

# Connecting cities at high speeds in a sustainable way

EuroTube Foundation Annual Report 2021





<b>The EuroTube Foundation</b>	3
<b>Setting up a Research Organisation</b>	4
<b>Our Lighthouse Missions</b>	6
<b>Breakthroughs in Hyperloop Technology</b>	8
<b>Progress on our Lighthouse Missions</b>	10
<b>Creating Visibility and Value in the Community</b>	12
Linking Academia and Industry	
<b>Finance</b>	13
<b>Outlook</b>	13
<b>Annex</b>	15

## **The EuroTube Foundation**

Around the globe, key stakeholders are investing in hyperloop technology that bears the potential to become the next-generation transport system. Most parties are focussing on vehicle technology but fall short in truly innovating the development of the underlying infrastructure. While posing many challenges, we are convinced that revolutionising the infrastructure will assure the transport system's success, both technologically and economically. EuroTube's strategy is to fill this capital-intensive innovation gap to build a publicly available test track, creating flexible rail and vacuum conditions at full speed. Simultaneously, the facility will confirm the innovative technology of modular concrete tubes, which can be cast on-site and significantly minimise production and logistical costs.

Dominated by the pandemic, 2021 brought the travel and logistics sector to a standstill. For EuroTube, however, it has been a successful year. As a young and growing research foundation, we assembled a group of dedicated, highly skilled scientists, engineers and managers, installed our own lab, converted our ideas to first proofs-of-concept, and convinced industry and public stakeholders that hyperloop is an idea worth pursuing.

**2021 marked the year where we went from a handful of visioneers to a state-recognised research foundation looking to begin construction of our own first hyperloop track in 2022.**

## **Setting up a Research Organisation**

Starting with only six employees in January 2021, we recruited an R&D team with three separate departments (mechanical, civil and electrical), engaged transport and mobility engineers, and completed the operations team within the year. Moreover, professional structures and processes were put in place and with the set-up of a new management, principles of Good Governance have been implemented. By bringing in experts from all over the world, we thus achieved to cover the most important dimensions of hyperloop infrastructure development.

To accommodate the growing team, a new office was opened in May near Hardbrücke in Zurich. To allow for flexible and remote collaboration between office and lab, a collection of working tools for cloud and code storage, as well as progress tracking were set up. These have been used extensively in our daily work ever since.

In order to complete the set-up of our research organisation, we had identified the need to create our own laboratory for practical applications and the implementation of R&D activities. It became reality in July of the same year when we opened a research lab at the Swiss Federal Laboratories for Materials Science and Technology (Empa). It comes with fully operative vacuum chambers and test benches to perform tests and experiments essential to validate key performance metrics.

Moreover, to ensure swift development and transfer of knowledge, we have built up connections to many partners in the industry - a network that will continue to grow in 2022.



**In 2021 we opened  
our first research lab  
at Empa**



# Our Lighthouse Missions

**In order to pursue its goal of becoming a leading research hub in Europe, EuroTube pursues lighthouse projects that are meant to create a major impact on the development and realisation of hyperloop technology.**

1



## **AlphaTube (1)**

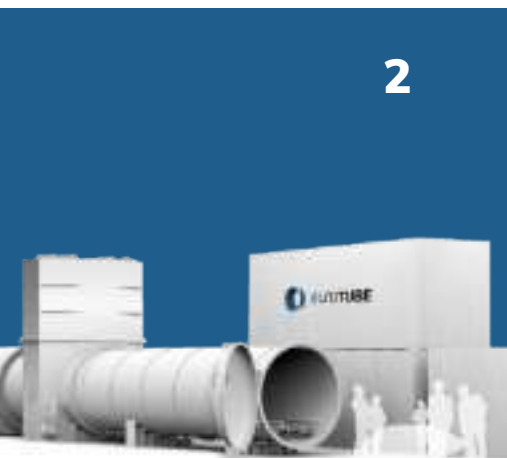
AlphaTube is EuroTube's effort to build the world's first high-speed hyperloop test track that is at the same time capable of demonstrating substantial cost reductions thanks to its innovative construction system. The approximately three-kilometer-long track in Valais (CH) will be built using the latest technology and manufacturing processes and then operated using state-of-the-art IoT and digital control instruments. In the project execution phase, the construction methods will not only be tested and applied for the first time but they will also be evaluated for scaling the hyperloop infrastructure on longer routes.

2



## **DemoTube (2)**

The DemoTube aims to set a benchmark in future vacuum transport mobility as the first test facility with its 120m long tube made of new innovative composite material. The DemoTube is not only intended to validate research work conducted during the development and implementation phases, but will also set a milestone in optimising energy consumption and manufacturing more scalable solutions for the AlphaTube Mission. This includes testing and optimising green propulsion technologies for future vacuum transport applications. Furthermore, DemoTube creates important learnings and associated visibility for partners in order to enlarge the vacuum



transport community. EuroTube has completed the permit documentation and started its permit process of DemoTube with a planned opening in 2023. With its central location in Europe, companies, research institutions and university teams will be able to test their technology and products within a few hours of shipping and travel only.

of Transport. The former will set up a model for passenger demand and passenger flows. The latter consists of a high-level feasibility analysis regarding energy consumption and carbon footprint in the lifecycle perspective. EuroTube expects to present the first findings of pilot TwinTube studies to new interested partners and users in 2023.

### **TwinTube** simulation platform (3)

In 2021, EuroTube launched the TwinTube mission to leverage the power of the digital space. First work on this mission was carried out in the form of two commissioned studies by an airport and the Federal Office

# Breakthroughs in Hyperloop Technology

**There are several key developments in 2021 constituting major breakthroughs and underlining EuroTube's unique expertise in the hyperloop landscape:**

## **Vacuum proof concrete tubes**

EuroTube is the first stakeholder in the hyperloop context to have successfully tested the concrete-tubes-concept connected through an elastomeric joint for hyperloop applications. The low permeability values achieved while testing imply that we are close to a practical prototype that can be used for DemoTube.

## **Tube casting procedure**

The first iteration of the half-scale concrete tube design has been finished. This includes a modular concrete casting procedure and an assembly process.

## **Half-scale valve**

Together with VAT and Inspire, our team completed the design phase of the valve prototype for commercial applications. The research was made possible through an Innosuisse grant. The key innovation consists of the incorporation of a carbon fiber valve gate to reduce weight and thus energy consumption to actuate it. In a next step, DemoValve will be manufactured in 2022.

## **Vacuum-simulation tools**

We set up in-house vacuum chambers through which we proved that certain electronics can perform under reduced pressure without overheating. Furthermore, we could prove that our suggested sealant can achieve the desired leakage rates.

## **Digital libraries**

We created a whole library of digital models for hyperloop components which allow simulation of linear drives, air dynamics, thermal management, and controlling for vacuum transport systems. The library allows us to test, validate and optimise digital scaled-up vacuum transport systems or components.

## **Technology vision**

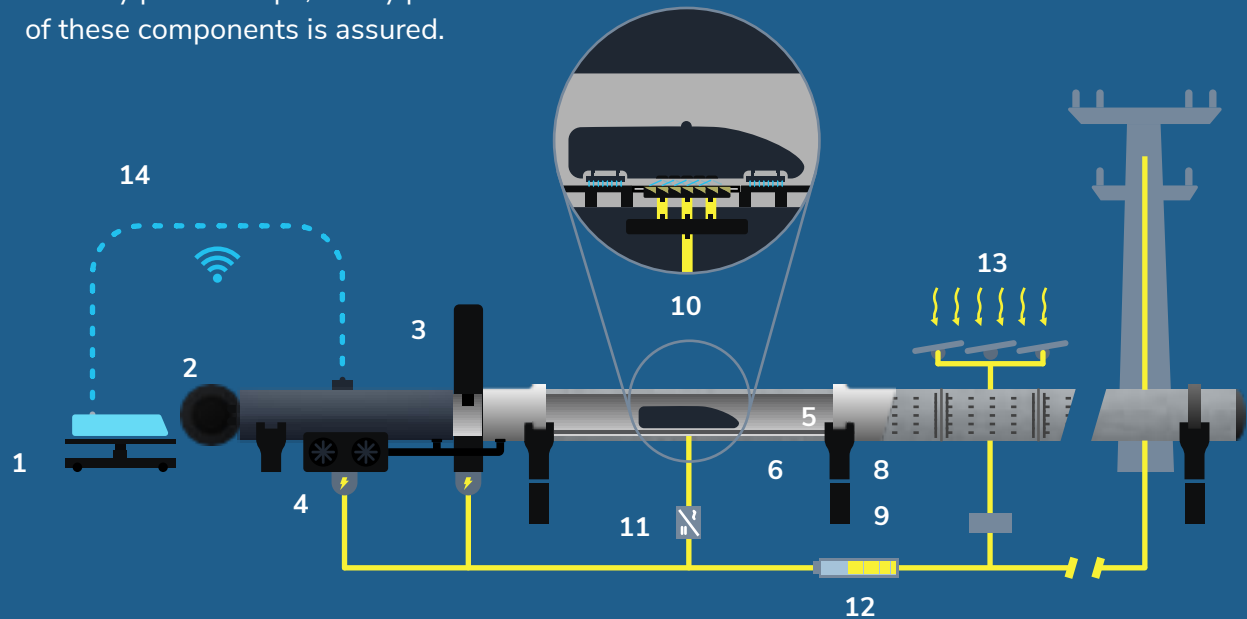
We also focussed on the long-term concepts of an eventual full-scale commercial hyperloop (OmegaTube). Key concepts for safety and traffic management were developed and extensive operative system analysis was performed, ensuring that all potential key factors are already considered today.



# Status of Different Technological Components of DemoTube

With the progress shown below, substantial design parts of the DemoTube were finalised in 2021 and are ready for manufacturing. Apart from the many technological breakthroughs, the control system for monitoring and operation is already built to a large extent.

Through the establishment of over 50 industry partnerships, timely production of these components is assured.



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

# Progress on our Lighthouse Missions

## AlphaTube (1)

In 2021, EuroTube developed the detailed design of the AlphaTube facility, including a design for a vacuum assurance system. Moreover, the designs for the construction system have been checked by regional experts to approve its compliance with local regulations and its highest possible standards.

At the time of writing, we have substantially progressed in resolving the objections by the opposition that could potentially delay the construction permit for AlphaTube. We expect to be able to move forward soon. Furthermore, the operations team set up a steering committee to ensure clear and equal communications with all partners. With this, the last obstacles were cleared from the path of completing the necessary zone change (spatial planning) for the AlphaTube.

## DemoTube

Also in 2021, the decision was taken to pursue an intermediate project before the construction of the AlphaTube. Apart from being the first-of-a-kind test facility made of concrete, it will allow for optimising designs and delivering proof-of-concept for entirely new elements developed by EuroTube in 2021. Any knowledge gained will significantly improve the quality of the construction of the AlphaTube.

In addition to technological advantages, DemoTube will create visibility for partners and the community, whilst bringing the EuroTube brand to a broader audience. Because of our central location in Europe, companies, research institutions, and

university teams will be able to test their technology and products. During the site evaluation, construction permits both at Empa and at the Innovation Park Zurich (IPZ) were pursued.

## TwinTube simulation platform

The EuroTube TwinTube mission was launched in 2021 with the aim to underpin vacuum transport scenarios with quantitative data regarding passenger flows, usage, and the environmental footprint over the life cycle. This analysis will also allow us to identify hyperloop routes with the most potential in terms of demand, revenue and construction cost. The TwinTube simulation platform will enable us to address and predict both the economic and ecological dimensions of any newly built infrastructure with its corresponding life-cycle assessment before it has to be built. As part of the TwinTube project, a large-scale high-level feasibility study was launched in collaboration with the Swiss Federal Office of Transport.

**1**

# **The first full-fledged vacuum transport demonstrator**



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

Several collaborative projects with external parties were launched in 2021. Firstly, and among these, is a mobility study commissioned by an international airport that analyses passenger flows and hyperloop routes based on a passenger simulation. Secondly, we became part of the European Hyperloop Development Program (1). We also joined several important associations, such as Swissmem (2) and JTC 20, which itself is part of the European Commission for Electrotechnical Standardisation CENELEC (3). The latter allows us to access a large database of norms and standardisation procedures. Finally, EuroTube is tightening the Swiss Hyperloop Alliance (4) collaboration with Swissloop and Swissloop Tunneling to lay the foundations for a complete ecosystem for vacuum transport in Central Europe.

1



2



3



In addition, EuroTube collaborated with academia in an Innocheque project together with HSLU to evaluate a suitable cooling technology for hyperloop vehicles. Since onboard cooling of the superconductive magnets - used for levitation - is a critical issue in the whole hyperloop concept, we are pursuing collaborations with ETHZ and SINTEF in Norway to research high-performance cooling systems for hyperloop pods later in 2022.

4



Together with Swissloop we hosted the third and fourth editions of the Vacuum Transport Seminar, a platform to share important news and discuss problems and potential solutions with other academic and industrial research partners in the field. Realising the potential of university student teams, EuroTube wanted to provide this exchange platform and start first collaborative research projects. As of 2021, EuroTube started research collaborations with Delft Hyperloop, Swissloop, and mu-zero hyperloop.

Born as an internal initiative, EuroTube further started hosting community calls with European Universities to foster the knowledge exchange in academia, as well as to increase EuroTube's visibility among student teams as a platform for public hyperloop research.

At the European Hyperloop Week 2021 in Valencia, EuroTube had the pleasure to serve on the jury and award the Community Award prize to the team with the greatest impact on the hyperloop community.

## Finance

The growth and professionalisation of the organisation is also reflected in the financials. The overall budget for 2021 rose to approximately 1 million CHF. The personnel expense accounts for roughly 80% of these which reflects the knowledge-heavy nature of our work. Already in this year, EuroTube could generate first commercial revenues by undertaking paid feasibility and technology studies for a government agency as well as a mobility provider. Thanks to the support of the State Secretariat for Education, Research and Innovation, EuroTube has a stable financial situation for the upcoming year. Nevertheless, substantial funds will have to be mobilised for the realisation of the flagship projects DemoTube and AlphaTube.

## Outlook

After a successful 2021, we expect to start the construction of our very first in-house engineered hyperloop track, the DemoTube, in late 2022. This will bring the many concepts and components developed thus far to the test and confirm our infrastructure engineering approach.

In 2021, a feasibility study of the entire hyperloop infrastructure has been launched in collaboration with the Federal Office of Transport, which will both deliver KPI values such as cost and emission, as well as allow us to digitally search for the optimal hyperloop design.

The 2022 goal of the flagship project AlphaTube is to submit the application for the construction permit. This will require further design iteration on the definition of the civil structure, but also on the electrical system to fulfil the highest level safety standards. We are confident that AlphaTube will meet the expectations, demonstrate substantial cost reductions thanks to its innovative construction system, and open the door for further scaling of the technology for the future European hyperloop infrastructure.



## Annex

<b>About EuroTube</b>	15
<b>Our Research Philosophy</b>	16
<b>Team</b>	17
<b>Finance</b>	18



## About EuroTube

The EuroTube Foundation was founded in 2019 to accelerate sustainable transport with a focus on the development of high-speed vacuum transport technologies to meet the challenges of mobility across continents. EuroTube is a non-profit research institute recognised by the Swiss government as a research facility of national importance to study, engineer, and build testing facilities for hyperloop technologies. EuroTube's non-profit framework aims to build the basis for venture-capital-backed markets and enables independent and critical research by building test infrastructures with the required accessibility and capabilities to promote the conditions for proprietary developments by a wider base of academic or industrial users. In other words, as a Swiss foundation, EuroTube aims to provide research and open access to testing infrastructure for universities and industry in Switzerland and Central Europe.

Our vision is to enable humankind to travel and transport goods at ultra-high speeds in a safe, reliable, and sustainable way. We strive to bring people together and we intend to achieve it through green technologies that reduce the impact of humans on the environment. Hence, aiming at lowering carbon emissions for the transportation of goods and humans, EuroTube investigates the hyperloop technology, also known as vacuum transport, which has the potential to replace short- to medium-distance flights and reduce emissions by up to 95%.

Our mission is based on three important pillars which enable us to develop our organisation further. The first pillar is to foster R&D for sustainable transport. By promoting R&D activities, we connect industry with academia to advance vacuum

transport technologies. The second pillar is to provide research infrastructure. By providing easy access to research facilities, we are supporting young engineers and entrepreneurs as well as established companies and institutions to test their technologies. Last but not least, EuroTube aims to set industry standards for the safe and efficient deployment of vacuum transport technologies. By ensuring outstanding industry standards, we enable private organisations and university student teams to enhance their technologies in compliance with state-of-the-art testing and regulation practices, thereby reaching an 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.

## Board of Trustees



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**Philippe Rathle**  
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of Solar Impulse

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R&D Director



**Dominik Scherrer**  
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**Antoine Juge** Electrical Engineer  
**Daniel Lehmann** Vacuum Mechanical Engineer  
**Matteo Dragoni** Systems Engineer  
**Rajdeep Deb** R&D Civil Engineer  
**Saeed Abbasion** R&D Civil Engineer  
**Frank Tala Kuate** Propulsion & Levitation Control Engineer  
**Giacomo Pareschi** Sustainable Transport Engineer  
**Julian Ehwald** System Conception and Design  
**Jay Gupta** Senior Information Engineer  
**Ioannis Stavropoulos** Electric Hardware Engineer

## Operations

**Anastasia Mihajlova** Operations Manager  
**Damla Karapinar** Community Manager  
**Isabelle Beretta Piccoli** Team Assistant  
**Stefan Kaspar** Head Partnerships  
**Tobias Kauer** Brand Design  
**Luca Erdmann** Partnership Manager

## Balance Sheet | Income Statement

### Balance Sheet

#### Assets:

Current Assets	CHF 1'840'938.-
<b>Total Assets</b>	<b>CHF 1'840'938.-</b>

#### Liabilities:

Current Liabilities	CHF -237'993.-
Dedicated Funds	CHF -1'573'860.-
Foundation Capital	CHF -29'084.84.-
<b>Total Liabilities</b>	<b>CHF -1'825'134.80.-</b>

### Income Statement

#### Revenues

Revenues from donations and sales	CHF 2'704'514.-
<b>Total Revenues</b>	<b>CHF 2'704'514.-</b>

#### Expenses

Direct Expense	CHF -95'912.-
Personnel Expense	CHF -833'606.-
Miscellaneous Expense	CHF -204'172.-
Extraordinary items	CHF 3'000.00.-

#### Change in dedicated funds

New dedicated funds	CHF -2'580'000.-
Usage of Funds	CHF 1'006'140.-
<b>Net Profit</b>	<b>CHF 0.-</b>

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