

INEEL/CON-01-01087  
PREPRINT

**Roadmapping The Resolution Of Gas  
Generation Issues In Packages Containing  
Radioactive Waste/Materials**

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**September 3, 2001**

**PATRAM 2001 (international Symposium On The  
Packaging And Transportation Of Radioactive  
Materials)**

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# ***ROADMAPPING THE RESOLUTION OF GAS GENERATION ISSUES IN PACKAGES CONTAINING RADIOACTIVE WASTE/MATERIALS***

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## **Abstract**

Gas generation issues, particularly hydrogen, have been an area of concern for the transport and storage of radioactive materials and waste in the Department of Energy (DOE) complex. Potentially combustible gases can be generated through a variety of reactions, including chemical reactions and radiolytic decomposition of hydrogen-containing materials. Transportation regulations prohibit shipment of explosives and radioactive materials together.

This paper discusses the major gas generation issues within the DOE Complex and the research that has been and is being conducted by the transuranic (TRU) waste, nuclear materials (NM), and spent nuclear fuels (SNF) programs within DOE's Environmental Management (EM) organization to address gas generation concerns. This paper presents a "program level" roadmap that links technology development to program needs and identifies the probability of success in an effort to understand the programmatic risk associated with the issue of gas generation.

This "program level" roadmapping involves linking technology development (and deployment) efforts to the programs' needs and requirements for dispositioning the material/waste that generates combustible gas through radiolysis and chemical decomposition. The roadmapping effort focused on needed technical & programmatic support to the baselines (and to alternatives to the baselines) where the probability of success is low (i.e., high uncertainty) and the consequences of failure are relatively high (i.e., high programmatic risk). A second purpose for roadmapping was to provide the basis for coordinating sharing of "lessons learned" from research and development (R&D) efforts across DOE programs to increase efficiency and effectiveness in addressing gas generation issues.

## **Introduction**

To ensure that the various gas generation activities within the Office of Environmental Management were being properly integrated, Mr. David Huizenga, DOE EM-20 and Mr. Gerald Boyd, DOE EM-50, established a Task Group to develop an integrated gas generation research and development (R&D) plan (i.e., a "program level" roadmap). Members of the Task Group included DOE and contractor representatives from: the Nuclear Materials (NM) programs, which includes the Nuclear Material Focus Area (NMFA), the Nuclear Materials Stewardship Program, and the 94-1 Program; the National Transportation Program (NTP); the Spent Nuclear Fuel (SNF) program; the TRU Waste program, including the Transuranic and Mixed Waste Focus Area (TMFA); and site personnel associated with these programs. It is anticipated that future assessments will integrate data from the high-level radioactive waste (HLW) and mixed/low-level radioactive waste M/LLW programs to better determine if those programs also have gas generation issues.

The roadmap that was developed identifies the major gas generation programmatic issues within the DOE complex and the research that has been and is being conducted to address gas generation concerns.

### Purpose

The “program level” roadmapping effort was intended to focus needed technical support to the baselines (i.e., the major steps for final disposition of waste/material) where the probability of success is low (high uncertainty) and the consequences of failure are relatively high (high programmatic risk). The roadmap identified where emphasis is needed, i.e., areas where investments are large, the return on investment is high, or the timing is crucial for dispositioning the waste or material. A second purpose of the roadmapping was to provide the basis for coordinating sharing of “lessons learned” from R&D efforts across DOE programs to increase efficiency and effectiveness in addressing gas generation issues.

### Roadmapping Approach And Methodology

Development of the roadmap involved identifying the major steps needed for final disposition of the waste/material (or for storage pending disposition) and the associated R&D and certification activities required to ensure the viability of each step. In a typical disposition pathway, four major functions are needed: (1) treatment, (2) packaging, (3) transportation, and (4) disposal/storage. Each of these functions was examined to determine what technical support would be needed to make the function successful. The timing to have the technology in place was also captured to identify those areas where emphasis should be placed or where resources should be reallocated.

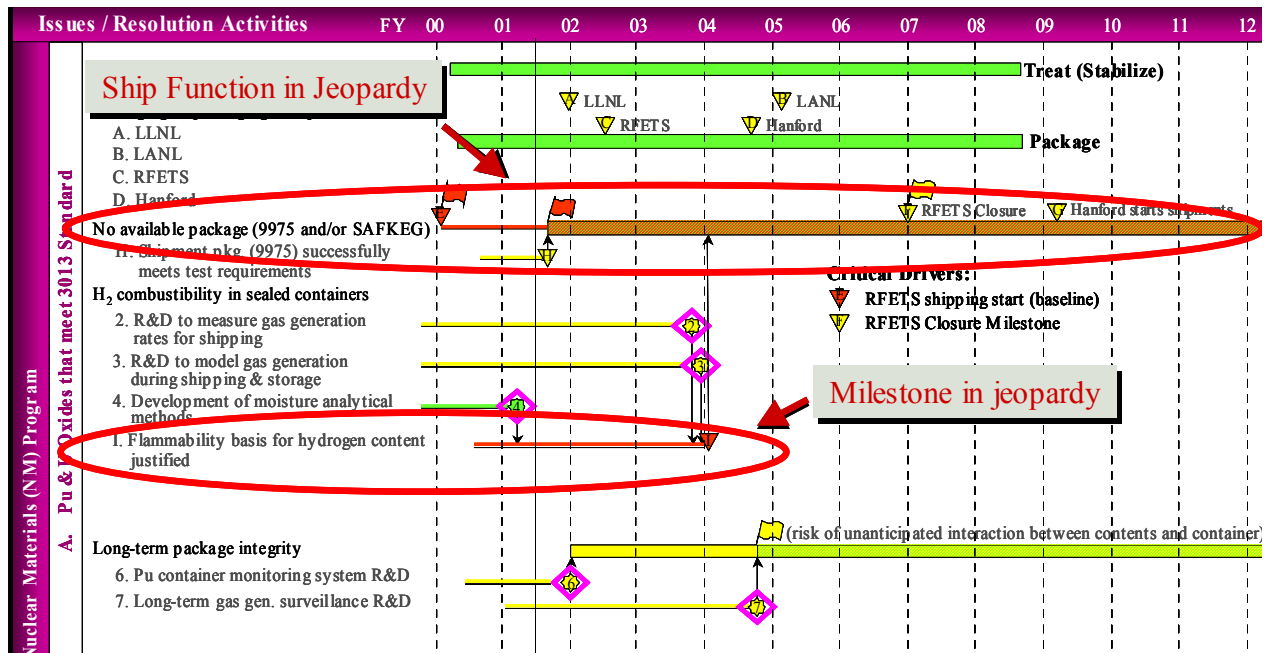


Figure 1. Example of the integrated gas generation roadmap summary showing the relation of R&D actions to functions over time. This view shows that a function and a milestone are in jeopardy.

## Roadmap Summary Explanation

The gas generation roadmap summary (example shown above as Figure 1) shows at a glance the functions involved to disposition a waste/material type, the R&D and also regulatory activities associated with successfully completing a function, plus the current condition of the functions and activities. The roadmap summary was designed to focus on how resolution activities enable a function to begin or improve. The timeline column identifies four dimensions for an activity: (1) risk, (2) time, (3) type of activity, and (4) possibility for sharing across programs. Risk is depicted by the colors and time is shown by the location of an icon in relation to the timeline. The shape of the icon, as defined in the legend, shows the activity type. The possibility for sharing is defined by a purple diamond surrounding an icon.

The gas generation roadmap summaries for each of the programs evaluated are included as Figures 2-5.

## Findings

By performing the roadmapping effort, the Task Group found that:

- There are no significant overlaps in planned R&D activities, nor appreciable duplication of R&D activities already performed
- There are many opportunities for sharing information about gas generation issues and potential solutions. Areas of greatest potential cooperation appear to be in sharing methods, approaches, and strategies
- Some nuclear materials, such as some impure oxides and residues, do not have a clear disposition pathway. It appears that these orphan nuclear materials need priority attention to make sure shipping packages can be certified, shipments can be approved and expedited, and pathways for disposition can be quickly developed (or the Rocky Flats Environmental Technology Site (RFETS) closure schedule needs to be revised)
- There are pathways that have significant risk, which may indicate more emphasis should be placed on contingency planning, for example, getters development and impure oxides and residues disposition
- For the RFETS shipping schedule to be met, both the SAFKEG and 9975 packagings must be certified, as they are both needed for transportation campaigns of nuclear material
- The baseline schedule for shipping of SNF to a repository is very much in jeopardy due to anticipated lack of funding for continued development of a transportation packaging (cask)
- The TRU program R&D activities being performed are to enhance performance of existing functions e.g., to allow greater amounts of waste in the shipping package thus decreasing transportation costs and schedule

# TRU Waste Gas Generation Roadmap Summary

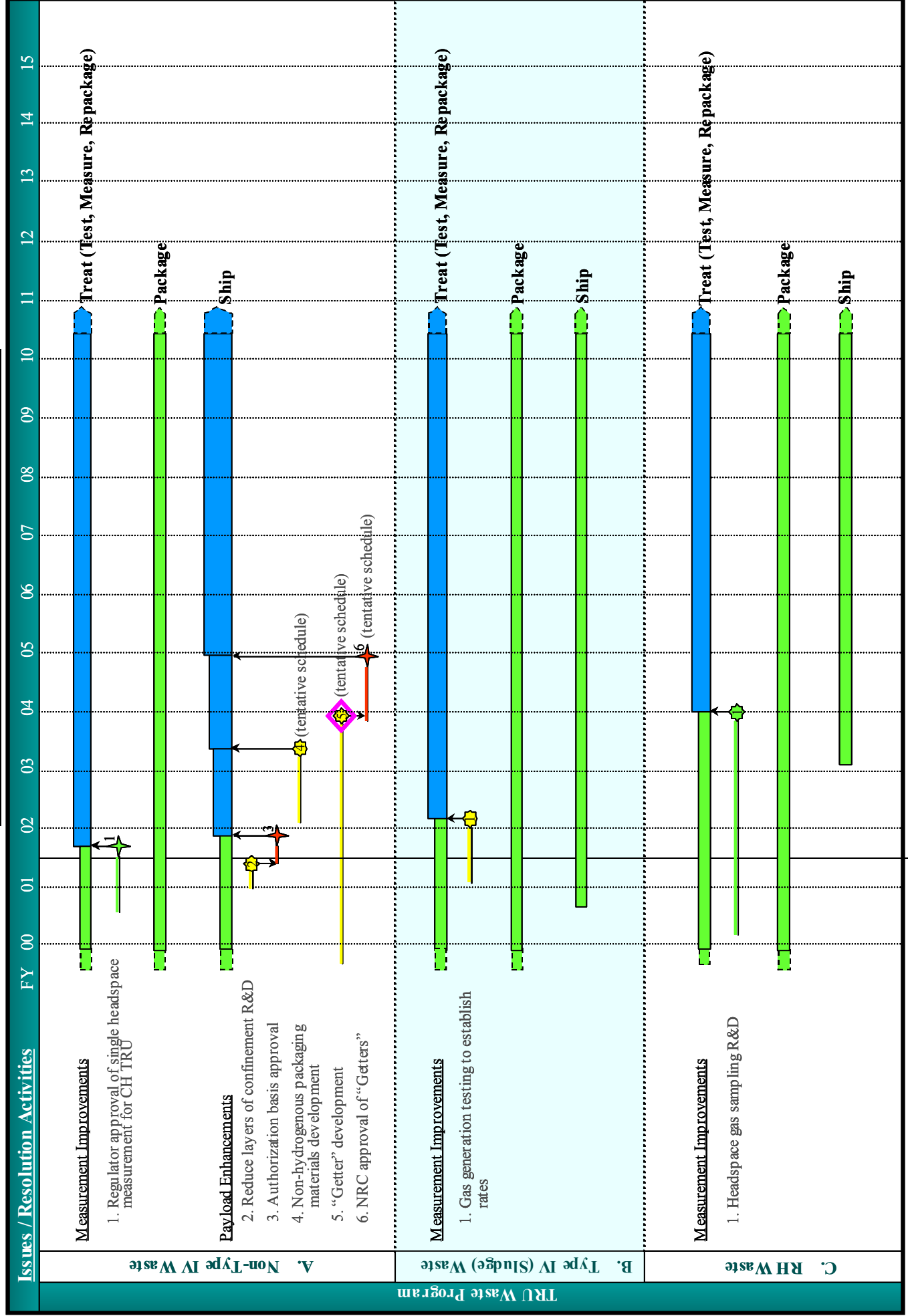


Figure 2

# Nuclear Materials Gas Generation Roadmap Summary

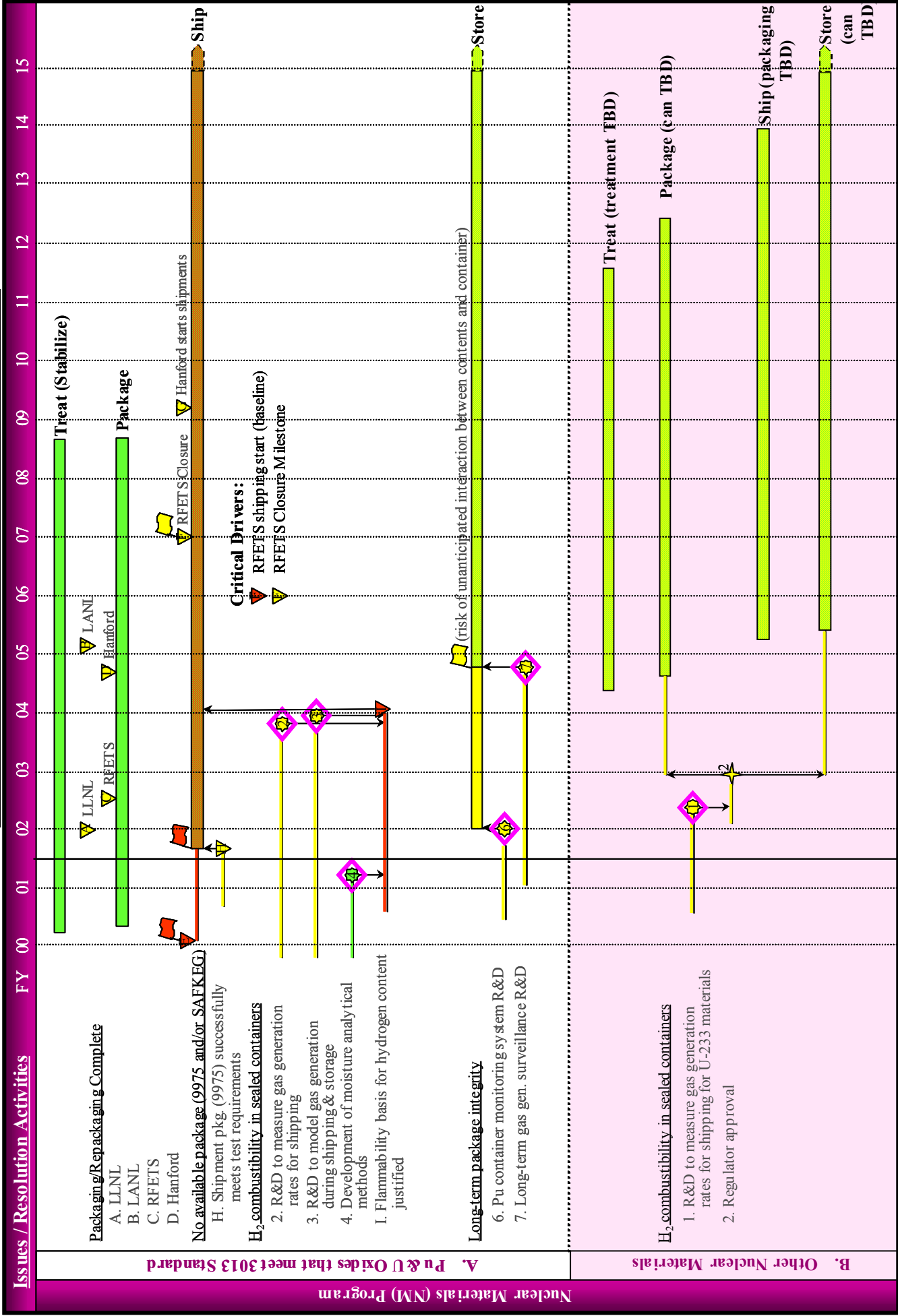


Figure 3

# Nuclear Materials Gas Generation Roadmap Summary (cont.)

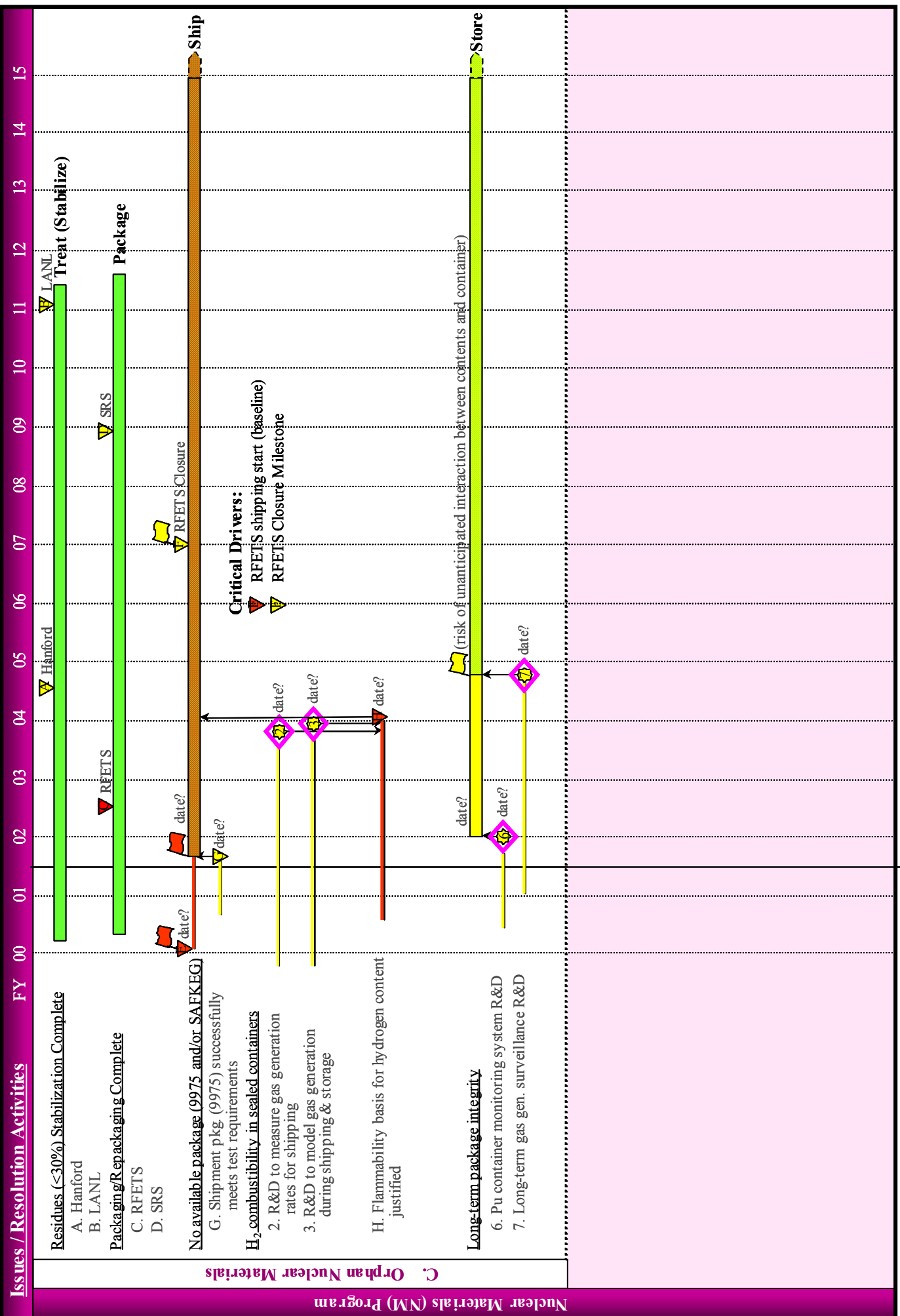


Figure 4

# SNF Gas Generation Roadmap Summary

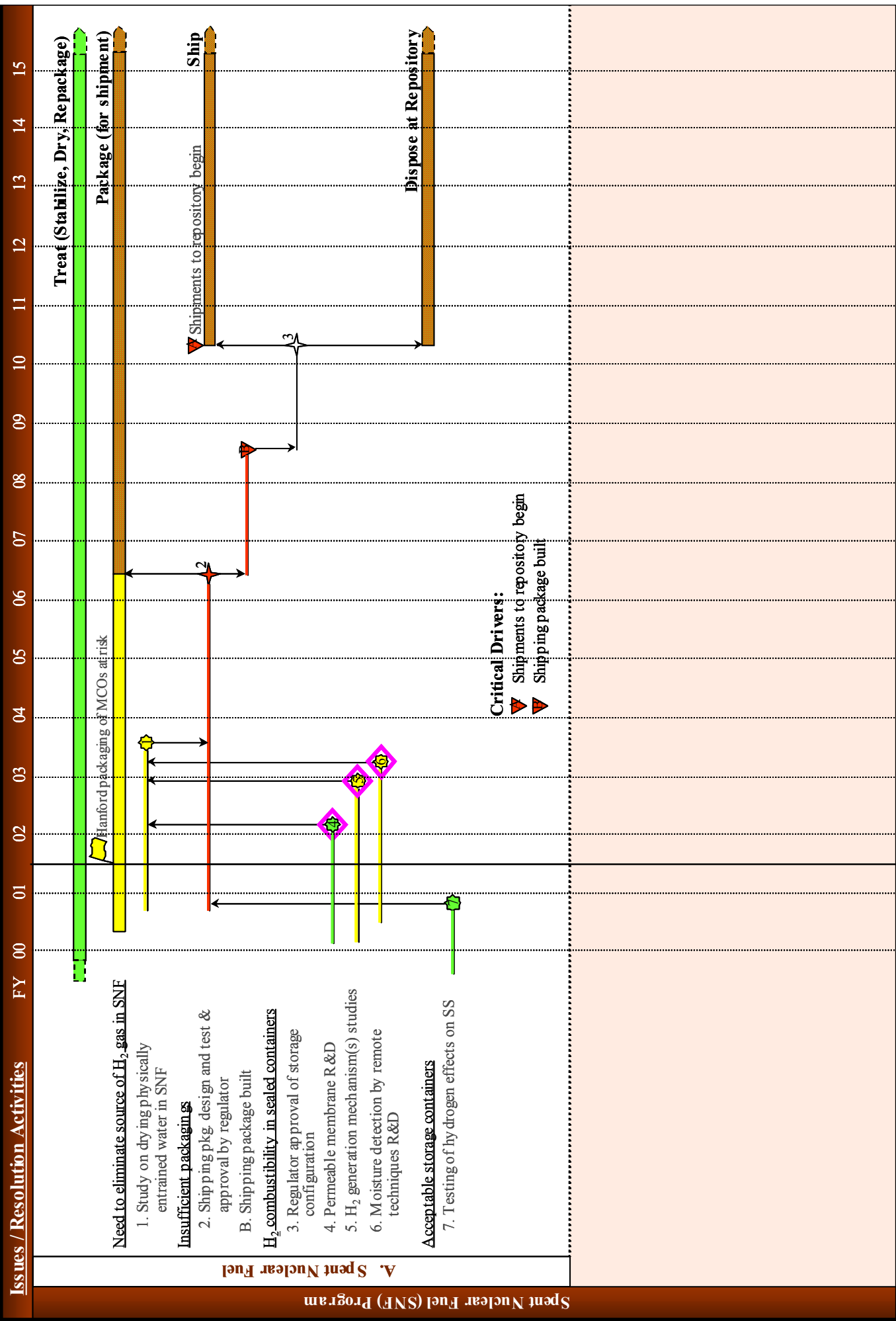


Figure 5



## Recommendations

The Task Group offered the following recommendations for consideration:

- There are four areas that have the most potential for sharing of information
  - Methods for measuring gas generation rates
  - Mechanisms for gas generation
  - Gas generation modeling methodologies
  - Approaches for elimination of gas generation or mitigation of impacts
    - Use of getters
    - Permeable membranes
    - Drying/stabilization techniques
    - Use of inert atmospheres
- Contingency planning

The following should have contingency plans developed:

  - RFETS shipping schedule for impure Pu oxides and residues
  - Use of getters - Because of the real risk that the regulator may not approve the use of getters, the programs should plan for other contingencies
  - Use of permeable membranes – As with getters, the regulator may not accept the use of permeable membranes to vent hydrogen gas buildup in shipping and/or disposal containers
  - SNF funding – Evaluate funding adequacy and timing of the SNF packagings to assure meeting shipping schedules and impacts of not meeting them
- Establish an independent peer review group to:
  - Review proposed R&D and programmatic activities
  - Perform quality checks on applications to regulators
  - Provide greater influence with the regulator(s) by facilitating submittals from the applicants to the regulators and by having a more consistent approach

## Next Steps

Roadmapping efforts to date have proved very worthwhile. However, the roadmap will only continue to be relevant as it is used and updated with more detail. Programs will benefit from identifying issues and then tying them to research and development needs identified in the roadmap.

The roadmap effort found that gas generation issues can adversely affect DOE milestones in a variety of programs at different sites. It was also recognized that gas generation issues represent a large risk to accomplishing DOE's environmental management mission to clean up DOE sites.

The Task Group that created the roadmap recognized that current research efforts are based on identified needs, but that those efforts could be better coordinated to address the issues. The Task Group recommended that a group of experts from appropriate DOE programs continue to further develop the roadmap and prioritize issues and research efforts.