



Project Forte – Digital Reactor Design - Thermal Hydraulics

Carolyn Howlett

17th September 2018



Project Update

- ▶ Recap
 - ▶ Project activities to date

- ▶ What's New?
 - ▶ Workshop in Glasgow
 - ▶ Output
 - ▶ Ongoing model development projects

- ▶ Looking ahead to phase 2



Project Update

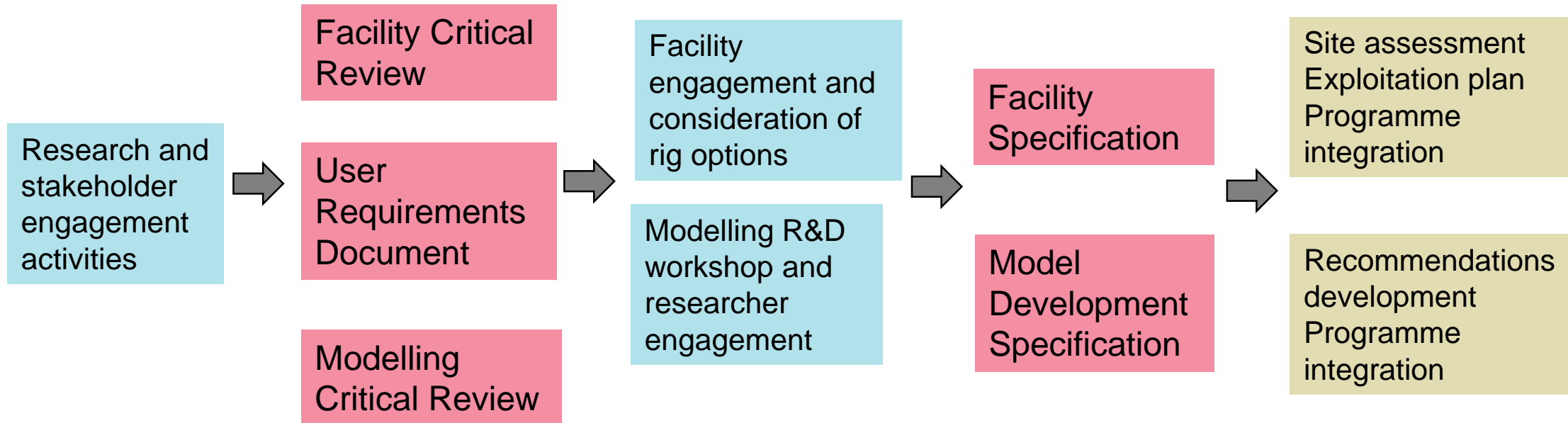
Thermal Hydraulic Modelling – 2 years

- ▶ A Critical Review of the State-of-the-Art in thermal hydraulic prediction capability.
- ▶ A Specification for an innovative thermal hydraulics modelling capability.
- ▶ Initial Innovative Models.

Thermal Hydraulic Test Facility – 1 year

- ▶ A Critical Review of the State-of-the-Art in thermal hydraulic test facilities worldwide.
- ▶ A Specification for a UK thermal hydraulics test facility.
- ▶ Identification of opportunities to use the facility to benefit other 'NIRAB' programmes.

Summary of activities



Modelling Development Activities

- Single phase flow and heat transfer
- Two phase flow and heat transfer
- Innovative coarse grid methods
- SFR cover gas dynamics

The First Challenge

- ▶ State-of-the-art in thermal hydraulic modelling and test facilities, across all technologies, world-wide!
- ▶ The requirements for improvements in thermal hydraulic modelling and testing, across all technologies!

The Challenge:

- ▶ Reactor Thermal Hydraulics is BIG.....

.....Really, Really **BIG**.



The Second Challenge

- ▶ The UK currently has AGRs and one PWR.
- ▶ The UK will be getting more PWRs and some BWRs.
- ▶ The UK Government has stated a commitment to nuclear generation.

The Challenge:

.....What Next?





Addressing the Challenges

Inclusive approach

- ▶ Advantages
 - ▶ The most complete picture;
 - ▶ Enables the work to support future decisions as the situation in the UK develops;
 - ▶ Allows the differences and similarities between different technologies to be drawn out.
- ▶ Disadvantages
 - ▶ Broad, necessitates shallow in some areas;
 - ▶ Impossible to be exhaustive.

Stakeholder Engagement

- ▶ Promotes input from all (not just those who publish);
- ▶ Gets an up-to-date picture on the highest priorities;
- ▶ Highlights differences and consensus in opinion.

Test Facility Critical Review

- ▶ Huge scope has identified significant facilities throughout the world, particularly in: Canada, China, France, Germany, India, Italy, Japan, Korea, Switzerland, Russia and the USA.
- ▶ In light water technologies alone we identified over 25 integral test facilities and over 60 separate effects facilities still in operation.
- ▶ For GenIV technologies the lists are also extensive.

- ▶ There are a lot of test facilities world-wide but, despite this, the need for testing to support model development, design and safety system substantiation still remains a pressing requirement.

- ▶ The UK does not have a major nuclear thermal hydraulics test facility.
 - ▶ Test rigs that exist in the UK are privately owned and designed to answer a specific question for a specific reactor design.
 - ▶ Testing for research purposes is carried out abroad, e.g. India



Modelling Critical Review

- ▶ Huge scope encompassing:
 - ▶ Tools including: system codes, subchannel codes, ‘standard’ CFD, ‘advanced’ CFD.
 - ▶ Thermal-hydraulic phenomena including: natural convection, turbulence, two-phase flow, particulate transport, fluid-structure interaction, conjugate heat transfer, unsteady flows.
 - ▶ Reactor challenges: Fuel heat transfer, mixing plenums, whole system, multi-physics, multi-scale, alternative fluids.
 - ▶ Current best practice: scaling, validation/ benchmarking databases, uncertainty evaluation.
 - ▶ Current/future state-of-the-art: High performance computing, AI/Machine learning, DNS, technology transfer from other industries.
- ▶ Wide range of tools available and used.
- ▶ The thermal hydraulic complexity of plants places a high demand on ‘first principles’ tools.
- ▶ Rapid pace of development in advanced modelling tools.

User Requirements (Testing and Modelling)

- ▶ What do people want/need?
- ▶ Large stakeholder engagement activity, including 59 different organisations, encompassing:
 - ▶ Academic researchers;
 - ▶ Reactor designers (GenIII and GenIV);
 - ▶ Fuel Vendors;
 - ▶ Regulator;
 - ▶ UK Reactor Operator;
 - ▶ Code Developers;
 - ▶ Providers of technical services.
- ▶ Overall we were encouraged by the level of engagement.
 - ▶ Level of engagement was very good from light water technologies.
 - ▶ Level of engagement was mixed from the GenIV technologies.

MSR VHGR
AGR SFR BWR
LFR PWR
SCWR
GFR



What next - Facility

- ▶ Although this project started with the idea that we were developing a specification for a test rig, the work has developed.
- ▶ The emphasis is now on a multi-functional space which is suitable to house thermal hydraulic test rigs relating to different technologies. A nuclear thermal hydraulics test 'centre'.
- ▶ Our current understanding is that this specification and the business case (which is being developed in parallel – not by us) will be reviewed in the context of the budget and an ITT will go out for the design and build.



What Next – Model Development

- ▶ We have a very large number of requirements.
- ▶ Currently in the process of developing and down-selecting requirements.
- ▶ We are planning a workshop for April to generate and discuss ideas for addressing the challenges.
- ▶ A specification for further work will be developed, which we are assuming will form the basis of Phase 2 of this task.



Timescales

- ▶ Test Centre Specification due to be completed very soon (end of March).
- ▶ Modelling Specification due to be completed end of June 2018.
- ▶ Phase 1 Model Development work due to be completed in March 2019.



Carolyn Howlett, Principal Consultant

Email:c.howlett@fnc.co.uk

www.fnc.co.uk