

*Gateway for Accelerated
Innovation in Nuclear*

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What are the Problems/Issues?

- Time to market for nuclear technology is too long
- Facilities needed for RD&D activities are very expensive to develop and maintain
- Capabilities (e.g., facilities, expertise, materials, and data) at government sites have not been easily accessible by entities trying to commercialize innovative systems and components
- Technology readiness levels vary, requiring differing research and funding opportunities
- Many technology developers require assistance working through regulatory process for new nuclear technologies

What do we need to do?

- Provide nuclear innovators & investors with single point of easy access to broad range of capabilities – people, facilities, materials, and data – across DOE complex
- Provide focused research opportunities and dedicated industry engagement, ensuring that DOE-sponsored activities are impactful to stakeholders
- Expand upon DOE's work with the Nuclear Regulatory Commission (NRC) to assist technology developers through the regulatory process

What is the DOE initiative?



- Public-private partnership, headquartered at INL, to manage a distributed test-bed and demonstration platform.
- Dedicated to **accelerated commercial readiness of innovative technologies**

DOE recognizes the magnitude of the need, the associated sense of urgency and the benefits of a strong and agile public-private partnership in achieving the national goals.

Gateway for Accelerated Innovation in Nuclear

VISION (By 2030)

The U.S. nuclear industry is equipped to lead the world in deployment of innovative nuclear technologies to supply urgently needed abundant clean energy both domestically and globally.

GAIN is.....

The organizing principle for the relevant federally funded nuclear energy RD&D programs.

GAIN is

A public-private partnership framework aimed at rapid and cost-effective development of innovative nuclear energy technologies toward market readiness.

MISSION

As the organizing principle for the relevant DOE-NE programs, provide the nuclear energy industry with access to technical, regulatory and financial support necessary to move innovative nuclear energy technologies toward commercialization in an accelerated and cost-effective fashion.

GAIN Initiative: Simultaneous Achievement of Three Strategic Goals

- **GAIN** is based on the following premise:
 - National and global demand for nuclear energy is increasing and U.S. global leadership is eroding
 - There is a sense of urgency with respect to the deployment of the innovative nuclear energy technologies
 - An effective private-public partnership is required to achieve the goals
- Achievement of **GAIN's Strategic Goals** will bridge the gap between technology leadership and industrial leadership, and combined with optimized domestic deployment, will enable rapid, cost-effective development of innovative nuclear energy technologies towards market readiness



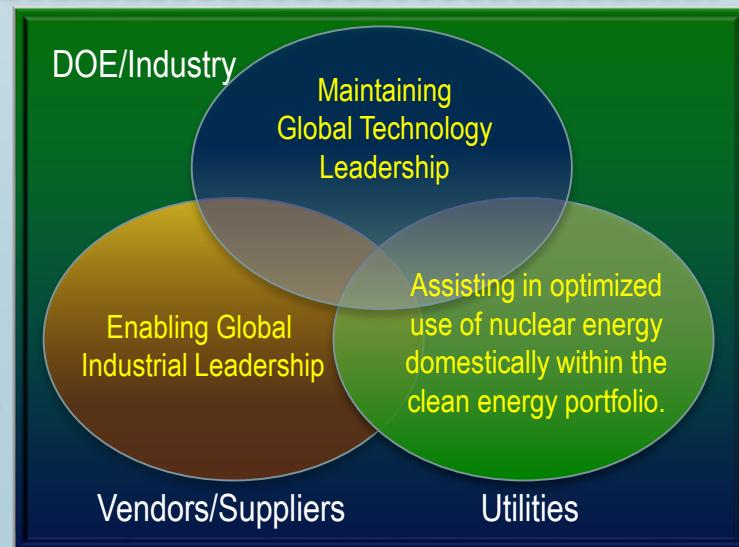
GAIN Explores New Model For Faster and More Cost-Effective Innovation Cycle for Nuclear Energy

OLD: SEQUENTIAL PROGRESSION FOR INNOVATION

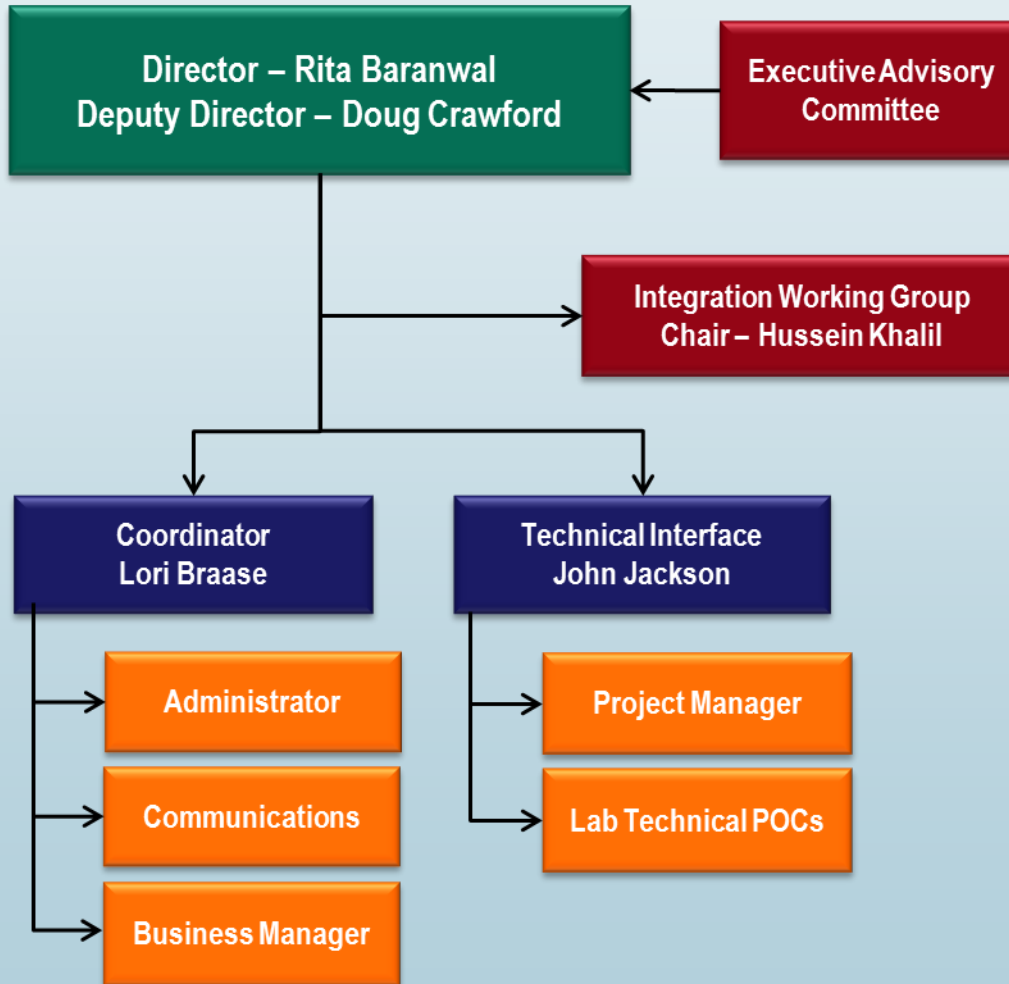


For complex technologies such as nuclear energy, the sequential model becomes less effective when federal funding is limited and the technology maturation cycle is long.

NEW: INTEGRATED PROGRESSION FOR INNOVATION TO ACHIEVE STRATEGIC GOALS SIMULTANEOUSLY



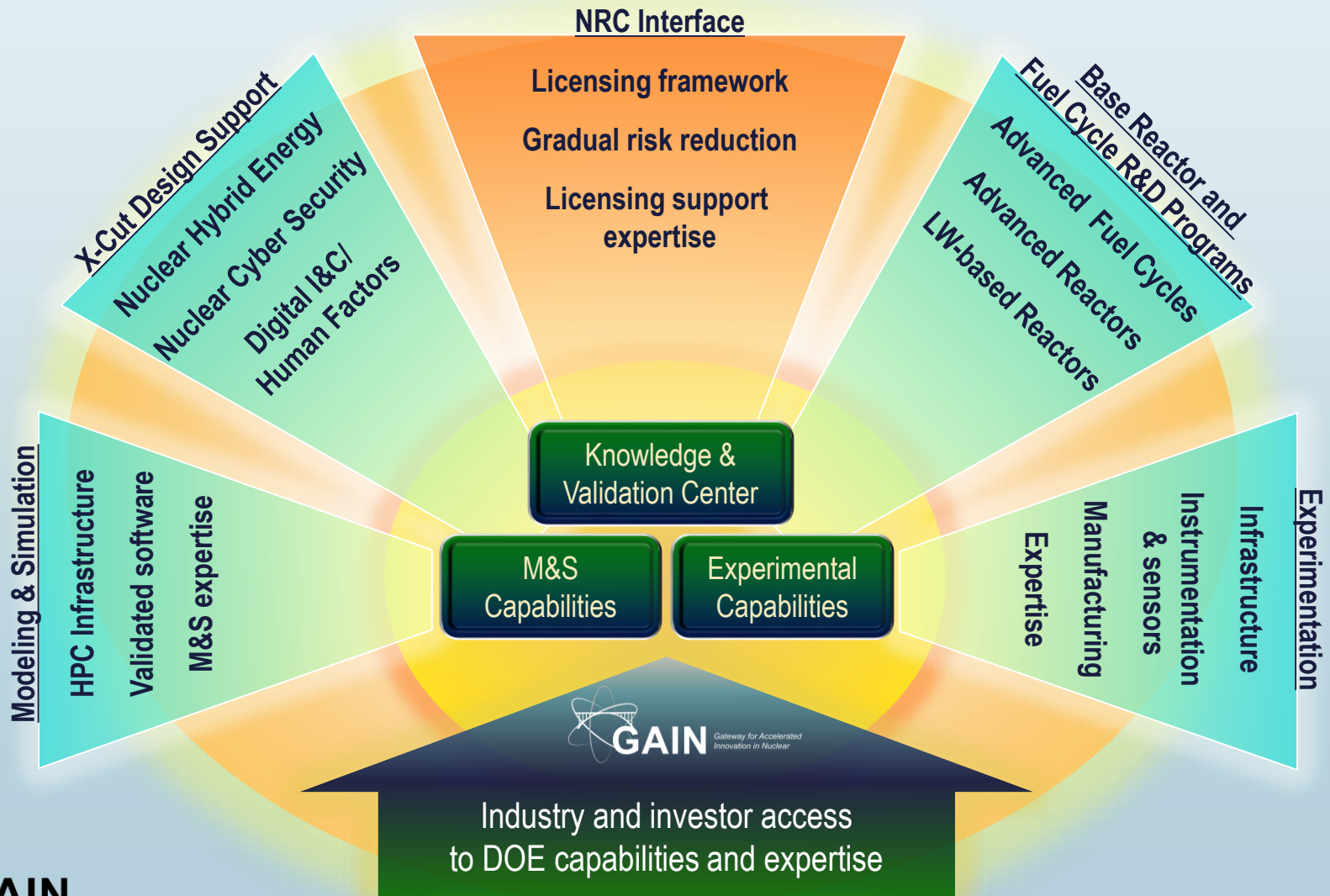
GAIN ORGANIZATION



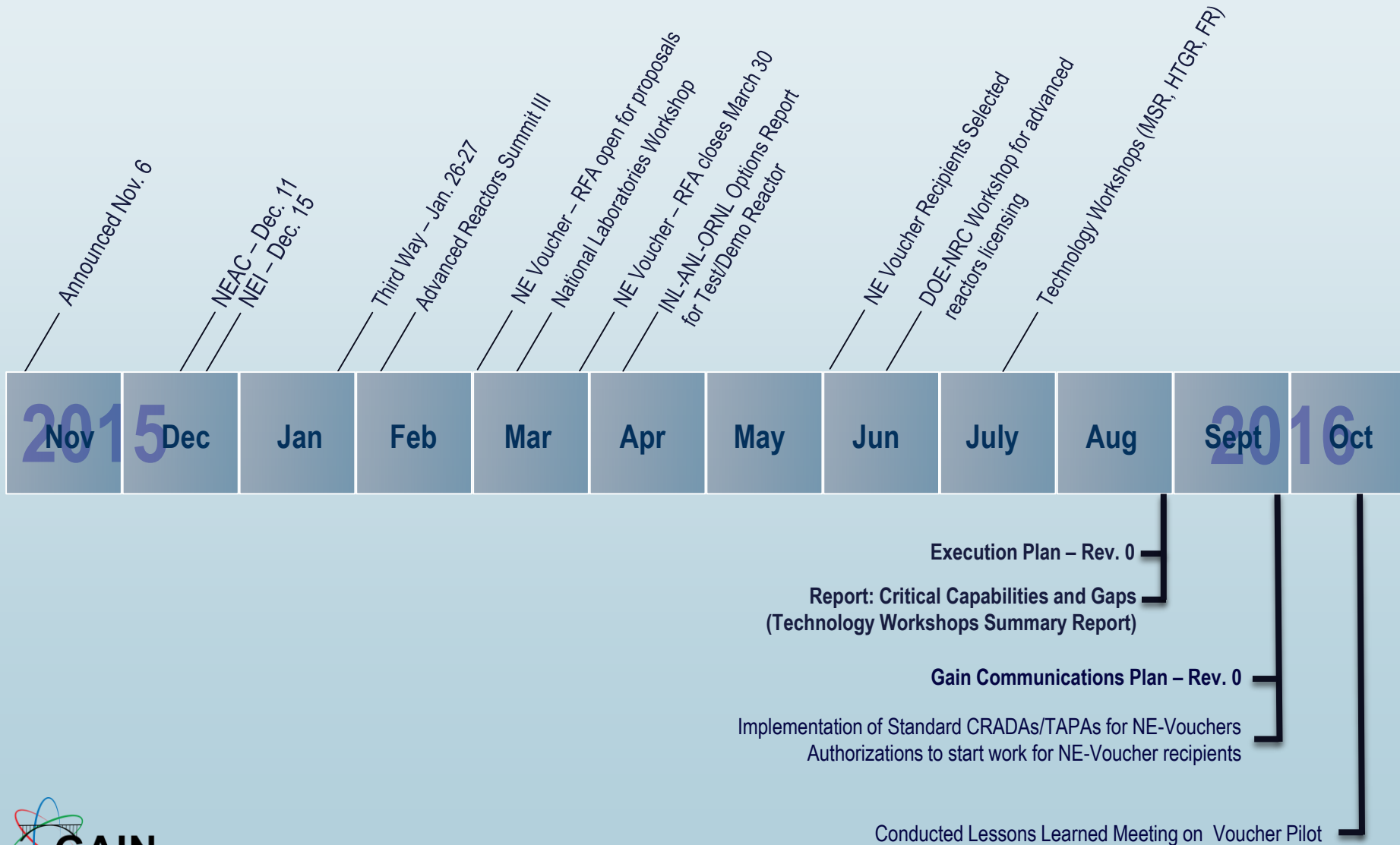
Neil Wilmshurst, EPRI – Chair
Dale Klein, University of Texas
Maria Korsnick, NEI
Steve Kuczynski, SNC
Peter Littlewood, ANL
Thom Mason, ORNL
Chris Mowry, ARC
Mark Peters, INL
Ray Rothrock

Expert oversight of GAIN execution strategy and high-level documents/deliverables.

GAIN: Organizing Principle for DOE-NE RD&D Programs Through Comprehensive Systems Analysis



GAIN First Year Activities



Activities to Date

- **GAIN Operations**
 - Established small, agile organization
 - Issued GAIN Execution Plan
 - Issued Draft GAIN Communication Plan, Revision 0
 - Issued Technology Specific Workshops Summary Report
 - Implemented Standard CRADAs/TAPAs for NE vouchers
- **GAIN Outreach**
 - Presented GAIN to multiple conferences/meetings to solicit input from stakeholders
 - Organized 3 Technology Specific Workshops (with NEI and EPRI) to solicit input on private-sector R&D needs for DOE-NE R&D program
 - Sponsored: DOE Summit Improving the Economics of America's Nuclear Power Plants (May 19, 2016) and DOE-NRC Workshop on Advanced Non-Light Water Reactors (June 7-8, 2016)
- **GAIN Support of Private Sector**
 - Awarded \$2M USD to developers in pilot NE Voucher Program
 - Initiated industry-led, laboratory-supported expert group for advanced reactor licensing framework development
 - Submitted FY 2018-2022 DOE-NE RD&D funding request consistent with GAIN strategic goals

Early activity: NE Voucher Program

- Eight small businesses were awarded for the initial pilot in 2016 (~\$2M total)
- Goal: Assist small businesses accelerate development and deployment of innovative nuclear technologies by granting them access to extensive nuclear research capabilities available at DOE's national laboratories and Nuclear Science User Facilities (NSUF) partners

NE Voucher recipients	Proposal	Partner Facility
Creare LLC Hanover, NH	Investigation of Materials for Continuous Casting of Metallic Nuclear Fuel	Idaho National Laboratory
Columbia Basin Consulting Group, LLC Kennewick, WA	Lead-Bismuth Small Modular Reactor (SMR) Licensing Development	Pacific Northwest National Laboratory
Terrestrial Energy USA Ltd. New York, NY	Verification of Molten-Salt Properties at High Temperatures	Argonne National Laboratory
Transatomic Power Corporation Cambridge, MA	Optimization and Assessment of the Neutronics and Fuel Cycle Performance of the Transatomic Power Molten Salt Reactor Design	Oak Ridge National Laboratory
Ceramic Tubular Products Rockville, MD	Robust Silicon Carbide Cladding for LWR Application - Corrosion and Irradiation Proof Test of Low Cost Innovations in MIT Research Reactor	Massachusetts Institute of Technology
Oklo Inc. Sunnyvale, CA	Legacy Metal Fuel Data Exploration for Commercial Scale-Up	Argonne National Laboratory/Idaho National Laboratory
CompRex, LLC De Pere, WI	High Efficiency Heat Exchanger for High Temperature and High Pressure Applications	Argonne National Laboratory
BgtL LLC Laramie, WY	High efficiency and low cost thermal energy storage system	Argonne National Laboratory

Technology-Specific Workshops

- Hosted by GAIN, NEI, and EPRI
- Discussed RD&D needs of advanced nuclear energy technologies
- Identified technical issues that DOE is uniquely suited to address

<i>Molten Salt Reactor Technology Workshop July 11-12, 2016 EPRI Offices</i>	<i>High Temp Gas Reactor Technology Workshop July 14, 2016 NEI Offices</i>	<i>Fast Reactor Technology Workshop July 21-22, 2016 NEI Offices</i>
Elysium Industries Flibe Energy Southern Co. Southern Co. / TerraPower LLC Terrestrial Energy USA Transatomic	AREVA General Atomics X-Energy	Advanced Reactor Concepts General Atomics General Electric-Hitachi Oklo Westinghouse

Technology-Specific Workshops: Industry Provided Concept Information and RD&D Needs

- General concept overview
- Technology commercialization strategy; demonstration reactor vs. pilot scale vs. first-of-a-kind
- Schedule constraints and critical path items
- RD&D needs; generic and not necessarily design-specific (e.g. modeling & simulation, test loops)
- Infrastructure gaps; major missing infrastructure that requires substantial investment and time
- Licensing support, e.g. safety analysis tools and licensing strategies
- Recommendations on contracting and collaboration mechanisms with DOE

Technology-Specific Workshops: Collaboration

- **Formation of three Industry-Led Technology Working Groups (TWG)**
 - Initial meetings held in September 2016
 - Molten Salt Reactor
 - Fast Reactor
 - High Temperature Gas Reactor
- **Roles & Responsibilities**
 - EPRI: engage with subject matter experts and stakeholders
 - Define gaps in M&S code development and V&V for design and licensing for all three advanced reactor technologies
 - NEI: facilitate and coordinate activities of TWGs with those of NEI Advanced Reactor Working Group (ARWG)
 - Coordinate with GAIN and EPRI to support working groups
 - Work with industry, DOE, and NRC to understand issues associated with obtaining 5% < enriched uranium < 20%

Technology-Specific Workshops: High-Priority Recommendations to DOE on Cross-cutting RD&D

- **Access to Applied Technology (AT) documents**
 - Create database of AT-marked documents
 - Streamline access to AT documents, removing AT designation where appropriate
- **M&S Code Development and V&V for Design & Licensing**
 - Describe DOE-NE's advanced M&S tools
 - Develop plans for additional code development to address gaps
 - Develop joint strategy with stakeholders for V&V of advanced tools, including cross-cutting and design specific issues
 - Develop joint strategy with NRC for V&V and usage of advanced tools for licensing analyses
- **Advanced Reactors Licensing Framework**
 - Accelerate joint work with NRC for advanced reactor licensing
 - General design criteria
 - Gradual reduction of licensing risk
 - Risk-informed and performance-based licensing strategy

Technology-Specific Workshops: High-Priority Recommendations to DOE on Design-Specific Technology

- **Molten Salt Reactor Technology**
 - Perform feasibility assessment for megawatt scale, molten-salt fueled critical system to be tested at DOE site
 - Identify alternatives to critical-system demonstration for meeting all identified data needs using different and simpler options
- **Fast Reactor Technology**
 - Complete options and requirements assessment for domestic fast spectrum test reactor
 - If need and feasibility are validated, complete mission need
- **High Temperature Gas Reactor Technology**
 - Complete on-going TRISO fuel and graphite qualification program

Technology-Specific Workshops:

Potential DOE-NE Program Tasks to Support MSR

1. Measurement
 - Nuclear data (e.g., cross sections)
 - Physical properties (base salt, fuel salt, fission product salts).
2. Establish laboratory spaces with molten salt loops for thermal-hydraulics testing and materials testing
 - Although multiple options exist, the right capability and capacity is lacking (per Transatomic and Terrestrial Energy)
 - Effort could start with survey of available capabilities and gap analysis
3. MSR codes/methods/M&S development
 - Per outcome of EPRI workshop and roadmap
4. Minor accommodations in FCT and ART programs could address:
 - Back-end fuel cycle schemes for spent molten salt
 - Flow
 - Neutron instrumentation for MSRs
 - Chemical sensors and chemistry control would be more significant change

Technology-Specific Workshops:

Potential DOE-NE Program Tasks to Support Fast Reactors

1. Initiate conceptual design of versatile test reactor that accommodates diverse testing needs identified in NEAC study with national lab and GAIN support
2. Assess and document anticipated validation needs for M&S tools for licensing advanced fast reactors in US
 - Assess adequacy and pedigree of available validation measurements
3. Enhance/accelerate ART and FCT program activities on technology innovations identified in workshop:
 - Advanced fuel and cladding
 - High-temperature and strength structural materials
 - Monitoring and inspection in high temperatures and opaque coolants
 - Passive decay-heat removal testing and model validation
 - Mechanistic source term
4. Establish and maintain fuel fabrication capabilities
5. Industry-lab staff exchanges

Technology-Specific Workshops:

Potential DOE-NE Program Tasks to Support HTGRs

1. Test and validate models of reactor-vessel passive cooling and other passive safety features or phenomena
2. Establish facility/capability for testing of gas turbines and other components of advanced HTGR power conversion systems
3. Establish and maintain fuel fabrication capabilities
4. Industry-lab staff exchanges

Future Activities 2017

- **Identify/develop Streamlined Contracting Process**
 - Streamline and tailor DOE contracting mechanisms to meet GAIN's goals
 - Identify candidate project and participants for multi-party CRADA (contracting pilot)
- **NE Voucher Activities**
 - Second NE Voucher Call Pending DOE approval and Congressional funding and authorization (March 2017)
- **Complete a small-scale technology demonstration feasibility study for a megawatt scale critical molten salt loop with dissolved fuel**
- **Support development of a flexible fast spectrum test reactor options study based on industry requirements**
- **Develop database of historical advanced-reactor documents to support knowledge transfer; facilitate access to key documents through OSTI**
- **Create an electronic catalog for modeling and simulation applications that is accessible for industry**

Summary

- **GAIN is underway to fulfilling a 3-way partnership**
- **GAIN is being implemented as the organizing principle for relevant DOE programs**
 - Technology-Specific Workshops provided critical input towards aligning NE-funded base programs towards industry/investors' needs
 - \$2M USD NE Voucher Awards provided initial new access to national laboratory expertise
- **Future efforts intend to improve GAIN effectiveness and impact**

