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## Projectising an Operating Nuclear Facility Transition from Operation to Deactivation

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### ABSTRACT

This paper will discuss the evolution of an operations-based organization to a project-based organization to facilitate successful deactivation of a major nuclear facility. It will describe the plan used for scope definition, staff reorganization, method estimation, baseline schedule development, project management training, and results of this transformation. It is a story of leadership and teamwork, pride and success.

Workers at the Savannah River Site's (SRS) F Canyon Complex (FCC) started with a challenge – take all the hazardous byproducts from nearly 50 years of operations in a major, first-of-its-kind nuclear complex and safely get rid of them, leaving the facility cold, dark, dry and ready for whatever end state is ultimately determined by the United States Department of Energy (DOE). And do it in four years, with a constantly changing workforce and steadily declining funding. The goal was to reduce the overall operating staff by 93% and budget by 94%.

The facilities, F Canyon and its adjoined sister, FB Line, are located at SRS, a 310-square-mile nuclear reservation near Aiken, S.C., owned by DOE and managed by Washington Group International subsidiary Washington Savannah River Company (WSRC). These facilities were supported by more than 50 surrounding buildings, whose purpose was to provide support services during operations.

The radiological, chemical and industrial hazards inventory in the old buildings was significant. The historical mission at F Canyon was to extract plutonium-239 and uranium-238 from irradiated spent nuclear fuel through chemical processing. FB Line's mission included conversion of plutonium solutions into metal, characterization, stabilization and packaging, and storage of both metal and oxide forms. The plutonium metal was sent to another DOE site for use in weapons.

Deactivation in F Canyon began when chemical separations activities were completed in 2002, and a cross-functional project team concept was implemented to successfully accomplish deactivation. This concept had to allow for continued operations in FB Line until 2005, while providing distinct task-oriented teams for deactivation of the FCC.

Facility workers, always the most knowledgeable about any facility, were integral parts of the project team. The team defined the scope, developed a bottoms-up estimate, reorganized personnel to designated project teams, and developed a baseline schedule with about 12,000 activities. Training was implemented to prepare the facility workers to use project management tools and concepts, which were to execute the project, coordinate activities and track progress.

The project budget was estimated at \$579 million. The team completed F Canyon and FB Line deactivation in August 2006, four months ahead of schedule and under budget.

### INTRODUCTION

F Canyon is a 816-foot-long, 122-foot-wide radiochemical processing plant that historically used the PUREX (Plutonium-Uranium Extraction) process to process and stabilize plutonium and uranium materials for the national defense and, later, for the United States' environmental cleanup mission. Processing occurred in two parallel, heavily shielded sections called a hot canyon and a warm canyon, separated by a central operating and service section.



F Canyon and FB Line were constructed in the 1950s.

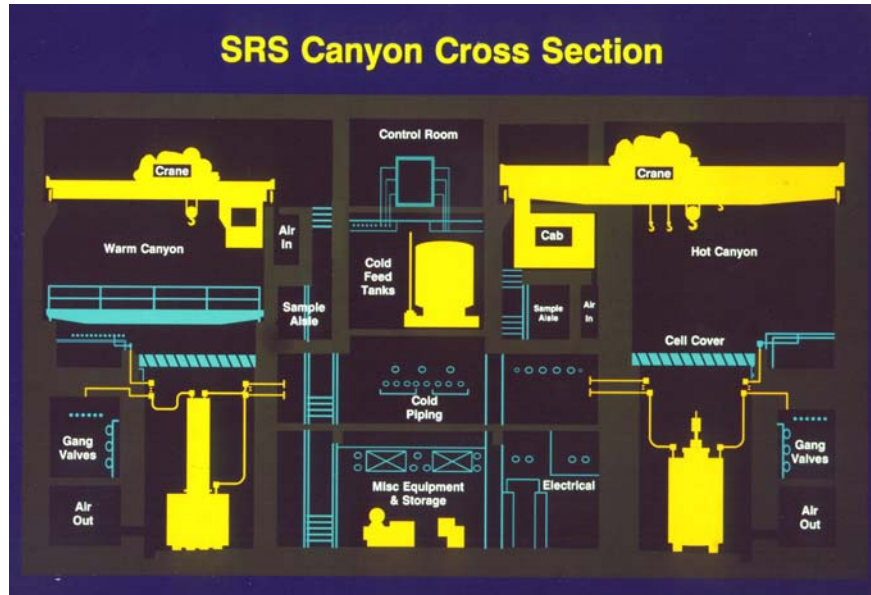
F Canyon is as long as three football fields. The building, constructed almost entirely of concrete, extends four stories underground and six stories above ground. FB Line is a two-story facility located on top of F Canyon, with some of its operations occurring on the second, third and fourth levels of the canyon.

The Outside Facilities, which provided direct support to F Canyon operations, included processes for feed preparation, waste stream handling, chemical storage, solution hold-up, evaporation, acid recovery, plant utilities, and other services required by FCC operations.

Throughout their history, different kinds of work have been done in almost every area of both facilities, and hazards existed in unexpected places. In some areas, deactivation work had to be done remotely because of high radiation levels from activities that had been conducted there for decades. And, some process areas had been shut down and abandoned for years or even decades, making deactivation much more difficult.

## HISTORY

SRS, then known as the Savannah River Plant (SRP), was built beginning in 1951 by E.I. du Pont and Nemours Co. at the request of President Harry Truman to produce plutonium and tritium for the national defense. By 1953, the first facilities were on line. F Canyon and FB Line started up in November 1954. F Canyon was the first facility of its kind to operate in the United States, followed by similar facilities in SRS's H Area and at the Hanford Site in Washington State. Over nearly a half-century of operations, F Area facilities produced a third of the United States' weapons-grade plutonium. A Hanford facility produced the other two-thirds.



A cross section of canyon operations.



Workers in F Canyon's main control room, which runs the length of the 800-foot-long facility.

By 1955, in what was then the largest construction project the world had ever seen, the entire complex was operational, including five nuclear reactors, waste management facilities, heavy water extraction and processing plants, chemical separations facilities, and support facilities.

Workers took pride in their contributions to their nation. Many came to SRP with Du Pont to design and start up the new facilities and subsequently spent their entire careers at the site. Du Pont operated SRP until 1989, when WSRC won the contract. Many of the original workers continued with WSRC. Some were still in F Area at the time of deactivation and provided invaluable institutional knowledge.

When the Cold War ended in 1992, so did F Area's defense mission. F Canyon and FB Line abruptly halted operations and remained shut down until they received direction to restart and process materials that had been stranded in the miles-long process, which snakes throughout SRS. They started back up in 1995 to stabilize "at risk" nuclear materials and spent fuel from throughout the DOE complex. Materials produced were not used for defense purposes; instead, they were stored in FB Line to be dispositioned later.

As operations were completed, a new era began – an era of suspension, deactivation, and eventually decommissioning. The FCC Deactivation Project Plan (DPP) was developed to provide the scope of work to deactivate the FCC. This included F Canyon, FB Line, and several support facilities with a total area of 835,000 square feet. The purpose of deactivation was to reduce risk while providing a seamless transition from operations to a low-cost surveillance and maintenance mode.

Although the F Canyon production mission ended in March 2002 with the last PUREX campaign, FB Line had to complete its operations mission, which was to characterize plutonium materials, stabilize them by packaging into 3013 containers, and

ship the material to a materials storage area. As a result, deactivation activities in F Canyon led those in FB Line. Because the facilities are so interdependent, however, FB Line hazards had to be removed before F Canyon could complete deactivation.

With direct support from subject matter experts who had deactivation experience at other DOE sites, F Canyon began working on a detailed suspension plan that would ultimately see the entire building safely laid up, with all vessels and systems flushed.

DOE authorized suspension work in February 2003. A building placed in suspension could be restarted relatively easily. A deactivated building could be restarted, but with considerably more work and expense. Until DOE could determine that it had no further need for F Canyon's unique capabilities, much deactivation work was on hold. Several months later, however, DOE issued the deactivation order. SRS's other canyon, located nearby in H Area and operated by Washington Group International, now represents the nation's only chemical separations capability.

Then, in September 2004, came approval to decommission – or permanently render buildings no longer operational. This might mean demolition, or it might mean another end state. The ultimate decommissioned end state for F Canyon and FB Line has not yet been determined.

The DPP development work was accomplished using a systematic technique employed at other DOE sites to specify desired end points. Each facility system and space was assigned a desired end point that was compared to the expected condition at the end of the applicable operating mission. Specific tasks were identified to take that system from its existing state to its deactivated state. The scope of the deactivation effort was defined by these thousands of tasks. These tasks were integrated into the facilities' mission schedule.

## THE CHALLENGE

When F Area leaders first began planning how to deactivate their facilities, the challenge seemed significant. When they began to delve more fully into the task ahead of them, it became even more daunting. Some items for which disposition paths had to be found were:

- More than 33,000 55-gallon drums of depleted uranium oxide (DUO), which could have a commercial use but for which no buyer could be found
- More than 140,000 gallons of depleted uranyl nitrate (DUN), which has been used as a criticality “poison” in F Canyon, but was no longer needed
- More than 60,000 gallons of radioactive organic solvents, which remained from the days of PUREX operations and were no longer needed
- Two large tanks of americium/curium (Am/Cm) solution, considered by some to be a priceless national asset, but for which no user could be found
- Plutonium solutions remaining in the canyon vessels and systems

Individual teams were tasked to figure out how to dispose of each individual substance. First, the teams exhausted all avenues for reusing the materials. In some cases, they were successful, and the materials could be reused. When this was impossible, the materials were declared waste and disposed of accordingly. Other deactivation tasks included:



Dawn Manning (right), a member of the Design Lab, installs a glovebag during deactivation work in F Outside Facilities.



FB Line's outer can welder was key in the facility's final mission of safely stabilizing and packaging legacy plutonium items.

- Isolation and draining of process and chemical lines and tanks
- Removal of all but residual fissile material, chemicals, loose combustibles and tools
- Isolation of all facilities
- Labeling of equipment and spaces as deactivated
- Sealing of gloveboxes
- Appropriate management and disposition of waste generated during deactivation
- Deactivation of Contamination Areas and subsequent relabeling as Inactive Contamination Areas
- Sealing of pathways where contamination could potentially migrate out of the facility



- Isolation of utilities outside the facility
- Deenergising of ventilation supply/exhaust systems

In addition, items accumulated or were discovered in the course of deactivation, such as radioactive sources, aerosol cans, freon, dry chemicals, transuranic wastes, PCB ballasts, lead-containing materials and others – all of which are controlled substances and must be disposed according to stringent regulations and guidelines.

There were also functions that were still performed by canyon personnel, in canyon facilities, that had to be moved elsewhere before the facility could be deactivated. In all cases, that meant additional training; in some cases, it involved minor or major construction work. Examples are chemical loading and unloading operations, lab waste receipt facilities, and emergency management responsibilities.

As always at SRS, safety is a prerequisite for doing all work. The challenge was even greater in F Area, because workers were deactivating old facilities that, in some cases, had been abandoned for some time, and workers did not always know what they would be up against. Even in the cases where they knew exactly what the hazards were, the challenge was significant.

## A NEW MINDSET

Before the work could begin, a new mindset had to be instilled in the workforce. Since the Cold War ended, workers had lived with uncertainty about how much longer F Area would remain open, but more work was always identified. When the end of scheduled processing approached in March 2002, many thought more work would come, as it always had. Even at the celebration that marked the safe, successful completion of planned operations, many didn't believe it.

So, when it came time to take the existing workforce, uniquely skilled in nuclear operations, and transform it into a deactivation force, significant organizational retooling was needed. WSRC leadership decided on an approach that centered on the workers themselves.

A representative group of high-performing F Area personnel was selected, with instructions to figure out how to best effect a culture change in F Area, and to design an organizational structure tailored to the completely new kind of work the people would

be doing. This was called the breakthrough process, and it was successful because the workers were empowered with creating and implementing their own organization to facilitate their own work.

FCC leadership held a workshop to identify performance areas that could be modified consistent with the risk reductions that would occur during deactivation. These breakthrough sessions identified specific issues, goals, risks and benefits for each change in each focus area. This was the first step in determining bottlenecks in the work processes and areas to target for change in F Area. The outcome of this workshop identified a number of focus areas and issues including authorization basis processes, organizational structure and work planning and execution.

A second breakthrough workshop was held to group small, diverse teams to develop high-level approaches for the primary issues identified in the initial workshop. The results were remarkable. Through implementation of the breakthrough initiatives, the project experienced a 30% reduction in cost and 30% acceleration in schedule, while reducing project and personnel risks.

## THE DESIGN LAB

These approaches were provided to a selected team called the Design Lab, a diverse group made up of representatives of operations, maintenance, radiological controls, engineering, first-line managers, group managers, and technical staff. Their job was to analyse this dynamic, transitional period and identify process, workforce, and efficiency improvements to help facilitate the deactivation process. They were charged with building upon and establishing new processes and testing them in a lab structure to resolve issues before implementation.



Deactivation workers check final details near the end of FB Line deactivation work.

The Design Lab also identified skills required to achieve success. They analysed the skill groups and levels of the existing workforce to identify the existing skills of the workers and those needing additional training required. They then produced a plan to redistribute specialised workers across the deactivation teams to provide the most comprehensive skills coverage possible for all identified tasks and projects.

The Design Lab also developed a plan for increasing existing skill levels and expanding existing skill sets and filling gaps in the deactivation teams for the various identified skill sets.

Finally, a program called Flexible Skill Assignments (FSA) was put in place to allow for the voluntary participation of workers who wished to be a part of the deactivation project and participate as valuable members of the deactivation teams.

The Design Lab's next task was to improve the method of conducting the various work involved with deactivation. Some programs and processes required did not add value when considering the life cycle of the facility. The team identified procedures that the facility would maintain in full compliance, those that would be maintained in partial compliance, and those that would not be adhered to. The exceptions were submitted and approved as an addendum to the deactivation project requirements.

One major change was the improvement of the process used to develop and approve work packages. The work management system that was being used was designed for an operational facility. For deactivation activities, it was cumbersome and much more involved than necessary.

Every activity performed during the deactivation process required an analysis for hazards, and mitigation for each hazard identified, to ensure a safe accomplishment of each deactivation milestone. The Design Lab learned that a user-friendly hazards analysis program was being developed and would be rolled out at about the same time the deactivation teams would be ready to begin work. The Automated Hazards Analysis (AHA) software turned out to be an excellent tool to combine the hazards analysis, develop mitigation of the hazards, and define instructions to perform deactivation work.

Empowering the deactivation teams to develop their own methods and objectives to achieve the assigned deactivation end points created a sense of ownership and pride in their achievements and was a key factor in their many successes in meeting the milestones and goals of the DPP.

## **USING INTEGRATED SAFETY MANAGEMENT**

The project team made efficiency gains through intelligent use of principles within the Integrated Safety Management process. Examples are:

- Transition from operations missions to deactivation resulted in elimination of many historical hazards. Safety analysis documentation was modified such that operational requirements could be more easily eliminated once specific hazards were removed.
- Many tasks were pre-screened for hazards and complexity reducing time for work document generation.
- Staffing plans were developed to manage facility resources in accordance with the project baseline.
- Team field workers were directly involved in analysing and planning work, which reduced the frequency of work package rework.
- Standardized fire protection, environmental, and industrial safety checklists were developed.
- The facility management team had an active self-assessment program. Emphasis was placed on safety, areas for improvement, and identification of best practices. Findings were presented at weekly team lead meetings.
- Work release authority was delegated to the team lead for work on systems that were out of service, turned over for deactivation, and had no potential to adversely impact overall facility status.

## **DISPOSING OF LEGACY MATERIALS**

When teams and procedures were in place, work began to dispose of legacy materials that had built up over a half-century of operations. Each material was unique and needed its own disposition path.

### *Americium-Curium*

First up was 30,000 gallons of americium/curium, stored for years in F Area as a national asset. After futile attempts to find a new owner for the material, it was classified as waste and sent into SRS's high-level waste system.

The transfer itself was a first-of-a-kind event. F Canyon materials had always been sent to F Tank Farm, which serves F Area, and later sent to H Tank Farm, which serves H Area. A continuous radioactive transfer from F Canyon to H Tank Farm had never been done.

Because of the nature of the material, it had to be sent in one shot to its destination tank, rather than a little at a time. This involved intensive, tightly linked coordination between eight control rooms in F Canyon and both tank farms, as the material traveled for 18 hours through intricate infrastructure along a route that extended for more than two miles.

The Am/Cm was safely and smoothly transferred in early 2003 and has now been turned into stable glass at the Defense Waste Processing Facility. This marked the removal of the last highly radioactive material remaining in the canyon.

#### *Plutonium Solutions*

Plutonium solutions in the canyon vessels and systems were processed in canyon dissolvers and other processes until all possible plutonium materials had been extracted from the solution. The plutonium was converted into metal in FB Line and is now stored with other plutonium materials in K Area.

After plutonium had been removed to the extent economically feasible, the remaining solution, which still contained trace amounts of plutonium, was sent to F Area's waste tanks for eventual vitrification.



Drums of depleted uranium oxide are loaded onto boxcars, one at a time, by forklifts.

When all plutonium solutions were removed, so was the potential for criticality in F Canyon.

#### *Organic Solvents*

Solvents represented the only remaining flammability concern in F Canyon. After examining the situation, the team determined that the solvents were no longer needed. They were used in canyon operations, but F Canyon no longer needed them, and H Canyon had all it needed.

The challenge came in finding a way to get the solvents out of the canyon systems, as there was no built-in mechanism to do that. Engineers devised a way to flush the systems to remove the solvents, which then needed to be washed to remove contaminants before final disposition.

When all the solvents had been removed, they were placed into tankers and sent to the site's Solid Waste organization, which disposed of them via solidification at a Texas plant and disposition at the Nevada Test Site.

#### *Depleted Uranyl Nitrate*

In the case of SRS's 140,000 gallons of DUN, no user or site process could be found. An arrangement with Permafix Materials and Energy Corp. in Oak Ridge, Tennessee, allowed the DUN to be shipped in special tanks – built for this purpose in South Africa – to PM&EC to be turned into a non-hazardous, concrete-like low-level waste form. The ultimate resting place for SRS's DUN material is the Nevada Test Site.

In June 2005, the last of the DUN left SRS for Tennessee.

#### *Depleted Uranium Oxide*

The path forward for DUO has been determined, but is proceeding slowly due to funding constraints.

More than 36,000 55-gallon drums of the material, each containing about 1,500 pounds of DUO, have been stored at SRS since the 1970s. No customers could be found, so efforts began to find another disposition path. In the summer of 2003, a successful pilot program was conducted whereby one-tenth of the material – the tenth that was deemed most risky – was sent via rail cars to a disposition site in Utah. The pilot was completed safely and successfully, and other shipments are conducted as funding becomes available.

So far, more than 6,000 metric tons of DUO have been shipped out of F Area.

### *Radioactive Sources*

During deactivation, 119 radioactive sources were located in F Canyon, FB Line and support facilities, and all had to be disposed of appropriately. Sources are radioactive materials in different shapes and sizes, used in radiological operations to ensure that the instruments used to monitor processes are working as they should. The radiological content of the source depends on the instrument to be calibrated. Of the 119 sources identified, it was determined that 24 could be reused elsewhere on site, leaving 95 to be disposed. Depending on the radiological properties, they were classified either as low-level, TRU or mixed waste and disposed accordingly.

### *Other Materials*

In the deactivation and demolition process, a myriad of other materials have been identified for disposal. Many of these materials were found in former operations areas that were being deactivated. Anything that came out of a radiological area had to be decontaminated. Some of these things – such as aerosol paint cans – required special treatment. Dozens of aerosol cans were discovered and treated before disposal.

Tanks, located behind the canyon building, once contained materials needed for operations. They were emptied, packaged and sent to the on-site Solid Waste Management Facility for burial.

Areas of the canyon contained petroleum materials, such as the building's old cranes that were used to transfer materials within the canyon. When deactivating the cranes, all the oils, hydraulic materials and other fluids had to be drained out and disposed. Shielding inside the building – usually lead, but sometimes oil – had to be dispositioned appropriately.

Consolidating and disposing of dry chemicals was a major task. The work involved relocating, sampling, repackaging, labeling and banding 36 different types of hazardous and non-hazardous chemicals in drums, in preparation for shipment. The chemicals were sent to an offsite vendor.

Even when an administration building – with no apparent hazards – is demolished, there were considerations. If light fixtures are older than the mid-1980s, they likely contained PCB ballasts that had to be disposed in specific ways. Batteries and other lead-containing materials have another set of prescriptions. Air conditioners, which contain freon, have yet another set.

## **VESSEL FLUSHES**

A major activity was to remove nuclear materials from the hundreds of vessels, lines and tanks within F Canyon and FB Line. This was done by reducing levels as much as possible, flushing the heel with acid, and finishing with at least three full volume flushes. Every effort was made to minimize the amount of acid added, because the goal was to finish with a heel that had a pH of greater than 2 so the remaining liquid would be classified as non-hazardous.

After a vessel was flushed, it was isolated to ensure that other vessel flush solutions could not inadvertently enter an already deactivated vessel. This was critical for knowing and ensuring the final known state of the vessel and for accountability / inventory status. This was achieved initially by lockout of the steam to the gang valve or pump. Eventually, jumpers were removed. All configuration changes were documented on the F Canyon scroll. The scroll, when deactivation was completed, was removed and kept as a log of the canyon's final configuration status.

After deactivation began, a decommissioning program was initiated. The scopes, while somewhat different, overlapped in some cases, particularly in Outside Facilities support areas. For example, the purpose of deactivation is to minimize or reduce hazards, while decommissioning is to eliminate hazards. Much of the piping had only been drained, not flushed, which caused additional work that could have been avoided had the program been integrated in the beginning of deactivation.

During deactivation planning, it was critical to know the disposition path for all legacy materials such as degraded solvent or depleted uranium solutions in order to prevent deactivation of equipment too early that may be needed for its disposition. This lesson was learned when it came to disposing of contaminated water.

Once the vessels, sumps, and aprons were flushed, the deactivation plan was to grout underground tanks and aboveground aprons and sumps to eliminate water handling. This plan was determined to be faulty, because grouting would lead to what



The 100,000-square-foot 247-F complex, located near the rear of F Area, is demolished.



was considered closure, which cannot take place until decommissioning occurs. But all equipment capable of treating the water had been deactivated. So, a suitable location for disposition of the contaminated water had to be found. Fortunately, H Canyon still had an operating evaporator, and the water was trucked there.

## HOW THEY DID IT

Ultimately, the teams succeeded by coming up with new, common-sense ways of getting their work done safely. In one instance, there was a known radioactive source in an area of the building not normally occupied, and the source had to be moved out before deactivation work could be done. Every known solution involved exposing a person to high levels of radioactive material.

The team won WSRC's highest award for their simple solution, which was to use one of the building's cranes to carry a can of paint into the area. The crane then picked up the source, put it into the can, and brought it out – safely shielded within the paint.

As deactivation work was completed, support buildings in F Area were freed up to be demolished. All told, nearly 50 buildings were on the ground by the end of FY06.

## SUCCESS

In January 2005, F Canyon reached the “residents out” stage, which meant suspension work had been completed. Several weeks later, FB Line completed final operations to stabilize and package its inventory. Final shipments out of the facility were completed in February. In late February, security in F Canyon and FB Line was downgraded and 110 security guards were moved out, saving more than \$20 million annually in safeguards and security costs in F Area.

Shortly after, members of the media were invited into FB Line for the first and last time. It was the first time because, until then, FB Line had been one of the most highly classified facilities at SRS. It was the last time because the facility had been turned into a construction zone, in full deactivation.

As F Area work was completed the manpower level steadily decreased. Personnel were successfully placed in other site areas that could benefit from their expertise. Within three years, a workforce that numbered more than 600 was pared to about 90. Deactivation work was completed in F Canyon and FB Line in August 2006, four months early and significantly under budget. F Area's deactivated status will save \$150 million each year.

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A member of the FB Line leadership team checks a deactivated room.