SYSTEMATIC APPROACH FOR DECOMMISSIONING PLANNING AND ESTIMATING

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ABSTRACT

Nuclear facility decommissioning, satisfactorily completed at the lowest cost, relies on a systematic approach to the planning, estimating, and documenting the work. High quality information is needed to properly perform the planning and estimating. A systematic approach to collecting and maintaining the needed information is recommended using a knowledgebase system for information management. A systematic approach is also recommended to develop the decommissioning plan, cost estimate and schedule. A probabilistic project cost and schedule risk analysis is included as part of the planning process. The entire effort is performed by a experienced team of decommissioning planners, cost estimators, schedulers, and facility-knowledgeable owner representatives. The plant data, work plans, cost and schedule are entered into a knowledgebase. This systematic approach has been used successfully for decommissioning planning and cost estimating for a commercial nuclear power plant. Elements of this approach have been used for numerous cost estimates and estimate reviews. The plan and estimate in the knowledgebase should be a living document, updated periodically, to support decommissioning fund provisioning, with the plan ready for use when the need arises.

INTRODUCTION

Nuclear facility and power plant owners are facing an increasing challenge for protecting their business operations and investment. They must know the true future cost for decommissioning and must be ready to execute decommissioning when the facility is shutdown. For power plants no longer in the rate base, the responsibility is now on the owner and not the ratepayer (public). In the past, decommissioning estimates were produced to meet NRC and/or Public Utility Commission (PUC) regulatory requirements. However, the estimates were not necessarily done as one would if a decommissioning project was contemplated in the near future. To ensure that the estimate is based on the approach that may be taken for decommissioning, management needs to ensure that the team does not just prepare an estimate but performs preliminary decommissioning planning as part of preparing the estimate. The plant owner, as part of the team, needs to validate the technical basis for the plan/estimate. There are many factors that affect the decommissioning plan/estimate to be considered during and subsequent to the planning and estimating effort. A plant owner needs to ensure that the estimate is kept current through

periodic reviews and updates to support regulatory and company budget reviews. As plant modifications and operational activities can affect the decommissioning plan and estimate, the plant owner needs to track impact of such modifications and operations on the estimate. Due to many uncertainties, multiple scenarios should be evaluated and risk analyses performed as part of the planning and estimating. For these reasons and since the decommissioning may be done some long time in the future, a systematic approach to planning, estimating, updating, tracking, and documenting the planning and estimating work is needed to ensure it is understood, retrievable, and ready for use.

A SYSTEMATIC APPROACH TO PLANNING AND ESTIMATING

A systematic approach is required to perform the decommissioning planning and cost estimating effort. A recommended approach is depicted in Figure 1. This approach covers all aspects of decommissioning planning and estimating:

- Define Requirements & Constraints
- Prepare Basic Approach and Guidelines
- Prepare Overall Decommissioning Schedule
- Estimate Costs
- Perform Risk Analysis
- Evaluate Risks
- Perform Scenario and Sensitivity Analyses
- Report Results
- Utilize Knowledgebase to Support Analysis and Document Results
- Provide Inputs to Knowledgebase from Industry and Plant Data

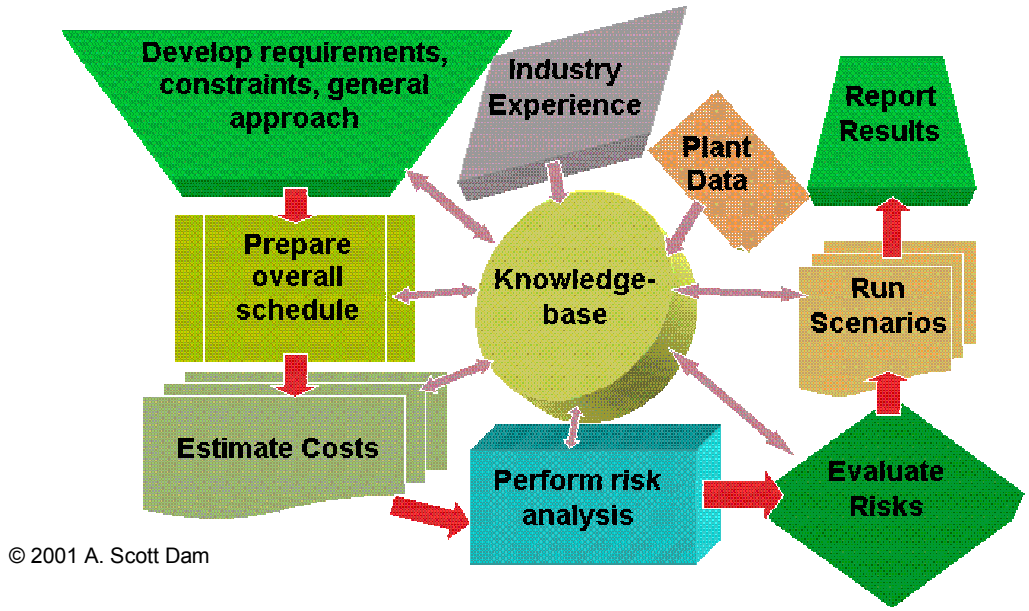

Fig. 1. Systematic Approach to Decommissioning Planning and Estimating

This recommended, systematic approach was developed by the author and utilizes integrated software systems such as XtremePM™, Primavera Project Planner (P3) or MS Project, MS Access, and At-Risk. The planning and estimating is performed by a small, knowledgeable team with owner representatives participating in key activities such as the risk workshop, which is described later in this paper.

Define Requirements & Constraints

Using the systematic approach, the first step is to develop the requirements and constraints for the decommissioning program. Requirements and constraints to be considered include the following:

- Decommissioning fund status
- Decommissioning method – DECON, SAFSTOR
- Planned Shutdown Date
- Purpose & management expectations
- Site conditions & space considerations
- End state desired – full or partial site release
- Site type – one or more units
- Extent of plant and site contamination
- Site release or cleanup levels, site-specific analysis
- Waste storage
- Labor agreements
- Waste disposal availability
- Spent fuel storage capacity (full-core off-load)
- Staff experience in D&D

Prepare Basic Approach and Guidelines

Within the constraints identified, prepare a general approach for the planning including identifying the expected timing, whether the final site cleanup will be prompt or delayed. Also, include in the basic approach the planned performing organization for the work, a decommissioning contractor or an internal organization (self-performing / contract management approach). As part of determining the approach, the owner should validate assumptions made in topics such as site release criteria, removal date for spent fuel, and future availability of low-level waste disposal.

Prepare Overall Decommissioning Schedule

The second, iterative step is to prepare an overall schedule for the decommissioning using work breakdown structure (WBS) tasks and milestones with MS Project or P3. This information is loaded into the database (e.g. XtremePM™) and forms the WBS for the cost estimate, or Estimate Breakdown Structure (EBS). The scheduling should be done as a phased effort with

major activities identified. The schedule should be arranged with a logical work flow, considering the ability to move spent fuel into a wet or dry storage facility or off-site. Options in the schedule should be identified. The team should analyze the high-risk items, such as the spent fuel and large component removal approaches. EPRI decommissioning project has been preparing guidance documents to help the planning and scheduling activities. Lessons learned from other decommissioning projects should be incorporated into the planning.

Estimate Costs

The cost estimate is prepared using standard tasks as the basis, developed from R.S. Means & Co. and industry data, which are frequently updated. The standard tasks are modified for special conditions. Guidelines for this estimating approach can be found in various references, including an older report from the former Atomic Industrial Forum (now Nuclear Energy Institute) (1) that still provides useful reference information. The labor and material cost rates are updated using Means and industry data mentioned above. Use of a purchased software system such as the XtremePM™ system is recommended as it can include standard tasks as part of its base and can integrate Means data for other tasks. It is set up to use special conditions modifiers. If a previous estimate has been performed and there have been no major changes in the plant design, levels of contamination, etc., that previous estimate can be used as the basis for quantities, presuming it provided breakdowns for by plant areas. Typically decommissioning is done by areas and not by systems. Before a previous estimate is just used as is and just escalated, the planning basis assumptions, approach, etc. need to be carefully evaluated. If the plant data is out of date due to modifications or if there is a concern about the validity of the estimate, new material takeoffs should be made and a "bottoms-up" estimate prepared. Note that the material removal portion of the estimate is only about one third of the total estimate, with spent fuel and waste disposal and site labor accounting for the other two thirds of the estimate. As part of the cost estimate a waste processing and disposal model (using the by-product operations portion of XtremePM™). Once the base estimate is prepared (prior to risk contingency being added), the NRC formula (2) should be reviewed as a comparison for power reactors. Table I is an example of a cost estimate summary work sheet for a large BWR. The costs are developed for each EBS

Table I. Cost Estimate Work Sheet

Typical Large BWR Decommissioning Summary Cost Estimate									
WBS		Activity	Decon	Remove	Pack	Ship	Bury	Other	Total
			1999 $000 US						
		Total Cost	**$17,041**	**$65,596**	**$7,821**	**$4,204**	**$49,432**	**$204,797**	**$348,891**
1		**Planning**	**$2,206**	**$6,674**	**$625**	**$559**	**$3,488**	**$47,397**	**$60,949**
	1.1	Planning and Site Preparation						$2,681	$2,681
	1.2	Additional Costs	$1,418	$5,680	$427	$495	$1,189	$13,552	$22,761
	1.3	Period 1 Undistributed Costs	$788	$994	$198	$64	$2,299	$25,031	$29,374
	1.4	Staff Costs						$6,133	$6,133
2		**Decommissioning**	**$11,591**	**$41,482**	**$7,140**	**$3,643**	**$45,732**	**$101,961**	**$211,549**
	2.1	Nuclear Steam Supply System Removal	$1,154	$7,033	$1,429	$1,496	$22,936	$824	$34,872
	2.2	Removal of Major Equipment		$605	$122	$51	$459	$7,865	$9,102
	2.3	Disposal of Plant Systems	$2,462	$16,665	$1,682	$785	$6,313	$5,924	$33,831
	2.4	Decontamination of Site Buildings	$4,927	$2,496	$3,505	$1,184	$13,142	$6,127	$31,381
	2.5	Period 2 Additional Costs						$7,232	$7,232
	2.6	Period 2 Undistributed Costs	$3,048	$14,683	$402	$127	$2,882	$39,717	$60,859
	2.7	Staff Costs						$34,272	$34,272
3		**ISFSI**	**$3,244**	**$783**	**$56**	**$2**	**$212**	**$49,366**	**$53,663**
	3.1	ISFSI Capital Expenditure						$40,055	$40,055
	3.2	ISFSI Site Restoration	$3,244	$783	$56	$2	$212	$250	$4,547
	3.3	Period 3 Undistributed Costs						$8,536	$8,536
	3.4	Period 3 Staff Costs						$525	$525
4		**Site Restoration**		**$16,657**				**$6,073**	**$22,730**
	4.1	Demolition of Remaining Site Buildings		$11,511					$11,511
	4.2	Site Closeout Activities		$2,318					$2,318
	4.3	Period 4 Undistribute Costs		$2,828				$4,885	$7,713
	4.4	Staff Costs						$1,188	$1,188

item and rolled up to the summary level shown in the table. The costs are categorized by general types of activities shown – decon, remove, pack, ship, bury, other – and by phases. Note that these values do not include a classical estimated percentage contingency. A risk contingency is calculated as described later.

Perform Risk Analysis

Once the basic costs are developed, a probabilistic risk analysis is performed to determine the risk contingency to be added to the estimate. The first step is to develop the list of risks and cost impacts. A risk workshop is convened to develop the risks with participation by the plant owner. In the workshop, the workshop participants use their experience and the project plans to identify potential risks, such as increased costs for waste disposal, delays in receipt of regulatory approvals, and schedule delays due to equipment breakdowns. Potential activities with a high risk include spent fuel removal and reactor vessel removal and disposal. Typically, a workshop identifies about 60 to 100 risks for a large decommissioning project. During the workshop risks are categorized by potential for occurrence (low through high), impact (cost or time in actual values or level – low through high), and EBS elements affected. Some specific cost analysis may be needed to determine the potential cost impact. This data is entered into a database. The cost and risk data is evaluated by Monte Carlo simulations. A good software program for performing this analysis is AtRisk® with the database in MS Excel. The program is run to generate the confidence curves on the estimate. Figure 2 shows a typical confidence curve.

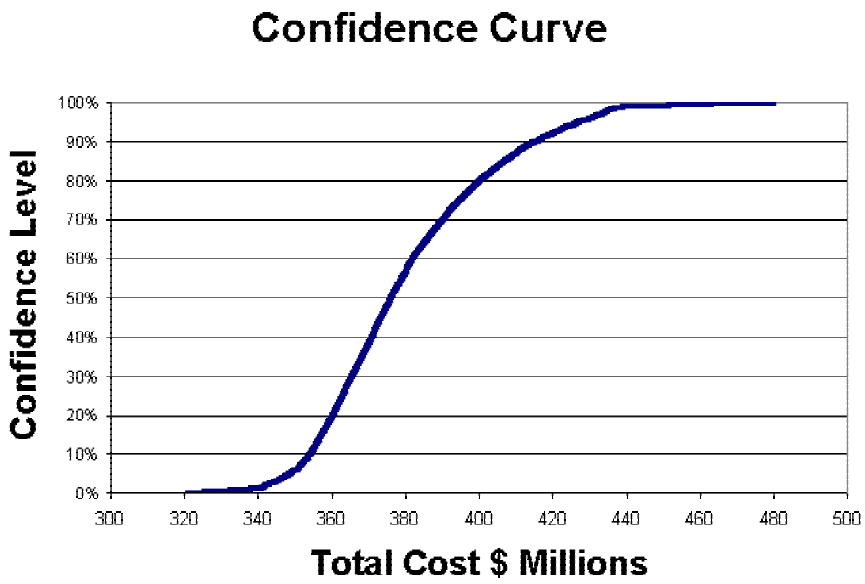

Fig. 2. Risk Confidence Curve

Evaluate Risks

The team reviews the risks and makes adjustments depending on severity and overall impact. Both cost and schedule impacts should be evaluated. As part of the risk generation process, potential mitigation measures should be identified. The analysis is usually performed assuming that the measures are not effective. However, certain risks may completely overwhelm the analysis. These should be removed and handled separately and discussed with management. Assumptions that lead to high risks should also be reviewed. Actions to reduce or further quantify risks should be considered.

Perform Scenario and Sensitivity Analyses

Identify alternative scenarios for further evaluation. For example, if an assumption is made on disposal availability and costs, an alternate assumption could be made and the analysis re-run. Another key factor is spent fuel removal from the site. The basic assumptions may be altered and additional scenarios performed. Results should be kept in a usable and retrievable form for the future by providing the backup data and estimates in a XtremePM™ file.

Utilize Knowledgebase to Support Analysis and Document Results

To ensure that plant data is available for use in the planning and estimating process, use a knowledgebase with ability to share with others, e.g., "Owners Group" or other company projects. One knowledgebase system useful for decommissioning planning and estimating is XtremePM™ developed by Merrimac Corporation of Cherry Hill, New Jersey. This system provides the tools to implement a total project (or program) virtual work environment and includes modules for cost estimating, facility structure, work breakdown, processing & operations, performance monitoring and reporting, administration - security, HR, and library (relational reference information: diagrams, drawings, specs, photos, videos, characterization maps). Figure 3 shows the elements of the XtremePM™ system and how they fit together into an integrated system.

Fig. 3. XtremePM™ Knowledgebase System Concept Diagram

The system is set up to interrelate the data for all the activities, including updating for lessons learned and evaluating scenarios. The system is a LAN-based client-server with distributed input (PC) and uses Visual FoxPro as the database system. The system is set up to interrelate the data for all the activities, including updating for lessons learned and evaluating scenarios. The system is a LAN-based client-server with distributed input (PC) and uses Visual FoxPro software.

Figure 4 is a schematic flow diagram for the system.

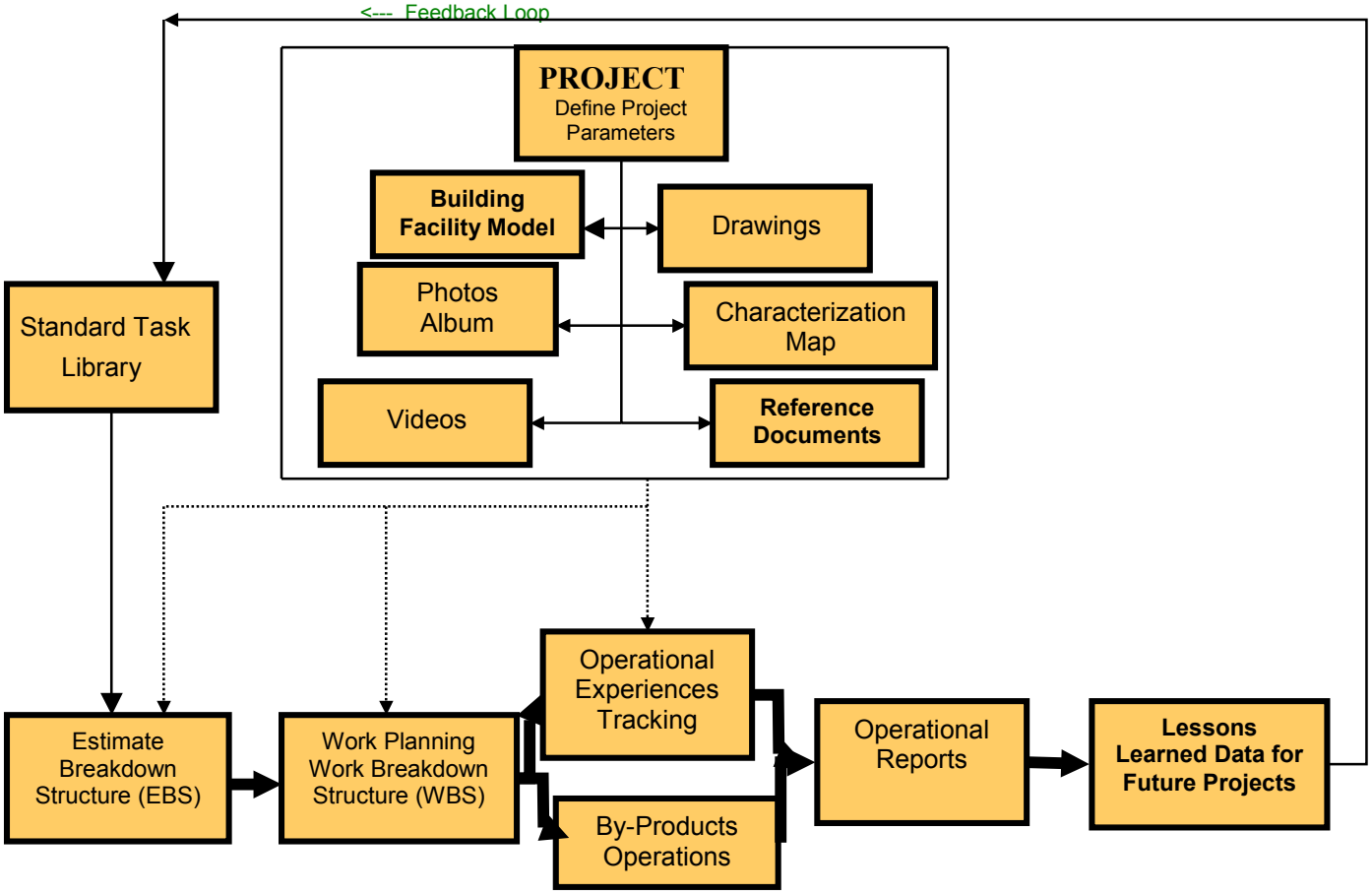

Fig. 4. XtremePM™ System Flow Diagram

Report Results

The results of the planning and cost estimating should be accumulated into a report for management. The entire database and analysis would be available as part of the complete planning effort. In addition to reporting for management, the results should be share in public

forums, as appropriate depending on the competitive situation. Current plant owners are learning from each other on how best to perform planning and actual decommissioning. It is also important to ensure that commonly owned operations use common system and share data and experiences.

EXPERIENCE

Elements of this systematic approach have been used on a number of projects over the past three years for a variety of plants and facilities.

- A small BWR decommissioning project utilized moat of the elements of this process and is utilizing XtremePM™ for records management and data collection
- Two large plant (1 PWR, 1 BWR) decommissioning planning projects used the systematic approach and XtremePM™ cost estimating system, waste processing system, and database management
- For a large number of plants the cost & risk analysis methodology and described were used for evaluation and updating of cost estimates

Experience with the system has generally been very good, depending on the interest, dedication, and training of the users. On the two decommissioning cost estimating projects the use of this system saved time and cost over conventional estimating approaches. In one case the effort was about 20% of the cost using a conventional estimating method and allowed alternatives to be evaluated with very high quality documentation.

SUMMARY

A systematic approach to decommissioning planning and cost estimating is necessary to ensure a complete and usable plan and estimate. By utilizing available software systems the effort can be reduced with improvements in data availability and retrievability overall, as summarized below

- Transportable knowledgebase system allows easy updating / modification / scenarios & risk assessment
- Analysis results in real baseline D&D budget, defendable, and usable for the future project
- Methodology for planning & cost estimating which captures experience and proven approach
- Knowledgebase available for sharing and future use

This approach is recommended for any group, owners or consultants, performing decommissioning planning and estimating work.

REFERENCES

1. Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates, National Environmental Studies Project, Atomic Industrial Forum, Inc., AIF/NESP-036, May 1986.
2. Reporting and Recordkeeping for Decommissioning Planning, Title 10, U.S. Code of Federal Regulations, Part 50, Section 75 (10 CFR 50.75)