Project Forte – Reactor Thermal Hydraulics

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SYSTEMS AND ENGINEERING TECHNOLOGY

FRAZER-NASH CONSULTANCY

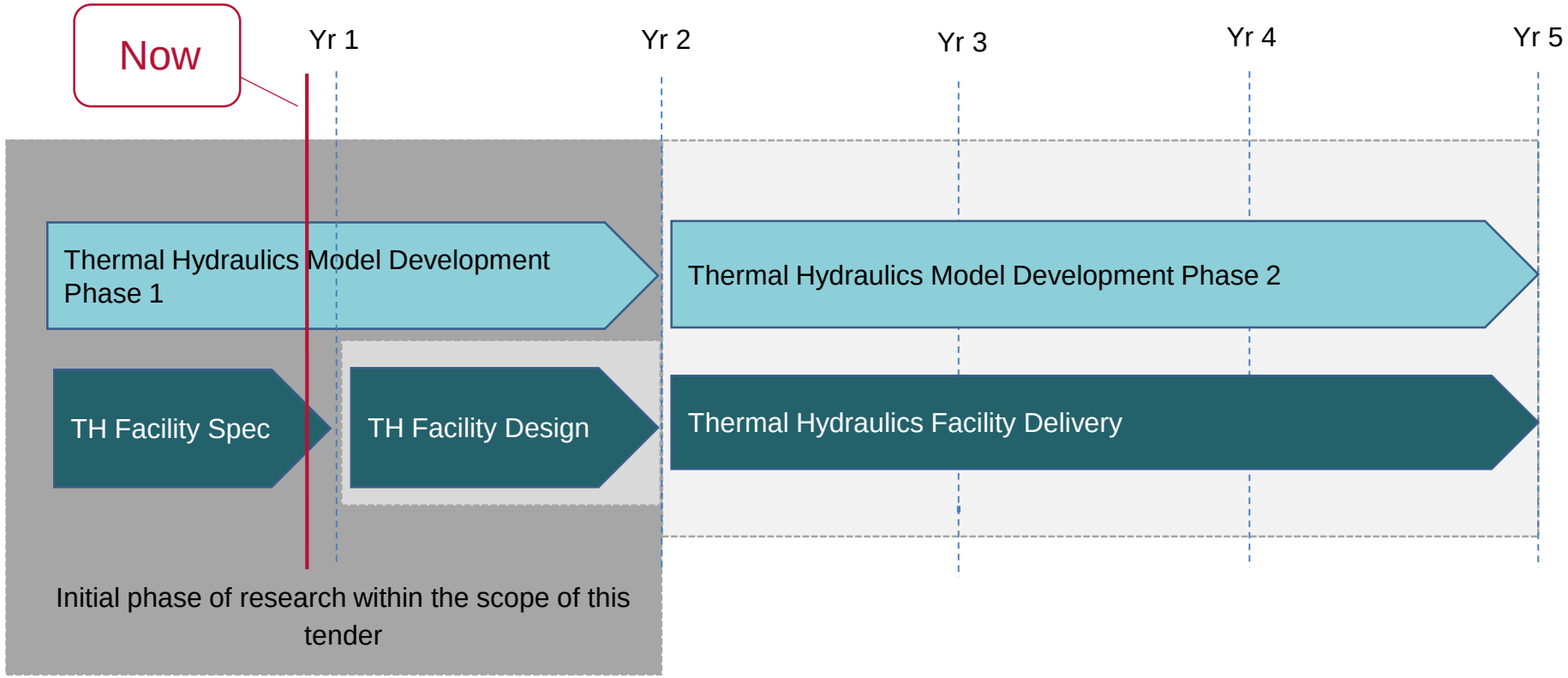
Project FORTE

- Digital Reactor Design – Thermal Hydraulics
- First phase of work originating from the NIRAB recommendations.
- Contents of presentation:
  - Reminder of programme and team;
  - First phase objectives;
  - Challenges;
  - Approach;
  - Critical Review Tasks;
  - Specification Tasks.

NOT PROTECTIVELY MARKED

Progress Through Original Plan

- 5 year Integrated Programme of R&D for Reactor Thermal Hydraulics



Thermal Hydraulics – The Team

- Lead by Frazer-Nash, the team comprises 6 core members:

Thermal Hydraulics - First Phase Objectives

- 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.

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.

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.

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