The APQC (American Productivity & Quality Center) has identified a flow process that describes how knowledge flows through organizations. It's a seven-step cycle:

1. **Create** new knowledge (this happens every day, all the time, across all areas of the business)
2. **Identify** knowledge that is critical to strategy and operations
3. **Collect** knowledge so it can be shared with others
4. **Review** knowledge to evaluate its relevancy, accuracy, and applicability
5. **Share** knowledge through documentation, informal posts, and collaborative activities
6. **Access** knowledge through pull (e.g., search) and push (e.g., alerts) mechanisms
7. **Use** knowledge to solve problems faster and make more informed decisions.

This framework can be split into two separate elements: the first considers the processes for finding and sharing LFE and the second considers the process for making use of the information available. This is described in the table below.

Collect, Review and Share	Access & Use
• Collect lessons learned from known sources (quarterly) • Review information and add to LFE List • Share LFE List with users	• Users search LFE List as applicable • Users are notified when LFE that is relevant to them is added • Users follow a standard approach to make best use of the information available: lessons learned and potential solutions used elsewhere

Table 3: American Productivity and Quality Center Framework for Managing LFE

4.1 Collect, Review and Share

The schematic in Figure 1 below illustrates the process for the first element of the Framework. This approach would be best served by having a person or group accountable and would need to be conducted on an ongoing basis with regular reporting (quarterly is suggested). It is important that information is regularly added to ensure relevancy, and, in due course, the information collected can be analyzed to determine whether new observations replace previous ones, thereby indicating improvement in learning lessons.

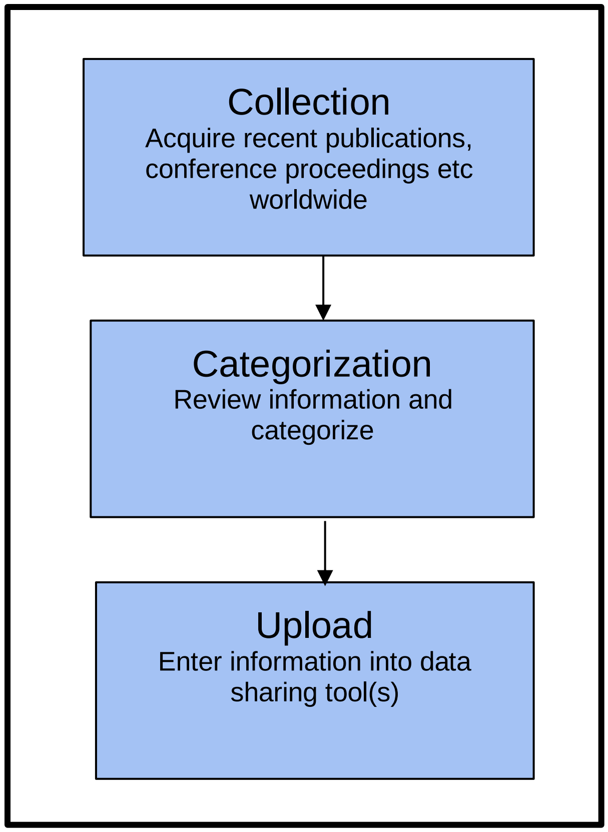

Figure 1: APQC Creation and Sharing Process

4.2 Access & Use - Experience from Past Activities

The schematic in Figure 2 below illustrates the process for the second element of the Framework.

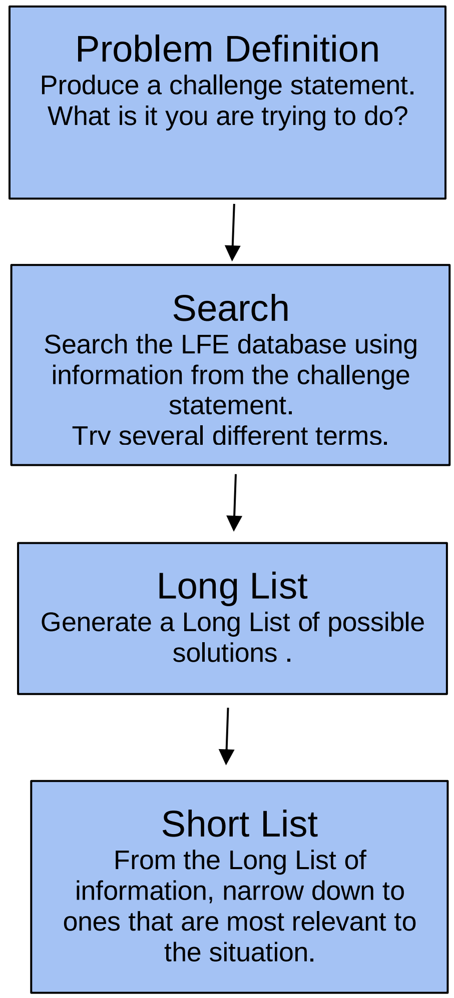

Figure 2: APQC approach to Lessons Learned Review and Implementation

The worked example shown in Appendix 2 describes the steps taken to use the information collected from the LFE List. This was based around an example for glovebox remediation. It follows the steps shown in Figure 2 to search the LFE List to create a Long List (Figure 3), then narrow this down to a Short List (Figure 4) and, finally, to identify Focus Areas (Figure 5) to look for solutions.

Figure 3: Example of a Long List

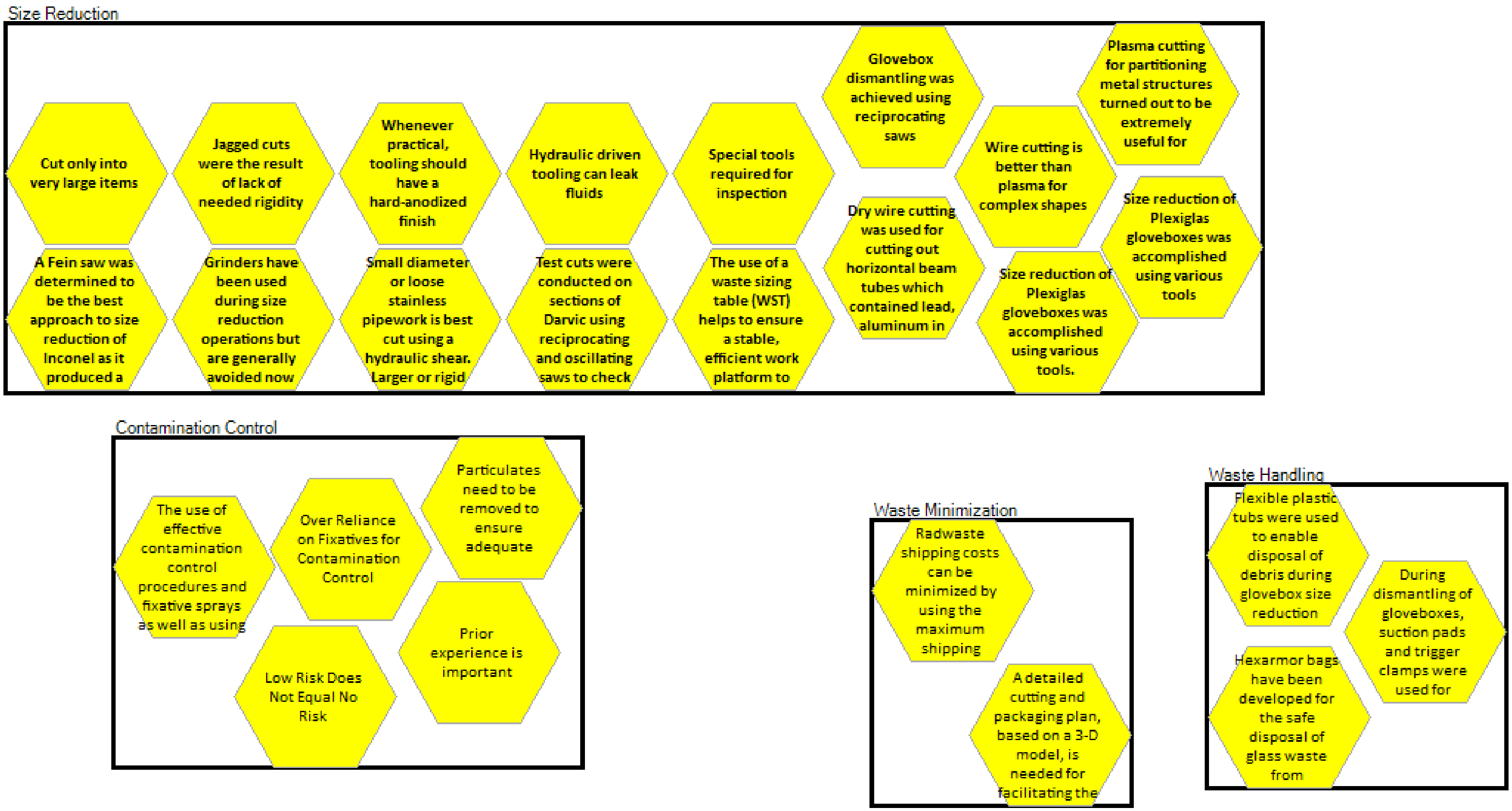

Figure 4: Example of a Short List

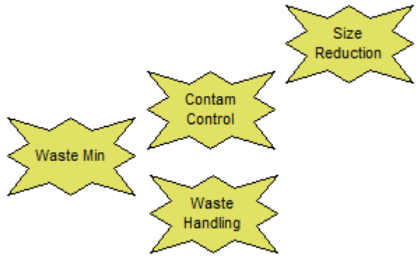

Figure 5 Example of Focus Areas

4.3 Access & Use - Potential Solutions from Commercial Databases

The worked example in Appendix 2 also includes use of another LFE Tool called the Idea Catalog. This is structured around the technologies that might be applicable to addressing the problem and contains a large number of examples that have been used elsewhere, both in nuclear and non-nuclear industries. The combination of the two tools therefore provides a very rich and detailed study of what others have found when carrying out similar projects. Figure 6 illustrates the steps used to look for potential solutions.

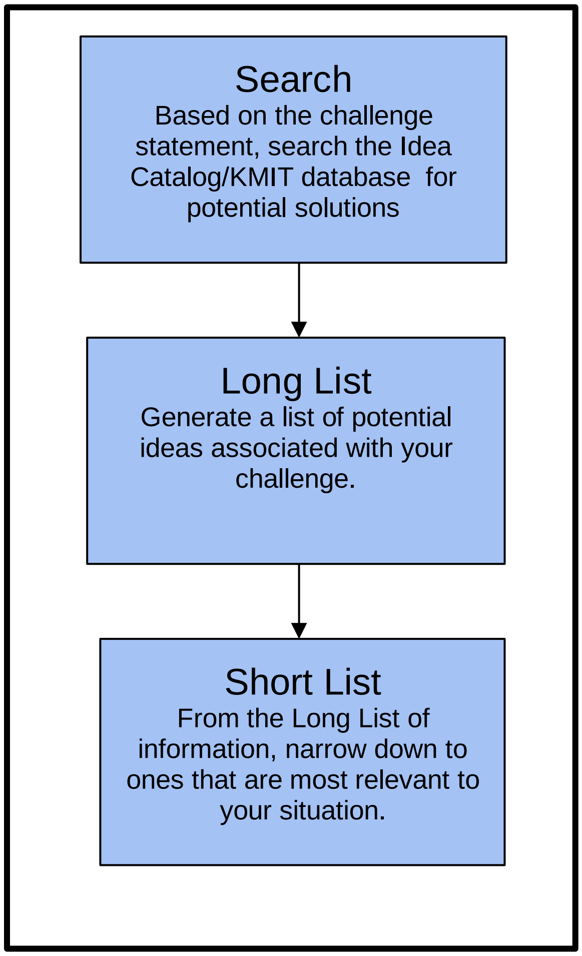

Figure 6: Application of Commercial Databases to Addressing D&D Challenges

Searching for potential solutions for the focus areas follows the steps shown in Figure 6. The long lists were generated by searching the Idea Catalog for ideas covering waste handling (Figure 7), waste minimization (Figure 8), size reduction (Figure 9) and strippable coatings/fixatives (Figure 10). For the worked example, a short list was not generated as this would be specific for the real-world problem that is being addressed.

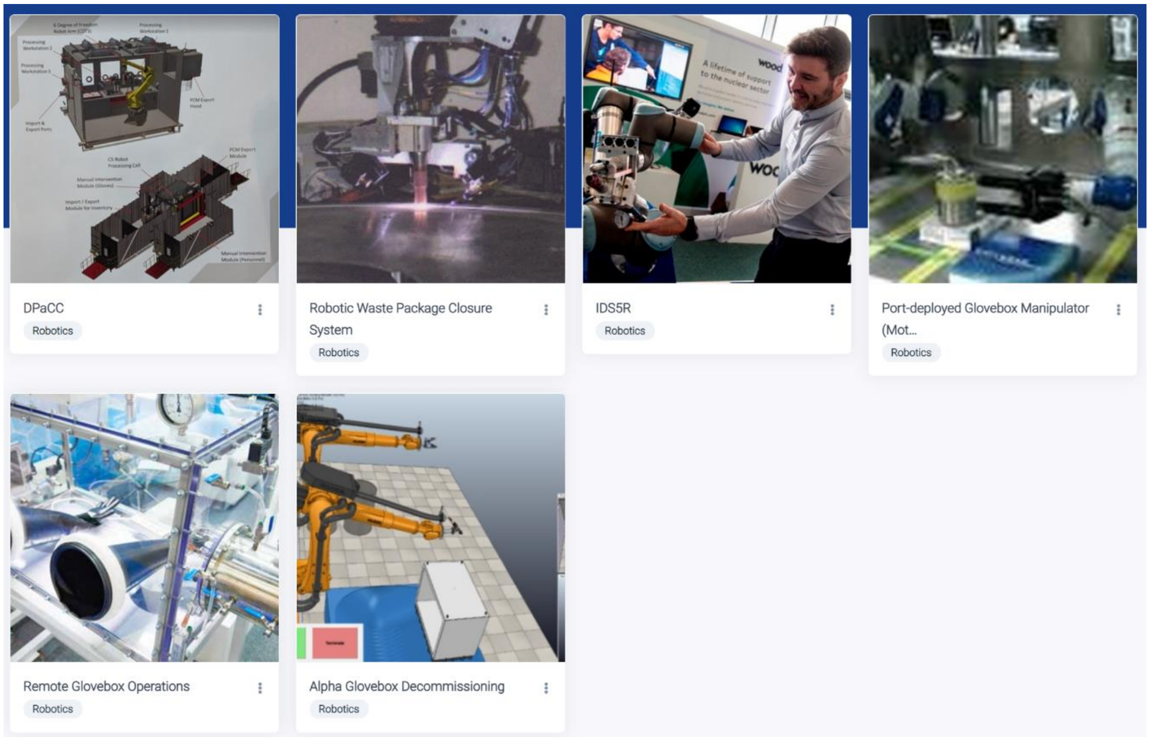

Figure 7: Example Long List – Waste Handling

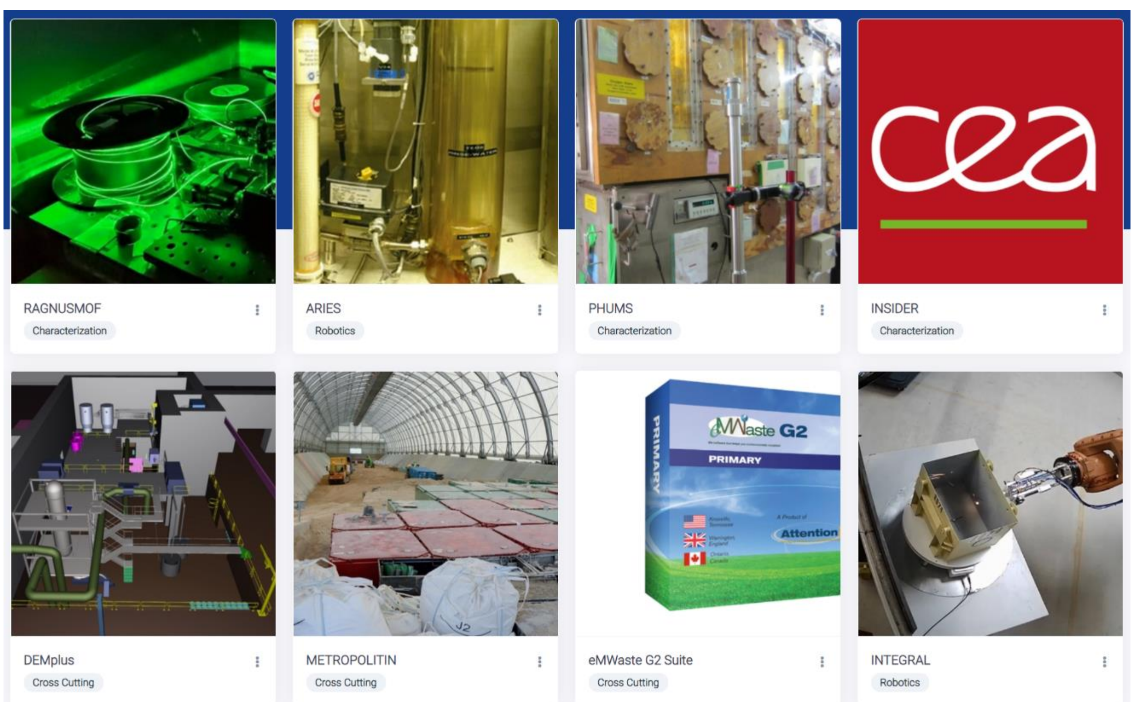

Figure 8: Example Long List – Waste Minimization

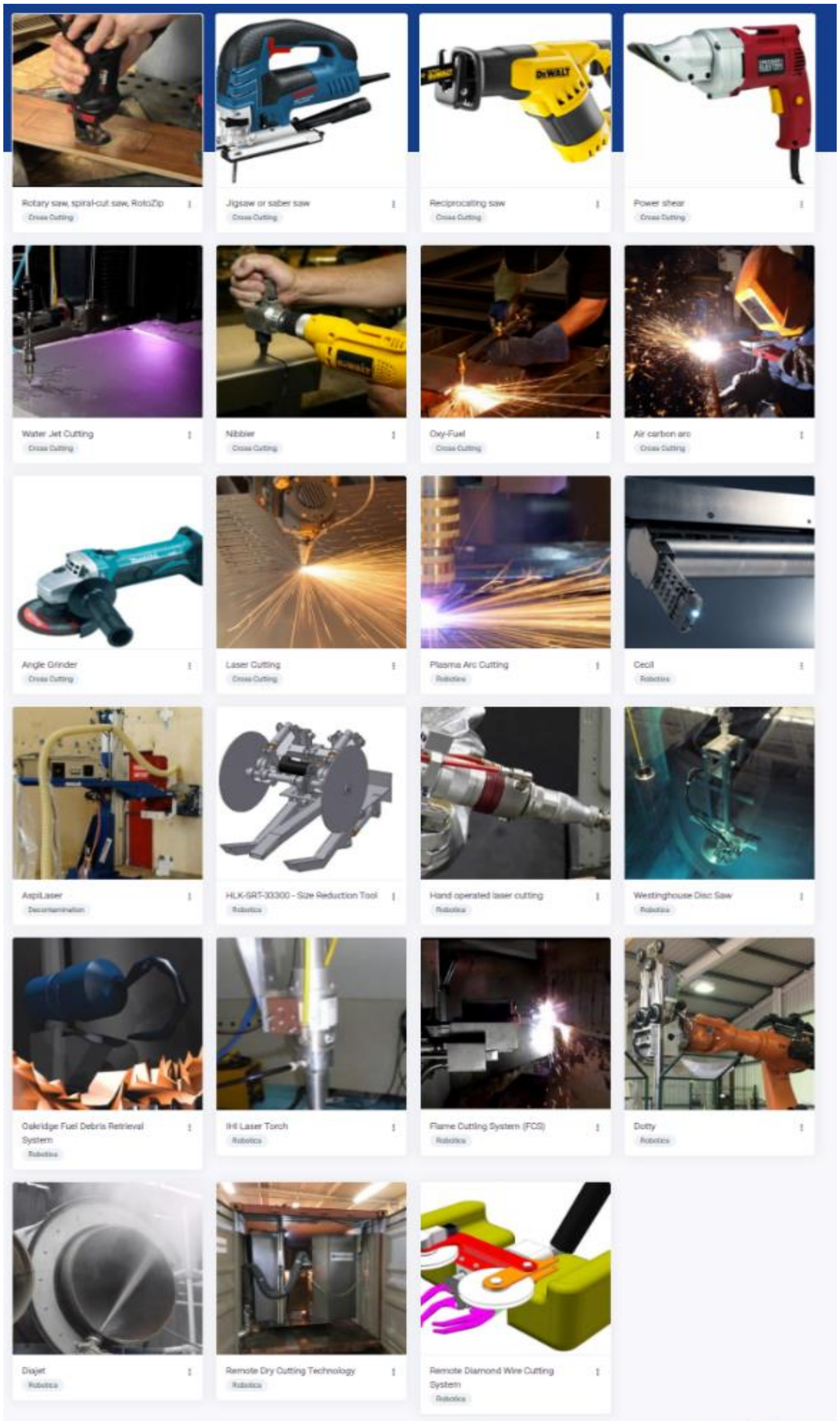

Figure 9: Example Long List – Size Reduction

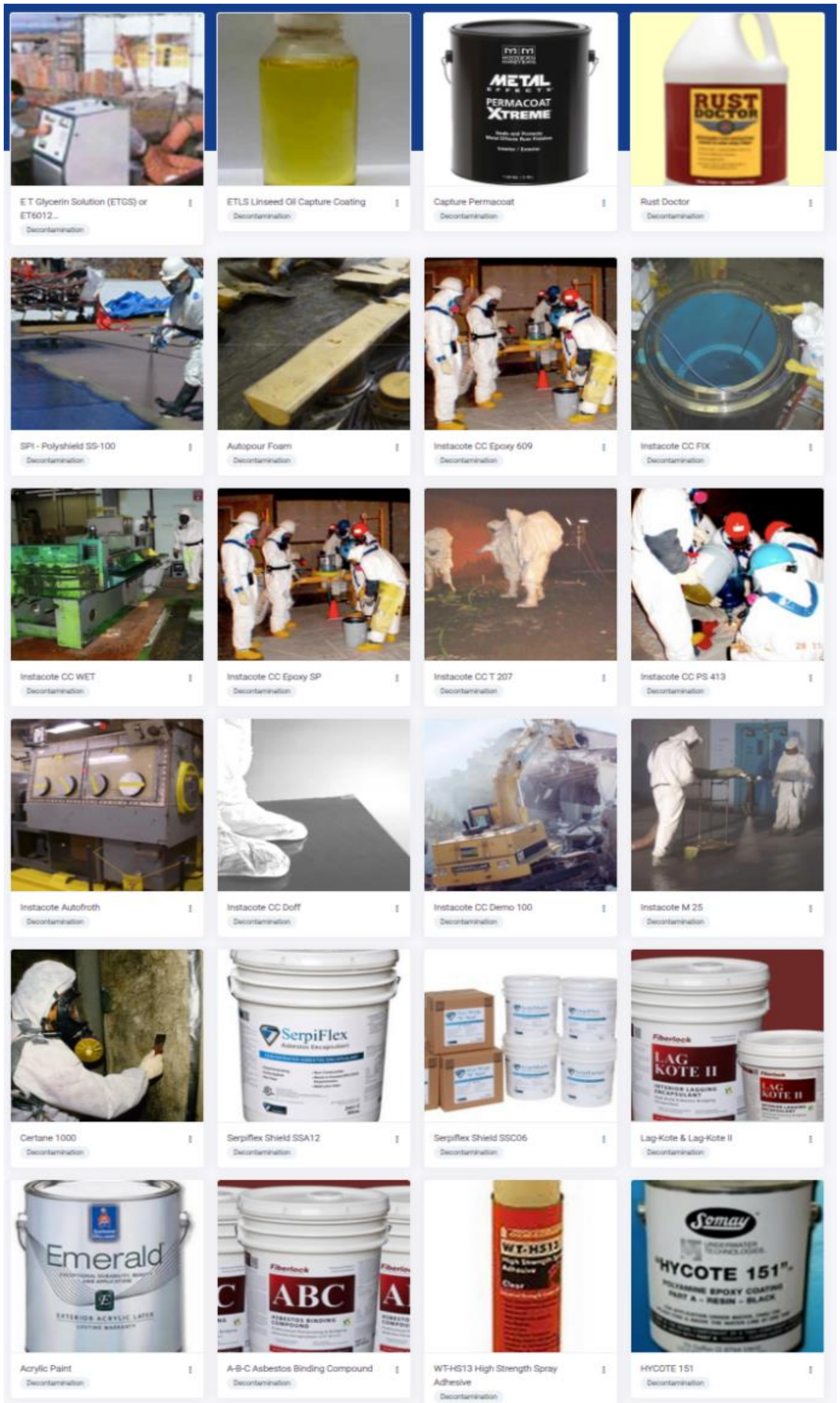

Figure 10: Example Long List – Strippable Coatings and Fixatives (1)

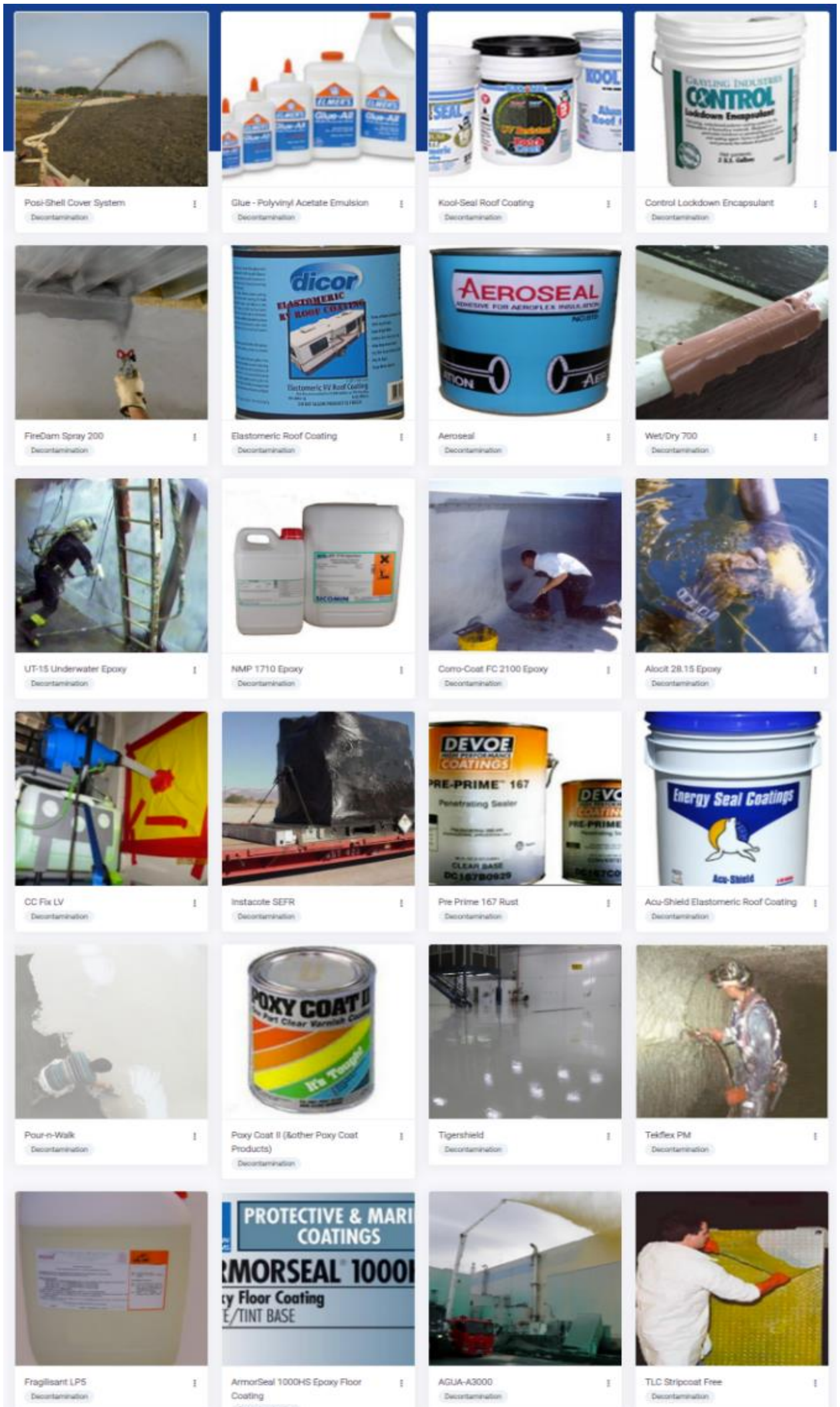

Figure 11: Example Long List – Strippable Coatings and Fixatives (2)

Appendix 2: Worked Example - Glovebox Remediation

Challenge Statement

The disposition of gloveboxes is a common occurrence across the worldwide nuclear industry. Typically, they are made from stainless steel and Perspex (Plexiglas) and contain alpha emitting materials. The resultant contamination is extremely hazardous to workers and very mobile.

Remediation is normally carried out in stages:

- nuclear material is removed followed by the internal equipment to leave the box ‘empty’
- The box is internally contaminated and different methods are used to remove or fix the contamination
- size reduce the box for subsequent disposal or dispose as an entire unit

Conceptually, the process is straightforward but as it is a hands-on project requiring workers in pressurized suits there are many operational challenges to ensure that it is carried out safely.

Review of LFE

A review of the LFE List identifies a large number of potential lessons learned from carrying out glovebox operations across the world. Different search terms reveal different LFE

The Long List

The Long List presents all the information received from a search term. It does not, at this stage, attempt to evaluate any for relevance or adequacy (this is done later).

Search term = Glove box

- The use of effective contamination control procedures and fixative sprays as well as using gloveboxes as containments helped to reduce the migration of contamination
- Size reduction of Plexiglas gloveboxes was accomplished using various tools
- Flexible plastic tubs were used to enable disposal of debris during glovebox size reduction operations as they could be placed directly into waste drums thereby minimizing waste

handling by the operator. Debris could also be poured directly into the waste drums but this reduced packing efficiency

- Hexarmor bags have been developed for the safe disposal of glass waste from gloveboxes. They provide operators with protection from needle-stick like injuries. The contents of the bag can be size reduced using a plastic or a rubber mallet although iof the size reduction was conducted against a hard surface, some glass shards could penetrate the bag. These bags are more effective than traditional leather bags
- A ventilated PVC tent was used during dismantling operations which were carried out in PVC suits and respirators. Glovebox dismantling was achieved using reciprocating saws.
- During dismantling of gloveboxes, suction pads and trigger clamps were used for handling glovebox panel sections. Suction pads did not work well as they could not create a vacuum on the panels because of the tie down coatings and the trigger clamps tended to cause wrist strain
- Waste management aspects associated with this work require extensive planning, coordination, and compliant work execution to ensure safety to the worker, the environment, and the public.

Search term = Size Reduction

- Wire cutting is better than plasma for complex shapes
- Cut only into very large items
- Special tools required for inspection
- Cutting of concrete with a diamond wire has been successfully used during a number of decommissioning projects
- Use of MDM to remove bolt heads showed that this method had decided disadvantages
- Problems experienced with AWJ cutting enclosures were directly tied to the number of gaps in the containment system
- Jagged cuts were the result of lack of needed rigidity in the supporting mast
- Whenever practical, tooling should have a hard-anodized finish
- Hydraulic driven tooling can leak fluids
- Evaluate the pool activity and area radiation impact resulting from cutting operations
- The use of plasma arc to cut various thickness of metal can be readily deployed in the field
- Plasma arc cutting should be limited to the lower irradiated internals components until the cutting technology is improved
- Experience demonstrated that the Cutting Mast stiffness/stability is very important to accurate cutting
- Most mechanical cutting equipment functioned acceptably
- The video system was marginal in observing the BMT cutting
- Abrasive water jet cutting material collection was challenging

- Abrasive water jet cutting material for testing was different from the actual material provided
- Clamshell lathes were successfully used to cold cut contaminated piping.
- Surgical removal of the embedded piping, while leaving the buildings intact and structurally sound, would substantially increase costs due to structural considerations and the depth of embedded pipe. Given the expense, The project chose to clean and survey in place the bulk of the embedded piping to meet final status survey acceptance criteria,which was accomplished with much success. After the NRC accepted the final survey readings, the piping was filled with grout
- Since most of the pipe was embedded in walls and floors, core drilling was used as necessary on various pipe runs to provide additional access locations to the drain header for both cleaning and survey.
- Radwaste shipping costs can be minimized by using the maximum shipping container volumes which satisfy transport regulations and truckload weight limits. Larger containers result in fewer cuts in components and structures and a reduction in shipments.
- Mechanical cutting worked very well for cutting RV and RVH.
- Plasma cutting for partitioning metal structures turned out to be extremely useful for decommissioning purposes
- Dry wire cutting was used for cutting out horizontal beam tubes which contained lead, aluminum in parts of their structures. Local dust extraction minimized the spreading of dust.
- Size reduction of Plexiglas gloveboxes was accomplished using various tools.
- A Fein saw was determined to be the best approach to size reduction of Inconel as it produced a slow, aggressive cut
- Grinders have been used during size reduction operations but are generally avoided now due to safety risks
- Small diameter or loose stainless pipework is best cut using a hydraulic shear. Larger or rigid pipes are best cut with a Fein saw. Cutting small or loose pipes with a reciprocating saw usually results in blade snagging and breaking due to movement of the pipe.
- Size reduction of stainless steel vessels was difficult.
- The Brokk Minicut proved to be very reliable.
- The original remote shear tooling supplied did not allow for movement i.e. twisting created during cutting operations and this quite often resulted in excessive forces and the manipulator would 'trip out', drop the tool and collapse to the cell floor. This was remedied by installing a spring system to absorb movement between the tool and the manipulator
- A ventilated PVC tent was used during dismantling operations which were carried out in PVC suits and respirators. Glovebox dismantling was achieved using reciprocating saws
- The original plan was to use a concrete crusher to remove the plinth. Although it had worked well during the trials, it was abandoned due to the brittle nature of the plinth which resulted in a projectile hazard. Concrete breakers and reciprocating saws were used instead but progress was slow because of the reinforcing bars.

- Bolt croppers were preferred for copper pipe cutting and crimping over a hydraulic power pack as the pressure for the cut could be more easily managed.
- Test cuts were conducted on sections of Darvic using reciprocating and oscillating saws to check the efficiency and to ensure that the materials did not shatter. It was found that if too much pressure was put on the oscillating saw it resulted in melting of the dross from the Darvic.
- ALARA trade off due to the size of the buoyancy compensation (BC) tool verses the potential creation of a streaming pathway.
- The use of a waste sizing table (WST) helps to ensure a stable, efficient work platform to perform precise shearing/cutting operations by securing the materials undergoing size reduction.
- A detailed cutting and packaging plan, based on a 3-D model, is needed for facilitating the segmentation operation on site
- Mechanical cutting worked very well for cutting internals and maintains good visibility in the pool.
- The use of flexible tools that can be re-built at site has proved to be very valuable
- A detailed cutting and packaging plan, based on a 3-D model, is needed for facilitating the segmentation operation on site
- The use of flexible tools that can be re-built at site has proved to be very valuable

<u>Search term = Fixatives</u>

- The use of effective contamination control procedures and fixative sprays as well as using gloveboxes as containments helped to reduce the migration of contamination
- The lab walls were sprayed with Protectapeel multisurface as there were a variety of surfaces to seal. It worked well for steel, masonry and vinyl flooring/linoleum
- Over Reliance on Fixatives for Contamination Control
- Low Risk Does Not Equal No Risk
- Good Work Practice for Stabilization of Highly Radioactive Contamination in Pipes
- Fixatives used in the Nuclear Industry to Trap Radioactive Contamination and other Hazardous Materials
- D&D Toolbox Project – Demonstration of a Whirling Nozzle for Fixatives Application in Hot Cell Interiors – 10430
- Use of Fixatives to Accelerate Building Decontamination and Decommissioning (D&D) – 9047
- Prevent Spread of Contamination from Fixatives to Soil

<u>Search term = Decontamination</u>

- Prior experience is important

- The most prominent lingering hindrance was the undersizing of the secondary process flow through the ion exchange vessels
- Shorter tubes received better decontamination than longer tubes
- A second DfD did little to improve the activity removal
- The presence of chromium slowed down activity removal
- Particulates need to be removed to ensure adequate decontamination
- Dose rates taken on the Pressurizer are meaningless for determining effectiveness of the decontamination
- Lessons Learned from the In-Situ Grouting in the Subsurface Disposal Area
- D&D Decision Model and Mobile Application for Selection of Fixative, Strippable Coating, and Decontamination Gel Products
- Chemical and Foaming Stability of Foam Decontaminating Agents - 16137
- Decontamination of Organic Wastes Containing Radionuclides – 15122
- A Cradle to Grave Decontamination Process – 15266
- CNC Milling as a Decontamination Method for Pond Skips -14322
- A Novel and Cost Effective Approach to the Decommissioning and Decontamination of Legacy Glove Boxes – Minimizing TRU Waste and Maximizing LLW Waste – 13634
- Unanticipated Chemical Reaction During Waste Load-Out
- Work Being Performed in a Confined Space May Create Hazards that Create Permit-Required Confined Space Conditions
- Unexpected Nitrogen Dioxide Hazard Created by Hot Cutting Decontamination and Decommissioning Activities
- Understanding the Importance of Hold Points
- Failure to Implement Compensatory Measures Allows for Recurring Issues
- Workers Refine New Equipment and Process Prior to Field Implementation
- Glove Bag Seam Failures Experienced

The Short List

The Short List takes the items of most relevance and interest from the Long List to create a smaller subset of LFE. Some items in the Long List are not relevant for this particular activity and others have only limited relevance. This evaluation is based on the collective judgment of the team, but it should be noted that the Long List can always be reviewed subsequently to refine and improve the short list.

<u>Contamination Control</u>

- The use of effective contamination control procedures and fixative sprays as well as using gloveboxes as containments helped to reduce the migration of contamination
- Over Reliance on Fixatives for Contamination Control

- Low Risk Does Not Equal No Risk
- Prior experience is important
- Particulates need to be removed to ensure adequate decontamination

<u>Size reduction equipment</u>

- Size reduction of Plexiglas gloveboxes was accomplished using various tools
- Glovebox dismantling was achieved using reciprocating saws
- Wire cutting is better than plasma for complex shapes
- Cut only into very large items
- Jagged cuts were the result of lack of needed rigidity
- Whenever practical, tooling should have a hard-anodized finish
- Hydraulic driven tooling can leak fluids
- Special tools required for inspection
- Plasma cutting for partitioning metal structures turned out to be extremely useful for decommissioning purposes
- Dry wire cutting was used for cutting out horizontal beam tubes which contained lead, aluminum in parts of their structures. Local dust extraction minimized the spreading of dust.
- Size reduction of Plexiglas gloveboxes was accomplished using various tools.
- A Fein saw was determined to be the best approach to size reduction of Inconel as it produced a slow, aggressive cut
- Grinders have been used during size reduction operations but are generally avoided now due to safety risks
- Small diameter or loose stainless pipework is best cut using a hydraulic shear. Larger or rigid pipes are best cut with a Fein saw. Cutting small or loose pipes with a reciprocating saw usually results in blade snagging and breaking due to movement of the pipe.
- Test cuts were conducted on sections of Darvic using reciprocating and oscillating saws to check the efficiency and to ensure that the materials did not shatter. It was found that if too much pressure was put on the oscillating saw it resulted in melting of the dross from the Darvic.
- The use of a waste sizing table (WST) helps to ensure a stable, efficient work platform to perform precise shearing/cutting operations by securing the materials undergoing size reduction.

<u>Waste minimization strategy</u>

- Radwaste shipping costs can be minimized by using the maximum shipping container volumes which satisfy transport regulations and truckload weight limits. Larger containers result in fewer cuts in components and structures and a reduction in shipments.
- A detailed cutting and packaging plan, based on a 3-D model, is needed for facilitating the segmentation operation on site

Waste handling

- Flexible plastic tubs were used to enable disposal of debris during glovebox size reduction operations as they could be placed directly into waste drums thereby minimizing waste handling by the operator. Debris could also be poured directly into the waste drums but this reduced packing efficiency
- Hexarmor bags have been developed for the safe disposal of glass waste from gloveboxes. They provide operators with protection from needle-stick like injuries. The contents of the bag can be size reduced using a plastic or a rubber mallet although iof the size reduction was conducted against a hard surface, some glass shards could penetrate the bag. These bags are more effective than traditional leather bags
- During dismantling of gloveboxes, suction pads and trigger clamps were used for handling glovebox panel sections. Suction pads did not work well as they could not create a vacuum on the panels because of the tie down coatings and the trigger clamps tended to cause wrist strain

For each bullet point, further information along with a reference to the original source material is held within the LFE List. This can therefore be investigated further by the team to fully understand what is meant by the words and whether the lesson learned is applicable.

Focus Areas

In this example, the short list can be categorized into 4 key areas of LFE.

1. Contamination Control
2. Size reduction equipment
3. Waste minimization strategy
4. Waste handling

The Focus Areas can be used to identify others potential solutions that, in conjunction with the LFE observed previously can result in improvements.

Potential Solutions

A review of the Idea Catalog identifies a range of technological solutions from across the world that could help to address some of the challenges faced. For each example, the Idea Catalog contains further, more detailed information that can be used to fully understand the context and appropriateness.

Waste Minimization

- INTEGRAL
- eMWaste G2 Suite

- METROPOLITIN
- DEMplus
- INSIDER
- PHUMS
- ARIES
- RAGNUSMOF

Waste Handling

- Alpha Glovebox Decommissioning
- Remote Glovebox Operations
- Port-deployed Glovebox Manipulator
- IDS5R
- Robotic Waste Package Closure System
- DPaCC

Size Reduction

- Remote Diamond Wire Cutting System
- Remote Dry Cutting Technology
- Diajet
- Dotty
- Flame Cutting System (FCS)
- IHI Laser Torch
- Oakridge Fuel Debris Retrieval System
- Westinghouse Disc Saw
- Hand operated laser cutting
- HLK-SRT-33300 - Size Reduction Tool
- Aspilaser
- Cecil
- Plasma Arc Cutting
- Laser Cutting
- Angle Grinder
- Air carbon arc
- Oxy-Fuel
- Nibbler
- Water Jet Cutting
- Power shear
- Reciprocating saw
- Jigsaw or saber saw
- Rotary saw, spiral-cut saw, RotoZip

Contamination Control (Strippable Coatings and Fixatives)

- CBI polymer gel
- PeelAway 7
- RadBlock (Orion SC)
- Decon Peel
- Instacote CC Strip
- ALARA 1146
- DeconGel
- TLC Stripcoat Free Fixatives
- AGUA-A3000
- ArmorSeal 1000HS Epoxy Floor Coating
- Fragilisant LP5
- Tekflex PM
- Tigershield
- Poxy Coat II (& other Poxy Coat Products)
- Pour-n-Walk
- Acu-Shield Elastomeric Roof Coating
- Pre Prime 167 Rust
- Instacote SEFR
- CC Fix LV
- Alocit 28.15 Epoxy
- Corro-Coat FC 2100 Epoxy
- NMP 1710 Epoxy
- UT-15 Underwater Epoxy
- Wet/Dry 700
- Aeroseal
- Elastomeric Roof Coating
- FireDam Spray 200
- Control Lockdown Encapsulant
- Kool-Seal Roof Coating
- Glue - Polyvinyl Acetate Emulsion
- Posi-Shell Cover System
- HYCOTE 151
- WT-HS13 High Strength Spray Adhesive
- A-B-C Asbestos Binding Compound
- Acrylic Paint
- Lag-Kote & Lag-Kote II
- Serpiflex Shield SSA12

- Serpiflex Shield SSC06
- Certane 1000
- Instacote M 25
- Instacote CC Demo 100
- Instacote CC Doff
- Autopour Foam
- Instacote Autofroth
- Instacote CC PS 413
- Instacote CC T 207
- Instacote CC Epoxy SP
- Instacote CC WET
- Instacote CC FIX
- Instacote CC Epoxy 609
- SPI - Polyshield SS-100
- Rust Doctor
- Capture Permacoat
- ETLS Linseed Oil Capture Coating
- E T Glycerin Solution (ETGS) or ET6012-06 Waterborne Capture

Each of these technologies/entries in the Idea Catalog database can then be assessed and accepted or rejected to keep refining the available options for the job in hand. At the end of the process, the D&D Team will have a log of all of the options they considered plus why they selected the approach/tools they have. This effort also feeds into technology development programs by identifying challenges where there really is no solution or where there is only a partial solution. In addition, in going through the process the team will identify many approaches and technologies that they were probably unaware of previously, but which might be applicable to a different D&D challenge subsequently.