STEP

STEP Magnets Technology Development Programme 2025–2029

STUART WIMBUSH

Principal Magnets Engineer for STEP

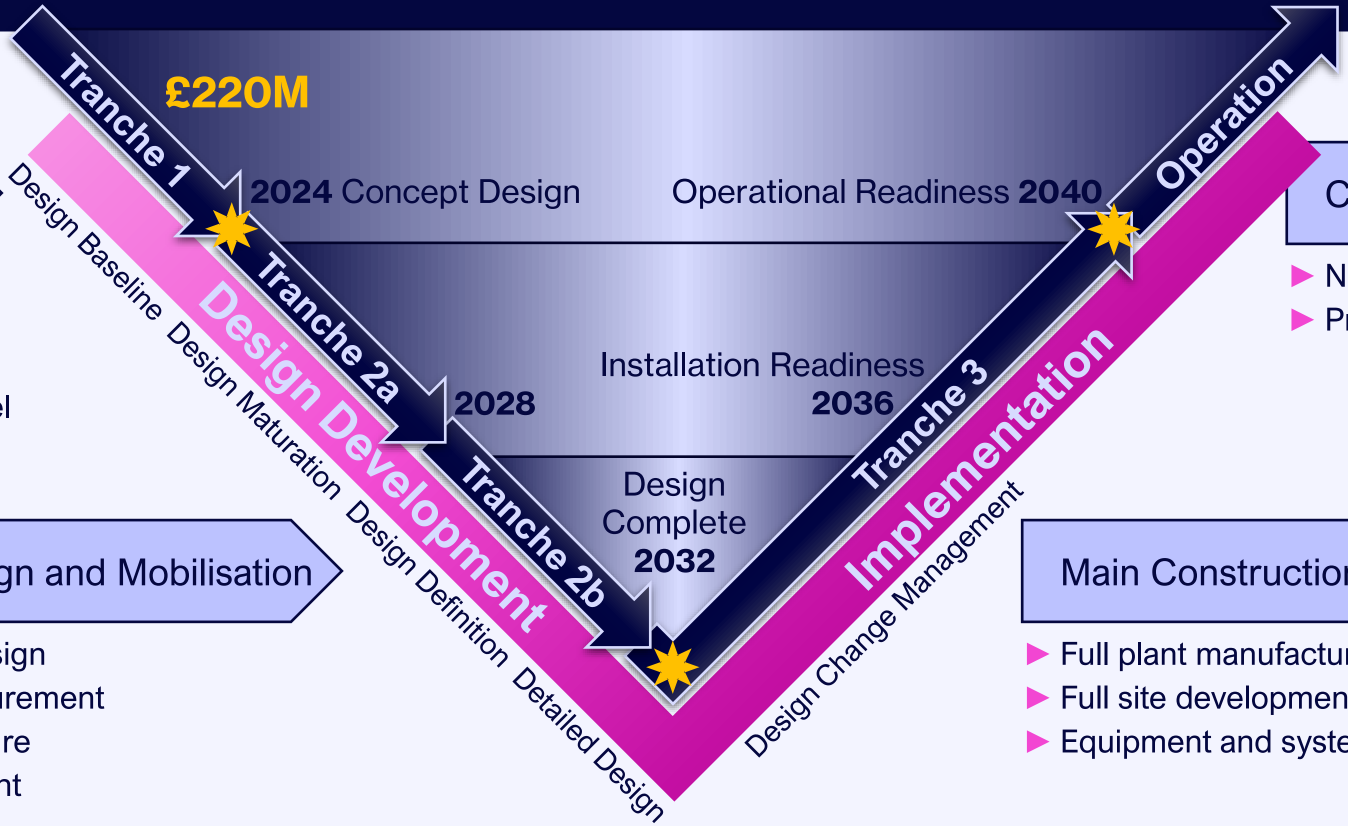
UK Industrial Fusion Solutions

2025 EUCAS

STEP TIMELINE

DELIVER A UK PROTOTYPE FUSION ENERGY PLANT, TARGETING 2040, AND A PATH TO COMMERCIAL VIABILITY OF FUSION.

STEP MISSION



Concept Design

- Concept / reference plant design
- Programme development
- Site selection
- Transition to target operating model

Commissioning and Operations

- Non-active and active commissioning
- Prototype operations

Detailed Design and Mobilisation

- Engineering design
- Long lead procurement
- Early manufacture
- Site development

Main Construction

- Full plant manufacture and assembly
- Full site development
- Equipment and system testing

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MAGNET TECHNOLOGY DEVELOPMENT 2025–29

BUILDING A STEP TOROIDAL FIELD MODEL COIL

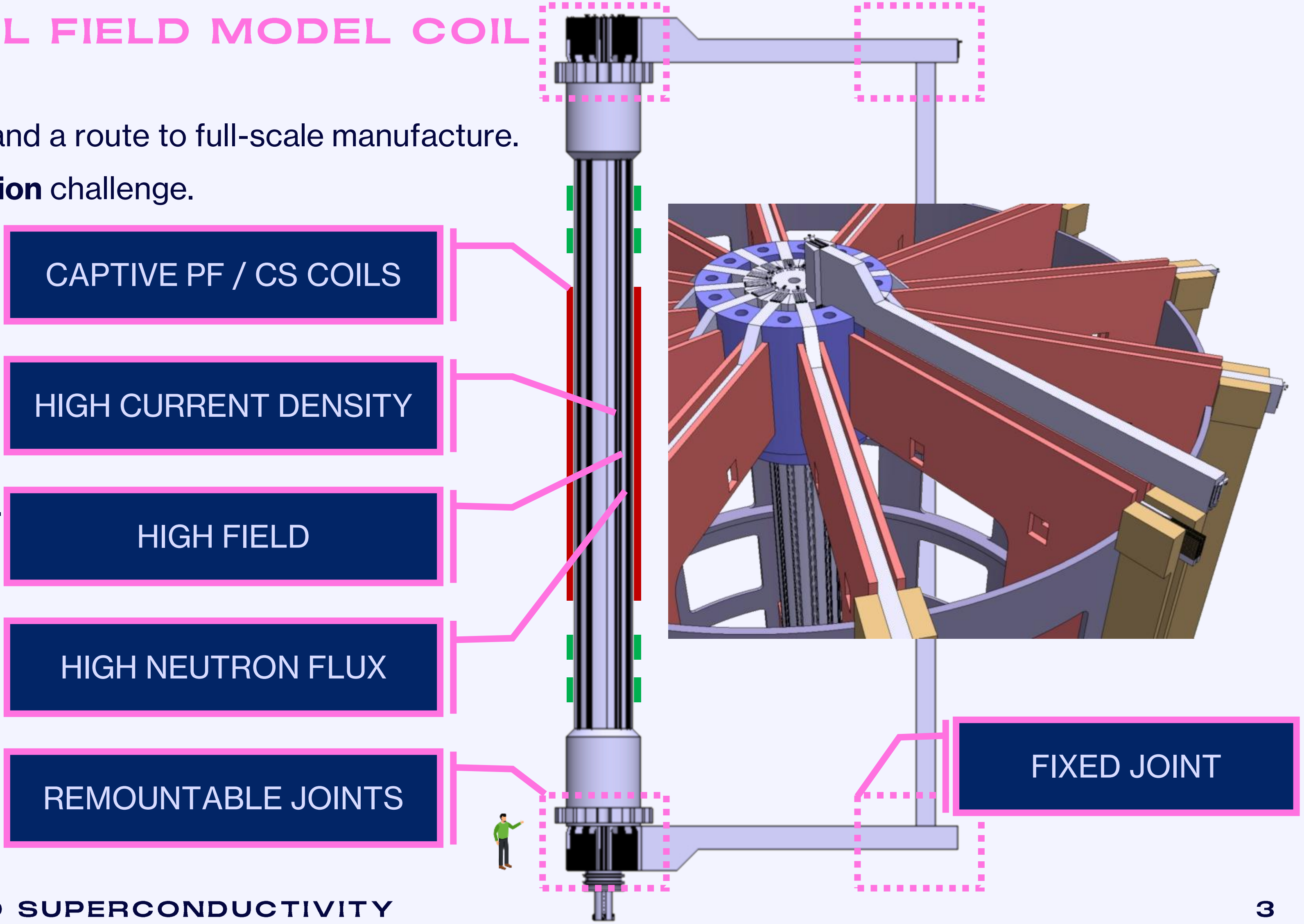
Test a TF model coil, demonstrating functionality and a route to full-scale manufacture.

Why the TF? Design driving – the biggest **integration** challenge.

- Extremely space constrained.
- Novel jointed architecture.
- Unprecedented scale.

Along the way:

- **Quench detection / protection** methodology.
- High current (90 kA) **dc cable** development.
- **HTS tape** selection and quality control.



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TAPE SELECTION AND QC

LARGE VOLUME SCREENING AND PERFORMANCE EVALUATION

The problem:

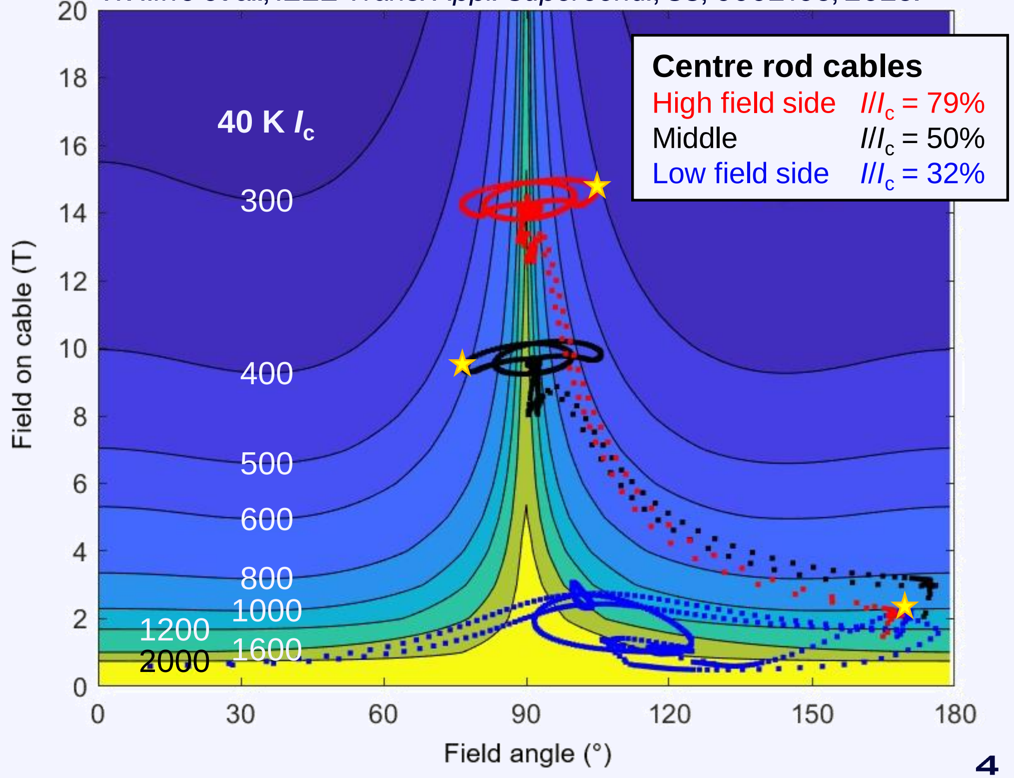
- STEP requires *something like* 30,000 km of tape. (Annual global production is somewhere around 5,000 km.)
- We need to control our margins (implies grading of cables).

Want to push as much of this work as we can onto tape manufacturers, but to do that, we need clear requirements.

Presently:

- Working with manufacturers to understand what they can offer.
- Working on potential standards for the industry.
- Developing and testing our models to see how accurately we can predict performance
  - up to 16–18 T
  - at 40 K.

W. Iliffe et al., *IEEE Trans. Appl. Supercond.*, **35**, 6602105, 2025.



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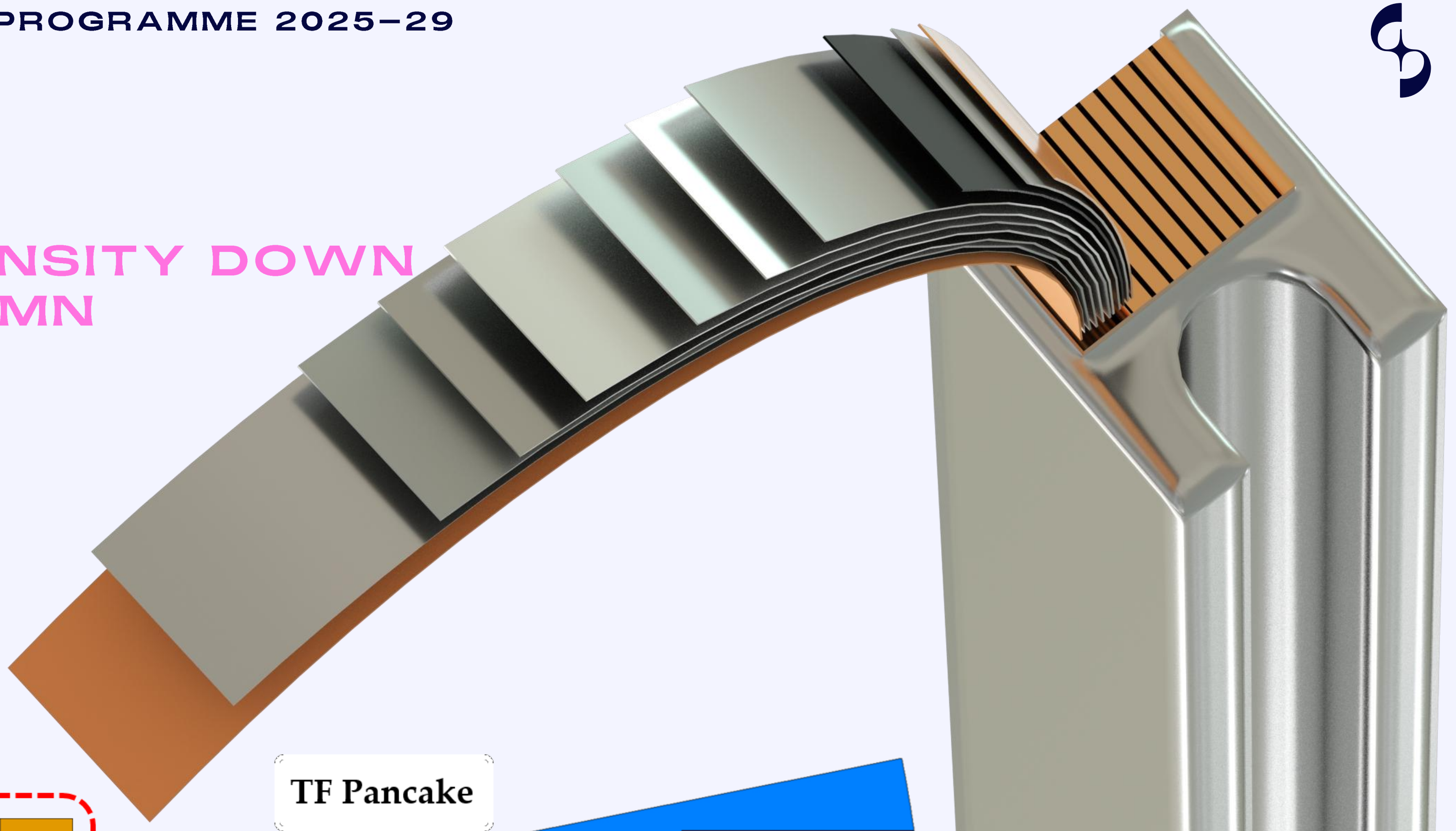
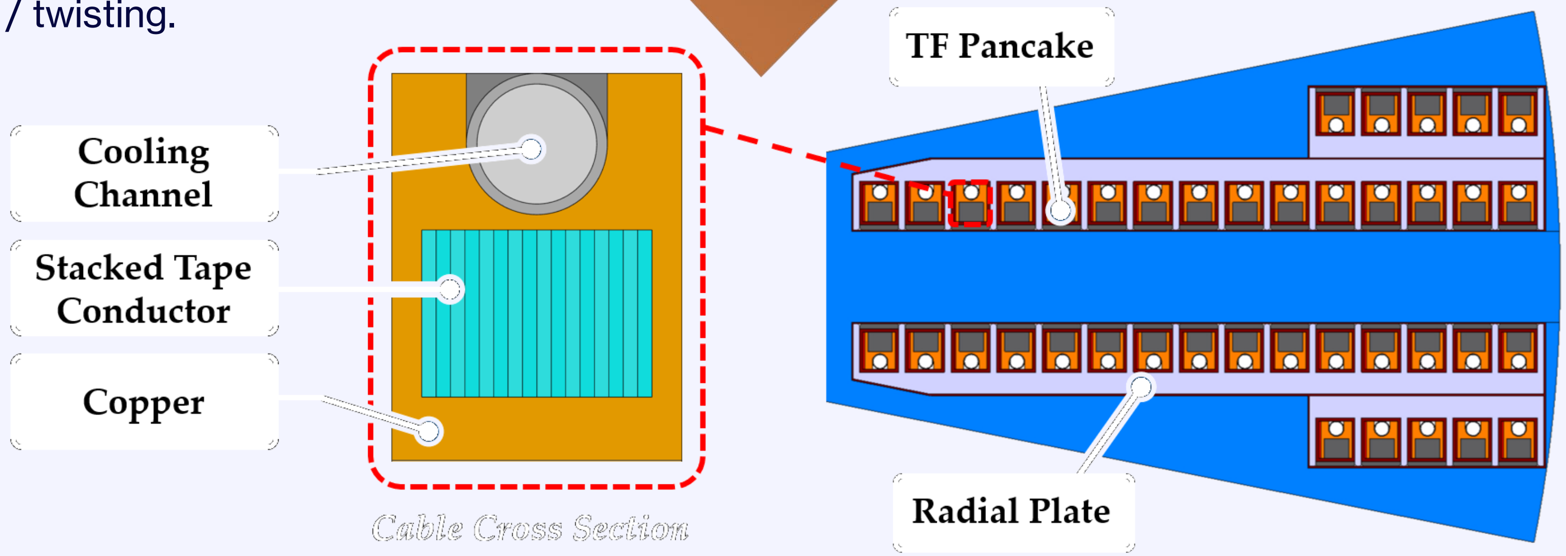
THE STEP TF CABLE

PROVIDING HIGH CURRENT DENSITY DOWN THE SLENDER CENTRAL COLUMN

- Stacked tape cable targeting high current density.
- ~ 225 12 mm tapes in a vertical stack.
- Targeting 90 kA at 20 K, 20 T.
- Integrated cooling channel.
- Single-plane bending.
- Internal/external mechanical support.
- No transposition / twisting.





Cable Cross Section

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TF CABLE DEVELOPMENT

3-LP-TM (Wednesday pm) **Jacob Rochester**
Manufacture and SULTAN testing of a TF cable design for the STEP tokamak

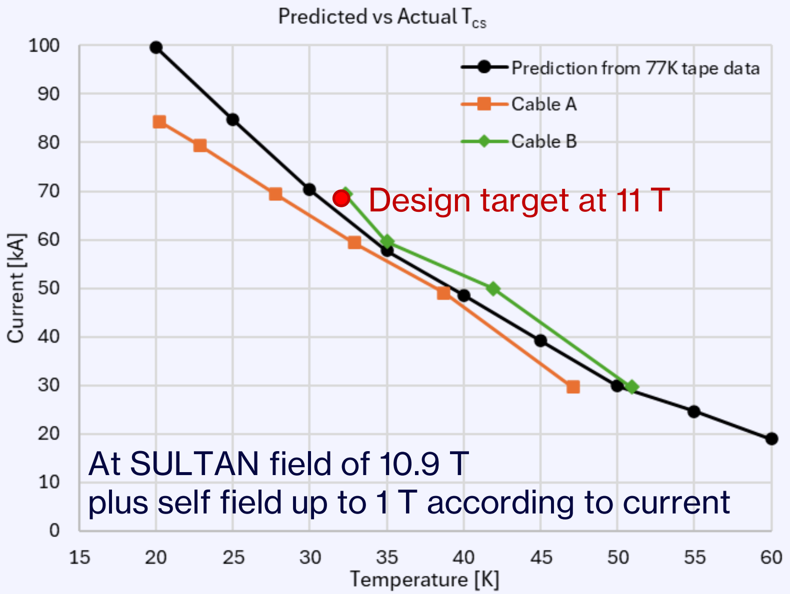
Tokamak Energy

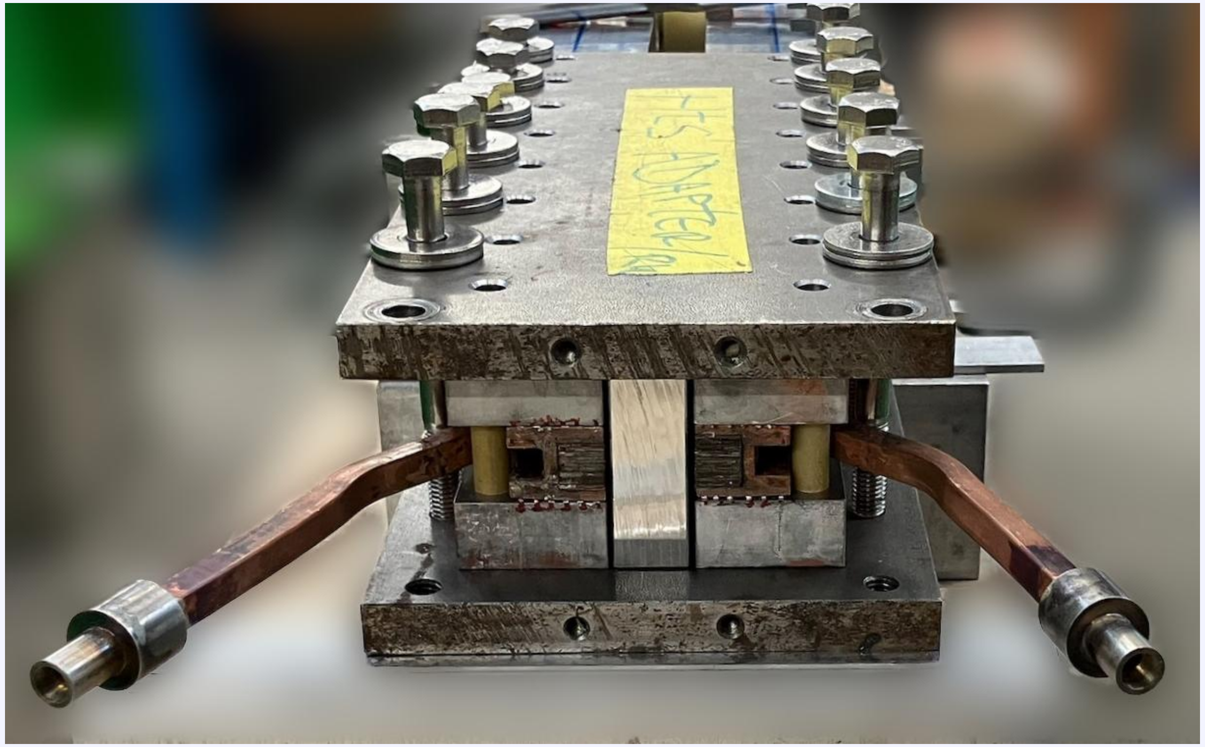
ACHIEVING A 90 kA CABLE

Three parallel development programmes with different partners, tested at SULTAN.

Each trials a different manufacturing approach to the same design, targeting slightly different things:

- Joint performance (65 tapes)
- SULTAN-matching performance (154 low-performance tapes)
- Full-stack performance (200 high-performance tapes)





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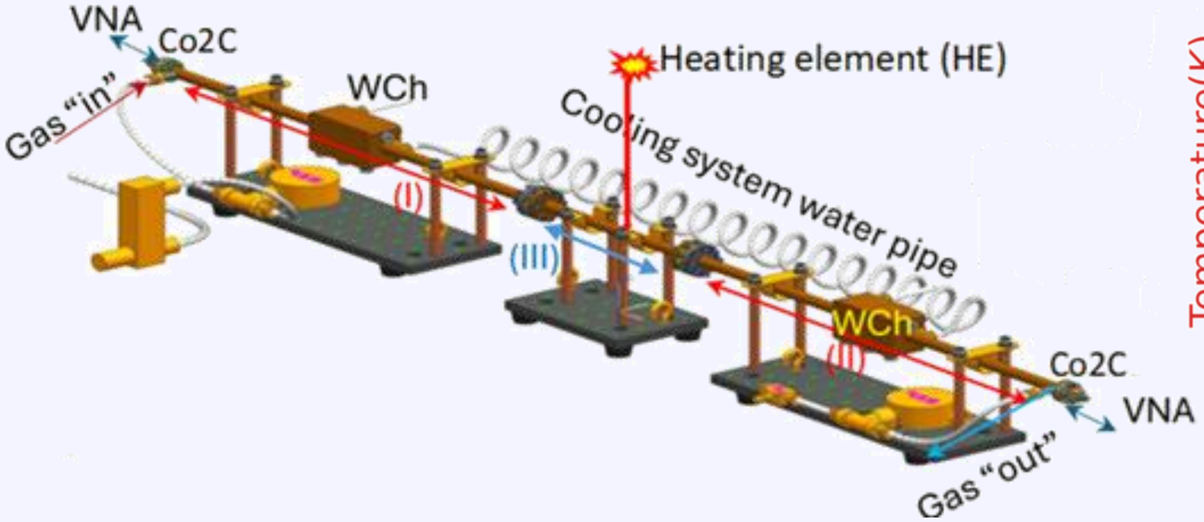
QUENCH DETECTION

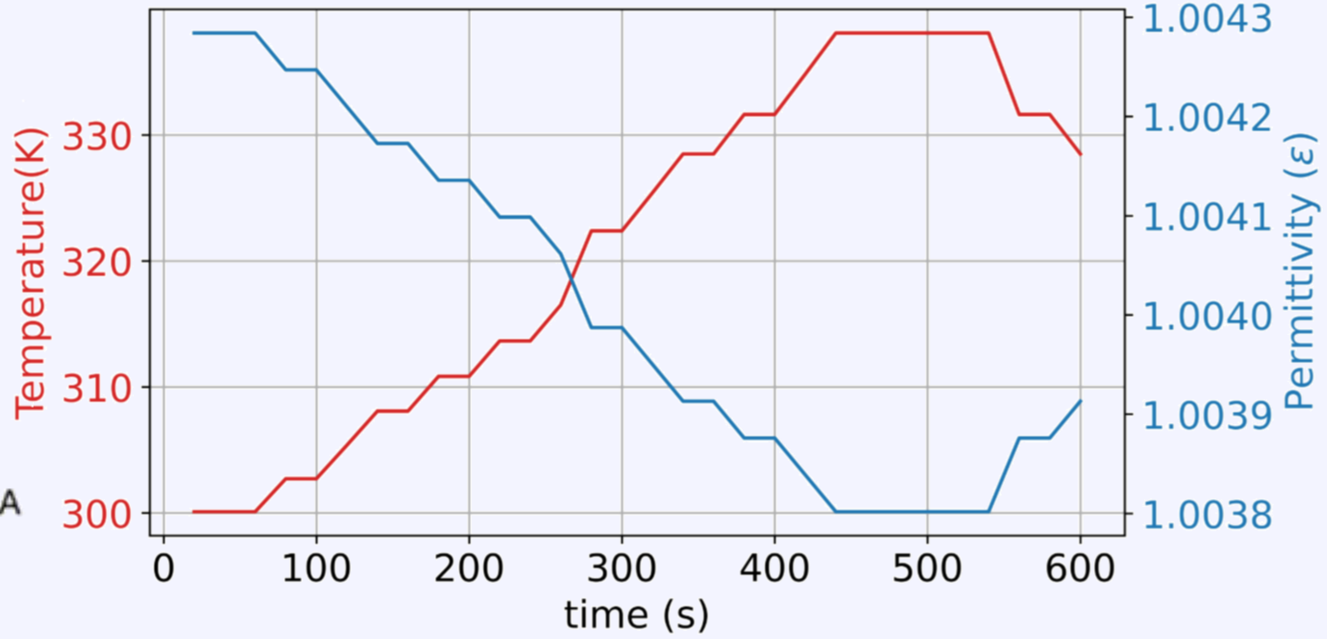
RF COOLANT TEMPERATURE MONITORING

- Need to detect the development of a localised hotspot within 10s of km of cable in the electrically noisy fusion environment.
- Concerns around degradation of optical fibres due to irradiation.
- Instead trialling a non-intrusive reflectometry technique utilising the embedded cable cooling channels.
- Technique first developed by ITER but suffered from attenuation losses.

I. V. Konoplev, O. Fernandez-Serracanta et al.
"High temperature superconducting magnet quench detection via coolant gas temperature monitoring"
submitted for publication to Phys. Rev. Applied 2025

Proof-of-principle lab testing (at room temperature):





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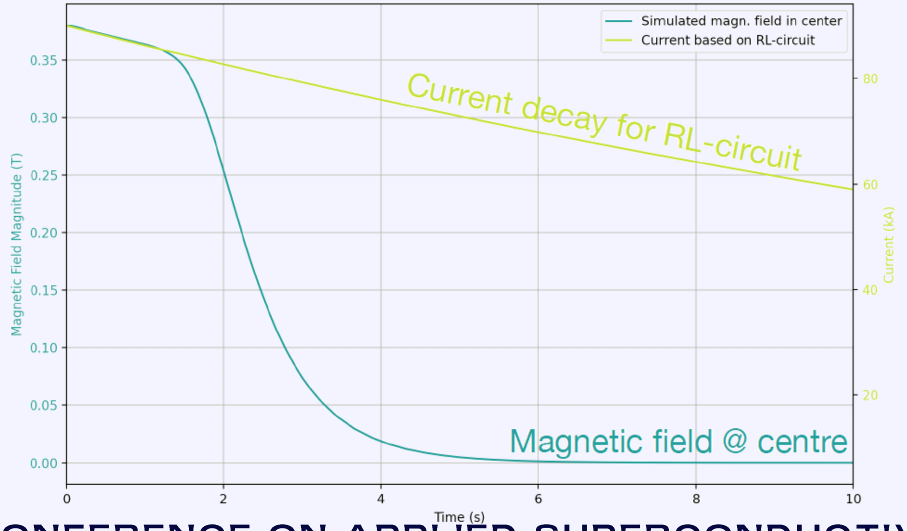
QUENCH PROTECTION

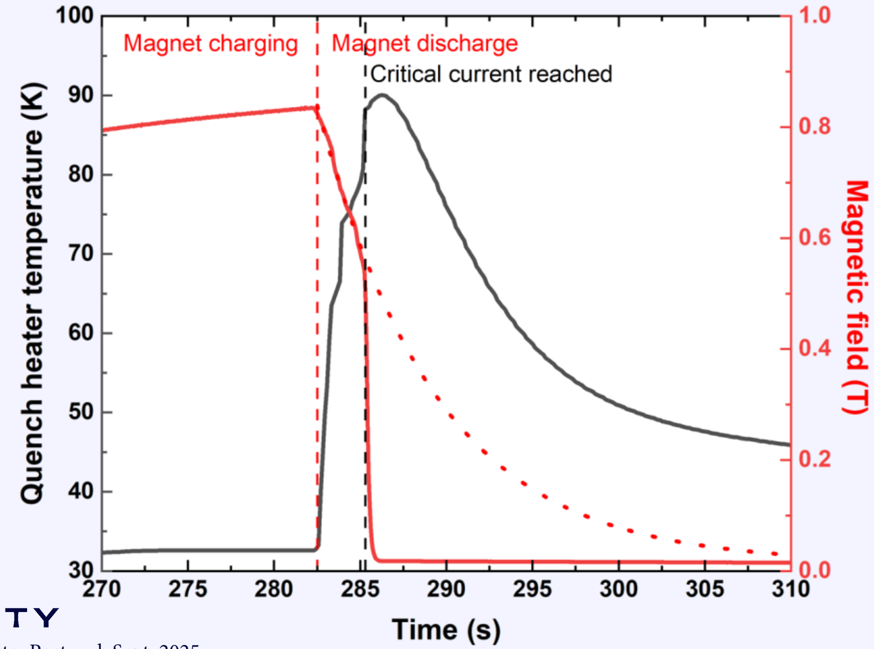
2-LP-QF (Tuesday pm) **Jiabin Yang**
Quench simulation of STEP TF coil cage system

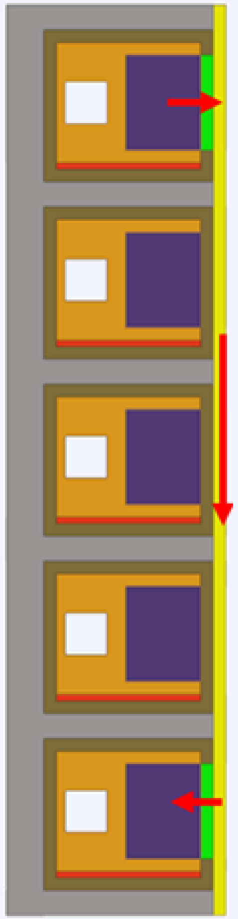
SELF-DISCHARGING LOW-VOLTAGE QUENCH PROTECTION SCHEME

- ITER and JT-60SA have highlighted the risk of Paschen breakdown in fusion magnets.
- Achieving reliable Paschen tightness on remotely assembled remountable joints is considered impractical.
- Our strategy is to pursue a quench protection scheme that maintains a voltage below the Paschen minimum (~100 V).
- **This rules out external dump resistors for the STEP TF coils.**
- We make each coil its own dump resistor: opening the circuit causes the coil to discharge its stored energy into itself.
- Having explored partial insulation schemes, we've now settled on the incorporation of a quench (discharge) heater into a fully insulated coil.

Little Beast engineering







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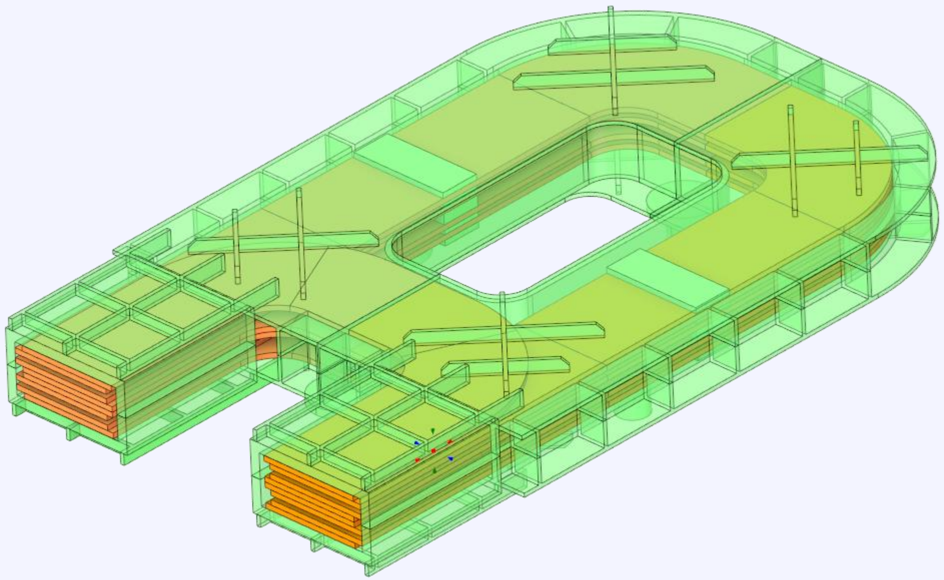
STEP TOROIDAL FIELD MODEL COIL

PROVING THE STEP TF MAGNET CONCEPT

A sub-scale coil designed to implement and test essential features of the STEP TF coil while advancing manufacturing capability.

Quench detection and protection
Remountable joints
High-current cables

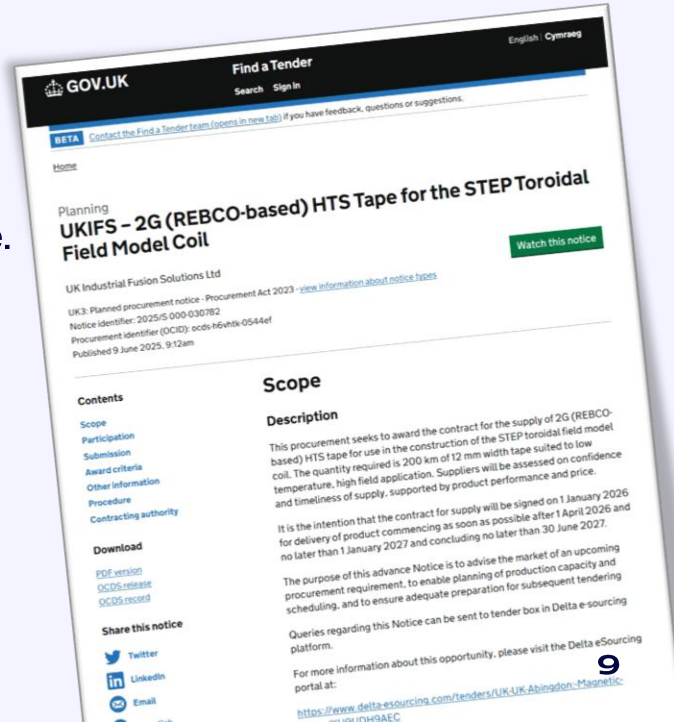
Pre-concept design



- Broadly 1⁄10 size: 3.6 m × 2.0 m.
- Two legs (instead of four) implementing two remountable joints for disassembly.
- Four pancakes, 15 cable turns per pancake.
- 90 kA (full) current capacity.
- ~ 100 km of 12 mm HTS tape – £7M Planned Procurement Notice issued in June.

Parameters

- Central field: 3.8 T.
- Max. field on tape: ~ 9 T.



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Planning
UKIFS – 2G (REBCO-based) HTS Tape for the STEP Toroidal Field Model Coil
Watch this notice

UK Industrial Fusion Solutions Ltd
UK3: Planned procurement notice - Procurement Act 2023 - view information about notice types
Notice identifier: 2025/S 000-030782
Procurement identifier (OCID): ocds-h6vhtk-0544ef
Published 9 June 2025, 9:12am

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Scope

Description

This procurement seeks to award the contract for the supply of 2G (REBCO-based) HTS tape for use in the construction of the STEP toroidal field model coil. The quantity required is 200 km of 12 mm width tape suited to low temperature, high field application. Suppliers will be assessed on confidence and timeliness of supply, supported by product performance and price.

It is the intention that the contract for supply will be signed on 1 January 2026 for delivery of product commencing as soon as possible after 1 April 2026 and no later than 1 January 2027 and concluding no later than 30 June 2027.

The purpose of this advance Notice is to advise the market of an upcoming procurement requirement, to enable planning of production capacity and scheduling, and to ensure adequate preparation for subsequent tendering

Queries regarding this Notice can be sent to tender box in Delta e-sourcing platform.

For more information about this opportunity, please visit the Delta eSourcing portal at:

https://www.delta-esourcing.com/tenders/UK-UK-Abingdon:-Magnetic-

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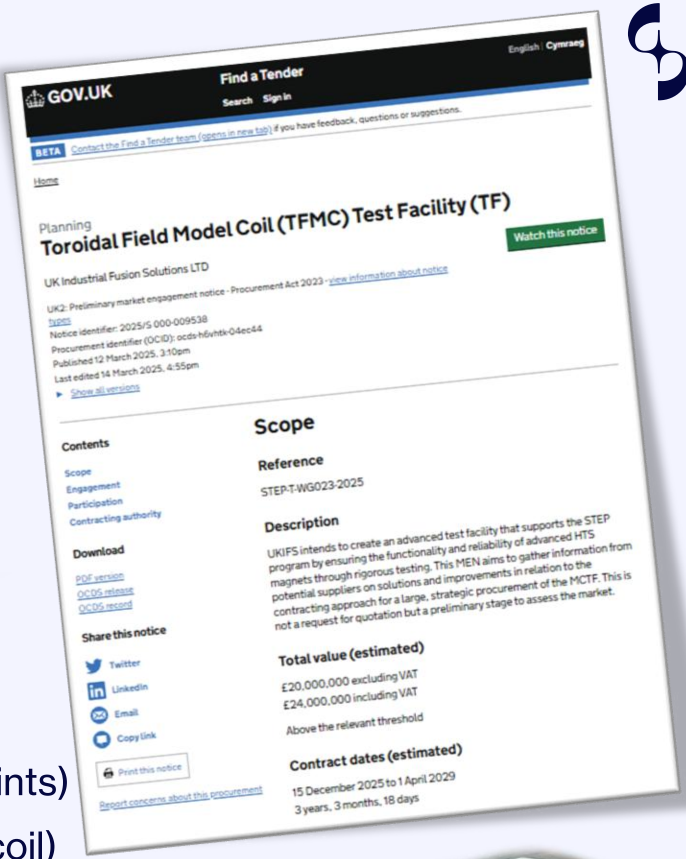
STEP MODEL COIL TEST FACILITY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Planning

Toroidal Field Model Coil (TFMC) Test Facility (TF)

Watch this notice

UK Industrial Fusion Solutions LTD

UK2: Preliminary market engagement notice - Procurement Act 2023 - view information about notice types

Notice identifier: 2025/S 000-009538

Procurement identifier (OCID): ocds-h6vhtk-04ec44

Published 12 March 2025, 3:10pm

Last edited 14 March 2025, 4:55pm

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Report concerns about this procurement

Scope

Reference

STEP-T-WG023-2025

Description

UKIFS intends to create an advanced test facility that supports the STEP program by ensuring the functionality and reliability of advanced HTS magnets through rigorous testing. This MEN aims to gather information from potential suppliers on solutions and improvements in relation to the contracting approach for a large, strategic procurement of the MCTF. This is not a request for quotation but a preliminary stage to assess the market.

Total value (estimated)

£20,000,000 excluding VAT

£24,000,000 including VAT

Above the relevant threshold

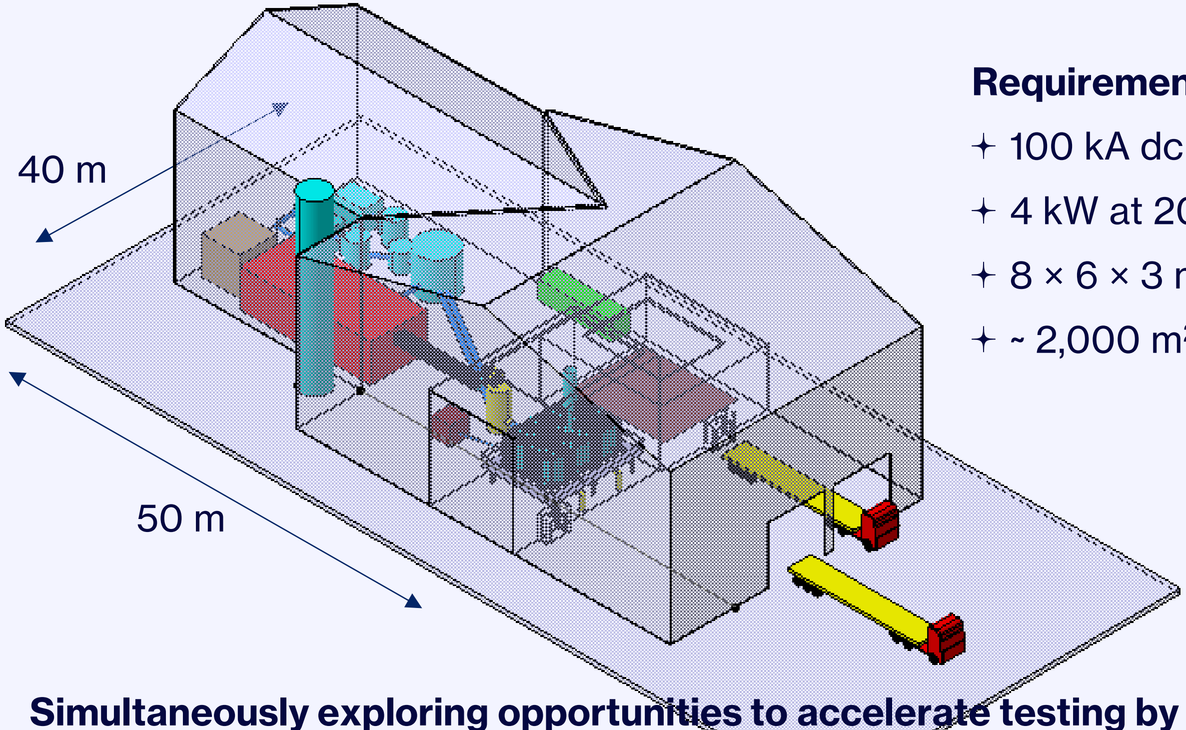
Contract dates (estimated)

15 December 2025 to 1 April 2029

3 years, 3 months, 18 days

THE UK'S MOST SIGNIFICANT MAGNET TEST FACILITY

- One of the first facilities to be built on-site at STEP in West Burton.
- Market Engagement Notice issued in March for £20M project to design, install and commission.
- Intended to evolve with Programme needs post-TFMC.



Requirements

- 100 kA dc power supply (to drive a quench)
- 4 kW at 20 K cooling capacity (to cool the joints)
- 8 × 6 × 3 m^3 cryostat (to accommodate the coil)
- ~ 2,000 m^2 footprint (to allow space for growth)

Simultaneously exploring opportunities to accelerate testing by partnering.

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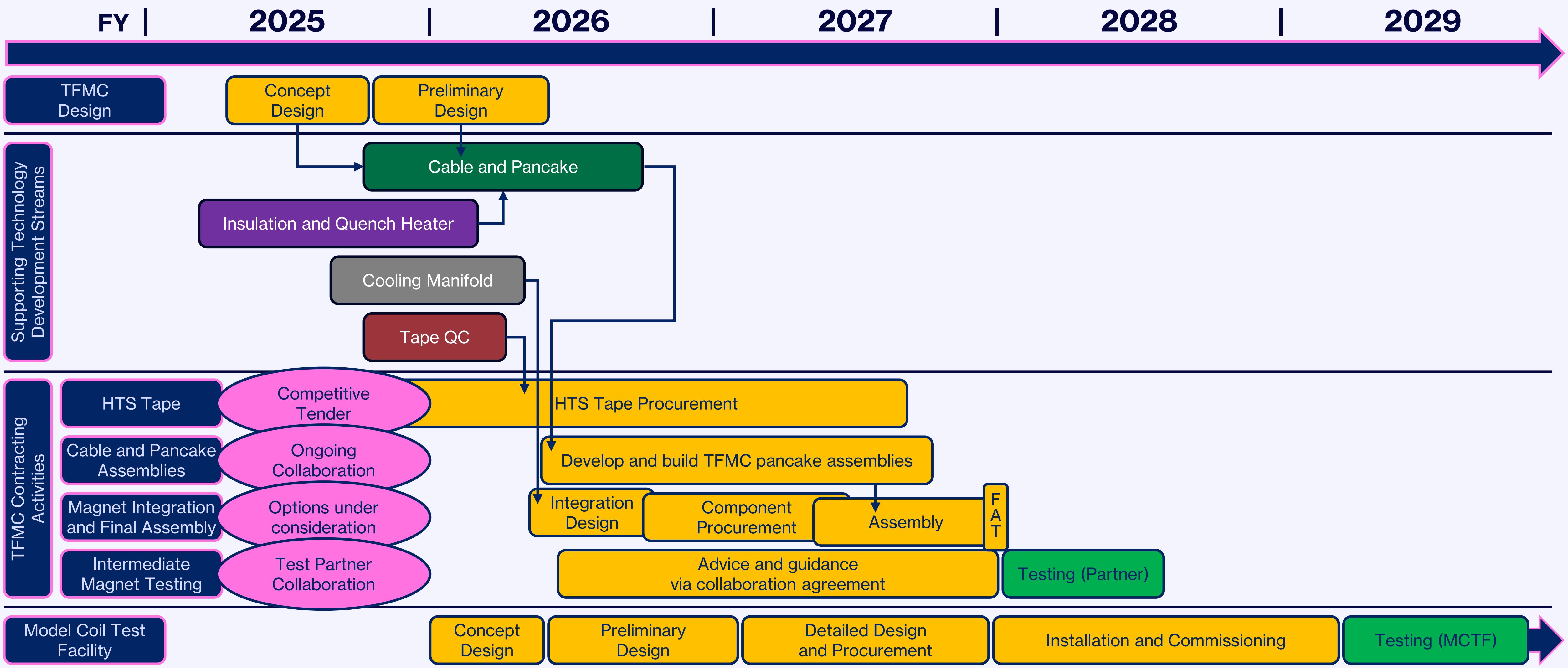
TIMELINE TO TFMC



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STEP

FORWARD TO FUSION