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INTRODUCTION

The management and structure of a novel research and development (R&D) project can be hard to navigate. This is especially true when it involves nuclear fuel. Familiarity with institutional safety and procedural requirements, a well defined scope, and accurate cost estimates can all help ensure successful project management from start to finish.

The Dry In-Pile Fracture Test (DRIFT) experiments performed at the Transient Test Reactor Facility are an excellent example of managing an R&D project within its scope and budget constraints. The objective of the DRIFT test was to develop fracture propagation data in a manner consistent with light-water reactors to validate and improve the fracture propagation models of uranium oxide fuels in the MOOSE (Multiphysics Object-Oriented Simulation Environment)-BISON-Marmot code framework [1].

Project Initiation

Defining the project objectives is one of the most important and difficult aspects of managing any novel R&D project. Key personnel involved in the initial project planning included an experienced technical R&D project manager; the principal investigator, who is the technical expert for the project; facility safety basis engineering, design engineering, and post-irradiation examination (PIE) experts; and neutronics, thermal, and structural analysis engineers. The project technical lead drafted the initial design requirements before team development. This carefully selected group then turned the preliminary project design requirements into well-planned, measurable requirements that set the project up for success.

The DRIFT experiment budget was set prior to involving the project manager. Therefore, careful management of the project budget was critical. Accurate labor and material estimates obtained early in the project then became vital. Project activities were defined at a granular level and then resources were assigned to each activity. An in-depth review of personnel hours with input from each resource involved allowed for an accurate bottoms-up estimate. Project risks, budget, timeline, and objectives were recorded in a project execution plan.

Project Execution

Defining the project requirements for any first-of-a-kind experiment is tricky. Combined with budget constraints, it can be difficult to accomplish any irradiation test for a reasonable amount of funding. As with most projects, initial cost estimates exceeded the allocated funding limits. Cutting nonessential activities from the schedule and revisiting the design requirements frequently throughout the design process is essential.

As shown in Fig. 1, the design process is iterative. As the design evolves, cost estimates and schedules are frequently revised. Based on the projected costs, the design and project requirements are then revisited to determine what requirements can either be removed or revised to meet the budget constraints. The DRIFT experiments are perhaps one of the better examples of this.

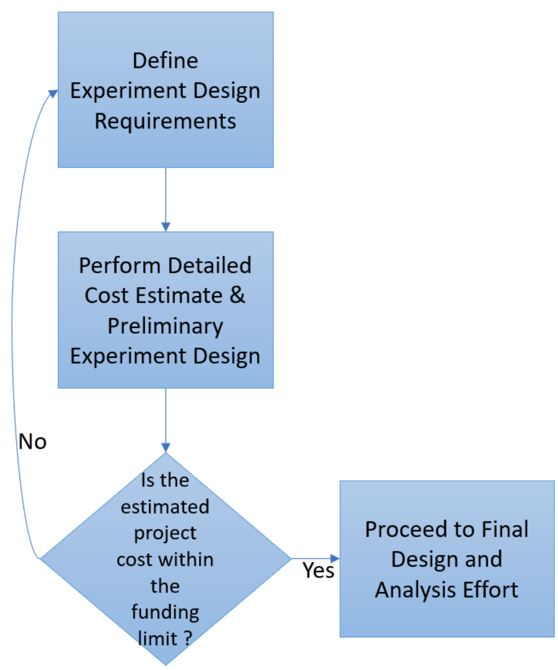

Fig. 1. Project Design and Cost Iteration Process

In order to achieve and measure temperatures throughout the heat sink, the design of the experiment involved some novel instrumentation, including a distributed temperature sensing fiber as shown in Fig. 2. Mock-up and dry run tests were performed several times early in the design effort. It was apparent during these early efforts that the labor hours required for assembly were going to be much more costly than first planned with the initial draft design. To offset and reduce the labor costs for assembly, the mockups were used to inform and change the experiment design. In some instances, concessions in the design requirements were also required, but the costs savings in the fabrication and assembly phases were worth revising the design objectives.

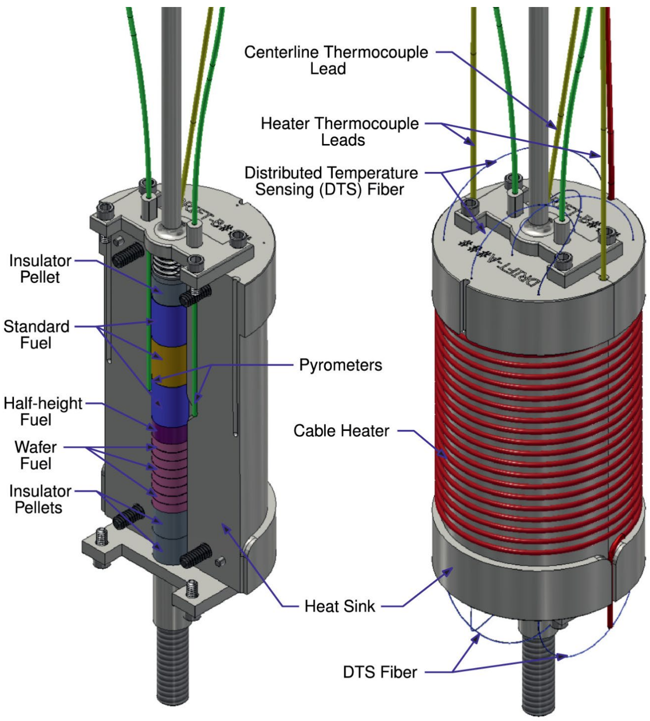

Fig. 2. DRIFT Capsule Design [1]

Additionally, these dry runs and mock-up activities helped reduce risk during the actual experiment execution. The delicate nature of the distributed temperature sensing fiber made it prone to breaking. The mock-up testing revealed that the direction in which the holes were made in the heat sink could affect the ease with which the fiber threaded through the heat sink. This very minor lesson allowed the design engineer to specify the direction of the hole drilling during fabrication, greatly improving the ease of threading the fiber and decreasing the risk of the fiber breaking during the assembly.

Lastly, the iteration and careful balance of scope and budget constraints pushed the design team to execute the irradiation test within an already analyzed primary containment boundary. Utilizing a pre-existing containment provided many benefits, such as allowing the team to focus solely on more flexible, programmatic analyses and decreasing the time and funding necessary to compare the design to reactor safety basis limits.

RESULTS

The DRIFT experiments performed at the Transient Test Reactor Facility were able to successfully meet project objectives in a fiscally prudent manner. Through careful upfront planning and well-thought-out design requirements, the project was able to leverage existing irradiation hardware to reduce the cost of project design and analysis efforts. In all, the project transitioned from conception to irradiation in about two years for about two million dollars. Throughout the design effort, the technical objectives and project costs were weighed against each other. However, this nimbleness of design and creative solutions to requirements was crucial in the project's overall accomplishment.

Other vital considerations that enabled the success of this project were the use of mock-up components to inform design changes early in the design effort, careful budget management throughout the project, and early involvement of key stakeholders to ensure both technical and facility objectives were met in a satisfactory manner.

The result was a set of irradiated fuel specimens that were analyzed through the PIE process. PIE yielded data that enabled the project to validate the MOOSE-BISON-Marmot code models and update them to simulate more accurate crack propagation data.

REFERENCES

1. B. SPENCER et al., "Dry In-Pile Fracture Test (DRIFT) for Separate Effects Validation of Ceramic Fuel Fracture Models," *Journal of Nuclear Materials, vol. 568 (2022).*