

Development and Testing of Work Package Automation for Plant Modernization



Light Water Reactor Sustainability R&D Program

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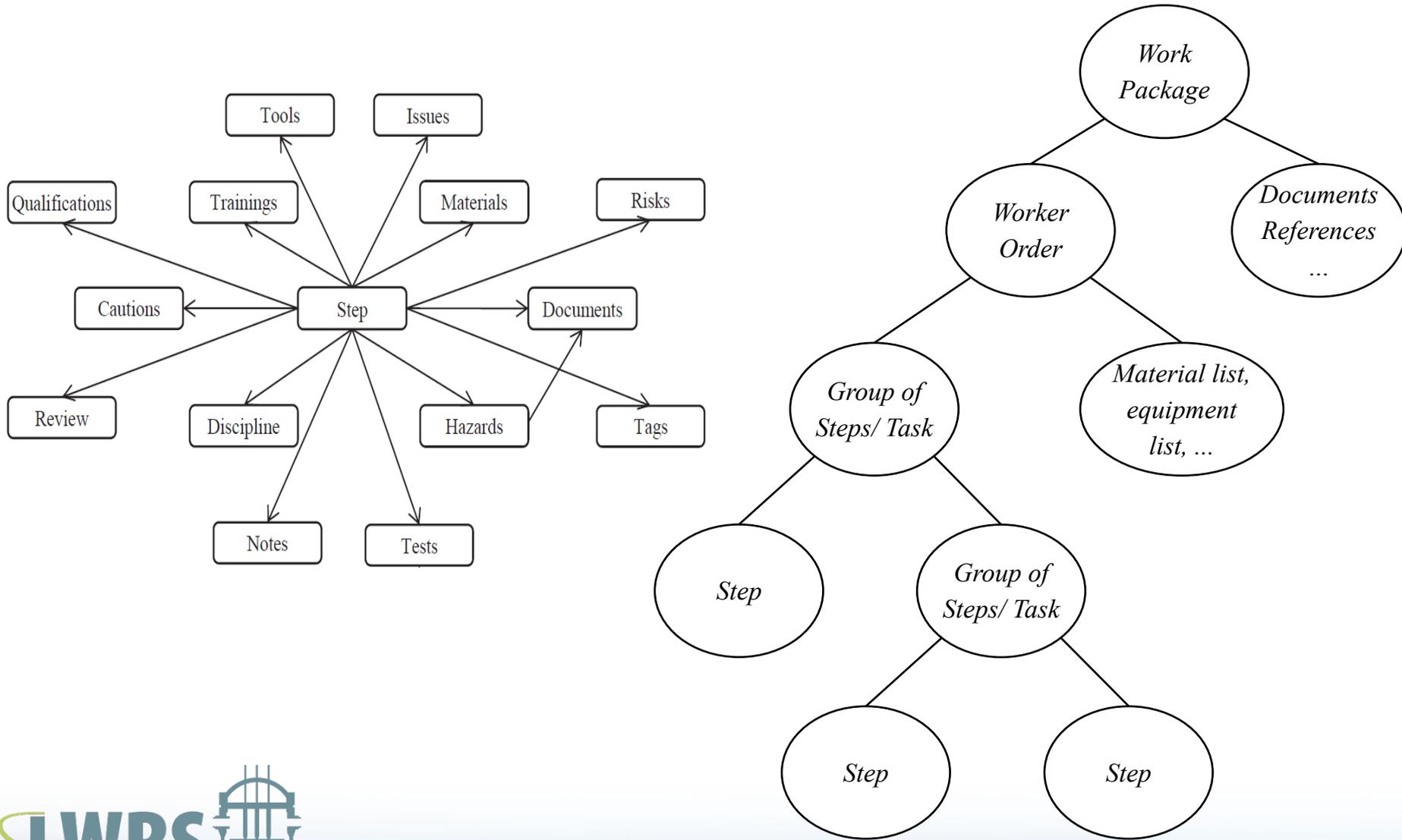


Acknowledgement

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- Other INL contributors:
 - Kenneth Thomas, Vivek Agarwal, Ronald Boring, Shawn St Germain, Johanna Oxstrand, Thomas Ulrich, and Brandon Rice.



Work Package



Development of Work Packages

Paper WP

Forms WP

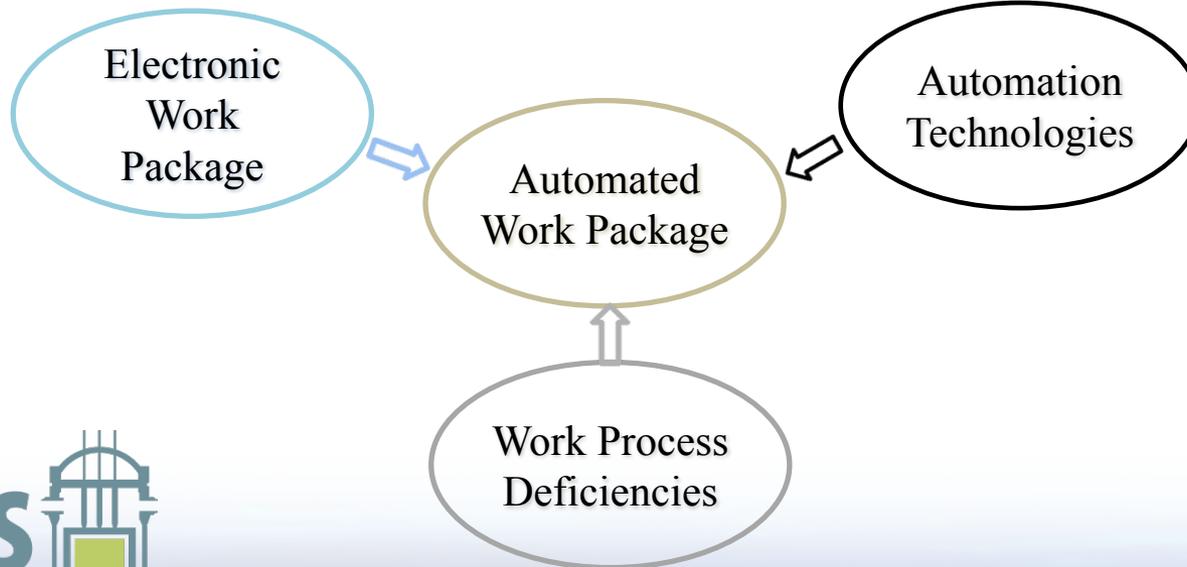
Intelligent WP



Scanned WP

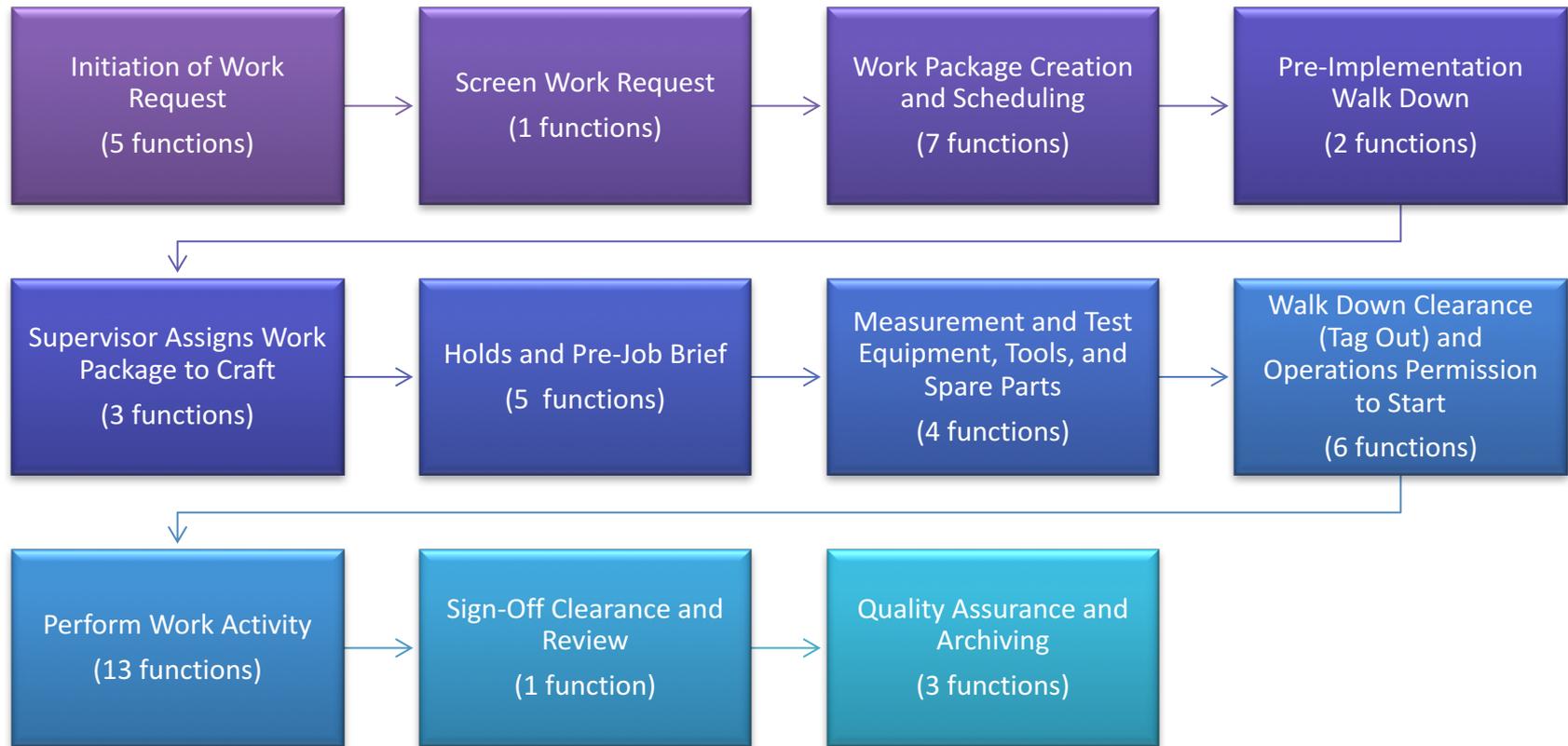
Interactive WP

Automated WP



Automation of Work Packages

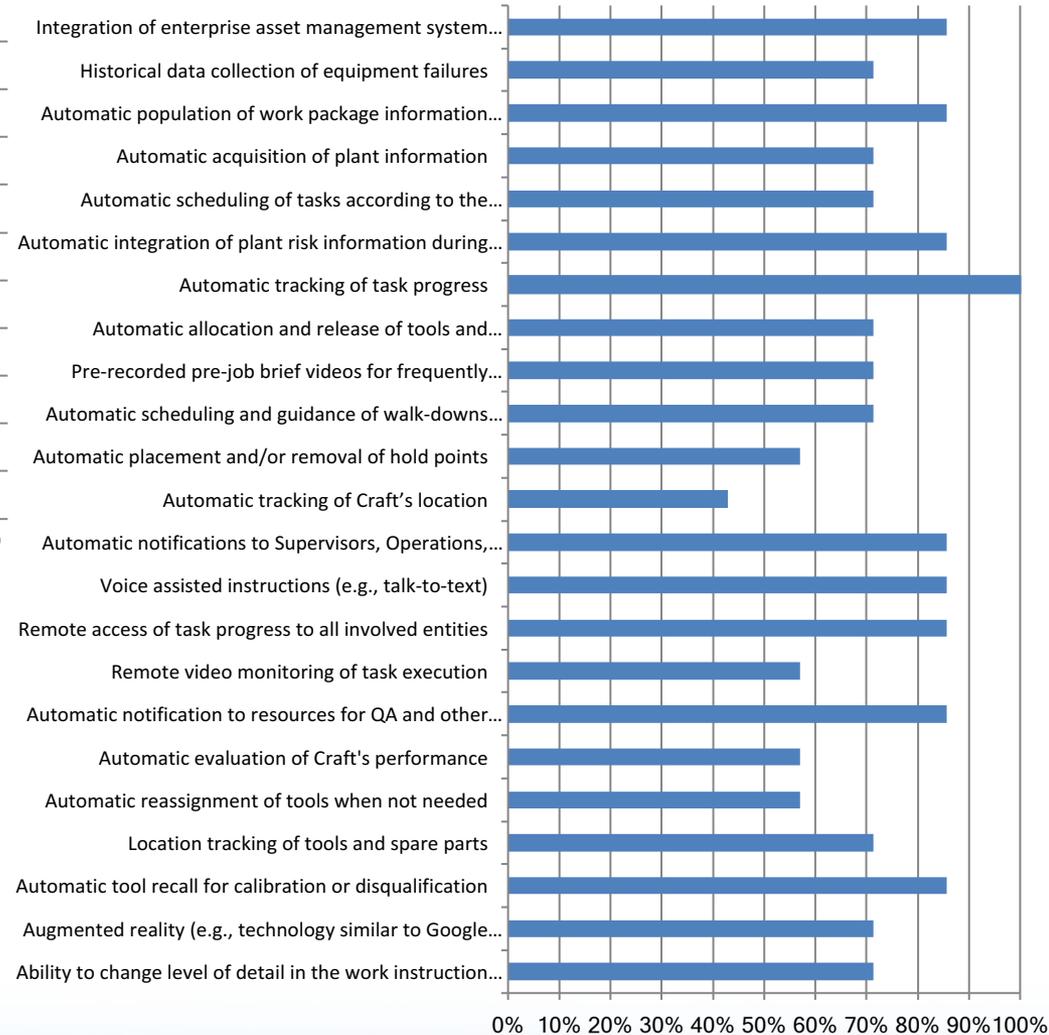
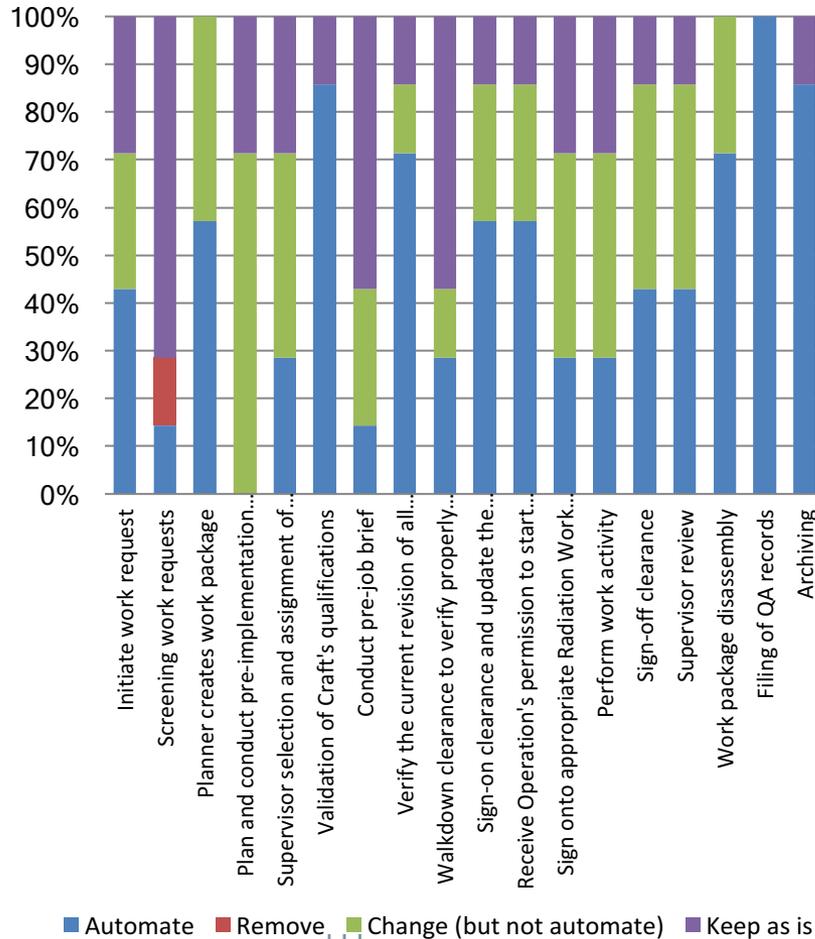
- Fifty functions envisioned targeting all phases of the work process.



Survey

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

What and How to Change the Process



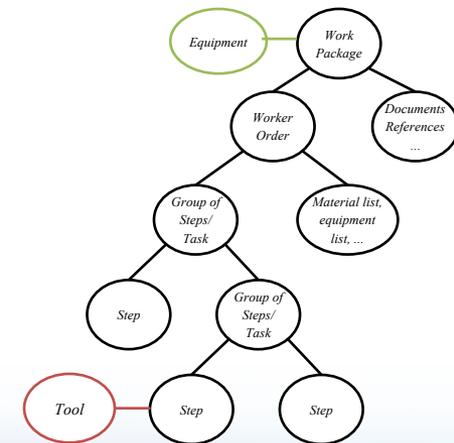
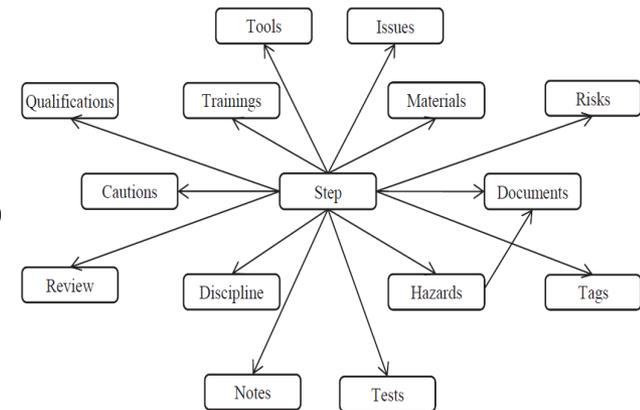
Infrastructure Development of Work Packages



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:

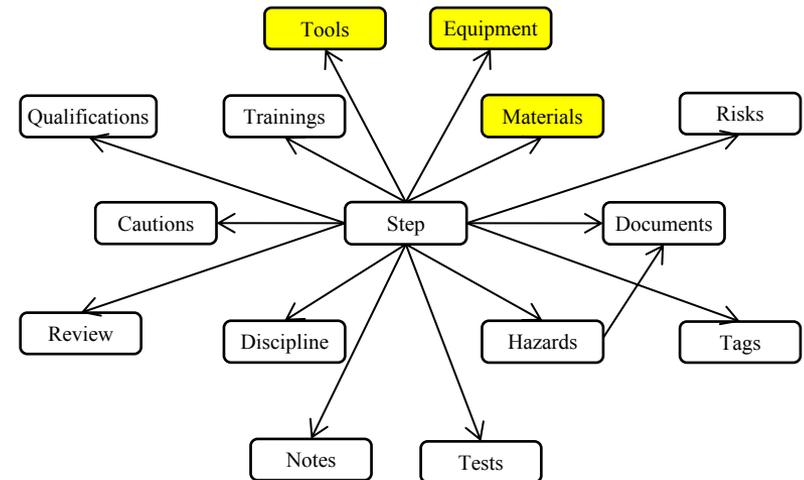
1. Topology: hierarchical mesh of data
2. Functionality: live and configuration versions of the same data.
3. Properties: aggregated upwards and downwards the hierarchy.



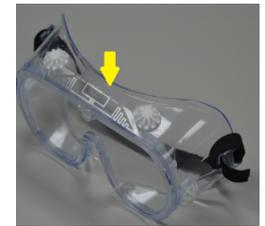
Materials, Tools, and Equipment

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

Select All
 Unselect All

Select All
 Unselect All

Select All
 Unselect All

Log In List

Ind.	Hits	Prox.(%)	ID	Description
0	34	100%	2016 1209 0851 8A01 1040 00C7	Screw driver Size 4
1	48	100%	0229 0500 0000 0000 0000 17EB	Adjustable Wrench RITCO
10	3	0%	0000 7DFC 0C09 0A1D E1F5 0B63	
11	5	0%	0204 9300 0000 0000 0000 0327	
12	4	100%	0229 0500 0000 0000 0000 17DE	Tools bag
13	1	0%	3008 3382 DDD9 0140 0000 0000	Procedure: MV seal repla
2	87	95%	E200 9A70 1003 1AF0 0000 3601	Wrench 3/8
3	73	100%	E280 1160 6000 0205 0055 825D	Multimeter FLUKE 8062A
4	27	100%	2015 0429 8511 0300 0102 03D0	Wrench 7/8
5	1	100%	2016 0409 1083 5A01 1020 032F	Saw small
6	10	0%	2016 0525 0878 5A02 1050 04E7	
7	5	0%	E280 1160 6000 0205 0055 826D	

Update List

Ind.	Hits	Prox.(%)	ID	Description
1	48	100%	0229 0500 0000 0000 0000 17EB	Adjustable Wrench RITCO
13	1	0%	3008 3382 DDD9 0140 0000 0000	Procedure: MV seal replacer
0	34	100%	2016 1209 0851 8A01 1040 00C7	Screw driver Size 4

Log Out List

Ind.	Hits	Prox.(%)	ID	Description
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Missing Items List

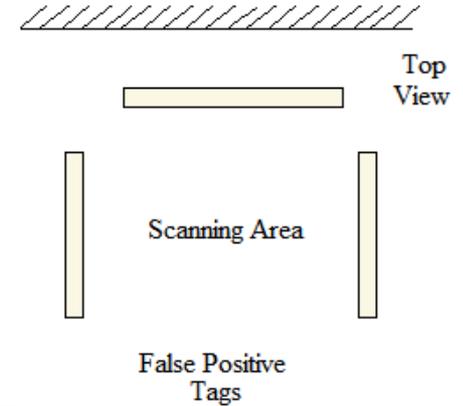
Ind.	Hits	Prox.(%)	ID	Description
0000 0000 0000 0000 0040 2989				Hammer Low Force

Unassociated Items List

Ind.	Hits	Prox.(%)	ID	Description
0	34	100%	2016 1209 0851 8A01 1040 00C7	Screw driver Size 4
1	48	100%	0229 0500 0000 0000 0000 17EB	Adjustable Wrench RITCO
10	0	0%	0000 7DFC 0C09 0A1D E1F5 0B63	
11	0	0%	0204 9300 0000 0000 0000 0327	
12	4	100%	0229 0500 0000 0000 0000 17DE	Tools bag
13	0	0%	3008 3382 DDD9 0140 0000 0000	Procedure: MV seal repla
3	73	100%	E280 1160 6000 0205 0055 825D	Multimeter FLUKE 8062A
4	27	100%	2015 0429 8511 0300 0102 03D0	Wrench 7/8
5	1	100%	2016 0409 1083 5A01 1020 032F	Saw small

Procedures List

Ind.	Hits	Prox.(%)	ID	Description
0	Ahmad Al Rashdan		3008 3382 DDD9 0140 0000 0000	MV seal replacer



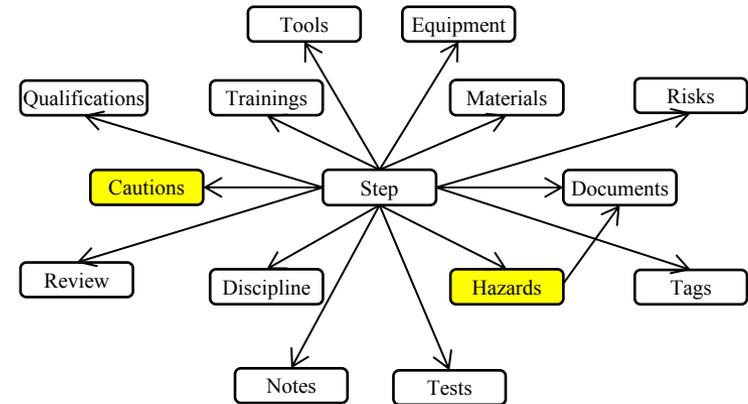
Example of study findings

- 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.

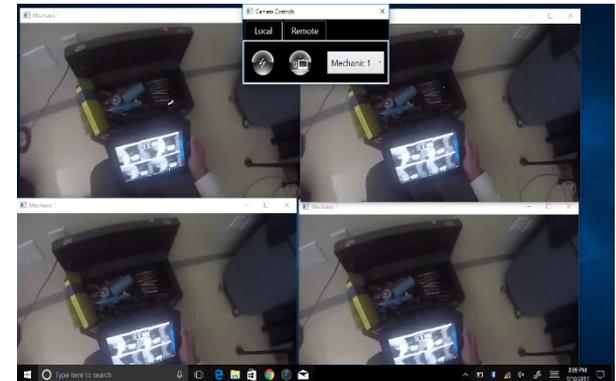
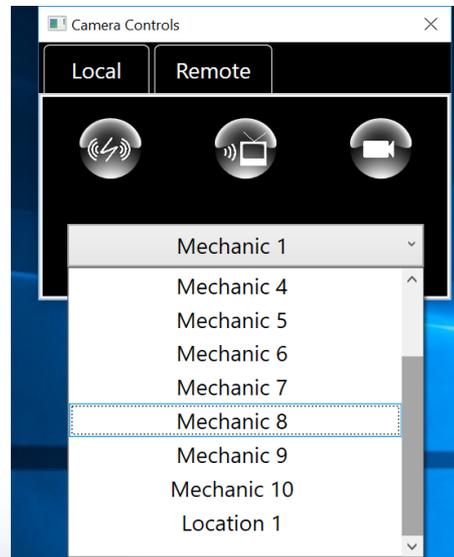
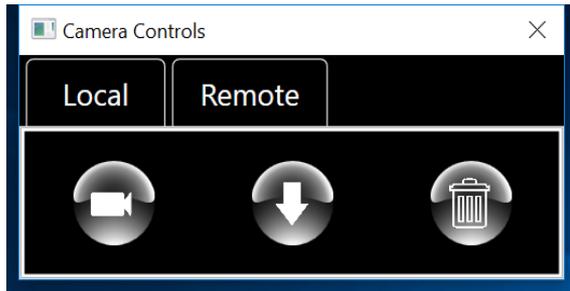
Example of study findings

- 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.



