INL/MIS-21-62718-Revision-0

2021 ATR Strategic Plan

May 2021

Changing the World's Energy Future

Jennifer D Eversull

Idaho National Laboratory

INL/MIS-21-62718-Revision-0

2021 ATR Strategic Plan

Jennifer D Eversull

May 2021

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

Advanced Test Reactor

Strategic Plan 2021

Idaho National Laboratory

Facility Engineer Gary Palmer puts a new Loop Operating Control System through its paces before installation in ATR.

CONTENTS

INTRODUCTION

Collaborative development of nuclear energy science and technology by three major sectors—academia, the commercial nuclear power industry, and the federal government—is key to meeting the challenges of nuclear energy. All three share a common need for experimental capabilities, whether for basic science investigations, applied research in nuclear fuels and materials, or validation of data. The Advanced Test Reactor (ATR) provides the unique irradiation capabilities to support the need.

ATR is recognized as the world's highest power operating test reactor. It is among the most technologically advanced and versatile nuclear test reactors in the world. The unique capability of ATR to provide constant or variable neutron flux during a reactor operating cycle makes irradiation in this reactor very desirable. ATR offers the ability to conduct irradiation for static capsules, instrumented leads, and pressurized water reactor (PWR) loop experiments, which can precisely represent the conditions in various types of reactors. The Office of Naval Reactors (NR) materials irradiation program integrates ATR's unique irradiation and test capabilities into its exclusive nuclear propulsion research program. The Department of Energy's (DOE's) Office of Science has a long history of isotope production at ATR. In 2007, DOE, via Idaho National Laboratory (INL), expanded ATR's mission to also support the Nuclear Science User Facilities (NSUF) (originally known as the National Scientific User Facility). In 2015, DOE announced the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative, which provides the nuclear community access to ATR and other INL facilities to test, develop, and demonstrate advanced nuclear technologies. The Nuclear Energy Innovation Capabilities Act of 2017 established the National Reactor Innovation Center (NRIC) at INL. NRIC enables the testing and demonstration of reactor concepts to be proposed and funded, in whole or in part, by the private sector. ATR has a key role in enabling this mission.

ATR

The Advanced Test Reactor is the world's most powerful test reactor.

Advanced Test Reactor

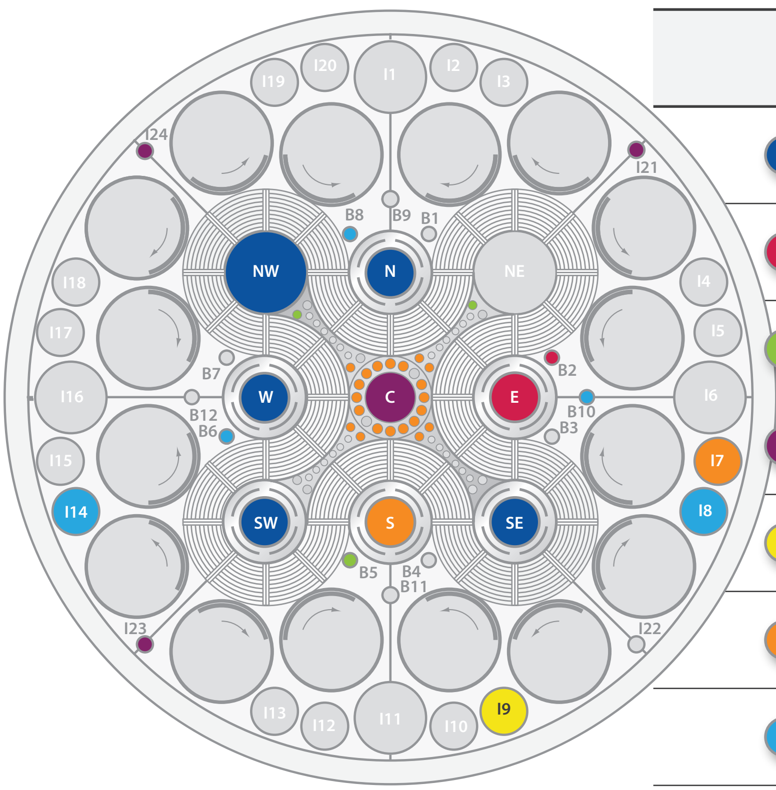
The ATR is a water-cooled, high-flux test reactor with a unique serpentine core design that allows large power variations among its flux traps. The reactor's curved fuel arrangement places fuel closer on all sides of the flux trap positions than is possible in a rectangular grid. The reactor has nine of these high-intensity neutron flux traps and 66 additional irradiation positions, each of which can contain multiple experiments.

Experiment positions vary in size from 0.5 to 5.0 inches in diameter by 48 inches long. The peak thermal flux is 1×10^{15} n/cm^2-sec and fast flux is 5×10^{14} n/cm^2-sec when operating at a full power of 250 MW. The PWR loops enable tests to be performed at prototypical PWR operating conditions.

These 75 irradiation positions (not including the north and south outer irradiation tanks) are available to customers, and demand for these positions has steadily increased over recent years. The Fiscal Year (FY) 21 Integrated Strategic Operational Plan (ISOP) (Rev. 1) posted a utilization of 61.1% prior to core internals change-out (CIC) and an occupancy of 80-90% post-CIC. There are 51 internal core positions that are in high demand, and occupancy for these high-demand core positions continually runs between 80 and 100% occupancy since FY18 and will continue well beyond CIC.

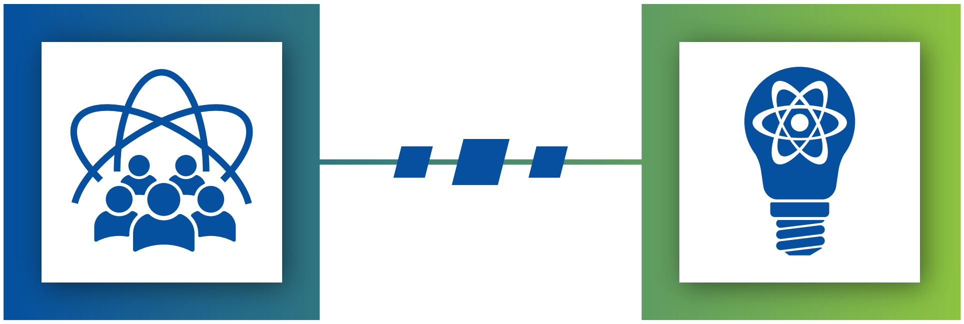
The Halden reactor shutdown has prompted investigations that focus on the development of the 24 lower flux positions to accommodate continued testing needs. Plutonium-238 production needs are focusing on utilizing any available core position. ATR currently provides irradiation services to a wide spectrum of users including:

- NR
- NSUF
- Advanced Reactor Technology
- Nuclear Fuel Cycle and Supply Chain (NFCSC)
- National Nuclear Security Administration Office of Material Management and Minimization
- United States High Performance Research Reactor (USHPRR) fuel initiative
- DOE Office of Science (Isotope Production)
- Strategic Partnership Projects
- Cooperative Research and Development Agreements and Laboratory Directed Research and Development
- National Aeronautics and Space Administration (NASA).



Test Space/Position Program	Owner
NW, N, SE, SW, W loops **Naval Reactors (NR)**	NAVAL NUCLEAR LABORATORY
E flux trap, B2 **Advanced Reactor Technologies (ART)**	ART
A9, A12, B5 **Strategic Partnership Projects, Lab Directed R&D and CRADAs**	SPP, LDRD, and CRADA
C loop, I21, I23, I24 **Nuclear Fuel Cycle and Supply Chain**	NFCSC
I9 **National Nuclear Security Agency (NNSA)**	NNSA
S flux trap, A1-A7, H1-H16 except H3 & H11, I7 **Isotope Production**	U.S. DEPARTMENT OF ENERGY Office of NUCLEAR ENERGY
B6, B8, B10, I8, I14 **Nuclear Science User Facilities (NSUF)**	NSUF

This diagram illustrates the key experiment positions in use during recent operating cycles - in this case, 169A which ran from January through April 2021.



VISION

ATR will be
the national and international
materials and fuels irradiation testing
facility of choice.

MISSION

ATR will provide
unique irradiation capabilities
for nuclear technology
research and development.

Advanced Test Reactor Critical Facility

ATR Critical Facility (ATRC) is a low-power version (same size and geometry) of the higher-powered ATR core. It is operated at power levels less than 5 kW with typical operating power levels of 600 W or less. ATRC is primarily used to provide data for the design and safe operation of experiments in ATR, including supplying core performance data for the restart of ATR after periodic core internals replacement. ATRC may support stand-alone experiment capability to perform low-power irradiation of experiments, which will not be irradiated in ATR. Experiments can also be performed in ATRC to collect experimental data for computer code validations.

Vision and Mission

With ATR's significant role in the nation's nuclear future, the strategic posture requires periodic evaluation. Over the next 5 years, the strategic direction of ATR will be impacted through approaches adopted by the program as outlined in this strategic plan. ATR's management team developed the vision and mission to guide ATR's strategic path forward, including development of ATR-specific objectives to support an operational forecast beyond 2040.[1]

---

[1] *Memorandum of Agreement Between the Office of Nuclear Energy and the Office of Naval Reactors for Operation and Maintenance of the Advanced Test Reactor and the Advanced Test Reactor Critical Facility, May 11, 2016.*

ALIGNMENT WITH LABORATORY AGENDA

The 2021 INL Laboratory Agenda[2] presents four critical objectives. ATR supports the Lab Agenda by enabling advanced nuclear energy systems and delivering the GAIN/NRIC initiative. To ensure the success of the GAIN/NRIC initiative, INL will expand testbed capabilities at ATR and serve as a demonstration platform in partnership with industry.

Achieving this outcome requires the following:

1. Sustained and expanded nuclear energy leadership to advance a low-carbon energy future and increase the contribution of nuclear energy to the nation's energy mix.
2. Demonstrable progress towards closing the carbon cycle via technology development and demonstration of methods to harness and use a variety of forms of nuclear energy products (radiation, heat, and electrons) in conjunction with other clean-energy sources to accelerate the deployment of an economy based on clean, reliable, and sustainable energy.
3. Increased performance and economic competitiveness of materials for extreme environments, including advanced energy-generation and management systems, and space and defense systems.
4. Increased security and resilience of critical infrastructure and defense platforms.

ATR's mission, vision, goals, and outcomes align with the lab plan and sets us on a path to fulfill the lab's mission and vision.

[2] *The 2021 INL Laboratory Agenda is currently in progress.*

ATR is tasked to accomplish the following:

1. Develop and demonstrate technology breakthroughs, technical solutions, and capabilities that substantially improve the performance of existing and future nuclear energy systems and enable the expanded use of nuclear systems.
2. Provide safe, secure, sustainable, and efficient facilities and end-to-end infrastructure that meet mission needs while supporting goals to consolidate and revitalize our campuses.
3. An effective and integrated program for life-cycle management of radioactive materials and waste, including disposition of INL past and future waste and spent nuclear fuel (SNF).

ATR welders practice with a new customized orbital welder system that will be used to connect new inpile tubes to experiment loops in ATR's subpile room.

STRENGTHS, WEAKNESSES, OPPORTUNITIES, AND THREATS

To initiate the strategic planning process, the ATR management team executed a structured approach to identify the strengths, weaknesses, opportunities, and threats for ATR. The output of that broad effort was used to focus the development of the specific ATR objectives and then identify strategic initiatives necessary to support those objectives. A summary of the key strengths, weaknesses, opportunities, and threats are noted.

Strengths

The following strengths are attributes of the organization and capabilities that distinguish ATR and are beneficial in meeting its objectives. Over the last two years ATR has achieved new strengths, which include the following:

- Improved outage readiness and execution
- Engaged workforce.

Improved Outage Readiness and Execution

Three years ago, ATR's workforce invested in improving outage execution and the payback was observed in early FY19 when two unplanned reactor outages occurred due to equipment-related failures. The first equipment failure involved an outer shim control cylinder gearbox. The gearbox was successfully repaired without unloading experiments from the reactor core or draining the reactor vessel and resulted in significant time savings. The second shutdown was caused by a leaking inpile tube (IPT). The IPT replacement was completed in a safe, expedient manner. The two unscheduled ATR outages were efficiently planned and executed by Operations, Engineering, and Maintenance with Production Control adding in maintenance items that could be worked while the reactor was offline.

Not only were the unscheduled outages well planned and executed, but they also resulted in fewer maintenance days needed during subsequent scheduled maintenance outages. The DOE authorized entering a Technical Safety Requirement Limiting Conditions for Operation (LCO) to perform maintenance. Entering an LCO during reactor operation allows for performing maintenance activities that would normally be performed only during reactor outage. Over time, entering LCOs during reactor operation to perform maintenance will support reducing outage durations and increasing operating days in support of ATR's mission.

Engaged Workforce

Improved outage execution is one example of ATR's engaged workforce--improving experiment pre-irradiation planning and execution is another. ATR set a record eight new experiments starting irradiation in a single cycle, which is significant for the number of new experiments and the number of continuing experiments together. This record met a new capacity milestone. The effort required to meet this milestone required close coordination between organizations and adherence to the outage schedule. Frequent meetings were held with stakeholders to ensure success. As a result, significant improvement to directorate integration and collaboration across INL (Nuclear Science and Technology [NS&T], Materials and Fuels Complex [MFC], and ATR) was achieved.

Another lasting outcome from this effort was the creation of a monthly risk and mitigation meeting between organizational management and stakeholders. The risk and mitigation meeting provides status and discusses issues potentially impacting ATR's operating schedule, as well as challenges to experiment on-time delivery to meet the reactor startup timeline.

ATR led the coordinated effort between Battelle Energy Alliance (BEA) and Fluor-Idaho to support direct shipments of ATR SNF from the ATR canal to the Idaho Nuclear Technology and Engineering Center's Irradiated Fuel Storage Facility (CPP-603) in the High Load Charger cask. The effort required extensive canal support by the ATR staff, resulting in completing initial SNF shipments in the second quarter of FY19 and enabling INL to place ATR SNF in dry storage in support of the 2023 Idaho Settlement Agreement milestone.

Unique Irradiation Capabilities

ATR supports nuclear science and engineering missions for DOE Office of Nuclear Energy (NE) research and development programs, as well as a variety of other government and privately sponsored commercial and international research. It is the only research reactor located in the United States capable of providing large-volume, high-flux neutron irradiation in a prototypic environment.

The capabilities and features of ATR include

- High power (250 MW) test reactor operating at low pressure and temperature, but with individual experiment conditions adjustable to greater than 500°F and greater than 1,000 psig
- Reactor cooled by light water with a beryllium reflector for high neutron efficiency
- Unique serpentine core allows the reactor's corner lobes to be operated at different power levels, permitting multiple simultaneous experiments to be conducted under different testing conditions
- Large test volumes (48 inches long and from 0.5 to 5.0 inches in diameter)
- Seventy-five testing positions
- High neutron flux (up to approximately 10^{15} n/cm^2/sec at 250 MW$_{th}$ reactor power)
- Fast/thermal flux ratios ranging from 0.1 to 1.0
- Constant axial power profile
- Individual experiment pressure and temperature control possible
- Capable of installing instrumented experiments with real-time monitoring
- Experiment reconfigurations possible during each outage
- Capable of isotope production (e.g., Cobalt-60) for commercial and other research applications.

Long-Term Stakeholder Commitment to the Future of ATR

In the years leading up to 2015, ATR experienced lower levels of investment and base funding support, and the effects of this could be seen through the lower availability and reliability of the reactor and its ability to support the sponsors' objectives.

Previously, the operational horizon of ATR necessary to meet the sponsors' irradiation objectives was uncertain. The sponsors, NR and NE, have now determined that long-term programmatic needs require that an ATR capability be available to 2040 and beyond.

These key stakeholders are now committed to ensuring the long-term viability of ATR's unique capabilities to support advances in naval nuclear propulsion and nuclear power production.[3, 4] The primary sponsors are expected to request future budgets that provide sufficient funding support to base operations and investment in plant health for equipment and system upgrades to address aging and obsolescence and reverse the trend of decreasing days of actual irradiation each year.

---

[3] *O'Kelly and Holmstrom to Bishop and Davis, March 21, 2018, "Advanced Test Reactor; Plan to Develop Business Case Evaluation for the Future of Irradiation Testing; Plan for Information and Request for Funding Authorization," CCN 242360.*

[4] *Davis and Bishop to Merlino, August 10, 2018, "Advanced Test Reactor – Resource Loaded Plan to Determine Irradiation Capabilities Up Through and Beyond 2040; Partial Approval with Comments."*

A September 2020 aerial drone photo of the ATR Complex shows progress on recent construction activities.

Plant Health Process

ATR continues to utilize a plant health/equipment reliability process, which is used to identify, evaluate, monitor, maintain, repair, and upgrade site structures, systems, and components important to the safe and reliable operation of the facility. Outputs of the Plant Health process provide inputs to the Long-Range Planning process and together these processes identify the priority, risk, funding, and timing needed to address issues that may impact the safety, reliability, or mission of the ATR.

The plant health/equipment reliability evaluation process assigns a risk score (numerical value) to each issue identified, based on the answers to specific questions as to whether the problem poses a nuclear or industrial safety issue and/or mission reliability issue. The evaluation process also determines the issues potential to cause an unplanned reactor shutdown or reactor outage extension by assigning a risk category of "low," "medium," "high," or "very high" based on likelihood of occurrence (probability) and impact on the plant (consequence). The risk score and risk category are used to prioritize component and system health issues for resolution. The evaluation process takes place within the Long-Term Asset Management (LTAM) module of the web-based software application called "ER Suite."

Weaknesses

The following weaknesses exist within the ATR Complex and its capabilities, which could present challenges to ATR's ability to meet its objectives.

Process Efficiency

Over time, processes at INL/ATR have become more complex. This has resulted from factors like additional steps included in procedures to address past events or increased conservatism. This contributes to a situation where a relatively simple workflow can become overburdened with forms, signatures, and reviews. ATR must continually challenge the processes and procedures to make workflow more streamlined and efficient.

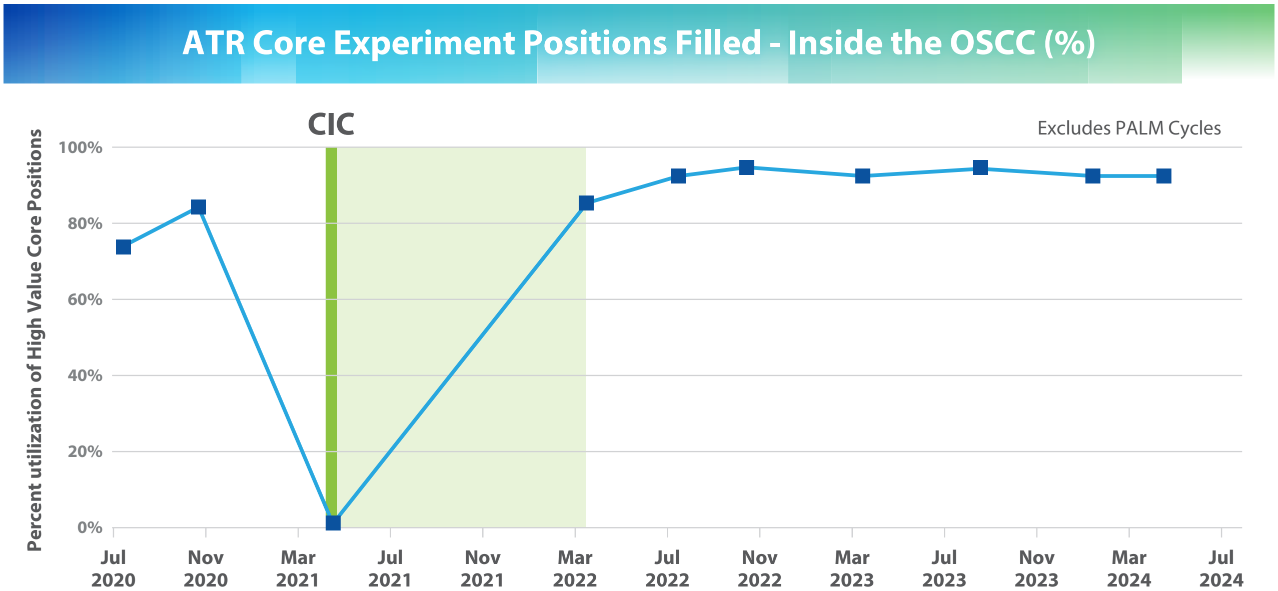
Annual Irradiation Days Delivered

As shown below, the current high demand for those irradiation positions within the outer shim control cylinders (OSCCs) will continue in the future. ATR must continue to collaborate with stakeholders to develop/implement a robust core prioritization vetting process that will ensure core positions are available to serve the nation's highest value programs.

System Engineering Organization Capacity

The system engineers are required to perform many functions in support of the safe operation of the ATR. They need to understand and determine the condition of all the Structures, Systems and Components (SSCs) that make up the plant and maintain the equipment as operable. System engineering owns the configuration management and requirements for all plant SSCs. The system engineers are a major contributor to plant health/equipment reliability program with the responsibility to evaluate, monitor, and maintain SSCs, through system health reporting, and to provide input to the long-range planning process to ensure the plant remains reliable into the future.

Due to the age of the ATR, many of the SSCs are well beyond their expected life. Equipment failures are increasing which require attention from the system engineers to troubleshoot and resolve. Engineering staffing is not at a level to effectively support the core required activities of system health monitoring, configuration management, and future planning, nor support the ever growing need to respond to emergent plant equipment issues. ATR's priority is to adhere to the operational schedule (ISOP), which results in emergent equipment issues receiving immediate attention from system engineering to the detriment of other engineering priorities and activities.



Percent utilization of high value core positions.

Opportunities

Through analysis of ATR's strengths and weaknesses, opportunities for improvement emerged that will help overcome the challenges ATR encounters and build upon the strengths.

These opportunities include:

- Improving processes to support increased reactor power day capacity
- Working with NSUF and GAIN to improve utilization of ATR's various core positions
- Decreasing cost and time to perform experiment irradiations
- Providing customer-driven new capabilities
- Enabling staff retention and recruitment through professional development, training, and progression
- Increasing ATR core position utilization for isotope production.

These opportunities are either internal regarding improvement areas or external regarding areas to capitalize and promote growth.

Naval Reactors and Fluor Marine Propulsion, LLC (FMP) investment in ATR

The NR Program and Fluor Marine Propulsion, LLC (FMP) recognize the need to invest in ATR's future. A collaborative effort was initiated in 2016 to develop a plan for identifying the specific plant investments necessary to revitalize ATR. This long-term planning horizon acknowledges the value ATR brings to the NR Program and represents an opportunity to fund the needed investments in ATR's infrastructure beyond 2040.

An additional opportunity may exist to consolidate hot cell capabilities from the Naval Reactors Facility (NRF) to ATR. Creating equivalent hot cell capability could increase ATR's value to NR and FMP.

To further support the FMP relationship with ATR, two specific activities have been chartered: one in support of the development of the ATR Beyond 2040 Business Case Development Plan,[5] and the other in support of potential reactor design concepts that would be incorporated into the Business Case as part of a Class 5 estimate used in support of an options analysis.

Threats

The final step of the analysis was to identify areas that are or could be a threat to ATR. We may be able to influence the outcome of a threat, but seldom can we control it. The following threats were identified for ATR:

- Funding uncertainties
- Competition for customers
- Workforce turnover from competitor opportunities and retirements.

ATR and many of its experiment customers are federally funded programs and must deal with the fiscal uncertainties in the federal budget.

Although ATR is unique and highly desirable, other facilities exist around the world to irradiate experiments and represent alternatives for ATR customers and, therefore, become competition. Similarly, other employers exist locally, nationally, and internationally, representing a continuous challenge for staff retention at ATR.

Growth in INL initiatives (NRIC/SMR/VTR)

INL strategic initiatives to achieve critical outcomes include enabling the Small Modular Reactor (SMR) and the Versatile Test Reactor (VTR) at INL as part of the NRIC.[6] It is expected that the deployment of the first domestic commercial SMR and a new "fast" reactor (VTR) can be enabled through INL's knowledge, expertise, and nuclear capabilities. While this is a positive outlook for INL, this represents a potential threat to ATR. The potential threat is related to a loss of some portion of the ATR workforce, both current and future staff, to the SMR and VTR effort, especially if they offer competitive or higher salaries. This directly ties to the recruiting and retention challenge outlined in Objective 1 of this plan.

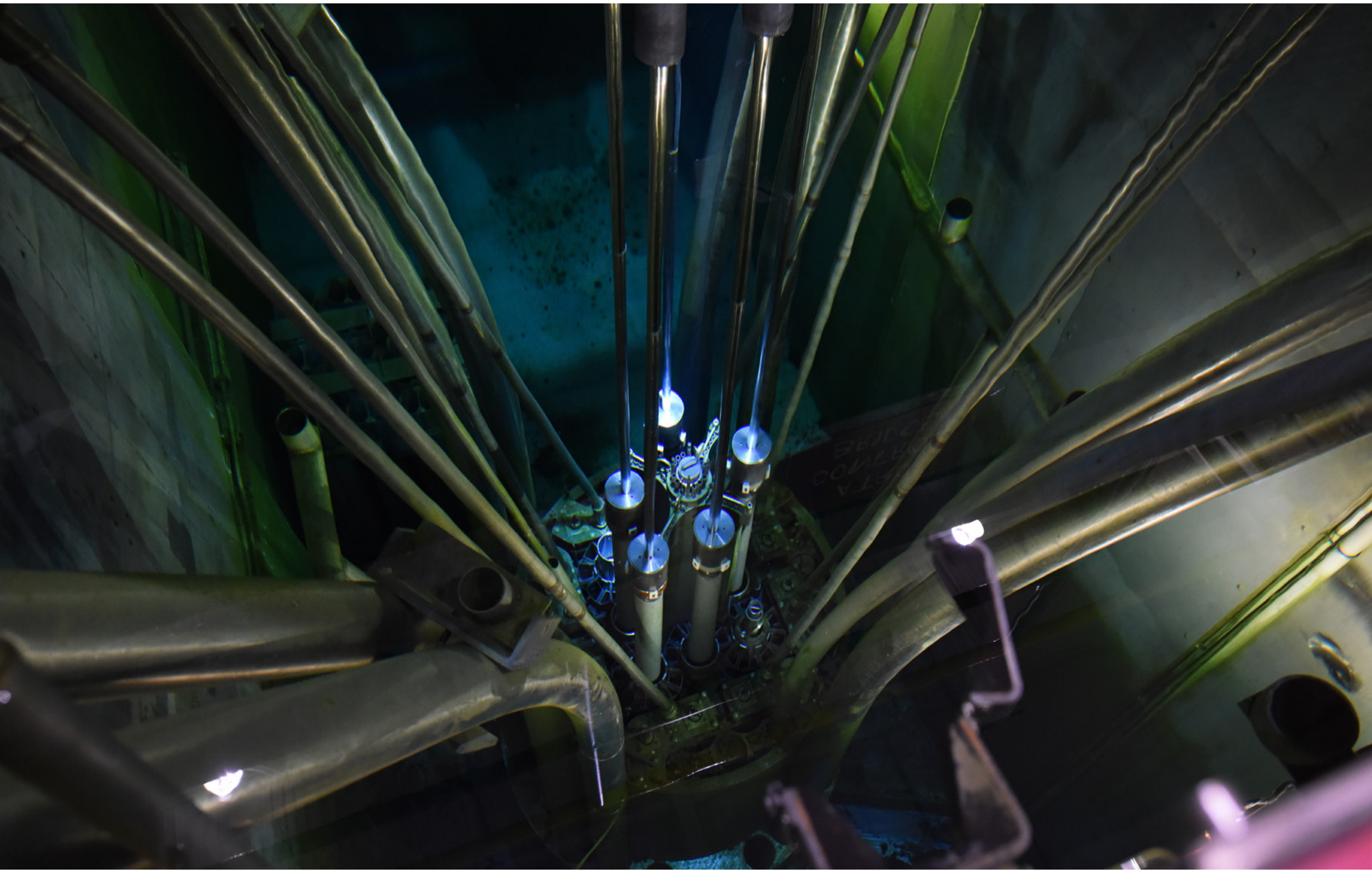
---

[5] *Strategic Thermal Irradiation Capabilities Business Case 2020, Idaho National Laboratory and Naval Nuclear Laboratory, INL/ITD-20-58707, Rev. 0, July 2020.*

[6] *Nuclear Energy Innovation Capabilities Act of 2017, https://www.congress.gov/115/bills/s97/BILLS-115s97enr.pdf.*

Talent Retention

Our ability to attract and retain top talent at the ATR Complex requires a competitive, market-based, cost-effective compensation and benefits program. INL moved to a new job classification system to provide flexibility for future changes to our evolving workforce. However, as our benefits suite evolves to address the shifting regulatory environment (with changes driven by the Affordable Care Act) and changes created by the broadening spectrum of generational differences in the workplace, ATR Complex will continue to experience staff turnover. ATR will need to address the unique challenge of managing a large, specialized workforce.



The core of the Advanced Test Reactor Critical.

ATR OBJECTIVES, STRATEGIC INITIATIVES, AND INDICATORS

INL, a multi-program national laboratory, conducts science, technology, engineering, and program operations for DOE and a variety of other customers. With DOE-NE establishing GAIN in 2015 to provide the nuclear community with access to the technical, regulatory, and financial support necessary to move new or advanced nuclear reactor designs toward commercialization while ensuring the continued safe, reliable, and economic operation of the existing nuclear fleet, and the 2018 legislation to further establish an NRIC, updates to the ATR strategic plan to address GAIN and NRIC are necessary. ATR objectives and strategic initiatives are outlined in the following sections that also build on the previously described strengths, weaknesses, opportunities, and threats analysis.

OBJECTIVE 1 Improve recruiting, retention, and training processes to support ATR objectives.

OBJECTIVE 2 Steadily increase ATR's irradiation days.

OBJECTIVE 3 Reduce time & cost to perform work at ATR.

OBJECTIVE 4 Enhance ATR's experiment capabilities.

Craig Winder at the new digital control panel for the ATR Critical Facility.

OBJECTIVE

1

Improve Recruiting, Retention, and Training Processes to Support ATR Objectives

To achieve ATR's potential, as well as INL's potential as a national laboratory, ATR must overcome the challenges of maintaining and developing the work force.

ATR must continue to attract, develop, and retain top talent. It can be challenging for ATR to attract the unique skills and capabilities to sustain its mission, and this becomes even more of a concern with impending retirements, increasingly mobile workforces, and shortages in key technical areas. Unless ATR and INL address the ability to attract, develop, and retain this top talent, we could fall behind in key programmatic areas. ATR and INL leadership must work together to cultivate an exceptional cadre of next generation operators, scientists, and engineers to meet future needs. This objective will be worked in conjunction with laboratory initiatives.

Strategic Initiative

Working with human resources, improve the ability and process to hire and retain employees.

The Human Resources Roadmap identifies the need for improved processes and recruiting tools, and is also on the Business System Working Group five-year strategy plan and one of the top three issues identified by INL management, which is to "Recruit, Retain, and Invest in Human Capital." Improving recruitment will have long-term impacts on INL's ability to fulfill its mission. Improving inclusion and diversity will create a more enjoyable and rewarding work environment. Employees accomplish the mission of INL and increasing ATR's capacity to hire, along with improving its tools, increases its success.

Indicators

- Increased utilization of INL recruiter to find quality employees
- Increased intern hiring
- Improved employee retention
- Improved inclusion and diversity.

Strategic Initiative

Develop a plan to strengthen development and educational advancement opportunities (development plans) for its employees.

Individual Development Plans (IDPs) are needed to help employees develop their skills, further their organization's mission, and achieve their career goals. IDPs are an excellent tool that supervisors can use to develop and motivate their staff. By encouraging a focused approach to each individual's training/developmental needs, managers can help their employees enhance their job skills and become more effective and productive. Managers who promote the use of IDPs also send a clear message to their charges that they view each person's professional development as a priority. Single-point vulnerabilities are identified and addressed resulting in reduced risk to mission execution while supporting employee opportunities.

Indicators

- Management looks to the progression to help promote their staff
- Employees are promoted within, versus leaving the site for new opportunities
- Single-point vulnerabilities are managed through development pipelines
- Completed management/supervisor training.

Strategic Initiative

Develop salary structures that align with the external market and have atypical design.

Recruiting and retaining key resources for ATR and INL's workforce require competitive pay. Paying competitively requires market comparisons and applicable pay practices. The goal in reviewing the job classification system is to ensure INL's ability to pay competitively and to meet both contractual and regulatory requirements. An updated and improved classification system will more consistently group employees and more accurately compare their salaries to available market rates.

Indicators

- Decreased employee turnover due to competitive salaries elsewhere.

Strategic Initiative

Improve the staffing pipeline for the Operations Division.

ATR Operations has historically experienced a chronic minimum staffing posture. This posture leads to limitations with staffing development opportunities, stressful work environment, and high staff turnover.

Improving the staffing pipeline would include activities like developing workforce plans, improve human resources strategies and approaches, and adjust organizational models—all of which will help to improve the effectiveness of facility operations.

Indicators

- Improved staffing pipeline for the Operations division
- Developed nuclear training academy
- Enhanced bonus structure.

Strategic Initiative

Modernize the ATR Operator training program.

ATR will need to develop an online learning program for Nuclear Operator Training. Due to the length of classroom training and the limited

The new ATR security building nears completion in the foreground, with the new ATR Maintenance Support Building in the background.

training resources at ATR, the Training department can only support one 6-month Nuclear Operator Fundamental school and one 3-month Reactor Operator school per year. Development of an online learning program for nuclear operators would allow the hiring of new operators into the program throughout the year and begin training as soon as they arrive at the ATR. This will eliminate having to wait until the annual school start dates to begin the course work (as currently designed).

Indicators

- Obtained 2-year project funding to support the hiring of 2-3 FTEs for the development of the online learning program
- Completed analysis of the Nuclear Operator Fundamental school and the Reactor Operator school curricula to determine which course can be converted to online learning
- Developed the selected courses into online learning courses.

Strategic Initiative

Continue Path to Excellence initiatives started in FY19.

The initiatives are outlined in ATR's Path to Excellence Plan (PLN-5876) and Human Performance Improvement Plan for the Advanced Test Reactor (PLN-5817). ATR will continue implementation of Intent Based Leadership (IBL). Human performance improvement (HPI) will continue to expand and include having ATR's HPI lead practitioner focus on training and development of dynamic learning activities. Failing safely and building a capacity for resilience is an emerging area at ATR Complex and is closely coordinated with the Lab wide roll-out. Improving communications across the workforce will continue to bring visibility to a focused set of tools called the ATR Core 4.

Indicators

- Completed actions from ATR's Path to Excellence Plan and the Human Performance Improvement (HPI) Plan.

ATR's Expanded Use of IBL Concepts.

The ATR workforce has largely read, understands, and adopted many of the concepts taken from the IBL model.

Using multiple techniques, ATR rolled out the IBL concepts and allowed the workforce to provide feedback on which concepts would be most beneficial if adopted at the ATR Complex. This roll out was performed through multiple working groups composed of an intentional mix of new and senior ATR employees. This involvement fostered ownership in the ATR workforce.

The ATR workforce has demonstrated through measurable performance metrics that the concepts have made step improvements in execution of work and event reduction. IBL simply rolls decisions to where the knowledge resides, allowing our workforce to expand their input, role, and accountability in assigned tasks versus being bound to restrictive oversight and process.

Indicators

- ATR continues to provide professional training on IBL concepts
- ATR has incorporated IBL concepts into video examples of "what good looks like."

OBJECTIVE

2

Steadily Increase ATR's Irradiation Days

ATR must provide predictable and reliable days of irradiation in support of customer experiment objectives.

The optimum number of irradiation days for ATR is a balance between the irradiation needs of the ATR user community and accommodating maintenance and experiment handling. The current primary driver of outage length is the corrective maintenance on plant and experiment equipment that is operating past its design life. The goal is to steadily increase operating days while performing the maintenance deemed necessary to support long-term operation of the facility (e.g., Plant Health Program (PHP) and overall Life Cycle and Aging Management Programs under development to support strategy for aging and obsolete equipment replacement).

Strategic Initiative

Implement the ATR PHP Improvement Strategy based on the highest priority plant health issues.

ATR has a list of plant health improvement activities that were developed utilizing a formal assessment process. The process determines the risk category (e.g., Low, Medium, or High) a certain component or system poses to operational reliability or how they affect mission sustainability. This assessment process also assigns a risk score to every identified equipment issue. The scores are captured in the LTAM database in ER Suite. ATR then objectively prioritizes the equipment or systems that require repairs, refurbishment, or replacement based on the risk category and risk score of each activity. The priority activities are populated in the yearly revision of the ATR PHP Improvement Strategy.

Indicators

- Executed and completed planned plant health activities within scope, schedule, and cost
- Continued reduction of plant health risk and deferred maintenance
- Increased annual days of achieved irradiation
- Continued support of sponsors toward the investment in plant health.

Strategic Initiative

Optimize ATR cycle designs to improve efficiencies and utilize 3D neutronics modeling to reduce ATRC impact on the Core Safety Assurance Package development schedule.

During the past 2 years, the transition to HELIOS physics modeling has been completed. The Core Safety Assurance Package (CSAP) development process was thoroughly reviewed, and improvements have been made. Except for cycles involving significant changes in the experiment loading or operating parameters late in the CSAP development process, the CSAP has been issued a week or more ahead of ATR pressurization during startup. This is well ahead of critical path.

After further review, it was determined that extended cycle lengths provide limited value. There is only a small net increase in irradiation days per year and a negative impact on fuel utilization.

However, combining the two planned high-powered axial locator mechanism (PALM) cycles each year into a back-to-back sequence using the same fuel load has the potential to significantly increase the irradiation days per year. Cycle design studies and experiment handling to support back-to-back PALM cycles will be completed in time to implement following the next CIC.

The 3D neutronics modeling code MC21 has become available for ATR to use in collaboration with Naval Nuclear Laboratory. This 3D neutronics capability has the potential to reduce a significant amount of new experiment testing in the ATRC currently specified by the CSAP development process. Verification and validation of MC21 for ATRC application was completed in 2020 to allow the removal of ATRC testing from the critical path for test insertion in the ATR. There will still be some ATRC testing of individual experiments, but these will be confirmatory in nature and not tied to reactor insertion.

ATR fuel utilization will be evaluated for efficiency improvements. A fuel utilization technique needs to be developed that ensures the optimum balance of new and recycled fuel is achieved for each operating cycle.

The CSAP development process is complex due to the multiple inputs required from outside organizations. This process, repeated every operating cycle, requires these inputs on a set schedule that is tied to the date for reactor startup. The typical duration for development of the CSAP is 8 to 12 weeks. When any one input is not delivered on time, or requires rework when an error is discovered, then the CSAP is at risk for not completing on time.

Indicators

- Improved balancing of using new fuel with recycled fuel by developing a new model for fuel selection and utilization to optimize fuel consumption
- Incorporation of back-to-back PALM cycles using a single fuel loading into the ATR ISOP
- Issuance of verification and validation Engineering Calculations and Analysis Reports demonstrating MC21 results as a viable replacement to ATRC results for new experiments.

Strategic Initiative

Improve outage performance by focusing on four key drivers: Experiment Needs, Preventive Maintenance, Corrective Maintenance/Backlog, and Projects.

Outage preparation will be improved by focusing on the experiment needs, which is the CSAP and Experiment Safety Assurance Package (ESAP) processes. This will ensure timely completion of the required paperwork needed for every startup. We also need to ensure the CSAPs and ESAPs are analyzed to run for several days longer than the ISOP run time. This will allow ATR to run longer if startup can occur early.

Outage preparation will also be improved by utilizing the ATR PHP and Operations input when selecting preventive maintenance and corrective maintenance scope. If we fix the right equipment, we should be able to startup on time and complete an entire run.

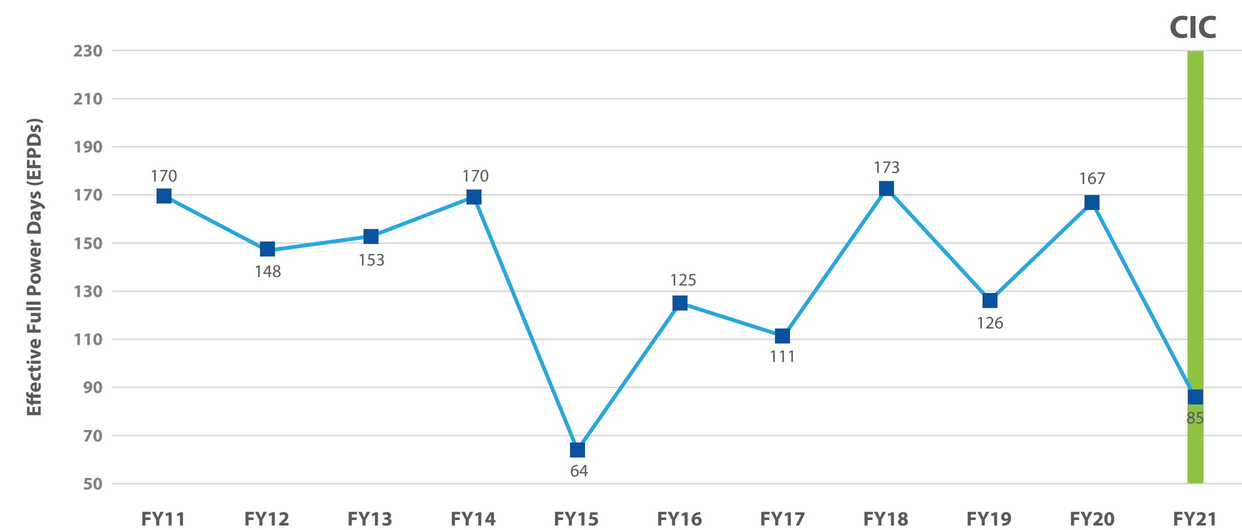
Outage execution will improve as we move toward a more flexible scheduling process that can more easily accommodate project scope and resource changes. This should result in more predictable startups and reduce our reliance on overtime.

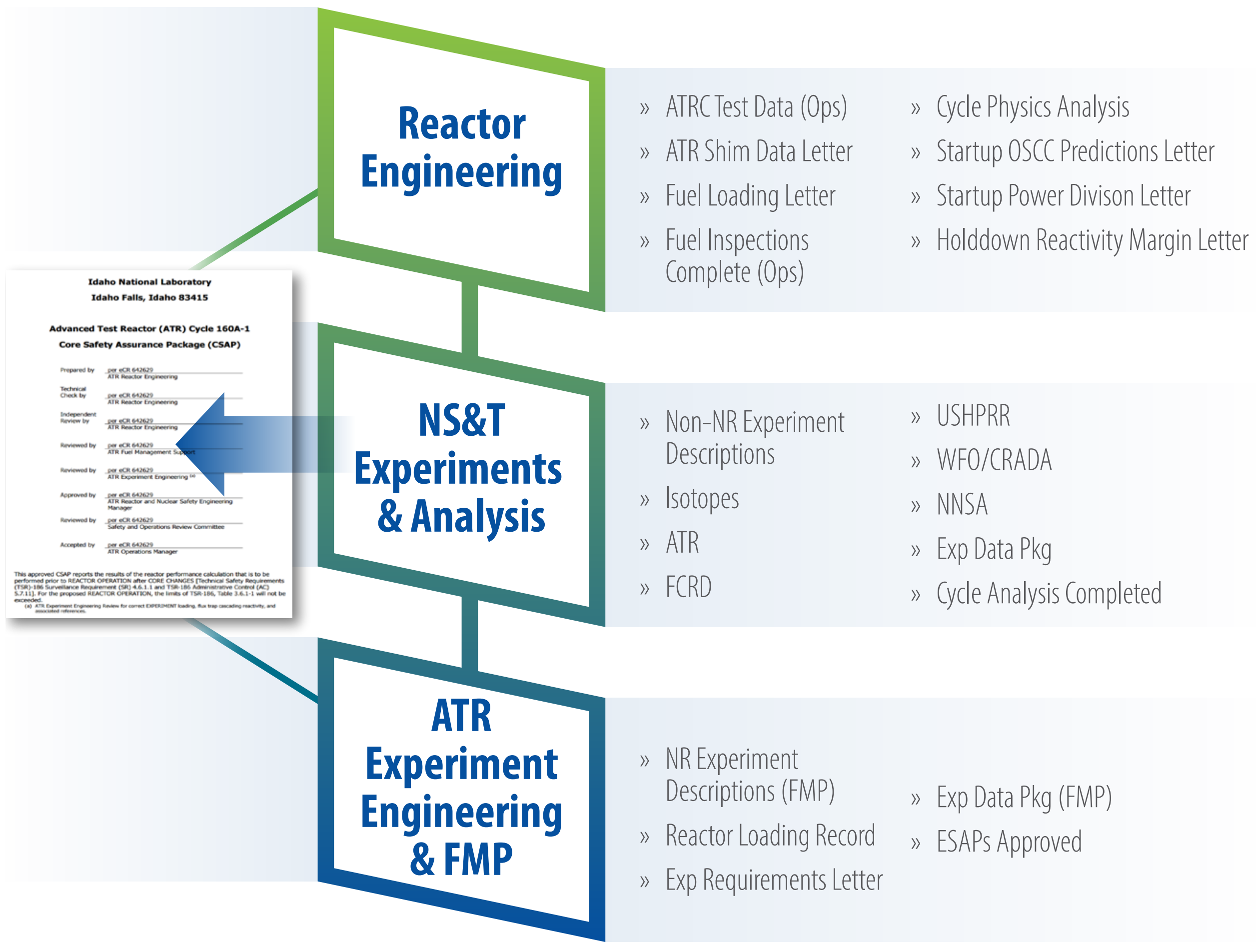
As we work toward continuous outage improvements, focus will be on some other areas such as: more stringent scheduling process, early scope freeze, major activity review board, resource loading, hiring project resources, integrating detailed project schedules into the outage schedule, researching software solutions to give real time status of work, and managing backlog.

Indicators

- Achieved startups on or before approved ISOP dates
- Increased irradiation days above ISOP goals
- Optimized utilization of workforce.

ATR Operating Day Tempo





OBJECTIVE 3

Reduce Time and Cost to Perform Work at ATR

ATR must continually challenge and streamline the processes and procedures to improve work efficiency.

An underpinning of long-term success is "value." ATR's customers must perceive both the cost of business at ATR and the timeframe associated with experiment irradiations to be of value to their programs. The balance between time and cost is often different for individual customers, so ATR must be cognizant of that balance and tailor the services provided, where possible and appropriate. ATR must challenge processes that lead to inefficiencies. Process improvements will assist ATR to maximize its value and be a cost-effective resource for the nation.

Strategic Initiative

Improve experiment flow through ATR and improve the level of understanding with the experiment customers.

Experiment Engineering is a key organization for understanding the requirements of the experiment customers and the concerns that those customers may have about completing work at ATR. The Experiment Engineering group will analyze the suite of concerns to communicate appropriate expectations of performance where misunderstandings exist and endeavor to address and fix real issues and inefficiencies where noted. ATR representatives will continue to stay engaged and support an ongoing INL-level initiative to improve the entire experiment life-cycle process. ATR efforts for 2020 focused on ensuring that Experiment Safety Analysis (ESA) requirements are identified during the conceptual design phase and identifying potential Safety Analysis Report (SAR) revisions to clarify requirements for experiment insertion in the ATR.

Indicators

- Executed and completed experiment deliverables (Reactor Loading Records, ESAs, Travelers, Operating Letters) on schedule.
- Completed process improvement of delivering experiment ESA requirements to design team at conceptual design phase. Currently a letter is issued from the ESA author to the Experiment Manager (EM). Instead of the letter, change the process defined in the EM guide to require the ESA author to input the requirements directly into the Functional and Operational Requirements (F&OR) method of experiments documenting ESA requirements, how compliance to each requirement will be met, and indication of which requirements need to be included in the F&OR.
- Issue PLN-6134, "Advanced Test Reactor Safety Analysis and Experiment Process Strategy Plan," that captures the strategy for ATR safety basis and process changes for improving the experiment design and analysis process. The strategy segments the improvements into achievable goals.

- Reduced amount of time required and cost to produce experiment deliverables each cycle.
- Reduced rework of experiment deliverables.
- Achieved an environment where ATR Programs and its experiment customers work as a seamless team toward irradiation objectives.
- A revised ISOP after each cycle completion as appropriate.

Strategic Initiative

Develop and support one or more standardized experiment designs as an option to customers that will reduce the design, safety analysis evaluations, and fabrication effort (i.e., standard lead-out design, standard material capsule design, etc.).

A standard lead-out or capsule design would provide flexibility to accommodate multiple customers with minimal cost. Utilizing a standard design would eliminate the need to perform a unique design for each customer. Rather, each customer would be provided a standard test rig design and would be asked to design their test coupon such that it would work with a standardized test rig. If the customer requirements prevent utilization of a standard test rig, then a more expensive option of a unique design would be available. The benefit of utilizing a standard test rig is that a bounding analysis would be provided with the test rig.

The ESA and fabrication cost would be lower. Ultimately, the time and cost from initial customer contact to delivery of post-irradiation examination (PIE) data would be reduced.

Indicators

- Eliminate requirement to complete Air Permitting Applicability Determinations on experiments prior to inserting into the reactor
- Completed National Environmental Policy Act (NEPA) review for series experiments and addenda, as needed, thus streamlining NEPA review process
- Collaboration with other organizations (i.e., S&T, FMP, and French Atomic Energy Commission [CEA]) and research reactors (i.e., High Flux Isotope Reactor [HFIR], Belgian Reactor 2 [BR2]) to develop enhanced experiment capabilities at the ATR.

Strategic Initiative

Revise the ATR Safety Basis to include bounding analysis for experiments, which will reduce repetition of similar analysis in support of ESAs and simplify the experiment evaluations.

Ensure appropriate requirements are clear and concise for ESA compliance. Eliminate unintended implied or process-oriented requirements.

Indicators

- Established bounding experiment accident sequences, analyses, and acceptance limits independent of SAR-153, Chapter 15 accidents and limits
- Established guidance for systems and functions relied on in the ESA
- Reestablished specific accident scenarios to be addressed in the ESA (e.g., loss-of-flow accidents, reactivity-initiated accidents, loss-of-coolant accidents)
- Reconstituted basis for departure from nucleate boiling ratio limit (greater than or equal to 2.0) with a consideration of a revised limit
- Resolved experiment-related unreviewed safety questions.

Strategic Initiative

Continuous monitoring and review of ATR work control process efficiency.

The ATR Maintenance Work Control Process requires continuous monitoring for efficiency improvement opportunities. The process will be evaluated against industry best standards and closely monitored with comprehensive Key Performance Indicators (KPIs) for sought improvements. Work control efficiencies are key to ATR Outage Planning and Execution, having a significant impact on overall ATR and INL Mission success.

ATR needs to continue its leadership role in the immediate term reduction of process inefficiencies. ATR can ensure its position through collaboration, and will continue to seek industry leading efficiency and performance improvement opportunities from other INL mission centers as well as external organizations including the American Nuclear Society (ANS), Institute of Nuclear Power Operations (INPO) and the DOE/NNSA Maintenance Managers Working Group (MMWG). ATR Maintenance personnel currently hold key leadership positions in the DOE/NNSA MMWG.

ATR work control is fully integrated with the INL Management System Transformation Initiative (MSTI) initiatives and constantly seeks and challenges any internal restrictive processes. ATR has led efforts and will continue to participate in INL wide initiatives maximizing the efficient utilization of available maintenance resources. The improvement in these key areas will be monitored by the Maintenance KPIs.

ATR leadership in conjunction with the other INL mission centers have developed and implemented a Maintenance Resource sharing initiative. The Plan includes the obtaining, qualification, and utilization of a resource pool, home organizationally located in the INL Facilities and Site Services (F&SS) Division. Mission centers, including ATR, will be capable of drawing from that resource pool during peak execution periods. ATR Maintenance personnel hold key leadership positions on the INL Maintenance Resource Sharing Initiative Team. ATR needs to challenge this process and take full advantage of INL wide resources improving execution.

Indicators

- Utilization of pool resources to increase efficiency and maintain ATR critical path outage schedules. Monitored by the KPIs
- Maintenance excellence (IBL) as demonstrated by KPIs
- Low threshold acceptance for in-process work order changes demonstrated by KPIs
- Low threshold acceptance of Maintenance re-work as demonstrated by the KPIs
- Continued monitoring and improvement in Preventive Maintenance (PM) issuing process allowing more effective long-term planning and scheduling, as demonstrated by the KPIs
- Work control process efficiencies gained from industry benchmarking, as demonstrated by the KPIs
- Authority being pushed to knowledge level first line supervision (IBL)
- Utilization of maintenance craft and supervision resources 7 days per week; on RED/GREEN and BLUE/GOLD overlapping crews during the CIC Outage.

Strategic Initiative

As a learning organization, ATR will track human performance events to enable continuous improvement and continue direct interactions with HFIR to discuss common issues and challenges, share lessons learned, and use equivalent measures of performance.

ATR's goal is excellence in performance as demonstrated by a reduction in events. ATR has revised GDE-546, "ATR Programs Human Performance Event Classification Guide," to correct recognized gaps in the metric. This initiative focuses on improving as a learning organization.

Indicators

- Completed actions from ATR's Path to Excellence Plan and the Human Performance Improvement Plan
- Regular interactions with HFIR or similar facilities.

OBJECTIVE 4

Enhance ATR's Experiment Capabilities

ATR must be responsive in providing the customer-driven new capabilities to support the research and development missions.

ATR and its supporting infrastructure have been reconfigured and enhanced many times to meet the irradiation needs of its customers. Over the years, the core has contained up to nine experiment loops and as few as five. Loops have then been reinstalled at the appropriate time to support current and projected research mission objectives. A dry transfer cubicle was configured to support sizing experiments in a dry environment and shipment for post-irradiation examination. Finally, a Test Train Assembly Facility was built to support the Science and Technology customers' experiment fabrication. These are just a few of the changes to ATR's experiment capabilities over the years, with each change providing a different irradiation or support capability and being driven by the customers' requirements. There is a high level of interest in expanding or providing new irradiation capabilities. At NR's request, ATR evaluated the possibility to increase the maximum lobe power from 60 to 70 MW to achieve more effective PALM testing. Scoping calculations determined it is feasible with some plant modifications. A project has been established for the modifications, analyses, and SAR revision. Implementation is expected to complete in early 2024. Although not directly related, there is also interest in the addition of another loop (to increase the total of seven available loops) that is also being reviewed as part of the Loop Recapitalization effort under ATR Plant Health. Additionally, with the closure of the Halden reactor, the Accident Tolerant Fuels Program has begun initial concept discussions with ATR to add an "I" position configuration that would enable some experiments supporting Accident Tolerant Fuels work. Concepts presented to date would add an IPT in an I position and loop support equipment in a shielded cubicle. The new top head closure plate to be installed during CIC will facilitate the installation of the new IPT in a future outage. ATR must continually be working closely with customers to understand their capability requirements, the timing of those requirements, and the feasibility to support the requirements. Enhancing ATR capabilities also must include extending ATR capabilities through collaboration with other laboratories and universities. This is also an area where ATR can grow its own research program with published outcomes, similar but minor in comparison to the NS&T programs, perhaps focused on areas such as redesign of ATR equipment, new capabilities, or new analyses.

Strategic Initiative

Use the ATR Users Working Group as a vehicle to understand the capability requirements and desires of new users, the existing user community, and plan accordingly.

Through the Users Working Group, ATR has a defined and well-supported process that has been in place for about 11 years. This process has proven effective at bringing the stakeholders together to understand the views, desires, and requirements of each, including the integration of maintenance requirements with irradiation objectives. The process has been used effectively to plan the ISOP for scheduling the reactor's irradiation and outage periods on an annual and notional out-year basis, determining power levels in the reactor, prioritizing experiment positions, and resolving the many experiment conflicts that arise across all fronts. The Users Working Group is the primary vehicle to address near-term planning and long-term objectives.

Indicators

- Coordinated and timely out-year capability planning between the Science and Technology programs and ATR that is appropriately reflected in notional out-year ISOPs
- Delivered new capabilities integrated with the objectives of the research customer
- Integrate ATR Business Case outcomes supporting NRIC, NSUF, and GAIN that are used to identify areas for expanding irradiation and analysis capabilities at ATR.

Strategic Initiative

Develop a strategy for better customer utilization of the ATRC, Gamma Tube, and outer irradiation facilities for experimentation.

The ATRC, Gamma Tube, and outer irradiation facilities are not heavily subscribed by experiment customers, resulting in excess irradiation capacity and capabilities in these areas. Further evaluation should be performed to determine the interest and desirability of these capabilities. Also, ascertain why these capabilities are underutilized, looking at factors such as whether the capabilities are well understood and recognized or if the capabilities no longer fit the requirements of the experiment customers.

Indicators

- Developed strategy determining customer interest in the ATRC, Gamma Tube, and outer irradiation facilities, and a level of customer interest is gauged.

Strategic Initiative

Continue supporting the "I-Loop" Project.

The unanticipated shutdown of the Halden Boiling Water Reactor in 2018 suddenly deprived the western world of an irradiation testing facility that had provided the U.S. commercial power industry with a unique set of experimental capabilities used for qualifying new fuels and addressing questions from regulators concerning issues with current fuels. At the time of the shutdown, the DOE-sponsored Accident Tolerant Fuels (ATF) program had plans to make use of Halden for testing needed to qualify commercial ATF technologies in the coming decade. At the direction of DOE-NE, an international workshop was held to assess the fuel testing gaps created by the loss of Halden, which was documented in an INL report (INL/EXT-18-46101). The report also included recommendations on how the most critical gaps might be addressed, one of which was the installation of one or more pressurized water loops in I-positions of the ATR, positions that typically see flux levels very similar to the Halden test positions. I-Loops would establish the ability to irradiate Light Water Reactor (LWR) fuel rods under prototypic PWR and Boiling Water Reactor (BWR) conditions, perform ramp and end-of-life testing, and readily accommodate fuel failures that commonly result under these scenarios.

ATR organizations continue to support the "I-Loop" project, sponsored and funded by the Deputy Assistant Secretary for Nuclear Fuel Cycle and Supply Chain, NE-4, through the NS&T Directorate, Nuclear Fuels and Material organization. The project is progressing in phases, with a replacement of the ATR reactor vessel Top Head Closure

Plate (THCP) during the CIC outage being the first phase. The second phase will include the fabrication, installation, and commissioning of the actual loop during the planned long outage starting in January 2023.

Indicators

- An experiment engineer assigned to support project objectives
- Updated Safety Basis to reflect future irradiation capabilities.

Strategic Initiative

Propose laboratory-directed research and development projects that would support enhanced experiment capabilities.

The INL Laboratory-Directed Research And Development (LDRD) program provides an additional possible funding source for the development of new experiment capabilities, new or improved experiment instrumentation, and the development of new or expanded PIE capabilities in the canal.

ATR management will continue efforts to increase staff engagement to develop projects that align with ATR's focus areas for LDRD projects. Combining LDRD projects with Associate Laboratory Director funding will enhance ATR experiment capabilities.

These new/enhanced capabilities will move ATR closer to becoming the national and international materials and fuels irradiation testing facility of choice by providing unique irradiation capabilities for nuclear technology research and developments.

Indicators

- Through collaboration, develop prioritized and funded ATR-specific LDRD projects
- Through collaboration with NS&T, French CEA, and others, develop plans to improve experiment instrumentation
- Completed feasibility study to identify capabilities that would support customer needs.

Strategic Initiative

Communicate ATR capabilities to potential customers.

The capabilities that ATR offers must be effectively and consistently communicated to potential customers whether locally, nationally, or internationally.

To date, this communication is often sporadic and one-off rather than consistent. In addition, over time, it has not been clear who has or should have the responsibility to market ATR capabilities. For this reason, ATR is developing a User's Guide to communicate capabilities to potential customers.

Indicators

- Increased utilization across all core positions
- ATR User's Guide issued.

Strategic Initiative

Continue support of ATR Strategic Thermal Irradiation Capabilities and Federal direction on next steps.

DOE-NE/NR responded (December 2020) to the submittal of the Business Case deliverable (July 2020) with direction to develop DOE Order 413.3B Critical Decision (CD) -0 content and submit high-tier CD-1 schedule and resource needs to support a potential project. The DOE-NE/NR request for a business case was to consider two options for meeting the irradiation testing mission through 2085.

The INL/NNL recommendation outlined in the business case was to pursue a replacement reactor while simultaneously maintaining ATR to at least 2040. Inclusion of a NNL hot cell project (Irradiations Infrastructure Recapitalization (IIR)) was also directed to be included in evaluation and cost estimates provided in the potential CD-0 Mission Need Statement outline and CD-1 development cost and schedule profiles.

ATR will continue to support the INL/NNL collaboration and development of the content for the respective critical decision information as requested and funded by DOE. The G910 organization will also continue their support to the PHP project development and execution activities that will sustain ATR well into the future.

ATR's Gamma Spectroscopy detection system.

ACRONYMS

ANS	American Nuclear Society
ATF	Accident Tolerant Fuels
ATR	Advanced Test Reactor
ATRC	Advanced Test Reactor Critical Facility
BEA	Battelle Energy Alliance, LLC
BR2	Belgian Reactor 2
CD	Critical Decision
CEA	French Atomic Energy Commission
CIC	core internals change-out
CRADA	Cooperative Research and Development Agreements
CSAP	core safety assurance package
DOE	Department of Energy
EM	Experiment Manager
ESA	experiment safety analysis
ESAP	experiment safety assurance package
F&OR	Functional and Operational Requirements
F&SS	Facilities and Site Services
FMP	Fluor Marine Propulsion, LLC
FY	fiscal year
GAIN	Gateway for Accelerated Innovation in Nuclear
HFIR	High-Flux Isotope Reactor
HPI	Human Performance Improvement
IBL	Intent Based Leadership
IDP	Individual Development Plan
IIR	Irradiations Infrastructure Recapitalization
INL	Idaho National Laboratory
INPO	Institute of Nuclear Power Operations
IPT	inpile tube
ISOP	Integrated Strategic Operational Plan
KPI	key performance indicators
LCO	Limiting Conditions for Operation
LDRD	Laboratory-Directed Research and Development
LTAM	Long-Term Asset Management
MFC	Materials and Fuels Complex
MMWG	Maintenance Managers Working Group
MSTI	Management System Transformation Initiative
NE	Department of Energy Office of Nuclear Energy
NEPA	National Environmental Policy Act
NFCSC	Nuclear Fuel Cycle and Supply Chain
NR	Department of Energy Office of Naval Reactors
NRF	Naval Reactors Facility
NRIC	National Reactor Innovation Center
NS&T	Nuclear Science and Technology
NSUF	Nuclear Science User Facilities
OSCC	outer shim control cylinders
PALM	Powered Axial Locator Mechanism
PHP	ATR Plant Health Program
PIE	post-irradiation examination
PM	Preventive Maintenance
PWR	Pressurized Water Reactor
SAR	Safety Analysis Report
SMR	Small Modular Reactor
SNF	spent nuclear fuel
SSCs	Structures, Systems and Components
STIC	Strategic Thermal Irradiation Capabilities
THCP	Top Head Closure Plate
USHPRR	United States High Performance Research Reactor
VTR	Versatile Test Reactor

The high-bay of the new ATR Maintenance Support Building, awaiting the installation of equipment.

Idaho National Laboratory

21-50232-R0