



An update on the UK fusion programme

Ian Chapman

Policy and Politics

Technical Challenges

STEP Programme

Other UKAEA issues

Government is backing fusion development

Overarching goals of the fusion strategy:

1. For the UK to demonstrate the commercial viability of fusion by **building a prototype fusion power plant in the UK**
2. For the UK **to build a world-leading fusion industry which can export fusion technology** around the world in subsequent decades

Towards Fusion Energy

The UK Government's Fusion Strategy



October 2021

UK Fusion regulation

Green Paper:

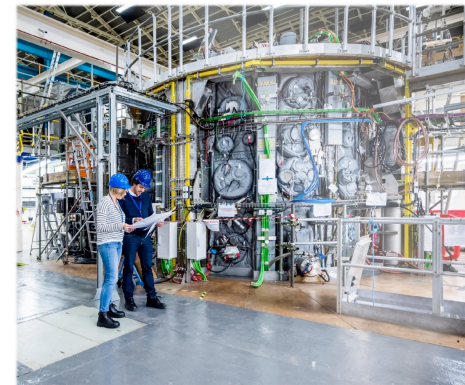
“We want to **trailblaze a proportionate and pro-innovation approach** and collaborate internationally to maximise fusion’s long-term global potential. With this plan, the UK hopes to lead the world on fusion regulation and enable the safe and rapid development of [fusion]”

Energy Security Bill:

“Creating a new pro-innovation regulatory environment for fusion energy.”

Towards Fusion Energy

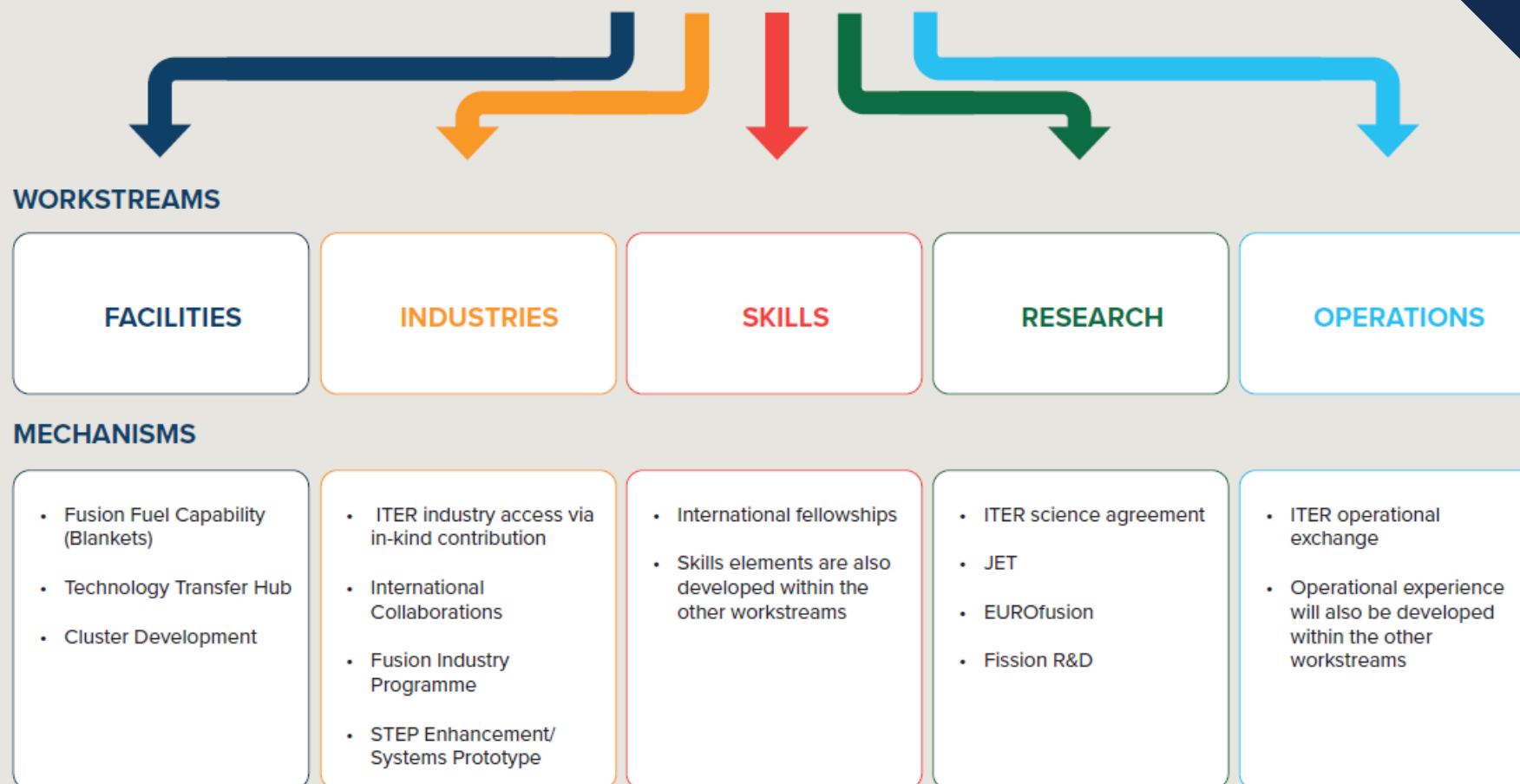
The UK Government’s proposals for a
regulatory framework for fusion energy



Closing date: 24 December 2021

October 2021

EURATOM ALTERNATIVES PROGRAMME



Pre-decision spend

Government have publicly committed to spending on certain items even before a decision about Association to provide some certainty to the sector. This is worth £480M and includes:

- £84M for JET and EUROfusion activities until the end of 2023
- £42M for a full Fusion Industry Programme (new)
- £200M for “Research Infrastructure” to be spent by Mar 2024 (new, not allocated)

Science Minister Open Letter: “The UK has done everything it can to secure association, including entering into formal consultations with the EU but the EU continue to refuse our request to formalise association. It remains the UK’s preference to associate to EU R&D programmes, and the government remains ready to discuss association with the EU, however we cannot wait forever.”

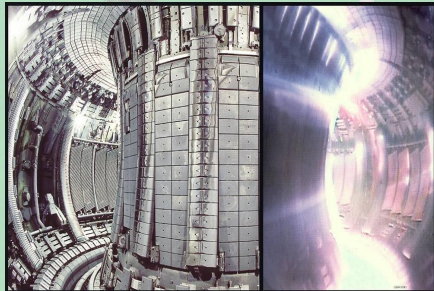
Policy and Politics

Technical Challenges

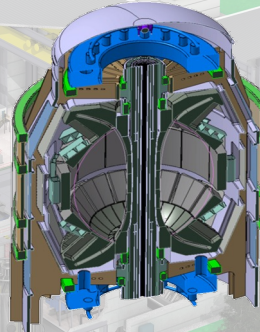
STEP Programme

Other UKAEA issues

Fusion needs integrated solutions



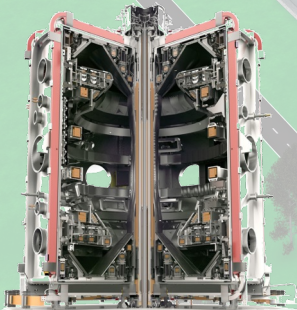
High performance
plasmas in JET



Powerplant Design
STEP and DEMO



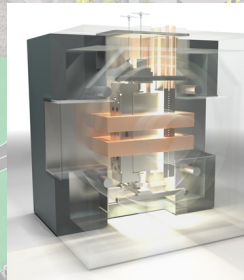
Advanced
computing and
digital design



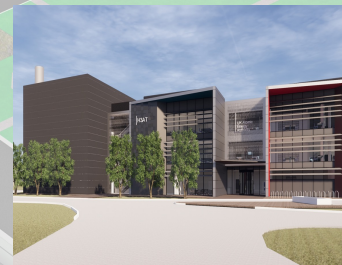
Heat exhaust in
MAST Upgrade



Develop materials in
Materials Research
Facility (MRF)



Test components in
Fusion Technology
Test Facilities (FTF)



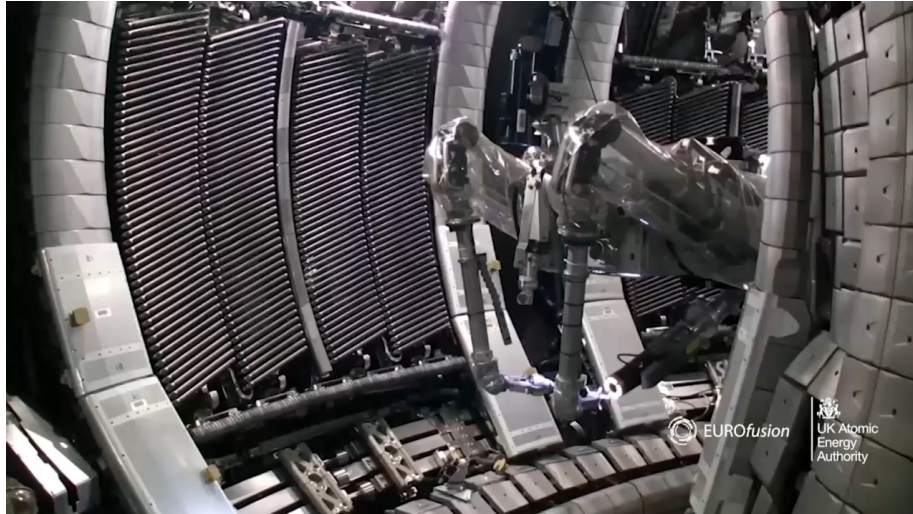
Tritium handling in
Hydrogen-3 Advanced
Technology (H3AT)



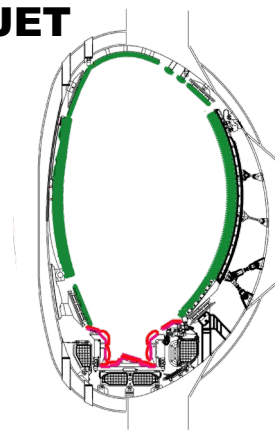
Robotic handling
in RACE

A major rebuild of JET

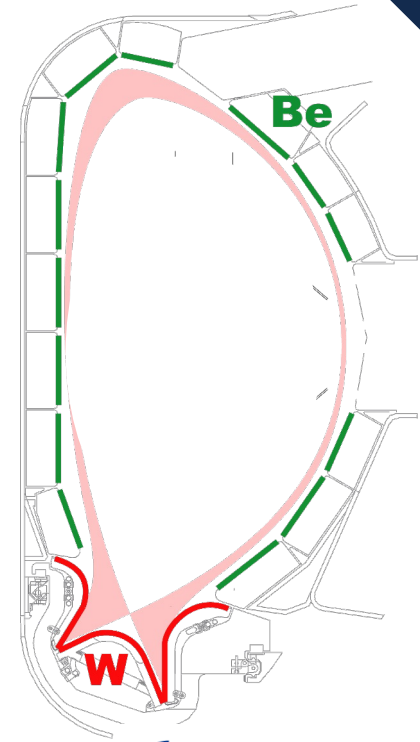
- A ten-year programme to demonstrate high performance with powerplant-fuels in an environment as close to ITER as possible
- First step to change the wall, all done with sophisticated robotics, to prove the tritium captured in the wall is low



JET

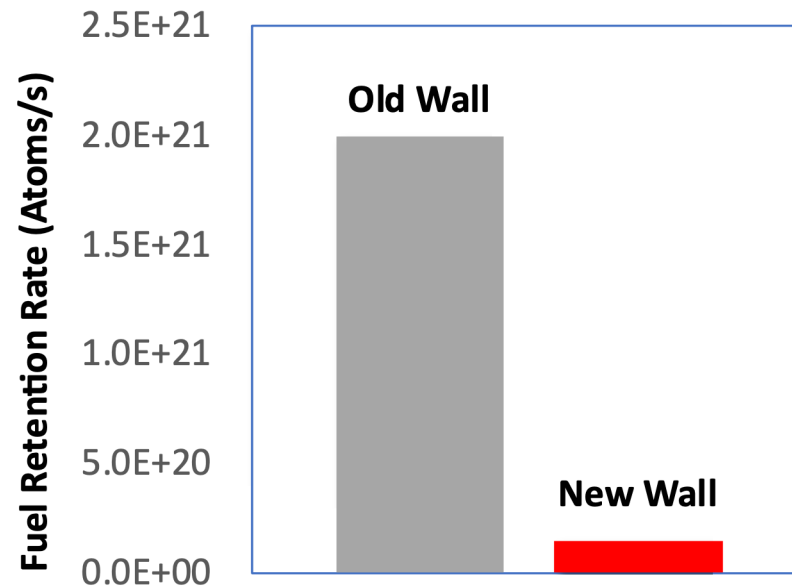


ITER

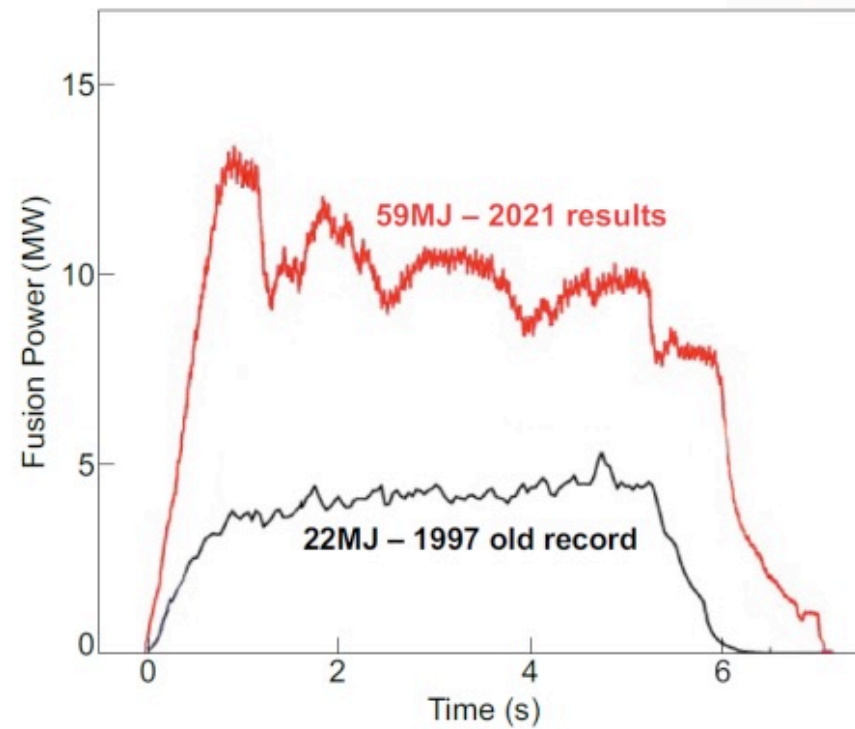


Fuel with the new wall

- > x10 reduction in fuel retention rate

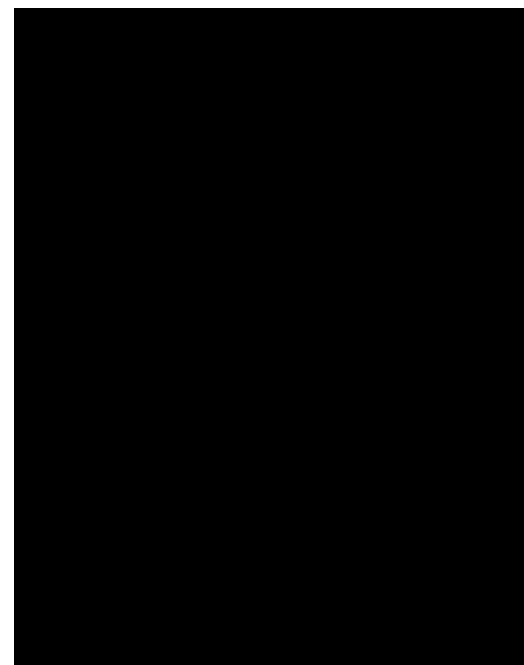


New world record in JET



JET latest

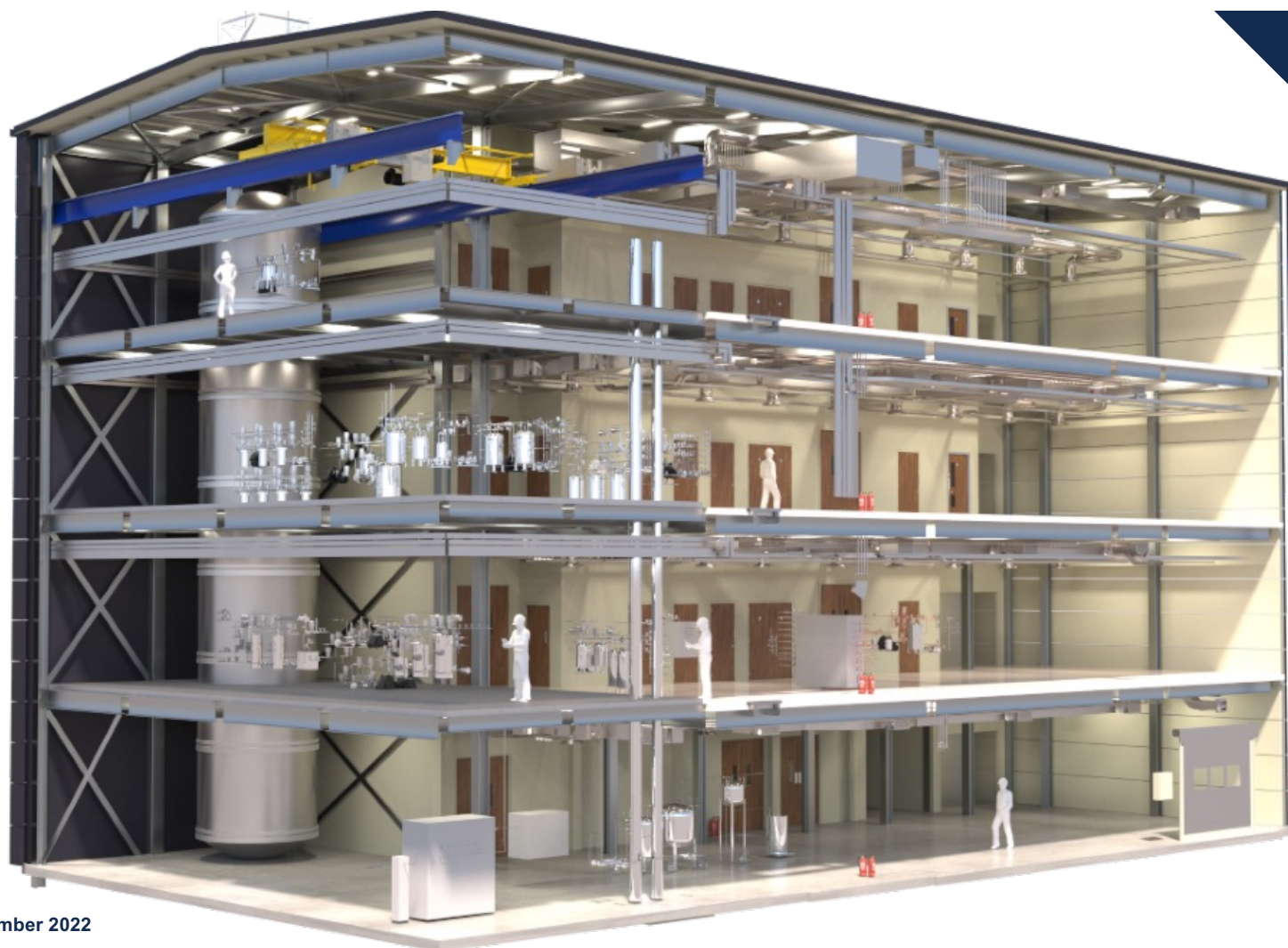
- **Helium campaign** complete including experiments on:
 - Tungsten fuzz formation and Beryllium migration
 - H-mode studies
- **SPI commissioning** complete
- **Deuterium campaign underway** to include:
 - SPI experiments
 - Seeding experiments
- Looking more closely at **operational systems and resources required in early years of Decommissioning programme**

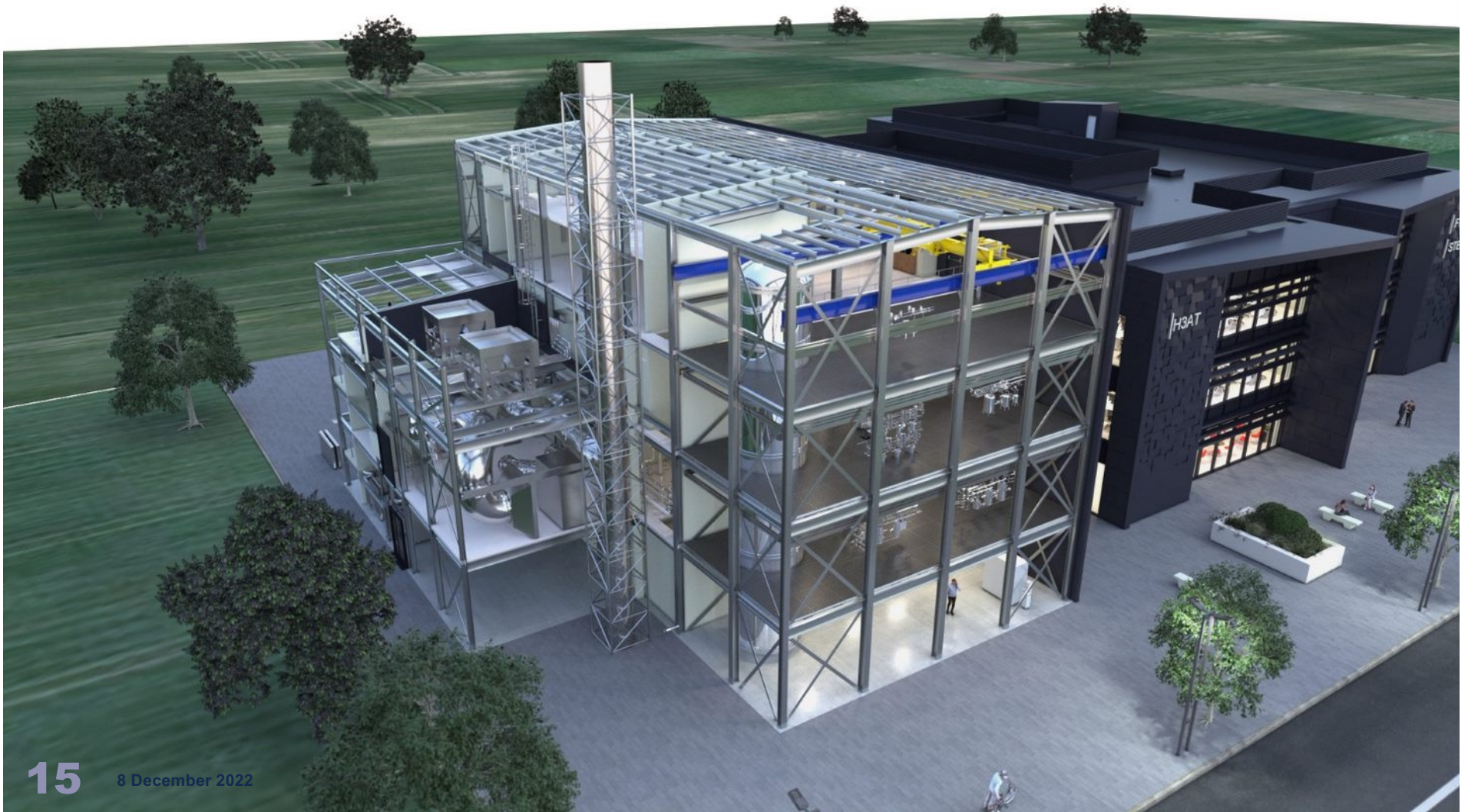


2022												2023											
j	f	m	a	m	j	j	a	s	o	n	d	j	f	m	a	m	j	j	a	s	o	n	d
03	10	17	24	31	07	14	21	28	04	11	18	25	02	09	16	23	30	06	13	20	27	03	10
04	11	18	25	02	09	16	23	30	06	13	20	27	04	11	18	25	02	09	16	23	30	06	13
05	12	19	26	03	10	17	24	31	07	14	21	28	05	12	19	26	03	10	17	24	31	07	14
06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17
07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18
08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19
09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20
10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21
11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22
12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23
13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24
14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25
15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26
16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27
17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28
18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29
19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30
20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31
21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02
22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03
23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04
24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05
25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06
26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07
27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08
28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09
29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10
30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11
31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12
32	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13
33	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14
34	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15
35	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16
36	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17
37	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18
38	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19
39	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20
40	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21
41	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22
42	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23
43	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24
44	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25
45	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26
46	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27
47	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28
48	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29
49	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30
50	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31
51	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02
52	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03
53	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04
54	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05
55	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06
56	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07
57	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08
58	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09
59	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10
60	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11
61	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12
62	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13
63	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14
64	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15
65	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16
66	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17
67	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27	04	11	18
68	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21	28	05	12	19
69	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22	29	06	13	20
70	17	24	31	08	15	22	29	06	13	20	27	04	11	18	25	02	09	16	23	30	07	14	21
71	18	25	02	09	16	23	30	07	14	21	28	05	12	19	26	03	10	17	24	31	08	15	22
72	19	26	03	10	17	24	31	08	15	22	29	06	13	20	27								

New building open Tritium / Technology









Magneto-thermal hydraulics test **CHIMERA**

Policy and Politics

Technical Challenges

STEP Programme

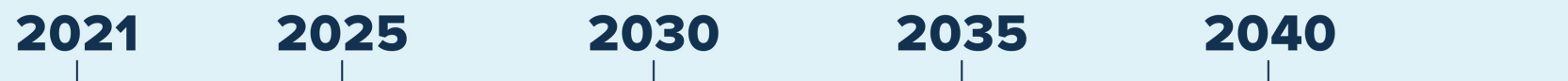
Other UKAEA issues

Spherical Tokamak for Energy Production

- Predictable net electricity production
- Aiming for lower capital cost than other fusion power plant designs
- \$300M investment for concept design by 2024



STEP high-level schedule



Concept (till 3/24)

- ▶ Concept / Reference Plant Design
- ▶ Programme Development
- ▶ Site selection
- ▶ Transition to Target Operating Model

Detailed Design and Mobilisation

- ▶ Engineering Design
- ▶ Long lead procurement
- ▶ Early Manufacture
- ▶ Site development

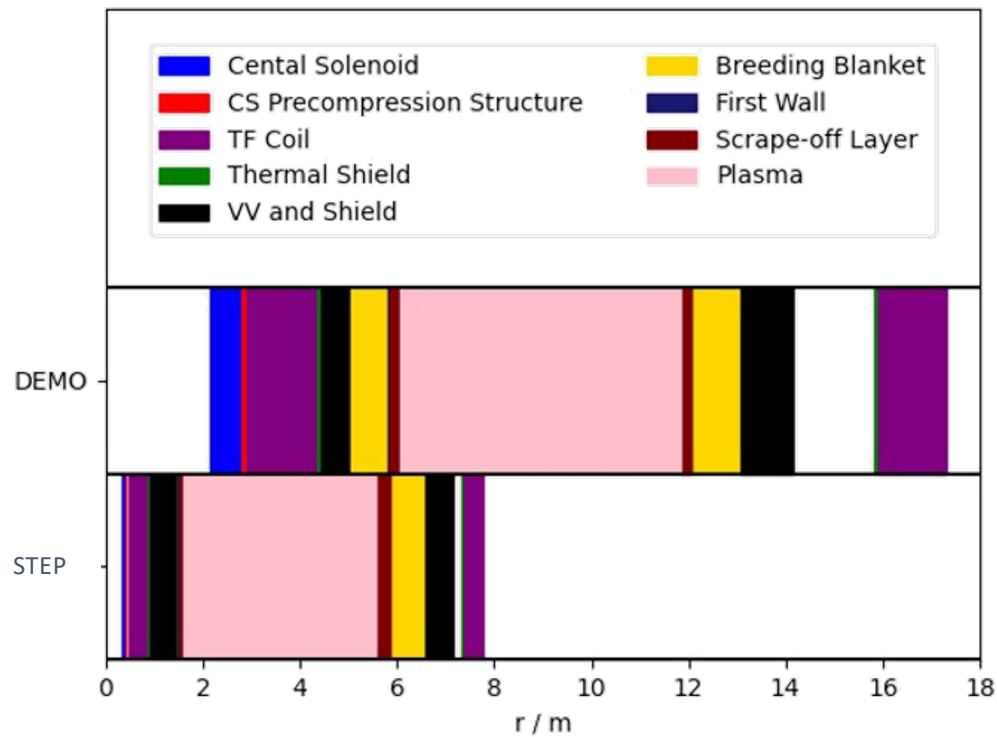
Main Construction

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

Commissioning and Operations

- ▶ Non-active and active commissioning
- ▶ Prototype ops

Reducing the size...



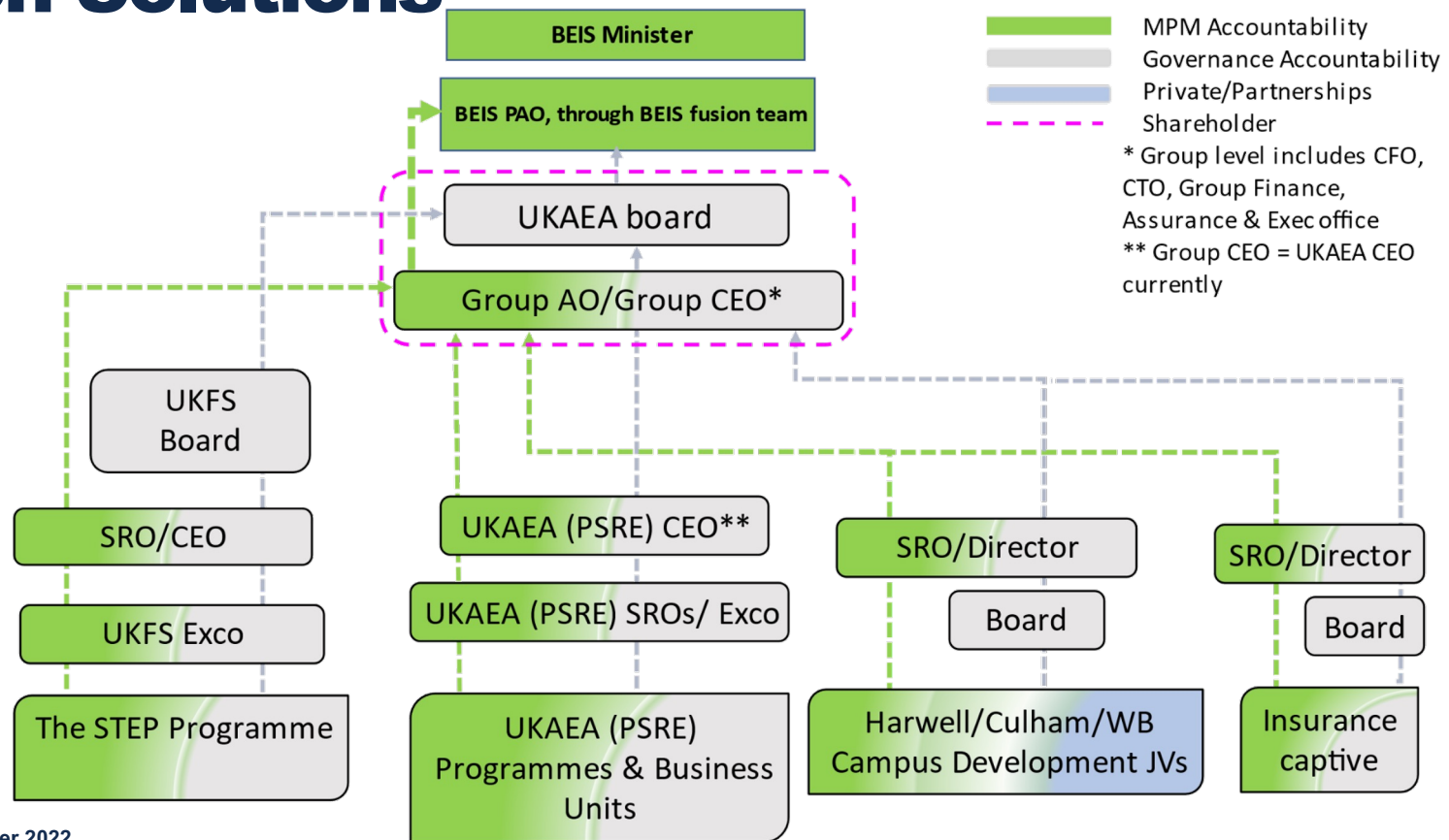
STEP Site = West Burton, North Notts

Direct abstraction from
River Trent

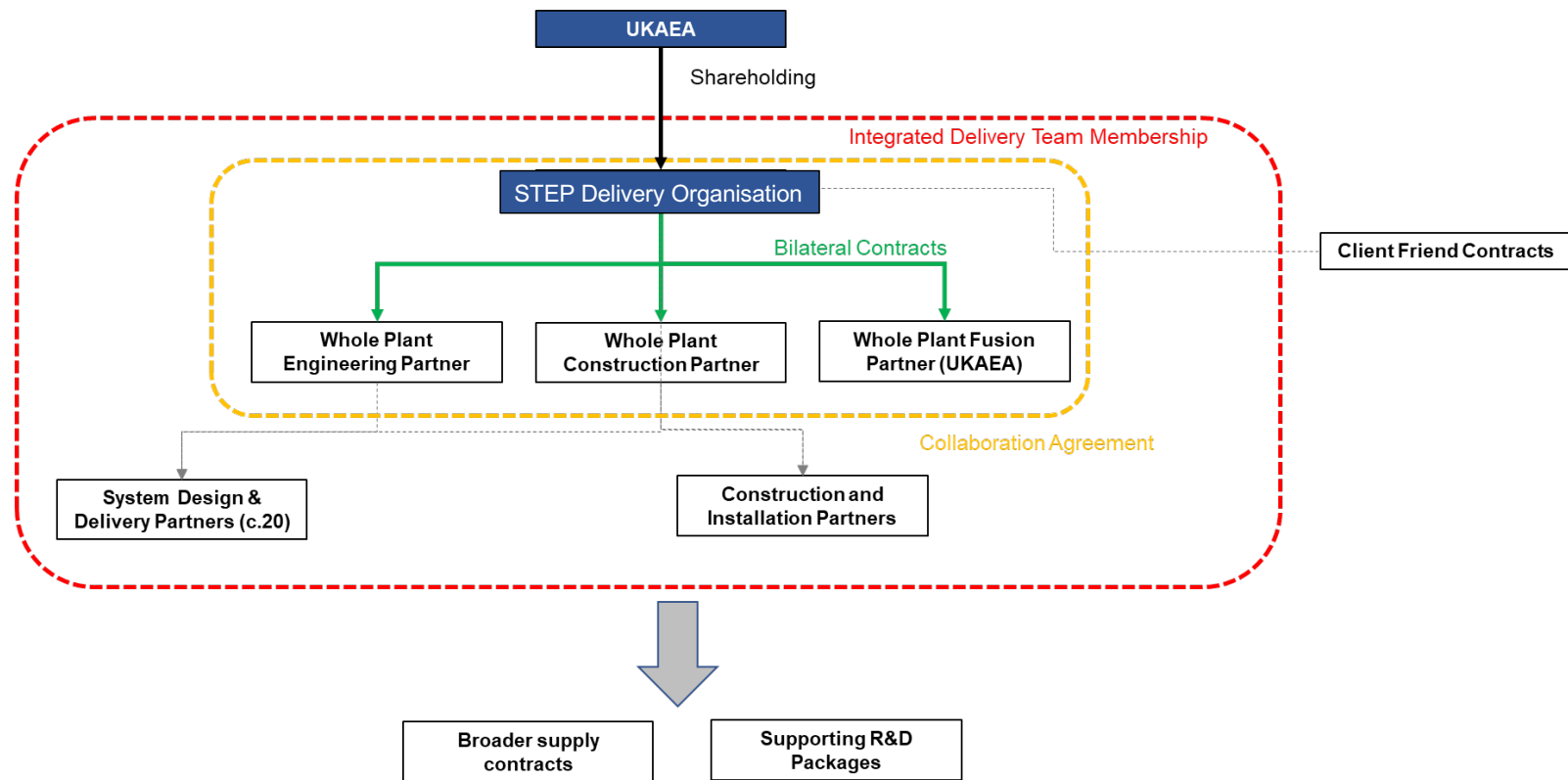
Direct 400kV connection

Trainline direct to site

UKAEA Group: Formation of UK Fusion Solutions



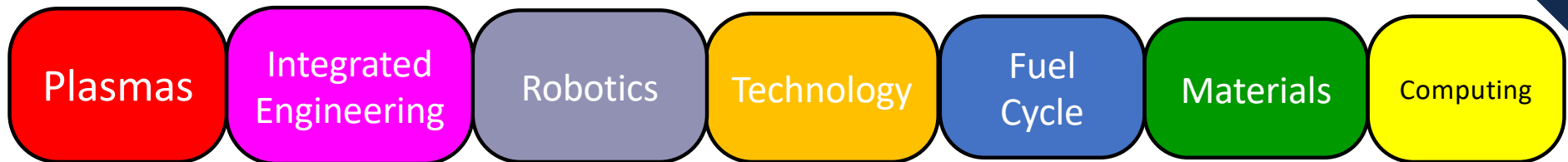
A collaborative approach (subject to approvals)



Policy and Politics Technical Challenges STEP Programme **Other UKAEA issues**

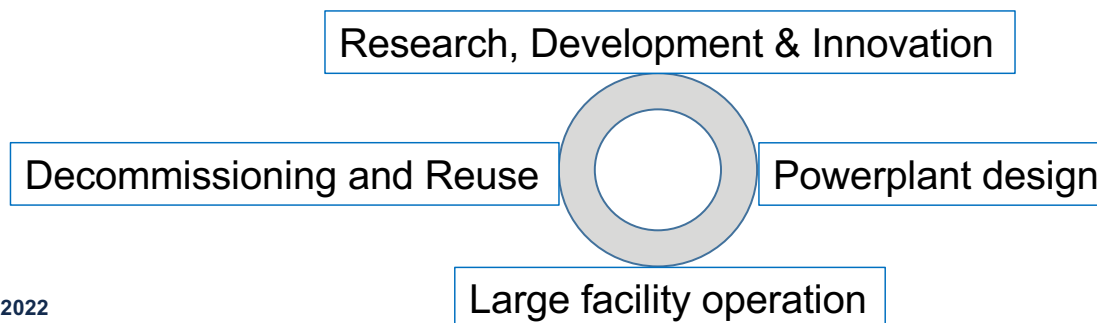
UKAEA's unique proposition

1. UKAEA has capability across the full spectrum of technical disciplines needed for fusion....

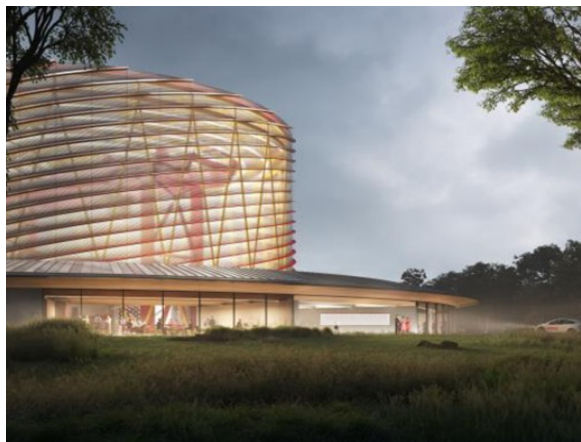


...working increasingly in partnerships with other organizations.

2. UKAEA delivers programmes across the full lifecycle of fusion:



Culham campus plans



Culham campus plans



Fusion Industry Programme

‘accelerate the growth of the UK’s fusion industry’

- £40M Challenge Scheme
- £2M Education Scheme: contact FIPSummerPlacement@ukaea.uk to host Summer 2023 students
- £2M Voucher Scheme: contact FIP-Challenge@ukaea.uk to use UKAEA’s facilities with free access
- £8M Equity Scheme: for fusion-related start-ups <https://ukinnovationscienceseedfund.co.uk/>



National fusion skills

Bring together and lead national and international collaborations:

- UK academia – 30+ universities, 13 Centres for Doctoral Training, 150 PhDs

Develop next generation with essential skills

- UKAEA has multi-award-winning apprentice scheme which provides skilled people for >20 industrial partners
- Currently training 280 apprentices with funding secured to expand to 1000 by 2025



JET Decommissioning Approach

There are a number of approaches, ranging from Containerised Storage, Detritiation of all components, and a Hybrid approach of these

Government will undertake the options selection for Decommissioning strategy in May 2023, and UKAEA will propose a high-tech (ie robotics disassembly and detritiation of in-vessel solids)



UK fusion is moving at pace



- Major advances this year: JET D-T, new facilities, campus regeneration
- STEP progressing on track. Concept design by 2024
- Growing fast – now ~2500 people in UKAEA and ~4000 people at Culham
- Major collaboration with industry and will see increasing support for this