

Building Bridges

A Bold Vision for the DOE Fusion Energy Sciences

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U.S. DEPARTMENT OF
ENERGY

Office of
Science

FES Mission and Strategic Priorities

MISSION

The mission of the Fusion Energy Sciences (FES) program is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundations needed to develop a fusion energy source. This is accomplished by the study of the plasma state and its interactions with its surroundings.

The Energy Act of 2020 **expanded the scientific mission of FES** to support **“the development of a competitive fusion power industry in the U.S.”**

FES PROGRAM PRIORITIES

1. Accelerate fusion development as a carbon-free energy source via public-private partnerships (“bold decadal vision”)
2. Support R&D Fusion Centers (“FIRE” centers) to establish S&T basis of a Fusion Pilot Plant (FPP)
3. U.S. participation in ITER to leverage engineering and study burning plasma science technology at power plant scale while expanding Inertial Fusion Energy (IFE) program
4. Support discovery plasma science and technology
5. Broaden participation in fusion and DEIA activities to enable the program

Imperative for U.S. to remain a fusion energy world leader

- Global race to secure leadership in fusion energy

EU: \$650M per year (EUROfusion ~ \$270M/yr)

UK: \$350M per year*

- Major investments** from UK, EU, Japan, Germany, and China

Germany: \$317M per year

Japan: \$237M per year

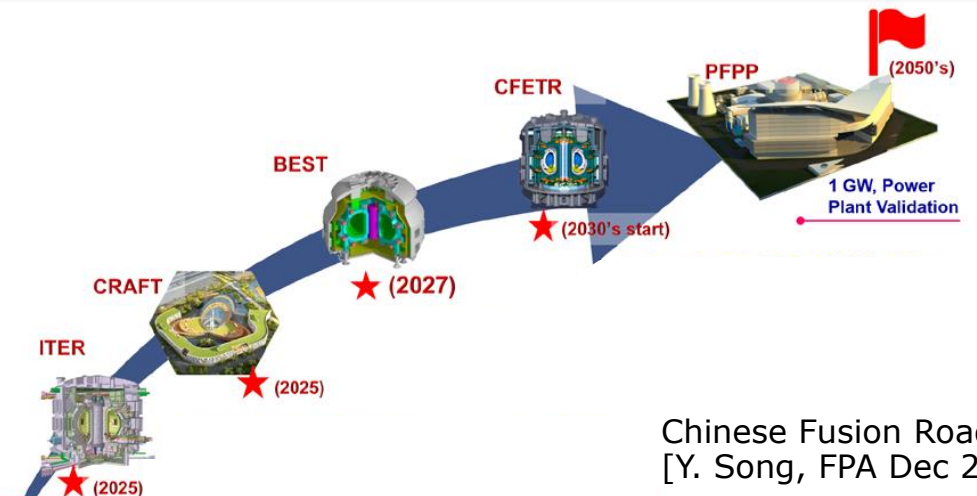
- Where does the U.S. fit into this landscape?

*excludes ITER contrib.

**NOTE: \$USD are estimates only with large variance

- In Feb 2023, it was reported that China has surpassed the U.S. in fusion technology patents [Astamuse, 2023]
- Chinese expenditures** in fusion energy **~1.5B/year**

**NOTE: \$USD are estimates only with large variance

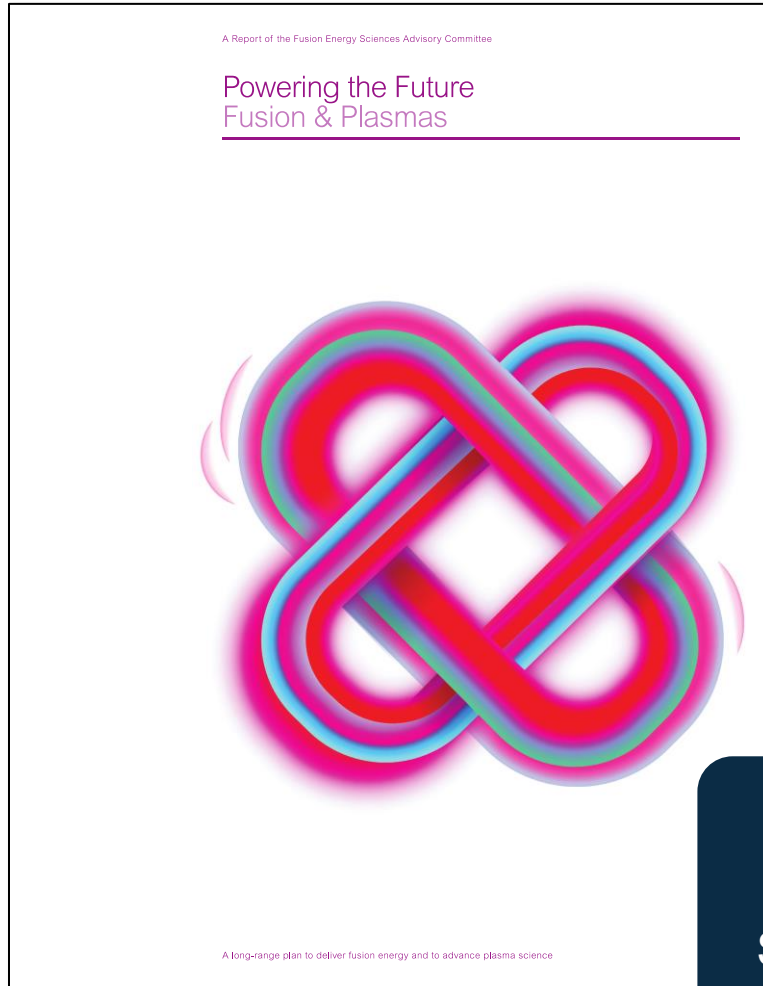


Chinese Fusion Roadmap [Y. Song, FPA Dec 2022]

China is making significant progress towards de-risking many fusion science and technology gaps we've known for decades



Vision for a balanced and bold FES program



2020 FESAC
Long-Range Plan (LRP)

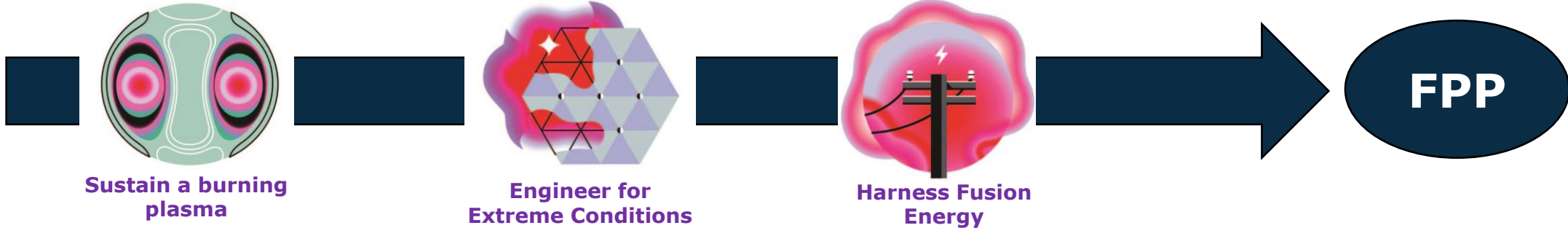
"Fulfilling the [fusion] energy mission demands a shift in the balance of research toward FM&T (Fusion Materials and Technology), which connects the three science drivers: Sustain a Burning Plasma, Engineer for Extreme Conditions, and Harness Fusion Energy." pg. 6 FESAC-LRP

- Fusion Science and Technology (S&T) Roadmap
- **Focus:** de-risking science and technology gaps
- Support public-private partnerships (PPPs)
- Leverage international collaborations



The Road to Fusion Energy is through *combined* public sector “push” and private sector “pull”- with key gaps to address

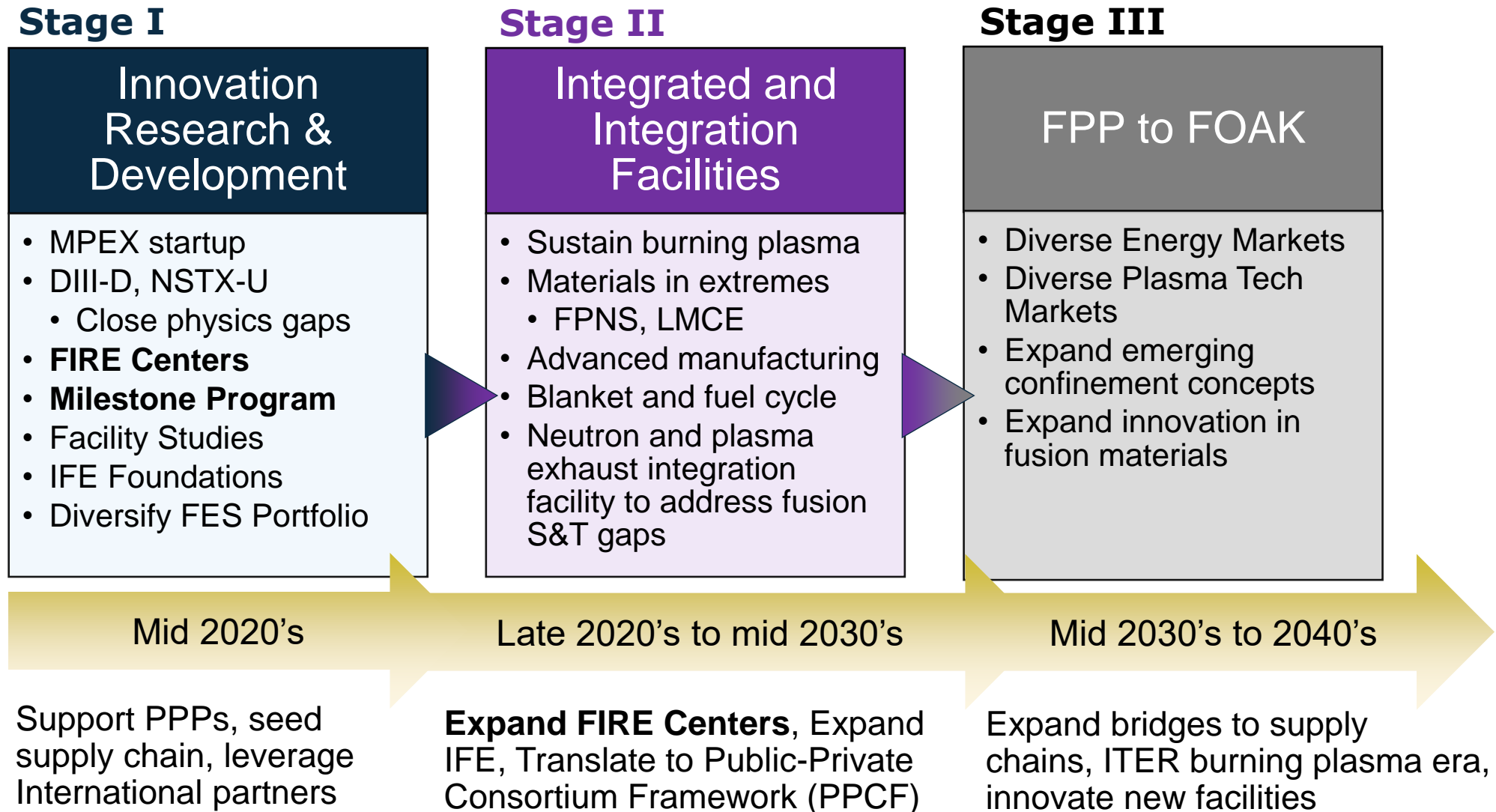
Build LRP
FM&T Gap
Facilities



A Fusion S&T Roadmap with metrics to track progress

- FES will **focus** on the science and technology gaps as a “bridge” to realize a viable path towards fusion energy (“interim stage”)
- Transitions will be key to leverage resources
- Our workforce will be top priority and therefore we will develop a plan for designing, building, and operating facilities enabled by PPPs on the path to a fusion pilot plant

Building the Roadmap: a staged approach towards FPP



Reshaping the FES

- A re-structure of FES budget elements to reflect our Long-Range Plan strategy
- We will leverage opportunities in strategic directions (e.g., PPPs, international partnerships, specialized facilities) and link them to FES best practices

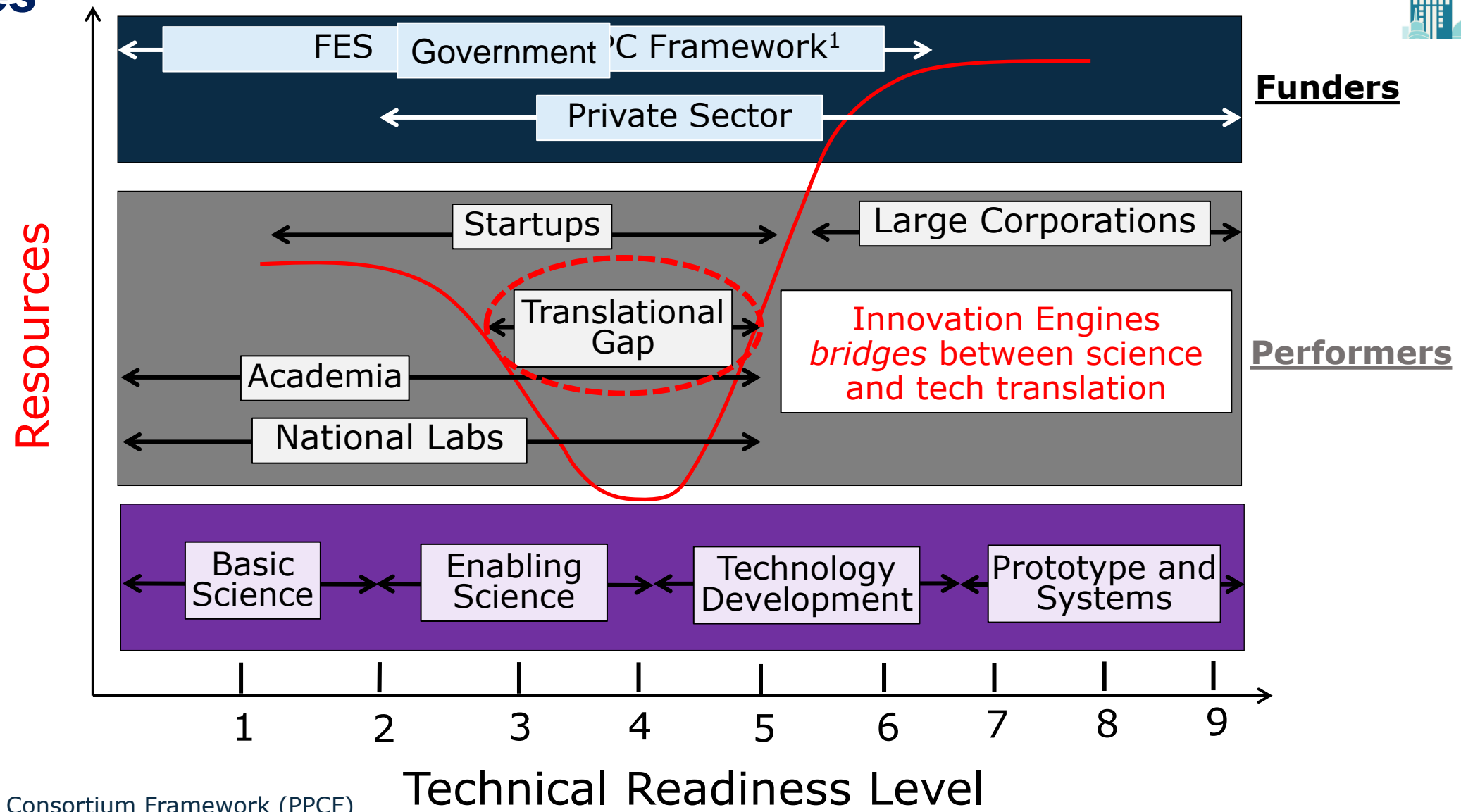
Theory and Simulation	Fusion Materials and Internal Components	Emergent Plasma Concepts	Closing the Fusion Cycle	Discovery Plasma Science and Technology
<ul style="list-style-type: none"> • Multi-scale modeling • Advanced Computing • FM&T multi-scale computation • AIML in control systems 	<ul style="list-style-type: none"> • Fusion Nuclear Materials • PFCs • Actuators • Liquid Metals • Adv. Manufacturing • MPEX 	<ul style="list-style-type: none"> • Advanced and Spherical Tokamak • Stellarators • IFE, MIF • FRC, Mirror 	<ul style="list-style-type: none"> • Nuclear Science • Blanket innov. • T, D, Li-6 mgmt • Balance-of-Plant • RAMI • Waste streams • Enabling Technologies 	<ul style="list-style-type: none"> • Foundational Plasmas and Astrophysics • Industrial Plasmas • HEDLP • MEC-U • QIS, Microelec.

Cross-threads: DIII-D, NSTX-U, PPPs, new strategic facilities, & ITER

Realizing the Bold Decadal Vision



Building the fusion ecosystem: *Identifying where to establish bridges*



¹Public Private Consortium Framework (PPCF)

FES Public Private Partnership Elements



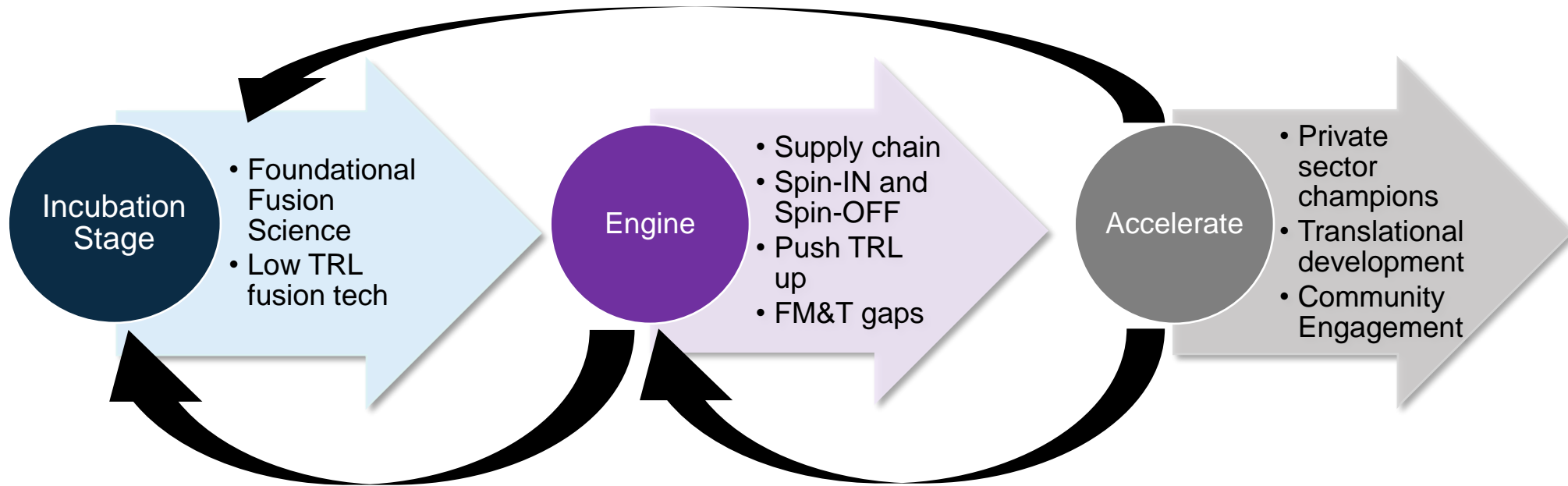
- **INFUSE (Innovation Network for Fusion Energy)**
 - Leverage National Laboratory and university infrastructure/capabilities for industry use
- **Milestone-Based Fusion Development Program**
 - Fusion companies partner with national labs and universities to provide viable FPP designs and technology roadmaps
- **New PPP funding and financing program**
 - Create a new bridge between the public and private sectors in fusion science and technology
 - Innovative PPP program to design and/or build facilities to de-risk low-TRL fusion technologies
 - Provide the public sector an opportunity to leverage strategic private sector infrastructure
 - CPP, FESAC LRP, FESAC IB, FESAC FCP, NASEM reports and US S&T Roadmap will all inform this program



Fusion Innovation Research Engine (FIRE) Centers

FIRE Centers address critical scientific and technology gaps and bring together discovery science, innovation, and translational research in partnership with multiple public and private partners.

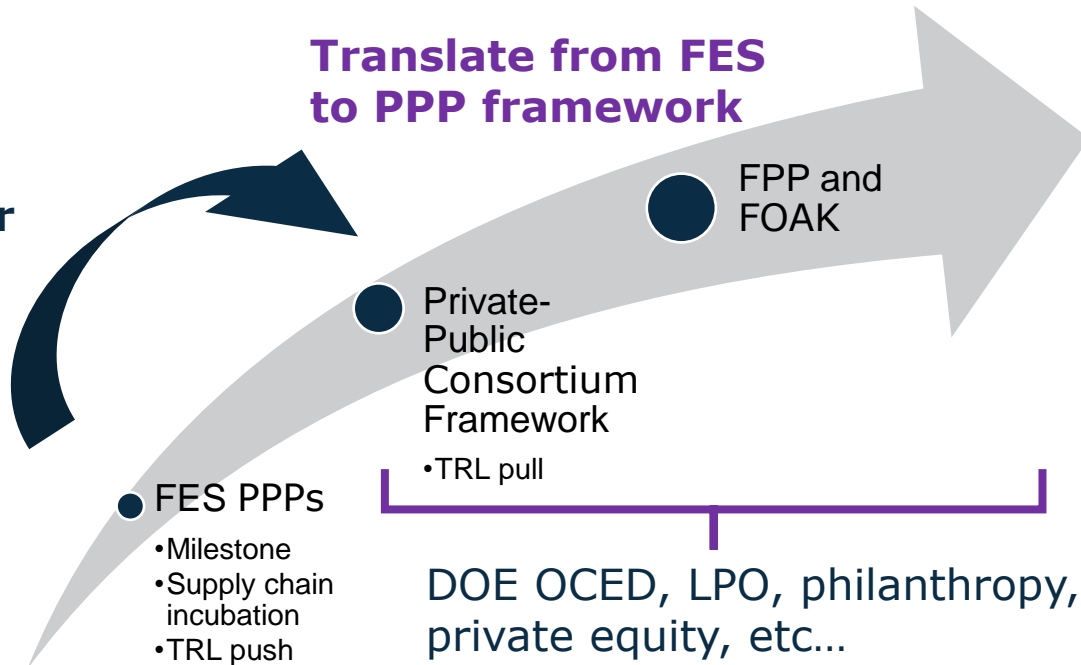
Science Drivers and themes: multi-scale computing and simulation, fusion materials, closing fuel cycle, plasma confinement innovation, blanket technology, and more.



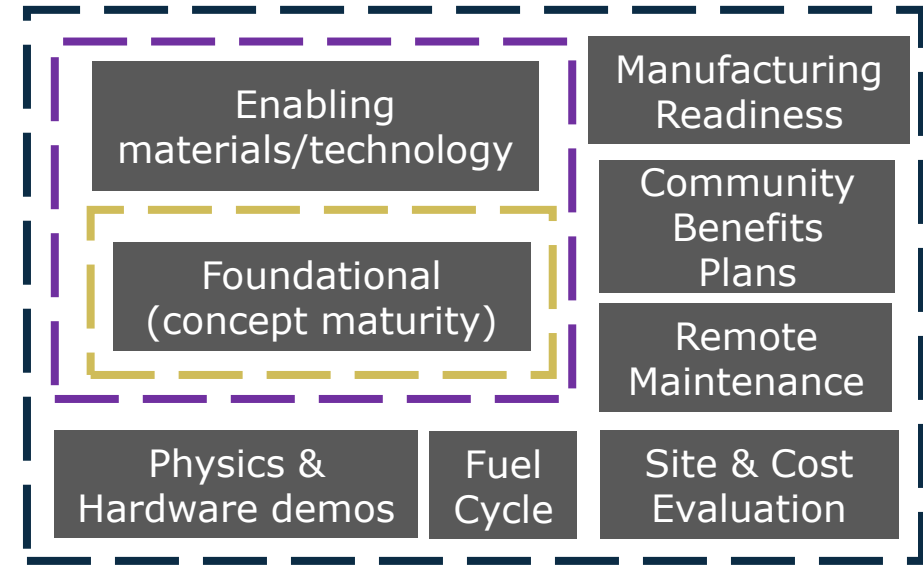
Milestone-Based Fusion Development Program in FES and beyond

- Building resilient public-private partnerships that are equitable and provides a bridge to our public expertise and know-how in FES
- **FES PPP portfolio:** “seeds” for further development that must be translated to a framework for collaborative participation on fusion FM&T gaps

FES Milestone program in FES provides the catalyst for further investment both from public and private entities in a PPC framework towards FPP



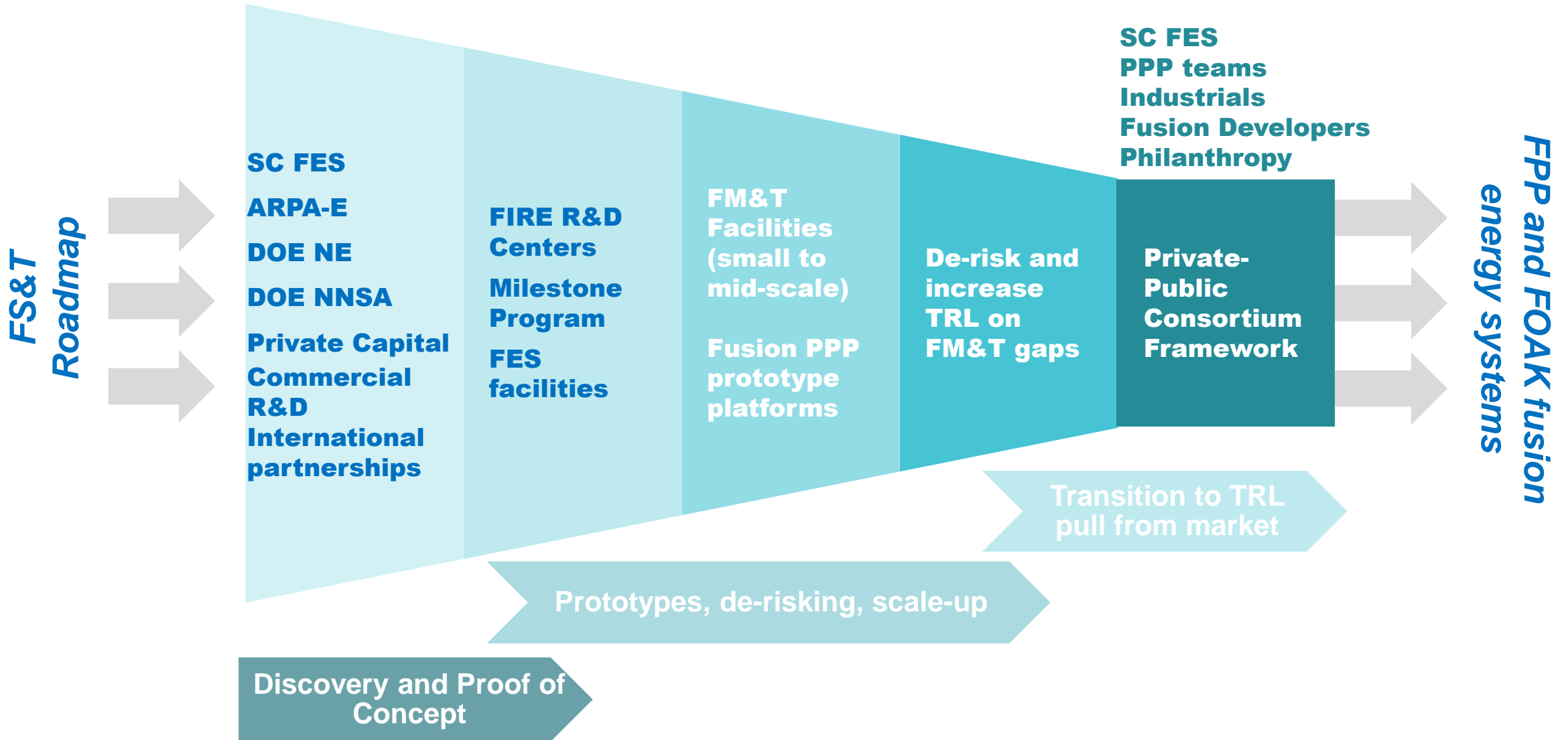
Milestone Work Scopes



Commercial Fusion Industry



Establishing a Fusion Innovation Ecosystem



Opportunities with a public-private consortium model

- A non-for-profit Consortium model manages risk of standing up a new government office and provides the flexibility and versatility needed for a nascent fusion industry
- Universities, NLRs, private sector performers (OEMs, suppliers, industrials, etc...) can engage with developers in pre-competitive ecosystem
- Commitments are managed with joint funding from both public and private sector at regional hubs in the US (e.g. CA, TN, WA, Mid-Atlantic, WI, SC, ...)
- Build supply chains leveraging CHIPS and other emerging public-private partnership programs
- Engage international partners and private sector focused on FM&T facilities, manufacturing, and translational research