FUSION FUEL CYCLES

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Fusion Fuel Cycles in the Private Fusion Industry Landscape

THE GLOBAL FUSION INDUSTRY

Recent Milestones:

2021: MIT's 20-tesla magnet breakthrough

2022: JET's 59 MJ record and NIF's net energy gain

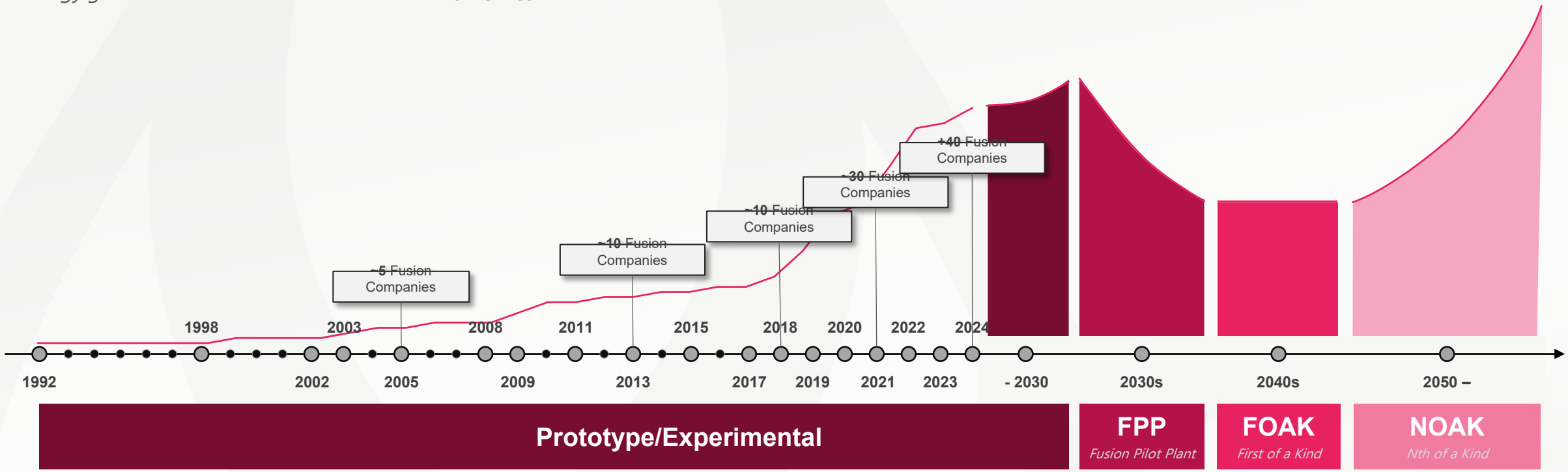
Rising Investments & Global Initiatives:

USD $9B+ invested to date; 40+ fusion startups globally

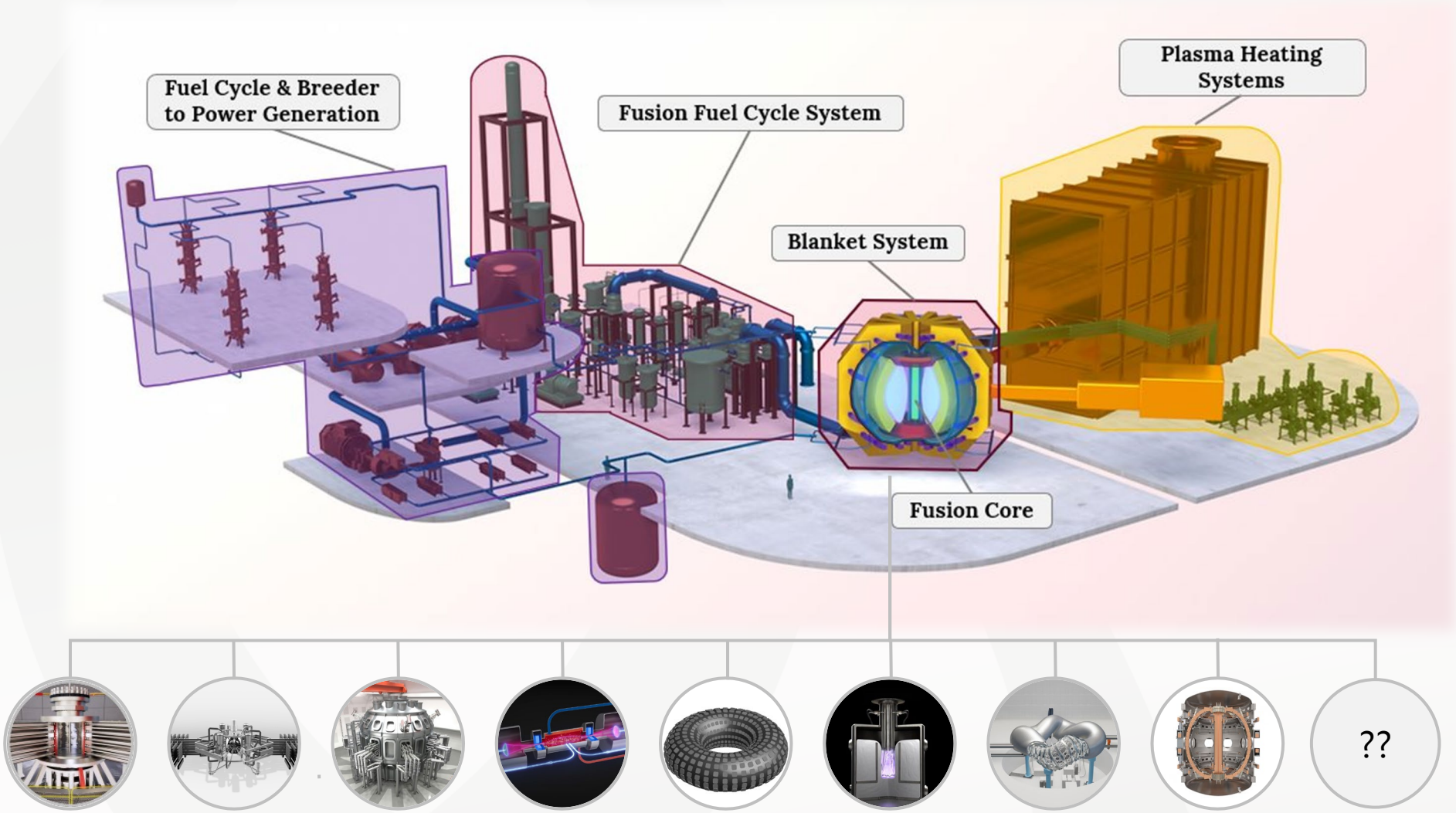
National programs (e.g., UK, US, Japan) accelerating timelines

50+ shots on goal:

Derisking scientific, engineering, and/or economic dead-ends.



CRITICAL PATH “BALANCE OF PLANT” NEEDS



*Adapted from FAST project – An energy converting fusion facility set to be operational in the mid-2030’s

OUR ORIGINS

A strategic venture combining CNL's tritium & processing capabilities with KF's fusion fuel cycle plant expertise

Canadian Nuclear Laboratories

- 9,000 acres in size, 200 acres lab complex
- 17 nuclear facilities, 70 major buildings
- ~4,000 employees (500 PhDs and Masters)
- 1,600 engineering, scientific and technical staff
- >300 skilled trades people

Canada's premier nuclear science & technology laboratory

KYOTO FUSIONEERING

Founded: 0ct 2019

Funding: $130+ Million CAD ($100+ USD)

Locations: Kyoto and Tokyo (JP), Seattle (USA), Reading (UK), Karlsruhe (Germany)

Employees: Total 130+ (as of Oct 2024)

"Pick-and-axe" strategy that complements fusion developers

WHO WE ARE

Company Details

Founded:	May 2024
Headquarters:	Chalk River Ontario, Canada
Structure:	Canadian, private, for-profit corporation
People:	40+ staff involved
Ownership	Kyoto Fusioneering & Canadian Nuclear Laboratories

Products & Services

- **Design and engineering consultancy services** for fusion fuel cycle systems (manufacturing through trusted supply chain)
- **Assembly, and commissioning** of fuel cycle components and integrated systems.
- **Field services and support** for delivered equipment and systems
- **Access to a fully integrated fusion fuel cycle system (UNITY-2)**

ADDRESSING THE CHALLENGES OF THE PRIVATE FUSION INDUSTRY

FFC will meet the growing demand for tritium handling and tritium-compatible technology

Global Expertise & Capabilities

- **600+ years** of combined Fusion Fuel Cycle knowledge
- **70+ years** of Tritium specific expertise
- Global network supported by access to parent companies' capabilities

Trust the experts

KYOTO FUSIONEERING

Canadian Nuclear Laboratories

QST

KIT Karlsruher Institut für Technologie

The First Fully Integrated, FPP Relevant Fuel Cycle

- **30 g tritium** licensed facility*
- **Elevating TRL of DT fuel cycle components**
- **First-hand knowledge** of developing fuel cycle, UNITY-2 and UNITY-1

Seeing is believing

UNITY-2 3D Rendering

** UNITY-2 has regulatory approval for up to 100g of tritium*

Focusing on your Milestones & Investment Journey

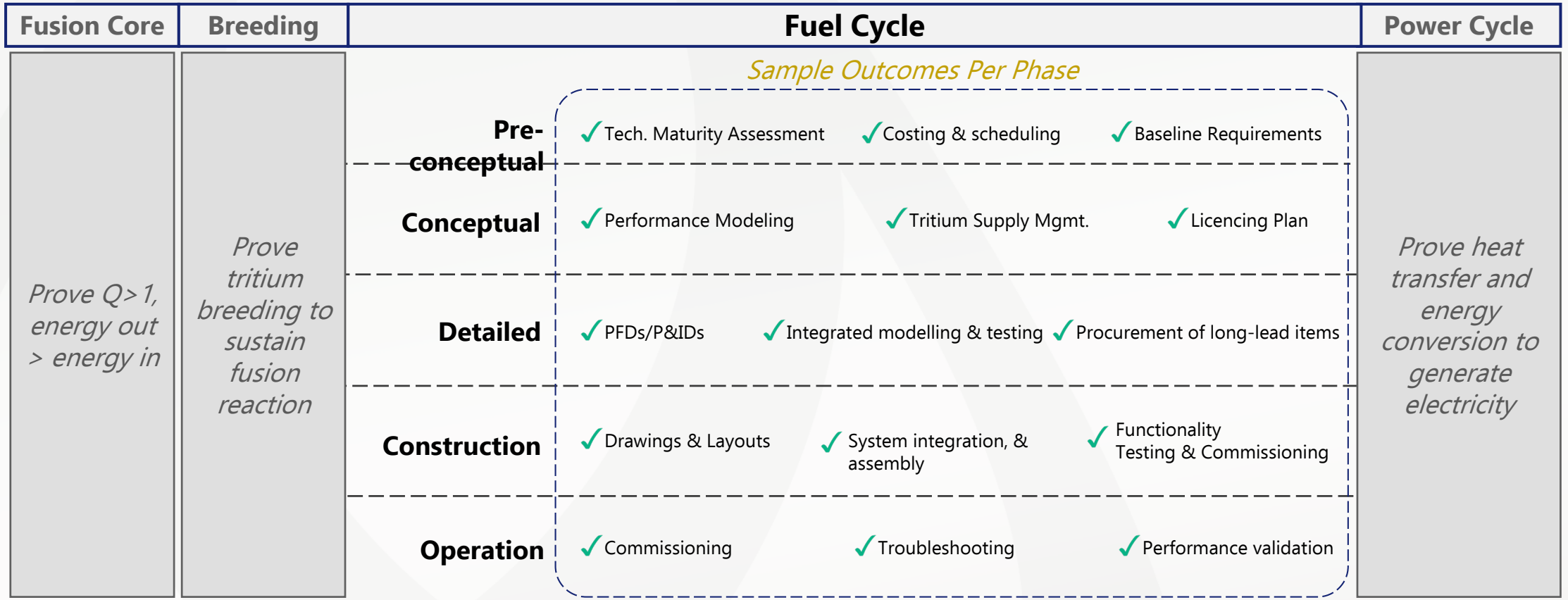
- Schedule, and costs of commercial relevant systems and sub-components to (e.g +/- 30% cost, P80 schedule)
- Fusion core-agnostic approach, recognizing investor and developer expectations

Predictable & timely delivery

The FFC team working on UNITY-2 conceptual design

LIFECYCLE ENGINEERING AT AN ACCELERATED PACE

Fusion Power Plant Areas



IMMEDIATE CHALLENGES OF PRIVATE FUSION DEVELOPERS

Understanding scope, assumptions, and costs and timeline constraints

Common Challenges of Fusion Developers

*What are the **key performance parameters** of our fuel cycle?*

How much space do these key systems account for?

*What is the current **TRL assessment** of fuel cycle components & system?*

*How can we **build credibility** and confidence within our estimates?*

Who can provide a **holistic** solution?

Preliminary Scope of Conceptual Design

FUSION FUEL CYCLES

WP1: Design Basis: Define interfaces, document assumptions, prepare stream tables, mass balances and heat balances, and preliminary process flow diagram.

WP2: Fuel Cycle Performance: Preliminary technology selection for each unit operation, model cycle performance, minimal optimization.

WP3: Technology assessment: Produce a technology readiness level assessment, and maturation plant.

WP4: Bill of materials: Prepare class IV estimate of major equipment, and components, preliminary footprint and sizing (i.e. CAPEX).

WP5: Risk Analysis: Produce risk analysis, technology, capital, and project delivery.

WP6: Schedule and cost for delivery of system: Produce Level 1 schedule and cost estimate for delivery of system.

WP7: Licensing plan: Support development of licensing application for system.

WP8: Tritium supply chain management: Recommend approach for procuring tritium.

sample

FUEL CYCLE - CHALLENGES & OPPORTUNITIES

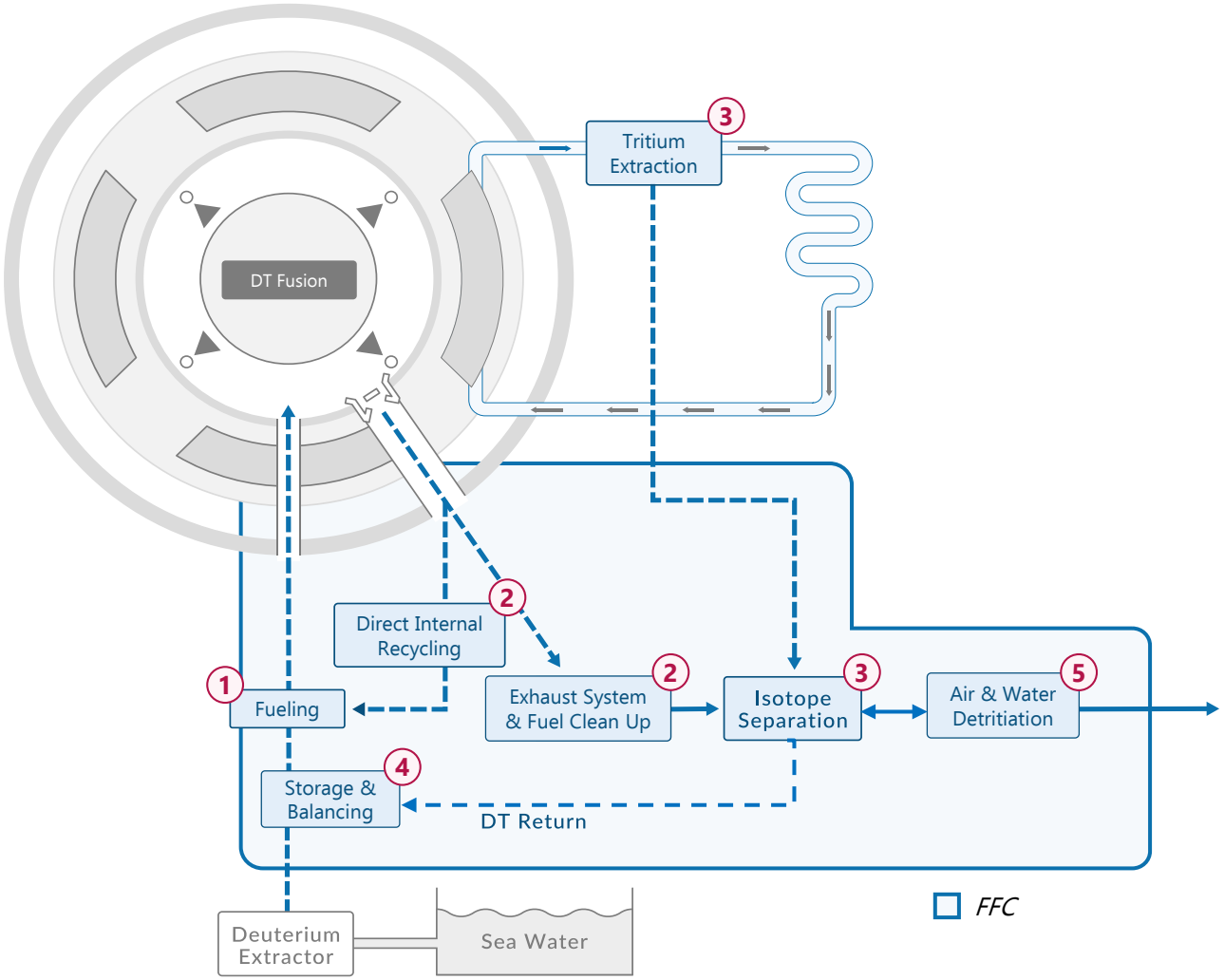
1 Fuelling
- Injector Technology
- Losses

2 Exhaust System & Fuel Clean Up
- High loads of unburnt tritium
- Initial fuel clean-up
- Methods for direct internal recycling (DIR)

3 Extraction & Isotope Separation
- Extraction
- Scale-up
- Fast response

4 Tritium Storage Systems
- Suitable metal hydrides
- Safety and security
- Decay and He-3 production

5 Water & Air Detritiation System
- High detritiation factors
- High removal efficiencies
- Handling tritiated water



Optimization is critical!
Understanding of integrated effects is essential.

FUSION FUEL CYCLES

FLAGSHIP PROJECT: UNITY-2

UNITY-2

Accelerating the commercialization of fusion

UNITY-2 will be housed in CNL's existing Tritium Facility in Chalk River, Ontario

Building B215 is a Class I licensed Nuclear Facility / Class A Radioisotope Laboratory

FUSION FUEL CYCLES

FUSION FUEL CYCLES

UNITY-2
THE WORLD'S MOST ADVANCED FUSION FUEL CYCLE

UNITY-2 PURPOSE

The world's first FPP-relevant fuel cycle test facility

- Remain agnostic to main core designs
- Provide an environment to mature individual technologies at low TRL
- Demonstrate the integrated continuous operation and control of the systems
- Demonstrate licensing and operability
- Provide relevant data for validation of the fusion fuel cycle simulator
- Tritium in systems by 2026

Current TRL *Improvement through UNITY-2*

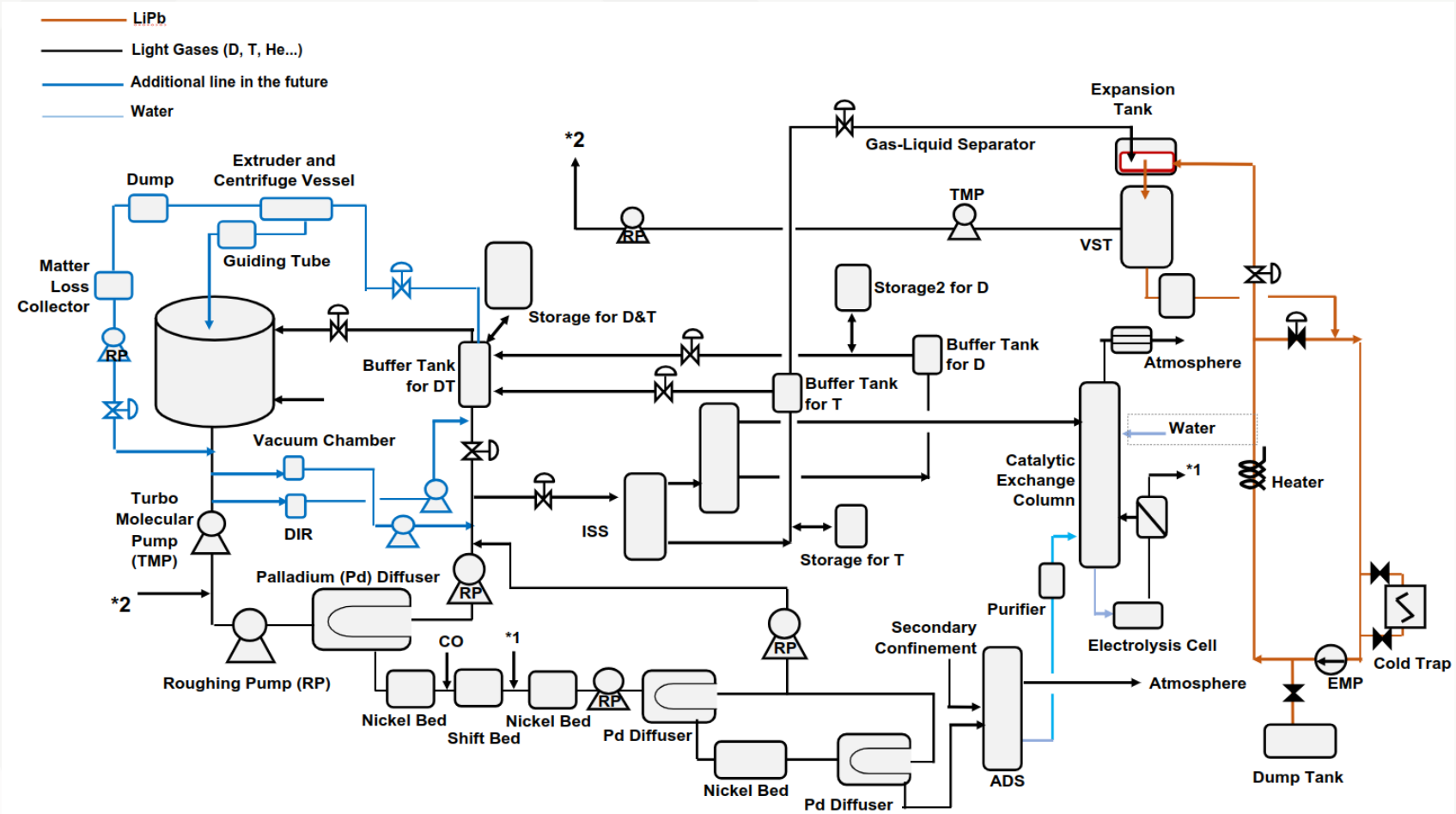
		TRL								
Function	**Technology**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Primary pumping	**TMP**									
	KFRP									
Fueling	**PIS**									
DIR	**Membrane**									
	PCP									
	MFP									
ISS	**CD**									
WDS	**CECE**									
ADS	**WSC**									
Storage	**dU**									
	ZrCo									

Requires separate testing under a magnetic field (planned)

Building Credibility and Trust ***Advancing Technology*** ***Fuel Cycle test stand for the COMMUNITY***

CONCEPTUAL DESIGN: COMPLETED IN MAY 2024

UNITY-2 will be the global first integrated continuously operated deuterium-tritium fusion fuel cycle test facility.



2023 ✓ — **2024** ✓ — **2026**

Initiation

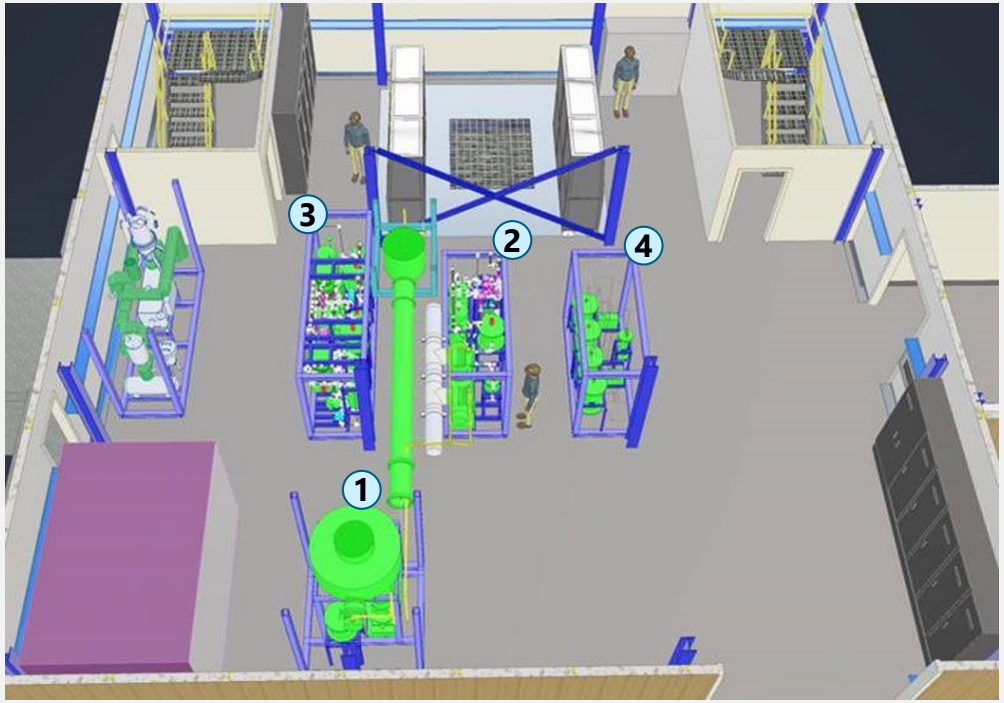
Procurement:
Long lead items

Installation:
Integration of systems.
Planned commissioning

PRELIMINARY DESIGN GATE: ACHIEVED IN APRIL 2025

Supporting the needs of fusion community, UNITY-2 provides technology commercialization of multiple key technologies

UNITY-2 Main Floor



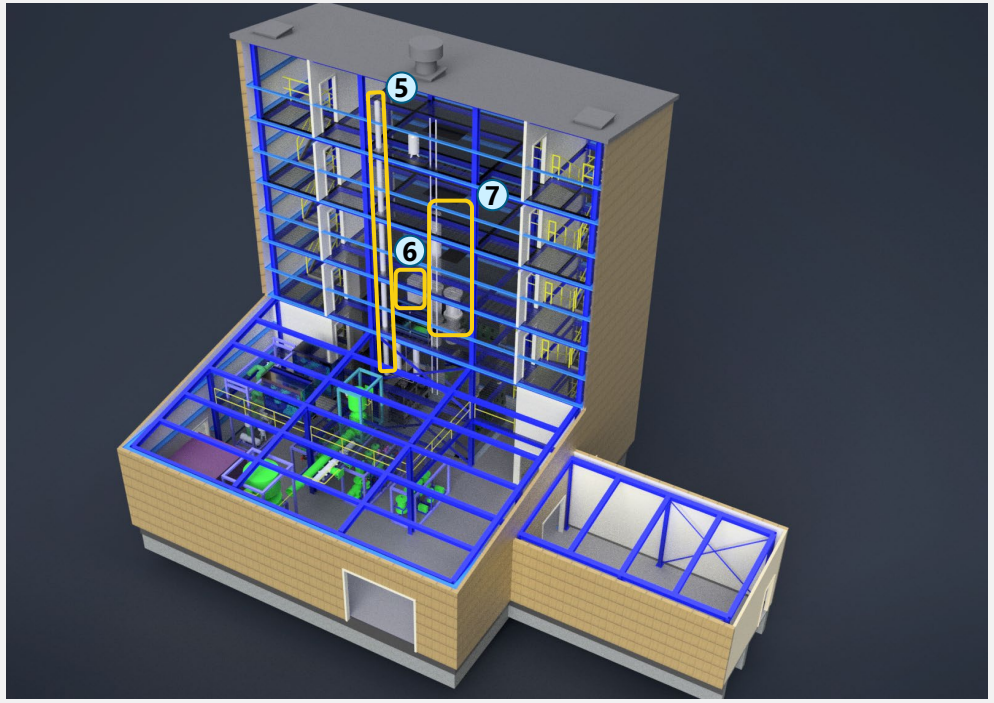
② Vacuum Pumping

③ Direct Internal Recycling

④ Fuel Cycle Clean Up System

① Pellet Injector System

UNITY-2 Tower



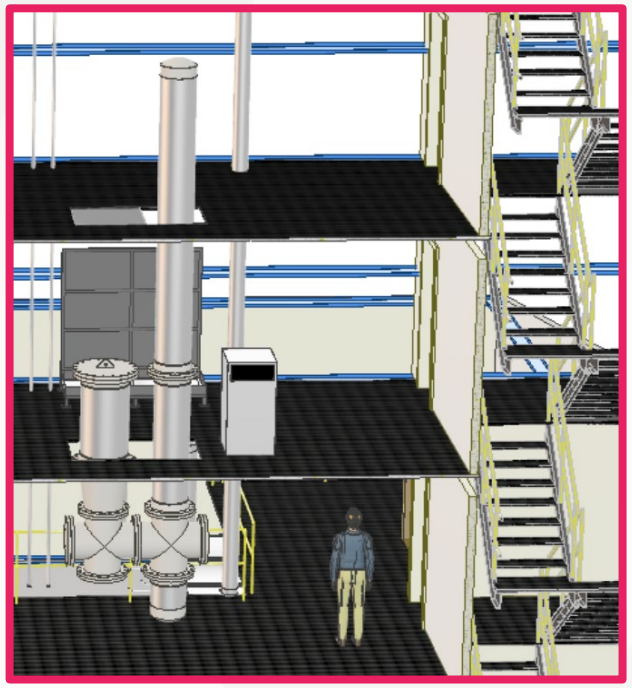
⑤ Air Detritiation System

⑥ Water Detritiation System

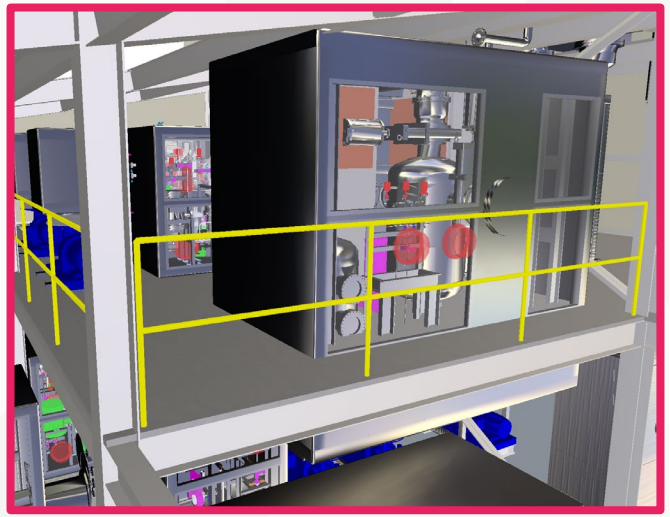
⑦ Isotope Separation System

DETAILED DESIGN TO BE COMPLETED 2025

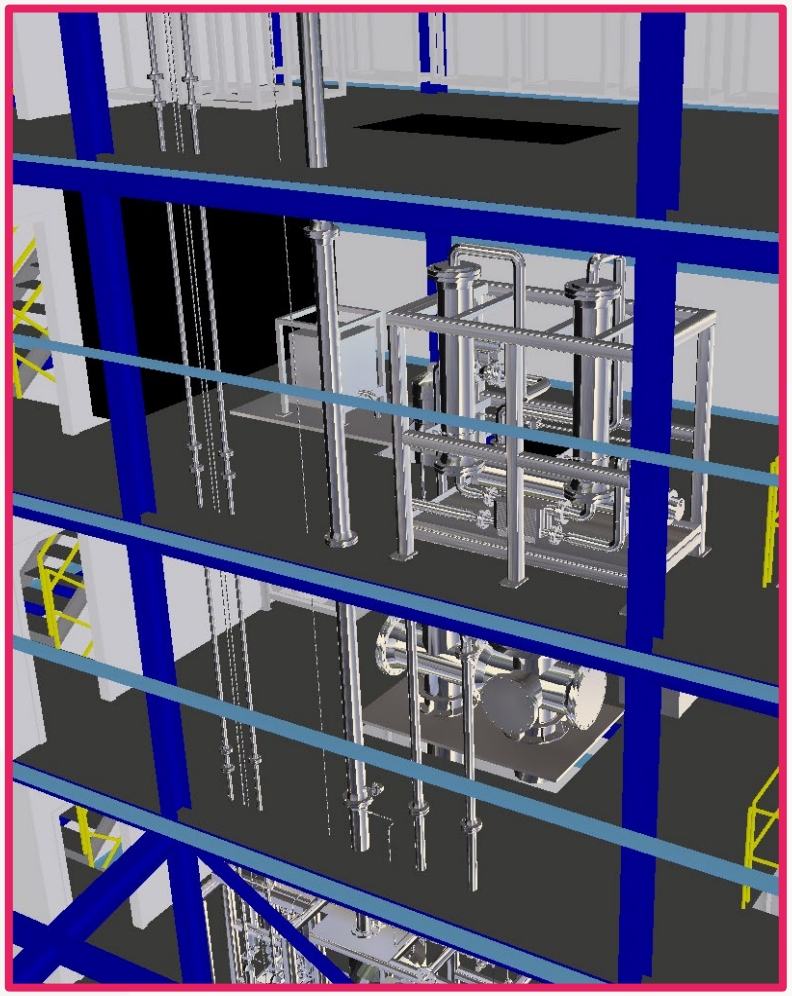
Fuel Clean Up System



Isotope Separation System



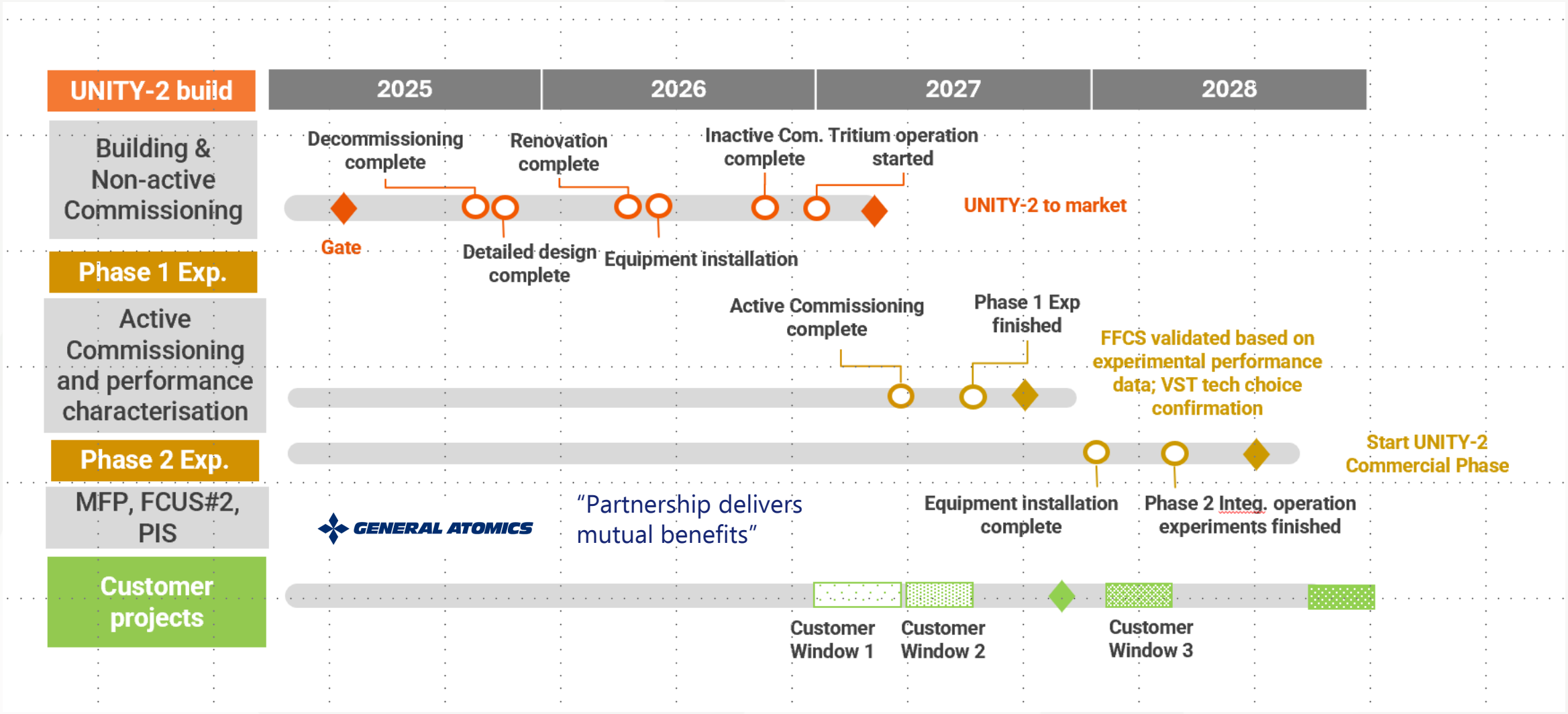
Fuel Management System



Air Detritiation System and Water Detritiation System

UNITY-2 SCHEDULE

Timelines and opportunities for customer projects



UNITY-2 TEAM

A global team with more than 40 mission-driven members

FUSION FUEL CYCLES

GENERAL ATOMICS

TRUSTED PARTNER IN YOUR FUEL CYCLE JOURNEY

For further details, please reach out to info@ffc.inc