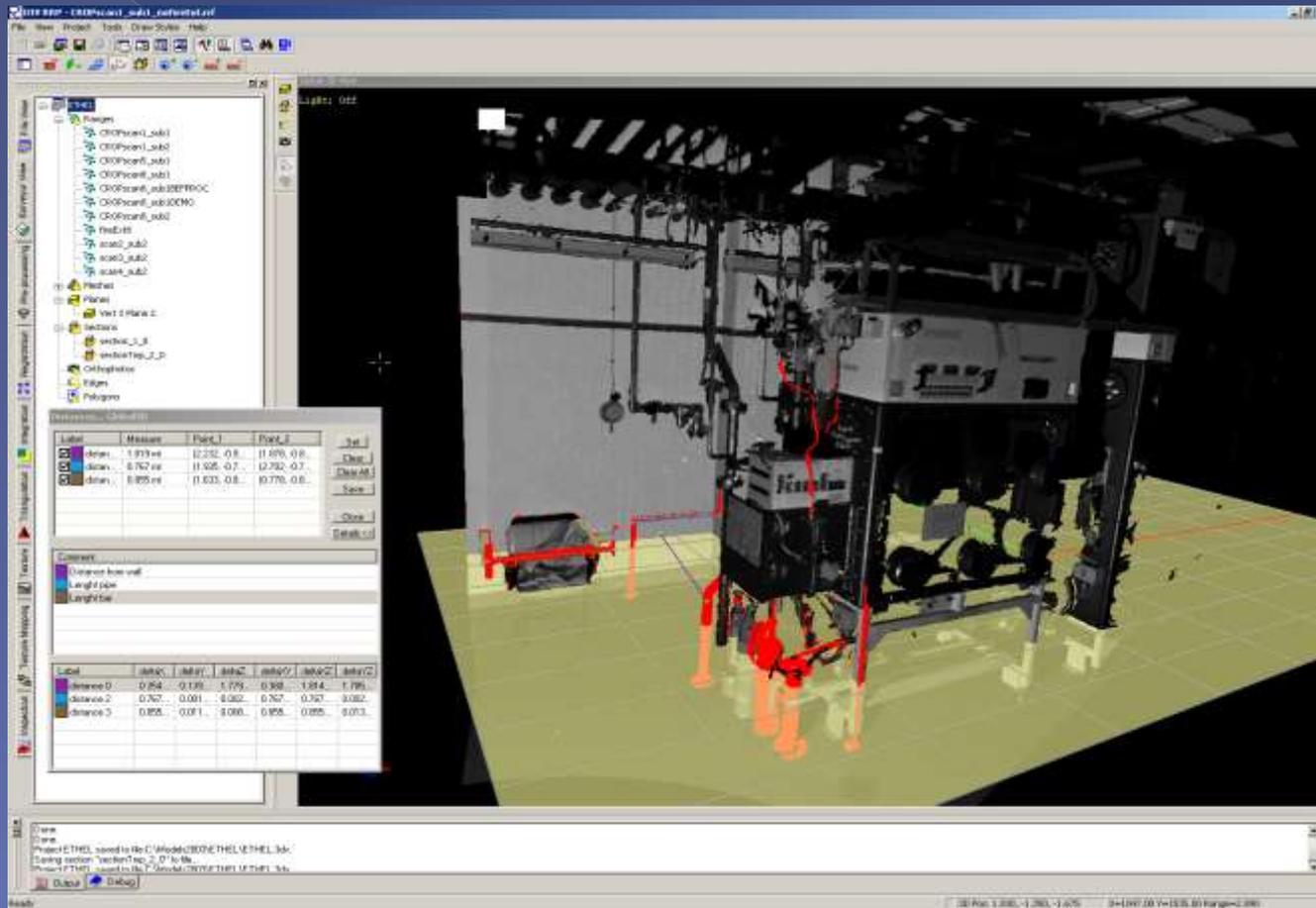


Reference Model



Re-verification scan

# Data Processing - Automatic Detection of Differences



# CHALLENGE #2

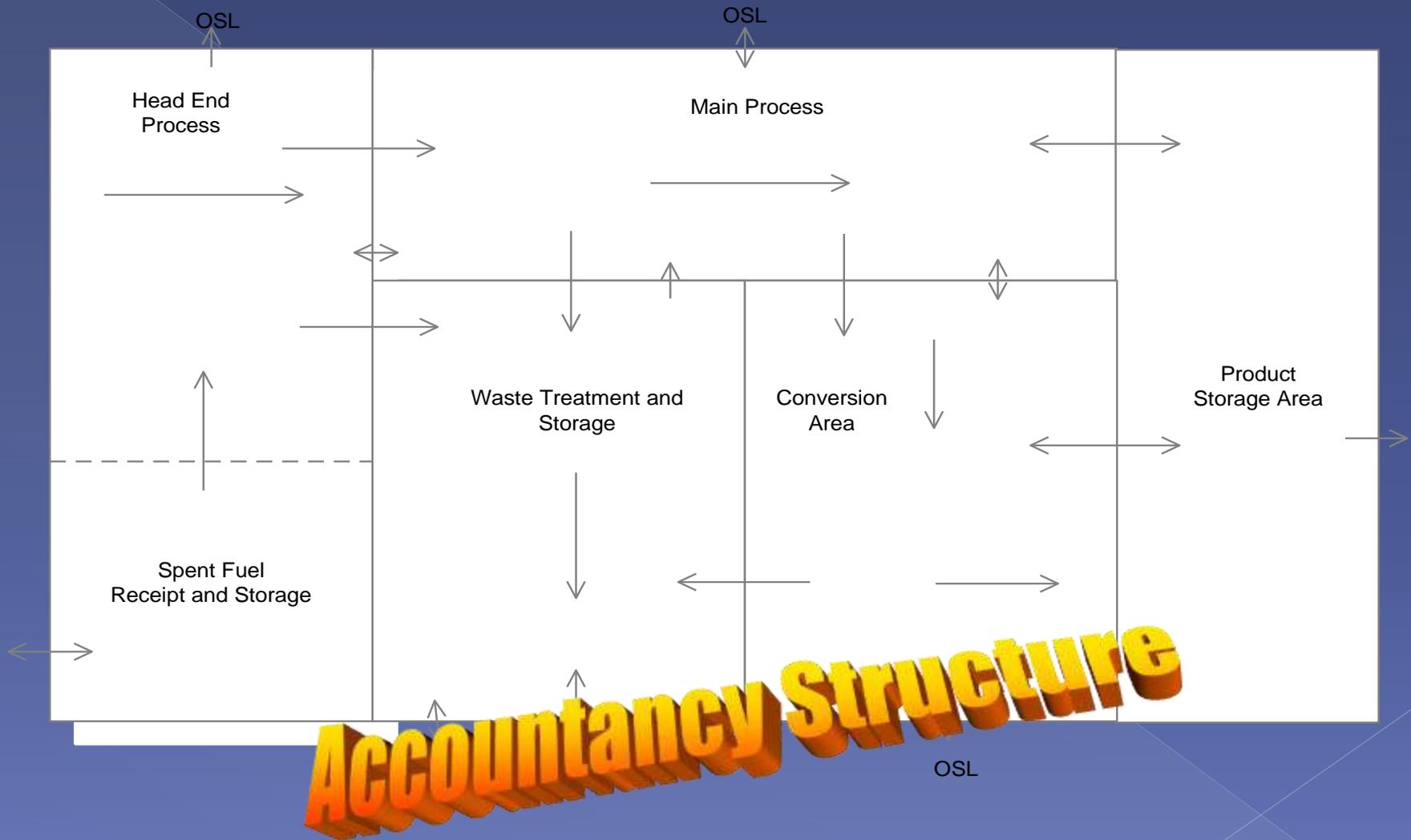
## Strengthened Safeguards Approach

*How to implement a safeguards approach that fulfils the IAEA Safeguards Criteria and provides assurance that the facility is being operated as declared?*

# DETECTION GOALS

- 1 SQ of unirradiated direct-use material:
  - > Pu,  $^{233}\text{U}$  – within 1 month
  - > HEU (>20%  $^{235}\text{U}$ ) – within 1 month
- 1 SQ of irradiated direct-use material:
  - > Pu,  $^{233}\text{U}$ , HEU – within 3 months
    - IS = Spent fuel away from reprocessing plant – 1 year
- 1 SQ of all indirect-use material:
  - > U (<20%  $^{235}\text{U}$ ) – within 1 year
  - > Th – within 1 year.

# CHALLENGE #2 – STRENGTHENED SG



# ACCOUNTANCY STRUCTURE

- **Material Balance Area (MBA)**
- **Flow Key Measurement Points (FKMP)**
- **Inventory Key Measurement Points (IKMP)**
- **Other Strategic Points (OSP)**

# ACCOUNTANCY STRUCTURE - MBA

- **Material Balance Areas (MBA)**
  - > To determine the quantity of material transferred into and out of; and
  - > To determine the book and physical inventory within.
  - > May be an accountancy area for Shipper/Receiver Difference (SRD) or Material Unaccounted For (MUF).

# TYPE OF MBA

- ⊙ **Material Unaccounted For (MUF)**
  - >  $BBI + \text{Increases} - \text{Decreases} = EBI$
  - >  $EBI - PIT = MUF$
- ⊙ **MUF = 0**
  - > Item facilities, ie, storages
  - > Measured material under C/S
- ⊙ **Shipper/Receiver Difference (SRD)**
  - > Difference between shipper values and receiver values
- ⊙ **NOTE: Usually caused because of measurement uncertainties.**

# ACCOUNTANCY STRUCTURE - FKMP

- **Flow Key Measurement Points (FKMP)**
  - > **Locations where Inventory Changes (IC) can be measured.**
    - **Operator declaration**
    - **Inspector verification**
  - > **Usually flow across MBA boundaries, but not always.**
  - > **Examples:**
    - **Receipts and Shipments**
    - **Nuclear Loss and Gain**
    - **Accidental Loss or Gain**
    - **Transfers-to and Retransfers-from Retained Waste**
    - **Measured Discard**
    - **Exemption and De-exemption of nuclear material**
    - **Termination of safeguards for non-nuclear use**

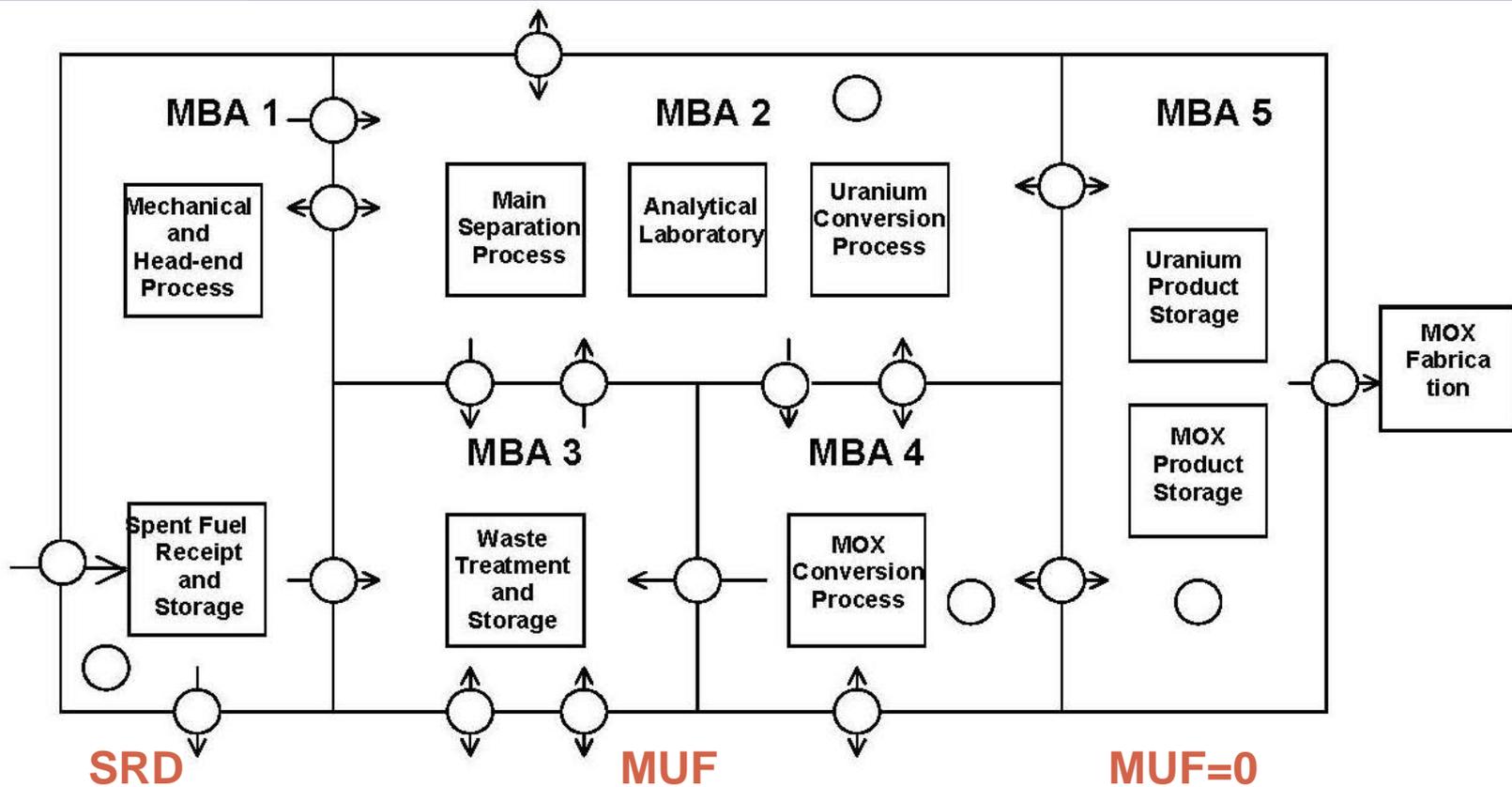
# ACCOUNTANCY STRUCTURE - IKMP

- **Inventory Key Measurement Points (IKMP)**
  - > **Location where Physical Inventory can be measured.**
    - **Operator declaration**
    - **Inspector verification**
  - > **May have more than one IKMP in an MBA.**
  - > **Material within usually has similar characteristics or measurement requirements.**

# ACCOUNTANCY STRUCTURE - OSP

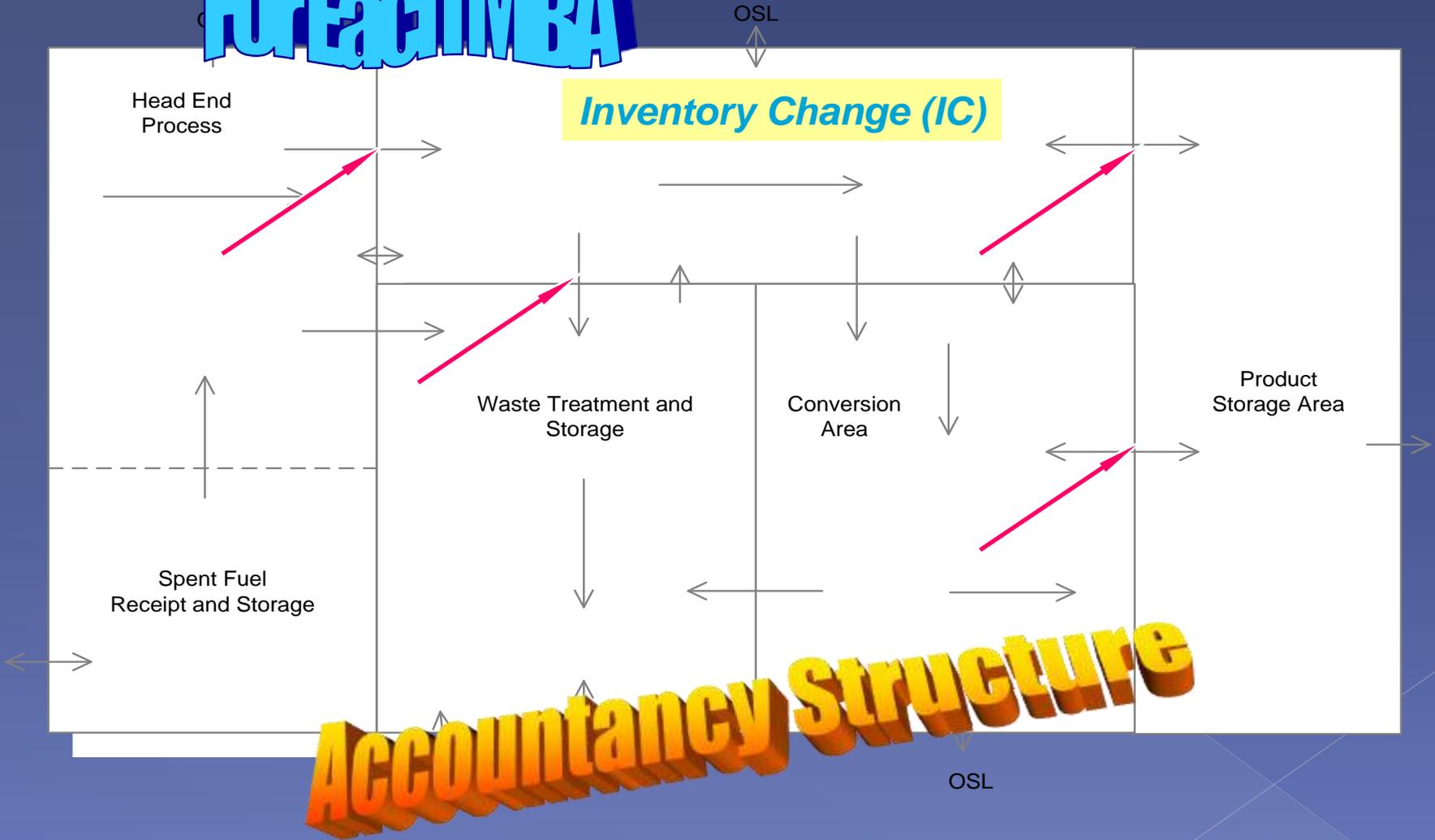
- **Other Strategic Points (OSP)**
  - > **Supports Accountancy Measures**
    - Provides Continuity of Knowledge (CoK)
    - Containment/Surveillance (C/S)
    - Monitoring
  - > **Provides Added Assurance**
    - Short notice check of operator measurement systems.
    - Verification of flow within the MBA.
    - Verification of operational status.

# MBA STRUCTURE



# CHALLENGE #2 – STRENGTHENED SG

**For Each MBA**



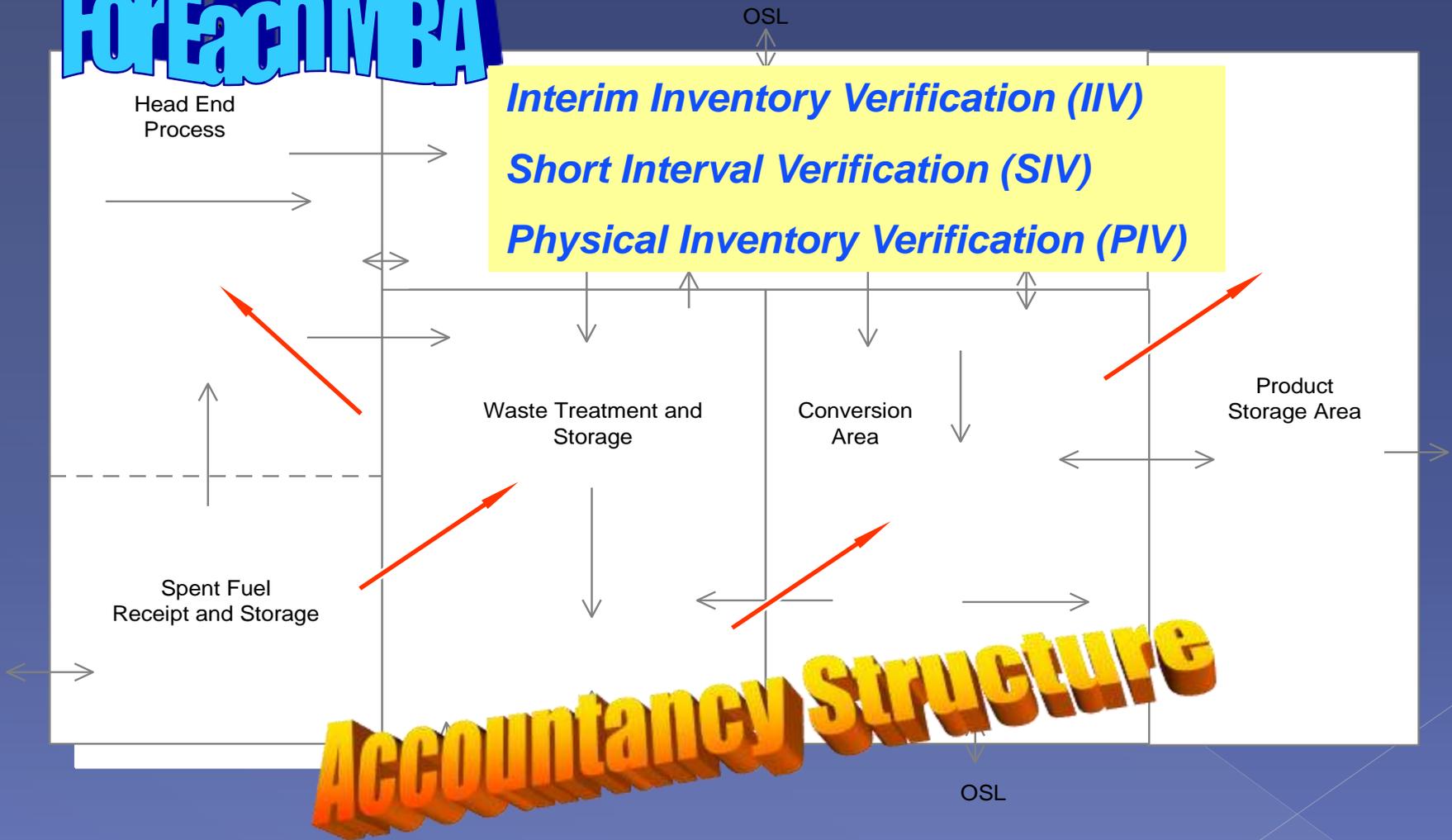
# CHALLENGE #2 – STRENGTHENED SG

## IC Verification Approach

- **Main process flows**
  - High confidence level
- **Waste streams**
  - Medium confidence level
- **Minor streams**
  - Medium to low confidence level

# CHALLENGE #2 – STRENGTHENED SG

**For Each MBA**



# CHALLENGE #2 – STRENGTHENED SG

## Inventory Verification Approach

- **Interim Inventory Verification (IIV)**
  - 1 per month for Pu
  - CoK using Solution Measurement and Monitoring System (SMMS) and Plutonium Inventory Measurement System (PIMS)
- **Short Interval Verification (SIV)**
  - 1 per 10 days for Pu
  - Added assurance for the IIV
  - CoK using SMMS and PIMS
- **Evaluation using NRTA methodology**

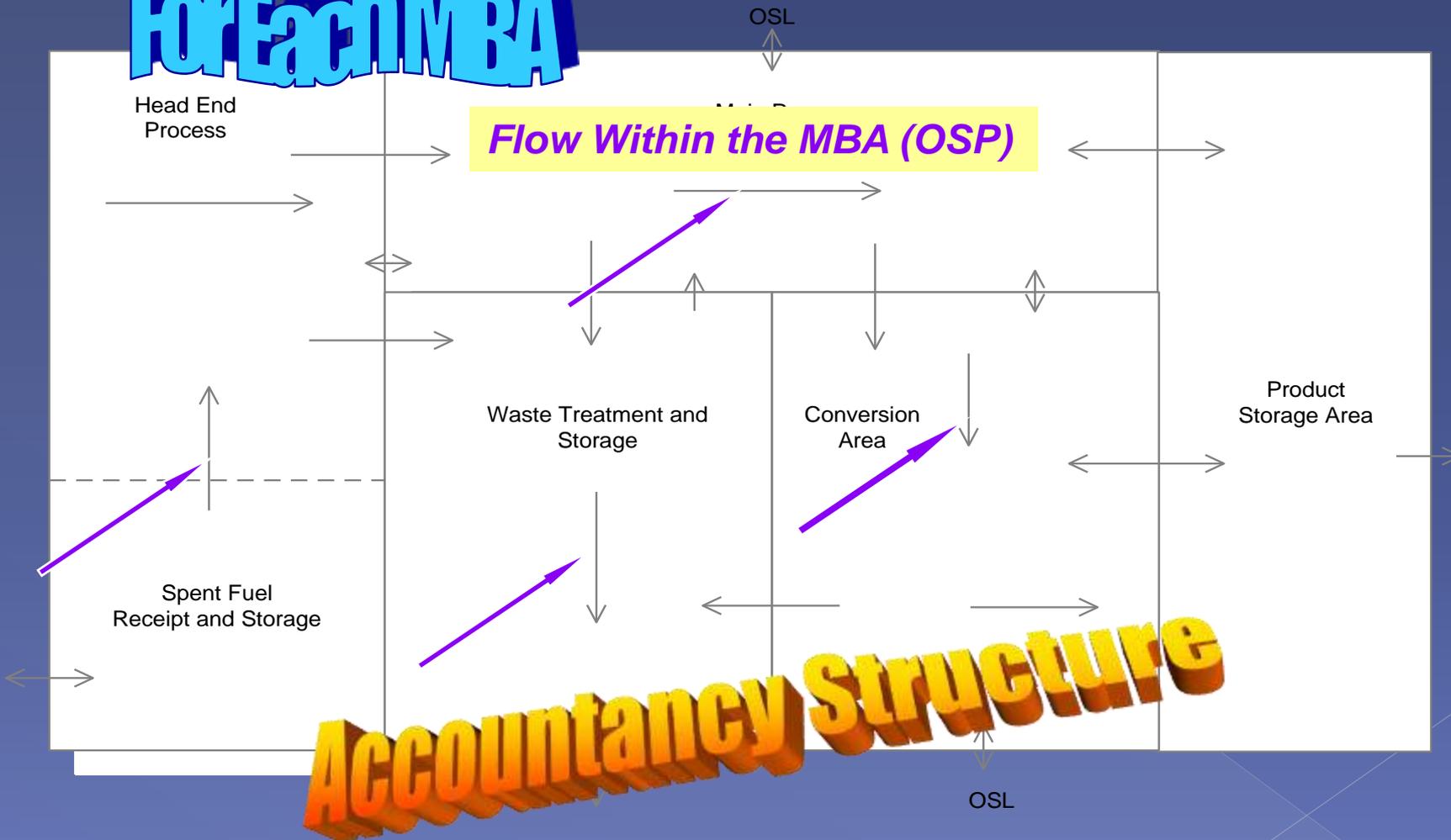
# CHALLENGE #2 – STRENGTHENED SG

## Inventory Verification Approach

- **Physical Inventory Verification (PIV)**
  - 1 per year for Pu and U
  - Process shut-down
  - Process cleaned-out
    - Verified using SMMS, PIMS and samples

# CHALLENGE #2 – STRENGTHENED SG

**For Each MBA**



# CHALLENGE #2 – STRENGTHENED SG

## Added Assurance Measures

- **Measurement and monitoring of flows within the MBA**
  - Added assurance to inventory and inventory change verifications
- **Other Strategic Points (OSP)**
  - Random, short-notice check/confirmation
  - Assurance that plant is operated as declared

# CHALLENGE #3

## Verification Systems

*How to introduce measurement and monitoring systems with sufficient sensitivity and reliability and yet keep the costs and inspection effort within a manageable limit?*

# CHALLENGE #3 – VERIFICATION SYSTEMS

## System Requirements

- > Unattended operation
- > Remote data transmission
- > Joint-use with State and operator
- > > 50 measurement and/or monitoring systems
- > ~70 surveillance systems

# CHALLENGE #3 – VERIFICATION SYSTEMS

## Installed Systems

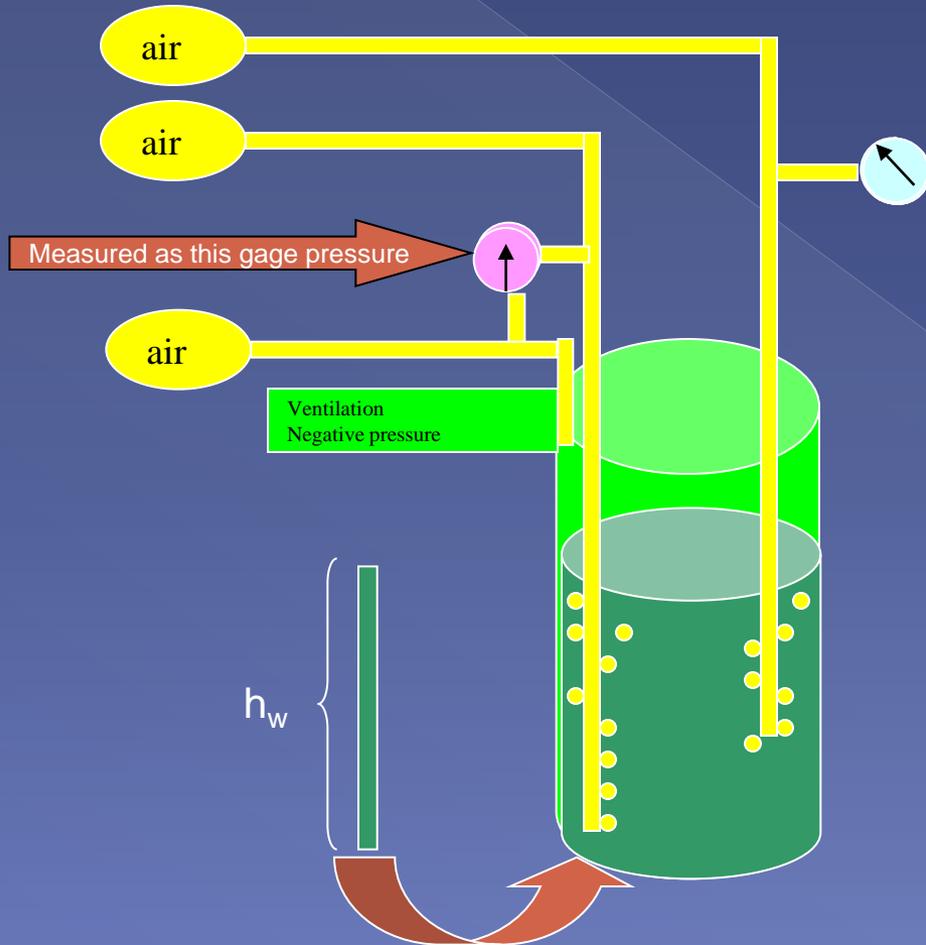
- Integrated Spent Fuel Verification System (ISVS)
- Integrated Head-end Verification System (IHVS)
- Solution Measurement and Monitoring System (SMMS)
- Independent Jug Passage Detectors (IJPD)
- Automatic Sample Authentication System (ASAS)
- Waste Crate Assay System (WCAS A&B)
- Waste Drum Assay System (WDAS)
- Vitrified Canister Assay System (VCAS)
- Plutonium Inventory Measurement System (PIMS)
- Temporary Canister Verification System (TCVS)
- improved Plutonium Canister Assay System (iPCAS)
- Directional Canister Passage Detector (DCPD)
- Uranium Bottle Verification System (UBVS)
- Uranium Storage C/S System (USCS)

# SOLUTIONS IN TANKS (IIV/IC/OSP/PIV)



# SOLUTION MEASUREMENT & MONITORING

## Bubbler Basics - Level Measurement



$$\cancel{\text{area}} \times \text{pressure}_{\text{gage}} = h_w \times \cancel{\text{area}} \times \rho_w$$

Our instruments at RRP measure pressure in kilopascals (kPa)

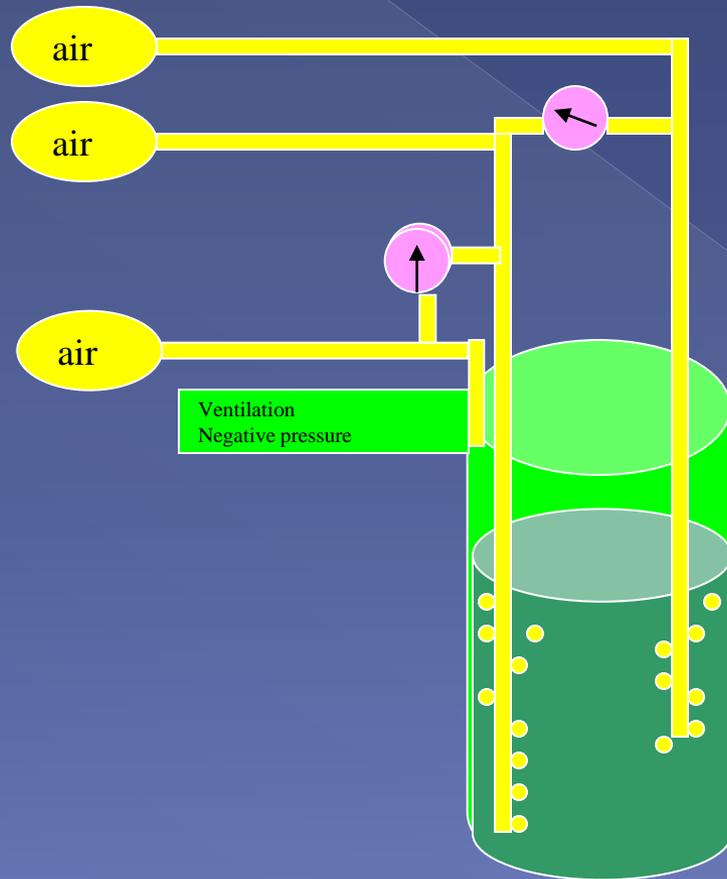
1kPa = 102mm H<sub>2</sub>O

Therefore,

When the solution is water ( $\rho_w = 1$ ), we are measuring the height of water ( $h_w$ ) directly.

# SOLUTION MEASUREMENT & MONITORING

## Bubbler Basics – Density Measurement



During vessel calibration

$$PS = \text{Pressure}_{\text{gage}} / \rho_w$$

Many measurements

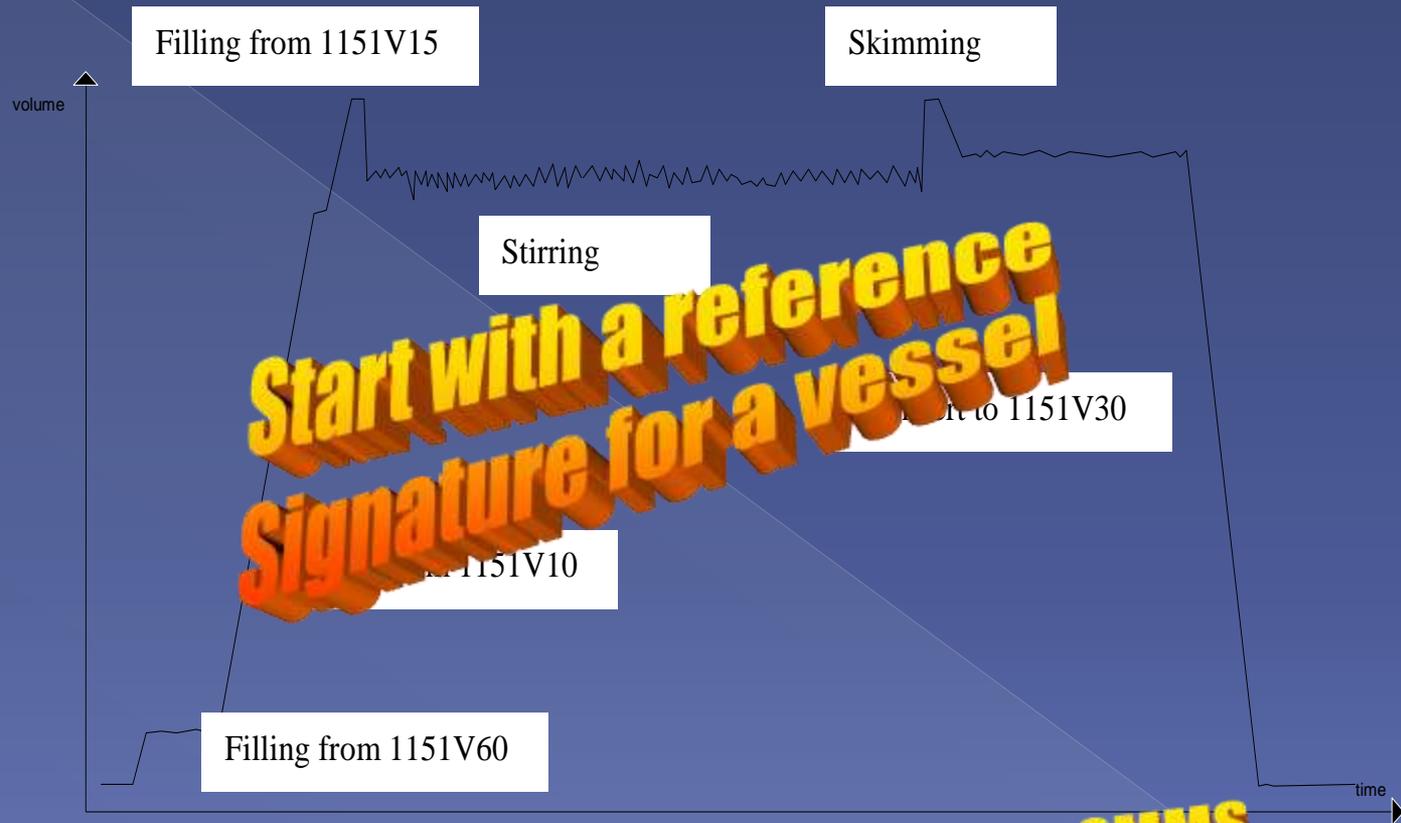
Tables, H<sub>2</sub>O at temp.

Also Known as "Probe Separation"

$$\text{Pressure}_{\text{gage}} \times \text{area} \times \rho_w = h \times \text{area} \times \rho_w$$

# SOLUTION MEASUREMENT & MONITORING

## ESTABLISH A REFERENCE SIGNATURE

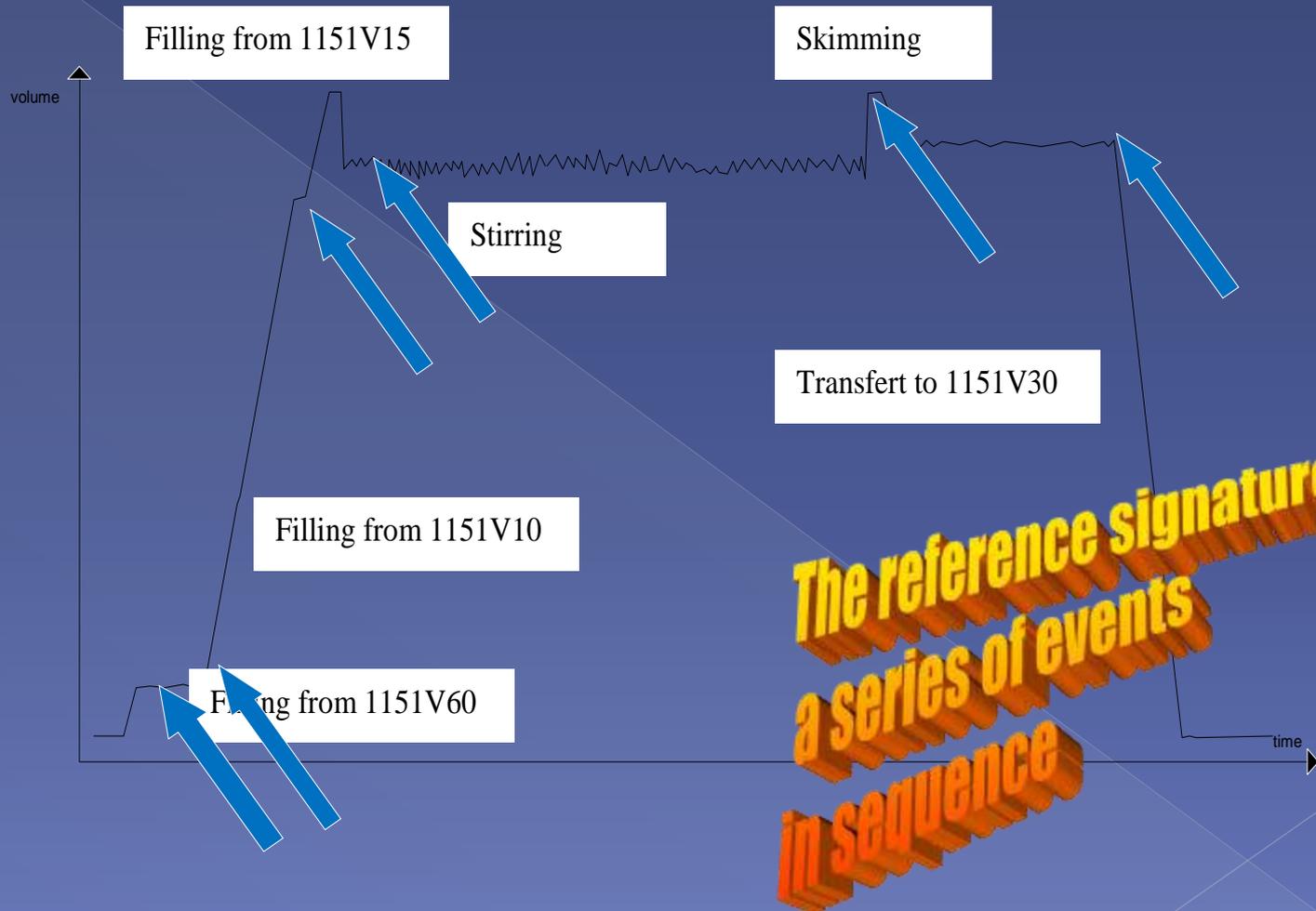


**Start with a reference signature for a vessel**

**A graph of time series data from SMMS**

# SOLUTION MEASUREMENT & MONITORING

## Configuration Module



**The reference signature is  
a series of events  
in sequence**

# GLOVEBOXES INVENTORY



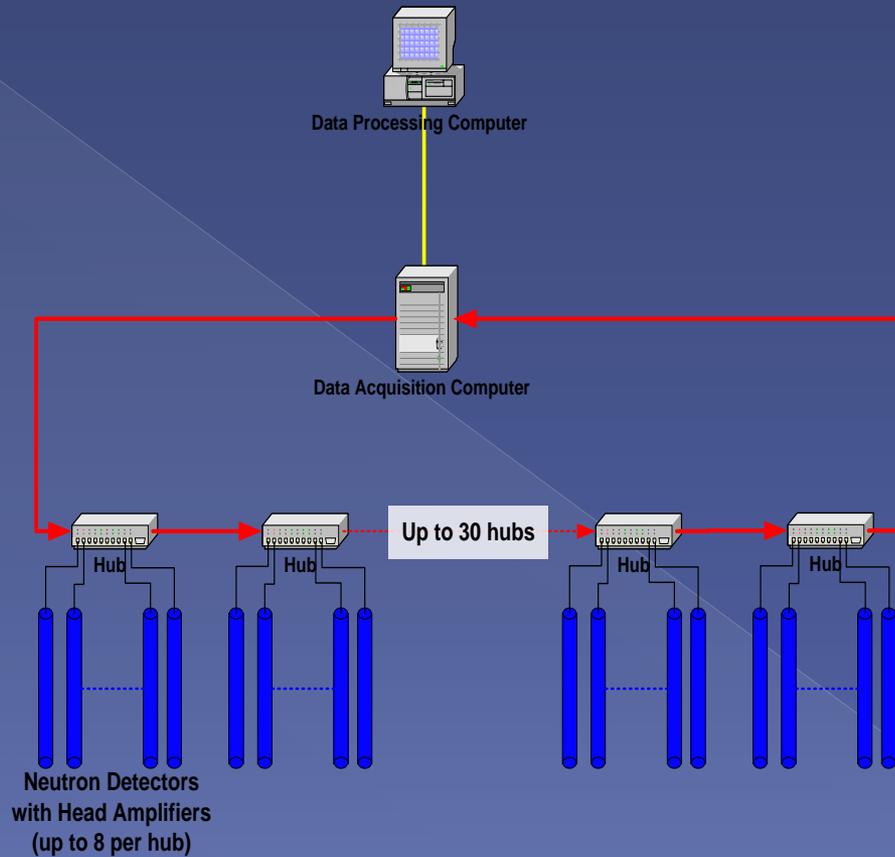
# GLOVEBOX MONITORING SYSTEM

**HUB box authenticated  
and sealed**



**2 detectors installed  
on a MOX  
conversion process**

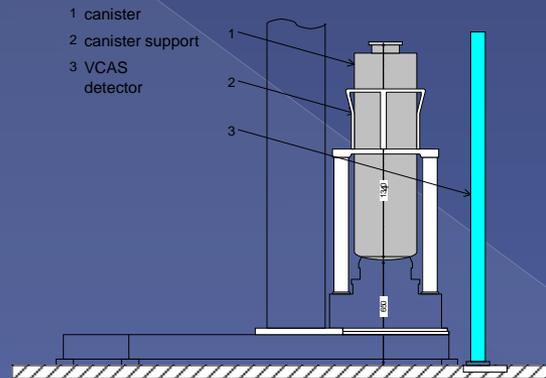
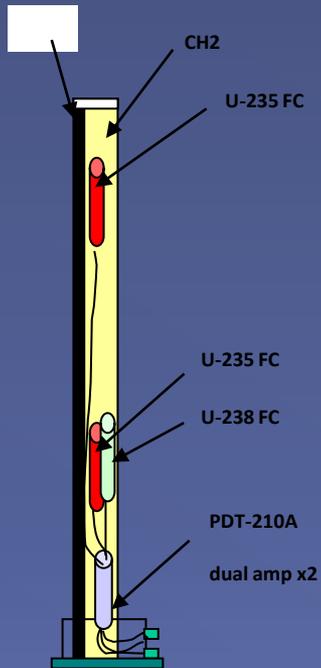
# GLOVEBOX MONITORING SYSTEM



# VITRIFIED WASTE IN CANISTER (LD)



# VITRIFIED CANISTER ASSAY SYSTEM



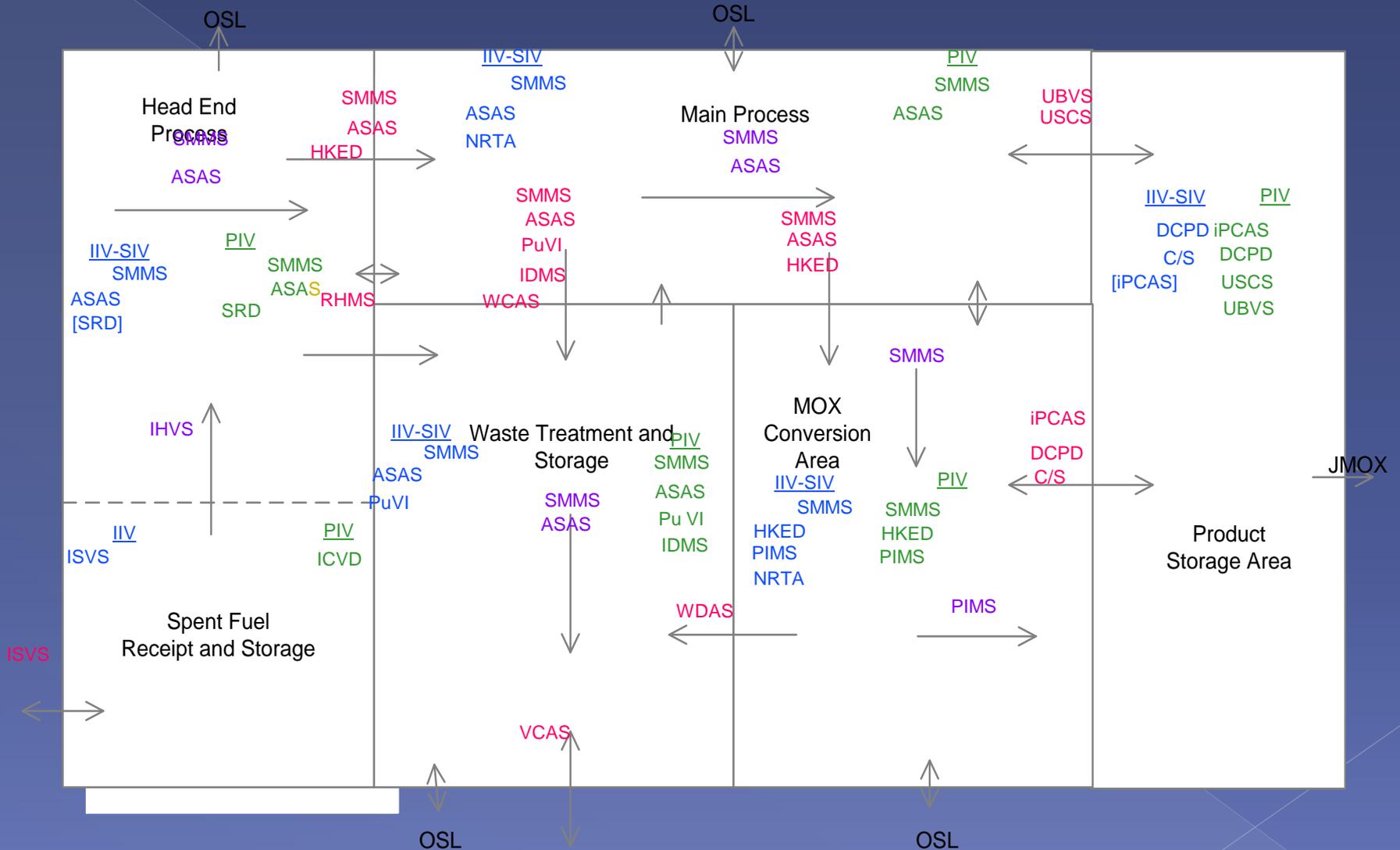
Vitrified Canister Assay System (VCAS)



# WASTE CANISTER ASSAY SYSTEM (TW)



# CHALLENGE #3 – VERIFICATION SYSTEMS



# CHALLENGE #4

## Sampling and Analysis

*How to take independent samples and obtain timely results?*

# CHALLENGE #4 – SAMPLING & ANALYSES

## The Solution

- Use operator remote sampling system
- Automatic Sample Authentication System (ASAS)
  - Independent Jug Passage Detectors (IJPD)
  - Correlated with SMMS, OSL and operator data
- On-Site Laboratory (OSL)
  - Joint-use with State
  - Timely results
  - Reduction of sample shipping costs

# CHALLENGE #5

## System Security and Authentication

*How to assure that unattended, remotely operated and jointly used systems provide valid and correct data?*

# CHALLENGE #5

## System Approach

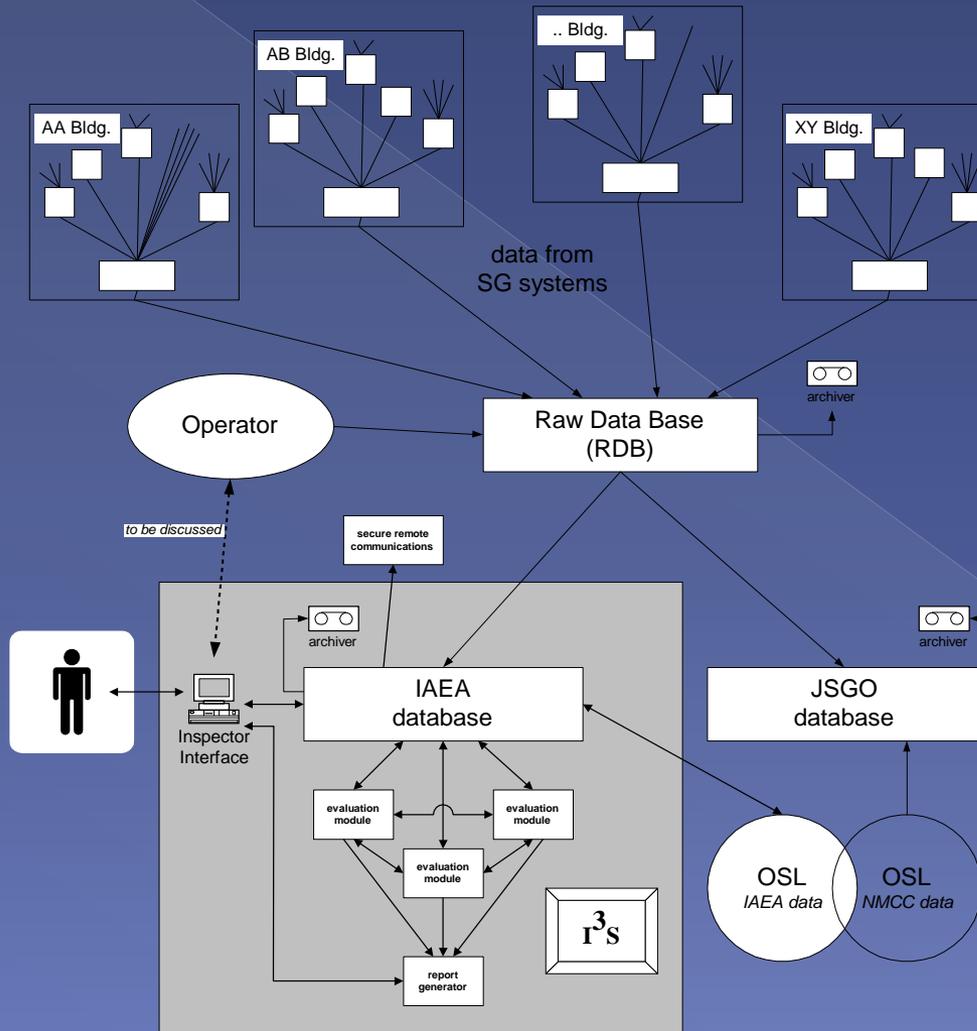
- Physical containment
- Technical approach (hardware/software)
- Procedural control

# CHALLENGE #6

## Data Collection and Evaluation

*How to collect, transmit and evaluate data from more than 100 measurement, monitoring and surveillance devices?*

# CHALLENGE #6 – DC&E SYSTEM



I<sup>3</sup>S

*Integrated Inspector Information System*

# OPERATOR-INSPECTOR INTERFACE

- Early submission of DI
- Early SG planning
- Shared resources
  - Financial
  - Expertise/staff
  - Equipment
- Maintain independence
- Evaluate joint-use systems carefully
- Optimize schedules
- Open and full cooperation

# EFFECTIVE AND EFFICIENT SAFEGUARDS

...requires the implementation of the '5-Ps'.

# PRIOR PLANNING PREVENTS P\*\*\* POOR PERFORMANCE

