Application of innovative, digitalisation and robotics based, solutions for decommissioning and life-cycle management of nuclear facilities

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The market need

- Technologies like IoT, sensor technology and unmanned vehicles (UVs) etc. are overcoming the primary obstacle (acquisition of required input data) for enabling integrated digital systems supporting operations in environments with industrial hazards.
- Robots are becoming feasible alternatives to humans for working in environments with industrial hazards.

However, integrated hazard awareness (‘intelligence’) (preferably real-time) is required for complementing such systems, e.g. for feasibility and safety demonstration, training, mission control, radiation protection, safety monitoring and other purposes.
Hazard Aware Digitalisation and Robotics in Nuclear and other domains
Core background

Risk assessment
- Real time radiation transport
- Geostatistics
- Monte Carlo radiation transport
- Source deconvolution
- 3D gamma mapping
- Aerosol inhalation
- Internal and external radiation exposure of workers

Non tech
- Workforce management – training
- Knowledge management
- Human and organisational factors

Technology
- 3D modelling
- Virtual and Augmented reality
- Advanced user interfaces
- Mobile and wearable devices
- Machine Learning (AI)
Radiological hazard modelling

Real-time (Point Kernel) radiation transport

MC radiation transport (MCNP, GEANT4)

Interpolation, Geostatistics

Source deconvolution

Atmospheric dispersion

Complex Source (with unknowns)

Background (measurements)

air

shield

shield

self absorption/attenuation

Heavy structure

Human body

Reflection
sky-shine

$C(x, y, z) = \frac{Q(x)}{2\pi \cdot \sigma_x(x) \cdot \sigma_y(x) \cdot u_{10}} \exp \left[ -\frac{y^2}{2\sigma_y(x)^2} \right] F(x, z)$

$C(x, y, z) = \frac{Q(x)}{\sqrt{2\pi} \cdot \sigma_y(x) \cdot A} \cdot \exp \left[ -\frac{y^3}{2\sigma_y(x)^2} \right]$
Examples of Hazard Aware Digitalisation and Robotics

applications in nuclear decom.

focus on radiation protection
Long term decom support projects by IFE abroad

Fugen NPP (JAEA) (1995 - )
Leningrad NPP (1999-)
Andreeva bay, NW Russia (2011-)
Chernobyl NPP (2008 - )
Towards holistic support

3D scanners
Hazard sensors
Other analyses codes

Documents →

Semantic info systems

Project planning, costing ... systems

3D sim. supported work planning/ training

VRdose family

- Radiological input data
- Custom importers from historical database(s)
- Linked documents

CAD model

MCNP
Holistic digital support for decom

- Radiation protection / safety requirement management
  - Safety reports
  - Info portal
    - Plant info
    - HR info, tools/technologies, requirements, documents ...
  - Project planning
    - Job resource needs
    - Costing
      - Resource needs, impacts (dose, waste, …)
      - Scenarios
  - 3D job planning
    - Job/strategic plans
    - Resource needs, impacts (dose, waste, …)
    - Environment, work plans
    - Risks, hazards
    - Scenarios
    - Modelling
    - Training
      - job specific training material
Prototyping integration of digital capabilities for decom

BIM

Characterisation

Information management

Project management

Costing

Radiological mapping

Job planning

Safety demonstration

Training
BUT how can we get the data?

- New cheap tech for 3D data
- New tech integrating 3D data acquisition into rad. characterisation champagnes
- New tech for deploying sensors/samplers – remote/robotic/autonomous systems
Strategic research programmes (SIS)

- DecomSIS: Competence building at IFE within nuclear decom.
- HaLeDi: Acquisition of 3D data for digital support

3D simulating based support platform
RoboDecom – Robotics for decommissioning

- Integrate standard / emerging equipment in a modular design
- Integrate digital, sensor and robotic tech
- Enable high autonomy
- Prove safety/security
- Validate in the field and prove efficiency
- Full scope support: design, training, control, ...
- Guidance for application to specific needs
RoboDecom prototypes

Digital support platform
Digitalisation + robotics

Support for: design (especially modular systems), feasibility testing, control, training, demonstration, ...

Input data

Robots with sensors

Digital twin of the facility/site

Digital twins of robots
OECD HRP Decom research 2021-23

Spatial Computing and Augmented Reality for Hazard Mapping and Visualisation

Automated Assessment of Field Worker Performance using VR and AR-based Simulator Training

Enabling Robotic and Remote Operations

Higley collaborative international research under OECD-NEA umbrella between more than 100 organisations.
The **MedProt** project

**Sub-project:**
**Automated manufacturing and dispensing of radiopharmaceuticals**
SMARTES - emergency management

To create an innovative cyber-physical system supporting first responders in complex emergency scenarios

1. Unmanned Robotics & Sensing
2. Digital twin & Hazard simulation
3. Acceptance
4. Decision making
5. Training

Environment conditions
Site information
Health data

Teams in the field
Command Centre

Physical World
Digital World

Health & Risk Modelling
Hazard Mapping

Digital Platform
Simulation
Live Data

Robotics
Tracking Systems
Physiological sensors

H2020 proposal
Digital twins for robotics
Machine learning and AI

Rust

Clean

Virtual

Real

Potholes and cracks

Visual quality inspection for radiopharmaceuticals
IFE - International Collaborating Centre of the IAEA

IFE – the first IAEA collaborating centre in the field of nuclear decommissioning

The IAEA and Norway’s Institute for Energy Technology will work together on digital innovation and transformation of decommissioning.
Training course
2020 Norway

DigiDecom ELINDER 2020
Innovative Course on Nuclear Decommissioning
Date TBD 2020, Halden Norway

Learn how to take advantage of exciting key technologies like virtual & mixed reality, robotics, AI and serious gaming for safe and efficient disposal of our nuclear heritage.

Learn about
- Current practices and lessons learned from real-life projects
- Innovative methods for safety assurance, radiological protection and knowledge management
- New trends for application of digitalization, robotics, machine learning and AI

Using
- VR immersive - interactive presence
- Serious gaming & simulation based story telling
- Augmented Reality based examples
- Digital twins of traditional/emerging equipment

Through
- Examples from real-life projects
- Friendly group competitions and prizes
- Learning by doing – practical exercises in VR
- Possibility for using data and examples from you

Hosted by IFE, a designated IAEA Collaborating Centre.
Targeted for professionals and newcomers with background in the nuclear and interests in digital innovation.
Elinder2020@digidecom.eu www.ife.no/digidecom-elinder-2020

Price: 2000 EUR incl. all lectures, eLearning package, facility visits, exam and certificate, as well as social events.

EU students qualify for applying for support through the ENEN+ project (see details on-line).

www.ife.no/digidecom-elinder-2020
DigiDecom 2021

International Workshop on Roadmap for Decommissioning Innovation

Digital transformation and other game changing trends

2021 March, Halden, Norway

The workshop aims at bringing together a multidisciplinary international community for open and highly interactive exchanges about experience from earlier applications, as well as opportunities for future applications of new technologies and methods.

www.ife.no/digidecom2021