Development and Testing of Work Package Automation for Plant Modernization

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Work Package

- Qualifications
- Trainings
- Materials
- Risks
- Cautions
- Discipline
- Hazards
- Tags
- Notes
- Tests

- Tools
- Issues
- Documents

- Step
- Group of Steps/Task
- Step

- Work Package
- Worker Order
- Documents References
- Material list, equipment list, ...

- Step
- Group of Steps/Task
  - Step
Automation of Work Packages

- Fifty functions envisioned targeting all phases of the work process.

Initiation of Work Request (5 functions)

Screen Work Request (1 functions)

Work Package Creation and Scheduling (7 functions)

Pre-Implementation Walk Down (2 functions)

Supervisor Assigns Work Package to Craft (3 functions)

Holds and Pre-Job Brief (5 functions)

Measurement and Test Equipment, Tools, and Spare Parts (4 functions)

Walk Down Clearance (Tag Out) and Operations Permission to Start (6 functions)

Perform Work Activity (13 functions)

Sign-Off Clearance and Review (1 function)

Quality Assurance and Archiving (3 functions)

Which of the listed capabilities would help increase the efficiency of the work package process?

Integration of enterprise asset management system...
Historical data collection of equipment failures
Automatic population of work package information...
Automatic acquisition of plant information
Automatic scheduling of tasks according to the...
Automatic integration of plant risk information during...
Automatic tracking of task progress
Automatic allocation and release of tools and...
Pre-recorded pre-job brief videos for frequently...
Automatic scheduling and guidance of walk-downs...
Automatic placement and/or removal of hold points
Automatic tracking of Craft’s location
Automatic notifications to Supervisors, Operations,...
Voice assisted instructions (e.g., talk-to-text)
Remote access of task progress to all involved entities
Remote video monitoring of task execution
Automatic notification to resources for QA and other...
Automatic evaluation of Craft’s performance
Automatic reassignment of tools when not needed
Location tracking of tools and spare parts
Automatic tool recall for calibration or disqualification
Augmented reality (e.g., technology similar to Google... Ability to change level of detail in the work instruction...
Perform .... on equipment... using tool ...; refer to document ... for information;....

The full migration of one work package from paper to data resulted in the following example data architecture findings:

1. Topology: hierarchical mesh of data
2. Functionality: live and configuration versions of the same data.
3. Properties: aggregated upwards and downwards the hierarchy.
The nuclear power industry is in need for means to automate materials, tools, and equipment's (MTE) tracking for:

1. Verification of proper MTE use by the craft.
2. Accountability in foreign materials exclusions zones (FMEZ) that impacts the plant critical path.
3. Enforcing calibration schedules for tools and equipment in the field.
4. Preventing removal of contaminated MTE.
5. Preventing loss of expensive MTE.
6. Inventory of outage containers.
Ultra High Frequency Radio Frequency Identification (UHF RFID)

- Passively powered tags.
- Various forms and sizes of tags.
- Various types of readers power method and antennas connection.
- Low-cost technology.
UHF RFID Prototype and User Study
Example of study findings

- **Tag Size:**
  - Large tags cause spurious detection; small tags are hard to detect. Optimal tag size was identified.

- **Setup Layout:**
  - Portable reader with an integrated antenna for FMEZ.
  - Portable reader with external antenna for searching of MTE.
  - Fixed setup with antennas gate for preventing removal of contaminated MTE and loss of expensive MTE.

- **Tag Mounting and Structure:**
  - Tags are almost always biased towards certain orientation, and need to be installed in a manner that favors exposure of that orientation
  - Tags are sensitive to interference (including human body), and need to be installed in locations that minimizes interference.
  - Some tags are more suitable for certain type of surfaces. For example, not all tags are mountable on metals.
  - Tags that have soft or rubber surfaces can be hard to decontaminate.
  - Radiation tolerance of tags remains unknown.
Cautions and Hazards:

As the nuclear power industry moves towards mobile devices, the industry is in need to detect the craft location for:

- Complementing the conventional warnings with electronic warnings.
- Automatically enforcing safety measures in critical situations.

Bluetooth Low Energy Beacons:

- Can be detected by any Bluetooth enabled device.
- Very compact, light, and easily attachable to walls and surfaces.
- Very low energy consumption.
- Inexpensive (tens of United States Dollars).
- Threshold triggering of radio signal strength was used.
- Threshold assigned to actions through a text file.
Example of study findings

– Broadcasts of the beacon ID and battery level are more suitable than peer to peer communication from a communication and power perspectives.

– Broadcasts frequency should be relatively low to preserve power, but not too low to result in misdetection. Multiple beacons to initiate the same action can be used to compensate for the low broadcasts frequency.

– Increasing the range increases the probability of detection but increases the power consumption and false positives. The signal strength needs to be optimized according to the nature of the location and the application.

– Radiation tolerance of the beacons are not expected to present a significant limitation. Modules can be replaced annually if needed, due to their low cost.
Video Recording and Remote Monitoring

The nuclear power industry is in need for means to improve the process of:

- Peer review
- Remote supervision and approvals.
- Training including just-in-time training.
- Pre-job briefings.
- Quality assurance.
Conclusions

• Identified 50 functions that can be addressed by automating the work packages process.
• Verified the alignment of the proposed functions with the industry through a survey.
• Developed the data architecture principles of fully digitized work package.
• Prototyped and studied the feasibility and impact of multiple work package automation technologies in nuclear power plants.