LINKAGE OF OPERATIONAL NEEDS FOR SPENT NUCLEAR FUEL DISPOSITION TO TECHNOLOGY DEVELOPMENT MAPS

Chris A. Dahl
Idaho National Engineering and Environmental Laboratory
MS 3135, P. O. Box 1625
Idaho Falls, ID 83415-3135

ABSTRACT

The Department of Energy is preparing spent nuclear fuel (SNF) for interim storage at the major SNF sites. At the same time, work is proceeding to analyze the requirements for disposal of the SNF in a geologic repository, currently proposed to be located at Yucca Mountain in Nevada.
To assist with the placement of SNF in either interim storage or the repository, certain technologies must be developed and implemented to assure that the storage can be safely and efficiently achieved. Technology development funding is diffused through a variety of resources within the DOE complex. A tool is required to show the integration of technology development activities with each of the funding sources, show the entities performing the development work, and demonstrate how the technology development assists with the interim storage and final disposition of SNF. A series of requirements for this tool were defined and a tool developed to assist with showing the required information. The tool has taken the form of Technology Development Maps that link development information, funding sources, entities performing development activities, and the material disposition path for each SNF type. These maps will be maintained as living documents to assist with integrating development activities for the SNF program.

BACKGROUND

The United State Department of Energy, Office of Environmental Management (DOE-EM) currently manages nearly 2,500 metric tons heavy metal of spent nuclear fuel (SNF). SNF is defined for these purposes using the same definition the DOE-EM SNF program used in various Environmental Impact Statements. SNF is fuel and targets that have been irradiated in a nuclear reactor, the constituent parts of which have not separated.

DOE-EM is preparing the SNF for interim storage at the major SNF sites. To reduce long-term cost, the SNF sites are executing interim storage plans to move the SNF to secure dry storage out of the existing wet basin storage. At the same time, work is proceeding to analyze the requirements for DOE-EM SNF disposal in a geologic repository, currently proposed at Yucca Mountain in Nevada. During the interim period to a final decision and license for the proposed national geologic repository at Yucca Mountain, Nevada, the SNF must be safely stored and maintained. At the same time, DOE-EM has to prepare a "safety case" analysis justifying planned treatment and packaging of SNF for disposition in the proposed repository. Risk elements and responsive control strategies have been defined for both pre-closure and post-closure activities. As these two activities proceed, attempts are being made to define and pursue complementary strategies for the activities. One of the goals of the DOE-EM SNF program is to overlay known requirements for interim and final storage to reduce duplication of SNF handling and minimize costs to prepare the SNF for disposal.

One of the goals of interim storage and final disposition is to place the SNF in dry storage such that minimum maintenance of the SNF in dry storage is required. To assist with the placement of SNF in either interim storage or the repository, certain technologies must be developed and implemented so that interim storage can be safely and efficiently achieved. Ideally, the same technologies to place the SNF in

interim storage can be applied to the repository analysis to demonstrate acceptance of the SNF. In this manner, the intent is to minimize both repeated handling of the SNF and duplicated efforts in technology development for storage and disposition of the SNF.

As the SNF is moved into interim storage and repository requirements are more finalized, the scope of potential technology development to support the activities becomes clearer. It has become obvious that there is a need for a mechanism to track the technology development activities. This paper discusses the requirements for such a mechanism and the mechanism developed to fulfill those needs.

DOE-EM SNF PROGRAM

The DOE-EM SNF program is charged with responsibility for the safe, efficient handling of SNF while transitioning from current states of the SNF to secure interim storage to final disposition of the SNF. The SNF program is comprised of several organizational entities, which can be compressed and described as two groups:

- The Site SNF programs – These programs, located at Hanford, the Idaho National Engineering and Environmental Laboratory (INEEL), and the Savannah River Site (SRS) are the programs with responsibility for the physical maintenance of the SNF. Each of these sites will receive and transfer DOE-EM SNF per previously published Records of Decision such that each site has primary responsibility for specific SNF types. These sites also have responsibility to prepare that SNF for final disposition at the proposed repository.

- The National Spent Nuclear Fuel Program (NSNFP) – This program, headquartered at the INEEL, is responsible to be the DOE-EM point of contact with the proposed repository. As a coordinating agency, this program has responsibility to integrate the EM-SNF program needs and disposal strategy with the license requirements for the proposed repository. This includes developing a strategy for inclusion of the SNF in the repository operating license and performing analyses of the overall SNF lot, including documenting the results of the analyses to assure that results are included in the repository license. The NSNFP is chartered to provide a common EM interface to the national repository and provide an integrating solution set to common site problems in preparing the requirements for DOE-EM SNF disposal. In this role, the NSNFP works with the repository and the SNF sites to define the nature of disposal requirements and demonstrate proposed solutions to show compliance with those requirements. In this manner, DOE-EM is pursuing the most cost-effective strategy for preparing DOE-EM SNF for ultimate disposal.

SNF PATH TO DISPOSITION

The DOE-EM SNF sites are storing the SNF pending final disposition of the SNF. The current path forward for DOE-EM SNF in general is to move to safe interim storage with ultimate disposal at the national repository. The timing for resolution of DOE-EM SNF problem areas is driven by the schedule for moving the SNF into safe interim storage over the next several years as well as assuring long-term capability to comply with the approved license requirements of the proposed repository. Actual evaluation and potential treatment of the SNF for compliance with repository licensing requirements will be done in the further future. Most of the technology development needs are driven by the shorter term schedule associated with moving DOE-EM SNF into interim storage and the need to demonstrate technologies available to the DOE-EM SNF holders that show compliance with still developing licensing requirements that will be iterated with licensing agencies over the next few years. The iterative nature of the licensing process creates some uncertainty in the technology development path to follow. This

requires good tracking of technology development efforts to assure that the efforts are in good synchronization with current license direction. Failure to assure that technologies are available to demonstrate compliance with license requirements could jeopardize placement of DOE-EM SNF in the repository and thus jeopardize the DOE-EM SNF disposition and cleanup schedules.

OPERATIONAL TECHNOLOGY NEEDS DEFINITION

As DOE-EM SNF disposition path forward was defined, it was recognized that a certain amount of technology development would be required to support the SNF sites operating schedules. During the definition of the disposition paths, it was assumed that a certain technology would be developed or that a suitable workaround for the lack of the desired technology would be found. The operational technology needs thus defined are specific to the disposition path assumed for each SNF. Technology needs have been identified, for both interim storage and final disposition, based on strategies that depend on the specific fuel, its location and condition, local regulatory requirements, and the schedule for storage and disposition. The needs set the boundary conditions for defining technology development systematically by material stream and defined disposition path. The DOE-EM SNF site programs have constructed a set of technology needs for specific SNF disposition. These programs have developed corresponding "SNF materials disposition maps" which indicate material flows to final disposition by DOE site and SNF type this information is linked to the needs and to the control strategies.

The DOE-EM SNF program has identified over 40 individual technology development needs. These needs are based on site-specific needs and integrated needs suggested by the NSNFP. Several of the individual sites have common needs, usually related to the disposal of DOE-EM SNF in the national repository. Because of the DOE-EM responsibility to demonstrate repository acceptability of DOE-EM SNF, needs here are based on the DOE-EM SNF program evaluations of acceptability relative to the repository requirements.

Twin with the requirements of technology development is the timing of the development. Thus, a series of technology insertion dates are established with the technology need description. In general, the technology insertion date is that date beyond which development of the technology will have no value for that SNF simply because it is too late to affect the plan for disposition of the DOE-EM SNF. As previously discussed, these schedules are often mandated by programmatic goals with roots in several legal agreements around the country.

SNF TECHNOLOGY DEVELOPMENT

The DOE-EM SNF program has been actively engaged in developing technology for the disposition of DOE-EM SNF over the last several years. In the last few years, however, technology development activities for DOE in general, including DOE-EM SNF, have moved to the purview of the DOE Office of Science and Technology. This move is specifically manifested through the use of "focus areas" for technology development. The intent has been for a focus area to integrate technology development across the DOE to minimize duplication and cost. The DOE-EM SNF Program has been working specifically with the Nuclear Materials Focus Area (NMFA) for developing statements of technology needs and assuring funding of high priority technology development using either SNF program funding or NMFA directed research funding. As a part of this effort, the site SNF programs have defined their technology needs as discrete statements for a specific need. These needs are linked to the DOE-EM SNF disposition maps in the DOE Integrated Planning, Accountability, and Budgeting System (IPABS) system.

In addition to the IPABS maps, the National Spent Nuclear Fuel Program has constructed a diagram displaying the proposed DOE-EM SNF safety case for SNF disposal in the repository. This map shows

where the DOE-EM SNF program intends to take credit for certain aspects of the DOE-EM SNF and packaging for disposal to demonstrate safety compliance for the DOE-EM SNF in the repository facilities. The credit taken indicates further technology development required. Together with the site maps, a comprehensive picture of material disposition paths for the DOE-EM SNF program as whole can be drawn.

A complete picture of required technology development to support the disposition of DOE-EM SNF has required, in the past, obtaining information from several different documents and assembling that information in some fashion specific to the reader. Even with this information retrieval, however, the total picture remained somewhat difficult to construct for the "casual" observer due to the individual construction of the information for a specific purpose. As different entities, such as the NMFA, became more involved in DOE-EM SNF technology development, it became obvious that there was a need for a mechanism to track overall operations technology development. As the definition of this mechanism evolved, there were several requirements put onto the mechanism to make it useful for all levels of the program. These specific requirements are:

- Identify Disposition Path – The mechanism should identify the proposed disposition path for each SNF from current storage to final disposition.
- Technology Development Impact – The mechanism should identify where the technology need affects the disposition pathway identified for each SNF and what priority that need has in the disposition path.
- Provide DOE-EM Safety Case Linkage – As with the individual site programs needs to show links to physical activities to move the SNF into safe interim storage, the mechanism should provide a way to link the strategies of the DOE-SNF safety case for repository disposal to the operational technology needs. This linkage should provide further support to the site development programs and the goal of handling the SNF for disposition only one time.
- Identify Entities Doing Work on the Need – The mechanism should identify which SNF program or non-program entity is working on the technology development. This information would be useful to reduce overlapping development activities.
- Identify Funding – With the number of potential funding sources available for research in the SNF program, it is important to identify which funding source is supporting a specific technology development. In this way, the impacts of changes in research budgets are easier to identify. This would be a better mechanism to assure the scarce research funds are being applied to the proper priority problem areas. This helps to assure timely support to SNF operations.
- Simplify Management View of Program – The DOE-EM SNF program is a complex set of activities. Views of activities must include the individual site programs as well as the integrating activities of the National SNF Program and interface with the disposal evaluation activities. One of the goals of the mechanism is to develop a simplified view of the development needs fit into the overall program in a manner that is easier for program management to monitor activities.

The mechanism discussed above eventually became a variant of the existing IPABS maps, which are the basis of the maps discussed in this paper. The technology maps, as they formed, enhance the available IPABS information by casting the information in a different format and including information that was previously not available in any single view. The major difference between these maps and the IPABS maps is showing the entity working on resolving the technology need, the expected time of resolution of the need, and the funding source of the work.

The development of the revised maps involved all of the major DOE SNF sites (Hanford, SRS, and the INEEL as well as the NSNFP. The development programs involved are the Spent Nuclear Fuel Product Line in the Nuclear Materials Focus Area (NMFA) and other, local, development programs and funding

such as Laboratory Directed Research and Development Program at the INEEL. These technology maps provide a simple mechanism to show the integration of technology programs to SNF operations and supporting technology programs with respect to planning and execution of technology development activities. They will help assure optimization of available funding to disposition SNF in the most cost-effective manner to meet program goals

TECHNOLOGY MAP EXAMPLE

Although technology development maps have been constructed for the entire DOE-EM SNF program, only an example map is shown and discussed here. This map is for the Hanford site SNF program. This map is still under development and should not be construed to be the final word on any aspect of the Hanford SNF program. Figure 1 shows the SNF disposition map. The light squares on each map leg indicate the SNF disposition path steps. The darker squares indicate the technology development needs as currently shown in the IPABS system.

Figure 2 is the second page of the technology map. Shown here are several important pieces of information that have been integrated into this map. Going across the map from left to right, these areas are:

- The title of the technology development need – This consists of the need alphanumeric identifier as well as the need title currently entered into the IPABS system. This section is color-coded to indicate the urgency of the technology need, including whether some type of development work has answered the need.
- DOE-SNF Safety Case Barrier – This consists of the identification of the spot on the repository safety case chart where this need applies to a barrier that will be used in demonstrating the safety of the DOE-EM SNF at the proposed repository and repository facilities.
- NMFA Category – This section indicates which area within the NMFA SNF Product Line that the need has been associated with. This helps with the grouping of the needs into a common area to look for commonalities among the needs, thus helping to reduce costs and work overlap. The six categories defined for tracking within the NMFA are:

    - Packaging – Packaging technologies to cost-effectively encapsulate or process spent fuel, including automation of processes, so that it is acceptable for disposition at the federal repository are required. This may include development of technologies to address issues associated with non-SNF materials currently packaged with the SNF.
    - Welding technology – Intelligent welding and real time non-destructive examination are needed to assure closure of the EM SNF package.
    - Treatment – DOE-EM SNF stored in wet basins must be dried. Some SNF also has organic bearing materials that must be removed before packaging and disposal.
    - Materials –Evaluations of materials of construction of both the SNF and SNF containers for compatibility with the storage environment are required.

Hanford Site Spent Nuclear Fuel Disposition Plan

January 8, 2002

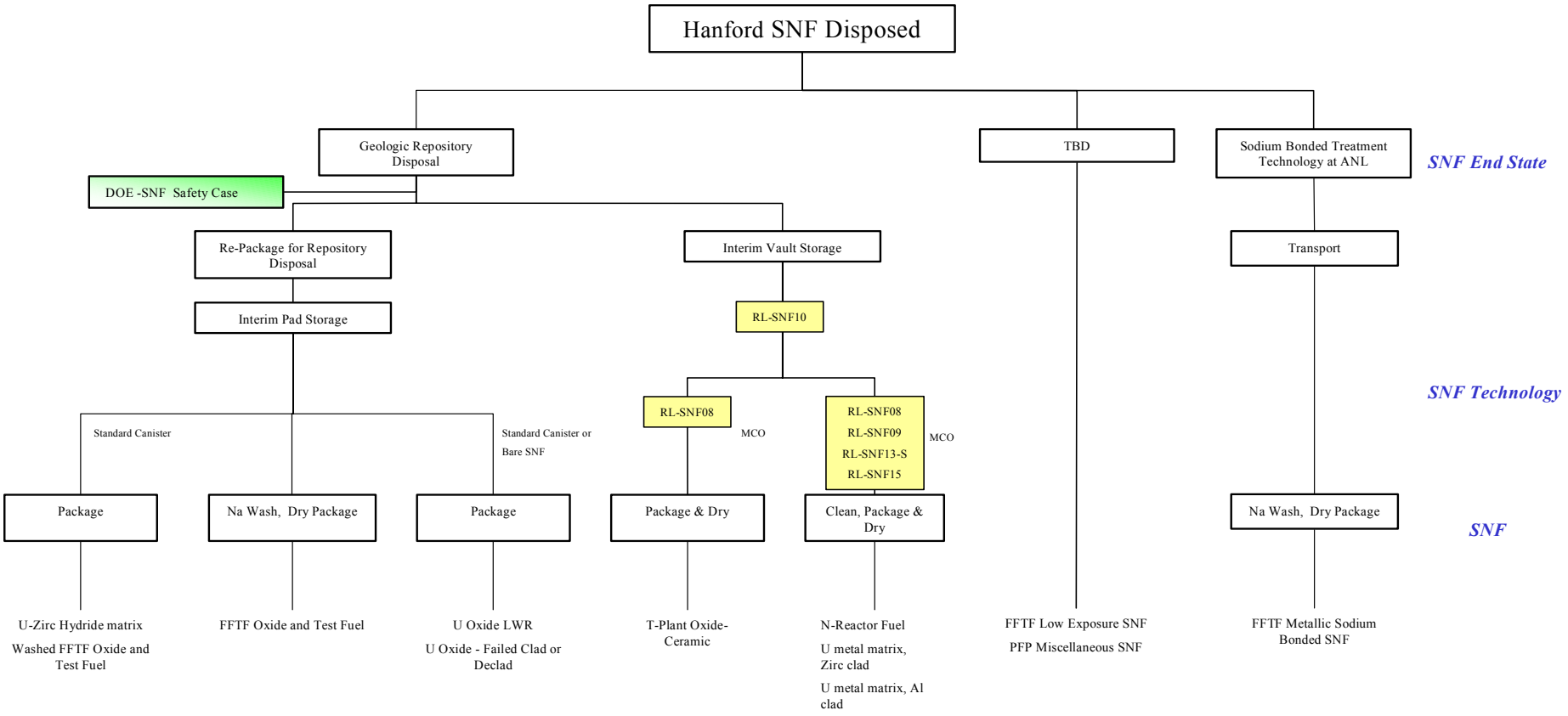

Fig. 1 - Hanford Spent Nuclear Fuel Disposition Plan, page 1

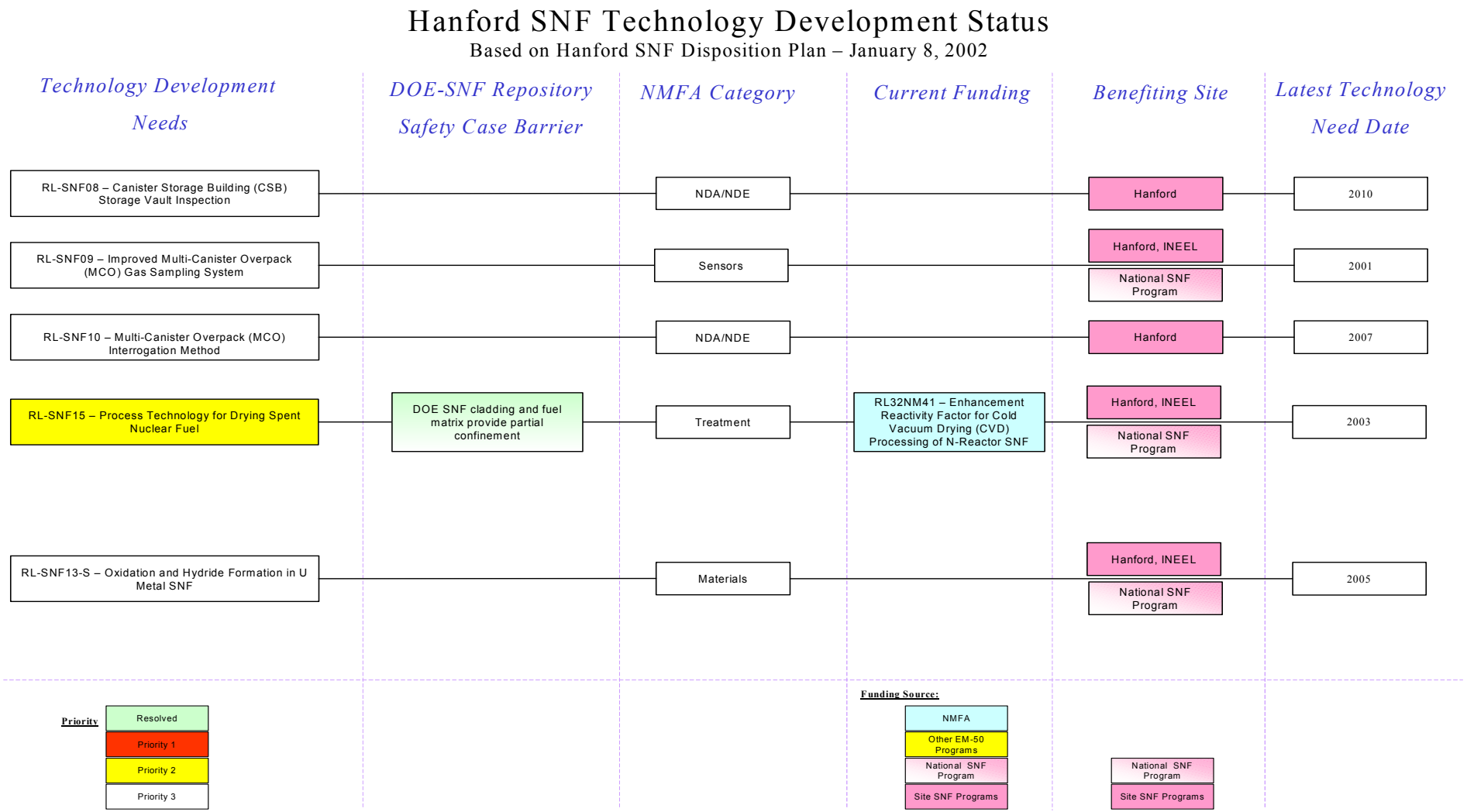

Fig. 2 - Hanford Spent Nuclear Fuel Disposition Plan, page 2. Note the various columns of information to enhance the flow sheet shown in Figure 1.

    - Sensors - Sensors and analysis methods must be developed to detect packaging or SNF degradation during storage.
    - Non-Destructive Assay - Techniques are needed to perform radiological assay of some loaded SNF canisters.
- Current Funding – This gives an indication of where funding to work a technology to answer the development need is coming from. In the case of NMFA funded work, the boxes indicate the Technical Task Plan Number and Title. In the case of DOE-EM SNF program funded activities, the boxes will indicate the site funding source funding the work.
- Benefiting Site – This section indicates where the benefiting activity within the DOE-EM SNF program is. As can be seen in the figure, in several cases there are multiple benefiting programs, and these are indicated on the chart.
- Latest Technology Need Date – This section indicates the latest date that the proposed technology development will be of use to the DOE-EM SNF program. This section helps with defining the priority of any proposed research for the program.

CONCLUSION

Technology development maps have been constructed for use in the SNF program. These maps have several features that will assist the program in it's goal of safe disposition of the SNF as well as assisting other funding agencies to allocate developmental funding to the proper priority areas.

The technology maps will allow SNF program management to evaluate the entities working on a particular development item and to assure that these is no programmatic overlap of activity for the technology. This will allow the maximal use of limited DOE resources to provide solutions to the technology problems facing the SNF program.

Tracking of funding sources for development of a particular technology will assist SNF program management with assuring maximum return on investment for the development funding. By showing multiple sources of funding these maps will assist with assuring the proper leveraging of scarce funding, and identify opportunities where a minor investment by one entity can significantly enhance the information available from the work of another entity.

These technology development maps will be maintained as living documents, with periodic updates each year. In this manner, they will provide an immediate picture of the status of technology development in response to identified needs of the SNF program and will continue to assist with the strategic development of required technology for the safe interim storage and final disposition of DOE SNF.