



UKAEA

The path to delivering fusion power

Ian Chapman



Q: What world-changing idea, small or big, would you like to see implemented by humanity?

A: **This is easy. I would like to see the development of fusion power** to give an unlimited supply of clean energy, and a switch to electric cars. Nuclear fusion would become a practical power source and would provide us with an inexhaustible supply of energy, without pollution or global warming.



Stephen Hawking, 'Brief Answers to the Big Questions', 2018

Government position on Brexit

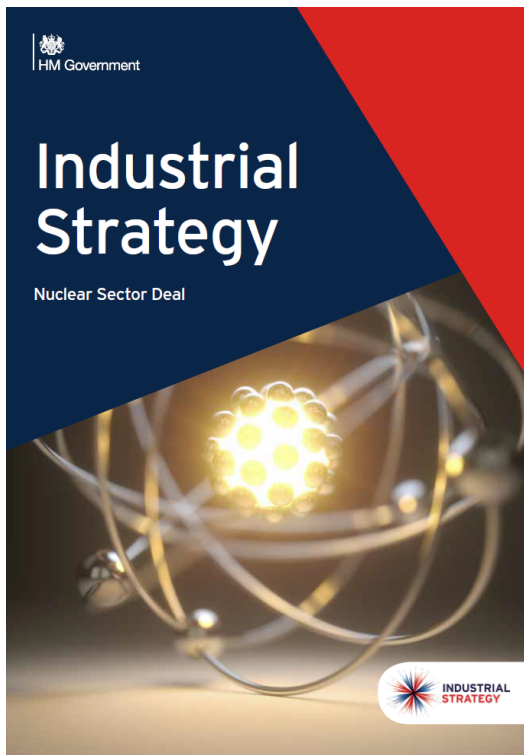
Greg Clark MP, Secretary of State for the Department of Business, Energy and Industrial Strategy, made the following written statement earlier this year:

“The UK’s specific objectives in respect of the future relationship are to seek a close association with the Euratom Research and Training Programme, including the Joint European Torus (JET) and the International Thermonuclear Experimental Reactor (ITER) projects”

The Prime Minister said on 21st May 2018: **“The UK would like the option to fully associate ourselves with ... Euratom R&D. Of course, such an association would involve an appropriate UK financial contribution, which we would willingly make”**

This is a clear statement that UK will seek an association which we hope will allow all of our current fusion programmes to continue after 2020

Nuclear Sector Deal



Government have agreed a nuclear sector deal as part of the UK's industrial strategy

This shows support for fusion

“UKAEA operates world leading fusion devices...and the government is investing in innovation to ensure the UK remains at the forefront of this nuclear technology”

“The government is exploring with UKAEA the scope for further expanding the Culham site as a hub for advanced nuclear technologies”

Science Minister Opinion Piece

“I think it is time for us to have some moonshots of our own as a country, like the Apollo mission. Tackling big scientific projects that are difficult to do, that will have huge impact when successful on our society and our economy.

“There are a number of sectors where Britain is poised to lead the world.
Firstly in the sector of fusion technology. This is the safest, cleanest more sustainable form of energy and no-one in the world has the expertise that we have here.



(Ex-)Science Minister Opinion Piece

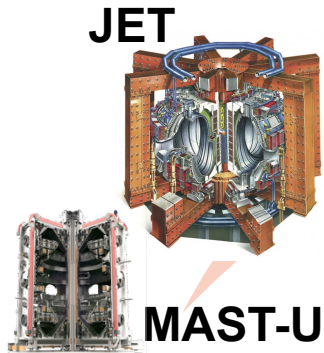
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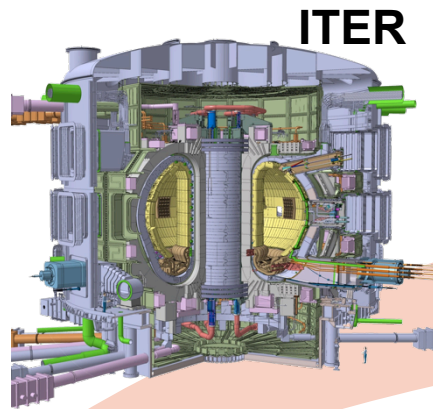
Goals on path to delivering fusion power

1. Maintain
leadership in
fusion R&D



MAST-U

2. Enable economic
growth and create
high-tech jobs



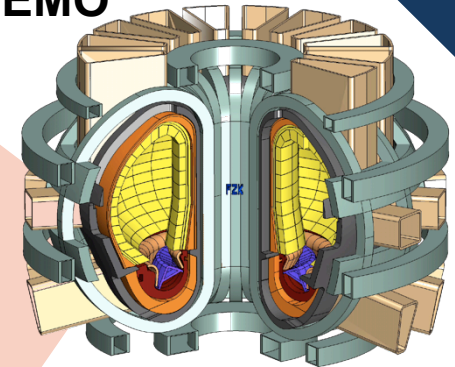
ITER

4. Design the first
fusion reactors



STEP

DEMO



3. Advancing fusion
materials and technology



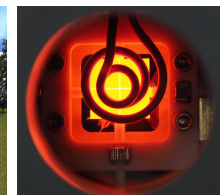
RACE



MRF

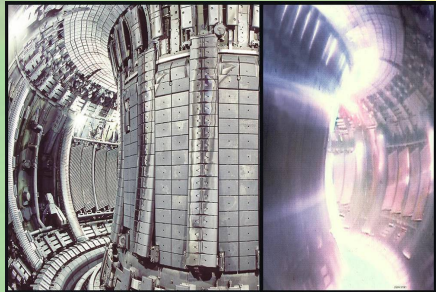


H3AT



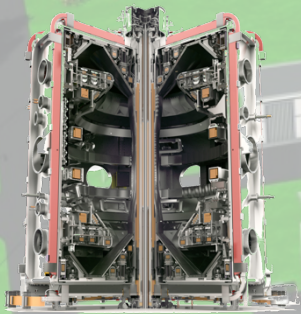
FTF

Fusion needs integrated solutions



JET

RACE



MAST
Upgrade



Materials Research
Facility



Fusion Technology
Test Facilities



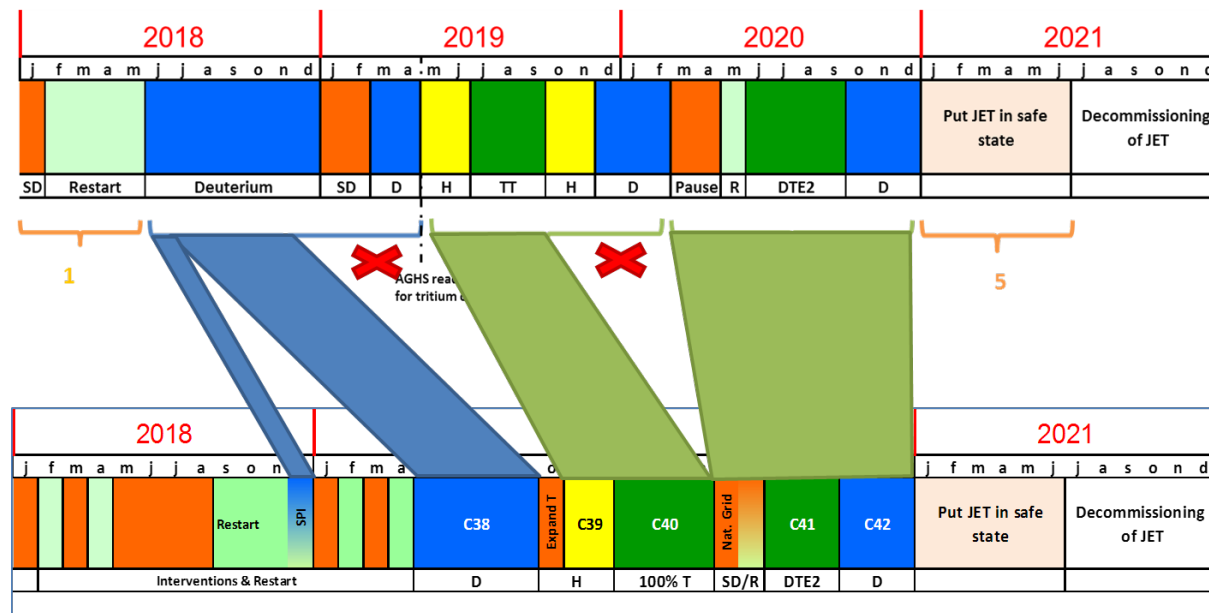
H-3 Advanced
Technology (H3AT)

Delays in the 2019-20 campaigns

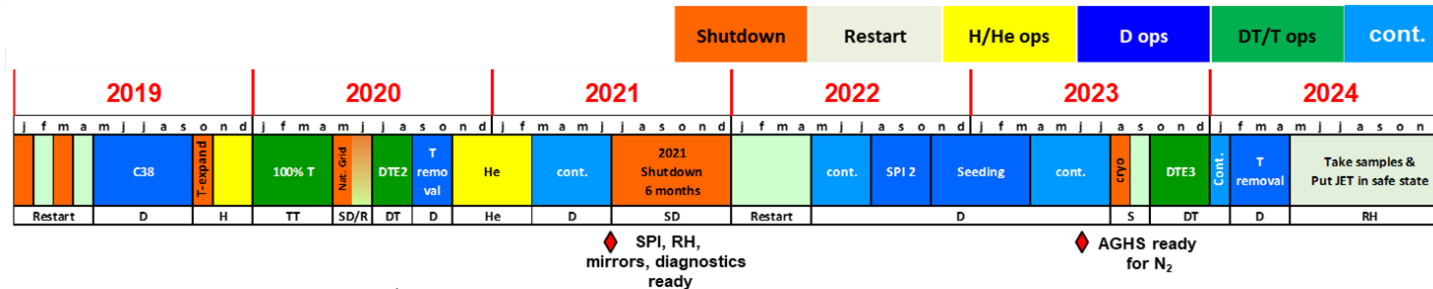
Two substantial delays:

A water leak in NIB8 means all PINIs need to be reconditioned

Two transformer surge arresters have been damaged after IS limiter fuses blew



JET until 2024



Programme elements ~fixed

DTE2: With 14 MeV neutron budget of 3×10^{20} (~10 pulses at 10-15MW/5s)

He for ITER (H-mode, ILW)
LIDS, Contingency for Seeding (bring forward 3-4 months)

6-month shutdown:

- SPI2
- ITER mirrors
- Diagnostics (14 MeV, radiation)
- Take samples from ILW

ITER disruption studies:

- with 2nd SPI
- ITER like operations**
- Seeding with ILW, $q_{95} \sim 3$

DTE3 & T removal:

- N₂ seeding, LIDS
- Budget: 13×10^{20} 14MeV

Put JET in safe-state:

- Remove ITER mirrors
- LIDS
- Diagnostic calibrations
- Take samples from ILW

MAST Upgrade



MAST-U Enhancements

Extra diagnostics (2018+19)

*X-point Thomson scattering
RT Langmuir probes
Multiple extra IR cameras
2 fast visible cameras*

Upgraded control (2018 - 20)

New Vertical Control and RT enhancements

Flexible Fuelling (2019)

Pellet injector + 48 gas valves

Cryoplant (2020)

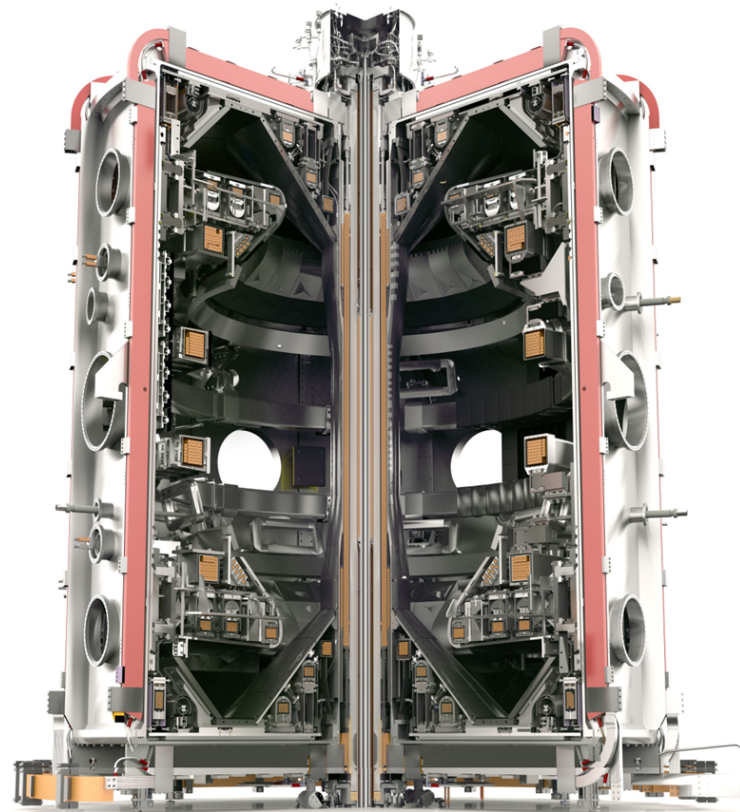
Divertor & DBB particle control

Double NBI Box (2021)

Additional 5MW auxiliary heating

Non PEX upgrades

*Power supply upgrade for 5 sec pulses
Galden cooling for solenoid
Etc.*



Latest on MAST Upgrade

Assembly is complete and first low-temperature fusion fuel operated successfully (including by Duke of Cambridge!)

Now commissioning power supplies and coils and expecting operation from mid-2019



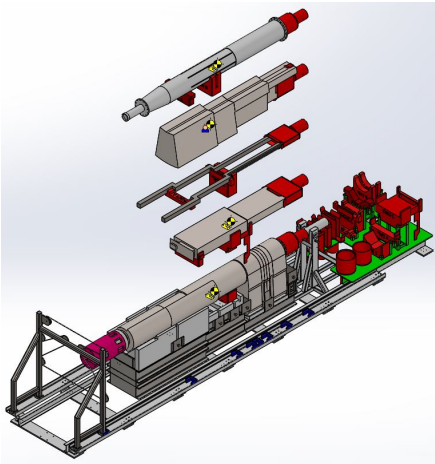
Materials Testing in MRF



Latest on RACE

RACE is now the biggest nuclear robotics lab in Europe (perhaps!)

Three examples: The cutting station for the European Spallation Source; delivering person-free glove boxes for nuclear decommissioning; in-bore cutting and welding



DEMO

Laser Welding Trials Inside a 90mm Pipe



Latest on RACE

The Telescopic Articulated Robotic Manipulator is now commissioned and being used for engineering tests

Will be a unique test bed for control systems, tools, sensors etc



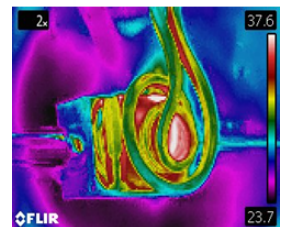
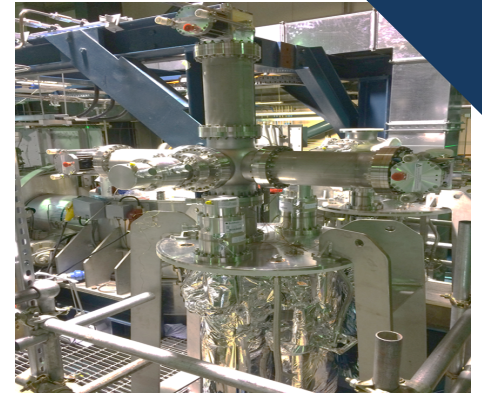
TARM
Joint Commissioning



FTF and H3AT

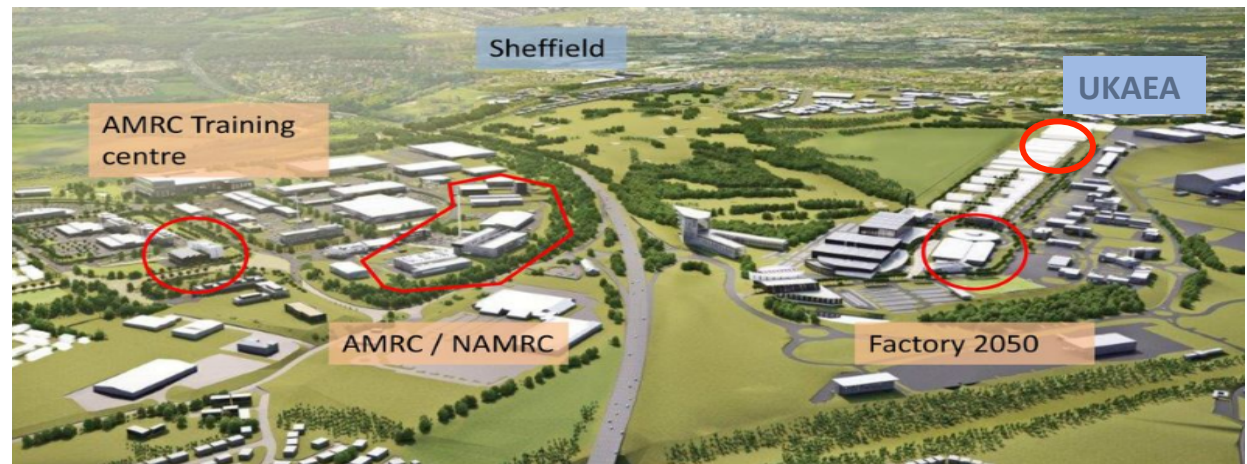
£86M investment announced one year ago by UK Govt

The Fusion Technology Facilities and the Hydrogen-3 Advanced Technology centre will be unique in the world for testing tritium storage/processing and equipment qualification under high heat flux + magnetic fields



Expanding off the Culham site (maybe)

- On condition of suitable lease terms
- Facility available summer 2020



Thermal Hydraulics Facility

- UK Government funding (£40m) for a national facility
 - Underpin safety case of future UK reactor designs
 - Support operation of new-build
 - Testing for next generation fission plants
- UKAEA commissioned to produce concept designs, delivery plan & business plan by mid-2019
- Government to decide whether to proceed in 2019. Future UKAEA involvement dependent upon business plan



Apprentice Training

Currently have an award-winning apprentice scheme, with ~80 apprentices

Expanding with a new building with £12M to train 125 p.a. from 2019, in partnership with many local businesses

Latest on OAS

OAS build
progressing
~1 year
ahead of
schedule

Advanced
Manufacturing
Training
Centre
appointed as
training
provider

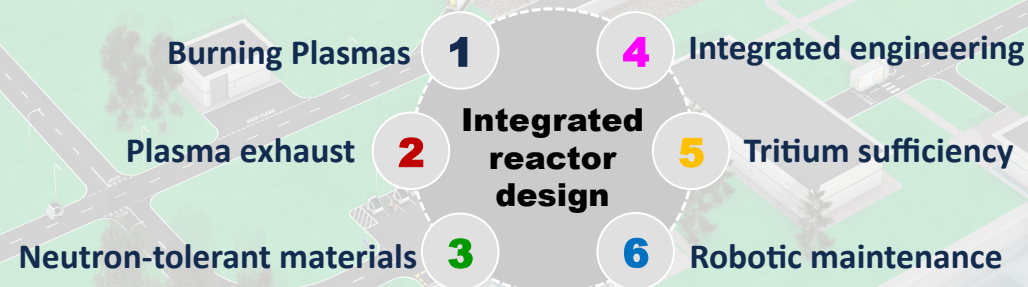


Spherical Tokamak for Energy Production (STEP)

We are beginning a conceptual design for an ST reactor – must produce net electricity, aiming for T self-sufficiency, and materials, availability etc which scale to an economic power plant

Programme is a tight collaboration between UKAEA and UK industry and academia. UK government have provided £20M to begin this work

Will retain a strong role in EU-DEMO. Large overlap between the two programmes



Conclusions

UK government have invested £86M in 2 new facilities: H3AT and FTF, both due to be operational from early 2021

Also invested £20M in the concept design of STEP (Spherical Tokamak for Energy Production). We are undergoing a review for potential future funding

We continue to grow significantly, though always in our role as a national lab to support the supply chain. Eg recruited >300 people during 2018