Advanced Safeguards Measurement, Monitoring and Modelling Laboratory (AS3ML) at JRC-ITU-Ispra

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CONTENT

AS3ML : Rationale

- Integrated modeling of plant behaviour : to have a comprehensive plant view and allow "inter-connection" of safeguards measurements & operator data
- Combine proven safeguards techniques (NDA, DA, C&S) with innovative tools: ambient intelligence, location/tracking techniques etc…
- Validation/test bed for integrated models (both of equipment and entire plants set-up) both in terms of processes and data treatment
- Enhanced data analysis/statistics: incl. correlation / consistency analysis
- Innovative concepts to be validated, vulnerability assessments needed
- Act as an advanced integrated safeguards laboratory, with capabilities for R&D and testing, benchmarking and interaction with operators
- Serve as a comprehensive demo and training facility for students, inspectors, operators etc…
- AS3ML will develop also simulators both for an on-site safeguards office and for the safeguards headquarters

RATIONALE 2

- **Increasing efficiency and effectiveness** without compromising the safeguards objectives
- **Providing a validated basis for revising safeguards practices**
  Use much more operator & plant process control data
  Have an integrated/intelligent/interactive model of the plant
- **Evaluating competing technologies and practices**
  Multiple solutions exist to address the same challenge
  All to be installed / tested to seek for optimal combination
- **Maintaining the Inspectorates' ability to independently draw safeguards conclusions while ensuring the effective protection against disclosure of commercial, technological and industrial secrets**
- **Demonstrate capabilities to foster modernisation/acceptance**
- **Come to a WIN-WIN situation between inspectorate & operator**

AS3ML : Layout

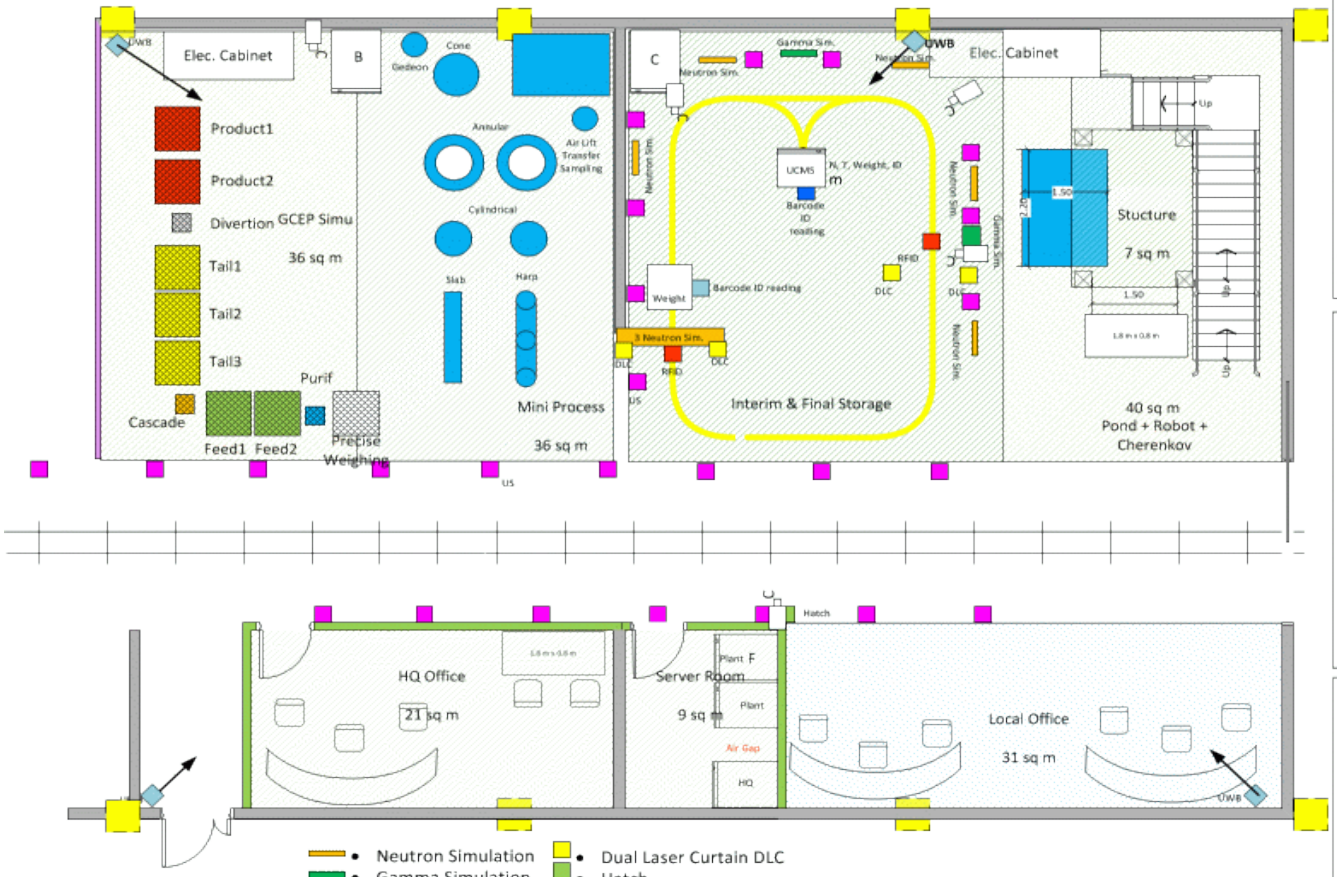
(Innovative) Safeguards Techniques

	Technology	Gas centrifuge	Fuel Fabrication	Reactor (operation)	Temp Storage Spent Fuel Pond	Spent Fuel Reprocessing	Final Storage / PuO2 Store	Models for techniques / sensors
T1	Electronic seals			X	X	X		
T2	US Seals				X		X	
T3	RFID	X				X	X	X
T3'	Geo-location	X	X	X	X	X	X	
T4	Camera (2D/3D)	X	X	X	X	X	X	
T5	ID (OCR) of cans		(X)			X	X	X
T6	3DLVS	(X)		X		X	X	X
T7	Laser Contnm & ID	X	X			X	X	X
T8	Investigative Inspector	(X)		X		(X)	X	
T9	2D Laser Curtains/DLC			X	X	X		
T10	Balance (mass)	X	X			X		X
T11	Pressure (level, density)	(X)				X		X
T12	Temperature	(X)				X		X
T13	Neutron	X	X		X	X	X	X
T14	Gamma counting	X	X		X	X	X	X
T15	Gamma spectrum		X		X	X	X	X
T16	On-site lab (*)					X		
T17	Cherenkov radiation				X			
T18	Micro gravimetry						X	
T19	DA-Analytics (*)	X	X			X		
T20	Satellite imagery	X		X			X	X
T21	Remote data transmiss.	(X)	X	(X)	(X)	X	(X)	
T22	Process/Data Analysis	X	X	X	X	X	X	X
T23	Integrated Plant Model	(X)		X		(X)		

AS3ML : Layout

European Commission

Innovative Safeguards Techniques



Interim & Final Storage

- Neutron Simulator
- Neutron Coincidence Counting
- Neutron Multiplicity Counting
- Gamma Simulator
- Gamma Counter
- Gamma Sprectrum
- ID Reader
- Barcode Reader
- Dual Light Curtain
- Secure Radio Frequency ID
- Weighing
- 3D Drum Authentication
- Geolocation
- Media Converter

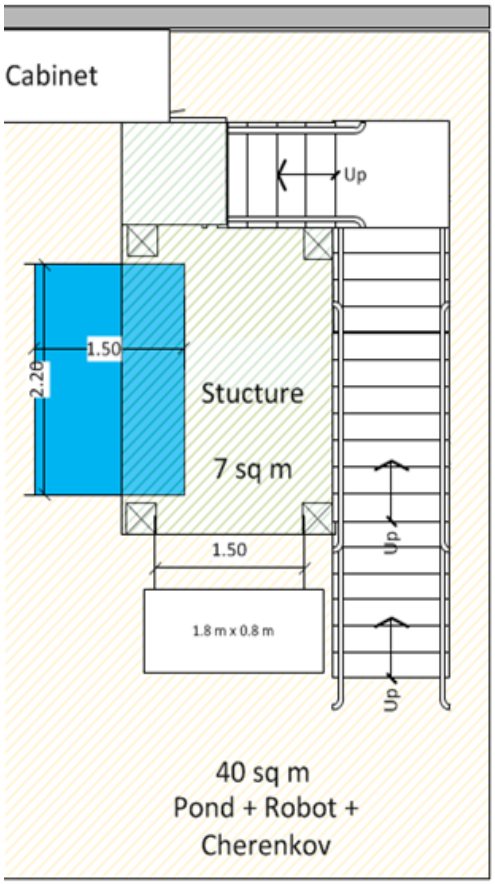
Mini Process

- Buffer Tank
- Cylindrical Tank
- Cone Tank
- Slab Tank
- Harp Tank
- Annular Tank
- Gedeon transfer
- Air Lift transfer / Sampling
- Siphon transfer
- Gravity transfer
- Pump transfer
- 3D Reconstructor

Pond

- Structure
- 2 Pools for separate test
- Cherenko simulation
- US sealing systems
- Fuel rack Mock-up
- Fuel ID Automated verification
- Horizontal laser curtain

Spent fuel pond
Linked to seals-lab



Demo & training on current & future underwater sealing implementation(such as in Cernavoda, Darlington, Karachi, La Hague, …)

Dry storage test area (US seals, electronic,..)

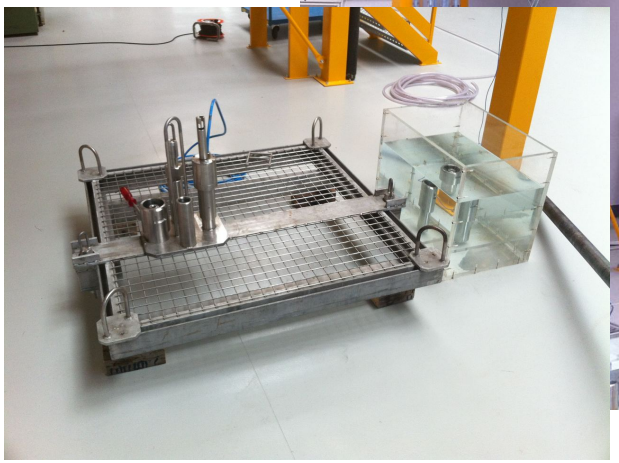
Mixed ultrasonic / fiber optic seal (Cat A)

R&D on new solutions
- unattended and/or remote verification
- laser curtain surface monitoring
- automation of the verification of US seals
- Cerenkov effect simulation
- Sonar 3D underwater monitoring

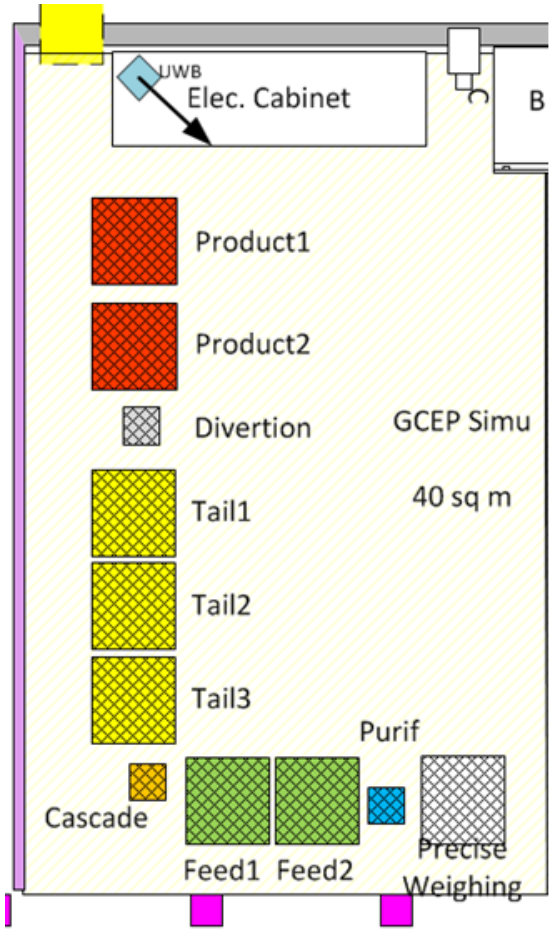
Mock-up of spent fuel racks are available for different reactors

Elevated Platform

- Simulation of the bridge over the underwater storage pond
- Enable use of real handling sealing tools
- Stable and safe to be used for development and training purposes



GCEP area
Linked to modelling



R&D on enhanced GCEP Safeguards including :

-Monitoring of the (feed, product and tail) load cells; coupled with

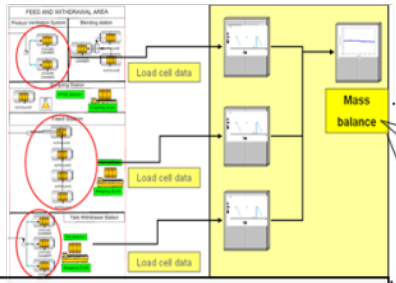
- Verification of plant operation through cascade/centrifuge modelling

- Tracking/identification/authentication of cylinders entering/exiting the facility

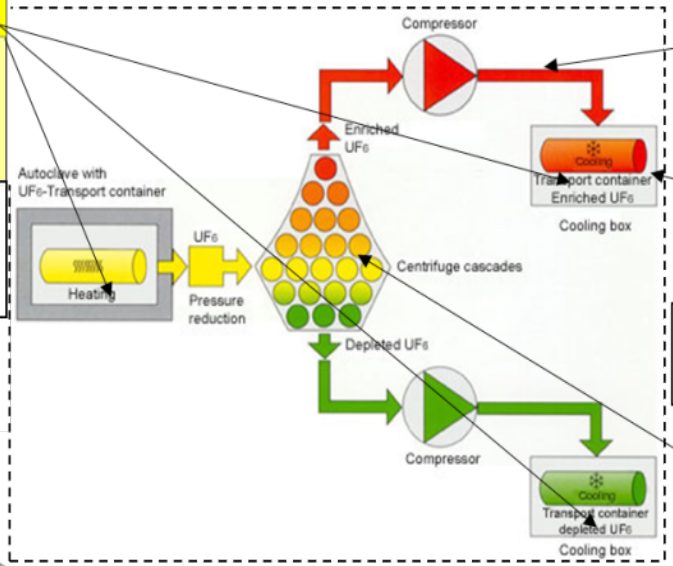
- Monitoring of activity through tracking of movements of the loading machine

Testing & optimization of acquisition parameters
Testing & validation of theoretical centrifuge/cascade models
Testing & training on software to detect diversion scenarios

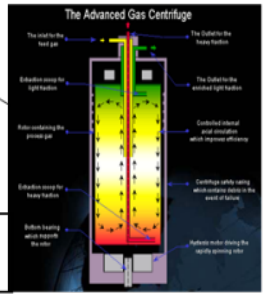
On-line enrichment monitor



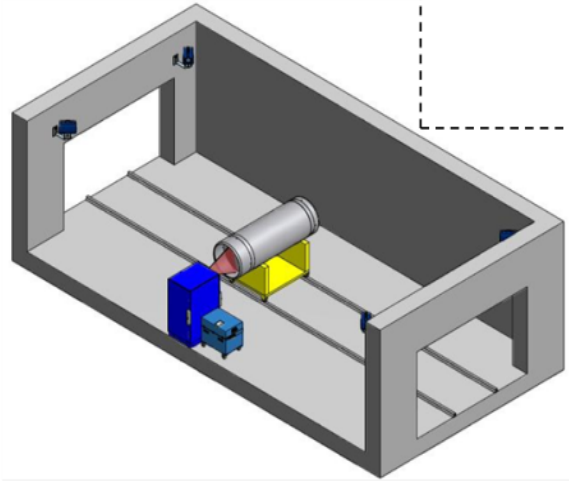
Real-time monitoring of load cells



Improved NDA for enrichment verification in product cylinders



Modelling of cascade

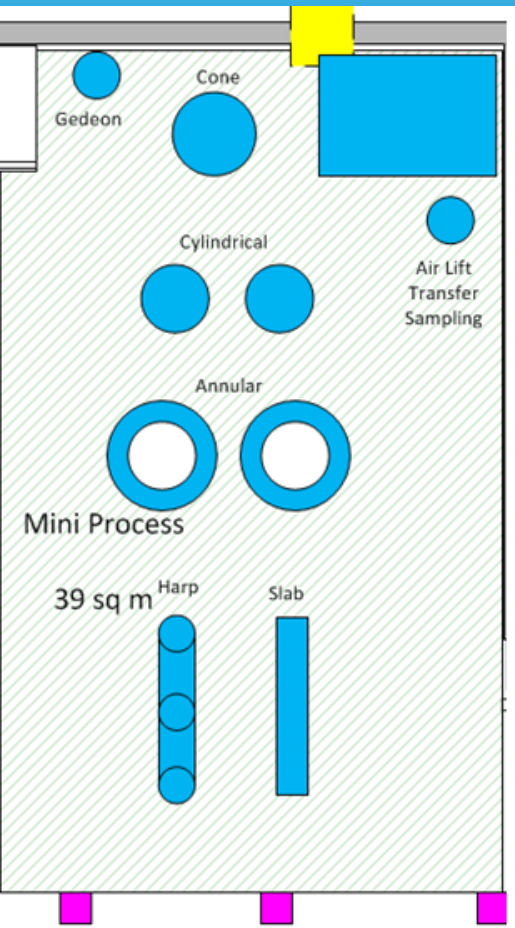


RFID cylinder tagging

UF6 cylinders identification and authentication

Portable mass spectrometers

Mini Process area



The Mini-Process area is mainly intended to

- simulate the transfer of solutions containing nuclear material in reprocessing plants
- test the software used to monitor the process
- train the inspectors in the review of data.

This area complements the full-size equipment of PML providing a variety of smaller scale vessels of different shapes (cylindrical, conical, slab, annular, harp,…) connectable with a choice of transfer systems (pumps, gravity, syphon,…).

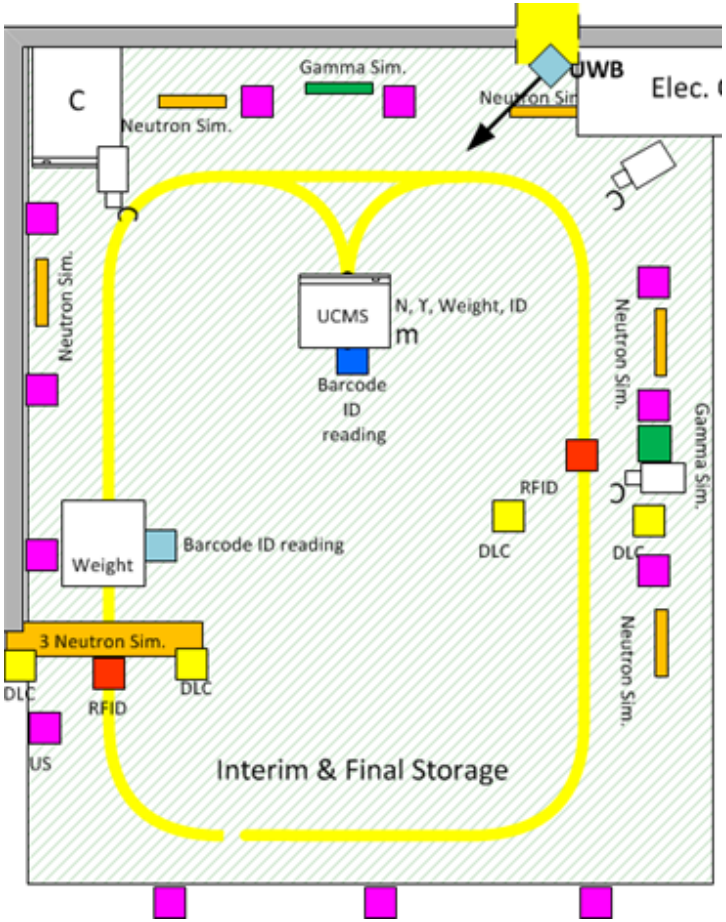
R&D :

- development and validation of software for automated calibration of mass/volume measurement devices and
- for the tank calibration verification by continuous flow mode

Use the monitoring software tool, called DAI (Data Analysis and Interpretation) specifically designed for process monitoring in RPs, nowadays allowing also monitoring most of the safeguards-relevant processes in other nuclear facilities.

This monitoring tool does more than just supervision: it interprets the signals and verifies the consistency and coherency with predefined criteria and without intervening in the process. These criteria are based on the design characteristics of the recipients and transfer mechanism.

Interim / Final store



All types of sensors that can be used to track and follow movements of items

- Simulated Radiation detectors (gamma and neutron)
- Surveillance equipment (cameras and lasers)
- Weighing systems
- Identification devices (bar-code readers, RFID,…)
- Localisation devices (UWB, ultrasound…)
- Seals

The storage area will also integrate results of the innovative work on 2D and 3D cameras and advanced review software and the 3D Laser Verification System.

AS3ML Interim & Final Storage

Interim & Final Storage Hardware			
Intelligent Industrial Sensor	3D sensor	3D Can authentication	T6, T7
	SICK DLC	Dual Light Curtain	T9
	COGNEX	2D 3D Bar code reader	T4
	BAUMER	OCR	T5
	QualiVision	2D Image Processing	T4
	EVT	2D Image analysis Software	T4
	AXIS	2D Camera	T4
	Mobotix M12	Dual 2D Camera (day nigth)	T4
	Mobotix Mx2Wire	Media converter	T4
	FLIR A615	Infrared Camera	T4
	GFM ShapeScan 3D	Phase Measurement Fringe Projection	T6
Material Movement	Robot	Simulation of nuclear material movements	T13, T15
	Mettler Toledo Weighing scale	Weighing scale Unattended Combined Measurement System	T10
	ds automation Sound & Vibration	GCEP Sound and Vibration Analysis	T22
Unified Architecture	OPC UA Data Authentication System	Data Authentication System	T21
Signal Simulator	Neutron Pulse	Neutron Source + Detector Simulator	T13
	Gamma signal	Gamma Source + Detector Simulator	T14, T15
Signal Acquisition	Neutron Pulse	Fast List Mode Acquisition + Analysis	T13
GeoLocation	Hexamite Ultrasonic/RFID positionning	Ultrasonic/RFID positionning receiver transmitter	T3'
Secure UHF RFID	Avonwood Receiver / Transmitter	Authenticated RFID	T3

Inspectorate Head Quarters

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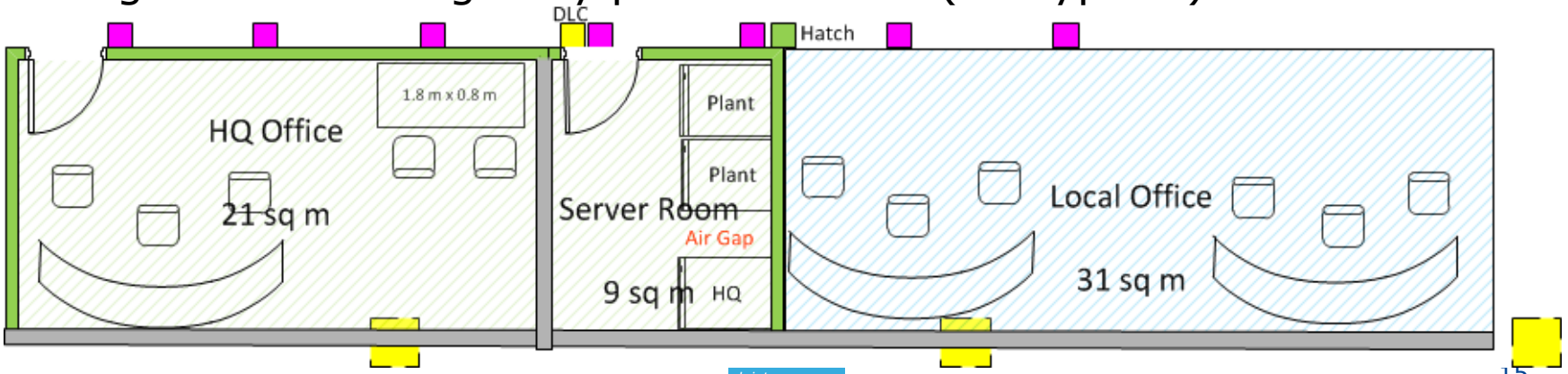
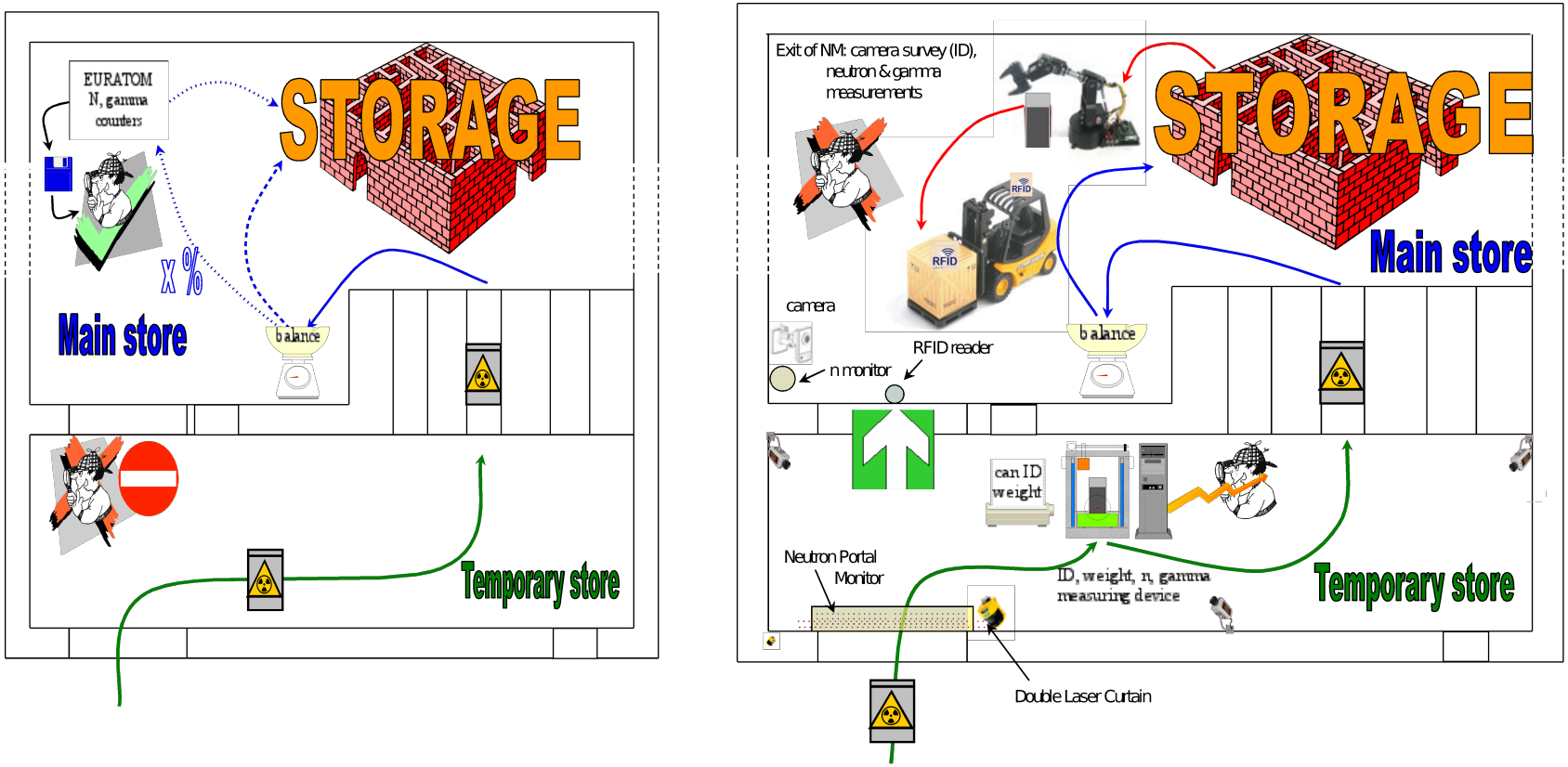
HQ Office		
	Server	Local Server with local Application
	PC	3 High end PC with Client Application
Server Room		
	Server	Local Server with local Application
	Data Historian	Data Historian for storage of acquired data
Local Office		
	PC	3 High end PC with Client Application
	3D Projector	Projector for 3D review
	Control Room equipment	Special equipment

- Simulation of the local inspector office and of the inspectorate headquarter to study and test remote data transmission issues
- Communication between facility and local office and between local and HQ offices should include authentication features
- Data communication between local and HQ offices shall have integrity strength to be managed by public internet (encryption)



Joint Research Centre

Example integration In PuO_2 Storage



Handling of PuO_2 canisters at the plutonium storage following the current procedure (left) and the proposed, new procedure (right), making integrated use of several surveillance and measurement devices and not requiring on-site presence of the inspector.

REF : R. Richir et al, Design and Implementation of equipment for enhanced safeguards of a plutonium storage in a reprocessing plant (S03-05)

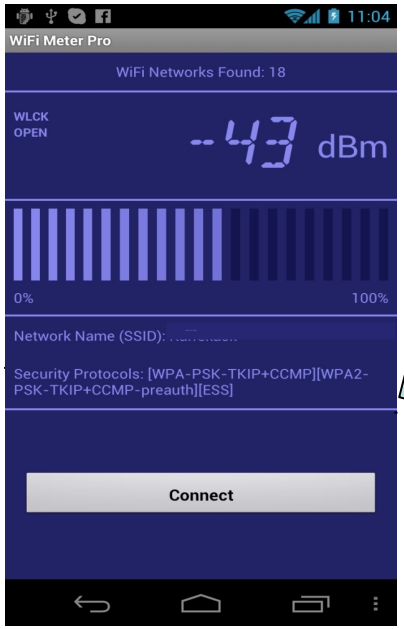
Nuclear materials simulation

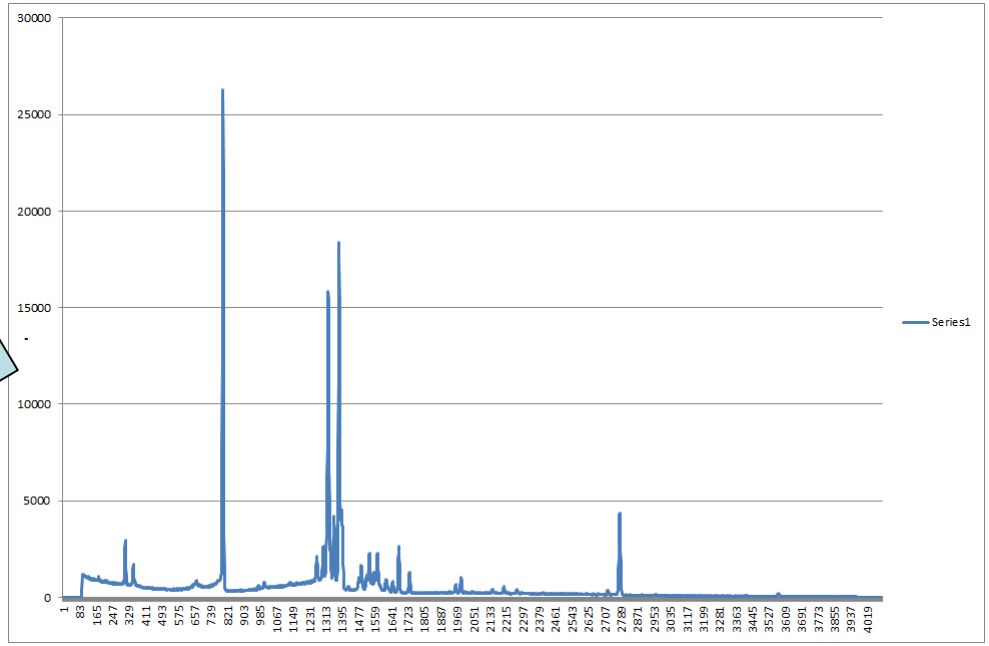
European Commission

Principle neutron and gamma simulator :

A Wi-Fi emitter sends its signal with ID

ID





A Wi-Fi receiver measures the signal strength and based on the ID generate the appropriate Pulse for the Multi Channel Analyser or Neutron Counter

Retrieve information (IC, mass,..) according to ID from the database

The pulse rate will be proportional to the signal strength

Conclusion


Innovation
WIN-WIN
Operator/
Inspector
AS3ML
Available
FOR YOU !
Testing &
Validation
Demo
&
Training