

Hydrogen Site Lampoldshausen – On-site Production of Green Hydrogen and Technology Transfer from Space Applications

June 2022

Dipl.-Phys. Dr.-Ing. Birgit Gobereit, Dr. Daniela Lindner, Andreas Haberzettl, Fabian Jörg
DLR Institute of Space Propulsion
Department Applied Hydrogen Technologies (AWT)



Knowledge for Tomorrow



DLR at a Glance

- Research institution
- Space Administration
- Project Management Agency

Areas of research:

- Aeronautics
- Space research and technology
- Transport
- Energy
- Security (cross-sectoral area)
- Digitalisation (cross-sectoral area)



Locations and employees

More than 9000 employees work in 54 institutes and facilities at 30 sites across Germany.

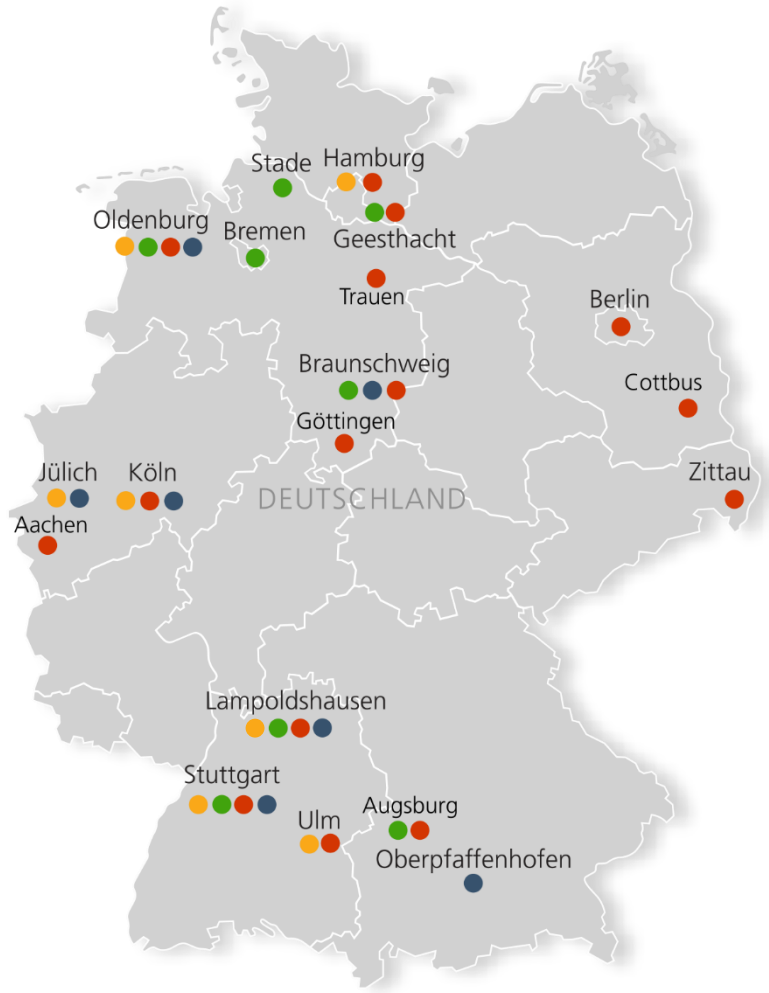
International offices in Brussels, Paris, Tokyo and Washington D.C.

Institute of Space Propulsion founded 1959 by Prof. Sänger

([DLR - Institut für Raumfahrtantriebe - Die Geschichte des Standorts](#))



DLR Sites with Hydrogen Activities



SPANIEN
● Almería



Production electrolysis & solar thermal processes



Storage & Distribution



Application



System/market analysis, technology assessment, sustainability



Hidden in the Harthäuser Forest...

... european test center for space propulsion systems

DLR-Institute of Space Propulsion

... one of the big hydrogen consumers in the world



Hydrogen Infrastructure at DLR Lampoldshausen

Andreas Haberzettl
Testing Department , RA-VEA



Test Facilities at Lampoldshausen Site

Research and development test bench P8
Pre-development

Technikum M3
Fundamental research

Research and development test bench P6
Pre-development

Test bench complex M11
"Green propellants"

Upper stage test bench P5.2
Upper stage tests

Main stage test bench P5
Engine tests

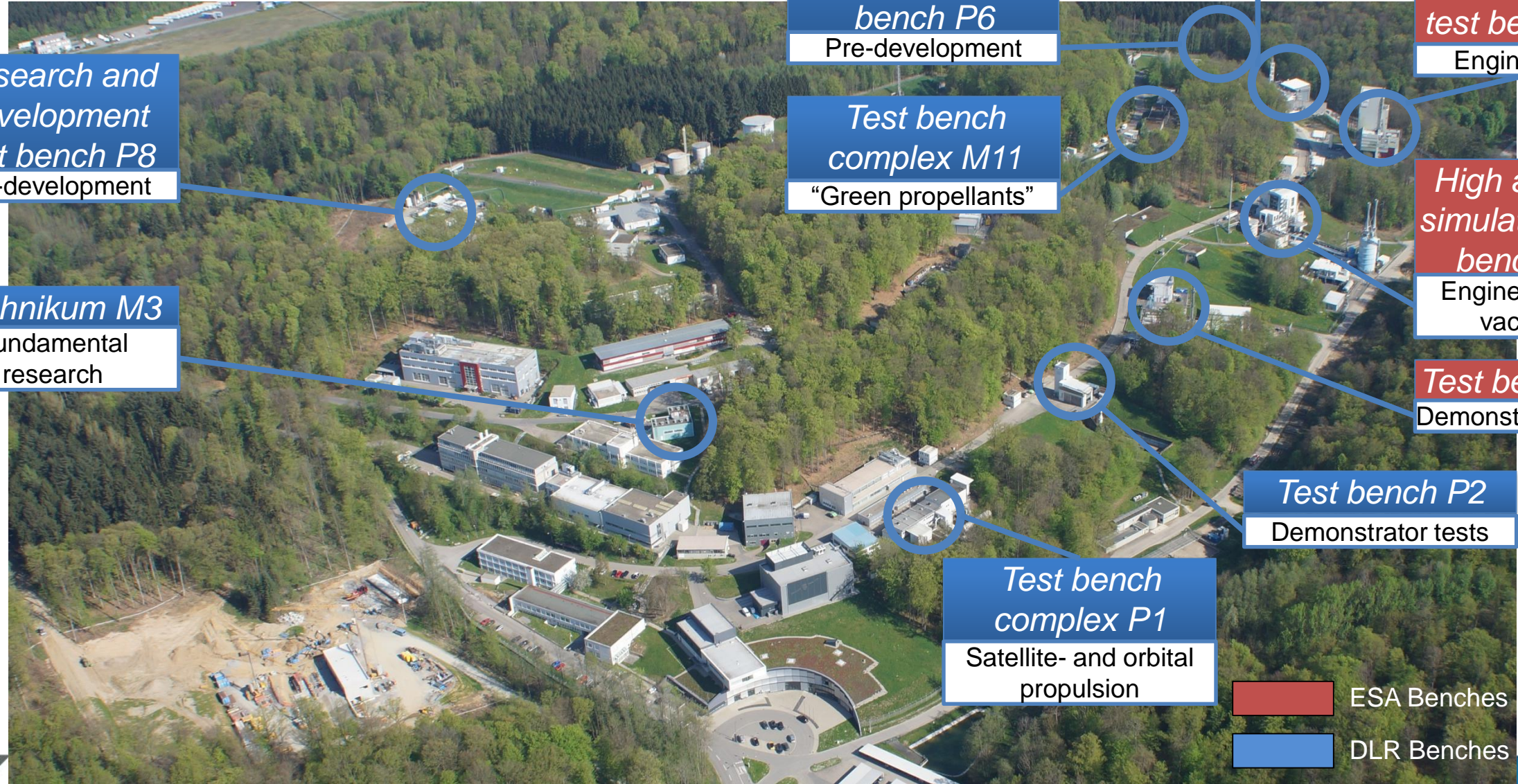
High altitude simulation test bench P4
Engine tests in vacuum

Test bench P3
Demonstrator tests

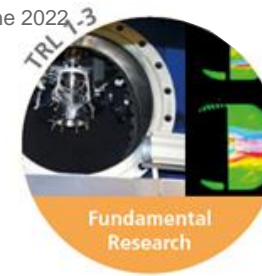
Test bench P2
Demonstrator tests

Test bench complex P1
Satellite- and orbital propulsion

ESA Benches
DLR Benches



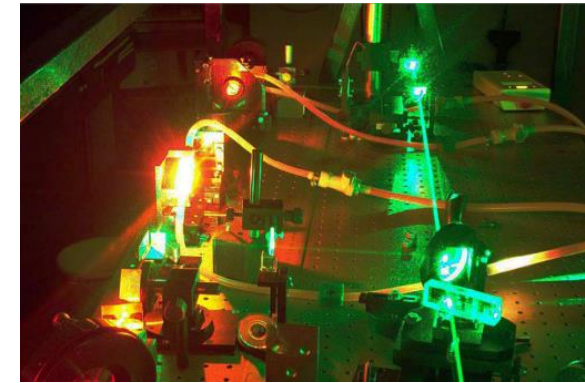
DLR Lampoldshausen – Test Operation



Test infrastructure and research facilities

M3 Testing field

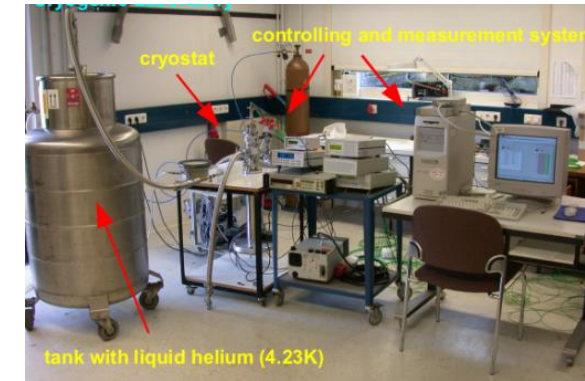
- M3.1: kryogene Fuel- injection and -combustion
- M3.2: Heat transfer
- M3.3: Combustion instabilities
- M3.5: Transient processes
- Physical Workshop
- Kryo-Lab
- Accoustic Workshop
- Chemical - Workshop



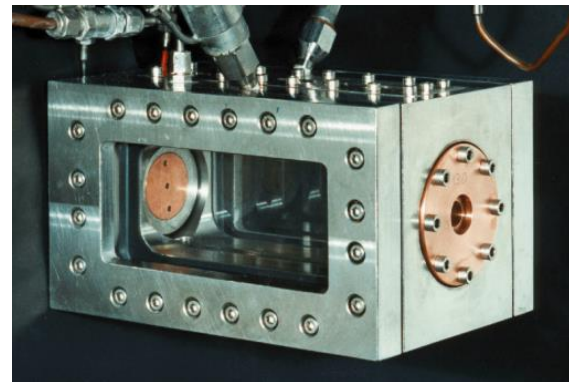
M3: physikalisches Labor



M3.3: Verbrennungsinstabilitäten



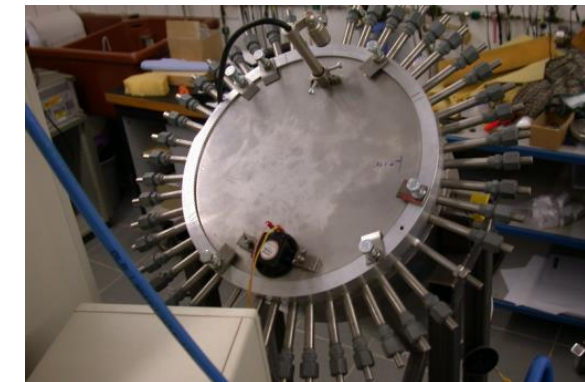
M3: Kryo-Labor



M3.1: Mikro-Brennkammer

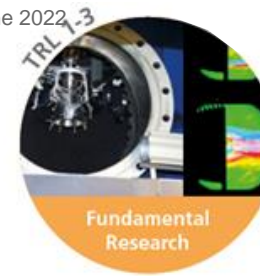


M3: Chemie-Labor



M3: Akustisches Labor





DLR Lampoldshausen – Test Operation

Test infrastructure and research facilities

Thermo- Mechanical Fatigue (TMF) test bench M51

M11 Test field

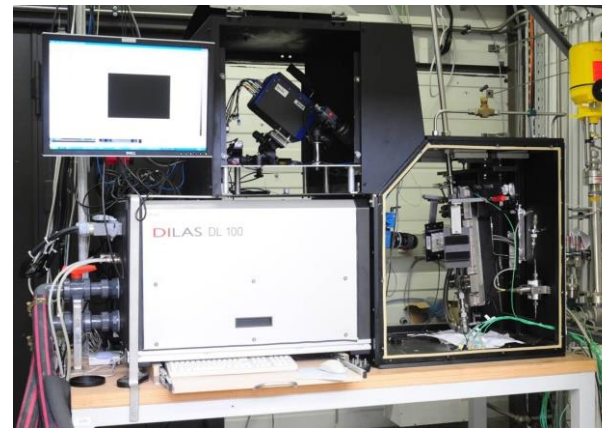
- 4 Positions in 2 Test cells
- 2 Positions student test field (M11.5)
- Fuel manufacturing
- Workshop test preparation



M11: Treibstoffherstellung



M11.1 – M11.4 Testzellen



M51: TMF Versuchsaufbau



M11 Testfeld

DLR Lampoldshausen – test possibilities

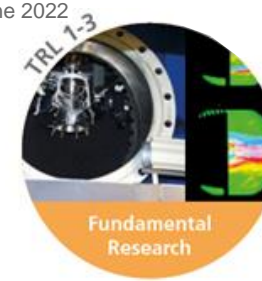
Test infrastructure and research test benches

Test bench P6.1

- Hot run test possibilities
- Mass flow rate up to 1,25 kg/s
- I/F pressure level up to 95 bar
- Propellants: LOX combined with LH2, LNG, LCH4

Test bench P6.2

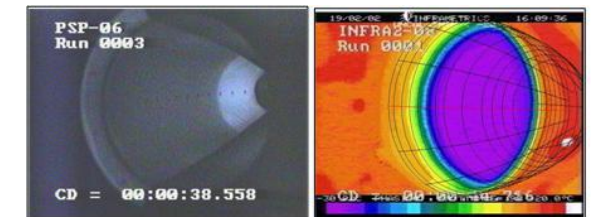
- Gas dynamic testing under cold gas conditions
- Simulation of transient ambient pressure conditions
- Study and improvement of technologies for high-altitude systems and research in the field of nozzles



Prüfstand P6.1

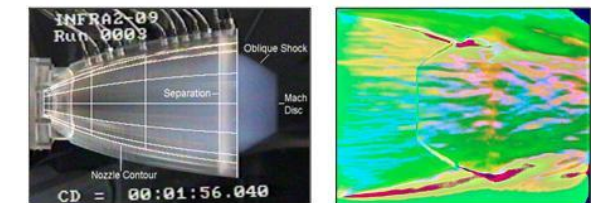


Prüfstand P6.2



PSP

IRT



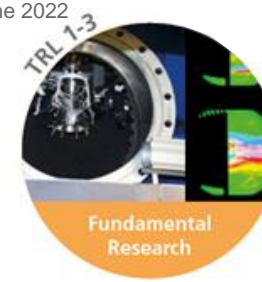
BFF

Schlieren

Visualisierungsmöglichkeiten am P6.2



DLR Lampoldshausen – Test Operation

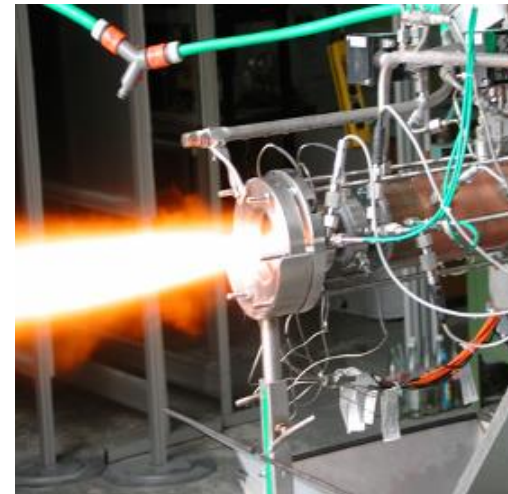
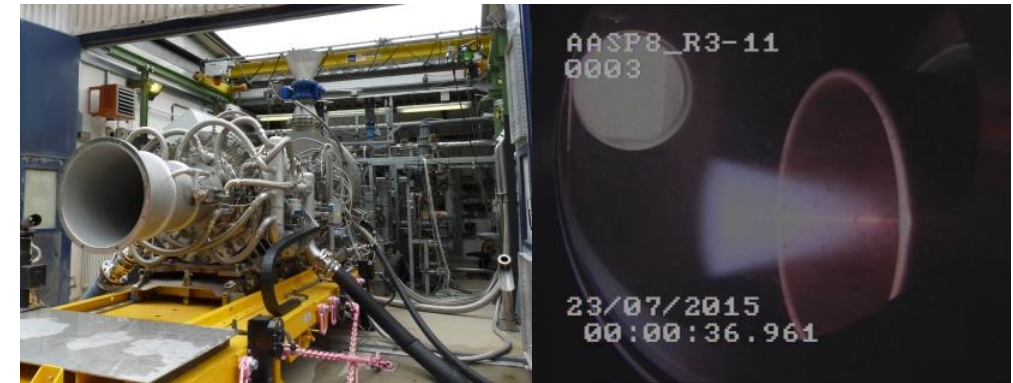


Test infrastructure and research test benches

Test bench P8 (P8.1 und P8.2)

- European research and development test bench
- High availability (up to 100 test days per year)
Optical measurement access from two adjacent diagnostic rooms per test cell possible
- Using an advanced altitude simulation system
- Mass flows up to 12 kg/s
- I/F pressures up to 360 bar
- Fuels: LOX with LH2, LNG, LCH4
Highly precise mass flow control with a maximum deviation of 1% and fast (< 1sec) operating point changes possible

Höhensimulation

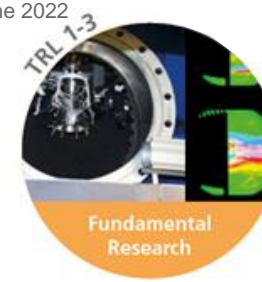


Heißlauf am P8



Heißlauf am P8

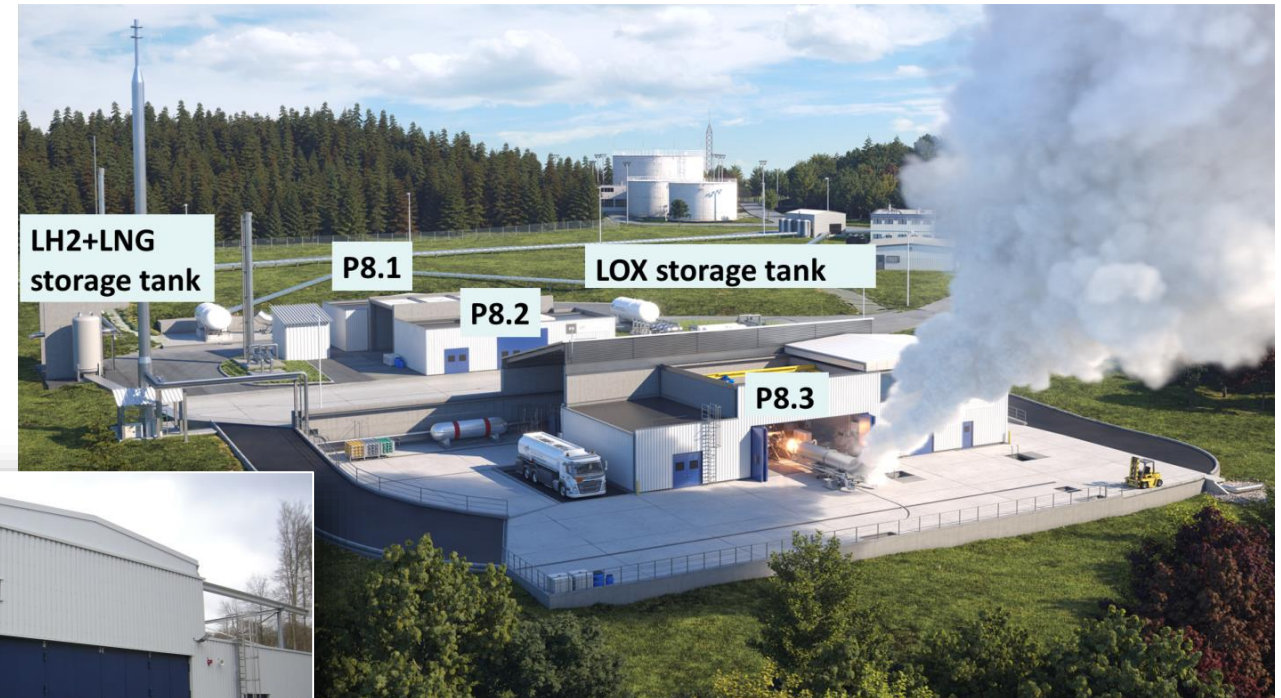
DLR Lampoldshausen – Test Operation



Test infrastructure and research test benches

Test bench P8 (P8.3)

- Completion and commissioning in 2020
- Test possibility for turbopumps, power pack and complete engines
- Mass flows up to 20 kg/s
- I/F pressures up to 14 bar
- Fuels: LOX with LH2, LNG, LCH4
Ethanol as “growth potential”.



LUMEN
25kN LOX/CH4
upper stage demonstrator engine



DLR Lampoldshausen – test possibilities

- Test infrastructure and test benches for development and technology demonstration

Test bench P2

- Two test positions available
- Operation with storable fuels (N₂O₄/MMH)
- Expansion of fuel capacity in planning (LOX)
- Thrust range up to 10 kN possible

Test bench P3

- ESA test bench for "full scale,,
- component tests
- Altitude system available
- Mass flow up to 330 kg/s
- I/F pressures up to 280 bar
- Fuels: LOX with LH₂, LNG, LCH₄



Prüfstand P2



Heißlauf am Prüfstand P3



Prüfstand P3

DLR Lampoldshausen – Test Operation

Test infrastructure and test benches for development, technology demonstration, qualification and acceptance of engines

Test bench P1.0

- Tests of satellite and orbital propulsion under high altitude conditions
- Fuels: N₂O₄, MMH, H₂O₂
- Thrust Range: 200N - 600N

Test bench P4

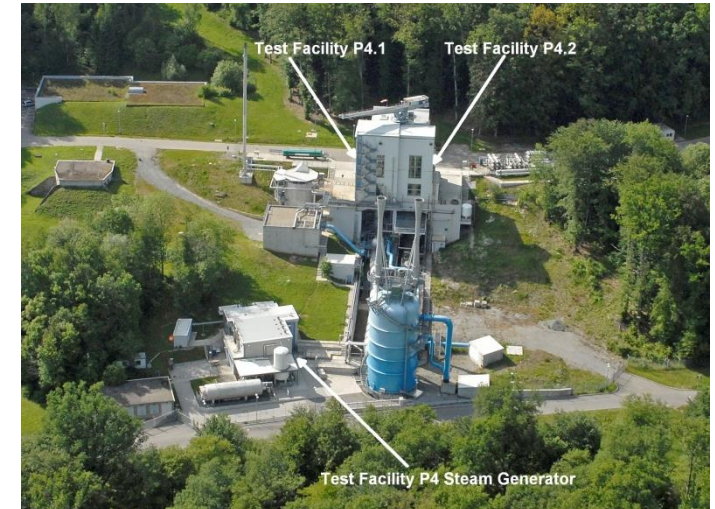
- ESA test bench with altitude simulation
- Cryogenic test position P4.1 (LOX/LH₂) up to a thrust range of 250 kN
- Storable test position P4.2 (N₂O₄/MMH) up to a thrust range of 30 kN
- Capacity of the steam generator plant up to 226 kg/s



Prüfstand P1.0



Prüfstand P4.1



Prüfstand P4 in der Übersicht

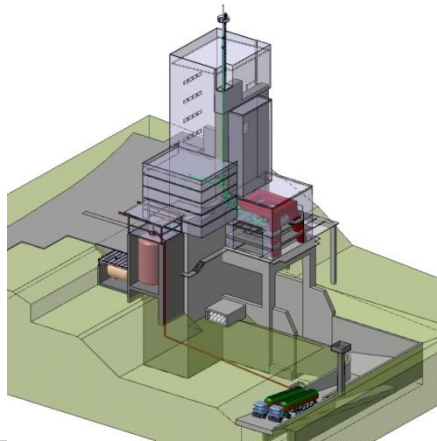


DLR Lampoldshausen – test possibilities

Test infrastructure and test benches for development, technology demonstration, qualification and acceptance of engines

Test bench P5

- ESA test bench for tests under ground conditions
- Fuels: LOX with LH2
- Extension with LNG/LCH4 in progress
- Thrust range up to 4,000 kN



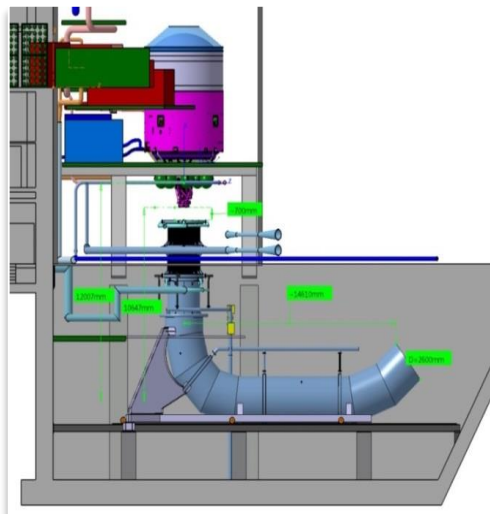


DLR Lampoldshausen – Test Operation

Test infrastructure and test benches for development, technology demonstration, qualification and acceptance of rocket stages

Test bench P5.2

- ESA test bench for cryogenic rocket upper stages
- Fuels: LOX with LH2
- Ariane 6 upper stage tests actually running
- Adaptable and modern test infrastructure



DLR Lampoldshausen – test possibilities



Supply systems for test benches

Fluide supply

- Central GN2 production from LN2
- Central helium supply
- Central GH2 production from LH2
- Central warehouses for LOX and LH2
- Central cooling water supply
- Key areas for storable fuels

Electrical power supply

- Uninterruptible power supply
- battery backup



DLR Lampoldshausen – test possibilities



Other necessary test bench infrastructure

Control rooms with real-time control computers (MCC - measurement, command, control)

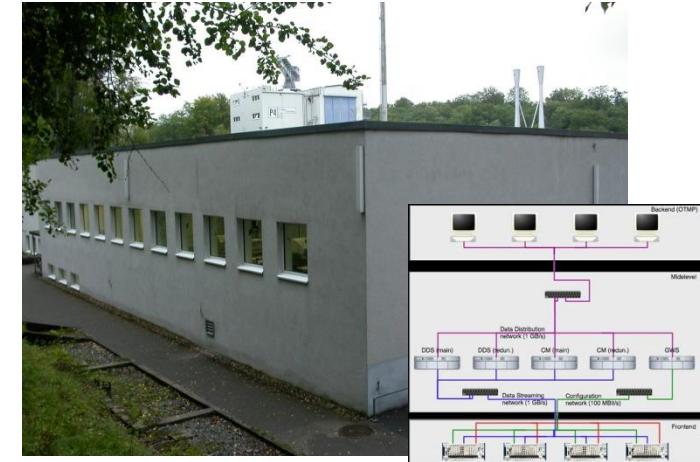
Integration and assembly halls

spare parts storage

workshops

clean rooms

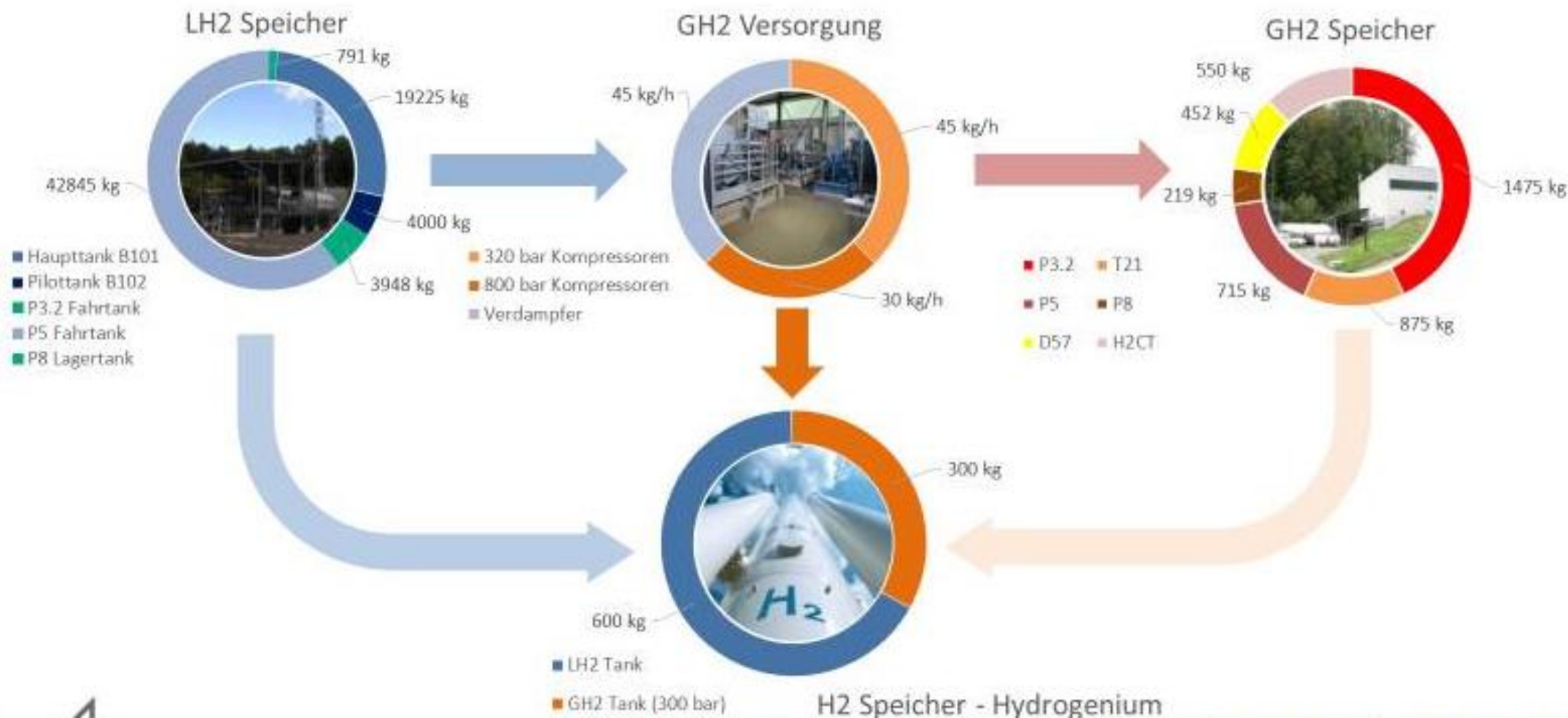
Neutralization system for storable fuels



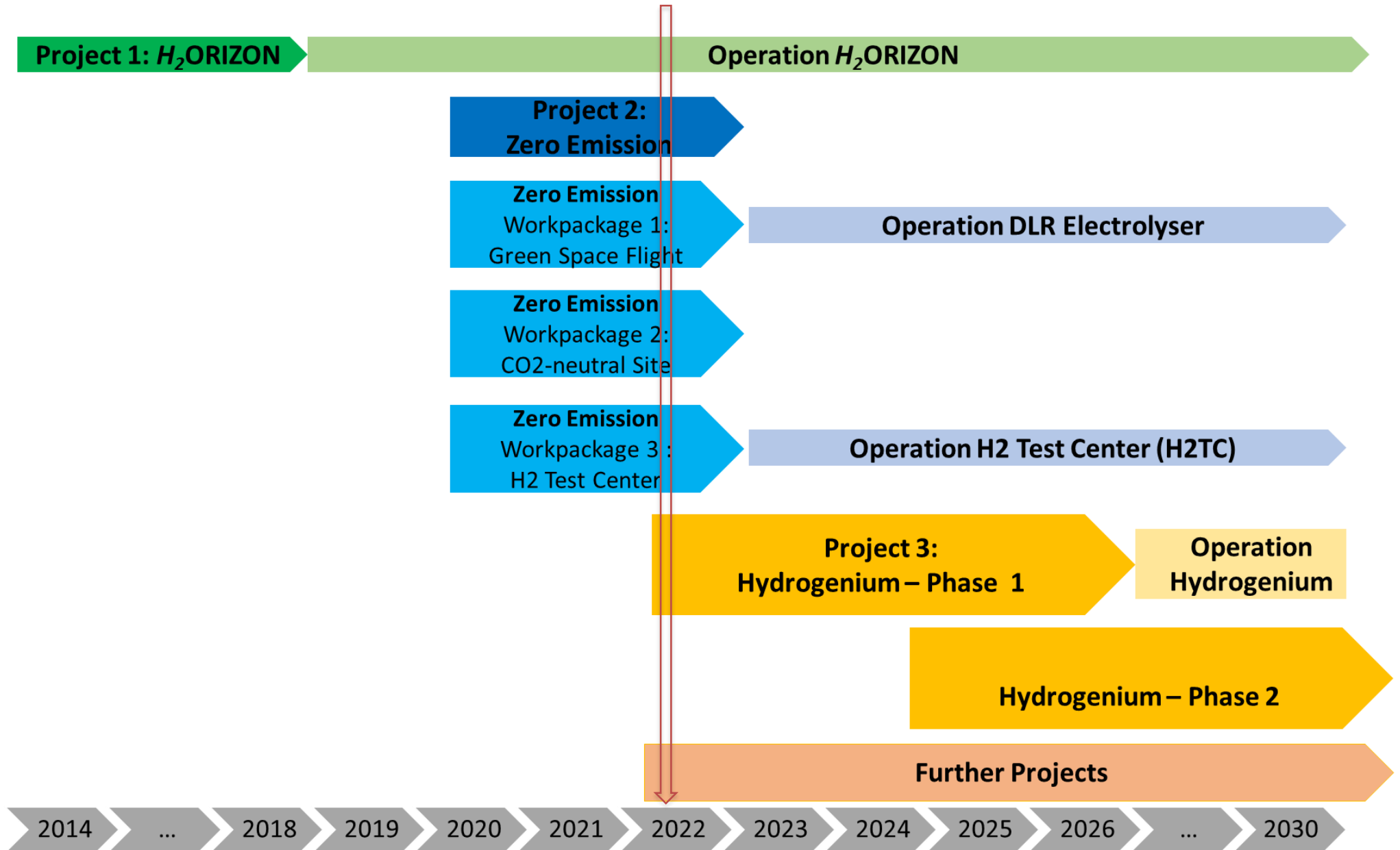
Consumption of Media [Nm ³], Supply Facilities--> Test facilities 2018							
	LH2	GH2	LOX	GN2	LIN	GHe	
P1.0	0	0	0	0	0	0	0
P3.2	0	45000	0	170875	0	0	
P4.1	539549	28000	0	401750	0	0	43138
P4.2	0	0	0	9500	0	0	0
P5	4522478	78000	2044329	476500	0	0	85575
P6.1	0	0	0	6250	0	0	
P6.2	0	0	0	0	0	0	
P8	0	67200	0	178800	0	0	
200bar BN				195875	0	0	
M70				12800	0	0	
M11					7200	0	
M3					6260	0	
Sum	5062027	218800	2044329	1452350	13460	0	128713



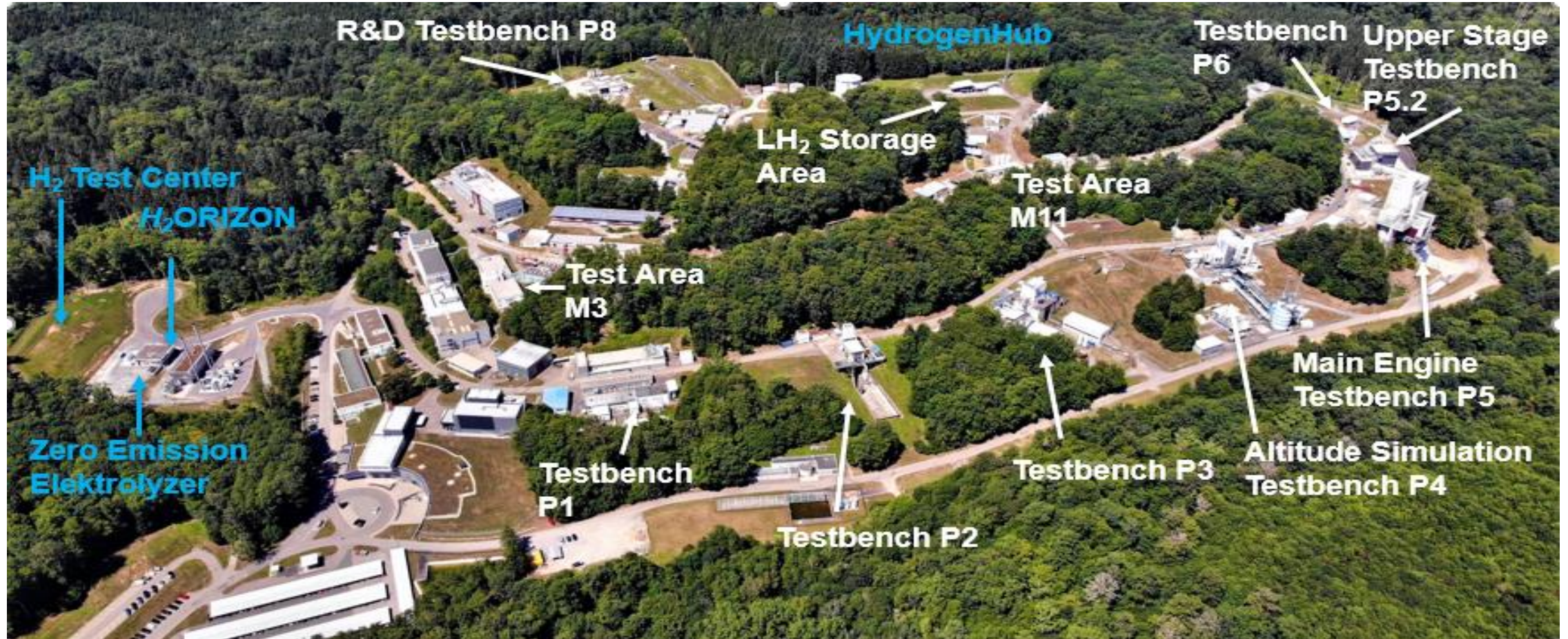
Supply of Media DLR Center Lampoldshausen



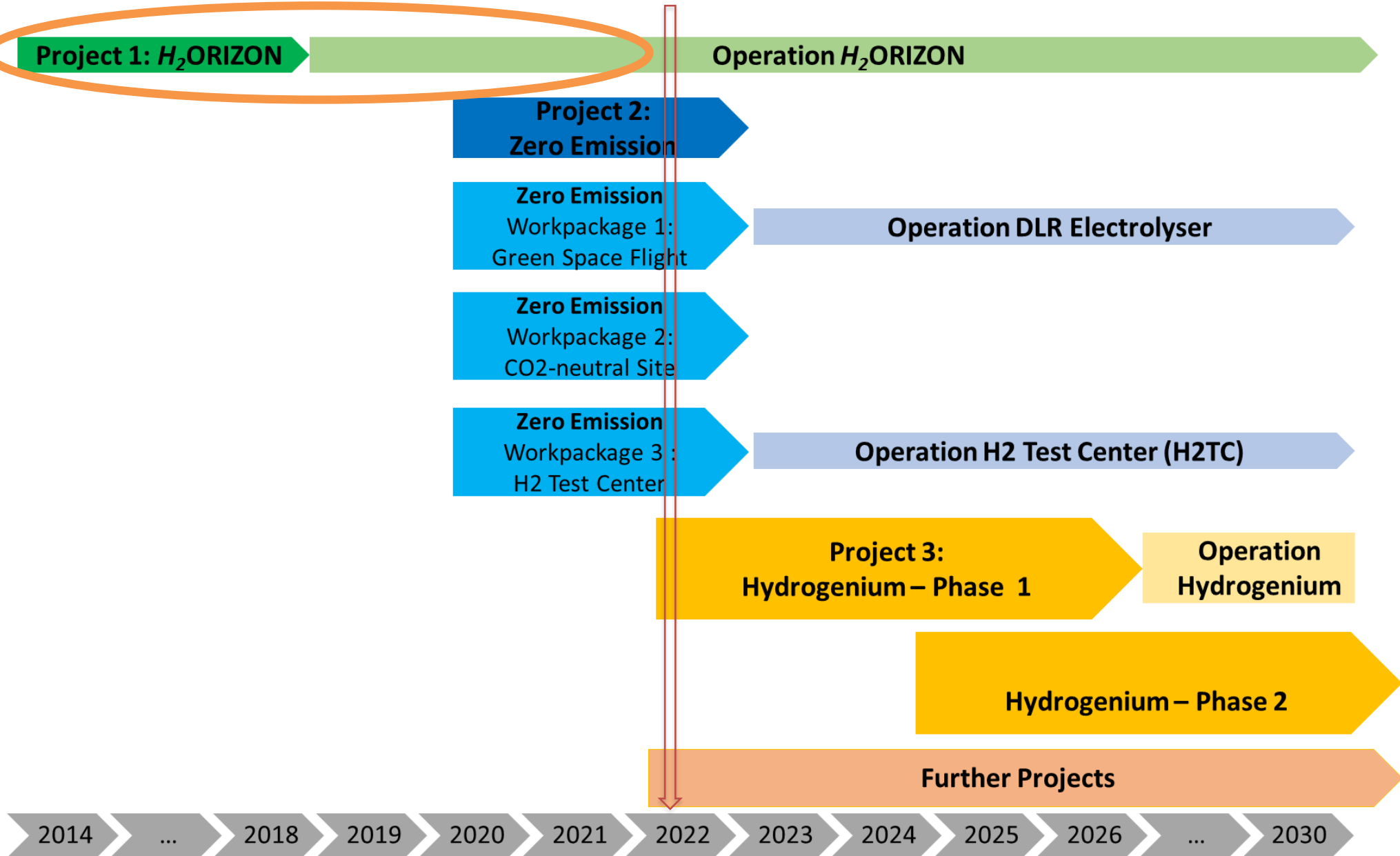
Outline



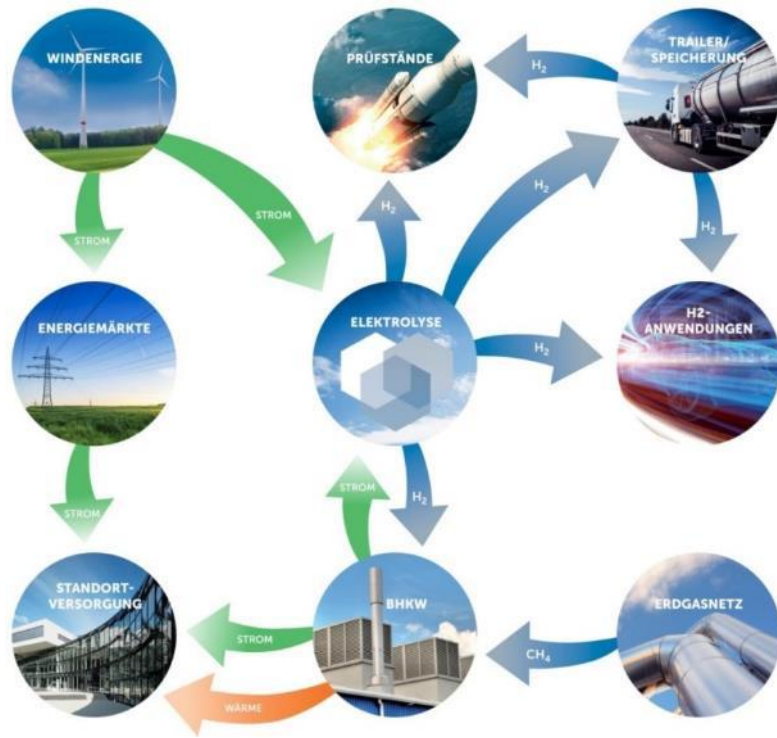
DLR Site Lampoldshausen



Outline



H₂ORIZON: Research- and Demonstration Platform



Fact sheet

Project start 2015

~ 900.000 Euro funding Ministry for the Environment, Climate and Energy Management

Project Partner ZEAG Energie AG

PEM Electrolyzer as **Research platform**

Hydrogen production via wind power

Usage of hydrogen for rocket engine tests and in H₂ test center

Power & heat generation via BTTP with methane hydrogen mixture

Start of normal operation 03/2022

✓ Usage of existing **Infrastructure**

(54MW wind park & DLR test facilities)

✓ combining of **Competences**

(Research, hydrogen & energy economy)

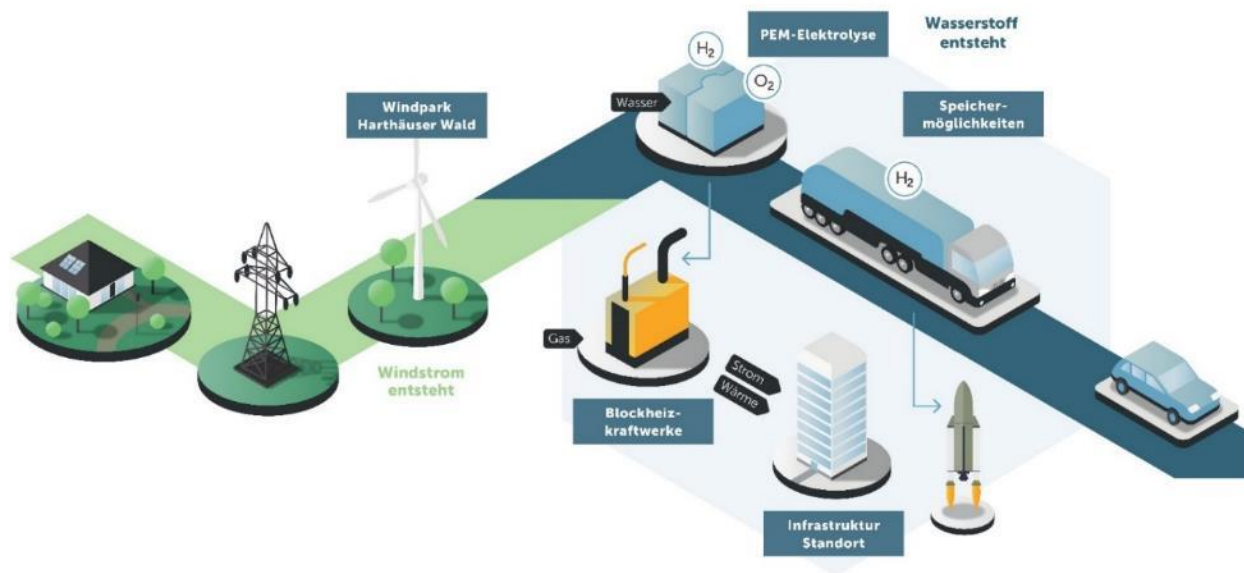
✓ **Sector coupling** for an optimized operation

(space flight, energy economy & Traffic)



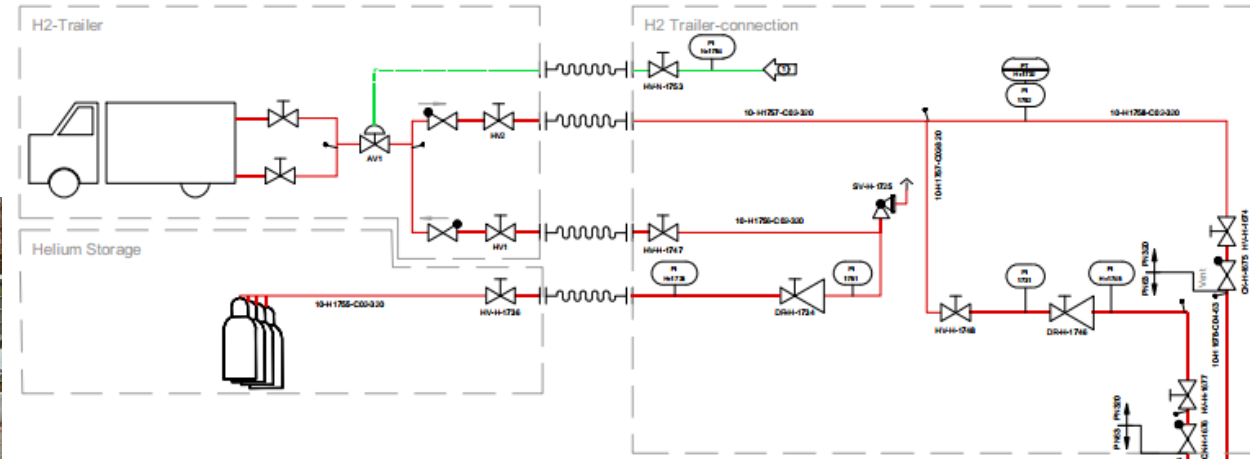
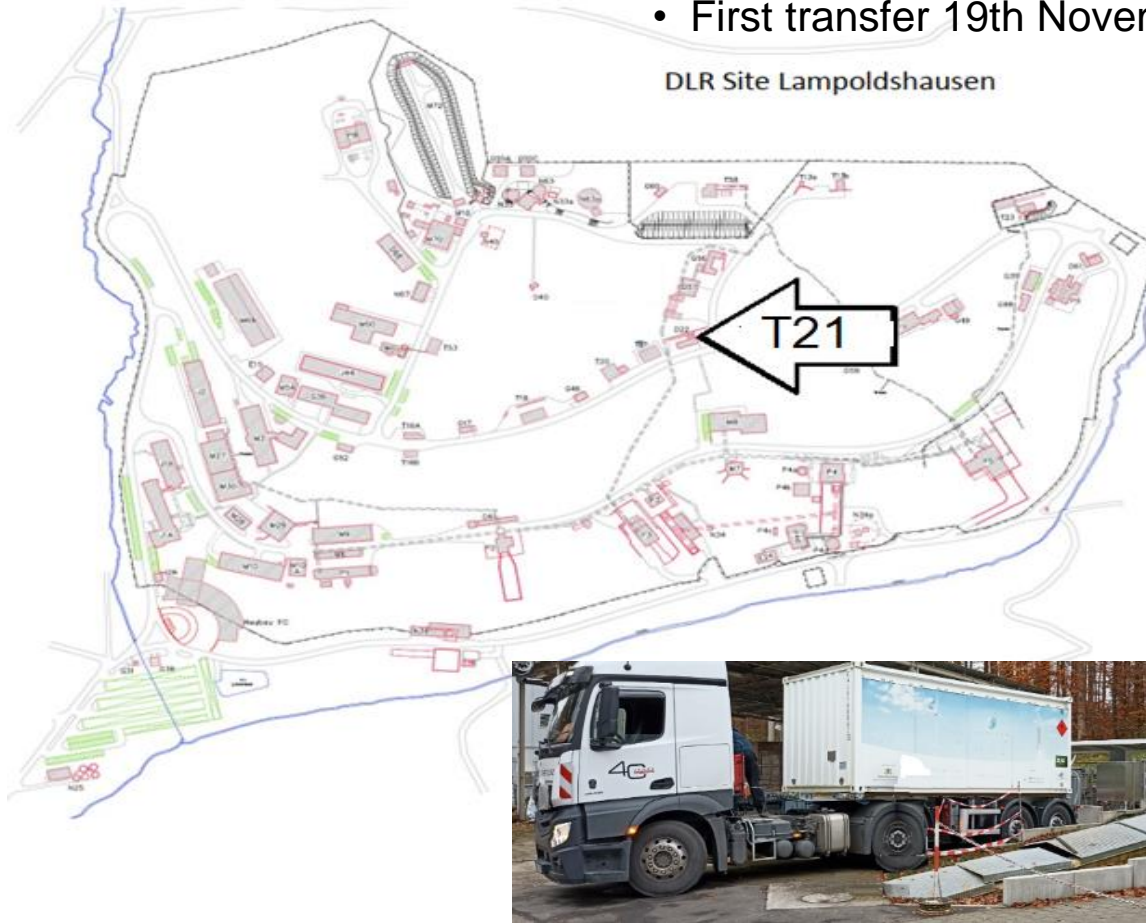
H₂ORIZON at a Glance

- PEM electrolyzer (880 kW electrical power, max. 14,1 kg/h GH₂)
- 100 % green hydrogen from wind energy
- Compression auf 300 bar
- Tube trailer as buffer storage (about 300 kg @ 300 bar)
- Combine heat and power plant with gas motor peak power 1,7 MW (thermal) und 1,4 MW (electric)

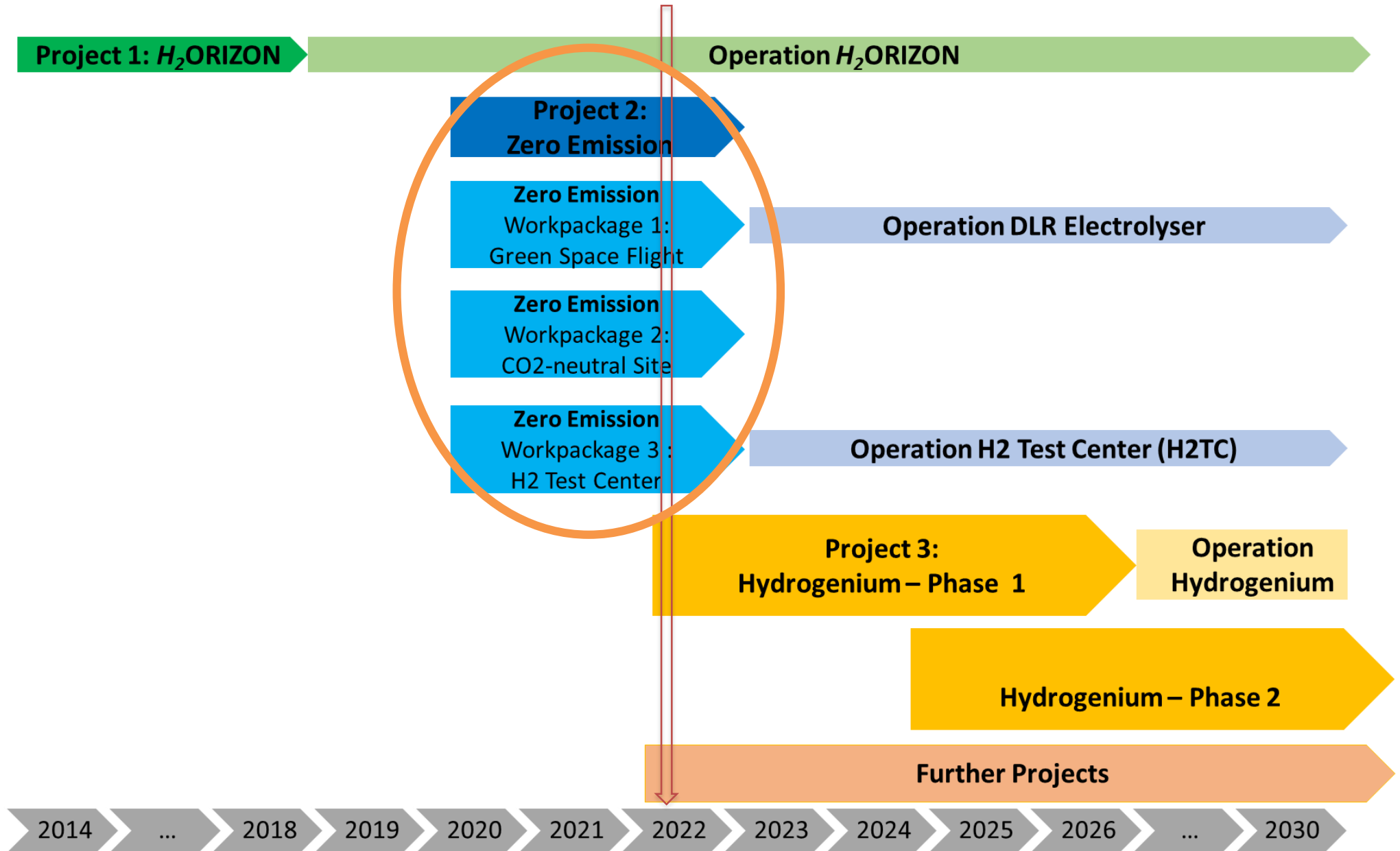


GH2 Transfer

- Hardware status unloading panel at T21
 - ZEAG trailer
 - First transfer 19th November 2021





Outline



Project: Zero Emission

 Green Space Flight

 CO₂ – neutral Site

 H₂ Test Center


 Enhance production of green hydrogen with 2nd PEM electrolyzer (about 3 MW – 300 t/year)

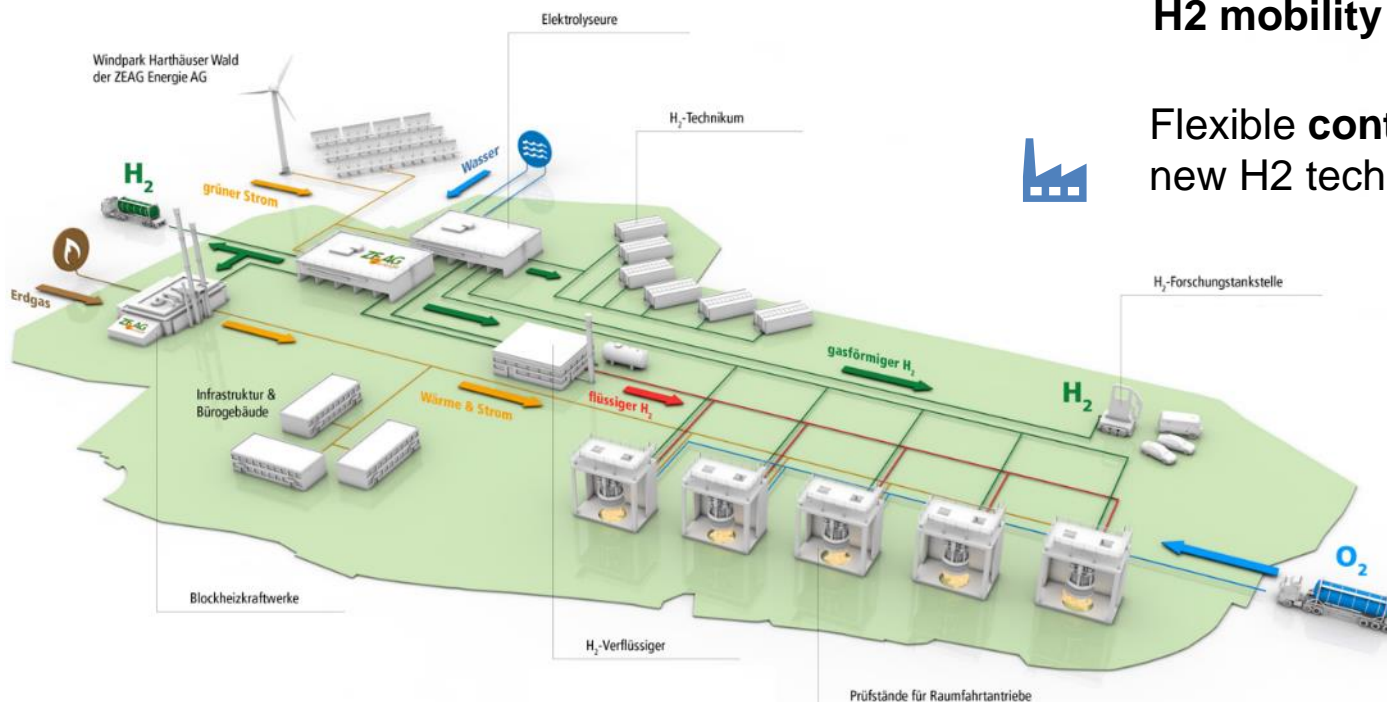
Extension of H₂ infrastructure (storage & distribution system)

On-site production of LH₂ with **liquefier**

 Assessment and optimization of **site energy system**

H₂ mobility (vehicles & fueling station)

 Flexible **container based test center** to support development of new H₂ technologies in cooperation with industry and science



Realization framework

Project duration: 05/2020 to 12/2023

~16 Million € Funding
Ministry of Economics, Labor and Housing
Baden-Württemberg

Zero Emission – Green space flight

Erection of an additional electrolyzer

- Increase of H₂ generation capacities
- Construction of a pipeline to connect the electrolyzers and the H₂ test center to each other and to the on-site media supply for the test bench facilities

Erection of a liquefier

- Additional supply of approximately 140 tons of liquid hydrogen per year

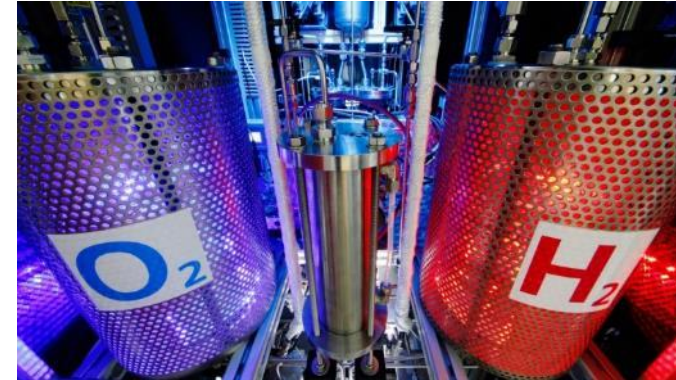


Foto: DLR / Thomas Ernsting

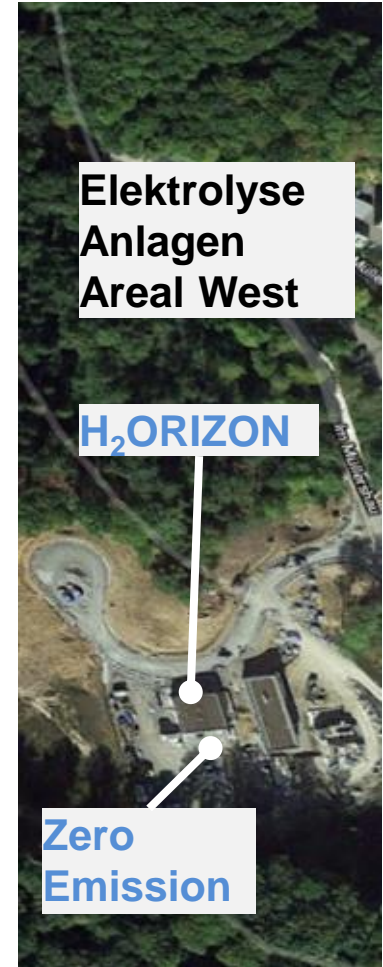
Electrolysis capacities

ZEAG Energie AG: 0,9 MW

100 tons of H₂ per year

DLR: 2 MW

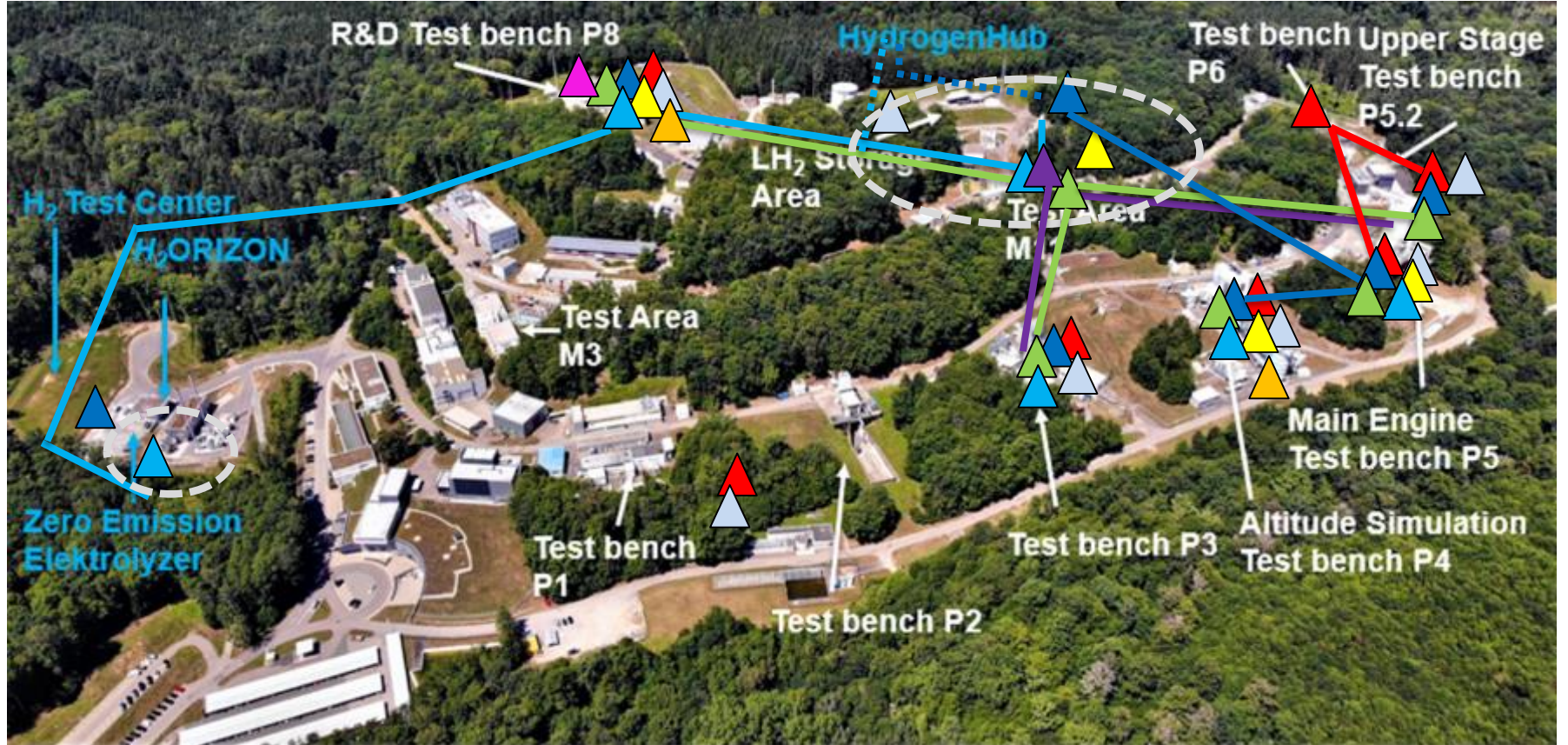
180 tons of H₂ per year



Main media supply systems

	Piping	Tank
GH ₂		
LH ₂		
GN ₂		
LN ₂		
GOx		
LOx		
CH ₄		
GHe		
Water		

Production and/or Refilling area



Zero Emission – CO₂-neutral site

Expansion of the site's energy supply system based on a sustainable design

- Design of an ideal energy system (generation, storage, sector coupling).
- Design of the new energy system, development and implementation of an optimal operation management with machine learning methods

Reduction of emissions in mobility

- (Procurement and operation of a mobile H₂ filling station)
- Expansion of the vehicle fleet with fuel cell vehicles
- Clarification of research questions on H₂ mobility

Fuel Cell car Toyota Mirai II



Project partner

DLR Institute of Networked Energy Systems

DLR Institute of Vehicle Concepts

DLR Institute of Space Propulsion

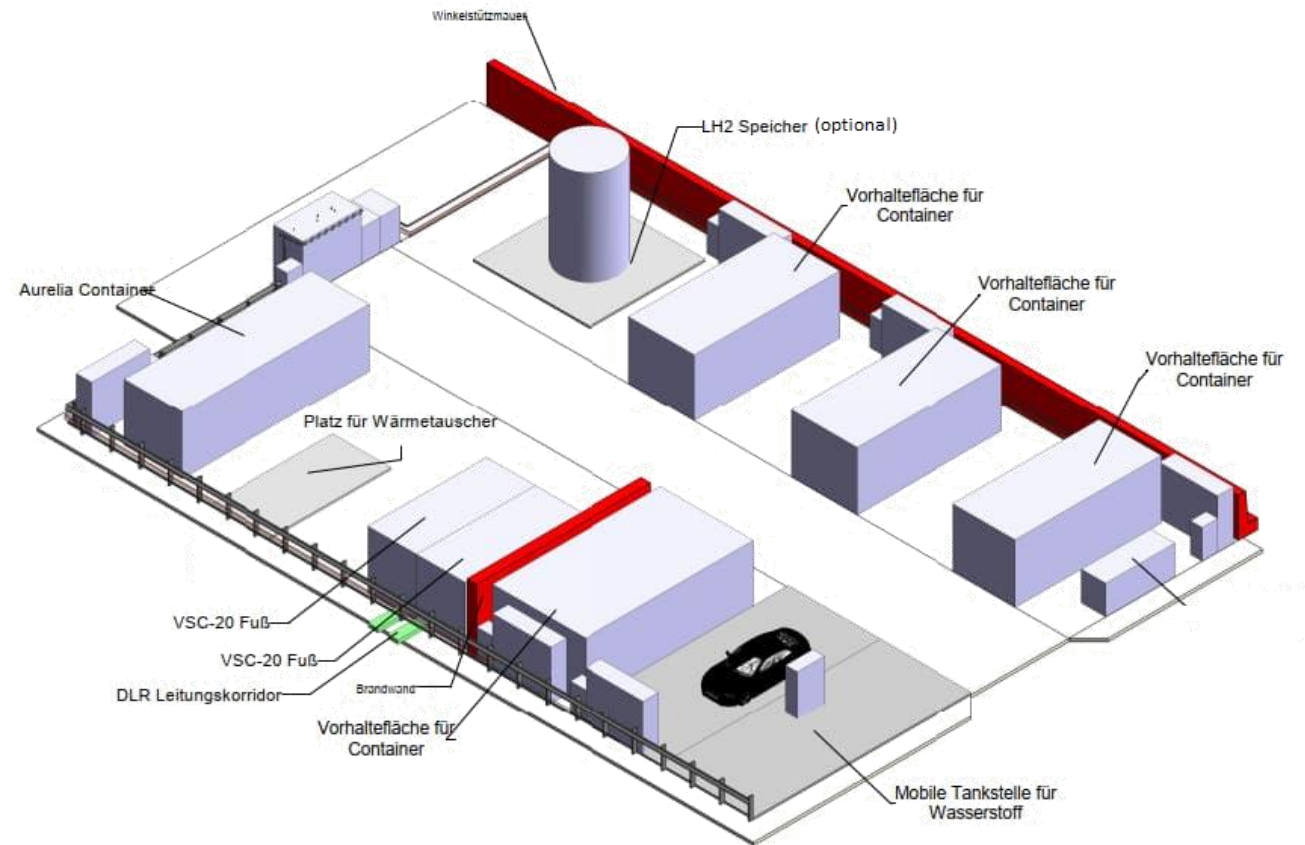


H2CT - Container-based Hydrogen Test Center

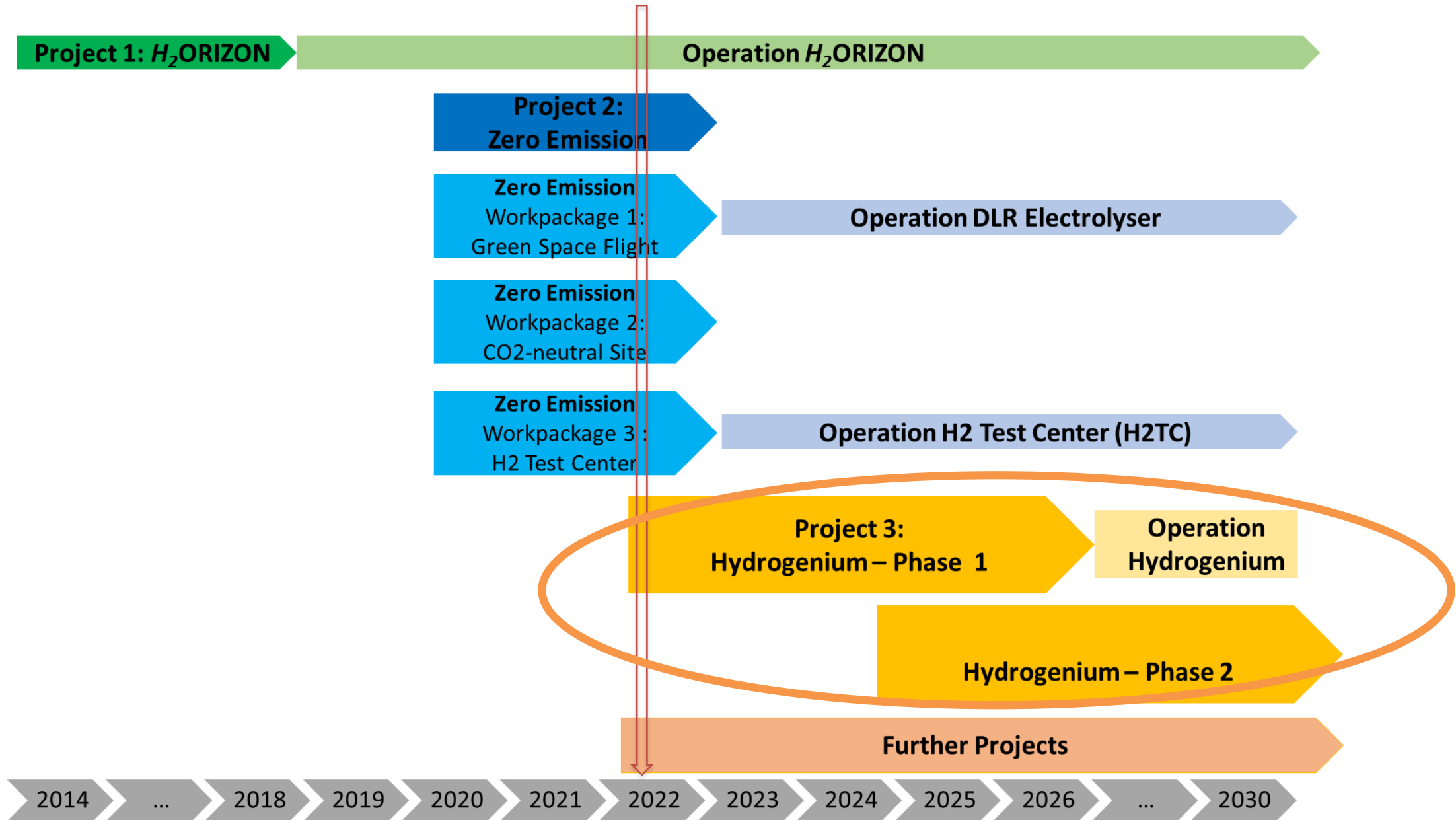
- Hydrogen test center with 7 test positions, centralized media and safety infrastructure, 24/7 operation
- Start of operation Q2 2023

Main supplies:

- Green GH2 from own electrolyzer
 - 30bar (for 24/7 operation)
 - 300bar (not for 24/7 operation)
 - Max. 60kg/h
- Liquid H2 supply as growth potential (one test position blocked)
- Nitrogen 300bar (purge & valve control)
- Power up to 500kW
- Use water
- Ultra-pure water



Outline



Hydrogenium

Expansion of a permanent test, application and transfer center on an industrial scale for medium-sized companies:

- Development and testing of hydrogen components and systems
- Innovative solutions from idea generation to market maturity of systems and components
- Various studies by partners, such as a diffusion study in the Heilbronn-Franken region
- Test infrastructure focusses:
high mass flows and liquid hydrogen



Realization framework

Project duration: 07/2022 to 12/2026

~12 Million € Funding

EFRE, EU & Ministry of Economics,
Labor and Housing Baden-
Württemberg

Project management: Heilbronn Region
Economic Development Agency



Hydrogenium

Media Supply with green liquid and gaseous hydrogen:

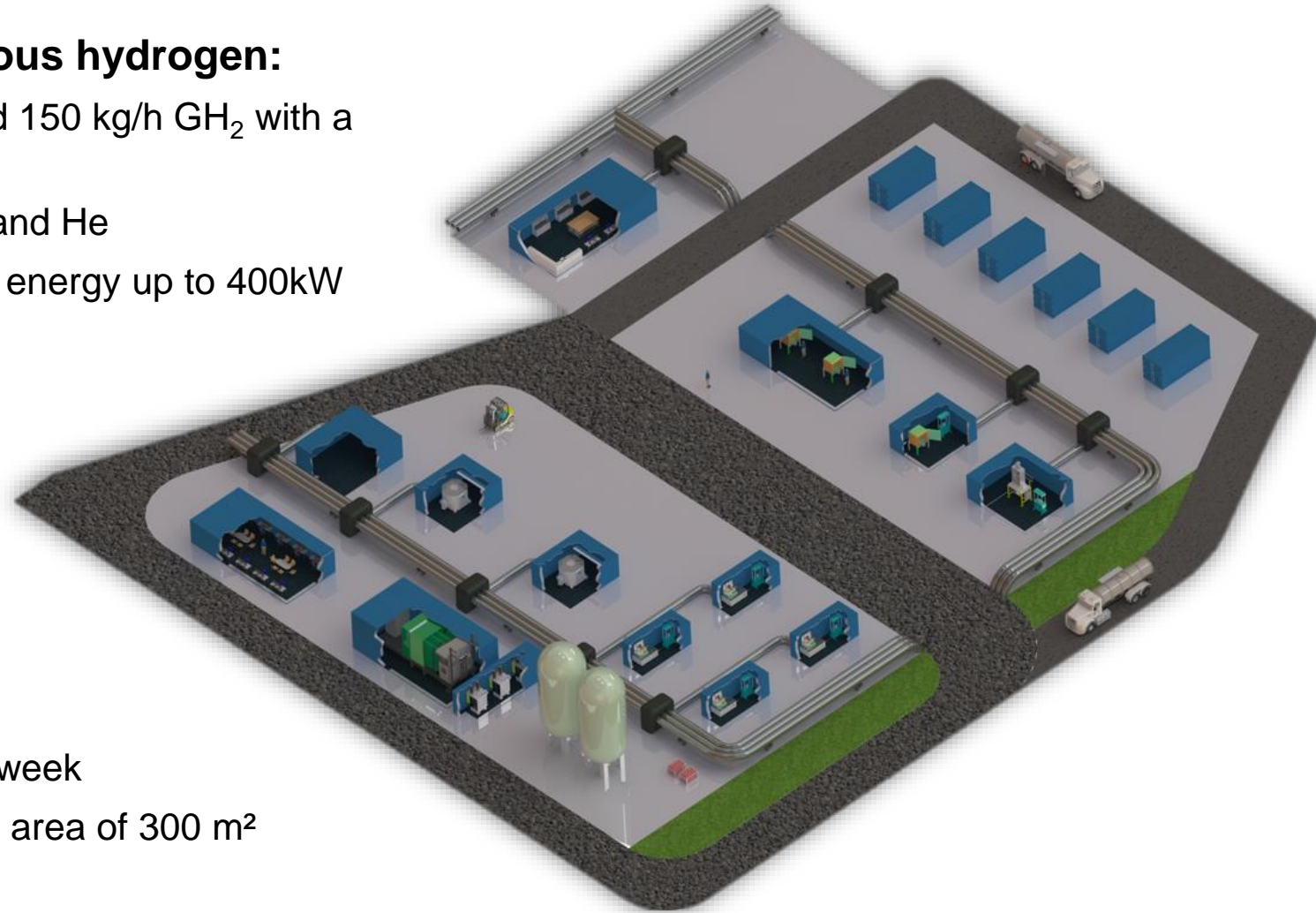
- Reliable supply up to peaks of 500 kg/h LH₂ and 150 kg/h GH₂ with a maximum pressure of 300 bar
- Additional supply of every test bench with GN₂ and He
- Demand-based supply and delivery of electrical energy up to 400kW

Services:

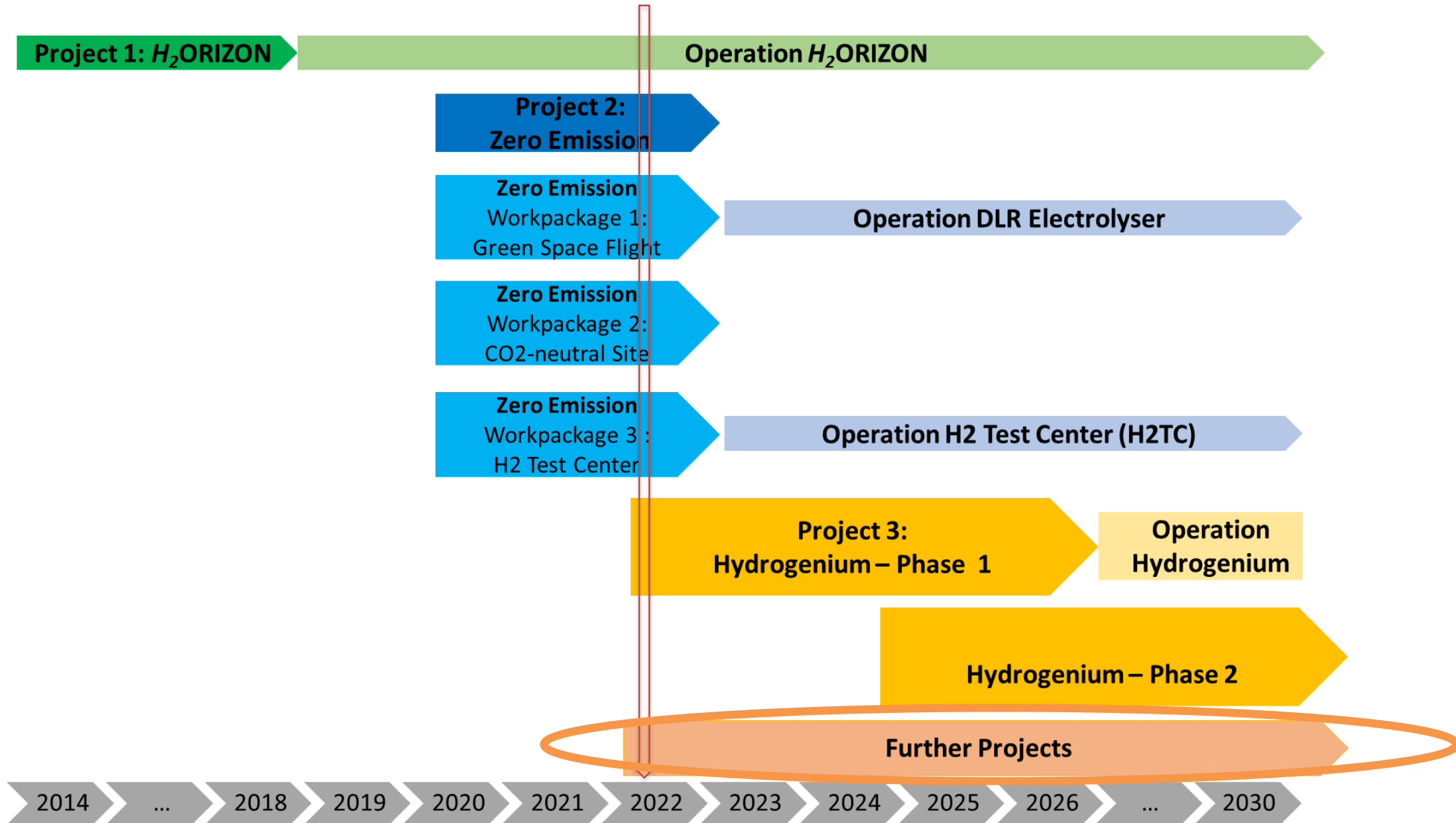
- Support in projects
- Support for erection and operation
- Preparation area

Hydrogen Cluster of Excellence:

- Opportunity of testing 24 hours a day, 7 days a week
- Flexible, container based test positions up to an area of 300 m²
- Open to all sectors/technologies



Outline



Further Projects

Do228FC LH2 flight demonstrator of MTU und DLR-FX

- Flight demonstrator of a FC driven DO228
- RA-AWT: Design und erection of a ground fueling station at DLR-FX airfield in Oberpfaffenhofen

A320 H2 Demonstrator of Lufthansa Technik

- Ground demonstration of operation of a FC system in an A320 plane with LH2 supply
- RA-PTE: Design of LH2/GH2 System incl. tank in plane
- RA-AWT: System simulation of the design (in parallel)

HYTAZER (HYdrogen Tank ZERtifizierung)

- DLR internal Impulse project

BALIS

- Test platform for LH₂ driven fuel cell systems >1MW
- RA supports planning and erection of LH2/GH2 systems

KENTECH (Korean University in planning phase)

- Feasibility study of Fraunhofer concerning Liquification as research and lab topic

Systogen 100

- LA as living laboratory

...



Summary & Outlook

- Expansion of test capacities and extension of the test portfolio for applications from the maritime, aviation, mobility and energy sectors.
- On site production of green hydrogen.
- Further hydrogen projects with research and industry.



Thank you for our attention



Contact

Dipl.-Phys. Dr.-Ing. Birgit Gobereit

DLR Institute of Space Propulsion (RA)

Department Applied Hydrogen Technologies (AWT)

Phone: +49 6298 / 28 - 751

E-Mail: birgit.gobereit@dlr.de

