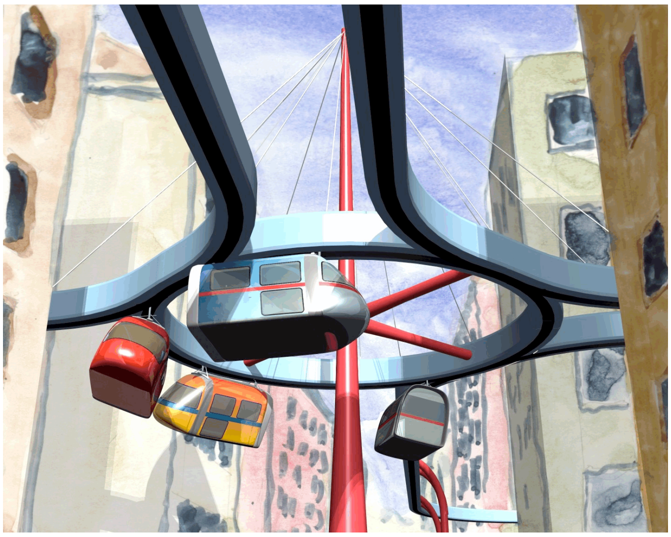
1. Excellence

1.1 Radical vision of a science-enabled technology

Conventional transport systems **(CTS)** have soon reached their end due to their need of roads and rails. They require ever more land and destroy valuable environments. Specifically they suffer from inherent shortcomings due to dependence of wheel friction, combustion engines and fragmentation of the service functions. These failings cause an overall low efficiency in the transport sector worldwide. Today we can get hold on advanced automation, slender infrastructure and electro-magnetic technologies to solve the immense problems.

We propose a novel **General Transport System (GTS)**. Most essential for GTS are magnetically levitated and propelled drive ***sleds*** running inside a levitated guideway. Suspended below these automatic sleds, are multi-purpose ***cabins***. Each sled also features a magnetic switch without moving parts. Cabins move individually at low speed in urban areas. However, platooning cabins automatically into trains will both enable a speed of up to 250 km/h and increase the capacity up to subway levels. Simultaneously increasing capacity and practical velocity will revolutionise land transport. GTS travel time over the full distance is much shorter compared to cars, public transport, high-speed trains and even short-haul flights. Not having to change vehicle is an important advantage of GTS.



This proposal is for research of the groundbreaking components and sub-systems. The broad societal perspectives of GTS will also be described. There will be four major phases. This proposal concerns the first, arriving at a Proof of Concept. It comprises scientific research, a laboratory demonstration and public surveys after visiting a full mock-up cabin (2019-21). The second phase embraces prototype and test track developments (2022-24). The third phase means building a line for passengers, e.g. the Ultuna Link in Uppsala (2025-27). In the fourth phase, large-scale commercial exploitation will start (2028-30). The long-term vision is thus local-, regional- and long-distance high-speed lines without transfer, just like a car. The only way to compete seriously with the car is to emulate it!

Most ground transportation depends on propelling wheels rolling on roads or rails. GTS, however, employs contact free electromagnetic propulsion, braking and levitation. No-slip braking, while also avoiding the street level, will enhance safety enormously. A completely new infrastructure is urgently needed, mitigating the pressure on roads and rails. GTS will truly increase the total transport capacity. The guideways are made as slender as possible, implying that the sleds and their suspended cabins must also be made light. Cabin floors will normally be elevated 4.7 meters above ground. The guideway, though, can be built at any level, even underground when needed. The cabins are automatically and seamlessly directed from origin to destination. Stations or gates will be placed on sidetracks, not to obstruct the main flow. Vehicle gates can be arranged e.g. in a fishbone structure, from the sidetrack. Gates may optionally be placed at ground level where possible. The area around the gates may often develop into local service centres.

Cabins are designed for persons or goods transport. The standard cabin size is adapted for both private and public travel with 5-12 passengers (pax), including bicycles, prams, wheelchairs, baggage etc. For long distance journeys, facilities like WC, kitchenette and beds may be fitted. Cabins may also be built as containers for carrying goods on pallets, waste or small vehicles. Alternatively, the cabin itself can be an electric vehicle using wheels (dual-mode) and self-driving “the last mile”. GTS is available, for all people including the disabled “24/7”, with no need for a driving license. The parking problem is eliminated, as each cabin just transfers to the next user, service or remote parking.

GTS uses very little direct electric energy. Solar collectors, placed on the guideway itself, may harvest energy. It produces no exhausts and very little noise. GTS releases ground-surface to be enjoyed for other purposes and will endow towns and landscapes with the functional beauty of a sustainable connectivity. This will partly compensate for the new visual intrusion. It is essential though, that the visual impact can be handled in all kinds of environment. Beams, pillars and bridges can e.g. be shaped and coloured in many ways. The project will show some examples, pinpoint principles, restrictions, and possibilities.

Our targeted scientific breakthrough is a Proof of Concept for fully automated, magnetically propelled, levitated, switched and platooned sleds. The sleds interact with both the elevated guideway and the cabins below. The comprehensive control system will form an “Internet of Mobility” (IoM). Several interdisciplinary boundary conditions must be observed though. The system must be safe, robust, easy to maintain, comfortable, fast and efficient. Dynamic platooning and separation at high speed are safety critical manoeuvres. In the first phase we will prepare for this feature to be possible in the future. Limiting platooning to stations will still increase the comparative value of the system enormously. Replacing slippery wheels with magnetic propulsion and braking, is a prerequisite for exact platooning. The sum of these advanced, combined, and fully integrated attributes characterizes a Technology of Excellence.
CTS are much more costly than GTS when summing up investment-, operational and maintenance costs. The severely disregarded wear on both wheels and tracks/ roads, is eliminated in GTS, using magnets. Propulsion is achieved through magnetic-lead-screw technology **(MLS).** Hybrid electro-magnetic suspension **(HEMS)** levitates the sled. Magnetic switches and automated platooning features will also be integrated into the sled. Thus, there will be no physical contact between the guideway and the sled reducing wear, tear, maintenance and friction simultaneously.

The project has the following **specific objectives** to be achieved within the duration of this phase:

1. **Develop the standard GTS sled;**
2. **Develop the GTS automation and motion control system;**
3. **Design the GTS cabins and guideway components;**
4. **Disseminate, exploit and communicate the findings.**
5. **Calculate costs, performance and impacts of the application.**

Measures of success in these specific objectives are specified in sec. 3, Implementation.

It may be harder to describe GTS than actually to develop it. For us in the consortium it is easy because we have been living with similar concepts for years or decades. For others, only accustomed to conventional transport technology, our solutions might seem impossible. Previous monorail systems have been criticized for low capacity, need for a new infrastructure and “weirdness”. Implementing any new disruptive system will naturally meet objections. The project team will meet this resistance with sensitive feedback. Our communication activities will be crucial for a successful realization. The public must be informed about the GTS advantages over CTS, like lower cost, faster connections, less wait and dual mode - in an interesting way. Market forces will then decide the share between GTS and CTS.

Our concept is far-reaching, comprising collaboration between many technological inventions, physical design and advanced communication. Project cost considerations only permit introductory perception in the human scale, rough logistics, simple ecological analyses, estimated social behaviour and coarse financial analyses. However, all these aspects will be fully developed in the next phase. The proposal is complex, engaging some 30 researchers in several countries. Advanced electric, magnetic and operational experiments together with laboratory test of a demonstrator and a full-scale mock-up cabin will be made as a unique design. Everything will be open to public review, at showrooms, mini-exhibits and on the Internet. Interdisciplinary studies will compare CTS and frontier technologies with GTS.

1.2 Science-to-technology breakthrough

New great paradigms of transport have been introduced once or twice every century since the industrial revolution, steam propulsion, railways, automobiles, diesel engines, electric propulsion and flying machines. Since the global jetliner network developed in the 1960’s, no groundbreaking new technology has developed, even though important but incremental changes have refined century old technologies. Technology for physical mobility is surprisingly stagnant while information technology is leaping forward rapidly. We think that a unique new transport technology may develop soon, and that the key lies in electro-magnetic features offering a general functionality by efficient platoonable cabins, without friction dependence and with on-demand service instead of fragmented service.

The Californian concept SkyTran uses electrodynamic technologies which resembles GTS. However we cannot see that it comprises the general functionality of GTS. Another Californian concept is Virgin Hyperloop One intended for nearly supersonic speed in a low air-pressure tube. How to serve local and regional travel is not explained. As can be seen in table 1.2a below, GTS differs from all other alternatives in five major aspects: Magnetic switching, low land use, platooning, dual mode and service at all times and distances in one combination. Roads and high-speed trains require large areas of land, often in conflict with other purposes and needs. A mainly elevated structure avoids these problems. Pedestrians, bicyclists, and animals don’t run any risk of serious accidents.

Table 1.2a State-of-the-Art-GTS compared to conventional and frontier alternatives

Develop	Technology					Function			
	Power	Automation	Motor	Levitation	Switch/Steering	Land use	Platooning	Dual mode	Service */**
CTS									
Road/Car	Fuel	No	Rot.	Wheel	Wheel	High	No	No	Dr.license
Rail/Train	Dir. electr	Part.	Rot.	Wheel	Rail	Fair	Fixed	No	Timetable
Road/Bus	Fuel/other	No	Rot.	Wheel	Wheel	Fair	No	No	Timetable
FRONTIER									
Electric car	Battery	No	Rot.	Wheel	Wheel	High	No	No	Dr.license
Selfdrive car	Fuel/batt.	Semi	Rot.	Wheel	Wheel	High	No	No	Dr.license
Driverless car	Fuel/batt.	Full	Rot.	Wheel	Wheel	Fair	No	No	Developing
PRT	Dir. electr.	Full	Rot.	Wheel	In veh.	Low	No	No	Local
SkyTran	Dir. electr.	Full	Lin.	Magn.	Magn.	Low	No	No	Low capacity
Hyperloop	Dir. electr.	Full	Lin.	Magn.	? N/A	Low	? N/A	? N/A	Long distance
Maglev	Dir. electr.	Full	Lin.	Magn.	Rail	Fair	Fixed	No	Timetable
Cableway	Dir. electr.	Full	Rot.	Wheel	No	Low	Cable	No	Local
El. cargo way	Dir. electr.	Semi	Rot.	Wheel	Wheel	Fair	Semi	No	Developing
Bicycle	Pedal/el.	No	Rot.	Wheel	Wheel	Low	No	No	Local
GTS	**Dir. electr.**	**Full**	**MLS**	**HEMS**	**Magn.**	**Low**	**Yes**	**Yes**	**All T&D**

* The most obvious restraint indicated for CTS and Frontier; For GTS service "All Times and Distances" (All T&D) is indicated.
** GTS cabins and stations will be permissively designed to easily bring your bicycle, pram, wheelchair or electric minicar.

1.2.1 Magnetic and other Core Technologies

The known "Maglev" systems using only electromagnets have proven to be rather expensive technologies (e.g. Transrapid). Electro-dynamically levitated vehicles also require a rather high speed before they start to levitate (e.g. Japanese SC). The proposed HEMS will radically reduce costs compared to earlier "Maglev" principles. In GTS, the propulsion, using MLS, is also advantageously decoupled from the levitation, using HEMS.

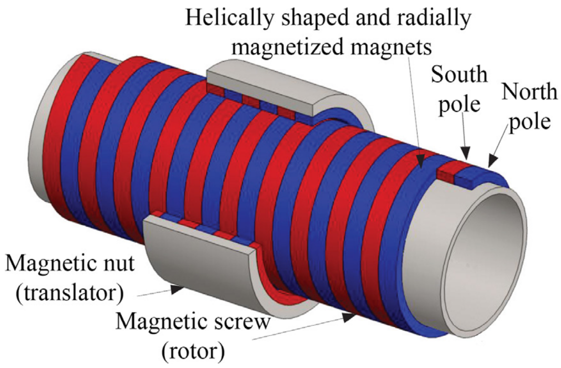


Fig 1.2.1a Simple MLS, Aalborg Univ.

Magnetically levitated systems often use cumbersome mechanical track switching and inflexible train sizes. MLS propulsion will also mean regenerative electric braking so that energy is recovered. The main goal for the research is first to evaluate different types of Linear Synchronous Magnetic propulsion (LSM) and then incorporate that in a technology for precise control. The challenge is also to avoid the cumbersome power transmission to the sled. Initial calculation shows, that adapting the MLS technology reduces the mass of the propulsion system by a factor of 18. The cost of it is reduced by a factor of five compared to current "Maglev" systems. The combination of guideway design and intelligent control system are crucial challenges. MLS-units can be fitted more densely where acceleration, braking and climbing is prevalent.

Magnetic levitation and guidance using HEMS is silent, efficient, compact and light, eliminating the physical contact between vehicle and guideway. HEMS, uses both electromagnets and permanent magnets. Initial calculations suggest that HEMS will be about nine times cheaper than normal levitation systems. Key challenges are safety, integration of levitation, guidance, propulsion and switching. That demands a robust and fault tolerant control of the sleds. Capabilities to withstand wind forces, and negotiate curves at varying speed, are other crucial challenges.

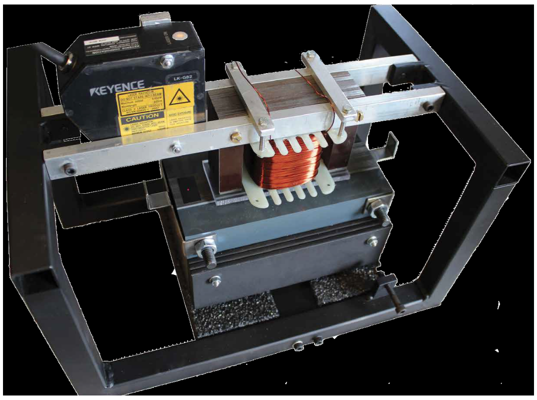


Fig 1.2.1b Simple HEMS experiment, Aalborg Univ.

Intelligently controlled **Magnetic switching** technology presumes a high safety level and a low maintenance level. Magnetic switches cannot be blocked by frost or foreign objects. Only magnetic forces will thus steer the vehicles either to the left or right in diverges. Switches must be made both failsafe and redundant. This method is new in contrast to the earlier "Maglev" that often switches the whole beam, precluding short headways between vehicles and high capacity of vehicles/hour.

Magnetic platooning control of vehicles at speed will be researched, as this allows for both a high line capacity and a high velocity, with a small energy demand as for normal trains. Platooning and separating platoons at speed demands exact control of the relative position and speed of each vehicle. This is a formidable task, which so far has been precluded in e.g. railway traffic. In the beginning, however, platoons will be formed at the stations. Smart connection between the sled and the suspended cabins is also researched. The cabins will swing out in curves, enabling a flexible vehicle curve speed. The smart connection also allows the cabin to be lowered to ground level, using a built-in elevator. This feature may also facilitate evacuation in case of emergency. In the first phase of the project this will not be studied in depth.

Fig. 1.2.1.c Platooning on GTS high-speed line

Power supply will also be researched to determine suitable voltage and power ratings. Some tramways operate at 750 volts DC. This can be a starting point for local power supply blocks. The general power supply to the blocks must run with a much higher voltage though (e.g. 10-25 kV). Emergency UPS power supplies, positioned at key points will deliver sufficient power for essential functions during power outage. Battery support on board will also enable the vehicles to move to a rescue point in case of power failure.

The **Physical design** of GTS in the human scale environment, poses new challenges in many perspectives. The design process includes technical and economic aspects as well as questions of adaption to the surroundings and the impact the design can have on future urban planning. It will constitute a new architectural element employing advanced materials combining appropriate scale, with rhythm, texture etc. GTS being lightweight and neat, free from emissions, noise and vibrations, opens new possibilities, e.g. building integration. The system may even be installed below ground and through or above buildings. The long-term vision is that GTS, properly designed, will be fully integrated in a future urban city and will make way for a more social use of public urban space. Spans may vary between 10 and more than 1000 meters. Transport of a bicycle, a pram, a wheel chair, a small vehicle or goods on pallet made easy. Entry and exit of a cabin should be possible in upright. Cabins must have a lightweight, safe, aerodynamic and ride-comfortable design. Dual-mode cabins must adapt to both road and GTS standard.

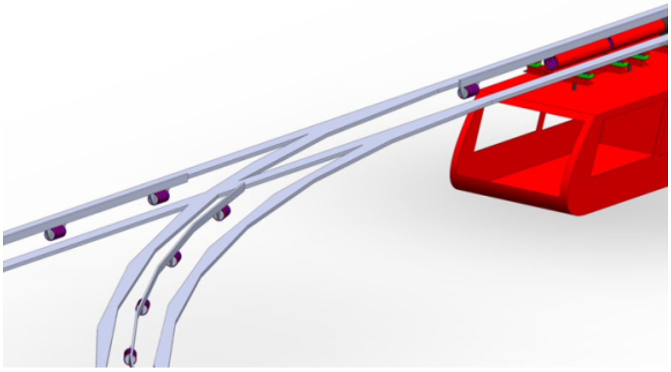


Fig. 1.2.1.d Simple switch sketch

Modelling of GTS differs from existing PRT simulators in two important aspects: 1) While PRT has one speed everywhere in the network, GTS has low-speed and high-speed networks connected by acceleration/deceleration ramps (and passengers remain in their cabin); 2) While PRT maintain safe stopping distances between vehicles, GTS cabins can be dynamically platooned and decoupled on the high-speed network. Task 6.6 will extend the functionalities of "PRTsim", developed by Logistik-Centrum, to allow micro-simulation of full GTS functionalities.

1.3 Interdisciplinarity and non-incrementality

Less than 30 years ago few of us could imagine that today we would be carrying around our telephone, radio, TV, newspapers, books, music, maps and documentation, wireless, in a tiny module in our pocket. GTS aims for a similar revolution for transportation in physical terms. Fragmentation of journeys would come to an end just like Internet has done with the fragmentation of information transfer. We call this a general functionality. Most of our mobility needs would be solved by one general system. The GTS concept differs from other frontier technologies in transportation due to this interdisciplinary unification.

GTS comprises infrastructure, sleds, cabins and various auxiliary systems like the control system, the electric supply system, the gate structure, service functions etc. The communication between the sled, the cabin, the guideway and other vehicles is a formidable task. Mechanical, electrical and communication interfaces, and networks man-to-machine must be specified. The guideway must not only be strong enough, it must also be beautiful and corrosion resistant. Taken together it is hard to imagine projects with a higher interdisciplinary nature, striving for a general functionality.

Our project will have a special supervision by the **Interdisciplinary Working Board** (IWB), consisting of all lead partners and other professionals to be called upon (see work package (wp) 1 MIC, task 1.3).

The GTS holistic approach presents a leap in the development of future transportation. GTS also uses computers to solve the whole traffic system logistics. Novel designs including the new motion-free switching, the new MLS propulsion technology and HEMS levitation, using microcomputers to control all aspects of motion. Thus, GTS is **not an incremental** change, it is a novelty. GTS is designed for multipurpose trips for all. Trips involving childcare, elderly, disabled, shopping etc. are poorly handled in ordinary public transport planning. This category however, stands for a quarter of all public transport use. Housekeepers without cars are often responsible for the majority of the care work. GTS may help bridge inequality between genders and other social categories.

1.4 High risk, plausibility and flexibility

GTS is in an early stage and carries a high risk because of its visionary character (see 3.2 and table 3.2b). If, however, our exploration of untried magnetic technologies and combinations of technologies is successful, the foundation of a radically new and plausible technology will be laid. New high risks will then occur as consequences of a fast developing market, even though limited by a firm structure by GTS Standards and Licensing System (SLS).

The high risk, involved in researching the GTS system will be mitigated by investigating multiple methods of meeting the various challenges, using advanced electromagnetic computerized prototyping techniques such as the Finite Element Method **(FEM)** and Computational Fluid Dynamics **(CFD)**. The results will be compared using innovation practices to ensure that the best solutions are selected for manufacturing demonstrator laboratory models.

To further mitigate the risks, the project must have a close collaboration with many scientific disciplines, for example: Electromagnetics, power electronics, control engineering, mechanical engineering, material science, architecture, industrial design and analytical procedures, to name but a few.

Introduction of GTS is plausible because the request for eliminating the detrimental effects of failing CTS is on the agenda in society. Due to vested interests in industry and infrastructure, financially strong decision-makers avoid the deeper analysis of the failings of CTS. Our site-partner, the **City of Uppsala**, like many other cities, and operative and industrial partners like **EUSKOTREN**, understand this dilemma and they are open for trying new paths as followers of the project.

Flexibility in research approach: The physical development and research will start with a mathematical phase using methods like the FEM and CFD. Prototypes in appropriate scales will then be built for experimental validation. The proposal therefore only covers advancement through Technology Readiness Levels **(TRL)** 1-3. We start by basic principles observed and end with experimental Proof-of-Concept of the new technology in the laboratory.

Apart from the inherent flexibility in our research methods we must state that in the essence of GTS lies a standard with a steady framework that cannot be abused, the height and width of the cabin being very typical examples of that whereas the length may alter slightly.

Specific methodologies for each work package are included in sec. 3 Implementation.

2. Impact

2.1 Expected impacts

The impact of GTS will be groundbreaking and indeed also ground saving! GTS will reduce the footprint of transport substantially, while also solving many ecology-conflicts. New spaces for playgrounds and parks, and fewer land barriers for animals are examples. Below are a few strategic subjects where the impacts are overwhelming.

Environmental factors; GTS fits the Paris Climate goals well. It could reduce carbon emissions in transport by 60 percent by 2050. The EU key goals for 2050, relevant for GTS, include a 50 percent shift of medium distance passenger and freight journeys from road to rail and waterborne transport, phasing-out conventionally-fuelled cars in cities and CO2-free city logistics in major urban centres by 2030.

EU transport policy has focused persistently on connectivity. There is now a particular focus on bringing innovation into the long distance networks. The European Rail R&D Initiative, Shift2Rail, is worth noting for its focus on accelerating the integration of new and advanced technologies into innovative rail. Beside this EU Policy, the EU has adopted a sustainable development agenda, including 17 goals, and the global agreement on climate. GTS delivers a considerable contribution to goal 03 health, 07 sustainable energy, 08 sustainable economic growth, 09 innovative infrastructure, 11 sustainable city development and 15 sustainable ecosystems.

A Strategic Environmental Assessment **(SEA)** will be undertaken to validate the impact GTS has on these aspects. We will also estimate the impacts of GTS on the economy, society and human wellbeing following the requirements of the 2016 Paris Agreement and the EU policies described above. Our goal is Zero casualties, zero emissions, zero fossil energy and zero congestion.

Travel time saving is one of the most advantageous features of GTS. Many random comparisons of traveling with CTS and GTS show halved travelling time. This factor will be analysed in wp 6 STA, task 6.1.

The core technologies; Small-scale experiments at Aalborg University have already shown promising results. HEMS, will radically reduce costs in comparison with “Maglev” and it can also impact many other engineering fields, like magnetic bearings. MLS is based on rotating magnets arranged to form a drive screw; Similar thoughts have been suggested by e.g. SkyTran, though maybe less efficient. MLS also enables rotational energy to be stored locally along the track for use when cabins pass. The electric power demand is then reduced, resulting in cheaper power transmission, better acceleration and improved gradient capacity. Such propulsion systems could also be used for e.g. trains or as launch systems for aircrafts. The track switching technique implies that the sled is magnetically attracted to the left or right side; this technique can also find applications in e.g. railways.

The Platooning technology. Conventional train safety demands that trains should travel a long distance from another to be considered safe. However, the individual wagons in a train can be mechanically very closely coupled and be still considered safe. Challenges only arise when two vehicles are approaching or separating from each other. An airplane fuelling in the air or a space module approaching the international space station are examples showing that this can be done in 3-dimensions! Platooning has even been proposed for self-driving cars. Platooning offers both a much higher capacity (pax per hour) and due to the reduced air friction, a higher speed. Platooning development is thus beneficial also for CTS.

Goods transport; Transport companies can have their own stations in the GTS network. Shipments will go directly without intermediate reloading. Transport times and reliability are improved, allowing just-in-time deliveries. Non-polluting and quiet operation, allows GTS stations to be integrated into buildings. A majority of all goods shipments can be put on EUR-pallets and sent directly to receiver, using GTS cargo cabins.

Uppsala South — a constructive pilot and pioneering example

In Uppsala, podcars have been demonstrated on a small test track, and GTS has been seriously discussed. Uppsala has recently adopted a master plan for 2050. Two of five city-nuclei are in the south, Bergsbrunna and Gottsunda. Bergsbrunna lies only 25 km from Arlanda airport, and is considered for a new train station on the line Uppsala-Arlanda-Stockholm. This is a catchment area to the airport and the greater Stockholm region. Uppsala plans to develop a link, between Bergsbrunna and the south-western nucleus Gottsunda. No such link exists today and it crosses a sensitive nature reserve along the river Fyris, ***Uppsala South***, and GTS would be an optimal alternative. Fig. 2.1a. show a 6.3 km GTS double-track including 7 stations. This could also be a starting point for a greater GTS system in Uppsala with its five nuclei.

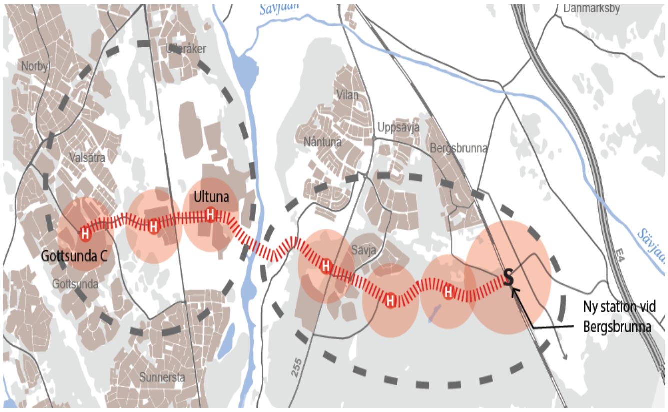


Fig. 2.1a Uppsala South, Uppsala municipal plan

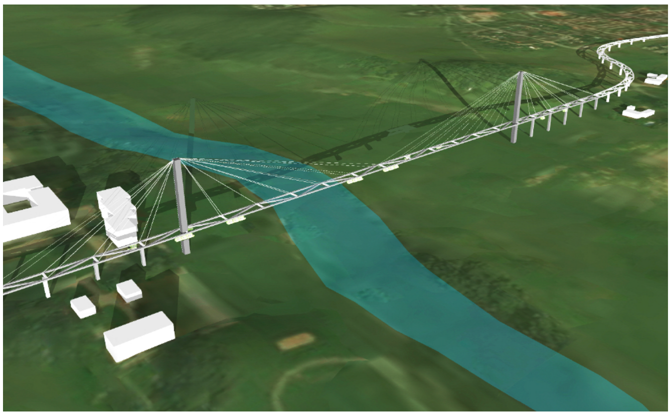


Fig. 2.1b Cable-stayed GTS bridge over River Fyris (AyCrete/Joakim Gustafsson)

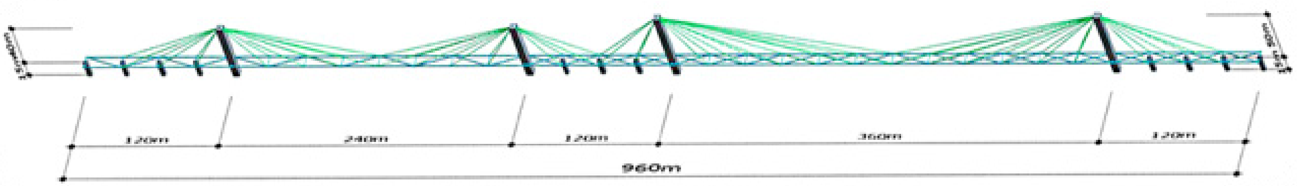


Fig. 2.1c Fyris river bridge, a calculated span for GTS and Bike&Walk (AyCrete Design)

Preliminary costs for Uppsala South; A pioneering track between Gottsunda and Bergsbrunna that measures 6.3 km with 7 stations, 1 depot and 60 cabins with sleds is estimated to cost 64 M€ (excluding technical development of beams and vehicles). This corresponds to 10 M€ per track-km. A comparison with eight recent LRT (Light Rail Transit) cost studies in great Swedish cities show an average investment cost of 36 M€ per track-km. Thus a Light Rail Transit (which is inside the current box of thinking) would cost 227 M€ along the 6.3 km "Uppsala South" line; trains and more expensive bridge not included (preliminary calculations by G. Tegnér, Transek).

Door-to-door travel time Stockholm suburb - Göteborg suburb

High-speed rail will save relatively little time and is from that angle uneconomical. GTS would be both faster door-to-door and cheaper to build. Apart from that, GTS would have a much wider use and larger development potential. A most wanted high-speed railway between the two major cities in Sweden, Stockholm and Göteborg, has recently been suggested for a top-speed of 320 km/h.

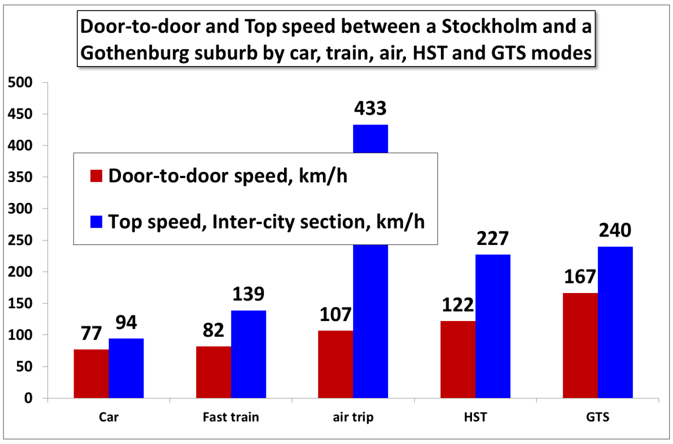


Table. 2.1d Effective door-to-door travel time with different travel modes (G. Tegnér/Transek)

However, the top-speed does not tell you what the average speed is, when the journey in fact is fragmented due to timetables, changes at stations, waiting, and in case of traveling by air, security. Comparing alternatives for average origins and destinations in greater Stockholm and Gothenburg, shows how GTS by its local, closer access, has the shortest, seamless travel time of all possible options (See table 2.1d). In table 2.1e, a High-Speed Train (HST) is compared with GTS financially and by carrying capacity. Total capital cost for GTS is 64 percent of the cost for HST, and the cost per passenger is only 49 percent with GTS compared to HST.

Global impact

GTS would have an immense effect even in rapidly emerging economies. The demand for cars and traditional public transport is growing at an incredible pace, the money is there but not the infrastructure. The costs to meet these demands are immense. GTS would offer a way to meet transport demands in a far more economical and ecological way. The benefits can surpass expectations in the whole world.

Standards and Success even when failing

The Swedish Standards Institute (SIS) would be willing to help establish a GTS standard as soon as a specific trade sector emerges. Simultaneously we may also have an opposition who could fear a disruptive technology. It is reasonable to believe that the project will have a strong impact if it succeeds, but even if it fails, the research for electromagnetic propulsion, levitation and platooning, may be beneficial even for other technological platforms.

Key facts, M€	HST	GTS	GTS/HST%
Total Capital costs	**10700**	**6800**	**64**
Capital cost/track-km	*24*	*14*	*60*
Total annual capital cost	310	220	71
Total annual operating cost	280	110	39
Total Annual Costs	**590**	**330**	**56**
Total Annual Costs/track-km	*1,30*	*0,69*	*53*
Annual passengers, million	**4,5**	**5,16**	**115**
Annual cost/passenger	*129*	*63*	*49*

Table. 2.1e Investment analysis of HST and GTS (G. Tegnér/Transek)

2.2 Measures to maximise impact

a) A draft plan for the dissemination and exploitation of results (see table below)

Media don't follow processes, they follow events. Findings will thus also be presented as events. By organizing events in relation to milestone conferences we will spread the GTS concept both locally and in European perspective. Introductory, concurrent and concluding conferences will be arranged for disseminating the ideas and results.

We will also take part in relevant international conferences on transport and magnetics like Transportation Research Board in Washington DC, USA; UITP Conference; ITS Europe & ITS World; European Conference on Mobility Management; UN Habitat conferences bi-annual, in relation with World Society for Ekistics; Swedish Transportforum (VTI), yearly transportation research conference; Podcar City Conferences, PCC, USA and Europe.

Time	Milestone	Site	Headlines	Local media	Science articles	Internet	Event
M1		Uppsala	Breaking news, A new transport technology	X		Start	
M6	1	Mondragon	Performance specific-s; Impact Steep Euskadi	X	X	and	X
M12	2	Aalborg	Laboratory scale model; Impact Jutland & Sea	X	X	on-	X
M21	3	Göteborg	Broad analyses and Design; Scandinavian fitness	X	X	go-	X
M24	4	Uppsala	Forecast final results; Uppland pioneering plans	X	X	ing	X
M36		Aalborg	Breaking news, The new transport technology	X		"	X

Contributions will be made to international scientific journals like Intermag, ECCE, ISIE, IEEE Transactions on Magnetics; Transportation Research C, Transportation Research Records and European Journal on Infrastructure, American Society of Civil Engineers (ASCE) world conference on Automated People Movers and Automated Transit Systems (APM-ATS) (bi-annual), where peer-reviewed papers are published in their proceedings.

The GTS homepage will be used for presentation of the on-going project parts. FAQ’s will be answered in lists on-line and news releases. Articles will be published by the consortium and also individually by all scientists in their respective domains; see below under b). Supporting seminar series and case studies will raise academic awareness, aiming at involving and communicating with students and young researchers (wp 6, task 6.5).

Open research data and organisational measures

The GTS Foundation will be reinforced by new capital and several new board members. A standard development and licensing structure will be prepared. A consortium agreement will be signed to manage key knowledge, IPR and data. The strategy for knowledge management and protection of the GTS core technology is to define the interfaces, and establish a Standard & Licensing Structure (SLS) that will support the market exploitation in the most favourable fashion. Research data will thus be spread openly to prevent hostile patent applications. The GTS Consortium AB will be ready to administer and develop the GTS standard, and to collate and preserve data as commissioned by the GTS Foundation. The SLS under GTS Consortium AB will be the holder and curator of all relevant data generated by the project. All partners involved in the GTS project will be invited to form the GTS Consortium AB when the time is ripe. The four phases of development will be structured as conceptualized: ⟶

Proof-of-Concept **2019-2021** 100% EU support GTS Consortium GTS Foundation	First test track and prototype **2022-2024** 75% EU support 25% Private support GTS Consortium AB + GTS Foundation
Small-scale pilot plants **2025-2027** 50% EU support 25% Governmental support 25% Private support GTS Consortium AB GTS Foundation, Licenser	Large-scale pioneering commercial exploitation **2028-2030** 70% private, 30% public; GTS Consortium AB, Standard & Licensing Structure (SLS); GTS Foundation, Licenser and Standard holder

b) Communication activities

Broad approach via physical experience, direct contacts, traditional and social media.

Promotion and implementation of GTS must be presented broadly and reach out to audiences outside the already well informed. This is not only a goal in itself, but will also be necessary to secure interest and leverage of target groups like policy makers and businesses.

A full-scale mock-up cabin will be designed and produced by Yovinn (wp MIC) to present the GTS in an interactive framework. The newly developed propulsion, levitation, switching and platooning, i.e. the development of the sled will be shown, as well as a wide-spread understanding of the GTS impact on society. This is planned to be located in Uppsala due to its pioneering status.

Another way of presentation is mini-exhibits, well suited to go hand in hand with public events (including lectures, demonstrations of the project and discussions). These events can take place at suitable libraries and other often visited public spaces in main capitals or other selected places, where the project partners live. This will be a good approach for meeting people, many of whom maybe curious, but not so technically minded. Such events will also be well suited to launch in media, local and national. Presentation help can also be handed out to key persons acting as nodes, within relevant fields; students, business associations, tenant unions etc.

In order to reach an international public and wide participation, an active presence with open access at universities and other relevant places, is essential. The Internet will be used through an active web-portal and on social media. This portal will also provide relevant information and data to different groups such as landscape designers, architects, engineers and construction companies, as well as game developers and simulator designers.

This allows citizens to engage and design future transportation solutions with comprehensive information about the possibilities in GTS. It creates an Internet of Mobility (IoM) comparable to and interacting with the Internet of Things (IoT), a real knitting together of real and digital mobility. We hope to see involvement and contribution from global citizen groups, especially from the younger generation, contributing and showing local examples and virtualization of the possibilities of GTS.

Public project information and research results, press releases, interviews with key researchers, and articles in more technical magazines, will stream out from the project, reaching transportation experts, architects, urban planners, decision makers and the like. Special promotion of master thesis projects will raise awareness in academia.

Internally, Sharepoint will be used by team members, with shared progress reports, document sharing etc. The management team will distribute newsletters with status, summary and prospects four times a year.

3. Implementation

3.1 Research methodology and work plan – Work packages, deliverables

The project is divided in seven work packages (wp) described below.

Wp 1, Management, Interdisciplinarity and Coordination (MIC) has uniting obligations, normal administrative procedures and coordination between all wp´s and tasks; Guidance by the Interdisciplinary Working Board (IWB).

Unique core technologies will be developed at Aalborg University (AAU), Department of Energy Technology (DET) in close cooperation with Mondragon University (MU), Department of Electronics Engineering. Their work is subdivided, and intertwined, in three wp's with distinct different tasks, **wp 2, Electro-Magnetic Research (EMR), wp3, Converter & Control Research (CCR) and wp 4, Demonstrator (DEM)**. DEM deals with demonstrating the GTS drive technology on a laboratory guideway. In order to test the technology over a longer period, the project span for this wp is prolonged with one year, preceding the concluding report for the whole project. AAU and MU use Standard methods for laboratory exploration; Performance specifications, conceptual analysis, selection of technologies using SWOT analysis; full-scale design concepts, scaled down model for lab. demonstrations, manufacture scale model for lab; testing, validation and reflections for a complete system.

Wp 5, Physical design, Construction & Visualization (PCV) develops the construction and design of the beam structure and cabin standard (Bjerking AB (BJE), and the Royal Institute of Technology, KTH, VinnEx Centre for ECO2 Vehicle Design (ECO), Stockholm). They are responsible for: Creation of a sustainable standard structure for beams, pillars, pylons, longer spans etc; optimization of standard cabin sections; design of devices joining cabins, sled-cabin-hooks etc in accordance with the BIM Handbook (see 1.1.1); Visualization of urban and landscape intrusion using drawings and perspectives. BJE and ECO have distinct different but related tasks. However they are too small to form different wp's.

Wp 6, Supervision, Trade-offs and Analyses (STA) deals with: scientific guidance, Trade-offs like Cost vs Benefits Analysis, environmental, social and logistics introductory analyses. Wp6 will use multifactor analysis as decision support in Specification trade-offs. Capital cost analysis is based on analogies with relevant existing systems, design costing, ground anchoring and utility relocations. Estimated cost brackets are made with a Delphi method. Demand estimations use non-linear elasticities with a Logit type model.

Wp 7, Communication (COM) involves dissemination, exploitaion and communication activities (Tottoro AB, Gävle-SE). COM will use methods like animation techniques for presentations, established measuring techniques to evaluate communication effects and quantitative and qualitative methods to measure attitudes.

The project spans over **3 years, 36 months, for all wp**, as we have to consider all final statements according to the result of the long time demonstrator test by wp4-DEM. Wp1 and 4 will be active more than 50 percent of full working time over all three years, whereas wp 2, 3, 5, 6 and 7 will have reduced staff and time during the third year. Wp's 5, 6 and 7 also reduce staff in Q8.

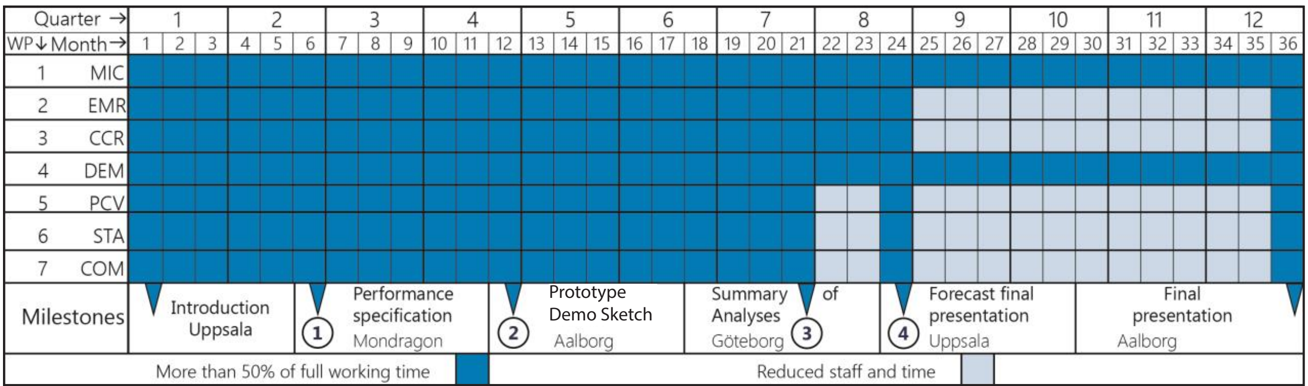


Fig. 3.1 Timing of the different wp & their components

Table 3.1a List of work packages

wp nr	wp, title and acronym	Lead part.	Short name	Manmonth
1	Management, Interdisciplinarity & Coordination (MIC)	1.1	GTS1	44
2	Electro-Magnetic Research (EMR)	2.2	AAU1	69
3	Converter & Control Research (CCR)	3.1	MU1	62
4	Demonstrator (DEM)	2.1 / 3.1	AAU1/MU1	67
5	Physical design, Construction & Visualization (PCV)	4.1 / 5.1	BJE1/ECO1	40.125
6	Supervision, Trade-Offs & Analyses (STA)	6.1	LOG1	17.875
7	Communication (COM)	7.1	TOT1	56
Σ				**356**

Table 3.1b Work package descriptions (3+ pages)

wp. nr, title	**1. Management, Interdisciplinarity & Coordination - MIC** – Lead beneficiary: **GTS**										
particip. nr	**1.1**	1.2	1.3	1.4	2.1-2	3.1	4.1	5.1	6.1	7.1	subcontractors
short name	**GTS1**	GTS2	GTS3	GTS4	AAU	MU1	BJE1	ECO1	LOG1	TOT1	BOnDS, Yovinn
manmonths	**9**	9	12	11.5	0.25	0.25	0.25	0.25	0.5	1	Task 1.4 & 1.5

1

Objectives: Conceptual leadership, comprehensive coordination, editing Proof-of-Concept and final report; Managerial and administrative efficiency, time keeping and accounting; HQ of the GTS MAGNET project; Chair of the Interdisciplinarity Working Board (IWB); Subcontracting Environmental analysis (BOnDS); Responsibility for subcontracting Yovinn building of full-scale mock-up cabin

Description of work

Task 1.1 Main coordination, visits on all locations, conceptual leadership and final reporting, future structure; GTS is ground-breaking and there is no business structure developed, what so ever. In relation to the anticipated successes in research tasks there will gradually develop clarity on the possible future structure of a GTS standard, licenseing and the industrial endeavour for creating and developing a global GTS market.

Task 1.2 Financial, administrative and HR management; periodical and final reports;

Task 1.3 Interdisciplinary Working Board (IWB) Interdisciplinary connections by IWB analyses and decisions, quarterly meetings, digital and physical. It will be the responsibility of all lead participants to open up their individual subjects to common understanding and dissertation; the main lead participant (GTS1) of GTS MAGNET will chair the IWB with the lead participant of technology as deputy chair (GTS2).

Task 1.4 Subcontracting Environmental analyses from BOnDS, Breda (NL). The resources for this first phase of GTS development does not allow for a full environmental analysis. However, transport environmental analyst by BOnDS SME in Breda, Netherlands, will present an overview of environmental factors in the relation between conventional and frontier transport technologies on the one hand and the emerging GTS on the other. The analyses will support the analyses and synthesis made in wp STA.

Task 1.5 Subcontracting Yovinn, Göteborg (SE), with relations to the automotive cluster of west Sweden, for building the full-scale mock-up cabin together with wp PCV see Task 5.3 Cabin design. Lead participant ECO (Royal Institute of Technology, KTH, VinnEx Centre for ECO2Vehicle Design). For practical reasons, the subcontracting of Yovinn for the design and fabrication of our full-scale mock-up cabin, is put in wp MIC. The ordinary public display of the mock-up cabin, will take place at a showroom adjacent to the GTS MAGNET HQ in Uppsala, in coordination with wp´s COM and PCV.

Deliverables 1dx Financial reports quarterly, Q1-Q12 1D1 Intermediate coordination and interdisciplinarity report, M12 1D2 Forecast final presentation report (Milestone 4), Research findings & recommendations M24, 1D3 Final report, "Inventing a General Transport System", M36

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wp. nr, title	**2. Electro-Magnetic Research - EMR** – Lead beneficiary: **AAU**								
particip. nr	**2.2**	2.4	3.1-	1.01	1.02	4.2-	5.2-	6.1	7.3
short name	**AAU2**	AAU4	MU1-	GTS1	GTS2	BJE2-	ECO2-	LOG1	TOT3
manmonths	**4**	41	22	0.25	1.25	0.125	0.125	0.125	0.125

2

Objectives: Find cost effective and safe mechanisms for transporting the cabin under the beam. Specifications of the electromagnetic suspension, propulsion, and switching actuators are the first steps. A radical new propulsion system based on lead screws will be investigated. A safe magnetic high-speed cabin switch mechanism and a levitation and guidance actuator will also be specified.

Role of Partners: AAU is the leader of the WP, and carries out the design of the propulsion system based on the MLS technology (T2.2). MU affords the design of the magnetic switching system (T2.3) and the design of the magnetic levitation and guidance actuators (T2.4). Both partners take part in the definition of specifications (T2.1) and in the full-scale design concept (T2.5).

Description of work:

Task 2.1 (M1-6) Agree on actuator performance specification; Vehicle mass, acceleration, deceleration, speed, wind effects, curvature and input from other work packages will dominate the design of all actuators and material.

Task 2.2 (M7-15) Radical new and cost effective and reliable propulsion and levitation actuator; Develop steady state analytic and finite element models of the novel linear electromagnetic propulsion and levitation actuator units. Design of a novel linear electromagnetic propulsion unit, using the magnetic lead screw (MLS) technology. This is expected to result in a cost reduction to 1/5 of the cost of earlier technologies, combined with a mass reduction of 1/20. The MLS propulsion unit design is combined with a magnetic levitation unit and integrated with a contact-less current collector. The results are relevant also for other work packages.

Task 2.3 (M7-18) A safe magnetic switch mechanism enabling switching at high speed; Design of a safe magnetic switch mechanism enabling switching at high speed. It must apply sufficient force to always direct cabins right safely. The magnetic switch will eliminate problems like stones, fallen leaves and ice common in rail switches.

Task 2.4 (M7-15) A cost effective electromagnetic levitation and guidance actuator. Develop dynamic models of the levitation actuator. This technololgy will also provide guidance. Guidance is closely related to the safe operation of the switching of task 3.3. The models developed will be used in task 3.2 to determine if the operation of cabins will be safe under the specified conditions included in task 3.1.

Task 2.5 (M16-24) A full-scale design concept of the propulsion, levitation, guidance and switching actuators. Use the combined results of tasks 2.2 to 2.5 compiling a full-scale design enabling CAPEX and OPEX estimations.

Deliverables
2D1 (Milestone 1) Initial performance specification M6;
2D2 Technical report on actuator models and design, M15;
2D3 Technical report on track switch and design, M18;
2D4 Technical report on full scale design concept, M22;
2D5 Preliminary Proof of Concept, M23 (also by GTS2)

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wp. nr, title	**3. Converter and Control Research - CCR** – Lead beneficiary: **MU**									
particip. nr	**3.1**	2.3-	3.4-	2.1	1.1	1.2	4.2-	5.2	6.1	7.3
short name	**MU1**	AAU3-	MU4-	AAU1	GTS1	GTS2	BJE2 E	ECO2	LOG1	TOT2
manmonths	**3**	25	27	2	0.5	1	0.125	0.125	3	0.25

3

Objectives: To find safe control systems for the electromagnetic levitation, propulsion, and switching. The control system should also allow for platooning and separation of cabins. The electromagnetic levitation should also be used for guidance sideways. The whole control system must be both cost-effective and control energy efficient.
Specific Objective 2: Develop the GTS automation and control system;
Measure of success: The system has been developed and found eligible by the consortium leadership.

Role of Partners: MU is the leader of the WP and carries out the control systems for propulsion, levitation and magnetic track switching (T3.2, T3.3). AAU and MU collaborates in the definition of technical specifications (T3.1) and in the full-scale concept (T3.5). In addition, AAU develops the high-level controller defining the required sensors and communication net between different elements comprising the whole system (T3.5) and the platooning system (T3.4). IWB6 participates in the platooning system as well (T3.5).

Description of work:

Task 3.1 (M1-6) Agree on sled system performance specification based input from other work packages. Specify the functions of a control system and develop and test its core elements for proof-of-principle.

Task 3.2 (M13-24) A propulsion and levitation actuator control system comprising controller and power converters; All control of the motion, levitation and guidance will be affected via controlled electric power converters. Models for a complete control system including converters will be built.

Task 3.3 (M13-24) A safe magnetic track switching system comprising controller and power converter enabling switching at high and low speeds. Models for a fail-safe system controlling the switching mechanism will be developed and simulated.

Task 3.4 (M7-24) A safe cost-effective platooning system comprising controller and power converter enabling very low high speed energy consumption due to minimal windage. Platooning of vehicles must control the distance and velocity relative to the cabin in front very precisely.

Task 3.5 (M7-24) Propulsion, braking and switching of drive sleds, will be monitored from controllers activating rotors and magnets. Sensors for position and speed can be placed in guideways and/or in drive sleds and also in the front of cabins. Communications between drive sleds and controllers can be done via dedicated short range (DSRC) or e.g. 5G broadcast. Safety monitoring and emergency brake activation are critical functions. Vehicle platooning at speed is a high-risk design but this target has already been set and demonstrated demonstrated for road vehicles.

Task 3.6 (M16-24) A full-scale design concept of the propulsion, levitation, guidance and switching control systems. Using the combined results of tasks 4.2 to 4.5 to compile an initial full scale design concept to form input to other work packages and enable estimates to be made of the CAPEX and OPEX

Deliverables
3D1 Initial performance specificationM6;
3D2 Report on actuator controllers & design M24;
3D3 Report on track switch controller & design M24;
3D4 Report on full scale design concept M24

wp. nr, title	**4. Demonstrator - DEM** – Lead beneficiaries: **AAU, MU**										
particip. nr	**2.1**	2.4-	**3.1**	3.5-	1.1	1.2	4.2	5.2	6.1	6.2	7.3
short name	**AAU1**	AAU4-	**MU1**	MU5-	GTS1	GTS2	BJE2	ECO2	LOG1	LOG2	TOT3
manmonths	**1.5**	47	**1.5**	15	0.5	0.5	0.125	0.125	0.5	0.125	0.125

4

Objectives: Specify, draw, & manufacture a small scale demonstrator laboratory prototype.
Specific Objective 1: Develop the standard sled;
Measure of success: the development has been achieved, M36.

Role of Partners: The total small-scale demonstrator will be assembled in Aalborg in order to test the overall system. A second partial demonstrator will be assembled in Mondragon in order to test the sub-components before they are integrated in the total demonstrator in Aalborg. MU will develop the controllers and power electronics devices for propulsion, levitation and guidance systems. AAU will build the rest of elements comprising both demonstrators.

Description of work:

Task 4.1 (M1-6) Agree on Demonstrator performance specification, based on demonstrator site etc.

Task 4.2 (M7-24) Draw & design cabins, track, drive sled, controllers and converters. Using input from other wp design, draw and compile a parts list for the demonstrator comprising a section of a scale model track with two operational cabins.

Task 4.3 (M21-26) Purchase components, parts and materials, and Manufacture Demonstrator. Purchase all materials. Efforts should be made to employ commercially available components to save costs and time.

Task 4.4 (M23-28) Assemble Demonstrator and Track. As parts become available, assemble the sub-systems, e.g. cabins, drive sleds, converters, controllers, track, etc.

Task 4.5 (M25-36) Test Demonstrator. Test the sub-components as they become available. Test the assembled demonstrator with individual cabin transport and platoon operation of two cabins.

Task 4.6 (M36) Demonstrator Show Demonstrate the scale model system to an invited audience. Make a video recording of the demonstrator in action. Make the video recording public on the Internet.

Task 4.7 (M36) Evaluation of Test Results Write a report of the test results with discussion and evaluation of the performance achieved compared to the specification.

Deliverables
4D1 (Milestone 2) Sketch Prototype Demo ready, M12;
4D2 Prototype laboratory scale model of a section of track with two operational cabins, M24;
4D3, 4D4 Technical report evaluating tests & performance of demonstrator. M30, M36.

wp. nr, title	**5. Physical design, Construction &Visualization - PCV** – Lead beneficiaries: **BJE, ECO**										
particip. nr	**4.1**	4.2	**5.1**	5.2	1.01	1.02	2.2	3.2	6.1	7.3	subcon.2
short name	**BJE1**	BJE2	**ECO1**	ECO2	GTS1	GTS2	AAU2	MU2	LOG1	TOT3	Lutfi Ay
manmonths	**4**	22	**3**	8	1.5	0.5	0.25	0.375	0.25	0.25	AyCrete

5

Description of work:

Task 5.1 Agree on a preliminary infrastructure performance specification. Based on input from other wp's, summarizing standards and regulations (stability, vibrations, tolerances, fire, earthquake, real estate etc) to be observed/questioned and an initial creative attempt to describe for example the function and design principles of a small station. What services should it render considering the door-to-door chain of transportation for people, goods and waste? What impact will it have on the neighborhood? Students from the Royal Institute of Technology (KTH), Architecture and Urban Planning will be engaged. Selections from this session will be published on Internet.

Task 5.2 Infrastructure, strength and design, R&D The general infrastructure consists of pillars/pylons and beams wherein the drive sled runs. The system to be created can be prefabricated and easily adapted to different situations, also integrated into buildings. The principles for mounting, maintenance and recycling must be established. Conventional materials such as steel and concrete will be used to start with. Advanced materials will also be scanned for comparison. Principles for foundation of pillars will be studied as well as optimal spans considering different situations. We plan for a close cooperation with the other workpackages solving challenges like switching, platooning, maintenance and robustness. Visualization of stops and guideways will be shown - and published on the Internet. Sub-contractor AyCrete, with advanced knowledge and experience of novel infrastructure design, in frequent cooperation with Bjerking, will support, producing calculations and CAD-sketches. Postgraduates from KTH will assist. Pilot sketches for Uppsala, natural protection area, GTS bridging Fyris river.

Task 5.3 Cabin design, optimization of volume and load, general functionality Cabin design for GTS demands a strict standardized cross section due to the dependence on a fixed infrastructure. The total weight should not exceed 2,5 metric tons. Platooning will always be made possible. Cabins can be designed in many special ways, like dual mode cabins/cars (3-5 pax), public high capacity cabins (12 pax) etc. The issues of low weight, aerodynamic and vehicle dynamic properties will be addressed through simulations. This will determine materials used and shape. The associated environmental impact will be assessed and optimized using life cycle analysis and eco-design methods. A standard cross section will be presented in drawings, models and visualization. Modelling and design support will be given by sub-contractor Yovinn, under wp MIC, with long experience of the art within automotive industry.

Objectives: Advanced calculations for a unique, new, sustainable infrastructure. Design and architectural studies forms the physical impact of GTS in the human, urban and landscape scale. Cabin design.
Specific objective 3: Design the GTS cabins and guideway components.
Measure of success: The design prototypes have been found eligible by the project leadership, and by the majority in an extensive popular inquiry among visiting people, craried out by COM, see also Task 7.3.

Deliverables
5D1 Initial performance specifications of guideway structure, M6;
5D2 Construction and visualization of GTS infra sketches, pilot sketches for Uppsala, M12;
5D3 Construction and design of GTS cabins, M12;
5D4 Construction & Visualization of GTS, M18;
5D5 Report evaluation, listing challenges to encounter in the next step, M24.

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wp. nr, title **6. Supervision, Trade-offs and Analyses - STA** – Lead beneficiary: **LOG**

6

particip. nr	**6.1**	6.2-	1.1	1.2	2.1-2	3.1	4.1	5.1	7.2
short name	**LOG1**	LOG2-	GTS1	GTS2	AAU	MU	BJE1	ECO1	TOT2
manmonths	**12**	3.25	0.75	0.25	0.25	0.625	0.125	0.125	0.25

Objectives: Integrate knowledge from previous PRT developments and certifications; Breakdown of system cost elements; Design and evaluation of the Uppsala application case.
Specific Objective 5: Calculate costs, performance and expected effects of the application;
Measure of success: a) Acceptance among planners, authorities and ordinary people (inquiry by COM, Task 7.3 ; b) Calculation of the total cost/km of the guideway, all auxiliary systems included, target 10M€

Description of work:

Task 6.1 Functional specification and Trade-offs Standards and certification requirements; Trade-offs incl. propulsion vs control, technology vs flexibility, cost vs passenger utility, cost vs visual appearance, technology vs environment.

Task 6.2 Cost Analysis Cost calculation of beams, supports, bridge, ground anchorings and stations. Cost of operation based on organisation, manning, energy, maintenance and parts.

Task 6.3 Summary of Analyses Comprehensive summary of functional specifications, cost analysis and environmental analysis; see wp MIC task 1.4 (Milestone 3).

Task 6.4 Design of the Uppsala case Non-linear elastic demand estimation; Costs revenues and socio-economic CBA.

Task 6.5 Training of young researchers. One-week seminar series for MSc, PhD students and post-docs are offered to the three participating universities KTH, AAU and MU. The participants will, under our supervision, model a local application of a GTS system involving site selection, network design, traffic strategies, demand estimation, resource dimensioning with resulting service level and cost estimates.

Task 6.6 Development of a GTS Simulation Model Existing micro-simulation models for Personal Rapid Transit deal with on-demand non-stop transport with ride-sharing and fleet management. GTS adds new functionalities such as platooning, high-speed and low-speed sections and transition/grouping terminals between them. This task sets out to enhance the PRTsim model developed by LogistikCentrum into a general GTS simulation model.

Deliverables
6D1 Functional specs, M12; 6D2 Cost analysis M21, 6D3 Summary of analyses, M21 (Milestone 3); 6D4The Uppsala Case M36, 6D5 research studies within the project, M36; 6D6 GTS Simulation model, M36

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wp. nr, title **7. Communication - COM** – Lead beneficiary: **TOT**

7

particip. nr	**7.1**	7.2	7.3	7.4-	1.1	1.2	2.1-2	3.1	4.1	5.1	6.1
short name	**TOT1**	TOT2	TOT3	TOT4-	GTS1	GTS2	AAU	MU1	BJE1	ECO1	LOG1
manmonths	**3**	14	12	24	1	0.5	0.5	0.25	0.25	0.25	0.25

Objectives: Communication activities on the web and at exhibition at our location in Uppsala (MIC/COM). Target groups will be exposed to information about the project and GTS. Raise the general awareness of GTS.

Description of work:

Task 7.1 Produce information material and artifacts; newsletters, progress reports, exhibits, web architecture and the like;

Task 7.2 Communication activities on a daily basis at exhibition, net and office location in Uppsala, quarterly reports;.

Task 7.3 Conduct and participate in events, seminars and external activities;

Task 7.4 Active media oriented input at each milestone, social and traditional media;

Task 7.5 Install and maintain the interactive center with a mockup cabin etc;

Task 7.6 Communication management, collecting info from other work packages for internal and external dissemination;.

Task 7.7 Communicate and inquire visiting people on the infrastructure and cabin design presented by wp 5;

Measure of success: a majority would accept the presented design.
Specific objective 5: Calculate costs, performance and expected effects of the application. ;
Measure of success: a) Inquiry lead to majority acceptance among planners, authorities and ordinary people, see wp 6.

Deliverables
7D1Webpage up and running, logo, M1;
7dx Press releases on all major occasions;
7dz Quarterly reports on project progress, Q1-Q12;
7D2 M12, M24, M36 Monitoring effects of exhibits and activities;
7D3 M12, M24, M36 Quantitative measurements, web and media;
7D4 M21, M36 Feedback on attendance and perceived impact;
7D5 M21, M36 Monitoring communication management activities.

Table 3.1c List of Deliverables (D; Note: quarterly reports, see more under each wp description.)

D. nr	Deliverable name	Lead P	Type	Diss.	Deliv.
7D1	Launching website and logo	TOT1	DEC	PU	M1
2D1	EMR Initial performance specification (Milestone 1)	AAU2	R	PU	M6
3D1	CCR Initial performance specification	MU1	R	PU	M6
5D1	Initial performance specification of guideway structure	BJE1	R	PU	M6
4D1	Prototype laboratory..sketch model of..track..with two cabins (Milestone 2)	AAU1	DEM	PU	M12
5D2	Construction and visualization of GTS infra sketches	BJE1	DEM	PU	M12
5D3	Construction and design of GTS cabins	ECO1	DEM	PU	M12
6D1	Functional specifications	LOG1	R	PU	M12
1D1	Intermediate coordination and interdisciplinarity report	GTS1	R	PU	M12
2D2	Technical report on actuator models and design	MU1	R	PU	M15
2D3	Technical report on track switch mechanism models & design	MU1	R	PU	M18
5D4	Construction and visualization of GTS	BJE1	DEM	PU	M18
6D2	Cost analysis	LOG2	R	PU	M21
6D3	Summary of analyses (Milestone 3)	LOG1	R	PU	M21
2D4	Full scale design concept	AAU2	R	PU	M22
4D2	Techn. report evaluating tests & performance of demonstrator	AAU1	DEM	PU	M23
2D5	Preliminary Proof of Concept	GTS2	R	PU	M23
3D2	Technical report on actuator controllers and design	MU1	R	PU	M24
3D3	Technical report on track switch controller and design	MU1	R	PU	M24
3D4	Technical report on full scale design concept	AAU1	R	PU	M24
1D2	Forecast final presentation report (Milestone 4),Research findings & recommendations	GTS1	R	PU	M24
5D5	Report evaluation listing challenges to encounter in next stage	BJE1	R	PU	M24
4D3	Techn. report evaluating tests & performance of demonstrator	AAU1	DEM	PU	M30
4D4	Techn. report evaluating tests & performance of demonstrator	AAU1	DEM	PU	M36
6D4	The Uppsala case, pilot and pioneering exanple	LOG1	R	PU	M36
6D5	Research studies within this project	LOG1	R	PU	M36
6D6	GTS Simulation model	LOG1	R	PU	M36
7D2	Monitoring effects of exhibits and media; M12, 24,36	TOT1	DEC	PU	-M36
7D3	Quantitative measurements, web and media; M12, 24, 36	TOT1	DEC	PU	-M36
7D4	Feedback on attendance and perceived impact; M21, 36	TOT1	DEC	PU	-M36
7D5	Monitoring communciation management activities; M21, 36	TOT1	DEC	PU	-M36
1D3	Final report, “Inventing a General Transport System”	GTS1		PU	M36

3.2 Management structure, milestones & procedures

Eight reporting occasions will be arranged and four will be coordinated with the milestones. They will also include external presentations. Two internal meetings are scheduled. The first two milestones are crucial for alleviating high risks whereas the two latter milestones open up for the final proof and presentation. See Fig. 3.1a and Table 3.2a. Probable risks are listed in Table 3.2b.

Milestones are placed after 2, 4, 7 and 8 quarters. See fig.3.1a and table 3.2a. Settling the performance specifications of the technology will be the first milestone after six months. We arrive at the second milestone when the sketched prototype demo is ready after one year. Nine months later we will arrive at the third milestone when construction and visualization of GTS and a full-scale design concept of the electro-magnetic technology can be presented. After two years all wp’s except the demonstrator wp 4 DEM have delivered their preliminary results and we will evaluate GTS at the fourth milestone; forecasting the final result that will be available following one year of testing the demonstrator. Final results will then be collected in the main GTS MAGNET report, Inventing a General Transport System.

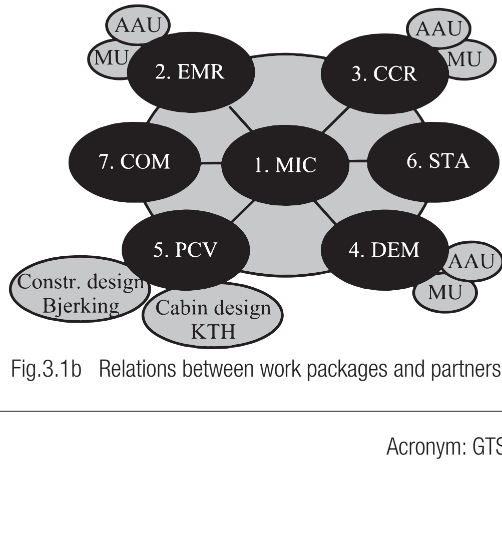

Fig.3.1b Relations between work packages and partners

Table 3.2a List of milestones (and other occasions, see also Fig. 3.1)

Nr	Name	wp	Date	Venue	Verification
-	Introductory presentation, HQ and public platform	all	M1	Uppsala	Seminar papers
1	**Milestone 1** Performance specification: Core technology, sled and beam for laboratory tests; public platform	all	M6	Mondragon	Deliverables
2	**Milestone 2** Sketched Prototype Demo ready: Core technologies, control system; infrastructure & cabin; Operational, environmental and financial analyses so far; public platform	all	M12	Aalborg	Deliverables; Prototype
-	Closed session, work meeting, preliminary	all	M18	TBD	Undeliverables
3	**Milestone 3** Summary of Analyses: Lab.test&validation; Control system&simulation software; Infrastructure & cabin design; Operational, environmental and financial analyses; Exhibition & public platform	all	M21	Göteborg	Conference Test results Deliverables
-	Closed session on Proof-of-Concept, reflections and comprehensive analyses report	all	M23	TBD	Undeliverables
4	**Milestone 4** Forecast final presentation; public platform	all	M24	Uppsala	Prel. final report; Deliverables
-	Final presentation; Long laboratory test results; public platform	all	M36	Aalborg	Final report

Table 3.2b Critical risks for implementation

Description of risks *(likelihood of risk)*	**wp**	**Proposed risk-mitigation measures**
a) The core technology does not develop as expected; power performance is too weak. - *low risk*	2	a) The reasons can be avoided by adjustments of specifications and early selection of alternatives (by SWOT analyses).
b) The demonstrator does not fill the proposed requirements. - *low risk*	3	b) V model design method is used in development. Its basis is verification and validation of each phase before passing to next. It reduces uncertainties in demonstration, as models have been tested previously (- also applied in automotive development).
c) The approaches proposed in wp2 and 3 are not enough precise for integration in wp4. - *low risk*	4	c) Wp leaders take actions to ensure an effective information flow between wp's to risk mitigation
Infra-construction causes severe problems with strength, maintenance or cost. - *low risk*	5	The reasons can be avoided by adjustments of specifications.
Human perception values the design and environ-mental effects difficult to accept. - *medium risk*	5,7	Communications must be sharper as to the full social, aesthetic and environmental improvements.
Key staff may unexpectedly be lost - *medium risk*	1	The leadership has back-ups
Works slow down for various reasons - *medium risk*	1	The coordinators take actions
Vested interests perform hostile - *high risk*	1	The leadership takes actions
Major faults can't be prevented or avoided -*low risk*	1	The leadership proposes closure of the project

3.3 Consortium as a whole

The registered GTS Foundation (GTSF) is the main partner in the project consortium. The founders are the main carriers of the GTS concept. As main coordinator and technical coordinator they also support the research, innovation and interdisciplinary work in all work packages. A financial manager controls the economy, HR and administration. A mind map of interrelations between all work packages is presented in fig.3.1b. The consortium will collectively govern the project by means of a leadership consisting of all lead participants. It will establish its office in Uppsala.

GTSF is a non-profit organization but it may own shares or other properties to a limited extent. After a successful project GTSF invites all partners in the project, building firms, cabin manufacturers, electric equipment manufacturers etc to form the GTS Consortium AB (GTSC). GTSC builds the first pilot and pioneering tracks and may continue building in order to develop skills and experience, parallel to competing license-holding industries.

GTSF collects license fees from GTS producing companies and operative fees from GTS licensed operators. This future business structure will secure the independence of GTSF as licenser and standard-holder. GTSF may also incorporate licences from other inventors and include them into the GTS standard when applicable.

The GTS Consortium has been created after years of searching for the right partners. We are now a collection of university research departments, skilled consultants and specific sub-contractors (SME) with special knowledge for creating, inventing, analyzing, synthesizing and visualizing our proposal (see sec. 4). Also, all partners have an open mind that makes our mission possible to accomplish; this is a necessary gate value for bringing our project to a happy end. All lead partners have accepted a Letter of Intent. See also section 4.

3.4 Resources to be committed

Table 3.4a Summary of staff effort

Workpackage	Staff	wp1 MIC	wp2 EMR	wp3 CCR	wp4 DEM	wp5 PCV	wp6STA	wp7 COM	Σ manmonth	Σ propartner
1.1	**GTS1**	**9**	**0.25**	**0.25**	**0.5**	**1.5**	**0.75**	**1**	**13.25**	**GTS**
1.2-	GTS2-	32,5	1.25	1.25	0.5	0.5	0.25	0.5	36.75	**50**
2.1	**AAU1**	**0.125**	-	**2**	**1.5**	-	**0.125**	**0.25**	**4**	**AAU**
2.3-	AAU3-	-	36	25	-	-	0.125	-	66.125	**122**
3.2-	MU2-	-	22	-	-	0.25	-	-	22.25	-
3.1	**MU1**	**0.25**	-	**3**	**1.5**	-	**0.25**	**0.25**	**5.25**	**MU**
3.3-	MU3-	-	-	27	-	0.125	0.125	-	27.25	**70**
2.2	**AAU2**	**0.125**	**4**	-	-	**0.25**	**0.125**	**0.25**	**4.75**	-
2.4-	AAU4-	-	-	-	47	-	0.125	-	47.125	-
3.4-	MU4-	-	-	-	15	-	0.25	-	15.25	-
4.1	**BJE1**	**0.25**	-	-	-	**4**	**0.125**	**0.25**	**4.625**	**BJE**
4.2-	BJE2-	-	0.125	0.125	0.125	22	-	-	22.375	**27**
5.1	**ECO1**	**0.25**	-	-	-	**3**	**0.125**	**0.25**	**3.625**	**ECO**
5.2-	ECO2-	-	0.125	0.125	0.125	8	-	-	8.375	**12**
6.1	**LOG1**	**0.5**	**0.125**	**3**	**0.5**	**0.25**	**12**	**0.25**	**16.625**	**LOG**
6.2-	LOG2-	-	-	-	0.125	-	3.25	-	3.325	**20**
7.1	**TOT1**	**0.5**	-	**0.25**	-	**0.25**	**0.125**	**3**	**4.125**	**TOT**
7.2-	TOT2-	0.5	0.125	-	0.125	-	0.125	50	50.875	**55**
Σ		44	69	62	67	40.125	17.875	56	356	**356**

Table 3.4b 'Other direct cost' items (travel, equipment, other goods and services) ??

Work package **Cost €** **Justification**

wp 1 MIC, GTS Foundation, main coordination, communications

Work package	Cost €	Justification	
Travel	28 800	6 meetings x 2p. + 12 travels by main coordinator; 24 x 1200€	
Equipment	20 000	Computers, server, smartphones, network, furniture, on short-term rental basis if possible	
	200 000	Cabin full-scale mock-up, publicly accessible at exhibition	Subcontractor Yovinn AB, Göteborg (SE)
	20 000	Introductory Environmental Analysis	Subcontractor BOnDS, Breda (NL)
Other goods and services	175 000	Central office in Uppsala, rent acc. to local market cost, for public communication, exhibition & work on short term rental basis; printing service, webpage service, conference costs.	
Total	443 800		

wp's 2 EMR, 3 CCR & 4 DEM Aalborg University, Department of Energy Technology (AAU), and Mondragon University, Department of Electronics Engineering (MU); Core technologies

Work package	Cost €	Justification
Travel	43 200	AAU + MU: Travels, 2 x 6 meetings x 3 p. x 1200€/meeting, 21 600€ each AAU & MU
Equipment	160 000	AAU: base structure 11000, HEMS demo 22000, MLS demo 22000, guidance 22000, software, control, sensors and verification 22000, material 30000, guideway 31000.
	10 000	MU: small scale material, 10000 (3 controllers dSPACE1104, fr.year 2).
Other goods	12 000	AAU + MU: General consultants, auditors etc. 12000€, 6000€ each AAU & MU
and services	57 000	MU: Material to build elements for the functional subsystems demonstrator: 3 power devices 15000€, track structure 5000€, magnetic switch 5000€, propulsion/levitation/ guidance device 20000€, flux SW license leasing, 3 years * 4000€/year: 12000€
Total	282 200	AAU 187 600€ and MU 94 600€

wp 5 PCV, subcontractor 2, AyCrete, Lutfi Ay

Work package	Cost €	Justification
Construction	106 000	GTS pillars, pylons and guide-way, calculations & drawings