An Integrated Approach to the Technical Development and Procurement of the UK's Intermediate Level Waste Containers – 14195

Jason Dean *, John Collins **, John-Patrick Richardson *
* National Nuclear Laboratory
** Idaho National Laboratory

ABSTRACT

The United Kingdom's (UK) intermediate level waste (ILW) is held in numerous container designs and stored within legacy stores. To actively mitigate any possible non-conformances, Sellafield Ltd (SL; the dominant user of the containers) initiated a Systems Engineering (SE) effort in conjunction with the UK National Nuclear Laboratory (NNL) and Idaho National Laboratory (INL). This effort was designed to facilitate the selection and acquisition of ILW packaging by developing a cost-effective path forward, collaborating across the supply chain, integrating the efforts of the various ILW owners, and underpinning container selection with the rigor needed to satisfy various stakeholders.

Evaluation criteria were developed against which the container supply options were rated. Ultimately, a box design was selected as the preferred container to store waste that will be retrieved from some ageing facilities on the Sellafield site in West Cumbria, UK. In this analysis, container design, procurement strategy, stakeholder buy in, and speed of risk reduction were evaluated to determine the option that most cost-effectively met the performance criteria. Building on this work, the same approach was taken to establish a UK-wide view and assess opportunities to collaborate with other UK nuclear installations.

The box selection delivered a clear way forward for the customer to guide future container acquisition through the linking together of all relevant existing information, which has facilitated universal stakeholder acceptance and lower costs, resulting in more robust and accelerated decision making and the establishment of a positive precedent for future collaboration on container procurement.

INTRODUCTION AND BACKGROUND

The UK's Intermediate level waste (ILW) is presently stored in legacy structures, including Sellafield. A breach of this storage could result in environmental contamination, significant cleanup cost and potential financial penalties.

Sellafield Ltd (SL) is responsible for the safe, clean and compliant management of ILW in the Legacy Ponds and Silos (LP&S) on-site. As the UK Government contractor, SL was planning for the safe and compliant retrieval, treatment, storage, transport and disposal of ILW (which differ in chemical reactivity, radioactivity, pyroforicity, etc.) from legacy facilities to meet enforceable regulatory milestones. In support of resolving this situation, a decision was required on the selection and acquisition of ILW containers to store the waste. This decision was complex as it required collaboration of stakeholders with differing objectives and the integration of information that resides across many business units.

To this end SL initiated a Systems Engineering (SE) Task (referred to as the "SE Task" hereafter) in conjunction with the UK National Nuclear Laboratory (NNL) and the Idaho National

Laboratory (INL) to facilitate the selection and acquisition of ILW packaging through an independent SE analysis with resultant recommendations [1]. Building on this work the UK Nuclear Decommissioning Authority (UK NDA) commissioned the same team to investigate and identify collaborative procurement opportunities, and further identify and quantify the associated benefits through stakeholder engagement [2]. Given the commencement of a number of significant procurement activities it is important that any recommendation be identified and initiated expeditiously.

This paper describes the SE tasks and successes realized in the procurement of ILW containers (including on-site transport flasks) for the Sellafield site and more broadly for the identification of collaborative procurement opportunities across the UK.

DESCRIPTION

The Challenge

In initiating the SE task for container selection at SL, it was determined that more than 11 different ILW containers (some with several variants) were in varying stages of development and use for final disposal or interim storage of waste. Each ILW owner was pursuing different strategies, perhaps optimized for their disposal/storage needs but suboptimal for the UK's requirements when considered as a whole. In light of these differing approaches, the independent SE task began challenging available assumptions and resulting strategies in order to recommend an underpinned decision on which container(s) should be used for the retrieval of waste at some of the Sellafield facilities including the Sellafield Legacy Ponds & Silos (LP&S), Windscale and Magnox Operating Plant (MOP) wastes. The decision was on the critical path and the preferred box solution was being challenged by a number of stakeholders, in particular from a Value for Money perspective.

The subsequent UK container collaboration task adopted the same approach to establish a UK-wide view and assess opportunities to collaborate with other UK nuclear installations.

Methodology

A number of SE tools and techniques were employed to deliver this project including:

- Trade Off Studies
- Alternatives Analysis
- Uncertainty Analysis
- Risk Mitigation

Fig. 1 outlines how the use of trade off studies underpinned the delivered ILW container acquisition strategy. Trade off studies are broadly recognized as the method for simultaneously considering multiple alternatives with many criteria, and the diagram demonstrates the key inputs and outputs from the trade off study process used by the SE team.

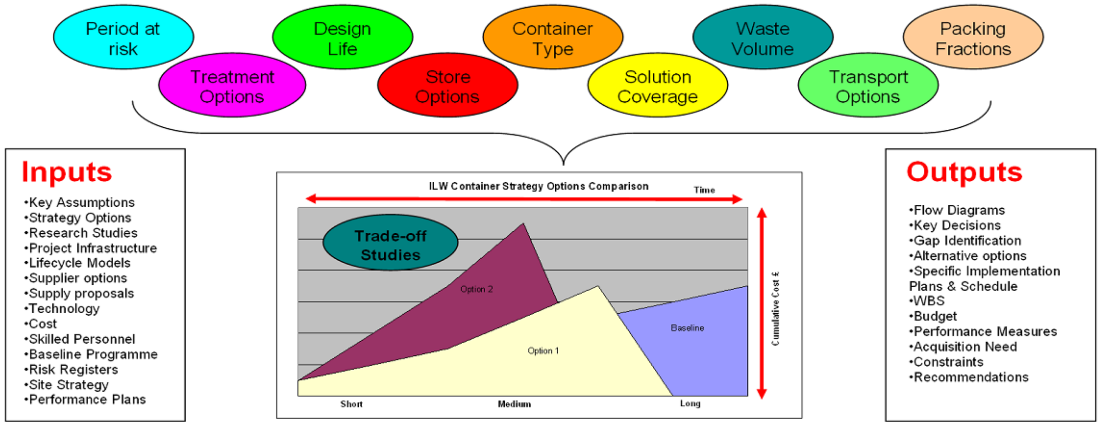

Fig. 1. Using Trade Off Studies to Underpin ILW Container Acquisition Strategy

Stakeholder Engagement

For the box selection it was necessary from the outset to consult widely within SL and with interfacing organizations (e.g. regulators) in order to explain the purpose and scope of the task and thus establish wide ranging communication channels, expectations and a means to maintain awareness of progress. As the decision on container selection was on SL's critical path, there was no time for extended post project stakeholder consultation.

An SE Working Group was also created to support this task delivery, comprising of Subject Matter Experts (SMEs) related to ILW container acquisition. This group became the key team to review, contextualize and challenge the SE task findings, and also to quickly connect the SE team with other resources (people, information) to support the effort.

The data required to underpin the best decision already existed amongst several business units, spread across various electronic and paper documentation, including spreadsheets and databases. The task was to identify the sources, review the data and agree with the data owner the validity of the SE team's interpretation of the findings. Data collection activities included 1-1 interviews, small discussion groups and desktop analysis of, the documentation and modeling work.

For the subsequent UK NDA Container Procurement project, quantitative data was primarily derived from the 2010 UK NDA National Inventory which provided a detailed inventory of waste data for each producer with associated attributes including package type and forecast demand by year. Where available this was supplemented with more qualitative information about the existing collaborations and anecdotal thoughts obtained through discussion with producers. This was also updated with the then-latest quantitative data underpinning Site License Company (SLC) positions, which hadn't at the time been formally included in the National Inventory.

DISCUSSION

The SE task of data collection, analysis and discussion led towards some key findings and tangible recommendations which allowed Sellafield Ltd to move forward into the procurement stage for the containers. The key recommendation was that ILW Container Procurement with 2 suppliers and 2 box variants should proceed forward immediately, following the agreed upon schedule, to engage suppliers and stakeholders in expediting the retrieval and more secure storage of ILW. The underpinning key findings and recommendations are discussed below.

Partitioning Of Procurement into Phases

The SE team developed a two-phase approach to the procurement of ILW containers. The working group agreed to adopt the recommended phased approach to procurement (illustrated in Fig. 2. as the volume demand for containers over time, with waste streams represented by different colors), with a focus on Phase 1 which supports the near-term retrieval of waste at a significantly reduced scale of initial procurement, without foreclosing options for waste streams that will be retrieved at a later date. The SE Team was aware of efforts at the time to accelerate retrieval and believed that this acquisition approach could be developed to accommodate acceleration.

Phase 1 included legacy wastes from the Sellafield Pile Fuel Cladding Silo (PFCS) which is planned to be essentially complete in 2023; it also included that amount of Magnox Swarf Storage Silo (MSSS) waste that would be retrieved up to the time of PFCS completion. The Pile Fuel Storage Pond (PFSP) retrieval was also planned to be accomplished prior to the end of 2023. Phase 1 included these three waste streams. Retrieval of four other wastes streams was scheduled to begin as early as 2021 but these were not included in Phase 1. This allowed a Phase 1 decision to be made regarding containers for near-term retrieval of waste without foreclosing options for waste streams that will be retrieved at a later date.

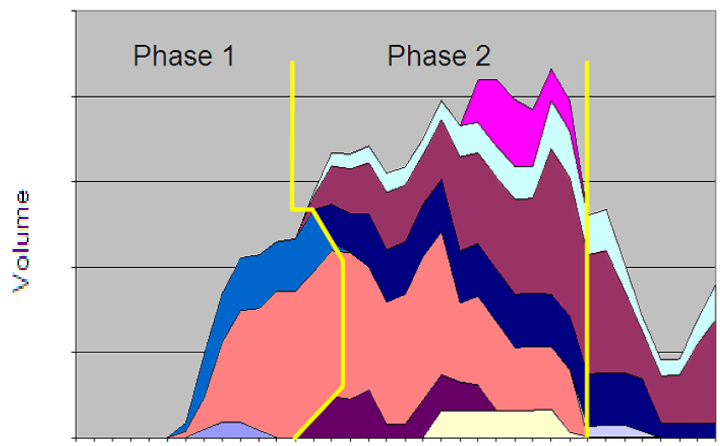

Fig. 2. Partitioning the Procurement into Phases

There were clear advantages for making the decision to acquire containers for only Phase 1 at the time:

- Allowed a decision to be made and the container acquisition process to begin quickly.
- Reduced the amount of near-term funding that is needed.
- Provided Phase 1 experience regarding vendor identification, qualification, contracting, fabrication, quality, and made this available to the Phase 2 acquisition.
- Allowed additional time to evaluate the viability of treatment options for Phase 2.
- Allowed advancement in materials and fabrication for Phase 2.
- Established a baseline for subsequent phases, which can be modified if proven cost

effective.

Constraints

The following sub-categories detail the various constraints uncovered during the SE task.

- **Container Selection**

A list of 11 ILW containers were being considered by SL, and these were assessed against a comprehensive set of requirements for containers to support retrieval of untreated PFCS waste and MSSS waste for subsequent treatment. The PFCS Concept Box option had been developed through a robust testing mechanism and became the benchmark for future developments. The key business needs that drove the current ILW strategy for the storage of waste in boxes included:

- Provision of Boxes endorsed by Nuclear Decommissioning Authority Radioactive Waste Management Directorate (UK NDA-RWMD) for eventual storage of ILW in the GDF including interim storage on site pending availability of the GDF.
- Provision of Boxes that meet user plant requirements.
- Ensuring the right commercial arrangements to supply boxes at the most economically advantageous cost, at the required rate and at the required time for each user plant.

Ideally, a single box design was preferred, however, at that time the PFCS and the MSSS user plants had each endorsed box designs that met each projects needs.

In order to select the best containers at the most reasonable cost, the SE team analyzed the multiple container attributes for each of the functions a container must perform. The results of this process were the selection of two containers, a Generic Single Skin with Liner box {Silos Direct Encapsulation Plant (SDP) Variant} and a Generic box with Double Skin (as selected by the PFCS and the MSSS projects).

These two container variants were chosen based on performance and cost. One of these containers would contain the treated waste with the other for untreated waste. Both showed excellent performance with a cost less than the PFCS box. Fig. 3 shows the PFCS box with the greatest performance of all the options with the selected container variants as part of the cluster of options, left of center of the Fig. 3.

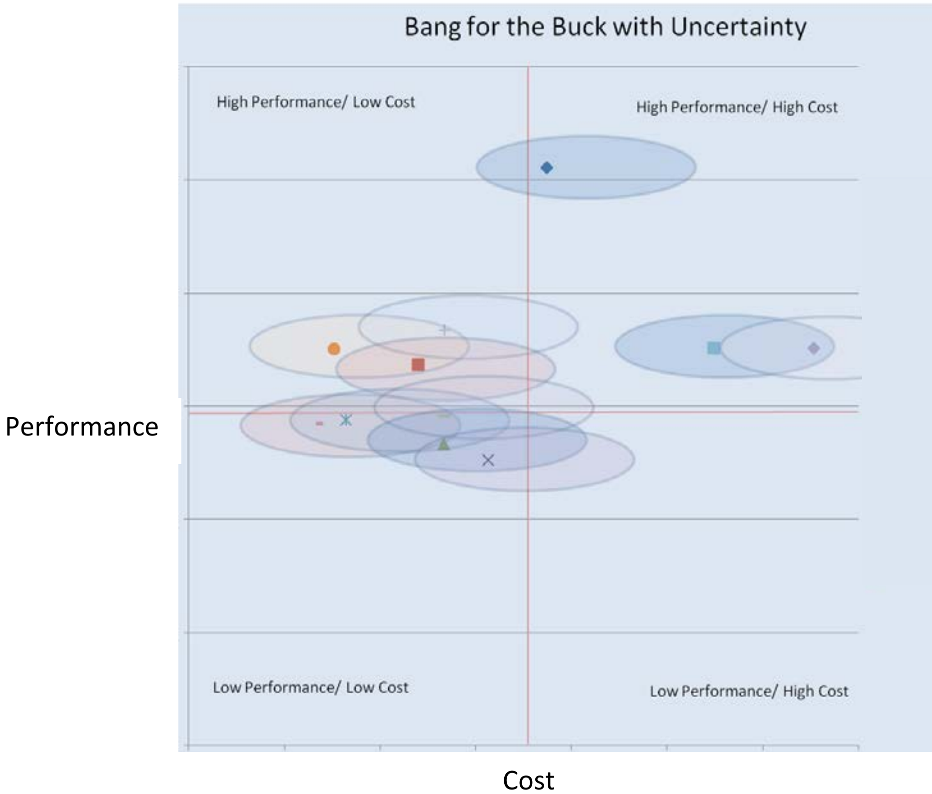

Fig. 3. ILW Container Performance

The SE Task independently validated that a sufficient degree of due diligence had been performed by both the PFCS and MSSS Projects in selecting and designing the Generic Double Skin (for untreated waste) and the Generic SDP Liner Variant (for treated waste). The PFCS box had made substantive progress towards authorization including drop testing. This fully engineered box was believed to meet all of the requirements for retrieval, transport, interim store, and disposal and was deemed invaluable in moving forward with the Generic Box - Double Skin. The Generic Box - Single Skin with internal Liner for the SDP Variant had substantial underpinning that can be used for other subsequent waste retrieval projects.

The SE team concluded that there was no compelling reason not to encourage both projects (PFCS and MSSS) to proceed with the Generic Boxes – Double Skin and Single Skin with Liner (SDP Variant) deployment for Phase 1. As the detailed Design for Volume Manufacture proceeds with the selected supplier(s), it was anticipated that common components (i.e. pressed floor or side plates) would be identified and simplify fabrication. When planning for Phase 2 begins, there will possibly be opportunities to develop a future box that leverages the best capabilities of both boxes.

Whilst the focus of the SE Task was on Phase 1, it was recommended that the PFCS raw waste and MSSS encapsulated waste boxes become the baseline requirements for container requirements in Phase 2. This would then provide a benchmark with which to compare new approaches as they became available.

- **Waste Treatment**

Having decided to manage procurement activities in 2 phases, it became clear that any new Waste Treatment activities would only impact Phase 2.

Managing ILW container procurement in phases allows decisions regarding treatment to be deferred until additional technology can be developed and proven. The following narrative summarizes the status of Phase 1 waste retrievals at the time of the SE task, as these affected ILW container acquisition:

- Waste retrieved from MSSS will be treated (solidified) in SDP with the intent that it will meet future GDF waste acceptance criteria.
- The PFCS project baseline option was to pursue a two-stage retrievals strategy for their wastes and its subsequent treatment, which represented both the ALARP and BPEO case for the waste stream strategy. Waste will be retrieved from the silo and placed into box containers, with no sorting or processing of the waste beyond visual characterization. The waste is then exported to one of two buffer storage facilities (BEPPS and/or EPS3). Waste containers will be removed from buffer storage once a treatment facility is available. After treatment and potentially repackaging to meet the Conditions for Acceptance (CFA) for the RWMD repository, the waste containers are transferred to BEPPS for surface storage prior to being exported to the GDF.

This strategy allowed for early retrieval of the bulk waste from the PFCS for storage in robust waste containers in a modern storage facility whilst developing, in parallel, a process to condition the waste into a form for disposal in the future within the GDF. Although this does not directly deliver (i.e. in one step) a final disposable product, it did deliver a solution which satisfies the Office for Nuclear Regulation (ONR) Specification.

- **Existing Equipment**

As part of the MSSS requirements, there were 9 flasks and 6 gamma gates from a previous manufacturing contract which were partially completed. Of the 9 flasks, 4 were fully complete and tested, 1 completed up to the wiring stage and the remaining 4 completed up to subassembly level. All gamma gates were manufactured in full. With the exception of 2 of the gamma gates, this equipment was all in storage along with the associated test rigs.

All existing flasks and gamma gates required significant modifications to incorporate design changes necessitated by the design of the SEP Mobile Caves i.e. passive hydrogen ventilation, revised flask maintenance philosophy within SMF, material change requirements and current legislation.

Uncertainty and Risk Management

The SE team determined that for Phase 1 ILW, the uncertainties were sufficiently reduced to facilitate Phase 1 ILW packaging selection and procurement.

Each of the individual projects adequately identified the significant project risks. These risks were captured in the ILW Container Project Risk Register and had risk ratings to allow focus on the highest risks, including uncertainties with waste forecast data, number of required containers, and cost data. These had thus far hindered the container selection decision and further analysis revealed the factors affecting the uncertainties as follows:

- Waste packing fractions.
- Waste characterization and segregation.
- Waste reactivity (i.e. pyroforicity).
- Waste handling and creation of secondary waste.
- The ability of the container to perform as required in terms of their retrieval, transport, storage, and disposal functionality.

If a greater number of containers than forecast were required, it was assessed that the impact would be:

- The supplier would need to manufacture boxes more quickly or the supplier would need to manufacture over a longer period.
- More interim and final storage space would need to be provided; also stores may be required earlier than currently estimated.
- The retrievals process may be executed over a longer period.

If a fewer number of containers than forecast was required, it was assessed that the impact would be:

- The supplier would need to manufacture boxes at slower rate or the supplier would need to manufacture over a shorter period.
- Less interim and final storage space would need to be provided.
- The retrievals process may be executed over a shorter period.

Detailed modeling work had been carried out and underpinned what the distribution around the mean number of containers required looked like. The SE team considered this as an acceptable data set that a given supplier could use to underpin the scalability of their container manufacturing which they could then use to price accordingly.

ILW Containers - Make vs. Buy

SL's "Make vs. Buy" decision was assessed regarding container fabrication. Two potential advantages of having SL fabricate their own boxes were identified, including increased autonomy (i.e. no dependence on a vendor), and a possibility that the total life-time cost might be less. Limited dependence on a vendor could be overcome with the use of two suppliers. Given this and the fact that the "make" advantages were not persuasive compared to the following disadvantages, it was recommended that external suppliers fabricate the boxes because:

- SL's defined Core Business does not include fabricating thousands of boxes.
- Difficulties in acquiring multi-million pound near-term funding to design, construct, and start-up fabrication facilities and equipment. Buying the containers allows this upfront cost to be distributed over the cost of each box over time.
- Unacceptable risk would be placed on SL that is normally transferred to a vendor at some acceptable cost.
- In making boxes it would be perceived that the "government" was competing with private commercial industry.

Procurement Strategies

Through the delivery of the SE task a significant volume of structured data was generated to underpin a series of discussions that generated the procurement strategy. This included lengthy internal stakeholder consultation in order to discuss the potential ramifications of the options being discussed.

The recommended strategy, which included two suppliers, target price, delivery rate guarantees, with early involvement of the supplier had the following detailed characteristics:

- Supplier - It was determined that a multiple supplier strategy was preferable over a single supplier to mitigate default risk and ensure back up in the event of unanticipated issues with one supplier. The first supplier would be dominant manufacturing about 90% of the containers with the remainder manufactured by the second supplier.
- Price – It was determined that a target price open was preferable with an open book policy where savings captured through efficiencies are shared with the supplier.
- Guarantee – A hybrid solution was identified and agreed to by all where this included a long-term strategic partnership with the two suppliers to ensure that container consumption rates were met and met for the anticipated variable demand rate.
- Bufferage – It was determined that bufferage could be best met by allowing the supplier to provide the bufferage needed to assure that their production and delivery rates were met in such a way as to avoid any penalty defined in the guarantee. Hence bufferage was removed as a variable, to be determined by the supplier.

Based on this procurement strategy, it was anticipated that the suppliers will be selected early to allow sufficient time to perform a Design for Volume Manufacture review with container modifications, as needed. Early Design for Volume Manufacture accelerates the mitigation of the risk that the ILOC will be invalidated and accelerates the overall risk reduction.

The UK NDA container procurement project comprised:

- A data collection and analysis exercise on baseline arisings / container projections in determining Intermediate Level Waste (ILW) container (and other SLC) requirements in relation to waste arisings. Data was sourced from the 2010 NDA National Inventory and supplemented with updated data obtained through dialogue with NDA, SLCs and other site operators.
- The development of a range of scenarios.
- A structured workshop to discuss the findings and agree a plan to develop further.

The purpose of the data collection exercise was to obtain data in order to create an up-to-date position on container options, volumes, timescales and procurement opportunities.

This data was then analyzed in order to develop a number of collaboration scenarios that could be developed as a starting point for discussion at a subsequent stakeholder workshop, involving the data originators.

The aim of the workshop was to discuss existing collaboration ideas and encourage further idea generation. These opportunities were then voted by preference against the criteria of cost effectiveness, risk reduction, socio-economic benefit, environmental (recycling), and ease of storage at the GDF.

The consolidation of effort across SLCs would demand a contract providing the best available opportunity for risk management and mitigation on pricing and security of supply with a supplier or suppliers.

If multiple waste producers have a demand for a similar waste product over a similar timescale, then the theoretical opportunity to collaborate arises. Barriers to collaboration notably included:

- Each waste producer having a key priority to reduce their own hazard without an enforced requirement to consider the bigger picture with other waste producers.
- The relatively fluid nature of forecast timescale and volumes, consistent with evolving strategy, that results in delays, which consequently doesn’t provide incentives for collaboration.

Only the HISSC was found to be delivering container collaboration with some stainless steel drum variants. Subsequent analysis of data and discussion with waste generators underpinned the generation of three potential container collaborations with two other opportunities for Self Shielded Containers and other stainless steel drums which needed further underpinning before they could have been investigated further.

When compared to the lifetime costs at Sellafield, the potential benefits appeared insignificant with the question raised as to if there was any benefit in moving forward at all with those collaborative opportunities. However all potential collaborators agreed that more communication between SLCs would better challenge conventional thinking, especially where some container costs seem excessive.

During the workshop participants were asked to vote on the main potential areas for collaboration with the sharing of information, learning, services, and knowledge between all SLCs taking the top four places in the vote.

CONCLUSIONS

This paper has described a robust approach to integrating information derived from relatively simple processes in order to derive a transparent integrated solution that can be readily understood by stakeholders and allow them to make key decisions quickly.

The significant accomplishments and recommendations of the SE task included:

a) Partitioning of the container procurement into phases with initial focus on Phase 1 which includes MSSS, PFSP & PFCS raw waste up until the end of PFCS disposition in approximately 2023, in order to limit uncertainty and facilitate decision making.
b) Establishing that waste treatment can only impact on Phase 2 container acquisition but will not impact Phase 1, thereby reducing forecast uncertainty and facilitating decision making.
c) Development of a plan for the proposed Volume Procurement Strategy framework with early stakeholder engagement prior to OJEU [Official Journal of the European Union] box supplier selection that will:
    - o Accelerate task risk reduction and reduce cost.
    - o Incorporate breakthrough innovation through early supplier engagement and design for volume manufacture that could for example include automated welding and replacing hold points with automated weld verification.
d) Recommendations to secure a long-term partnering arrangement with early OJEU engagement and selection of two suppliers to further the design for volume manufacture, obtain full container certification, fabricate the boxes, enhance flexibility in box consumption rates, and reduce the risks associated with the future delivery arrangements of containers.
e) Validation of the container Make/Buy decision to proceed with Buy decision on container procurement.
f) Validation of the decision to use only two variants of the box rather than multiple boxes or drum variants. The two variants are the double skin generic box (modified from the concept box) for untreated waste and the SDP variant of the single skin generic box with liner for treated wastes.
g) Validation that certainty in number of boxes needed is sufficient to allow proceeding with box acquisition. However, the uncertainty is important and must be reduced prior to tender.
h) Validation that a Common Product Transfer Flask should be procured and managed to reduce design and approval costs, and to improve on the economies of scale.
i) Production of a detailed schedule to support the path forward.

It was assessed that if the above recommendations were fully executed and the accomplishments become the accepted path forward, the accelerated risk reduction noted in Fig. 4 would be realized and the likelihood of task success increased.

SL have subsequently built on the Systems Engineering study and produced an associated container acquisition strategy, and initiated engagement with the supply chain to deliver the containers, which is currently on-going. The Magnox data indicated that Magnox were about to initiate a separate procurement exercise for their box requirements.

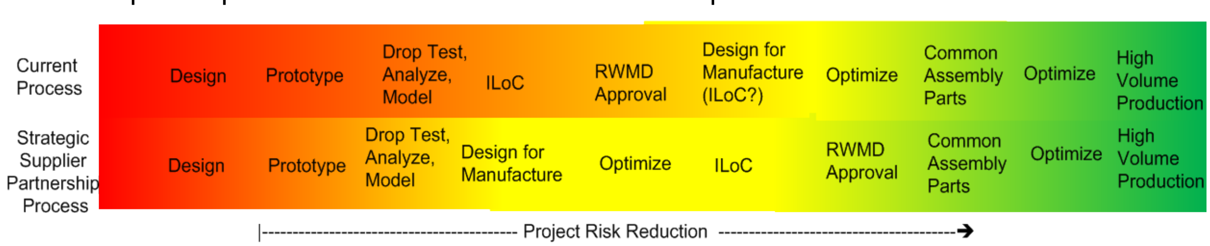

Fig. 4. Strategic Partnerships between SL & Supply Chain Accelerate Risk Reduction

The UK NDA Container Procurement project confirmed that Sellafield was the dominant demander of containers and consequently had the greatest potential for identifying savings in the future, e.g. beyond the initial procurement for boxes, development of Thermal treatments in preference to encapsulation could significantly reduce the amount of waste that is produced and thus the associated demand for boxes.

It found that a number of procurements were already in-flight / planned and whilst there was some evidence of technical collaboration with Magnox and EDF Energy on self shielded containers, there was no evidence of plans for new procurement collaboration initiatives, when there appear to be opportunities to do so.

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