



Nuclear Innovation Programme – Thermal Hydraulics

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SYSTEMS AND ENGINEERING TECHNOLOGY



Introduction

Thermal hydraulics underpins the performance and safety of all SMR and AMR technologies

Improved thermal hydraulics modelling is essential to enhance designs and improve safety

Increased confidence in thermal hydraulic modelling tools and understanding will lead to:

- ▶ Reduced costs
- ▶ Better efficiency
- ▶ Simpler designs

Opportunity for the UK to be an international leader in thermal hydraulics



Supporting the UK Nuclear Sector Deal



Phase 1 achievements and value



Phase 2 plan and expected benefits

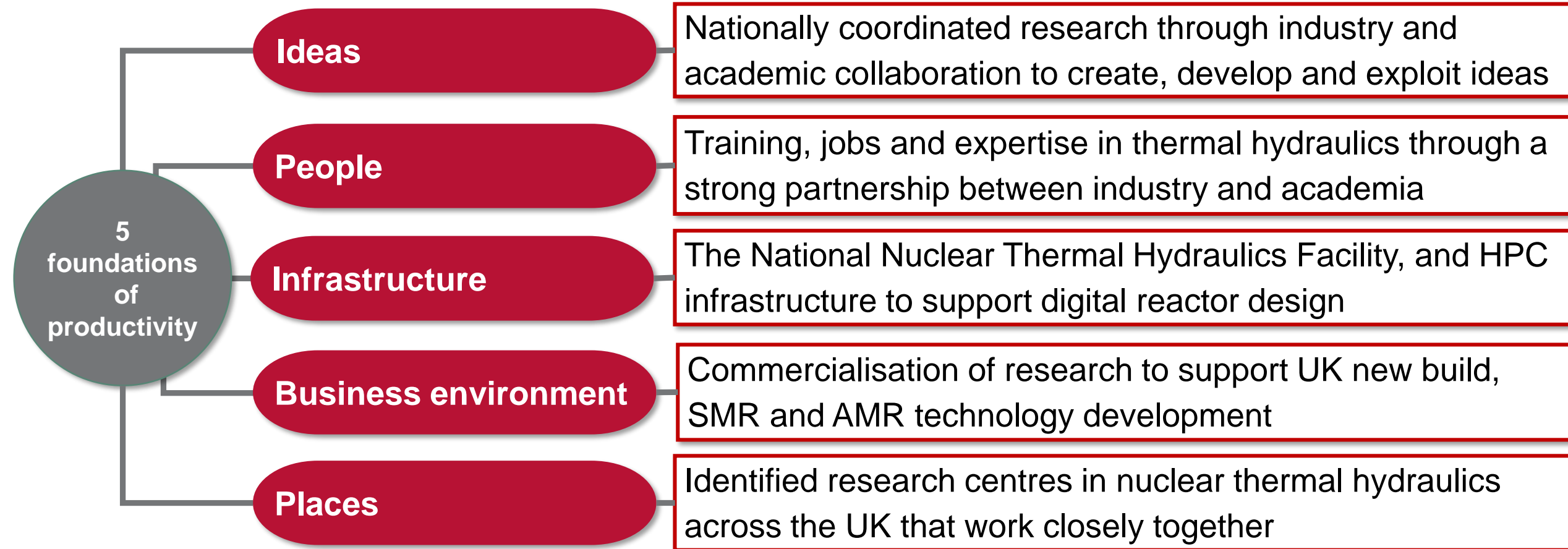


Application to advanced nuclear technologies

Our vision is to create an enduring, co-ordinated and industry focused nuclear thermal hydraulic capability in the UK

- ▶ Phase 1 project (2017 to 2019) delivered two key objectives:
 - ▶ Specification of a new thermal hydraulics facility
 - ▶ Specification of thermal hydraulic model development
 - ▶ Initial innovative model development
- ▶ Phase 2 project (2019 to 2021) will focus on **industrial application and commercialisation:**
 - ▶ Heat transfer and natural convection
 - ▶ Predictive capability for passive safety arguments
 - ▶ Upskill UK in modern digital methods
 - ▶ Relevant to all SMR and AMR technologies

Nuclear Thermal Hydraulics: Industrial Strategy Foundations



Nuclear Thermal Hydraulics: Supporting the UK Nuclear Sector Deal

Establish **world leading** UK capability in thermal hydraulics for **passive safety systems**, become preferred partner engaged in collaborative design projects for new reactors and **reduce the cost** of nuclear reactor design and build

Improved design

Enhance designs and create step change in delivery of nuclear design programmes.



Digital design process

Increase uptake of modern digital engineering practices within the UK nuclear industry.



Better efficiency

Improve understanding and safety of through life performance of reactor components.



Passive safety designs

Improve UK predictive modelling capability and understanding of passive safety arguments.



Upskill UK workforce

Develop a highly-skilled workforce to drive design improvements and underpin future operation.



International collaboration

Increase UK participation and collaboration in international activities.



Nuclear Thermal Hydraulics: Phase 1

Phase 1 has now finished. This section summarises what has been achieved during the project and the value that has been delivered

Phase 1: Our Team

- ▶ Phase 1 project had two key objectives:
 - ▶ Specification of a new thermal hydraulics facility
 - ▶ Specification of thermal hydraulic model development
 - ▶ Initial innovative model development



Phase 1 Team

Phase 1 Thermal Hydraulics Facility: Achievements

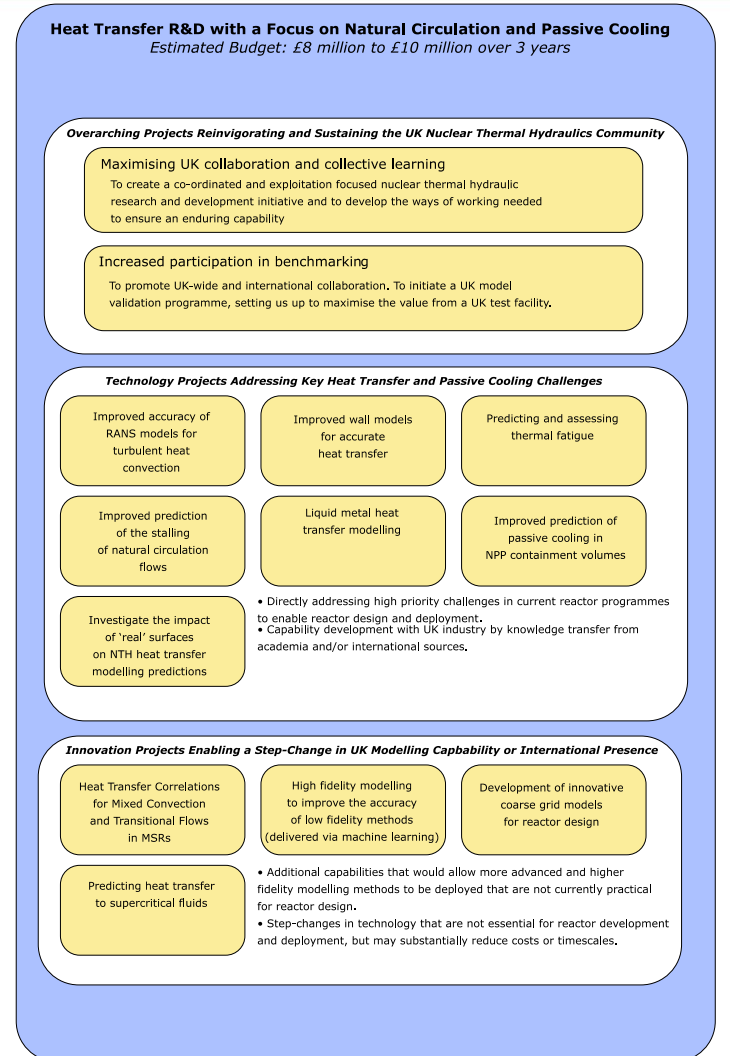
- ▶ Reviewed thermal hydraulic test facilities worldwide
- ▶ Captured user requirements for the facility
- ▶ Developed test facility specification that is:
 - ▶ Flexible, bounding and able to accommodate all SMR and AMR technologies
- ▶ Assessed Menai Science Park site against specification
- ▶ Developed commercial opportunities plan with vision for facility
- ▶ Investigated benefit to other Nuclear Innovation Programme projects
- ▶ Made clear recommendations for test facility to maximise value and appeal of the test facility
- ▶ UKAEA is now leading the design and build program for the test facility and has submitted a business case to BEIS for approval



Image courtesy of M-SParc

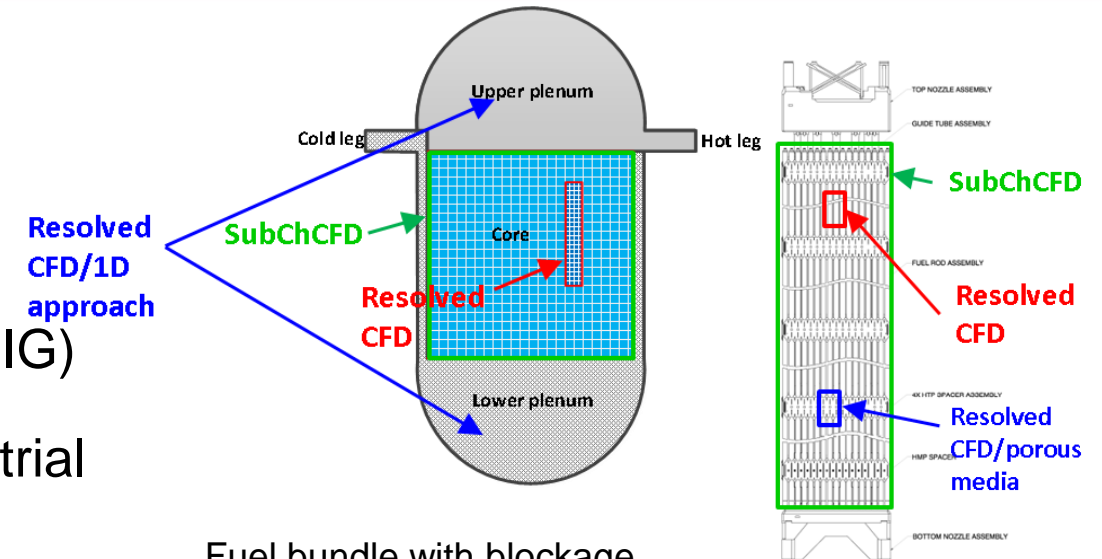
Phase 1 Model Development: Achievements

- ▶ Reviewed current state-of-the-art in thermal hydraulic prediction capability
- ▶ Captured user requirements for model development
- ▶ Specification for thermal hydraulic model development
 - ▶ Brought together UK thermal hydraulics community in workshop
 - ▶ 34 research and development proposals identified
 - ▶ Grouped into reactor and modelling technology programmes
- ▶ Initial innovative model development:
 - ▶ Single phase: Natural convection loops
 - ▶ Liquid metal: Cover gas aerosol dynamics and hot plenum region
 - ▶ Smart component models: Sub-Channel CFD (SubChCFD)

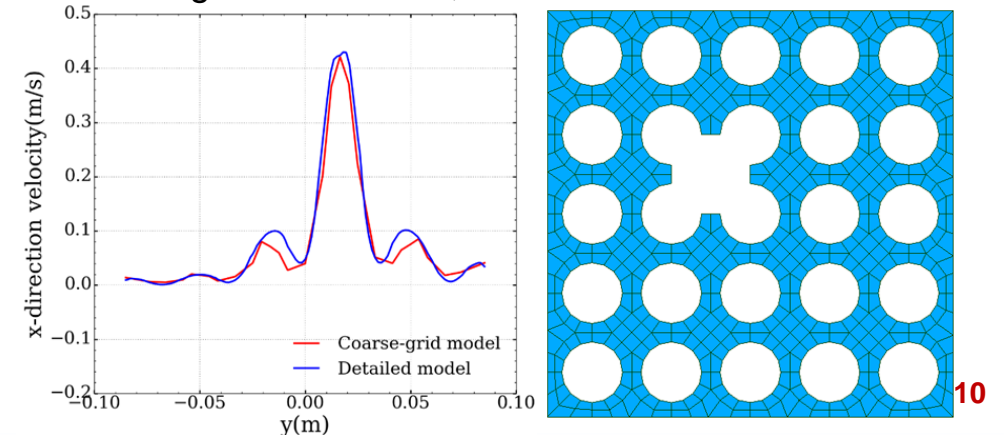


Phase 1 Model Development: Value

- ▶ UK thermal hydraulics community (industry and academia) has been brought together to improve collaboration and develop ideas
- ▶ Regular meetings now being held through Nuclear Thermal Hydraulics (NTH) Special Interest Group (SIG)
- ▶ Initial model development has the potential for industrial application and is being taken forward into Phase 2
 - ▶ For example, Sub-Channel coarse grid CFD has potential to simulate whole reactor core and replace existing subchannel codes
- ▶ Model development has upskilled UK in both SMR and AMR technologies and improved UK capability
- ▶ Built new relationships with SMR and AMR developers



Fuel bundle with blockage
Coarse grid 0.14M cells, detailed 21M cells



Nuclear Thermal Hydraulics: Phase 2

Phase 2 is now underway. This section summarises the plan for the project and the benefits that will be delivered as a result.

Phase 2: Our Team

- ▶ Phase 2 project (2019 to 2021) will focus on **industrial application and commercialisation:**
 - ▶ Heat transfer and natural convection
 - ▶ Predictive capability for passive safety arguments
 - ▶ Upskill UK in modern digital methods
 - ▶ Relevant to all SMR and AMR technologies



Phase 2: Plan

Phase 2: Provide predictive modelling capability for passive safety arguments for **SMRs and AMRs** (water, gas, molten salt and liquid metal) through innovation, development and commercialisation

6 Technical Volumes

Description of good practice for industry and regulators.



4 Case Studies

Demonstrate use of Technical Volumes to real SMR and AMR industrial applications.



Integration

Ensure thermal hydraulics project is integrated with Virtual Engineering program and test facility.



Focused R&D

Address gaps in knowledge and support case studies.



Dissemination

Disseminate research to UK community through NTH SIG and wider Nuclear Innovation Programme.



International engagement

Support international engagement and participate in next NEA CFD benchmark.



Phase 2: Industrially relevant case studies



SMR Case Study

Light Water Natural Convection relevant to an SMR.



LMFR Case Study

Passive Decay Heat Removal in a LFR.



MSR Case Study

Development of Heat Transfer Correlations in a Molten Salt Reactor with Uncertainty Quantification.

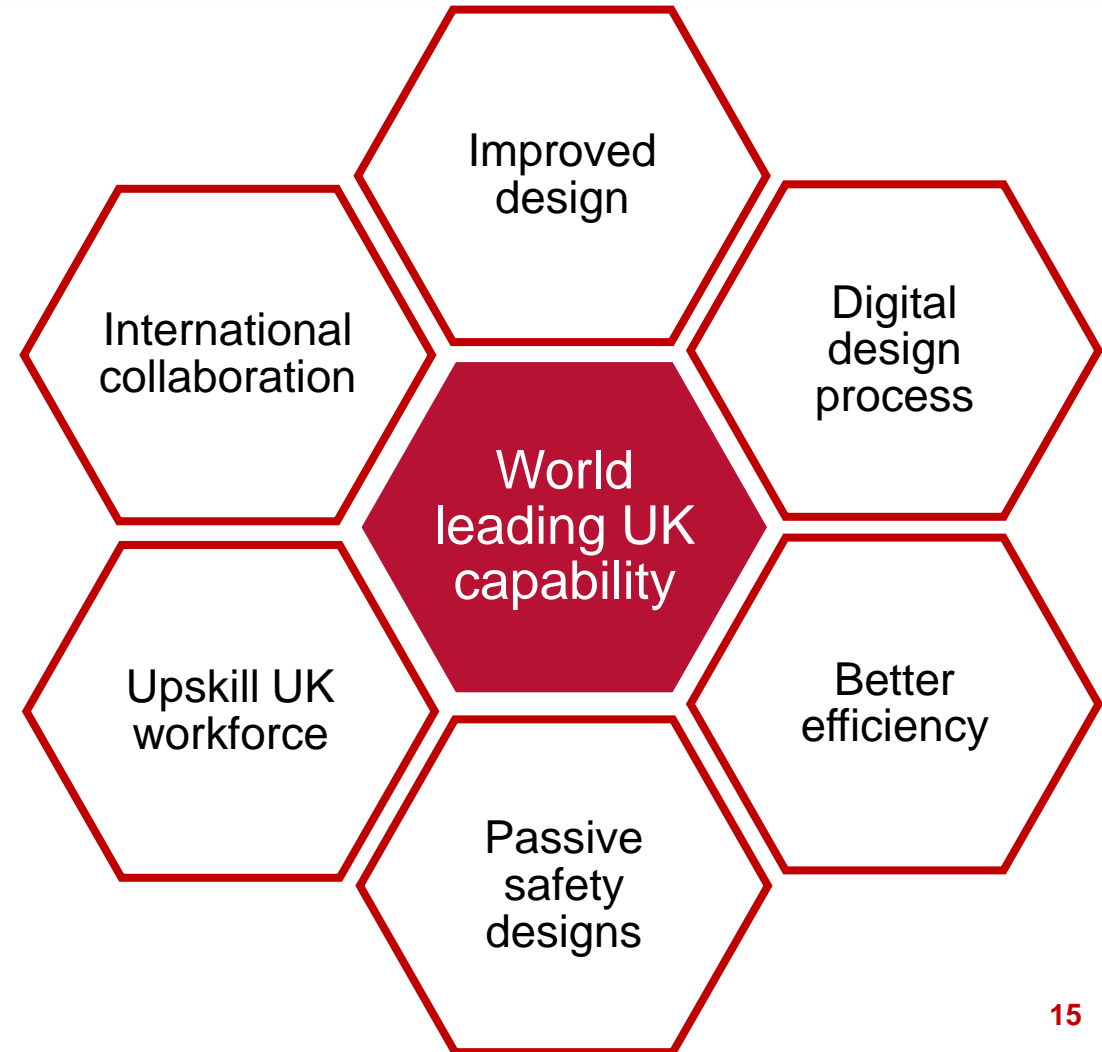


HTGR Case Study

Whole Core HTGR Model.

Phase 2: Target Benefits

- ▶ Set of Technical Volumes and Case Studies to upskill UK
- ▶ Thermal hydraulic tools integrated into Virtual Engineering toolset
- ▶ Passive safety understanding and best practice that can be applied to future reactor development
- ▶ Advanced modelling techniques to improve designs and enhance efficiency for SMR and AMR designs
- ▶ Closer links with SMR and AMR developers and increase international collaboration
- ▶ Engagement with GenIV International Forum and US National Labs on NEAMS



The Big Picture



4.6 million

Delivering new unique capability for UK export.



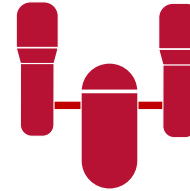
4 years

A long-term project enabling the establishment of an enduring UK capability and skills base



40 engineers

Upskilling UK workforce across industry and academia in new reactor technologies with wider dissemination to UK community.



8 reactor developers

Solving specific challenges for advanced nuclear technologies



2 collaborations

This work has directly led to Frazer-Nash involvement with international reactor developers to support their design.



International Influence

Enabled the participation in a multitude of international programmes.

Summary

Thermal hydraulics underpins the performance and safety of all SMR and AMR technologies

Phase 1: Model development and facility specification with initial innovative new methods

Phase 2: Developing advanced modelling practices for SMR and AMR technologies

Increased confidence in thermal hydraulic modelling tools and understanding will lead to:

- ▶ Reduced costs
- ▶ Better efficiency
- ▶ Simpler designs



Thermal hydraulics is key to meeting cost reduction target



Project focused on industrial applications for SMR and AMR developers



Upskilling UK workforce and disseminating knowledge to UK community



Providing route to international collaboration and commercialisation

Don't want to ask your question now? Come and find out more about our research and how you can be involved at Stand 11, in the exhibition room.

www.innovationfornuclear.co.uk

Thermal hydraulics

Securing skills and developing models through Nuclear Thermal Hydraulics research and innovation in the UK for SMR and AMR technologies.

Advanced Manufacturing and Materials

Developing understanding in advanced joining techniques for nuclear applications. Helping to unlock the blockers for the adoption of new technologies in nuclear new build

Safety & Security

Researching new techniques and methods that provide engineers with a greater insight into their reactor technology's safety and security performance, empowering them to make risk informed decisions that drive cost reduction.