

July 14, 2021

**Will Windes**

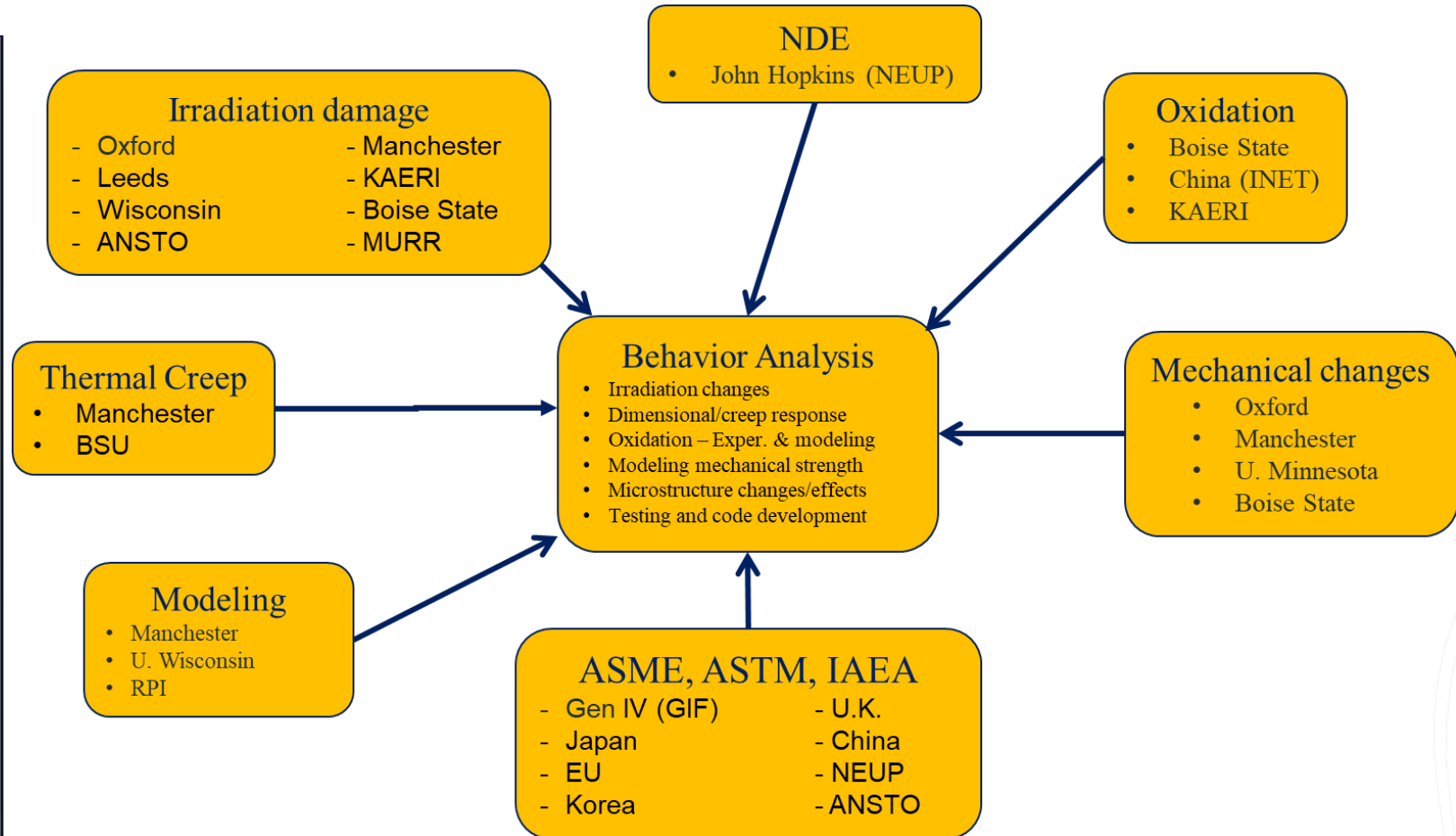
DOE ART Graphite R&D Technical Lead

# Graphite Collaborations

GIF, NEUP, Rx Vendors, NRC, EPRI, International Labs

# Collaborations

- Domestic and international collaborations are key elements to understanding results from ART program
- Commercial designers provide source of questions and issues
  - Irradiation response
  - Oxidation degradation
  - What data is important
- GIF Collaborations provide international data source
  - USA (DOE)
  - EU (Joint Research Centre - JRC)
  - S. Korea (KAERI)
  - China (Institute Nuc Energy Tech - INET)
  - Japan (JAERI)



# International Research and Development Programs

## Irradiation Tests

- USA DOE (Irr & creep)
- E.U. JRC (Irr)
- U.K. EDF (Irr & creep)
- KAERI (small Irr)
- JAEA (small Irr)
- China Tsinghau (??)
- Graphite suppliers

## Qualifying New Graphite Grades

- USA DOE
- China Tsinghau/SINAP
- Graphite suppliers

## Oxidation

- JAEA (SiC)
- KAERI (B<sub>4</sub>C)
- USA
- U.K. EDF
- Canada

## Fracture

- U.K.
- China Tsinghau/SINAP
- Australia ANSTO
- USA

## Molten Salt

- China SINAP
- USA DOE
- Australia ANSTO

## Core Component

- U.K.
- China Tsinghau

## Test Standards

- USA DOE
- U.K. NNL
- KAERI
- JAEA
- China SINAP
- Australia ANSTO

## Code Rules

- USA DOE
- China SINAP
- U.K. NNL
- HTR designers/vendors

# GIF (Generation IV Information Forum) Graphite Working Group

- GIF GWG Collaborations (new members)
  - Australia (ANSTO: Australian Nuclear Science and Technology Organisation) - 2020
  - U.K. (NNL: National Nuclear Laboratory) – 2021/2022
  - Canada (TBD) – 2021/2022
- New members bring additional experience and new interests
  - Specifically, **graphite waste** is of interest to the three new members
  - A new task is being added to the GIF VHTR Materials Project Plan (Revision 3)

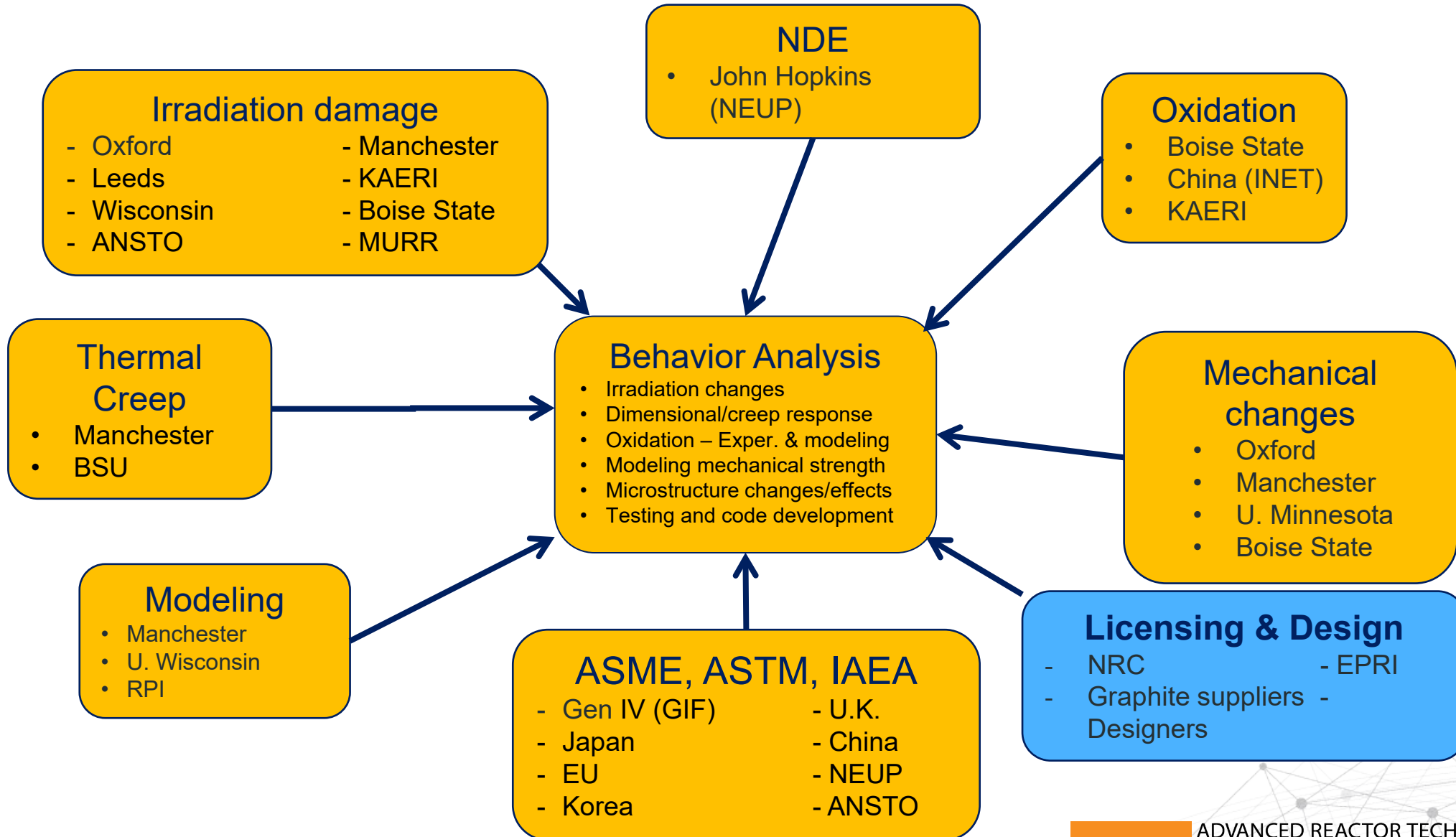
## **Task 2      Decommissioning and Disposal**

Issues surrounding waste disposal of core structural graphite are of importance for both existing as well as new construction designs. Data, selected studies, engineering strategies, and best practices established through experience in the areas of irradiated graphite handling, decommissioning, waste storage, waste minimization, and core disposal are of interest to the irradiated graphite community.

# NEUP Program – Graphite is Back!

- After a long time (5+ years) we have our first graphite NEUP call
  - **RC1.2 Effects of Irradiation Induced Microstructure Change in Graphite**
    - *An experimental/characterization focused research topic on irradiation damage in graphite*
    - *Two proposals awarded this year. Look for results at future GCR review meetings*
  - Looking forward to future graphite NEUP research areas
    - *Modeling irradiation induced defects*
    - *Irradiation damage mechanisms (dimensional change, creep, CTE, etc.)*
    - *Applied (engineering?) based research for commercial licensing*
      - Graphite - coolant interaction (wear from gas, from molten salt, from particulates)
      - Fracture in graphite components
      - Degradation models
    - *New testing methods (pre-ASTM standard development)*
      - Small sample testing methods (irradiated, oxidized, molten salt)
      - Elevated temperature testing methods
      - Testing methods for oxidized graphite

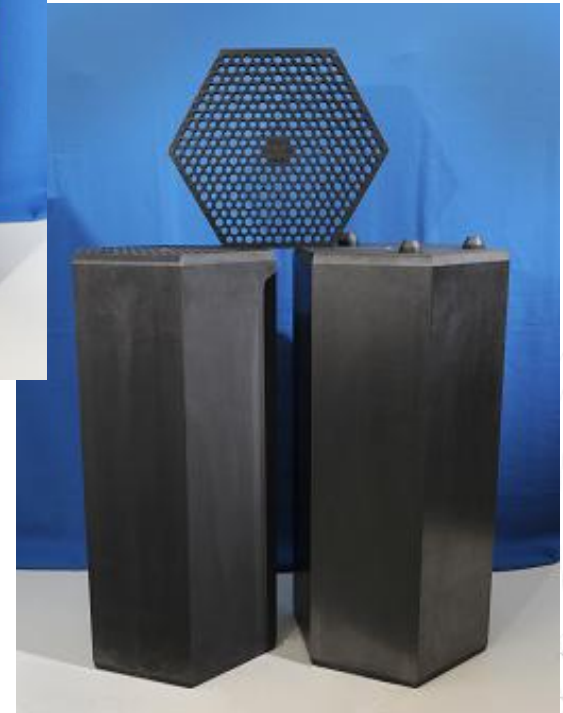
# New Collaborations – Commercial Licensing





# Commercial Vendor Collaborations

- **NRC**
  - ASME BPVC endorsement and interpretation
    - *Clarification of ASME code rules*
  - Graphite degradation model
  - General graphite behavior
- **Reactor designers and graphite suppliers**
  - Specific ASME code rule questions
    - *Testing plans and methods*
    - *Irradiation testing plans*
    - *Gaps in ASME code rules (i.e., molten salt)*
  - Graphite grade questions
    - *How much data? Unirradiated and irradiated*
    - *Qualifying new graphite grades*
- **EPRI** (long range issues)
  - Graphite qualification report/document
  - Development of a standardized “nuclear” grade



## Common Questions and Issues asked for licensing

- What about graphite fires and/or dust explosions?
  - **NO!** Just, no!
- How much data is needed?
  - Unirradiated, irradiated, oxidation, molten salt, combinations
- Lack of standard tests
  - How do you measure material properties without test standards?
- What is failure?
  - What constitutes failure when you already have a cracked component?
- Significance of turnaround dose
  - A lesson in risk management
- Irradiation creep
  - Creep in graphite is desired. But how do you take it into consideration?
- Behavior Models
  - Some material properties can only be determined by models





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