Annex 5: Challenges definition

WATER SUPPLY AND SANITATION

CHALLENGE 1: REDUCTION OF CLEAN WATER LOSS (LEAKAGES)

- Multi-sensing inspection robot for pressurized water pipes, able to enter through small access points and to identify defects,
- Multi-sensing inspection robot for water reservoirs, to identify defects,
- Robot able to perform repair tasks when a defect is detected,
- Robot for safe and rapid access and repair of underground pipes (including pavement cutting, detection of underground networks, ...),
- Multi-sensing inspection of large areas using aerial robots,
- Example of robotics' application in challenge 1: Inspection of water pipes including maintenance/repair.

CHALLENGE 2: INCREASE EFFICIENCY OF WATER QUALITY CONTROL (RELIABLE AND AFFORDABLE)

- Multi-sensing inspection robot for water and wastewater pipes, able to perform continuous measurements, detect water contamination issues, trigger alerts, and grab samplings if needed,
- Autonomous surface vehicles able to control and communicate water quality and to operate long-term without human intervention. Example of robotics' application in challenge 2: Warning systems which detect water contamination and active sampling.

CHALLENGE 3: ENSURE WATER INFRASTRUCTURES ARE OPERATIONAL AND SAFE

3 a) SEWERS

- Multi-sensing inspection robot for empty, partially full or full water pipes, able to enter through limited access points and to identify defects,
- Multi-sensing inspection robot for underground (empty) retention tanks, able to identify defects. Robot or Cobot to perform lifting of manhole covers while preventing musculoskeletal problems for field operators.

3 b) TREATMENT PLANT

- Multi-sensing inspection robot for treatment plants' underground facilities, able to identify defects.
  Example of robotics' application in challenge 3: Versatility, range, autonomous operation of robotics' maintenance and repair.

CHALLENGE 4: ROBOTICS TO ISOLATE WORKERS FROM RISKY INSPECTION IN CONFINED FACILITIES.

- Aerial robotics for tanks inspection without emptying the tanks. Able to take water samples for analysis,
- Robotics able to work in confined spaces in order to avoid human risks,
- Enabling technologies for increasing precision in robotics I&M tasks.

ENERGY GENERATION AND DISTRIBUTION

CHALLENGE 1: HYDRO POWER INSPECTION AND MAINTENANCE

- Damn wall inspection. Concrete infrastructure inspection both over and under water. Which are of difficult access,
- Tunnel/pressure duct inspection, Identifying the state of many kilometres of underwater tunnels,
- Water intake hatch inspection: Finding blockage, foreign bodies,
- Sand trap inspection: High-pressure/flow rate inspection at the bottom of the pressure duct,
- Turbine/generator inspection: Inspection in small spaces for e.g. cavitation detection.

CHALLENGE 2: ELECTRICAL POWER AND HEAT DISTRIBUTION INFRASTRUCTURE I&M

- Power line inspection and maintenance of electrical transmission grid including high voltage distribution net, medium voltage, domestic low voltage, and underground cables. Includes, e.g., vegetation along transmission lines.
- Substation/switching station inspection and maintenance.
- Power pole inspection, isolator inspection and maintenance.
- Heat distribution pipe inspection (e.g., automatic scanning, robots to withstand very high temperatures)
- Aerial manipulator robotics for tasks with contact in not electric risk point.
- High precision aerial robotics in order to work in proximity of high voltage target area.
- Contact-based operations to land in a power electric cable. Inspection of the power line.

CHALLENGE 3: SOLAR POWER I&M

- Solar panel inspection, both fixed photovoltaic and tracking mirror panels.
- Inspection of the base of a tracking solar panel .
- Solar panel or mirror cleaning.

CHALLENGE 4: ON-SHORE WIND POWER I&M

- Resident inspection and condition monitoring on site of e.g. electrical components.
- Resident maintenance, e.g. replacing electrical components, interacting with hardware.
- Turbine blade inspection for cracks and continuity to ground testing.

CHALLENGE 5: MARINE ENERGY GENERATION

- Inspection in the marine environment including off-shorewind turbines, ocean thermal converter, wave energy converter, salinity gradient converter, tidal energy converter,
- Safety infrastructure, e.g., monitoring and sampling for detection of the plastic wastes,
- Maintenance tasks with remote human presence.

CHALLENGE 6: OPEN

This open call provides the opportunity for value adding robotic solutions that can show significant impact within Energy Generation and Distribution and that do not fit within Challenges 1-5.

OIL & GAS AND CHEMICAL

CHALLENGE 1: DATA HARVESTING AND DATA ANALYSIS

- Robotized data harvesting supported by automated data analysis techniques that results in clear maintenance recommendations and generates inspection reports and relevant warnings or alarms (dashboard solutions).

CHALLENGE 2: ABOVE GROUND STORAGE TANK INSPECTION, CLEANING AND MAINTENANCE

- In service (i.e. partially full tank) robotic cleaning (preferably) or out of service robotic cleaning,
- Coating removal and coating application,
- Internal tank inspection, with focus on wall to floor weld, in service (preferably) or out of service (non-flammable liquid). Autonomous operation in tank with appurtenances and/or unclear content (e.g. poor visibility),
- Development of NDE methods to enable high-coverage tank inspections and measurements using robotics.

CHALLENGE 3: PRESSURE VESSEL INSPECTION AND DAMAGE CLASSIFICATION

- Internal visual inspection through a ‘4 inch’ nozzle,
- Adding further inspection capability to robots (ACFM etc.) to enable accurate classification of damages (deformations, erosion, corrosion, pitting, crack-development etc.),

- Resident robot performing regular in-service inspections,
- Inspection of space between vessel wall and insulation (possibly using nanobots).

CHALLENGE 4: PROCESS PIPING INSPECTION AND MAINTENANCE IN CHALLENGING ENVIRONMENTS

- Robots with the ability to climb over obstacles and to move and inspect on top of and underneath isolations / Corrosion Under Insulation (CUI) Inspection (e.g. moisture and corrosion),
- Autonomous inspection involving challenging geometries or obstructions, such as elbows, bridges, junctions, valves, underneath supports , CUPS (Corrosion Under Pipe Supports), etc.,
- Inspection of road crossing pipes,
- High-coverage robotic wall thickness assessment (external and internal),
- Resident robots for online internal inspection,
- Robotic removal and re-mounting of insulation,
- Robots for high coverage pipe rack construction & support inspections, both horizontal and vertical. Localization capabilities on pipe grid.

CHALLENGE 5: REMOTE OPERATORS

- Autonomous surveillance, anomaly detection and facility mapping,
- On-site robotic operator, tele-operated with autonomous capabilities (e.g. autonomous mission planning, localization, path planning etc.), to perform local readings (local manometers, temperature, etc.) and manipulation tasks such as opening valves, pushing buttons, taking samples, opening doors and other tasks that reflect the day-to-day operation needs,
- Robotic operator with the ability to perform temporary repairs,
- Develop semi-autonomous robots to function as first responders (e.g. provide situational awareness, gas or liquid leakages) and ultimately as emergency responders (e.g. robotic firefighters).

CHALLENGE 6: OFFSHORE INSTALLATION INSPECTION, MAINTENANCE AND REPAIR

- In-service use of Unmanned Underwater Vehicle (UUV) for inspection of ballast tanks, development of new UUV inspection techniques (such as the capability of measuring wall thickness) and development of an increased level of autonomy,
- Robotic removal and application of coatings in ballast tanks,
- Robotic solution to perform wall thickness measurements and coating repair in splash zones,
- Robotic solution to autonomously remove marine life attached to submerged structures,
- Robotic solution to autonomously clean the helipad,
- Resident Unmanned Aerial Vehicle (UAV) to provide autonomous monitoring of the state of the installation,
- Resident Unmanned Underwater Vehicle (UUV) for subsea inspection, maintenance and repair.

NUCLEAR

CHALLENGE 1: MAPPING OF SITE INFRASTRUCTURE

- Mapping HVAC, stacks, structures etc.,
- Site and location geometry characterisation,
- Special consideration should be given for applications or irradiated materials.

CHALLENGE 2: HEALTH MONITORING OF COMPONENTS DURING LIFETIME

- Monitoring any key characteristics of structures, systems and components (SSC) that will inform aging management best practice decisions such as proactive maintenance
- Monitoring the thickness / corrosion of walls/ civil works parameters (dome walls cementation cracks/areas),
- Taking material samples (limited to surface swab and corrosion material, i.e. if valve piston degraded).
- Monitoring the health of components (temperature, pressure, geometry over time - wall thickness),

- Access to confined regions (pipe systems, vessels, etc.),
- Monitoring/inspecting pipes internally (health of cabling, EMC, EMI etc).

CHALLENGE 3: INSPECT / SUPPORT REPAIR OF EQUIPMENT

- Taking samples of within spent fuel storage pools (such as water in vicinity of spent fuel or pool walls surface - not fuel samples per se),
- Inspection and plugging of steam generator pipes,
- Inspect/replacement of components or supporting activities.

CHALLENGE 4: CLEAN ROBUSTLY (PARTS OF) NUCLEAR INFRASTRUCTURE EQUIPMENT

- Cleaning of surfaces of such as in long-term storage pools and/or access restricted areas,
- Decontamination of irradiated items during the dismantling and decommissioning phase.

CHALLENGE 5: WASTE DISPOSAL AND DECOMMISSIONING ACTIVITIES

During the normal operations and decommissioning phase of a nuclear infrastructure, various standard and irradiated components and items have to be characterised, dismantled or have to be reduced in size for appropriate disposal.

Activities to support these operations via robotics solutions should be provided:

- Clean and/or reduce size of standard and irradiated components.
- Movement of the inventory of radioactive waste items within specified working areas (e.g. movement of a cut piece of irradiated steel from the area it was cut to a designated area related to the dismantling process) .
- Other dismantling operations of components such as cutting, unscrewing of bolts, re-shaping etc.

CHALLENGE 6: OPEN

The last challenge refers to any generic support tool or assistance, either via a robotic or automation system, that is not included in the above categories and aims at supporting the general operation or decision making process by the site management and/or supplements/reduces the need for human tasks in inspection and maintenance activities on the nuclear site.

Examples include, but are not limited to: access in areas where the thermal or radiation environment has limitations on the presence of a human activities; remote handling; transport of various loads in areas with environmental constraints; robotics solutions with sensors and tools that can withstand harsh environments and robotics for use in checking for any degradation parameters (such as corrosion etc) on infrastructure/items contained within a nuclear site.

URBAN AND SUBURBAN TRANSPORT ROUTES CONNECTED WITH CITIES

The Inspection & Maintenance (I&M) activities in this domain are based on human activity with small involvement from automation and robotic solutions. The human operator is at the centre of the I&M operations, that many times need to be performed under very difficult conditions, while the support from the technology is limited and mainly focused on reporting tools. The key challenges that need to be addressed, along with a small description for each, are provided below:

CHALLENGE 1: INCREASE EFFICIENCY IN THE I&M ACTIVITIES OF CIVIL INFRASTRUCTURE

One aspect that makes the execution of I&M activities difficult are imposed constraints which include the following cases:

- on a motorway, the infrastructure is not 100% available to citizens – it is essential to reduce the time inspectors need to perform the respective I&M operations,
- in rail infrastructure, I&M activities need to be undertaken on the outside (exterior) or during the night, leaving the operators exposed to the weather conditions,
- I&M activities must be stealthy, especially in urban areas – without negative environmental impact, noises, odours, dust, etc.,
- manual I&M activities, after an 8-hour shift, lead to low quality results.

This challenge should address the constraints above without excluding similar ones, and develop technologies capable to:

- minimize the time that facilities are not available due to I&M activities,
- increase cost-efficiency in the accomplishment of I&M activities,
- use multi-sensing inspection robots in order to detect defects in different infrastructures (rails, tunnels, etc.),
- use robotic solutions for approaching unreachable places and performing I&M operations,
- use a combination of methods and tools that can support the aforementioned resources to resist difficult environmental conditions (night conditions, windy areas, etc.).

CHALLENGE 2: REDUCE RISK FOR WORKERS DURING I&M ACTIVITIES ON CIVIL INFRASTRUCTURES

This challenge is partially related to the previous one in terms of safety from the operators' perspective, since the more dangers operators face, the less efficient they become. Typical examples of such cases are as follows:

- during I&M operations, operators need to access and work in high-risk areas such as motorways where vehicles pass by at high speed,
- in some cases, coring or sampling unknown material(s) onsite implies a specific method of sampling to preserve the health and safety (H&S) for the operators,
- difficulty in reaching areas in order to do their job, especially when there is a need to avoid digging close to other networks (e.g. water, electric, etc.).

This challenge is expected to be addressed by introducing innovative robotic solutions that will either facilitate operators reaching unreachable places (e.g. big heights) or robotic solutions that will reach those areas and perform the I&M operations while operators control them remotely and in safety, such as aerial robots; more specifically solutions that:

- increase supporting tools that will assist operators during the execution of I&M activities,
- introduce safety resources that will supervise operators' activity,
- improve safety conditions for operators while performing I&M activities,
- use safety approved devices and methods that will increase operators' safety during the execution of I&M activities,
- use supporting tools and methods for operators during I&M operations.

CHALLENGE 3: ENSURE THAT CIVIL INFRASTRUCTURE IS OPERATIONAL AND SAFE

An important aspect is the quick detection of defects in the infrastructure. Usually, Vision-Systems are used for such activities, but several innovative technologies are expected to address inspection activities. Additionally, smart algorithms that can process the raw data from the perception technologies are also included in this challenge.

Apart from that, decision making algorithms are also expected to be created in order to facilitate the automation of the whole I&M activity during the execution of the different activities.

- Perception technologies to detect defects,
- Sensor data processing for automating I&M processes,

CHALLENGE 4: WORKER – MACHINE ON JOBSITE COOPERATION

As technology evolves, people are using more and more heavy machinery and automation systems to perform I&M activities on job sites. For this reason, a high level of autonomy should be reached by each resource in order to cooperate efficiently. This challenge aims to be addressed by the following technologies:

- efficient autonomous navigation and motion planning on jobsites with obstacle avoidance capabilities,
- automation tools, such as product pouring machines that follow a predefined path or jobsite cleaning machines that automate repetitive tasks,
- risk planning, scheduling, and job organization algorithms that can help operators and their supervisors to track any open issues in time.

CHALLENGE 5: OPEN (FACILITATING TECHNOLOGIES DEVELOPMENT)

The last challenge refers to any generic supporting tool, either robotic or automation system, that is not included in the above categories and aims at supporting the communication for operators, either among themselves or with their supervisor, as well as supporting them in their I&M tasks by providing tools and instructions. Examples in this case are the communication problems that are faced on the jobsite of a long tunnel, before establishing power and any electrical infrastructure. Inspections and monitoring of the environment in connection with transportation infrastructure (e.g., to assess the risk of avalanches close to a stretch of road).

TRANSPORT, CARGO AND MOBILITY

CHALLENGE 1: PERIMETER INFRASTRUCTURE

This challenge is applicable to various types of transport hubs, safety and transport infrastructure.

Perimeter infrastructure is mainly focused on fences but may also include other objects like gates and walls. Keeping the perimeter infrastructure in good shape is crucial for safety and security. Detection of anomalies is useful to plan repair and can provide valuable information regarding security breaches.

This challenge focuses on value adding robotized inspection, repair and maintenance of the perimeter infrastructure to secure the safety of the cargo or people involved. Perception, GNNS positioning and communications are some of the facilitator technologies for monitoring not only the ground borders but also underwater areas.

CHALLENGE 2: WATERWAYS, QUAY WALLS AND LOCKS

Robotized inspection and monitoring of waterways shall detect siltation or obstacles. Securing safe and accessible waterways is of crucial (economic) importance. This challenge calls for robotizing these efforts, without interfering with possible operations at the waterways.

Quay walls and locks need to be inspected, repaired and maintained (IRM) to secure safety and accessibility. These operations involve divers and sometimes robotic systems. Since IRM of these assets impose significant danger and challenges for both divers and robotic systems, solutions in this matter are required.

CHALLENGE 3: RUNWAYS

This challenge calls for automatized/robotized inspection and maintenance of runways, for example visible and under surface condition, debris, ice and snow removal.

CHALLENGE 4: VEGETATION

Vegetation encroaching onto railway tracks or over related equipment impose safety and accessibility risks. Detecting, monitoring this vegetation and removing it in time by robotized systems is the focus for this challenge.

CHALLENGE 5: RAILS

Inspection, repair and maintenance of rails and power cables are challenging operations. Securing safety of inspection efforts, reducing downtime of the rail transport and timely detection of anomalies are important factors. Robotized solutions that tackle these challenges are called for in this challenge.

CHALLENGE 6: MARITIME: SHIPS & PORTS

Vessel and ship inspection for structural and/or machinery condition monitoring by incorporating new sensors and means to gather the information, creating new services or tools for performing I&M both, offshore and on locks. Securing safety of inspection efforts, which may involve moving large elements along quays and berth, boat elevators, etc. In addition, incorporation of robot solutions for enhanced performance of cargo or repairing activities. Robotized solutions that tackle these challenges are called for in this challenge.

CHALLENGE 7: OPEN

For Transportation Hubs and Airport Infrastructure, this open call provides the opportunity for value adding robotic solutions that show significant impact.