Savannah River National Laboratory Collaborative Innovation Pilot Team – 17560

A. P. Fellinger*, S. R. Bush*
*Savannah River National Laboratory, Aiken, South Carolina 29808

ABSTRACT

The Collaborative Innovation (COIN) program was established by the Savannah River National Laboratory (SRNL) in March 2016. The goal of the SRNL COIN program is to identify innovative options to significantly reduce program and project risks (improve safety, reduce schedule and cost) of high priority Department of Energy Environmental Management, National Nuclear Security Administration, and Nuclear Energy missions.

The COIN Advisory Board selected as the target outcome of the first COIN effort a 50% improvement to the Savannah River Site (SRS) H-Canyon spent nuclear fuel (SNF) processing "baseline," or current plan, as defined in the SRS Nuclear Materials Planning Roadmap.

A small team of SRNL and Savannah River Nuclear Solutions personnel with pertinent experience and expertise was co-located and largely sequestered for eight weeks to identify improvements to H-Canyon processing of SNF. Following the process defined in the SRNL COIN Charter, the COIN Pilot Team analyzed the baseline for processing SNF through H Canyon; generated alternative ideas; tested seemingly viable ideas by reaching out to other subject-matter experts; and identified options for consideration for implementation by the COIN Advisory Board.

The COIN Pilot produced a number of important outcomes, including important lessons learned for subsequent COIN efforts. The two principal outcomes are these:

1. The COIN Pilot Team conducted a comprehensive examination of the individual unit operations, the integrated system, and external interfaces to produce a timeline of H-Canyon processing and sampling times that had not previously existed. The general timeline served as the baseline from which the Pilot Team identified processing improvements. In addition, the timeline has already been employed in other planning efforts.

2. The COIN Pilot Team determined that innovations to the H-Canyon Dissolving unit operation alone could increase the number of SNF bundles processed through H Canyon by the target of 50%, but with little margin for error. To ensure that the gains in throughput in the Dissolving unit operation would be maintained throughout the facility, the Pilot Team identified four additional improvements to create greater efficiency and flexibility in downstream H-Canyon unit operations. The COIN Pilot Team's innovations reduce the processing time of a single batch of SNF through H Canyon from about 70 days to about 50 days.

This talk will review the COIN process and the results of the pilot of the process.

INTRODUCTION AND BACKGROUND

In March 2016, a SRNL Collaborative Innovation (COIN) Pilot Team of SRNL and SRNS subject-matter experts was charged to investigate ways to achieve 50% improvement in the baseline processing of SNF through the H Canyon at SRS.

SRNL COIN Program

The SRNL COIN program was established in March 2016. The goal of COIN is to identify innovative options to significantly reduce overall program and project risk (improve safety, reduce schedule and cost) for high priority DOE EM, NNSA, and NE missions, beginning with major efforts represented in the SRS Nuclear Materials Planning Roadmap (the Roadmap) and other life-cycle planning tools (e.g., System Plans).

A COIN project is divided into two phases. In Phase I, a small team of personnel with appropriate experience and expertise is co-located and largely sequestered for several weeks for intensive discussion and investigation of alternatives or improvements to a site process or of solutions to a site problem. Considerations may include facility/equipment optimization, application of new methods and technologies, waste minimization, and efficient use of staff and other resources. By design, COIN teams are expected to reach out to experts outside the teams (on site, university, other sites and national laboratories, commercial industry), as appropriate to the given tasks.

The Phase I team's deliverable is a set of defensible alternatives/improvements or proposed solutions delivered to the COIN Program Manager and the COIN Advisory Board for consideration for implementation or for further technology and engineering maturation in Phase II.

At the recommendation of the COIN Program Manager, the COIN Advisory Board selected as the target outcome of the COIN Pilot 50% improvement to H-Canyon baseline processing of SNF.

Overview of H-Canyon Uranium Processing

In 1955, H Canyon began operation using a chemical separations process to recover uranium-235 (U-235) and neptunium-237 from aluminum-clad, enriched-uranium fuel tubes from SRS nuclear production reactors and domestic and foreign research reactors for reuse in the United States weapons program.

After the Department of Energy (DOE) ceased recovery of enriched uranium in 1992, most of the inventory of highly enriched uranium (HEU) fuels and solutions remained in various stages of the SRS process. Some of the material deemed "at risk" was stabilized through H-Canyon chemical separations and stored on site until a disposition path could be determined.

2003 saw the beginning of the campaign to blend down the stored HEU solution with natural uranium (NU) to form low enriched uranium (LEU) to fuel nuclear power reactors. In July 2003, the first LEU shipment was sent off site for use in Tennessee Valley Authority (TVA) power reactors to generate electricity.

In 2006, H-Canyon facilities began dispositioning the inventory of spent nuclear fuel (SNF) from foreign and domestic research reactors and excess enriched uranium- and plutonium-bearing materials from across the DOE complex. This supports DOE environmental clean-up and nuclear nonproliferation goals, reduces the footprint and costs associated with maintaining the various DOE sites, and allows for the recovery of enriched uranium for blend down into LEU fuel.

In 2011, DOE ceased processing in H Canyon until the recommendations of the President's Blue Ribbon Commission on America's Nuclear Future were evaluated by DOE. H Canyon completed the TVA Agreement and transferred the remaining LEU solutions off site in 2011.

In 2013, DOE approved an Amended Record of Decision (AROD) allowing H Canyon to process a limited amount of enriched-uranium aluminum-clad SNF (1000 bundles of Material Test Reactor fuel, 200 High Flux Isotope Reactor cores). H Canyon has received DOE authorization to re-start Second Uranium Cycle and is awaiting authorization to re-start First Cycle. H-Canyon is expected to operate for at least the next ten years.

SNF COIN Pilot Team Approach

Nine SRNL and SRNS personnel with pertinent experience and expertise were selected to constitute the SNF COIN Pilot Team (Phase I). The SNF COIN Pilot Team was asked to take an unconstrained (that is, unbounded by considerations such as current funding, documented safety analysis, technology, politics) look at any manner of ideas to achieve 50% improvement in the baseline processing of SNF through H Canyon.

The SNF COIN Pilot Team convened in mid-March 2016. The team was co-located and largely sequestered for eight weeks, which facilitated the team's inventiveness. Largely freed from routine obligations and put on the clock to solve an interesting puzzle, the COIN Pilot Team established an idiosyncratic and effective approach to accomplish its task. It should be noted that the inquisitiveness and respectfulness of the individuals who constituted the team were at least as important.

As the Team set out to analyze the "baseline," or current plan, for processing SNF through H Canyon in order to identify alternatives or improvements, it found that numerous prior reviews had focused on individual unit operations or single aspects of operations but not on the overall process. Consulting sources such as the Roadmap, the SNF schedule, and experienced H-Canyon personnel, the Team examined each of the seven major unit operations and their interactions as well as HB-Line plans and the process schedule and volume flows for blend down of HEU to LEU in A Line. Based on its comprehensive examination of the individual unit

operations and the integrated system, the COIN Pilot Team developed a general timeline of nominal processing and sampling times. The timeline was developed to confirm that processing the numbers of batches/bundles per year projected in the current plan could be achieved and as a tool to compare improvements proposed by the SNF COIN Pilot Team.

The Team set out to generate alternative ideas; test seemingly viable ideas by reaching out to other subject-matter experts (SMEs); and identify options for further consideration by the COIN Advisory Board.

Over fifty ideas for improving the baseline were considered by the team.

The team down-selected to fourteen options that seemed to promise the greatest effect and ease of implementation toward achieving the goal and would be implementable early enough to make an impact within the 10-year time frame outlined in the Roadmap.

TABLE I. SNF COIN Pilot Team Recommended Disposition of Phase I Ideas in Phase II

High Impact Ideas: Work Towards Implementation in Phase II	
1. Charge Sequence Strategy	4. Reduced Sample Hold Time
2. On-line Monitoring	5. Waste Stream Optimization
3. Nature of the Process	
Indeterminate Impact Ideas/Implement Later: Merits Further Study in Phase II	
6. Additional Dissolver	8. Process Control Modernization
7. Hydrogen Control	
Low Impact Ideas: No Further Consideration in Phase II	
9. Alternative Chemistry	12. H-Canyon Laboratory
10. Bundle Redesign	13. Robotic Technology
11. Iodine Reactor Technology	14. Alternative Separations Technologies

Finally, from all the ideas generated, the SNF COIN Pilot Team recommended implementation of a small set of “high impact” ideas to achieve the 50% improvement to H-Canyon baseline processing of SNF.

COIN PILOT OUTCOMES

The COIN Pilot produced a number of important outcomes, including important lessons learned for subsequent COIN efforts. The two principal outcomes are these:

SNF Processing Baseline Timeline

As noted, the initial focus of the SNF COIN Pilot Team was the baseline processing of spent nuclear fuel bundles in H Canyon, with the goal of identifying alternatives to achieve a 50% increase over the projected 10 batch/200 bundle-per-year processing outlined in the Roadmap. The baseline review was intended to define the boundary in which the COIN Pilot Team would operate and understand baseline processing assumptions and limitations so as to identify alternatives. This review of

the baseline comprehensively examined inputs and outputs (primarily related to volumes and product constituents) as related to the major unit operations as well as current constraints and requirements, such as hold points for sampling for material control and accountability or criticality control. The major unit operations reviewed in this baselining effort are shown within the bold outline in Figure I and include:

1. Dissolving
2. Head End
3. First Cycle
4. Second Uranium Cycle
5. High Activity Waste
6. Low Activity Waste
7. Sumps, Spent Solvent Wash, and Sample Returns (SSSR).

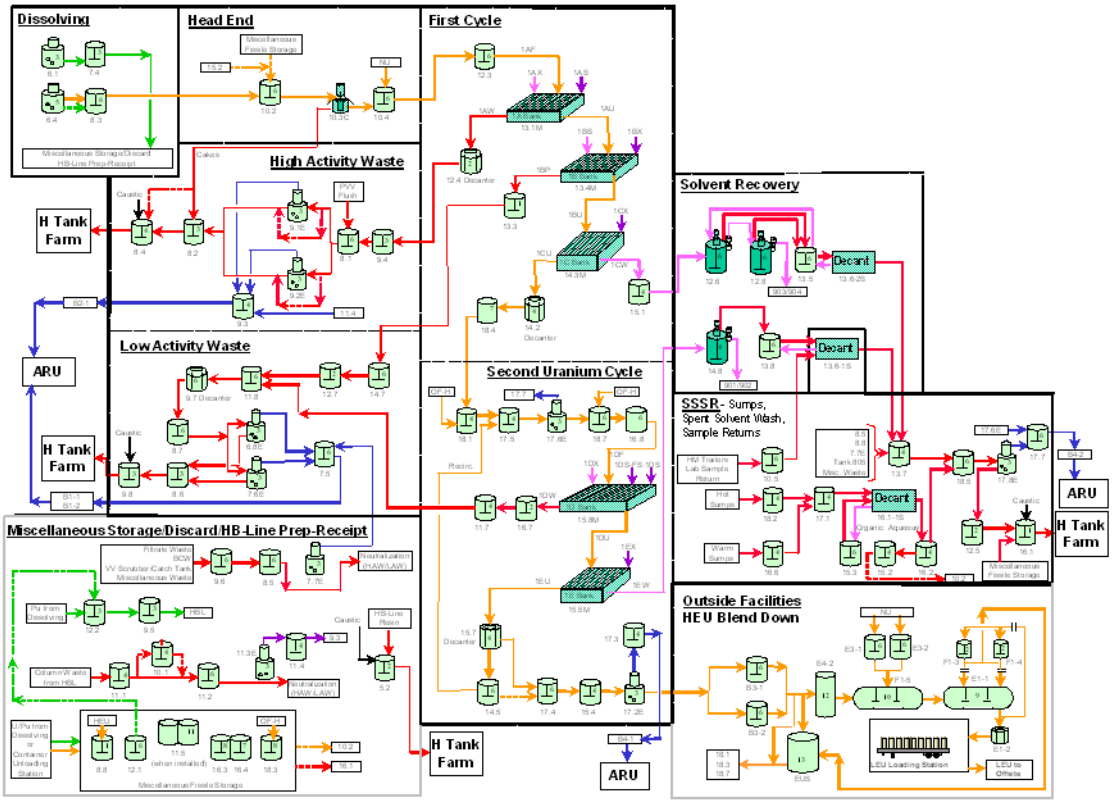
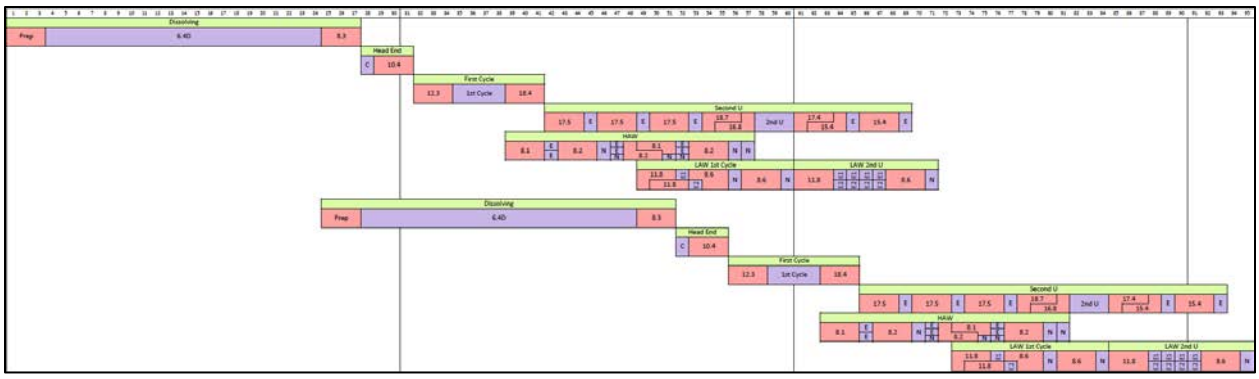


FIGURE I. Graphical flow-sheet representation of the major unit operations included in the review of the baseline

The team also reviewed interfaces and examined impacts with Miscellaneous Storage, HB Line, Solvent Recovery, H Tank Farm, F/H Analytical Laboratories, L Basin, and Outside Facilities (HEU Blend Down). Notably, numerous prior reviews were found to have focused on individual unit operations or single aspects of operations for processing fuel bundles in H Canyon whereas the COIN Pilot baseline review examined all major unit operations and interfaces needed for the projected Roadmap processing to be successful.

The H-Canyon baseline review established a single-cycle time of about 70 days. Allowances to start the next dissolver batch charging before the end of the entire prior 70-day batch processing cycle (start next batch as soon as 6.4D dissolver is empty) demonstrate that processing the 10 batches, or 200 bundles, per year projected in the Roadmap is achievable through all major unit operations in H Canyon (shown in Figure II), with the following assumptions:

- No constraints due to staffing resources (all operations can occur when needed)
- 20 bundles per dissolver batch
- 3-day sample analysis turnaround from F/H Analytical Laboratories (timing does not include collecting the sample or transporting the sample from H Canyon to F/H Analytical Laboratories)
- Full staff with requisite qualifications (operations, engineering, radiological control, maintenance, etc.)
- No impact from concurrent Pu metal processing in dissolver 6.1D
- No impact from Target Residual Material blending
- All equipment and instruments are operational and available
- No effect from HB Line and A line on the processing (initially; see Appendix B.5, “Waste Stream Optimization Details”)
- Nominal 300 day operating year to account for spring and fall outages.



(Note: Red indicates non-processing time; blue indicates operations.)
FIGURE II. Approximately 70-day timeline shown for two batches processed through major unit operations in H Canyon (By repeating the series, one full cycle batch is completed approximately every 24 days, and 10 batches can be completed in a year.)

This is a general timeline developed based on nominal processing and sampling times and should not be construed as a detailed project schedule. Times associated with both unit operations and specific tasks are, in most cases, very conservative estimates. The timeline was developed to confirm that the projected 10 batches/200 bundles per year defined by the Roadmap could be achieved and as a tool to compare improvements proposed by the SNF COIN Pilot Team. Actual number of cycles achievable by the canyon must be scheduled by the facility.

Set of "high impact" ideas to achieve 50% improvement to H-Canyon baseline processing of SNF

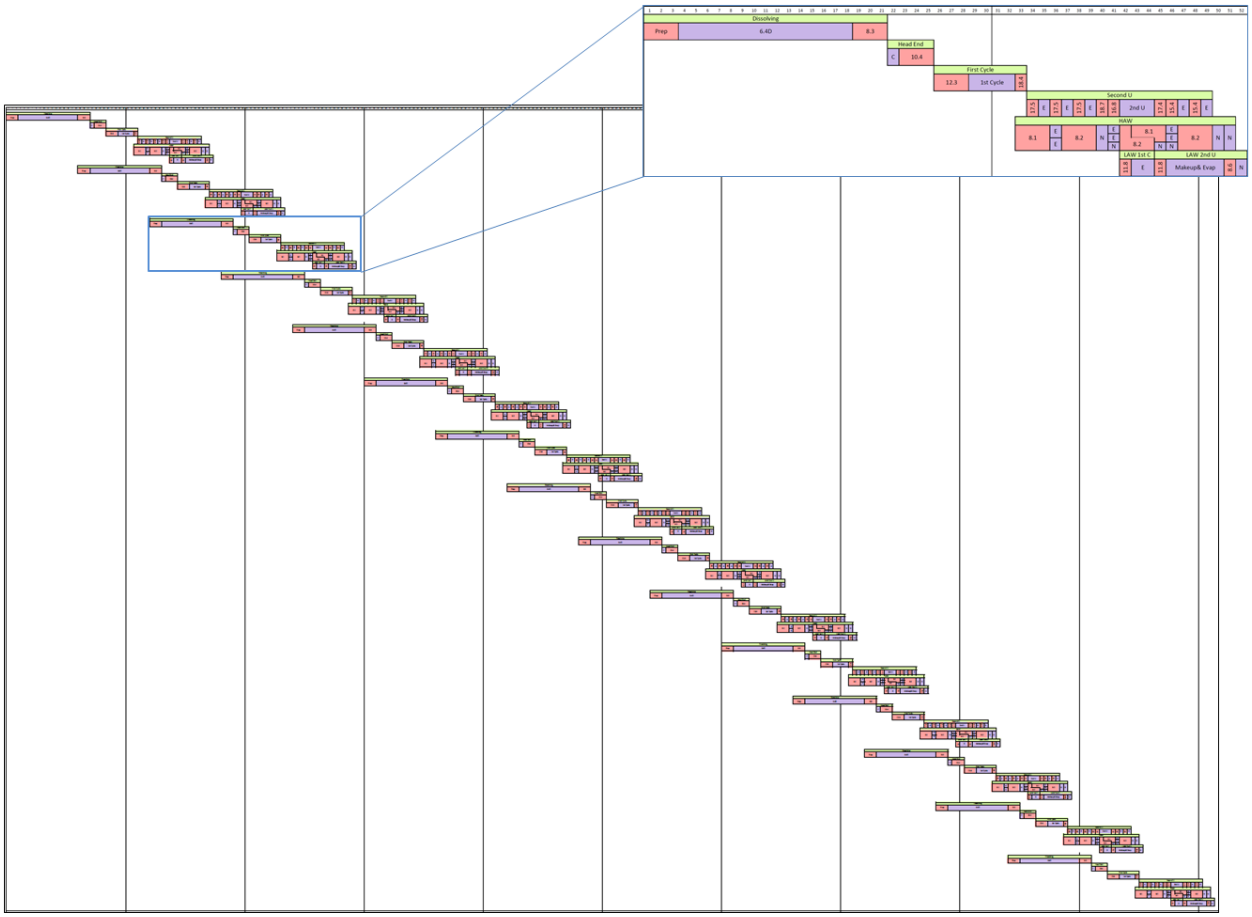
Also assuming that that all equipment and instruments are operational and available and that full staff with requisite qualifications are available, the SNF COIN Pilot Team further determined that innovations to the H-Canyon Dissolving unit operation alone could increase the number of SNF bundles processed yearly through H Canyon from the 200 projected in the Roadmap to at least 300, achieving the goal of improving SNF processing through H Canyon by 50%. The innovations to Dissolving unit operation include:

- Charging higher uranium-235 bundles early in a batch to allow removal of the five-well plug after the fourth charge, thus allowing more than five bundles to be charged to the dissolver near the end of the batch
- Better characterizing the hydrogen off-gas to increase the number of bundles in each batch
- Increasing cask car capacity and/or reworking H-Canyon bundle storage to handle the larger batch size
- Better characterizing the hydrogen off-gas to allow the first two bundles of a batch to be dissolved in a single charge.

However, the innovations to the Dissolving unit operation leave little margin for error in the balance of H-Canyon unit operations. Increasing dissolving throughput may require up to five parallel unit operations, which can significantly diminish the flexibility of operating Second Uranium Cycle, Low Activity Waste (LAW), and High Activity Waste (HAW).

Expecting the Dissolving unit operation to carry the full burden of increased throughput is unrealistic. To ensure that the gains in throughput in the Dissolving unit operation are maintained throughout the facility, instituting changes that create greater efficiency and flexibility in downstream H-Canyon unit operations is necessary. The SNF COIN Pilot Team recommends several additional changes to reduce the durations of downstream unit operations and otherwise alleviate the strain on the balance of the unit operations once dissolving rates increase.

The first additional change is implementation of an on-line monitoring program Throughout the H-Canyon process, numerous samples are required to meet requirements for material control and accountability (MC&A), process control, criticality safety, and technical safety requirements (TSRs). At many of the sampling points, H Canyon may not move solution forward until analysis results are reported, leading to significant pauses in unit operations. Installation of on-line monitoring at multiple locations—First Cycle and Second Uranium Cycle feed and product tanks, uranium and waste evaporator feed tanks, and neutralization feed tanks—would significantly reduce the durations of Second Uranium Cycle, LAW, and HAW. Setting up on-line monitoring equipment at the key measurement points within the H-Canyon process would lead to significant time savings and increased processing efficiency. Dissolving and on-line monitoring innovations could reduce the full-cycle time of a single batch through H-Canyon from the about 70-day baseline to about 50 days, as illustrated in Figure III.



(Note: (Red indicates non-processing time; blue indicates operations.)
FIGURE III. Graphical model of full batch cycles through all unit operations in approximate 300-day operating year after improved dissolving and on-line monitoring. Call out shows a single batch cycle after dissolving and on-line monitoring innovations, showing cycle time reduced to about 50 days from the about 70-day current baseline cycle.

Other supplemental changes include

- Applying “nature of the process” concepts
- Shifting paradigms regarding sample hold points.

It should be noted that it was not within the COIN Pilot Team’s charter to determine all the details of implementing the options considered, but the Team does propose some considerations for implementation of its major recommendations. The Team recognizes, for example, that implementing the COIN Pilot Team’s recommendations will likely result in more concentrated operator performance requirements than the current baseline. To institute the efficiencies recommended by the COIN Pilot Team and achieve maximum H-Canyon throughput of SNF, staffing and other impacts will need to be thoroughly examined and the details of implementation further refined.

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COIN Pilot Team Members

- Drew Fellinger, Environmental Stewardship, SRNL, SNF COIN Pilot Team Lead
- Sheryl Bush, Environmental Stewardship, SRNL
- Bill Clifton Jr., H Canyon/Outside Facilities and Technical Support, SRNS
- Glynn Dyer, Mission Development & Support Engineering, SRNS
- Mark Jones, Strategic Development & Innovation, SRNL
- Dick Murphy, Materials Control & Accountability, SRNS
- Pat O'Rourke, Analytical Research & Development and Material Characterization, SRNL
- Ed Sadowski, Nuclear Materials Management Programs, SRNL
- Lindsay Sexton, Non-proliferation Policy Support, SRNL

SRNL COIN Program Executive Sponsor

Terry Michalske, Executive VP, SRNS; Laboratory Director, SRNL

SRNL COIN Program Manager

Bill Bates, Acting Associate Laboratory Director, Nuclear Materials Management Programs, SRNL

COIN Advisory Board

- Sharon Marra, Senior VP, SRNS; Deputy Laboratory Director, SRNL
- Wyatt Clark, Senior VP, Environmental Management Operations, SRNS
- Rick Sprague, Senior VP, Technical Services, SRNS
- Natraj Iyer, Associate Laboratory Director, Nuclear Materials Management Programs, SRNL
- Jim Dollar, Director, Nuclear Nonproliferation Programs, SRNS

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