

Connecting cities at high speeds in a sustainable way

EuroTube Foundation Annual Report 2022



The EuroTube Foundation

The hyperloop technology has garnered the attention of key stakeholders as it presents the potential to serve as the next-generation transport system. Although the focus of many parties has been on the development of vehicle technology, there has been a lack of effort towards revolutionizing the underlying infrastructure. Despite the numerous challenges posed, it is our conviction that the success of this transport system, both technologically and economically, is contingent upon the innovation of its infrastructure.

In an effort to address the capital-intensive innovation gap, EuroTube has devised a strategy to construct a publicly accessible test track. This facility will not only provide flexible rail and vacuum conditions at full speed, but also validate the viability of the modular concrete tubes. These tubes can be cast on-site and significantly reduce production and logistical costs. By implementing this strategy, EuroTube aims to make a significant contribution to the development of the hyperloop technology.

The year 2022 was dominated by political and economic turmoil, with the remaining effects of the Covid19-pandemic posing challenges to travel, office routines, and logistics. Still, EuroTube managed to grow its team of dedicated, highly skilled scientists, engineers and managers, open a new office, move its research missions and lighthouse projects forward and bring together an ecosystem of industry and public stakeholders interested in hyperloop.

2022 showed the endurance and strength of the EuroTube mission, as our main lighthouse projects took shape and our network of partners kept growing. In 2023 we look to break ground on our first major fabrication project, the GammaShellPipe vacuum-proof concrete tube, which will be the main building block of our DemoTube project and serve as a benchmark for sustainably built hyperloop infrastructure components going forward.



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Expanding our R&D Lab - and moving our DemoTube project towards implementation

In 2021, we set up a research organization that included a lab and a growing team. In 2022, we leveraged our research and project development skills to further the progress on our projects.

Our laboratory at the Swiss Federal Laboratories for Material Sciences and Technology (Empa) now holds two vacuum chambers, and five test benches to test several subsystems of our DemoTube system (Pipe connections, feedthroughs, joints, liners and membranes, sensors, and others) and a fully-developed data acquisition system to store and gather test data reliably.

Our team kept growing and the chance to have both operations and R&D under one roof close to our lab meant that we opened an office in Dübendorf in proximity to Empa. At the same time we keep refining the tools we use to allow both remote and in-office work.

We now have industry partnerships in place for some of the most critical technical systems: concrete manufacturing and polymer fabrication for the tubes, and vacuum system components for our DemoTube demonstrator. At the same time, we continue to develop new relationships with companies active in our field, from rail technology, electrical systems, mechanical components to construction solutions - all the while we develop our technology further and join research collaborations.

We are now in a position to begin with the fabrication project for the first component for DemoTube, the GammaShellPipe prototype of a post-tensioned concrete tube with a vacuum-proof sealant.

Progress on our Lighthouse Missions

EuroTube is working towards becoming a leading research hub in Europe by pursuing lighthouse projects. These projects are designed to create a significant impact on the development and realization of hyperloop technology.



DemoTube

The goal of DemoTube is to establish itself as a comprehensive test facility for vacuum transport mobility, utilizing a 120m long tube made of a new and innovative composite material. This facility will validate research conducted during the development and implementation phases and set a new standard for optimizing energy consumption.

Progress in 2022

In 2022, the DemoTube project made significant progress. The technical design was completed, allowing for the subsequent ordering and production of all required components.

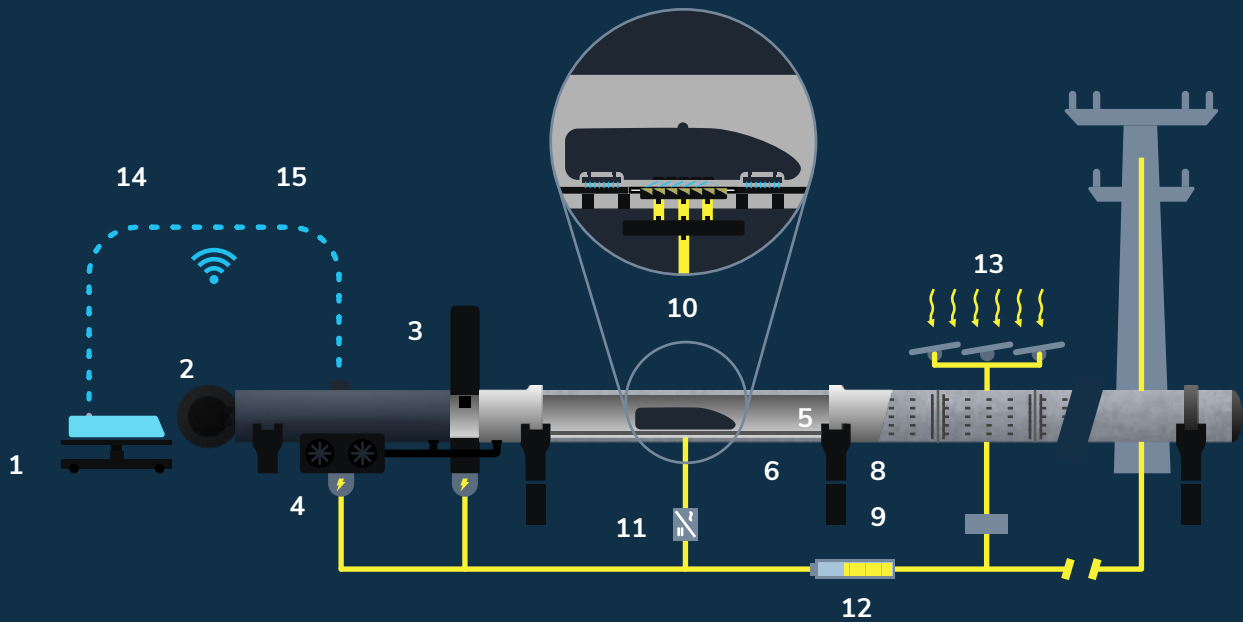
The permit process for the project remained ongoing, with two permits submitted and un-

der consideration by the City of Dübendorf. While the permit process is ongoing, and to reduce costs and streamline the project, the DemoTube was divided into staged sub-projects with lower cost thresholds.

The first of these sub-projects is the GammaShellPipe, which involves fabricating tubes and demonstrating the construction methods and materials required for a vacuum-proof hyperloop tube for DemoTube. EuroTube partnered with concrete manufacturers and producers of polymers and sealant technologies to ensure that the GammaShellPipe meets the necessary requirements.

Additionally, the DemoTube project established new partnerships with Standortförderung of Canton Zurich and received the endorsement from Switzerland Innovation, further supporting the project's progress.

Status of Different Technological Components of DemoTube



		System Requirements Review	System Design Review	Preliminary Design Review	Critical Design Review	Design Freeze
1	Sled	Progress	Progress	Progress	Progress	Progress
2	Airlock	Progress	Progress	Progress	Progress	Progress
3	Valve	Progress	Progress	Progress	Progress	Progress
4	VacAssurance	Progress	Progress	Progress	Progress	Progress
5	Pipe	Progress	Progress	Progress	Progress	Progress
6	Track	Progress	Progress	Progress	Progress	Progress
7	OpenAirTrack	Progress	Progress	Progress	Progress	Progress
8	PipeSupport	Progress	Progress	Progress	Progress	Progress
9	Foundation	Progress	Progress	Progress	Progress	Progress
10	Launcher	Progress	Progress	Progress	Progress	Progress
11	Inverter	Progress	Progress	Progress	Progress	Progress
12	Power	Progress	Progress	Progress	Progress	Progress
13	Energy	Progress	Progress	Progress	Progress	Progress
14	Control	Progress	Progress	Progress	Progress	Progress
15	Com	Progress	Progress	Progress	Progress	Progress

Progress made in 2022 █



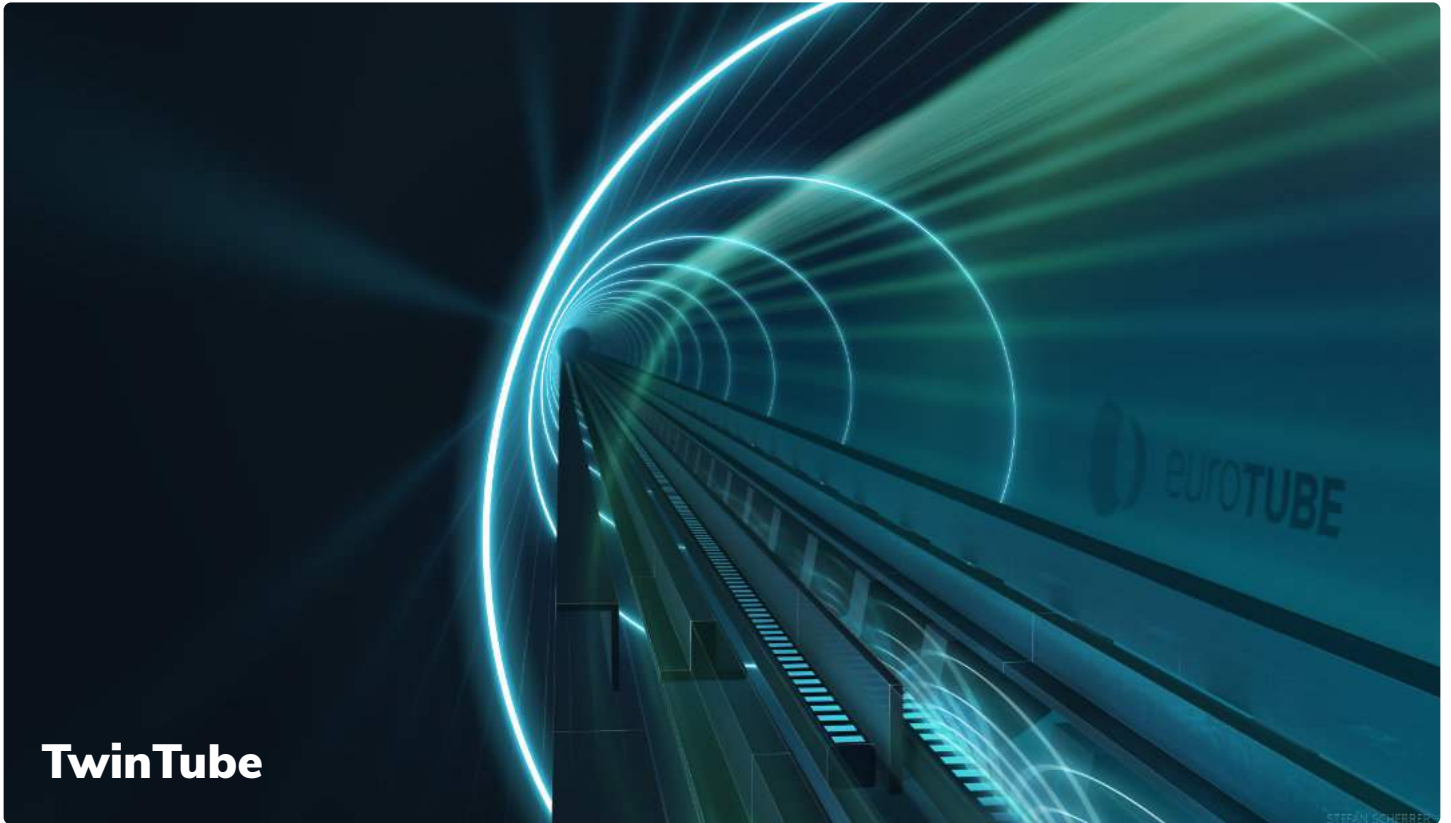
AlphaTube

Progress in 2022

AlphaTube is EuroTube's innovative project to construct the world's first high-speed hyperloop test track that showcases significant cost reductions through its innovative construction system. The project will feature a three-kilometer long track in Valais (CH) that will utilize the latest technology and manufacturing processes, and will be operated using advanced "internet of things" (IoT) and digital control instruments. In addition to testing and applying the new construction methods during the execution phase, they will also be evaluated for scaling the hyperloop infrastructure on longer routes.

In 2022, the AlphaTube project continued to make progress. Building on the detailed designs developed in 2021, the project was further advanced with the support of regional stakeholders.

A geotechnical study was completed to finalize the advanced anchoring foundations for the pylons that will support the tube. This study ensures that the design is structurally sound and safe for expected research applications.



TwinTube

Progress in 2022

In 2021, EuroTube introduced the TwinTube mission, which aims to harness the capabilities of digital twinning. Two studies, commissioned by an airport and the Federal Office of Transport, mark the launch of this mission. The first study will establish a model for passenger demand and passenger flows, while the second will provide a high-level feasibility analysis of energy consumption and carbon footprint from a lifecycle perspective. EuroTube plans to share the initial findings of the pilot TwinTube studies with interested partners and users in 2023.

The EuroTube TwinTube mission continues to analyse and provide quantitative data on passenger flows, usage, and environmental impact over the life cycle of vacuum transport scenarios.

In 2022, EuroTube made significant progress towards this goal. The team delivered the first two studies, one for a mobility provider on a potential continental hyperloop system and one for the Swiss Federal Office of Transport, which assessed energy demand and emissions from various transport technologies in comparison with hyperloop.

Furthermore, the TwinTube simulation platform was launched as a dedicated service offering for transport planners. The results of the studies as well as the available service portfolio outlining its capabilities are published on the EuroTube website.

Breakthroughs in Hyperloop Technology

EuroTube has partnered with leading Swiss and international companies to develop new materials, components, and systems for its hyperloop infrastructure. Digital models aimed at simulating and assessing the characteristics of hyperloop infrastructure are also part of the foundation's portfolio.

Steel-fibre reinforced circular concrete mixture for the tube (1)

Using a concrete mix with recycled aggregates allowing additionally for CO2 absorption. The concrete mix further contain steel fibres to increase the toughness of the material, allows construction of concrete structures without rebar, saving material and extra construction steps. This technology is part of a project involving concrete makers and further research partners.

Post tensioned segmented concrete tube design (2)

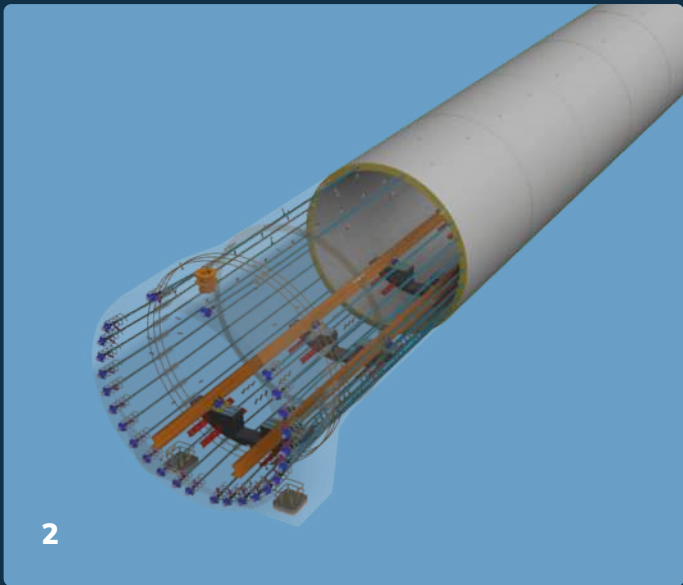
A post-tensioning system in collaboration with VSL Schweiz AG to construct stable 20m tubes from concrete segments. The design allows for in-situ casting in a mobile factory with lower logistics costs, saves material, and allows a more stable construction.

Sprayed-based coatings (3)

Through a cooperation with industry and academia, EuroTube was able to test alternative solutions to polymer-based coatings to air-tighten our concrete tubes. Key metrics such as concrete permeability, leakage or humidity have been studied to better understand the behavior of composite materials over its lifecycle.

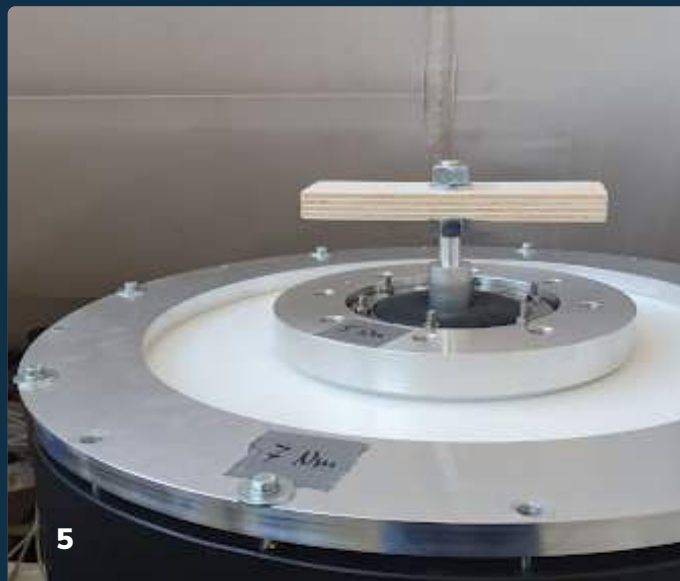
Test and validation of butterfly valves for our vacuum assurance system (4)

We tested successfully butterfly valves from the gas industry and qualified them for our vacuum applications. The leakage rates are in the order of magnitude defined for a nominal and safe operation of DemoTube.



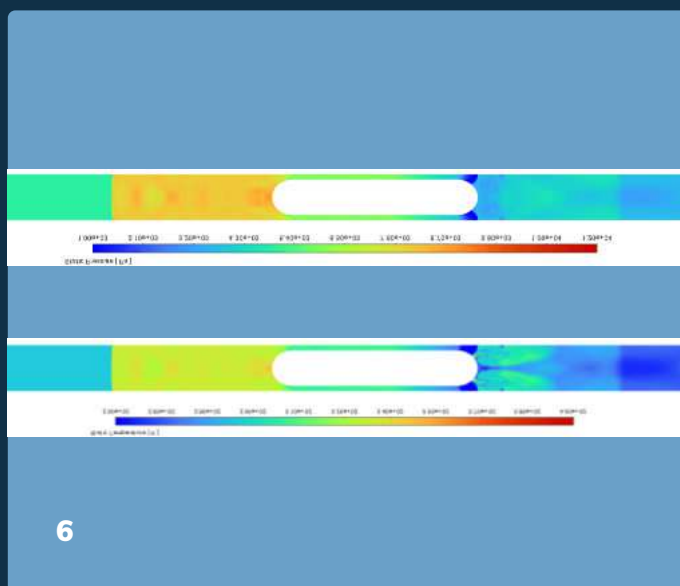
New vacuum chamber to design feedthrough (5)

EuroTube built an additional 100 cm³ vacuum chamber to test different feedthrough configurations for DemoTube, confirming the feasibility of steel feedthroughs in concrete vacuum tubes.



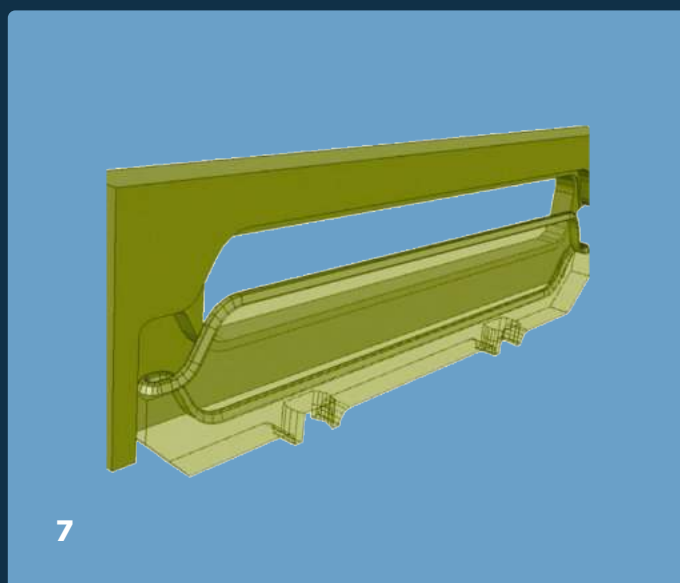
Analytical solution for shock propagation and reflection shock calculation (6)

A piston based analogy is used to estimate the maximum drag and energy requirement for the vehicle moving through a long closed tube with tube end walls. The results will also help design systems for smoother and more energy efficient travel inside a hyperloop tube.



Valve with hybrid carbon fibre gate (7)

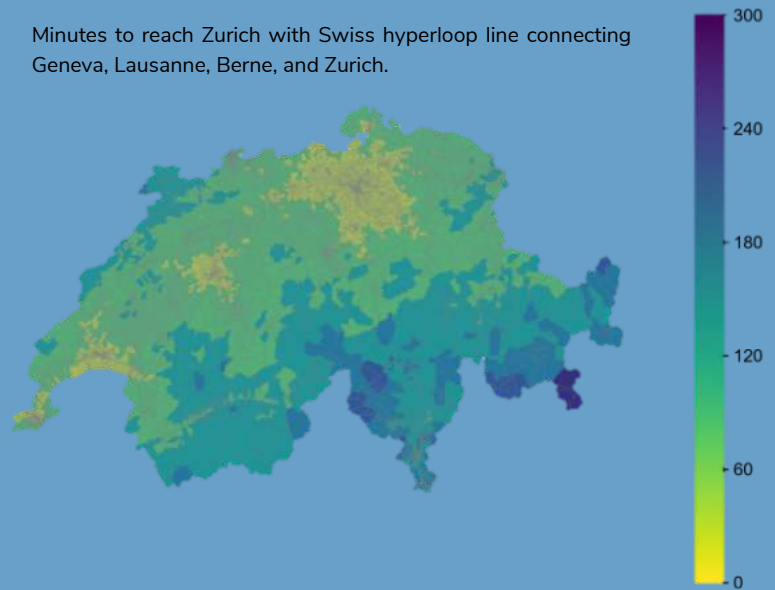
A hybrid carbon fiber gate has been studied to reduce weight and cost of the required valve's gate. The core of the gate is made from a wood core with carbon fibre cover, which has the same permeability as steel-based alloys but weighs 3 times less.



Predictive passenger modelling

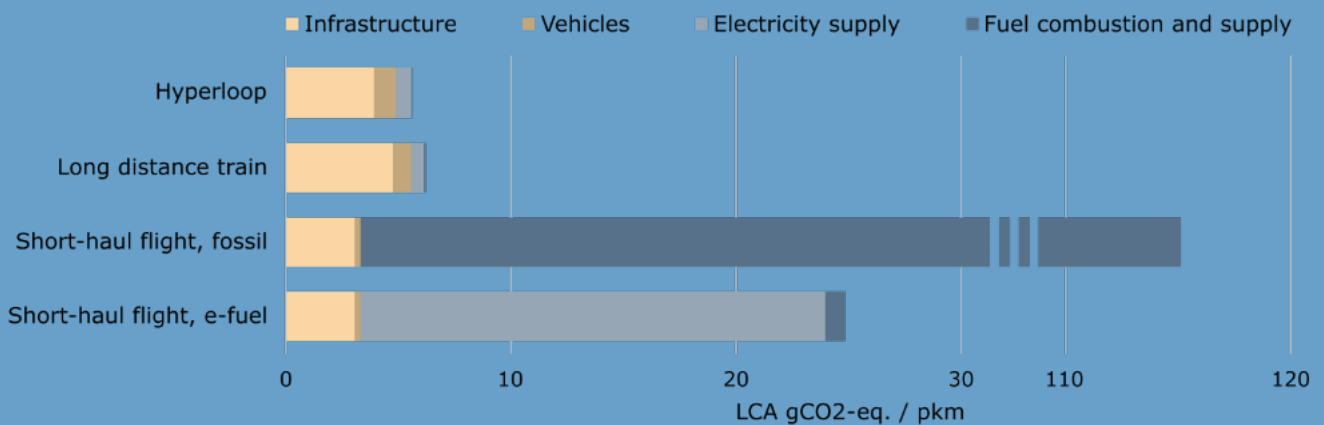
A predictive model is created for the future transport demand as well as the modal split of these passenger flows in a multi-modal network. Based on the predicted macroscopic passenger flow, we can now design and evaluate what a future hyperloop network could look like by optimising the number of passengers served under budget and technical limitations.

Minutes to reach Zurich with Swiss hyperloop line connecting Geneva, Lausanne, Berne, and Zurich.



Full Life-Cycle Analysis of a hyperloop system

The first full life-cycle assessment of a hyperloop system has been carried out: this includes all materials and energy going into the both the construction and the operation of a hyperloop infrastructure, and helps to benchmark hyperloop against other modes of transport (such as air travel), while showing where the biggest potential for improvement can be found.



Creating Visibility and Value in the Community - Linking Academia and Industry

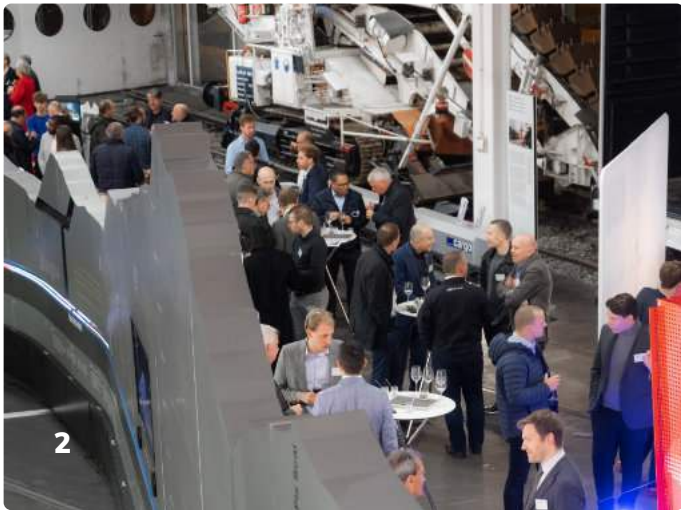
In 2022, EuroTube continued its collaboration with the European Hyperloop Development Program, which issued a major study on a European hyperloop system. EuroTube also completed its work on the first two standards developed by JTC 20, allowing access to a large database of norms and standardization procedures.

As part of the Swiss Hyperloop Alliance, EuroTube collaborated with Swissloop and Swissloop Tunneling to establish a complete ecosystem for vacuum transport in Central Europe. EuroTube hosted the fifth and sixth editions of the Vacuum Transport Seminar with Swissloop, creating a platform to share important news, discuss problems and potential solutions with other academic and industrial research partners in the field. Additionally, EuroTube initiated research collaborations with rail technology startup Nevomo and continued exchanging with other hyperloop startup and university groups.

EuroTube participated in ETH Zurich's "Urban Futures"(5) knowledge fair to engage future generations of students and increase awareness of the technological and business considerations around hyperloop. EuroTube also served on the jury at the European Hyperloop Week 2022 in Delft and awarded the Innovation Award, recognizing progress or ideas that can bring hyperloop technology a meaningful step forward.(4)

EuroTube showcased its hyperloop tube prototype at the Swiss Museum of Transport and presented its mission and technology to the public at the "Hyperloop – Mobility of the Future"(1,2,3) event, which coincided with the 175-year anniversary of rail travel in Switzerland. The keynote address was given by the President of the National Council of Switzerland and speakers and guests from politics, academia and industry had the opportunity to get a first glimpse at our prototypes and meet and discuss with our team.







Supporting Thesis Projects

At EuroTube, we are committed to supporting the development of the next generation of engineers and researchers. In 2022, we continued our collaboration with ETH Zurich to support thesis projects for their students.

We provided technical guidance and access to our facilities, allowing the students to conduct research on topics related to the development of the hyperloop technology. These projects covered a wide range of areas, including structural analysis, material testing, and control system design.

We believe that this collaboration with ETH

Zurich is an excellent opportunity for us to support the academic community and invest in the future of engineering. We look forward to continuing our partnership with ETH Zurich and other universities in the years ahead and contributing to the growth of the next generation of innovators.

2022 Thesis projects



„An IoT Smart Sensor to Monitor Airtight Vacuum Tubes at EuroTube“

Hua Shen, ETH Zurich



„Passive flow control measures to reduce the drag induced by shock-boundary layer interaction at the trailing edge of a hyperloop pod“

Denise Mühlethaler, ETH Zurich



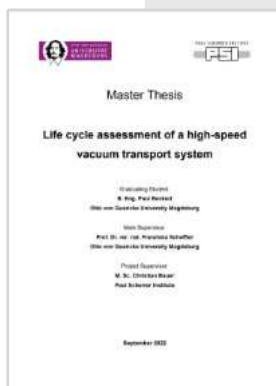
„Development of a Multi-body Simulation framework for Vacuum Transport Track-Pod Systems“

Luke Idiculla, ETH Zurich



„Experimental study on concrete recipes and measurement of concrete quality (humidity, permeation) to reduce permeability“

Martin Tanner and Oliver Bruni, ETH Zurich



„Life cycle-assessment of a high-speed vacuum transport system“

Paul Beckert, Otto von Guericke University Magdeburg, Germany



„High-Temperature Superconductors under AC Excitation“

Daniel Biek, ETH Zurich

Finance

The organization's growth and increased professionalism are evident in its financials. The team size grew to 17 full-time equivalents in 2022, resulting in an overall budget of around 2.1 million CHF. The personnel expenses account for approximately 80% of this budget, highlighting the knowledge-intensive nature of our work.

EuroTube also increased its revenue from activities such as conducting paid feasibility and technology studies for a government agency and a mobility provider. However, significant funding will be required to execute the flagship projects DemoTube and AlphaTube.

Outlook

EuroTube has made significant progress in developing the necessary technical concepts for building our hyperloop demonstrator. While we continue to raise the necessary funds, we have divided the project into staged sub-projects with lower cost thresholds. The first of these sub-projects is the GammaShellPipe, which involves the fabrication of our tubes and will demonstrate our construction methods and materials. The GammaShellPipe project is scheduled to be completed in 2023 and will then form part of the DemoTube in 2024.

We expect to receive the first of two permits for DemoTube in Dübendorf in early 2023. At the same time, we anticipate receiving clearance from the Canton of Valais for the zone change of the designated plot for AlphaTube's construction after resolving the remaining objections.

DemoTube will put our concepts and components to the test and validate our infrastructure engineering approach. Building on this experience, AlphaTube will be a full-fledged high-speed demonstrator that will help us further develop hyperloop towards a viable application.

In addition, we are concluding the second phase of a study supported by the Federal Office of Transport in 2023.



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About the EuroTube Foundation

The EuroTube Foundation was established in 2019 to accelerate sustainable transport by developing high-speed vacuum transport technologies that can overcome the challenges of mobility across continents. EuroTube is a non-profit organisation recognized by the Swiss government as a research institute of national importance for studying, engineering, and building testing infrastructures for hyperloop technologies. EuroTube's non-profit framework aims to enable our partner companies to enter the emerging hyperloop market with their own products and services and facilitate independent and critical research by constructing test facilities with the required accessibility and capabilities to promote conditions for proprietary developments by a broader base of academic and industrial users. Simply put, as a Swiss foundation, EuroTube provides research and open access to testing infrastructures for universities and industries in Switzerland and Central Europe.

Our vision is to enable safe, reliable, and sustainable ultra-high-speed travel and transportation of goods. We aim to bring people together through technologies that reduce the human impact on the environment. Therefore, EuroTube investigates the vacuum transport technology, also known as hyperloop, which has the potential to replace short- to medium-distance flights and reduce emissions by up to 95%.

Our mission is based on three critical pillars that enable us to further develop our organization. The first pillar is to foster R&D for sustainable transport, connecting industry with academia to advance vacuum transport technologies. The second is to provide research infrastructure by offering easy access to research facilities for supporting young engineers, entrepreneurs, as well as established companies and institutions to test their technologies. The last pillar is setting industry standards for the safe and efficient deployment of vacuum transport technologies, ensuring outstanding industry standards and enabling private organizations and university student teams to enhance their technologies while complying with state-of-the-art testing and regulation practices, thereby achieving excellent quality of all implemented systems.

Our Research Philosophy

We believe that there are three critical factors to the successful realisation of hyperloop:

- 1. A proof of concept that high speeds can be achieved.**
- 2. A safe infrastructure, built at a reasonable cost.**
- 3. States and large corporations that have trust in the organisations that develop the technology.**

For EuroTube it is clear that the major levers on these three success factors lie in the infrastructure. The single most defining factor of hyperloop are not the pods, but the tubes, that will be built along thousands of kilometres. Next to the tubes come the mechanical components (such as the valves) and the electrical components (such as the linear motors) before the vehicles.

The significant difference between the infrastructure and the vehicles is that the infrastructure is very hard to modify after it has been constructed, whereas vehicles can easily be brought to a garage and be modified later in their life cycle. Because it is so difficult to modify the infrastructure after it has been built, we have to do it right on the first attempt. This is why EuroTube has chosen an open and technology-oriented approach.

Within this infrastructure dimension, EuroTube sets different priorities:

- 1. Construction design and processes**
Infrastructure represents the largest cost of the hyperloop system. Hence, infrastructure is also the biggest lever for cost reductions. At the same time infrastructure needs to remain reliable over long periods of time. Hence, EuroTube is developing processes and components that allow both to reduce the construction cost and the construction time for infrastructure.
- 2. Optimization of carbon footprint**
With the sustainable transition, we need to watch our emissions ever more closely. The choice of construction materials and construction processes has a major impact on lifecycle emissions. Hence, EuroTube is focusing on the use of proven, low-carbon materials and innovating construction processes for a deployment that is quick and low in emissions. Moreover, with the forthcoming scarcity of energy, we are seeking to find the optimum spot between the energy saved from reduced air pressure and the energy consumption of the creation and upkeep of the vacuum.
- 3. Safety for passengers and cargo**
Passengers are only willing to use means of transport that they consider safe and authorities will only allow the usage of hyperloop once safe operations could be proven. EuroTube is integrating safety considerations very early into its design considerations in order to reach even higher levels of safety than aeroplanes and trains.

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Nader Zeinali Mechanical Engineering Intern
Damla Karapinar Technology Transfer Officer

Operations

Anastasia Mihajlova Operations Manager
Isabelle Beretta Piccoli Team Assistant
Stefan Kaspar Head of Partnerships
Tobias Kauer Brand Design
Steffen Hartmann Head of Communications
Nadja Oswald Partnership Manager
Victor Perez Financial Planning

Represents all team members working
at EuroTube throughout all or parts of 2022

Balance Sheet | Income Statement 2022

Balance Sheet

Assets:

Current Assets	1'107'342 CHF
Fixet Assets	100'002 CHF
Total Assets	1'207'344 CHF

Liabilities:

Current Liabilities	-180'096 CHF
Provisions and similar items required by law	-380'000 CHF
Dedicated Funds	-618'163 CHF
Foundation Capital	-29,085 CHF
Total Liabilities	-1'207'344 CHF

Income Statement

Revenues

Revenues from subsidies and services	1'550'795 CHF
Total Revenues	1'550'795 CHF

Expenses

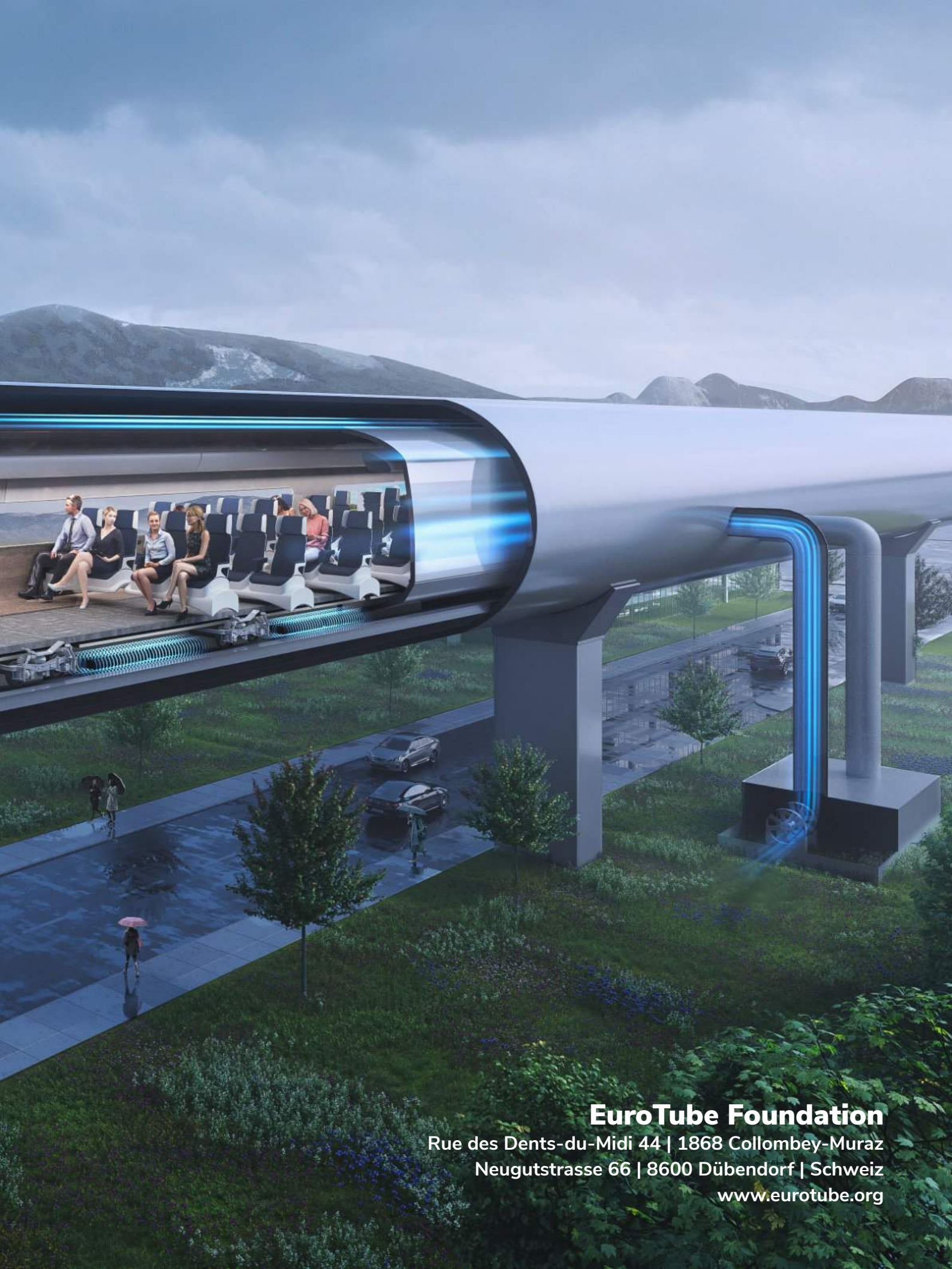
Direct Expense	-164'589 CHF
Personnel Expense	-1'720'881 CHF
Fundraising expenditures	-118'462 CHF
Operating expenses	-122'561 CHF
Provisions for wage obligations	380'000 CHF

Change in dedicated funds

New dedicated funds	-1'445'700 CHF
Usage of Funds	2'401'398 CHF



euroTUBE



EuroTube Foundation

Rue des Dents-du-Midi 44 | 1868 Collombey-Muraz

Neugutstrasse 66 | 8600 Dübendorf | Schweiz

www.eurotube.org

