U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Clean. Reliable. Nuclear.

DOE Microreactor Program

Microreactor Applications Research, Validation & EvaLuation (MARVEL) Project

GAIN-NEI-EPRI Microreactor Workshop

August 18th, 2020

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Microreactor Technical Lead

Nuclear Science and Technology (NS&T) Directorate, Idaho National Laboratory

Project Objectives

- **Demonstrate** Integration and control of microreactor with applications in a prototypic nuclear environment
- **Engage industry stakeholders** and potential end-users to demonstrate use of nuclear energy sources for non-traditional applications.
- **12-24 months rapid deployment** of a single, small nuclear microreactor test platform for evaluating and validating unique operational aspects and end-user applications
- **Streamline national lab capabilities** for development, authorization, operation and demonstration of advanced reactor concepts at a DOE site

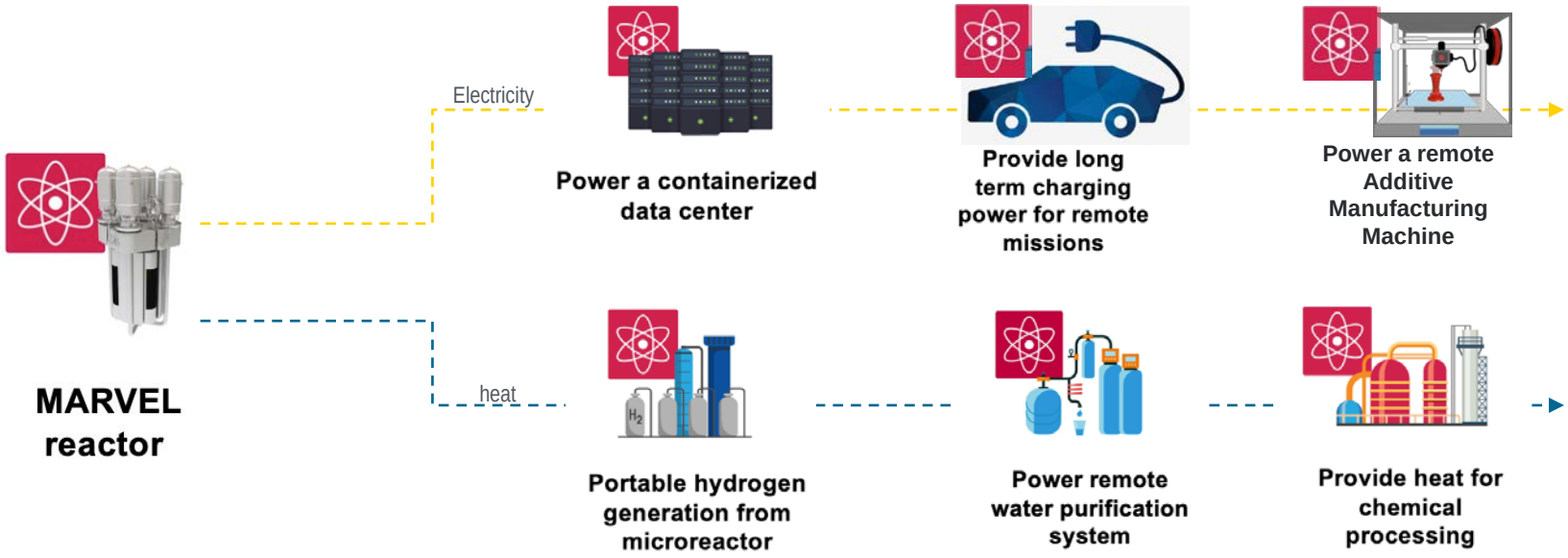
Program Alignment

- **Alignment with DOE Microreactor Program Objectives**
  - The nuclear microreactor applications test bed extends capabilities beyond those of the non-nuclear test bed (MAGNET) to provide a nuclear test platform that includes a full physics system representing actual operational features of a microreactor.
  - MARVEL can aid in demonstrations of key technologies to enable autonomous operation, remote monitoring and cyber-physical security.

- **Alignment with NRIC Program Objectives**
  - Provide NRIC with the experience base to support advanced reactor demonstration within a short period of time and reduce risks to successfully enable emerging demonstrations of industry advanced reactor technologies at national lab sites
  - Specific areas where readiness is enhanced by the project include exercising NEPA evaluations, operator readiness and training protocols, safety basis development, engineering, design and assembly workspace

Microreactor Applications R&D

- Envisioned end-users are those with applications of interest to connect to a reactor for testing and ultimate deployment
- End-users of the test best are being sought out and we encouraged to engage with the project
- Examples:



Show the world the U.S. leads nuclear innovation

Resources Needed for MARVEL Project

- Resources: The reactor portion of the project will conclude in 2022 and does not leverage nor compete with resources planned for DOE cost-shared advanced reactor demonstration projects
- Materials: Project will use less than 30 kg of high-assay uranium from available research materials at INL
- Site: Project does not utilize sites being considered for future industry reactor demonstrations. Due to the small footprint of this project, it can be accommodated in the TREAT storage pit, which is too small to accommodate commercial microreactor demonstrations
- Funding: Project will be accomplished under existing Microreactor Program and NRIC scope and R&D funding and is a very low-cost reactor

These resources do not compete with those needed for Private-sector demonstrations

Key Benefits of MARVEL Project

Benefits to Industry: Allows developers to implement microreactor technologies to integrate to end user applications for optimal operation (e.g. autonomous operation and remote monitoring)

Benefits to Universities and Education: Engage university researchers and students to perform research in the development of the test bed and its use

Benefits to DOE: Reinforces the U.S. leadership in nuclear Innovation compared to other competing nations (e.g. China, Russia, etc.)

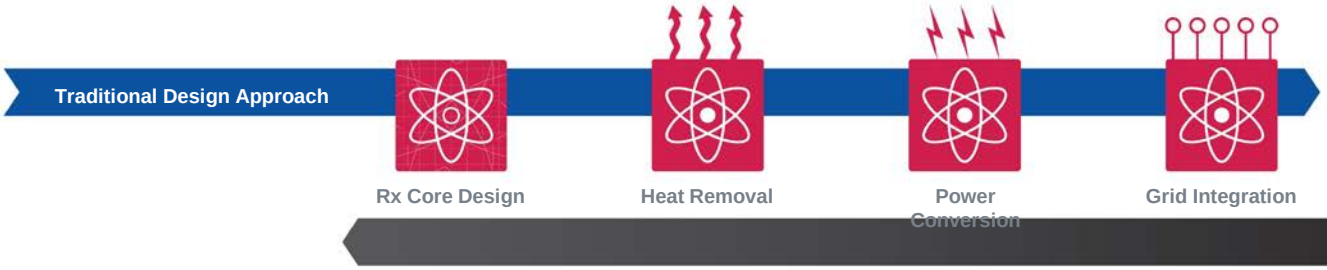
Benefit to End-users: Engage end users to drive technology adoption, policy and climate change goals

Project Approach

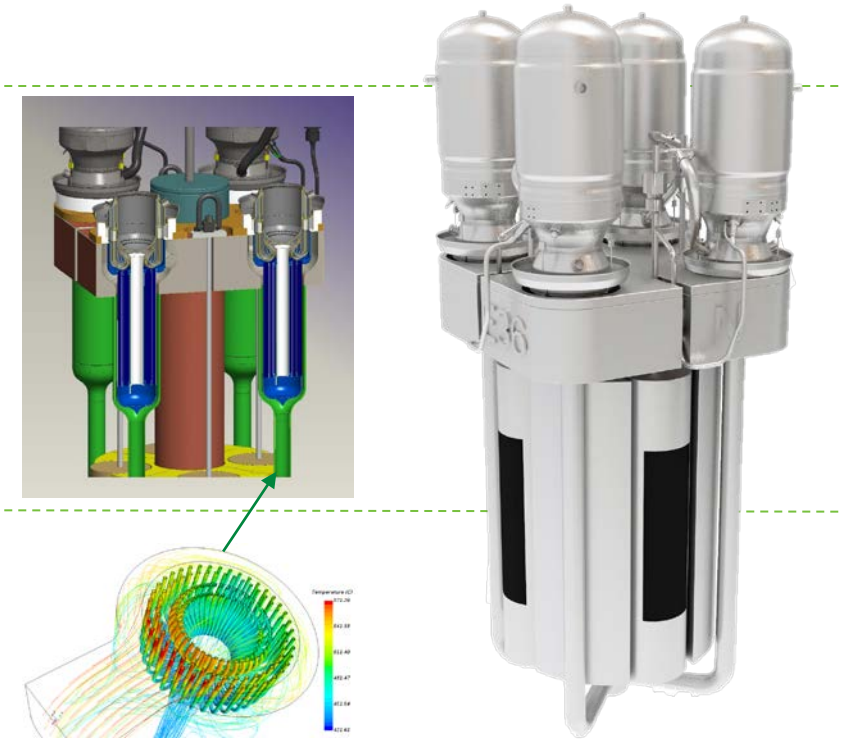
Requirements:

1. Produces electricity
2. Build to demonstrate in 24 months (aspirational 16 months)

Design Process:

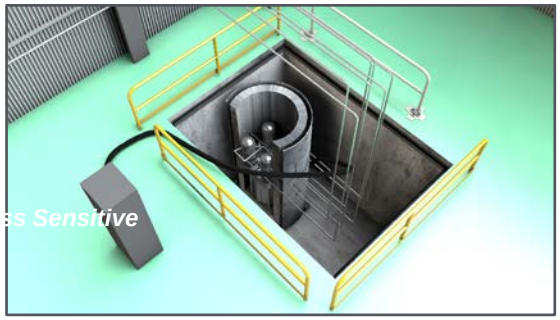


MARVEL Systems Design



- 100 kWth, 20 kWe, two-years core life
- UZrH1.7 fuel, 36 fuels pins
- Liquid sodium primary coolant
- Four Stirling engines @ 500-550 C inlet T
- Air is ultimate heat sink for primary and decay heat removal
- Two Diverse Reactor Control System
  i. Four independent, vertical control drums
  ii. Central shutdown rod

Site: TREAT Storage Pit (8'x12'x10') and TREAT control room



Reactor in TREAT storage pit

Control Room

Diverse Team

Program Leadership
MRP- Jess Gehin
NRIC- Ashley Finan

INL Leadership
NS&T- John Wagner
MFC- Ron Crone

DOE-ID Leadership
Robert Boston
Jihad Aljayoushi

DOE-NE Lead
Tom Sowinski

DOE-ID POCs
Garrett Kropp
Jason Sturm
Charlie Maggart

Project Leadership
Yasir Arafat
Steven Martinson
Kala Majeti

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J.R. Biggs
Blair Grover
Adrian Wagner
Doug Gerstner
Jim Parry
Jason Andrus
Travis Lange
James Sterbentz
Anthony Crawford
Brice Quirl
Carlo Parisi
Jim O'Brien
Rhett Rovig
Andreas Scheibe

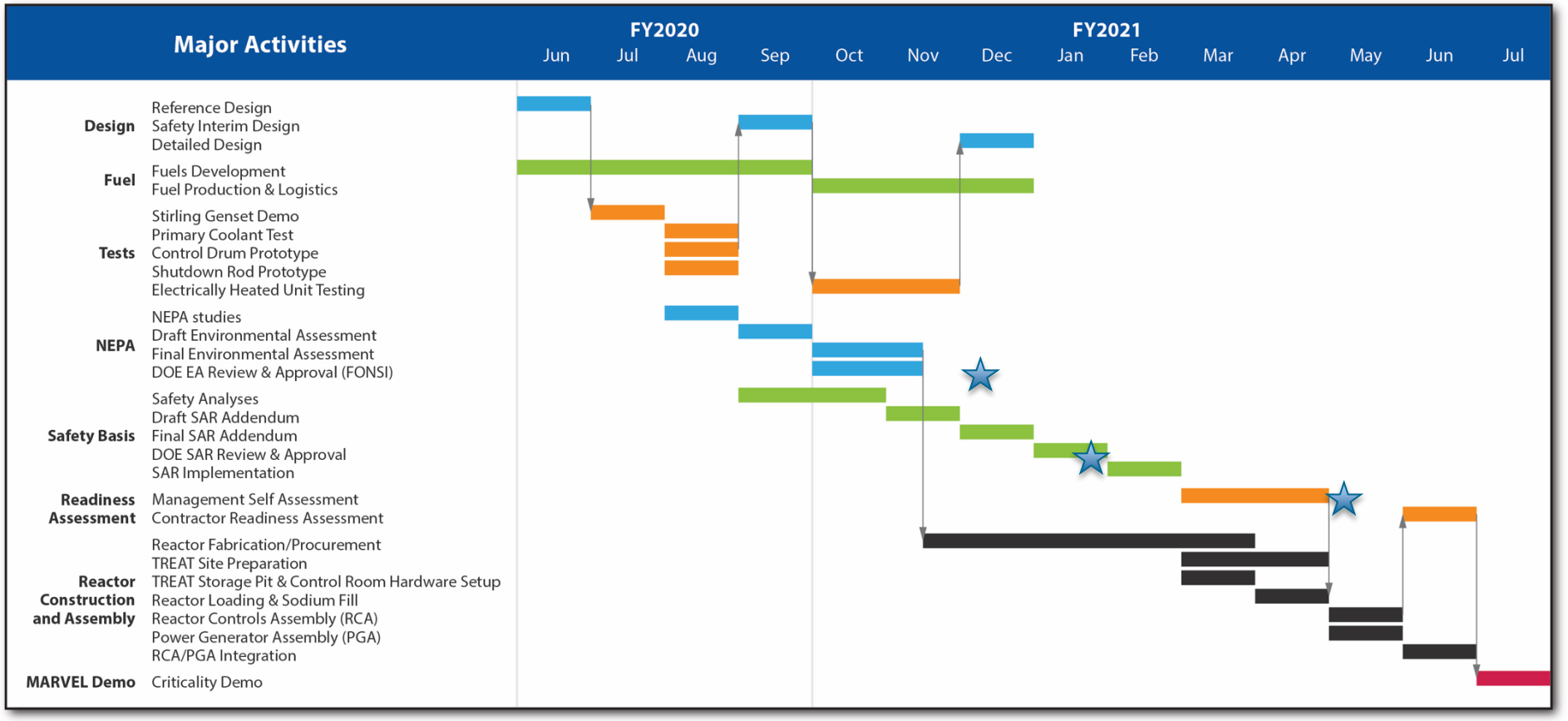
LANL
D.V. Rao
Holly Trellue
Eric P. Luther
John Carpenter
Adi Shivprasad
Jun Kim
Patrick McClure
Lindsay O'Brien
Kayla Molnar
Robin Pacheco

ANL
Christopher Grandy
Derek Kultgen

Management Support
Youssef Ballout
Doug Crawford
Stuart Jensen
Robert Miklos

MFC Support
Doug Crawford
Tom Pfeiffer
Raymond Clark
Derek Sommers
Mike Fish
Brett Horsburgh
Dan Vetter
E&HS
Safety Analyses

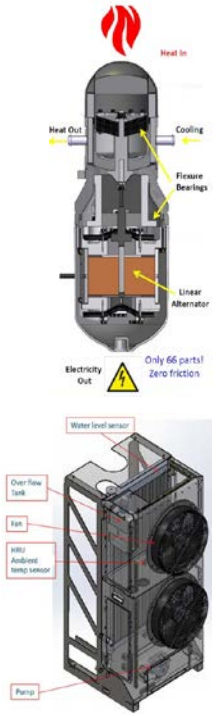
MARVEL Project Timeline (Preliminary)



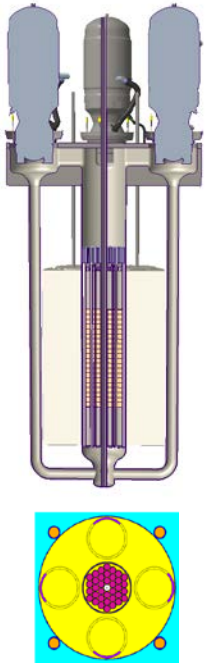
Baseline Schedule Under Preparation

Current Activities: Full-scale Separate Effects Tests

Power Conversion Test

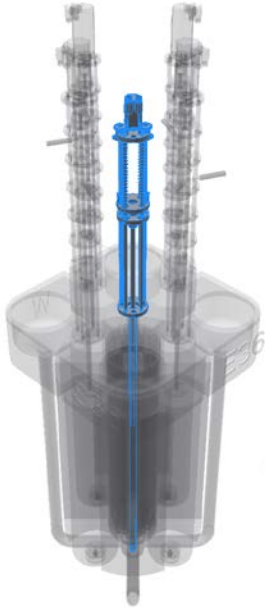


Primary Coolant Test

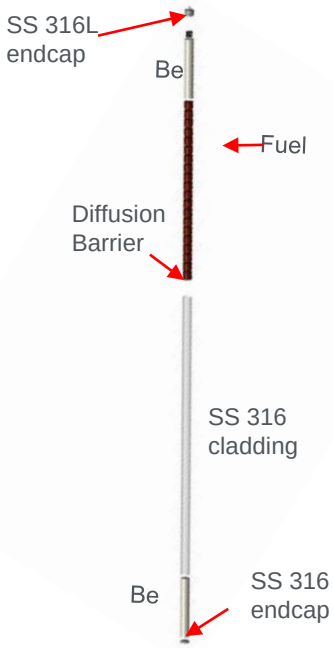


Control Drum Prototype

Shutdown Rod Prototype



Fuel Pin Prototype



We are currently seeking **end-users** to partner for demonstrations with MARVEL

Contact Information

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Backup Slides for Q/A

FY 20 Key Milestones

DOE Microreactor Program

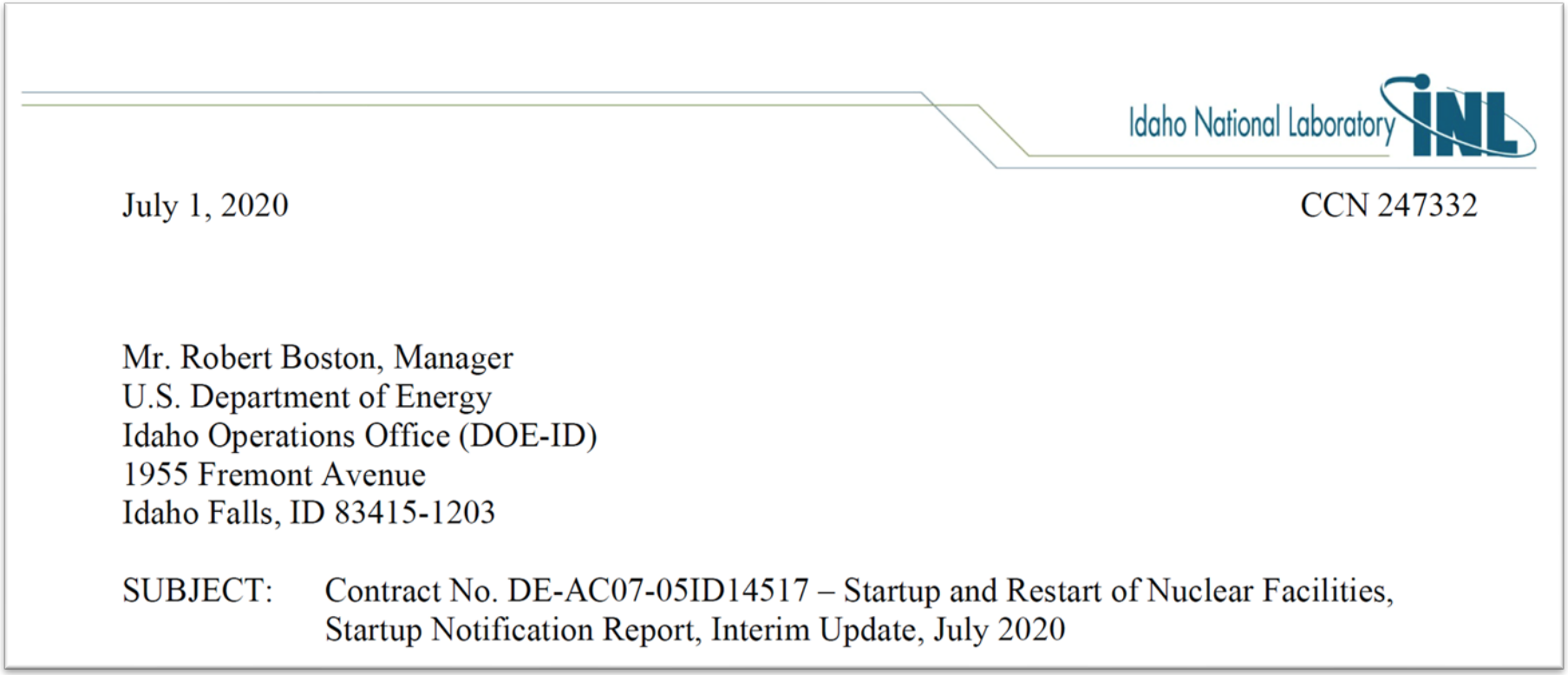
- Completion baseline program documentation (e.g. FY20-21 Project Plan)– 7/31/20
- Complete installation and operation of a power conversion system at MFC -8/31/20
- Completion of sub-scale primary coolant system test – 9/30/20
- Demonstration of control drum system functions – 9/30/20
- Demonstration of Shutdown Rod System functions – 9/30/20
- Fabrication completion of a single fuel pin – 9/30/20
- Complete Documentation of list of parts and costs – 9/30/20
- Perform and document system analysis to support microreactor point design – 9/30/20

National Reactor Innovation Center

- Prepare Office/Lab Space in the RCB for Innovator Teams – 7/31/20
- Complete Interim Working Space to Support Innovator Teams – 9/30/20
- Complete Preliminary SAR-420 Addendum (PDSA) for the MARVEL Project – 9/30/20
- Complete Draft Environmental Assessment for the MARVEL Project – 8/31/20
- Complete Final Environmental Assessment for the MARVEL Project – 9/30/20

Startup Notification Report

- BEA submitted MARVEL SNR to DOE-ID on July 1st 2020



Idaho National Laboratory INL

July 1, 2020

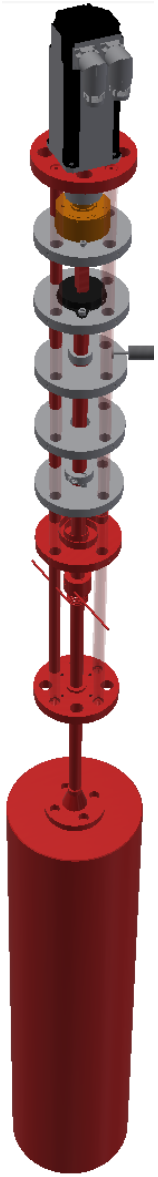
CCN 247332

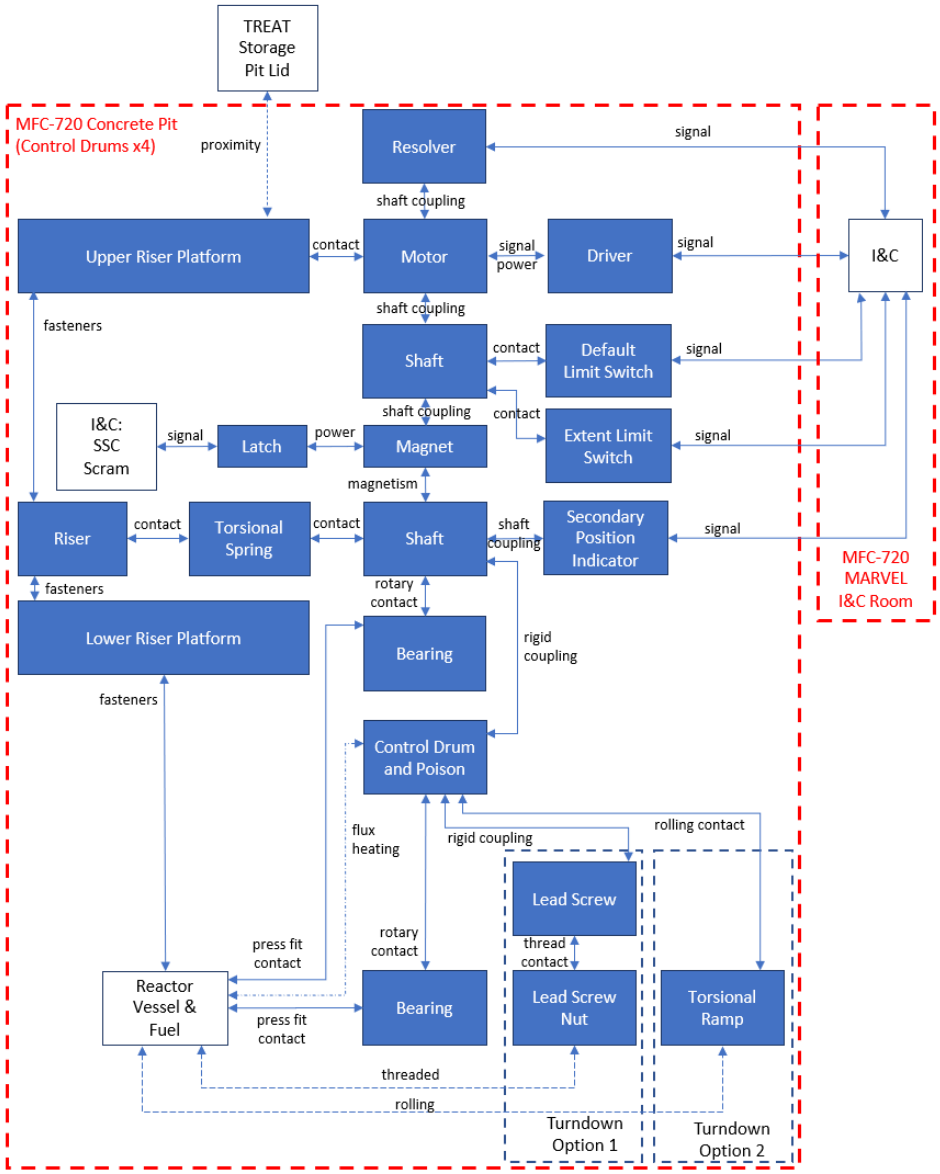
Mr. Robert Boston, Manager
U.S. Department of Energy
Idaho Operations Office (DOE-ID)
1955 Fremont Avenue
Idaho Falls, ID 83415-1203

SUBJECT: Contract No. DE-AC07-05ID14517 – Startup and Restart of Nuclear Facilities, Startup Notification Report, Interim Update, July 2020

Official Use Only

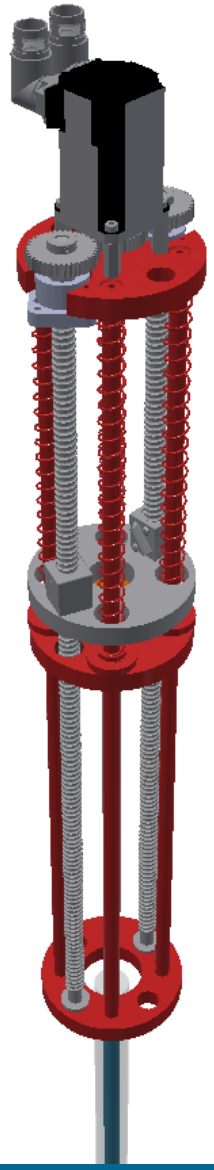
Control Drum Systems

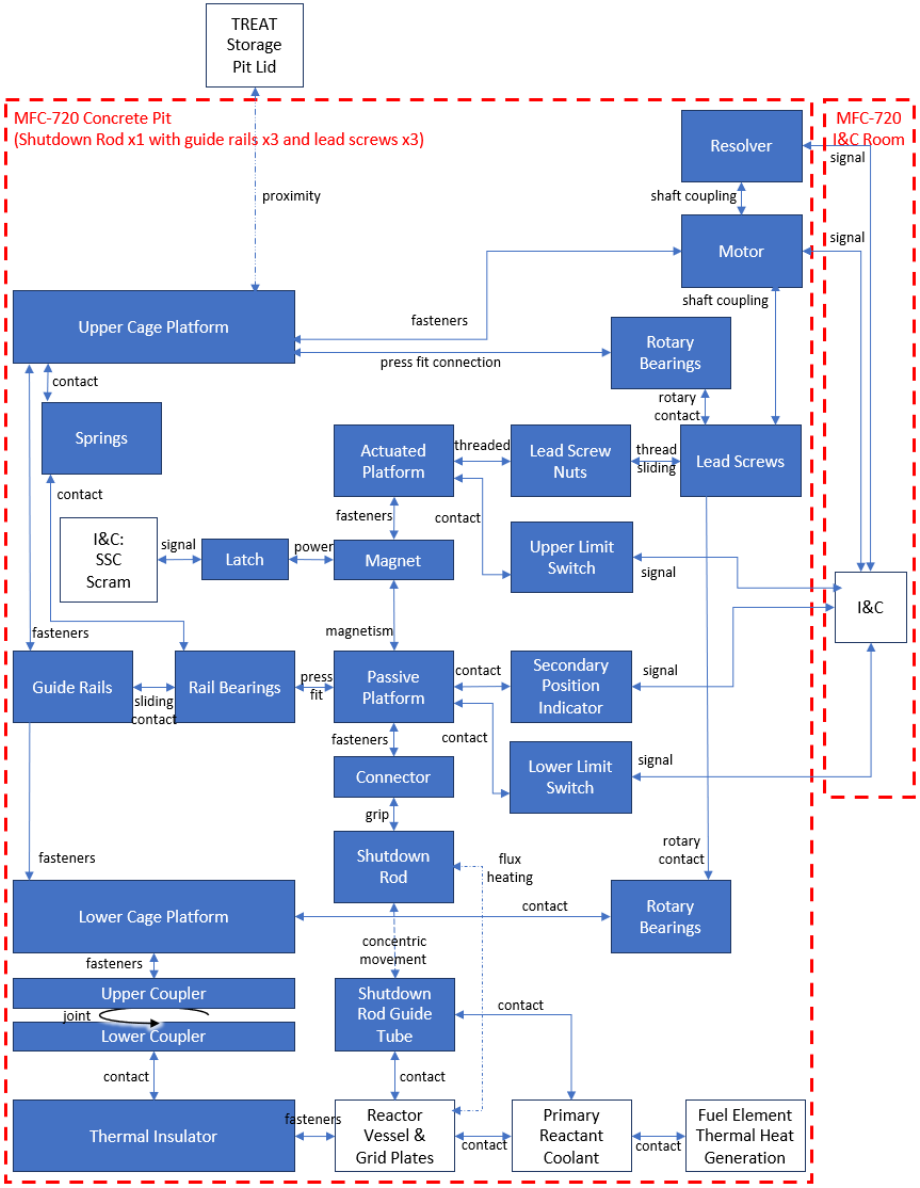


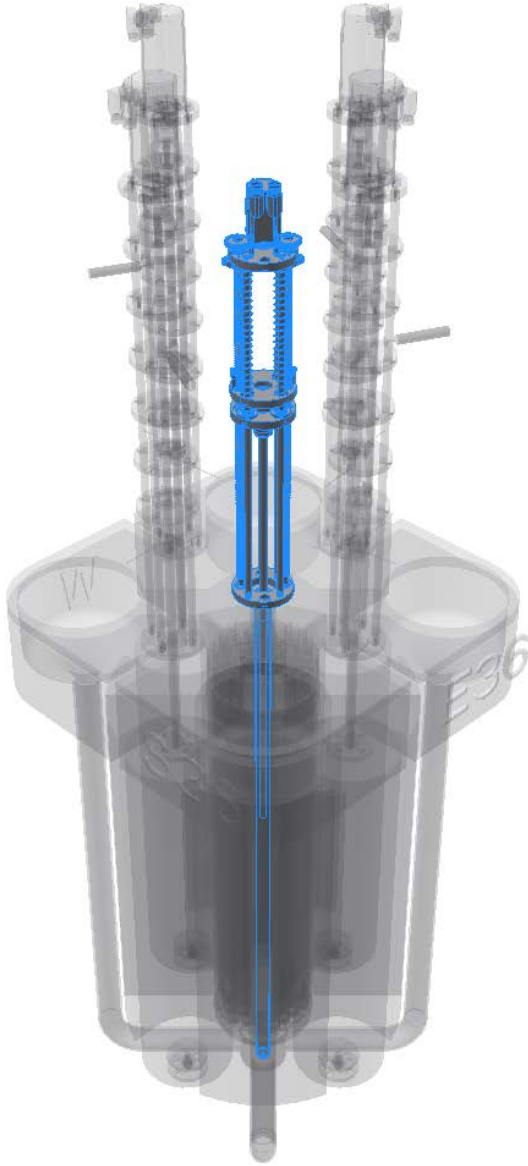


Shutdown Rod System

NSR-AR in Red



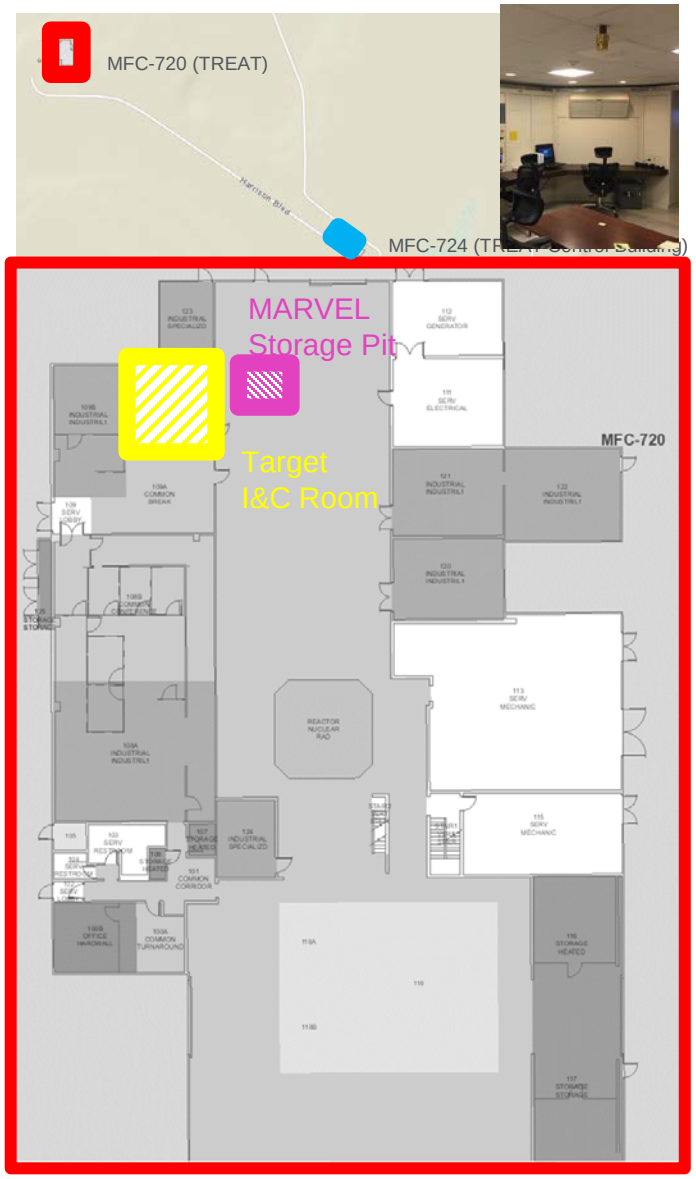




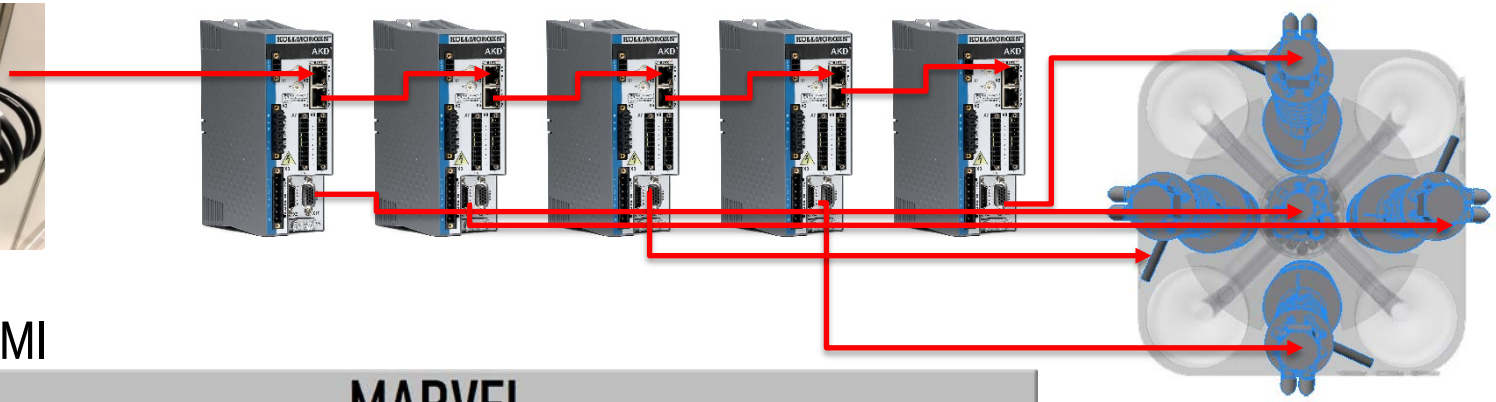
Instrumentation and Control System (ICS)

The primary control system paradigm's functions include:

- Reactor Core
- Reactor Trip Function (RTF)
- Reactivity Control Function (RhoCF)
- Manual Reactor Control Function (MRCF)
- Automatic Reactor Control Function (ARCF)
- Reactivity Interlock Control Function (RICF)
- Dedicated Information Function (DIF)



Instrumentation & Control



Target Intuitive HMI