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The Plutonium Inventory Measurement System (PIMS)

Validation & Performance Tests at the JNFL Rokkasho Reprocessing Plant (RRP)

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Introduction

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- Motivation
  - ➢Recent success of validation trials at JNFL Rokkasho Plant
  - ➢Integration of PIMS system (safeguards/process operations)
  - ➢Benefits of PIMS for real time monitoring
- About us
- PIMS Concept
- System Architecture
- JNFL Rokkasho PIMS System
- Safeguards Integrated RRP PIMS
- IAEA / JNFL Validation Results
- Summary

About us

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- Part of of British Nuclear Fuels Limited (BNFL)
- Highly qualified specialists across a range of scientific, technical and engineering disciplines including:
  - Project Management and Nuclear Engineering / Decommissioning
  - Environmental and Waste Management
  - CBRN
  - Services and Instrumentation (S&I)
- Specialists in providing integrated radiometric detection and measurement systems
- 50 years international nuclear experience
- Over 800 staff

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PIMS: Requirements

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Plant Operator Perspective

- **To provide a near real time monitoring system enabling continuous tracking of process material as it moves through the plant providing the plant operator with reassurance that the plant is functioning correctly and material blockages / spillages are not occurring**

Safeguards Perspective

- **A monitoring system that provides a 'snapshot' view of the inventory of the plant and its distribution. Enabling the plant operator to declare such inventories (in conjunction with book accountancy) and Safeguards to verify the operator declared data is correct**

PIMS: Concept

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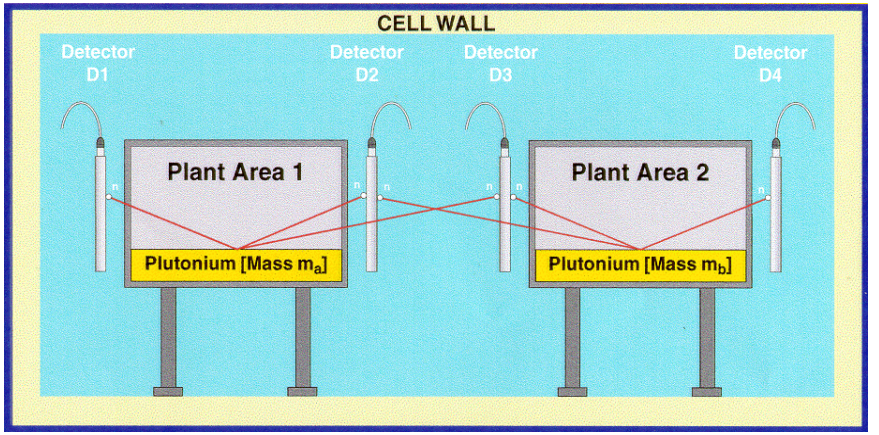
- **Array of neutron detectors positioned throughout the process plant**
- **Total neutron counting technique**
- **Matrix based solution to calculate neutron emissions and Pu mass**

$$R_1 = k_{1,1} \cdot N_a + k_{1,2} \cdot N_b$$
$$R_2 = k_{2,1} \cdot N_a + k_{2,2} \cdot N_b$$
$$R_3 = k_{3,1} \cdot N_a + k_{3,2} \cdot N_b$$
$$R_4 = k_{4,1} \cdot N_a + k_{4,2} \cdot N_b$$



$$R = k \cdot N \longrightarrow N = k^{-1} \cdot R \longrightarrow m = k^{-1} \frac{R}{SNE}$$

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PIMS Architecture: Schematic

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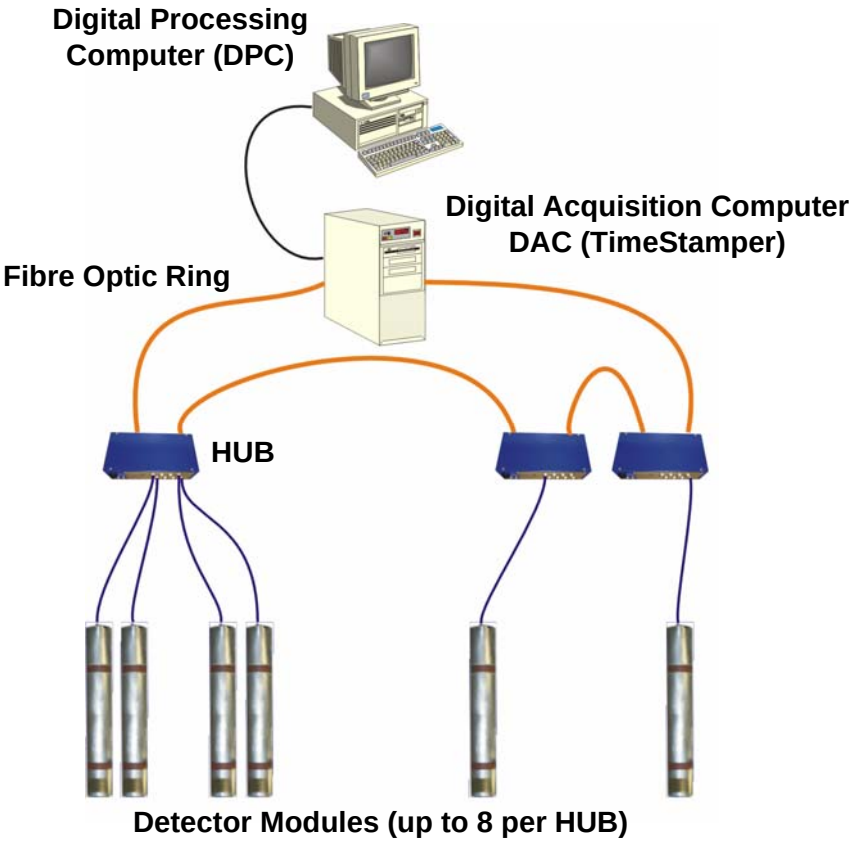

Design of detector module ensures no access to amplifier or detector

Permits use of IAEA safeguards seals

Directly mounted head amplifier

Close coupling ensures minimal noise pick-up

High / low voltage supplies

Signal Processing

Assigns digital address to each pulse

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PIMS Architecture: Benefits

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Scalability: 1-8 detectors/hub and up to 30 HUBS / DAC
Expansion beyond 240 detectors using networked DACs

Flexibility: Software based data processing, can be configured to perform total, coincidence or multiplicity analyses.
Minimises spares, retrospective analysis possible

Costs: Multiple cables (voltage / signal) replaced by single fibre optic loop

Reliability: Directly mounted amplifiers, reduced noise
Fibre optic - no noise potential during amplification

Resistance: No internal access to amplifier circuitry
HUBS located in sealable enclosures
Fibre optic ring monitored for continuity

RRP PIMS: Timeline

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Design / CAT	Installation	Installation Commissioning	Inactive Calibration	Inactive Proof Test	Active Validation	Optimisation

Timeline

- ✓ Implementation Design & CAT – 2002 (JNFL / IAEA / PS S&I)
- ✓ System Installation - Spring 2003
- ✓ Installation Commissioning - Summer 2003
- ✓ Calibration / System Test / Standardisation – August to November 2003
- ✓ Inactive Proof Testing (awaiting active plant go-ahead)
- ✓ Active System Validation Trials - Winter 2006 (IAEA / JNFL / PS S&I)
- ✓ Validation Reporting to JNFL / IAEA - Spring 2007
- ✓ System Optimisation - November 2007
- ➢ RRP Commercial Operations

RRP PIMS: Solution

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- Inactive Calibration (691 discrete point source measurements)
- Modelling (point source data and volumetric responses)
- 142 detector modules deployed
- 23 HUBs
- 4km of detector cabling (c.f. 14 km using traditional neutron electronics)
- 0.8 km of multi-core fibre optic
- 85 individual process areas
- 11 reportable gloveboxes
- 10 non-reportable gloveboxes
- Plant Total

Continuously Monitored

- PIMS Update = 60 seconds (Automatic Inventory Mode)

RRP Safeguards Integrated PIMS

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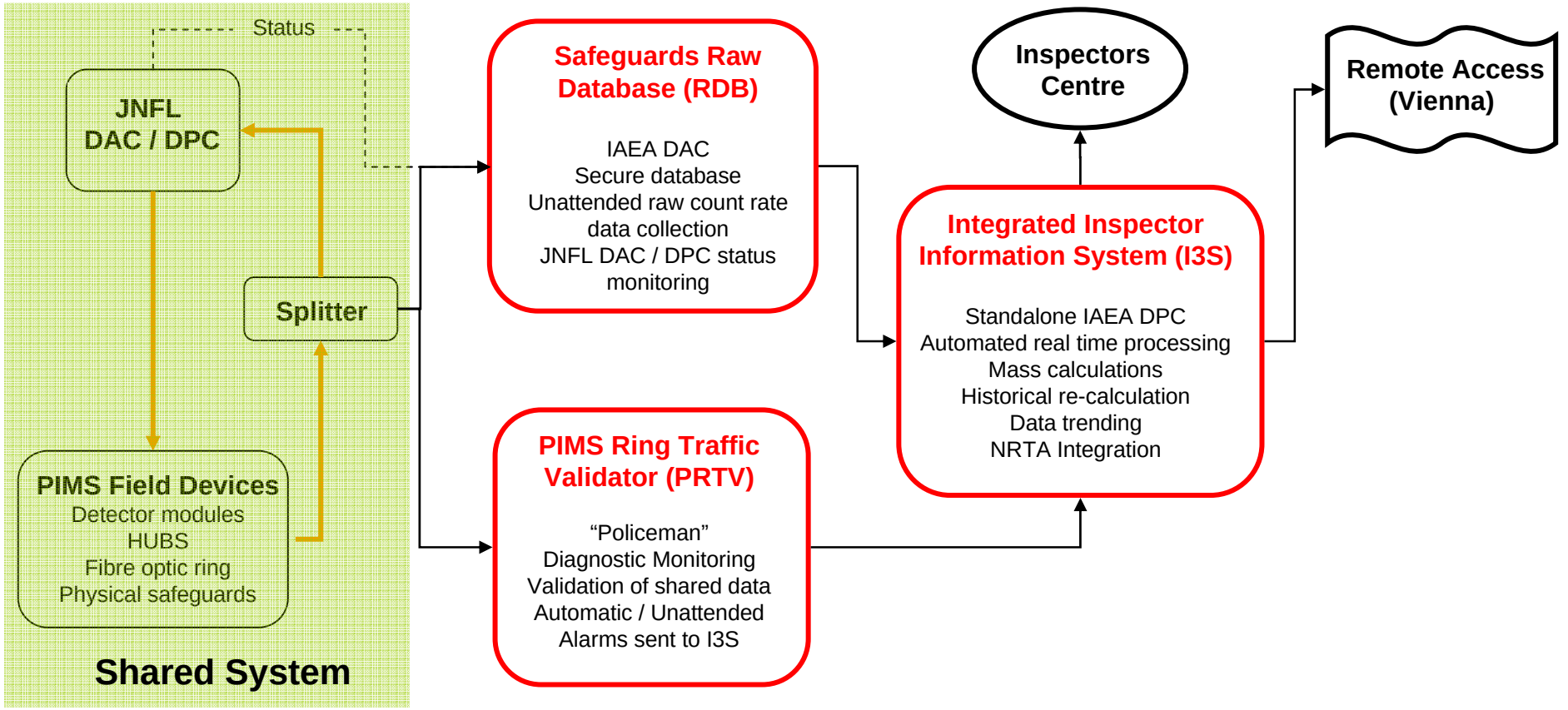

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PIMS RRP: Validation

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- Active material validation performed in November – December 2006
- Witnessed by IAEA / JNFL / Project Services
- Controlled input / output of material into process areas / gloveboxes
- Chemical sampling and DA used to support data analysis
- Comparison between JNFL declared and PIMS measured results
- Validation covered:
  - De-nitration Operations
  - Temporary Canister Operations (Calcination, Reduction, Milling GB)
  - Blender Operations – 25 batches of material
  - Process Monitoring (mass trending)

Plant Total Validation

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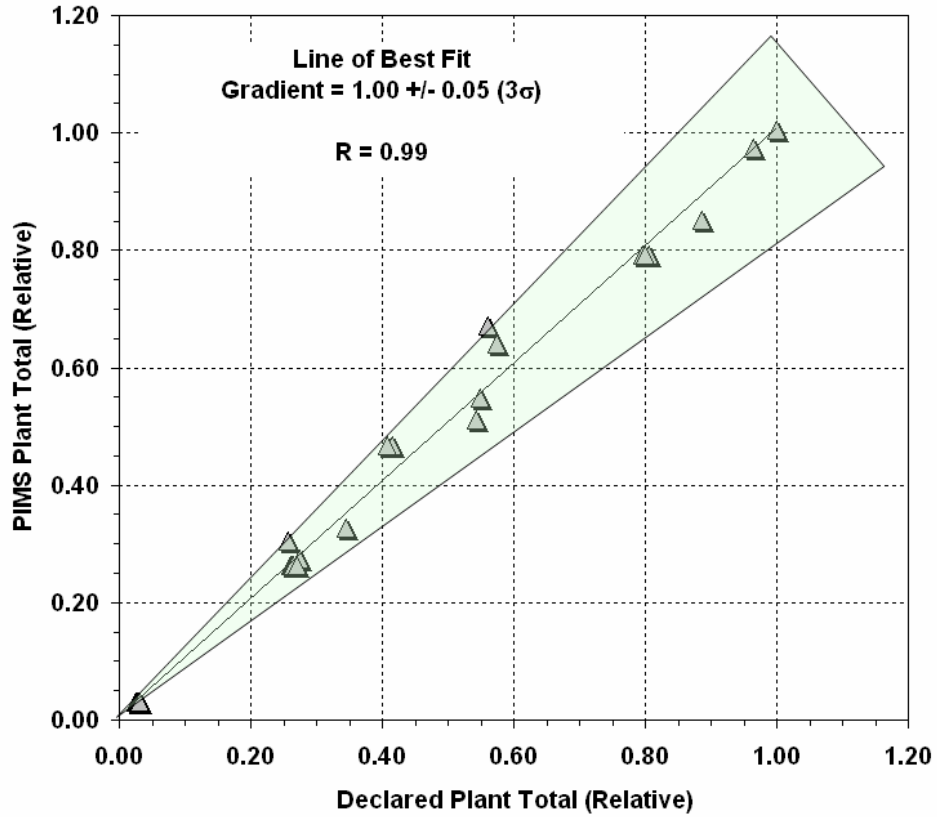

Comparison of PIMS measured and declared plant total inventories

The shaded region represents the target PIMS performance of +/- 6% (1σ)

Blender Validation

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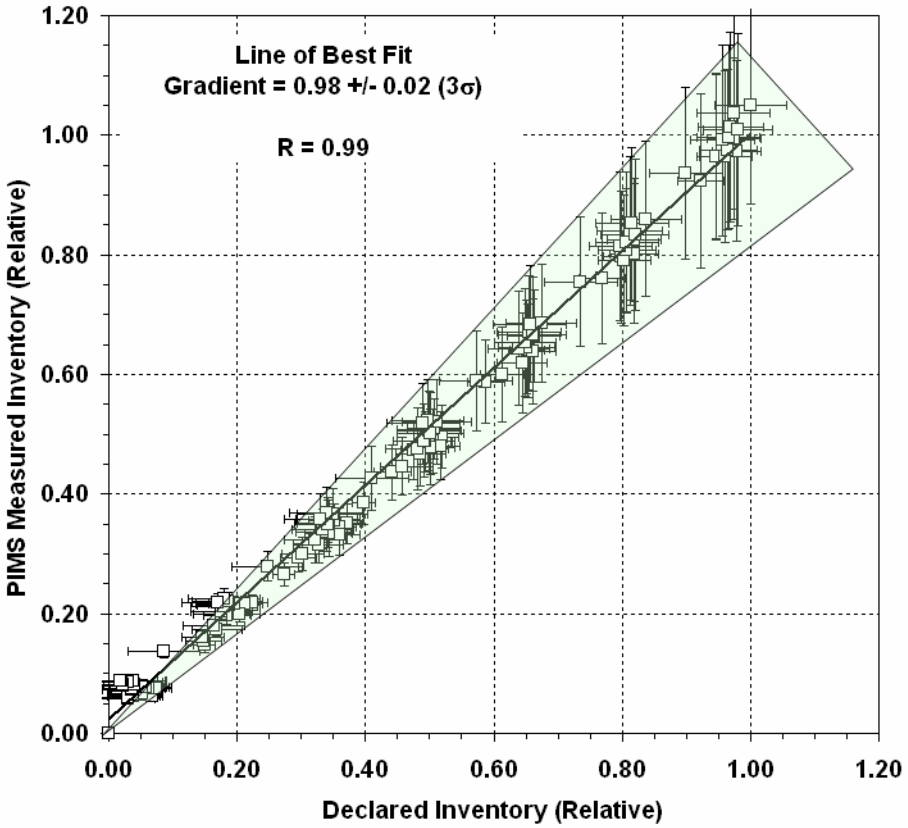

Comparison of PIMS measured and declared Blender inventories (Batches 1-25)

The shaded region represents the target PIMS performance of +/- 6% (1σ)

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Process Monitoring

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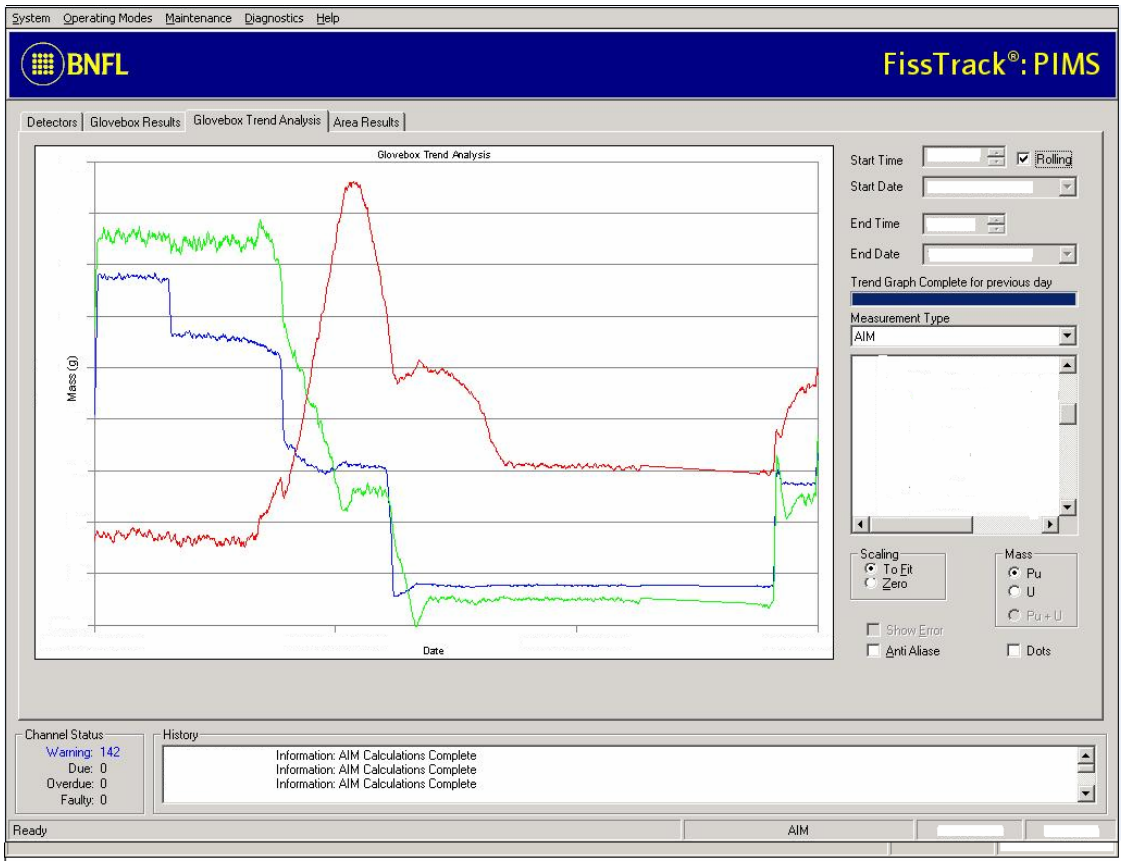

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Benefits of PIMS & Future Systems

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- A proven technique with experience from a number of operational Plutonium facilities (SMP, THORP, RRP)
- PIMS - real time Pu distribution and mass monitoring across an entire Pu processing plant - including MOX
- In Situ – no disruption to plant operations, no “quiet” phase
- Shared System designed for Safeguards & Plant Operations
- Continuity of historical data for investigation of previous events
- Re-analysis of historical raw data to maximise inventory accuracy
- Trending of raw and inventory data to aid identification of suspicious events

Benefits of PIMS & Future Systems

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- Proven integration with IAEA safeguards systems (NRTA, I3S)
- Shared detection system to minimise procurement costs
- Unattended with remote access to minimise operational costs
- Patented neutron timestamping solution
- Automated unattended real time tamper detection system (PRTV)
- Common spares
- Past investment = minimal future development costs
- Existing & Proven technology = no development risks

. . . . Finally

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- **Thank you for listening**
- **Acknowledgement of support and collaboration between IAEA and JNFL**
- **Please visit us on our exhibition stand for further information**

www.projectservices.com
www.bilsolutions.co.uk

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