Battelle
The Business of Innovation

Nuclear Energy R&D Facility Requirements

NEAC Meeting

Progress Report

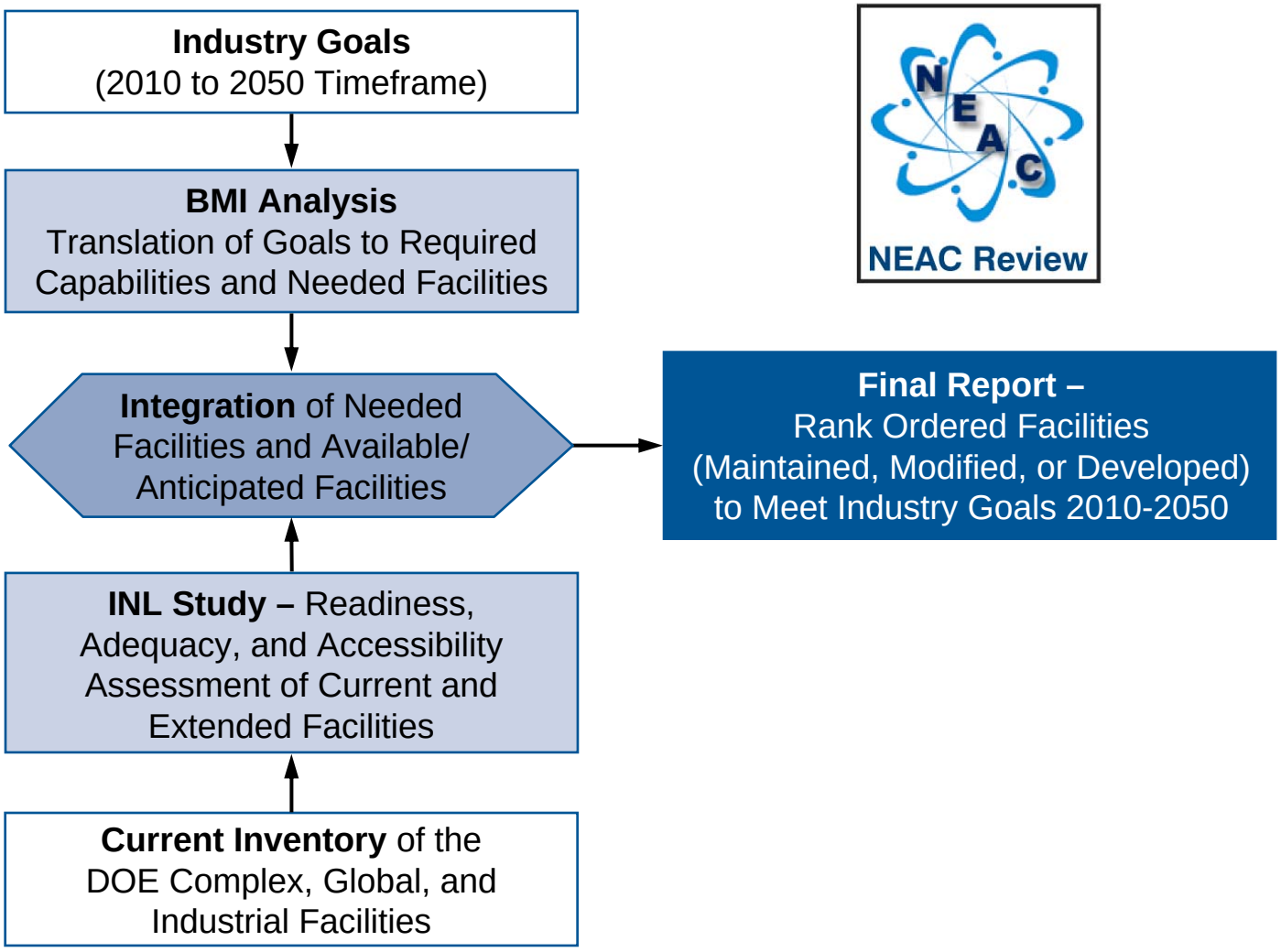
June 24, 2008

Facilitization of U.S. Nuclear R&D Infrastructure

Three-step study process:

- First, ASNE requested Battelle Memorial Institute to develop Industry-and-University–supported list of capabilities and facilities necessary to conduct a comprehensive nuclear R&D program.
  (Draft, June 12, 2008)
- Second, INL, using input from all DOE and other sources, will determine current facilities and their condition and availability to support next 20 years of nuclear R&D.
  (Draft, June 30, 2008)
- Third, recommendations will be made on priorities and on existing facilities to be maintained/preserved or otherwise supported by NE regardless of location or ownership.
  (Executive Team Meeting, July 1, 2008)

Top-Down/Bottom-Up Process



Industry and Academia Outreach

Employing a Multistep Process to Provide Opportunity for Input

Industry Participants

- AREVA NP
- Bechtel Corporation
- Dominion
- Electric Power Research Institute
- Entergy
- Exelon Corporation
- FirstEnergy Nuclear Operating Company
- General Electric Hitachi Nuclear Energy
- Global Nuclear Fuel
- Nuclear Energy Institute
- Southern Nuclear Operating Company, Inc.
- The Babcock and Wilcox Company – Technical Services Group
- UniStar Nuclear Energy, LLC (Constellation Energy and EDF)
- URS Corporation – Washington Division
- Westinghouse Electric Company, LLC

University Outreach

1. Working group, interview process – Georgia Tech, University of Florida, and University of Michigan
2. Internet collaboration focused on answering the question:

   What role should Universities play in the closure of the capability gap and what benefits will be realized by University participation?

- Participants:
  - MIT
  - UC Berkeley
  - Boise State
  - University of New Mexico
  - North Carolina State
  - Ohio State
  - University of Idaho
  - Idaho State
  - Oregon State
  - UNLV

Observations

Industry

- Generally supportive
- Strong emphasis on safety, economics, and cost effectiveness as business drivers
- Concerned about the work force
- Concerned about regulatory and construction delays
- Strong interest in new applications

Academia

- Multi-year R&D investments essential
- Desire more DOE/Industry collaborative opportunities

An Industry Perspective Nuclear Energy R&D Capability Requirements A 20+ Year Outlook

(Title change as suggested by NEAC Facilities Subcommittee)

Preliminary Results

Analysis Steps

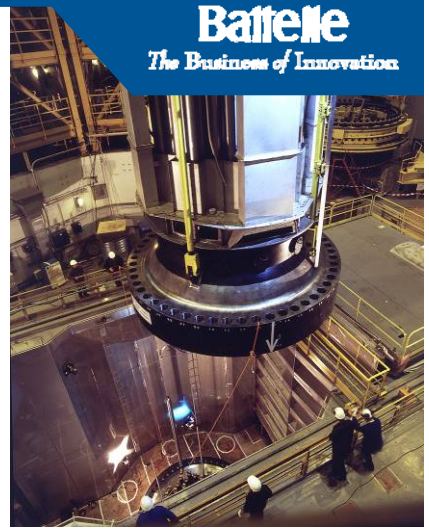
Definition of 2010-2050 Goals

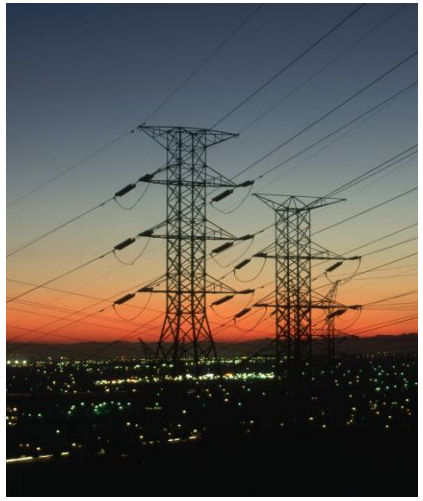
Definition and Prioritization of Required Capabilities

Identification of “Nuclear-Unique” Required Capabilities

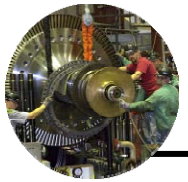
Identification of Required R&D Facilities

Development of Recommendations





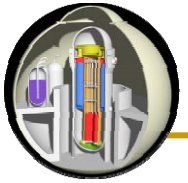
Identified Focus Areas and 2010 - 2050 Goals



Existing LWRs and ALWRs

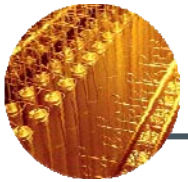
Workforce Development

Sustainable Fuel Cycle



Next-Generation Reactors

Regulatory Requirements



Safeguards and Security

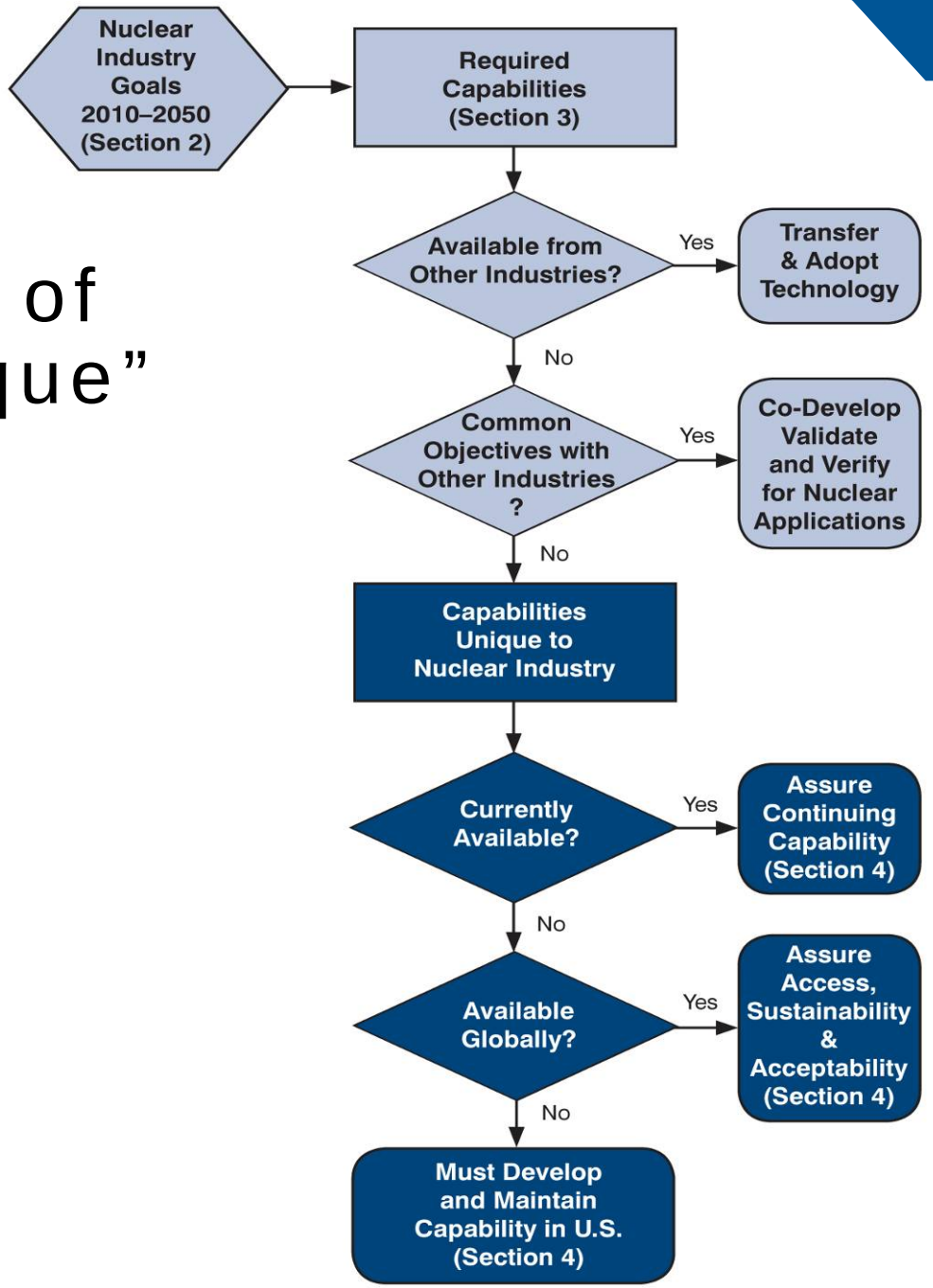
Identified Capability Priorities

Existing LWRs and ALWRs	• Manage the reliability of the plant systems, structure, and component (SSC) materials through the plant's extended lifetime • Improve fuel performance. • Adopt technology innovations to enhance plant performance and workforce productivity • Enhance manufacturing and construction methods for plant life extension upgrades and construction of new plants
Workforce Development	• Optimize training through adoption of proven approaches from other industries, greater use of technical training centers, new methods, and improved skill and aptitude assessment tools • Adopt knowledge management methods and techniques to enhance cross-generational knowledge retention, workforce development and effective use of lessons learned • Enhance nuclear education/training and research infrastructure to deliver a more effective multiyear, sustainable science and engineering R&D program to train the next generation of scientists and engineers • Enhance innovative energy educator programs to effectively reach K-12 students – working with industry to build the pipeline
Sustainable Fuel Cycle	• Develop a geologic repository for the disposal of used nuclear fuel and HLW • Develop an interim storage facility for receipt of used nuclear fuel • Develop recycling technologies that are economically competitive, increasingly proliferation resistant, and minimize impact on waste disposal

Identified Capability Priorities (con't)

Next-Generation Reactors	• Develop fuels • Understand heat transport for new applications • Enhance modeling and simulation capabilities • Materials development Includes grid-appropriate reactors, reactors for the production of process heat, and reactors required for closure of the fuel cycle.
Regulatory Requirements	• Improve the NRC license application and review process • Establish risk-informed regulatory basis for next-generation reactors and sustainable fuel cycle activities • Ensure appropriate regulator staffing and effective staff training to meet job requirements including next-generation reactors and sustainable fuel cycle activities
Safeguards and Security	• Use of technology to optimize use of guns/guards/gates • Enhance cyber security capabilities to ensure plant safety and security • Design advanced safeguards approaches and technology into ALWRs, next generation reactors, and fuel facilities

Identification of "Nuclear-Unique" Required Capabilities



Identification of Nuclear-Unique Required Capabilities (con't)

(NEAC Subcommittee: simplify Table)

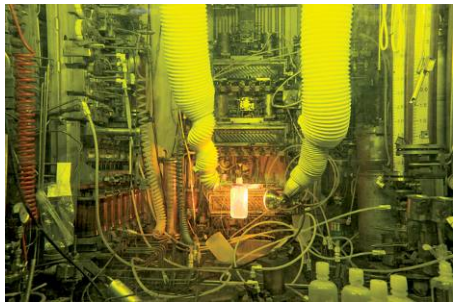
Required Capability	Transfer from Other Industries	Co-Develop with Other Industries	Nuclear Unique — U.S. Available	Nuclear Unique — Globally Available	Nuclear Unique — Develop in U.S.
			Nuclear Unique (see Section 4)		
Existing LWRs and ALWRs					
SSC Reliability	✓		✓	✓	
Fuel Performance			✓	✓	
Technology Innovations	✓	✓	✓		
Manufacturing & Construction	✓	✓		✓	
Workforce Development					
Optimize Training	✓	✓	✓		
Knowledge Management	✓		✓		
Sustainable R&D	✓		✓		✓
Innovative Energy Educator	✓	✓			
Sustainable Fuel Cycle					
Geologic Repository*					✓
Interim Storage**					✓
Recycling Technologies				✓	✓
Next-Generation Reactors					
Fuels Development			✓	✓	✓
Heat Transport	✓	✓			
Modeling & Simulation	✓		✓	✓	✓
Materials Development		✓	✓	✓	✓
Regulatory Requirements					
Licensing Efficiency	✓		✓	✓	
Basis for NGR & SFC			✓	✓	✓
Staffing	✓	✓			
Safeguards and Security					
Optimized Technology	✓	✓			
Cyber Security	✓	✓			
"Safeguards-by-Design"			✓	✓	✓

Identification of Required R&D Facilities

Required Capability	Nuclear Education Facilities	Thermal Irradiation Capability	Fast Irradiation Capability	Radio-Chemistry Laboratories	Hot Cells for Separations	Hot Cells for Post-Irradiation Examination	Thermal Transport	Fuel Development Laboratories	Licensing Demo-HTR	Licensing Demo-Fast Reactor	Specialized Engineering Development Laboratories
Existing LWRs and ALWRs											
SSC Reliability		X				X					
Fuel Performance		X		X		X		X			
Technology Innovations	X										X
Manufacturing & Construction											X
Workforce Development											
Optimize Training	X										
Knowledge Management	X										
Sustainable R&D	X										
Sustainable Fuel Cycle											
Recycling Technologies		X	X	X	X	X		X		X	X
Next-Generation Reactors											
Fuels Development	X	X	X	X		X		X	X	X	
Heat Transport	X						X		X	X	X
Modeling & Simulation	X	X	X				X		X	X	
Materials Development	X	X	X	X		X			X	X	
Regulatory Requirements											
Licensing Efficiency	X										
Basis for NGR & SFC	X								X	X	X
Staffing	X										
Safeguards and Security											
"Safeguards-by-Design"	X			X	X						

Required R&D Facilities

- Nuclear Education Facilities
- Thermal Irradiation Facilities
- Fast Irradiation Capabilities
- Radiochemistry Laboratories
- Hot Cells for Separations
- Hot Cells for Post-Irradiation Examination
- Thermal Transport
- Fuel Development Laboratories
- Licensing Demo – HTR
- Licensing Demo – Fast Reactor
- Specialized Engineering Development Laboratories

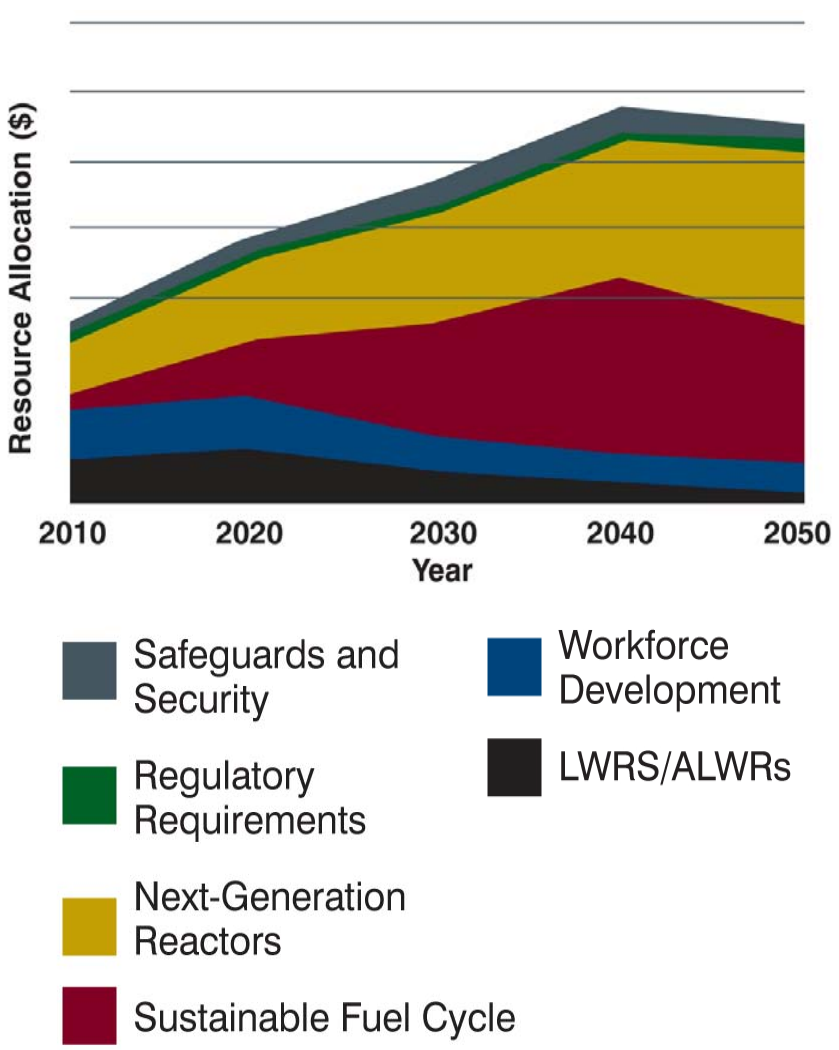


Recommendations

Establish ***Strategic Nuclear Energy Capability Initiative***

- Integrated, time-phased, and user-driven
- Provides multiyear investments
- Engage industry, universities, and national laboratories to define facility requirements, build support, and monitor progress

(NEAC Subcommittee: replace graph with list of priorities)



Additional Recommendations

- Improve use of enterprise models for trade-off studies
- Strengthen international collaboration
- Define living process for facility consolidation, retirement of old facilities, and replacement when appropriate
- Define process to ensure maintenance of “balance of plant”

Conclusions

- A robust, fully trained workforce is essential
- Nuclear energy industry has established meaningful goals
- Establishment of ***Strategic Nuclear Energy Capability Initiative*** is needed to provide essential R&D capabilities and facilities
- Foundation provided through ***Strategic Nuclear Energy Capability Initiative*** should be leveraged to build public-private partnerships and international collaboration

R&D Capabilities Report Schedule

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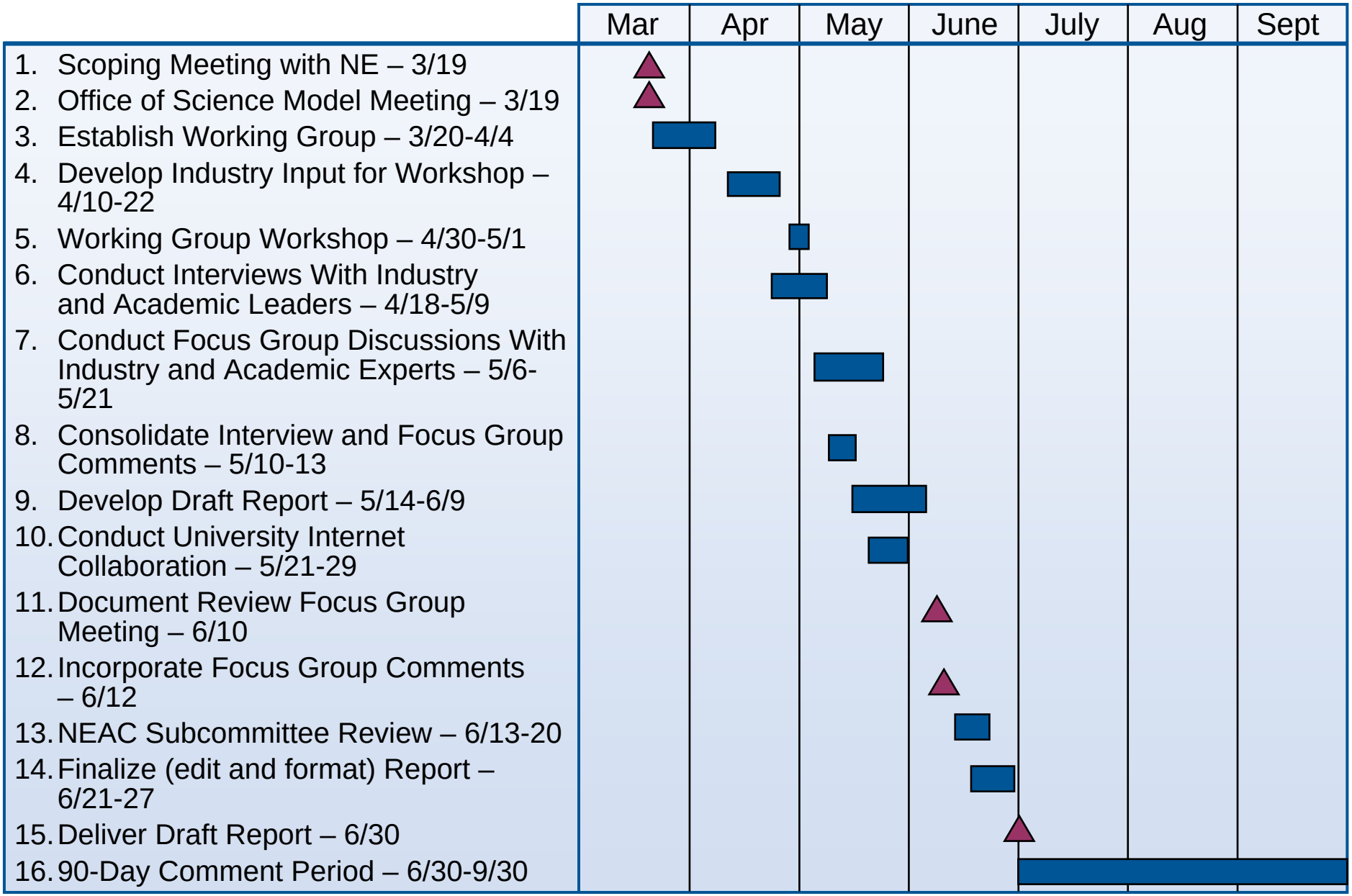


"Idaho National Lab Facilities Study"

AKA

Assets Required for a Nuclear Energy Applied R&D Program

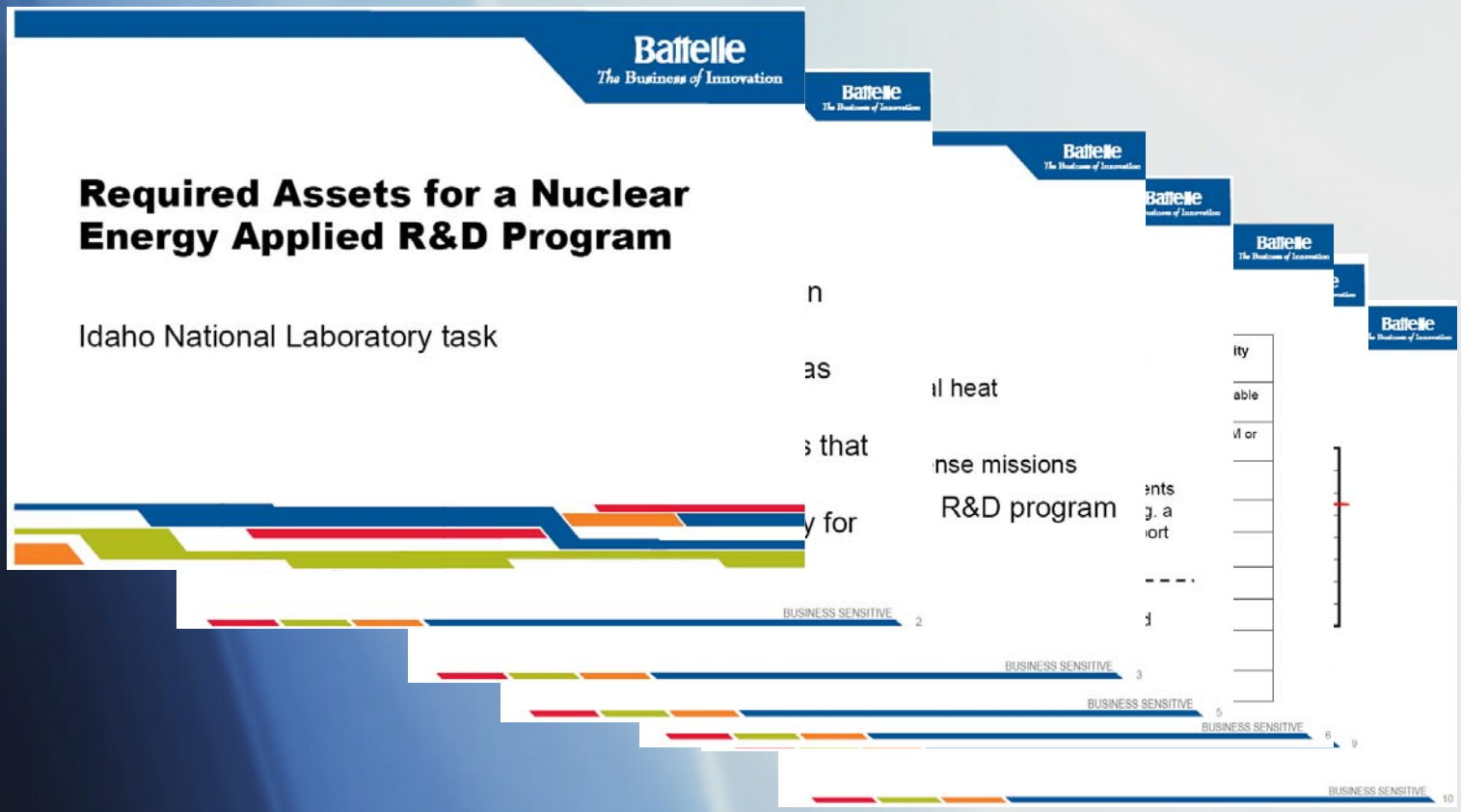
Harold McFarlane

Deputy Associate Laboratory Director

Nuclear Science & Technology

16 June 2008

Presentation at April 20th NEAC Meeting



Idaho National Laboratory

INL report structure

- Integrate Battelle/Industry Focus Areas/Required Priority Capabilities and DOE NE R&D programs requirements
- Crosswalk from required capabilities to facility descriptions in each category
- Identify needed facility improvements and gaps

Screening and binning rules

- *Class 1 and Class 2 facilities will be included in the evaluation.*
  Class 3 facilities will not be included in the evaluation.

- **Class 1**: **Major high-value nuclear facility** with attendant support functions. Examples are: research, prototype and demonstration nuclear reactors (e.g. ATR, HFIR, JOYO); large hot cell facilities (e.g. HFEF) or complex of smaller hot cells (e.g. Actinide Science and Separation Laboratories); Large multipurpose, multiple capability radiochemistry laboratories; large glovebox facilities (e.g. TA-55 Plutonium Facility)

- **Class 2**: **Major non-rad facility** with nuclear application (e.g. a components test facility); a multipurpose facility with some **nuclear application** use (e.g. a high temperature materials development laboratory); or radiological support facility

- **Class 3**: Facilities of a type that are either **ubiquitous** or would play a modest supporting role in an R&D program, or which have been removed from consideration by the responsible landlord (e.g. computer clusters, generic non-rad materials laboratories, facilities being decommissioned)

Stoplight evaluation for 6 criteria

Condition	Physical condition, age, and maintenance status of the facility and its supporting infrastructure
	Good physical condition with 20 years or more of useful life; capable of performing mission
	Capable of performing function with modest investment of ~$25M or less
	Capable of performing most aspects of function after substantial investment of $25M-$250M over several years
	Requires major investment exceeding $250M
Capability	Capacity, flexibility, location and accessibility
	Proven capability for intended function
	Proven capability limited by one or more attributes
	Significant limitations for proposed function without major modification
	Lacks most needed capabilities for mission

Evaluation criteria, cont'd.

Availability	**Projected availability in needed time frame**
	Currently available or performing intended function
	Has some competing missions but some available capacity; may require operational readiness assessment
	Not currently available, fully subscribed by alternate mission; limited lifetime; or requires restart
	Not available; e.g., currently scheduled for D&D
Regulatory	**Safety basis, EIS, safety management program, environmental management program, community support**
	Fully compliant
	Can be brought into compliance within 2 years with an investment of $5M or less
	Significant compliance issues that requires more than 2 years and sustained investment of several million dollars per year
	Serious safety and environmental liability

Evaluation criteria, cont'd.

Security	DOE security requirements for type of facility and materials handled: PIDAS, guard force, nuclear materials management system, cyber security, etc.
	Compliant with current S&S requirements and has implementation plan for emerging requirements
	Compliant with current requirements; significant effort to meet emerging design basis threat
	Unable to meet security requirements for mission without substantial capital and annual investment
	Unable to meet security requirements because of unfixable conditions such as proximity to public areas
Staffing	Requisite skills including R&D, operations, maintenance and support personnel on site or readily available
	Fully staffed with no projected cuts in critical skills
	All required skills available but augmentation needed to perform mission as well as staffing plan to deal with critical retirement issues
	Some but not all critical skills available for mission
	Requires essentially complete new workforce

Partial example for fast reactor R&D

Facility	Class	Condition	Capability	Availability	Regulation	Security	Staffing
Fuel Manufacturing Facility, INL	**1**						
Transient Test Reactor, INL	**1**						
Sodium Process Facility, INL	**3**						
TA-55, PF-4, LANL	**1**						
Materials Test Station, (LANCE), LANL	**1**	**proposed**					
REDC-7920, ORNL	**2**						
Zero Power Physics Reactor, INL	**1**						
High Flux Isotope Reactor, ORNL	**1**						

Actual result from 4/17 workshop with input by INL, ORNL, LANL, and consultants

Industry identified required capabilities

- Nuclear Education facilities
- Thermal irradiation capability
- Fast irradiation capability
- Radiochemistry laboratories
- Hot cells for separations
- Hot cells for post-irradiation examination
- Thermal transport
- Fuel development laboratories
- Licensing demo-HTR
- Licensing demo-fast reactor
- Specialized engineering development laboratories including fuel fabrication techniques

Facility Description Sheets

Arranged by required category

Advanced Test Reactor (ATR)

Location: Idaho National Laboratory

Currently Supporting: Multiple programs

Status: Fully operational

Remarks: Life extension upgrades are in progress

Light Water Reactors	Irradiated Fuel Separations	Advanced Fuel Development
High Temp. Reactor	Fast Spectrum Reactor	Grid Appropriate Reactors
Safeguards and Security	Modeling and Simulation	Space Power Systems

ATR was constructed in the early 1960s and began operation in 1967. It was established as a National Scientific User Facility by DOE in 2007.

ATR is a low temperature and pressure water cooled reactor and one of the most versatile test reactors in the world. The reactor is designed to study the effects of intense radiation on reactor materials and fuels. The high intensity of irradiation, the design of the core and the ability to run multiple tests simultaneously under different conditions makes the ATR a unique research reactor. In addition, ATR irradiates targets to produce valuable isotopes for medical, industrial and research applications.

The Advanced Test Reactor at the Idaho National Laboratory

Because of a serpentine fuel arrangement, there are nine high-intensity neutron flux traps where irradiation levels, temperatures and pressures for the experiments can be individually regulated. In addition, there are 68 irradiation positions in the reactor core and reflector regions, and 34 low-flux positions outside the reactor core.

ATR has been operating continuously since 1967, but because its internal components are periodically changed out, it remains a valuable research and test machine capable of decades more service. Additional life extension and capability improvements are in progress and planned.

Redirected focus for mid-June to mid-July

- Support Wadsworth Executive Recommendation Team July 1 meeting
- 95% draft on facility evaluations and descriptions
- Identify constraints
  - Support infrastructure
  - Transportation
  - Security requirement changes
  - Threshold scale for public/private partnership
- Prepare strawman decision constructs