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Preconditions for establishing and maintaining test sites for cooperative mobility

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Abstract

In the future, vehicles will communicate and cooperate more and more with each other and the infrastructure, enabling them to work together to reduce traffic jams and harmful emissions and to increase road capacity and safety. These cooperative driving and smart mobility solutions allow for better and safer traffic management and cleaner and more fluent traffic for travelers. To achieve these objectives, a lot of research and experiments are still needed. Especially sites allowing real-life tests are required. Not many good examples of these kinds of sites exist, although they are logical extensions of the traditional, controlled and closed research environments. This study identifies the main cornerstone factors for establishing and maintaining test sites for cooperative mobility by benchmarking two successful test sites. The results revealed that it is not about the technology but mostly about triple helix collaboration managed by a neutral party and supported by public authorities.

Keywords

Co-operative mobility, test site, business ecosystems

Introduction

Mobility – the movement of people and goods from one place to another – is undergoing a fundamental transformation. This rebirth is fuelled by new developments in data availability, vehicle technology and emerging business models. Artificial intelligence is making its way into cars as companies both old and new are racing to build automated vehicles and remake the way we move.

Vehicles, whether they are connected, automated or just plain manual, all share a common need for physical road infrastructure. Around the globe streets and highways are getting older and their condition is declining rapidly. Investments are needed to keep roads safe. Advancements in vehicle and communication technology bring out new kinds of questions about the form of these investments: should roads just be rebuilt or do we need to redesign them to take into account the needs and capabilities of connected and automated vehicles? Are separate lanes needed, and should we install communication equipment along the road network?

There is no shortcut to these answers. After connected and automated technology has passed muster in laboratory conditions, a great deal of testing in the real world and on real roads is needed. This part of the connected and automated mobility revolution is still in its early stages. Streets and highways are very complex environments where hundreds of agents interact with each other, directly or indirectly, in varying weather conditions. Continuous observation and prediction of immediate surroundings are needed.

An obstacle to this kind of comprehensive connectivity and automation testing is that there really are not that many environments where it can be undertaken. It requires wide-ranging cooperation between a variety of public and private stakeholders. This cooperation must be both vertical and horizontal. Vertical cooperation involves the whole chain from authorities to suppliers to manufacturers all the way to end-users. Horizontally suppliers have to work with other suppliers and manufacturer to make room for the creation and development of a sustainable business ecosystem, which is an economic community supported by a foundation of interacting organizations and participants.

In ecosystems, participants can co-evolve capabilities around new innovations by collaborating to support new offerings, satisfy customer needs and eventually discover innovations (1). Iansiti and Levien (2) have described a business ecosystem as a network that includes a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival.

This paper aims to identify the most important success factors in establishing and maintaining a test site ecosystem by examining two European case study examples. In the course of this examination, the paper will provide answers to the following questions: What is the role of business ecosystems in intelligent transport systems and cooperative mobility business? What are the roles of different stakeholders in test site ecosystems? What are the main preconditions for establishing and maintaining test sites?

Taking advantage of business ecosystems in supplying ITS test sites services

The emerging development of information and communication technologies (ICT) has introduced many changes in various sectors. It has transformed industries as well as the public sector from education to health care and is now in the early stages of transforming the transport system (3). Although intelligent transport systems (ITS) may refer to all modes of transport, EU Directive 2010/40/EU defines ITS as systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport (4).

ITS products and services comprise various applications. Alberta Transportation (5) divides ITS applications into the following eight major functional categories: Traveller Information Services (e.g. traveller advisory systems, Traffic Management Services (e.g. advanced traffic signal systems); Public Transport Services (e.g. electronic schedule information, real-time location and busses); Commercial Vehicle Operations (e.g. weigh-in-motion, electronic truck clearance and border crossings); Electronic Payment Services (e.g. electronic toll payment); Emergency Management Services (e.g. eCall), Vehicle Safety and Control Systems (e.g. in-vehicle technologies such as onboard computers, collision avoidance sensor technologies); and Information Warehousing Services (e.g. traffic safety data collection).

As a business, Marketsandmarkets (6) expects that ITS markets will grow at a Compound Annual Growth Rate of 11.6% from 2015 to 2020 reaching $34 billion in 2020. In Finland, Zulkarnain & Leviäkangas (7) studied the ITS market size, growth and structure. The study pointed out that in 2010, the Finnish ITS market size was about 300 MEUR and 1,700 employees. The market is dominated with local companies (72%), services providers (56% market share), and medium-sized and small companies. The market was seen as fragmented and no monopolistic or oligopolistic features were witnessed at first sight. The potential impacts of ITS have been widely studied and discussed; for example, Kulmala and Schirokoff (8) presented a rough estimation that the impacts of ITS may vary from 2-35% fewer fatalities, 1-34% fewer injuries, 1-20% reduced congestion and 0.5-20% fewer emissions. Ferreira (9) estimated that ITS can reduce congestion by 5-15%; 5-15% fewer fatalities and 5-10% fewer injuries; and possibly save 10-20% CO_2 emissions.

Business ecosystems as a cornerstone of ITS test sites

As the world's population expands, so does the number of cars clogging our highways and cities – there are now more than 1 billion vehicles worldwide and these vehicles cause 23% of all greenhouse gas emissions. More cars also means more demand for oil, more of a harmful impact on our environment, more congestion on the roads and more accidents and fatalities. Every day about 3,500 people die in car accidents while 50 million people are injured or disabled annually. Certainly more sustainable vehicles and transport modes will have a slightly reducing impact on the demand of oil and emissions but not so much on accidents and congestion.

In the future vehicles will communicate with each other and the infrastructure via smart technology, enabling them to work together to reduce traffic jams and harmful emissions and to increase road capacity and safety. These cooperative driving and smart mobility solutions allow for better traffic management and safer, cleaner and quicker individual traveler guidance.

In research and innovation activities strong focus has been put on developing ITS and cooperative systems. This has led to many projects researching specific elements and technology (V2I and V2V communication, safety systems, etc.). Common pitfalls of such projects are a purist approach that focuses on theoretical research while not giving enough consideration for deployment: e.g. demand side, customers and business models. Many projects have established and equipped their own test sites from scratch, but all the equipment have been dismantled after the project and often the established project partnerships have also fallen apart. By working like this, there is little room for deployment and bringing innovations to the market.

Therefore, test sites will play an essential role in ITS testing and deployment. A test site is a lasting research and innovation infrastructure, which is instrumented and comprises hardware, software, vehicles and users. It supports a variety of activities including field operational tests, pilots, methodology validation, impact assessment, simulation, user acceptance, product development and demonstration etc. It may support field operational tests, pilots, methodology validation, impact assessment, simulation, user acceptance, product development and demonstrations. It usually has a recognized status and governance structure in order to sustain its existence and business continuity.

Well-coordinated and dedicated activities are needed in order to bring the many valuable results of research, development and innovation activities together, focus them towards deployment and apply them to address today’s mobility challenges. Many of these addressed issues, benefits and activities can be better managed and further developed through test sites for ITS services and cooperative mobility. Often these test sites cannot be managed by or rest upon individual organizations but rather it is a matter of business and collaboration networks, which we regard as business ecosystems, in ensuring the development and deployment of cooperative mobility and other ITS services.

The functions performed by the ecosystem participants increase the total value of the output, and the members of the ecosystem can create and achieve more value together rather than working independently. In other words, the ecosystems provide services, products and functions that have value to the end users by combining ecosystem participants’ resources and functions. Resources must be understood not only as costs of providing a function but also as technologies, skills, tangible and intangible assets, market presence, and so forth. The list can include whatever the particular context may consider as a resource. Combining functions also enable sharing some of the resources, so that the efficiency of the ecosystem is enhanced without sacrificing value creation.

Test site ecosystems in the Netherlands and Sweden

This research is qualitative, and the data was collected from 6 semi-structured interviews (8 interviewees) which were conducted during November and December 2015. Four of those interviews (six interviewees) were conducted in the Netherlands and two in Sweden. The majority of the interviews were recorded and written up. Every interviewee was highly experienced (+15 years) with a long history of traffic management, ITS and R&D on cooperative systems and vehicles. Also, public material (e.g., company brochures, printed materials, annual reports) and direct information obtained from stakeholders was utilized in this study.

Because informal discussion and flexibility were seen as being very important to this research, the interview questions were broad and loosely defined. The main purpose of the interviews was to gain an understanding of how the test sites have developed and what have been the most important factors and stakeholders over this time. Since the test site ecosystems include multiple different levels and therefore different kinds of stakeholders, the interviews were conducted both with private organizations (e.g., service and product providers) and public organizations (e.g., public and road authorities). The end-users (e.g., consumers, "road users", commercial traffic) were not interviewed at this stage.

The Customer Value Chain Analysis tool (CVCA) developed by Donaldson et al. (10) was used to describe the current ecosystems. The information and material gained from the interviews formed a foundation for the ecosystem description and for illustrating the relationships between the ecosystem's stakeholders. Because one of the objectives of this study was to show the stakeholders' offerings and contributions to the ecosystems, the CVCA tool was also used to assess and analyse the existing ecosystem, for instance to distinguish the offerings (e.g., technology, product, service, guidance) of different stakeholders.

The Dutch ecosystem

The approaching closure of an automotive design and engineering unit in 2000 forced the city of Helmond to think how they could maintain those 300 skilled engineers who were going to be unemployed and probably moving elsewhere to find new jobs. Similarly Helmond also had a practical problem: a busy highway with a lot of heavy traffic, noise and other pollution divided the city in two parts, and the amount of traffic was growing higher than the capacity of the road was. Hence, Helmond decided to contribute to solving this problem by investing in better traffic management systems instead of building new infrastructure. At the same time, the Dutch applied research organization TNO was planning to build new indoor facilities and to focus its automotive research in the Helmond area.

Cooperation between local authorities, research organizations and forerunning industrial companies started at first in projects funded by the European Commission. During these EU projects, different kinds of road monitoring equipment were installed on a highway between Helmond and Eindhoven, and a non-profit organization named DITCM (Dutch Integrated Test site for Cooperative Mobility) was established in 2012 to manage and provide the use of this equipment and other test facilities. Since the establishment of DITCM any kind of organization – official partners and external ones - has been able to use this equipment and test environment for a fee. In practice, the test equipment and facilities are provided and managed by TASS International. DITCM partners paying an annual membership fee get a discount on the use of testing facilities while the price is higher for external users.

Based on the active approach of local actors, the Helmond area has become a vivid ecosystem for testing and piloting new technologies related to cooperative and autonomous driving. The focus areas in Helmond are now improvements in traffic safety and traffic management. Below Figure 1 illustrates the structure of the Dutch ecosystem for cooperative mobility.

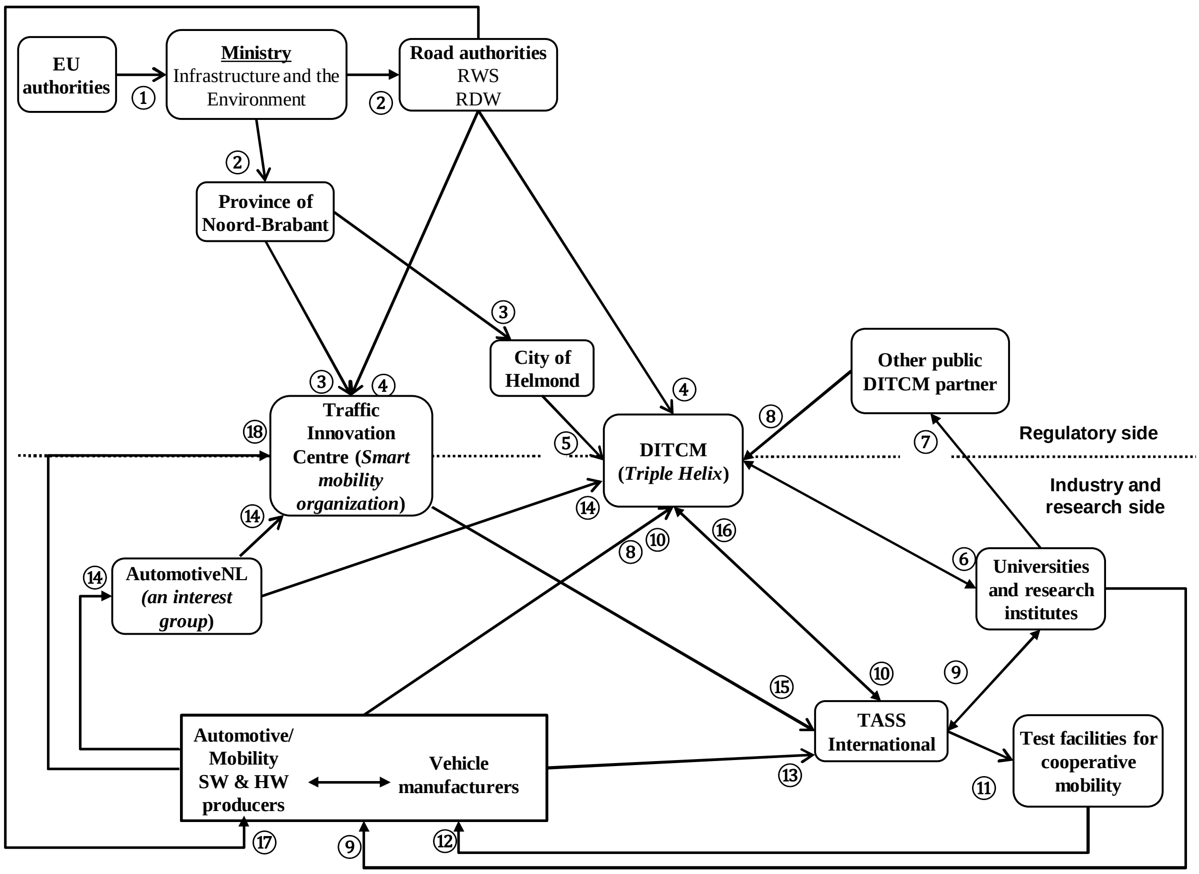

Figure 1 – Structure of the Dutch ecosystem

Table 1 lists the activities of the different actors in the Dutch ecosystem of cooperative mobility. The numbers correspond with the position of the offering in the ecosystem figure above.

Table 1 – Stakeholder activities and roles in the Dutch ecosystem

1. Regulation and guidance	10. Need for testing and piloting + annual fee (DITCM partners)
2.National agenda, top-sector programs, guidance, regulation	11.Actual testing and simulation services
3.Regional development and focus areas (e.g. Brainport development plan)	12.Standardized test and simulation services (by DITCM via TASS International)
4.Regulation, objectives, implementation plan, databases, standards, protocols etc.	13.Needs for testing and piloting (non-DITCM partners)
5.Local implementation and development tasks; support; infrastructure as a living lab	14.Interests of the Dutch automotive industry and top-sectors
6. Fundamental and applied R&D projects	15.Connection to RWS real-time traffic databases
7. R&D projects, reports, studies	16. Access to the test dataset
8. Pre-commercial R&D projects	17. Type approvals
9. Basic and applied research projects	18.Testing and developing smart mobility solutions

One success factor of the Helmond ecosystem is the successful implementation of the so-called Triple Helix approach that includes three different complementing parties: public authorities (both national and local), research organizations (TNO and three universities) and industrial companies from different sectors. These organizations have created Helmond into an innovative environment for testing and piloting new technologies related to cooperative and autonomous driving. At first, the initiators were the city of Helmond and TNO who were willing to invest in Helmond area. Now the city of Helmond is concentrating on being an ambassador for promoting the ecosystem and TNO is offering research support services for companies and is aiming to research new technologies and test them in Helmond.

Swedish ecosystem

Test Site Sweden and Drive Sweden are programs dedicated to developing test and demonstration environments in Sweden to support sustainable transport systems based on automation, digitalization and servicitization. They are meant to be neutral meeting places for joint research projects in ITS and cooperative mobility.

Test Site Sweden was established in 2006 as a program in Lindholmen Science Park on behalf of Sweden's Innovation Agency (VINNOVA). There has been and are in progress numerous large-scale projects under this program. These projects mainly get their funding from VINNOVA or other public sources. In addition, the partners have also financed the projects.

Test Site Sweden is led by a strategic steering group of development managers from Volvo Cars, Volvo, Saab Automobile, Scania and the Swedish Transport Administration. In addition, the universities (Chalmers, KTH Royal Institute of Technology and Luleå University of Technology) are represented in the operational steering group.

Test Site Sweden has two different business lines: transport and clean technology. The purpose of the transport business line is to enable new test and demonstration environments for vehicles and to support and enable the development of a sustainable transport system. This line has four focus areas: sustainability, winter testing, transport efficiency, and safety. The purpose of the clean technology business line is to work as "test beds for environmental engineering", and to help applicants and manage network activities. (11)

Drive Sweden was launched in 2015 by the Swedish government and it is hosted by the Lindholmen Science Park. Like in Test Site Sweden, VINNOVA plays an essential role as a financier, but there are also some other financiers as well: the Swedish Energy Agency and the Swedish Research Council Formas. Drive Sweden consists of multiple major partners from the industry, academia and the public side such as Scania, Volvo, Nobina, Ericsson, the cities of Gothenburg and Stockholm, Chalmers University of Technology, and SP Technical Research Institute of Sweden. When it comes to the program itself, it is planned to last for 12 years. Half of the program funding comes from VINNOVA and the second half from the partners.

Instead of focusing on concrete test sites like Test Site Sweden, Drive Sweden has a bit wider approach and vision. The program drives the evolution towards a transportation system based on automation, digitization and servicitization in order to create a sustainable society and to strengthen the Swedish industry. The objectives of Drive Sweden are: 1) creating a holistic perspective on vehicle automation through close triple helix collaboration, 2) striving for world-class projects and competence, 3) a clear coordination of national activities and a comprehensive overview of all relevant projects, including international activities, and 4) cooperation with all stakeholders to prepare for the next generation mobility (including financing, legal framework, integrity, safety and technology) (12). Figure 2 illustrates the general structure of the Swedish ecosystem for cooperative mobility.

As seen, these introduced Swedish programs are not mutually exclusive but on the contrary, they support each other. When the Test Site Sweden focus more on the test premises and facilities, Drive Sweden aims to change the processes, approach and the way of thinking to create better premises for the future mobility.

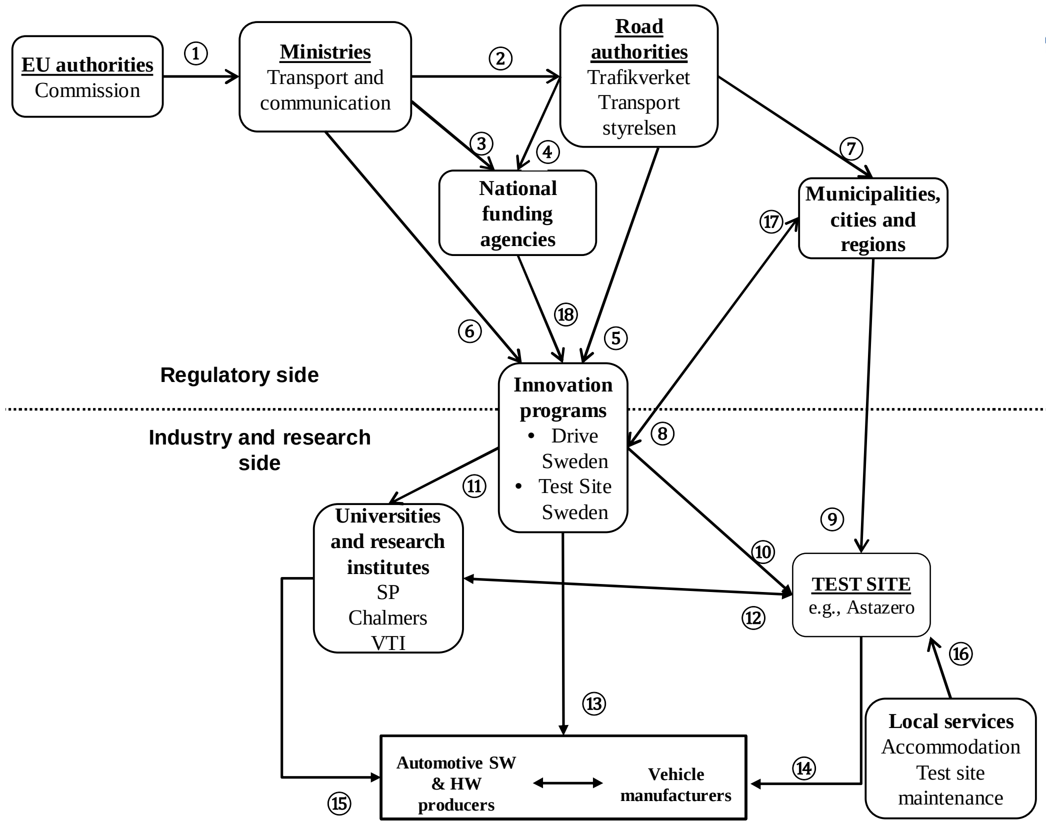

Figure 2 - Structure of the Swedish ecosystem

Table 2 lists the activities of the different actors in the Swedish ecosystem of cooperative mobility. The numbers correspond with the position of the offering in the ecosystem figure above.

Table 2 – Stakeholder activities and roles in the Swedish ecosystem

1. Regulations and guidance	10. Coordination, support, contacting, networking
2. Government program, spearhead programs	11. Networking, test beds, project management, pilots
3. Development and focus areas	12. R&D support and services and facilities
4. Development and focus areas of mobility and road traffic	13. Networking, test beds, project management, pilots
5. Requirements of transport systems	14. Test services, facilities
6. National activities and focus areas	15. R&D & Test co-operation, facilities, research support
7. Regional implementation and development tasks	16. 3rd party services
8. Regional steering, requirements and focus areas, infrastructure as a living lab	17. Testing in a real-life context (living labs)
9. Regulations, guidance and land-use planning; infrastructure	18. Strategic R&D funding

Test Site Sweden has a mandate to create a unique demonstration and test environment for products and services within ITS. It has close collaboration with the automotive industry, educational institutes, research organisations and public sector. Funding has mainly come from the public sector as many of the projects in Test Site Sweden are aimed to increase traffic safety which refers to the Swedish Parliament’s vision for road safety with zero dead and seriously injured in traffic. International and national collaborations have successfully been used to exploit joint marketing and to promote the brand of Test Site Sweden.

Conclusions and results analysis

Cooperative and automated vehicles have the potential to be a real game changer on the roads and deliver major benefits for road safety, social inclusion, emissions and traffic jams. Many countries have outlined cooperative mobility as one of the most important aspects of digitalization, and hence a lot of effort is put on research and technology to involve the best innovators and engineers and to provide opportunities for the automotive industry through comprehensive testing facilities and environments. For testing the functionality of new technologies and for validating the performance in a realistic context, the availability of suitable test environments is crucial. However, many successful test sites do not currently exist. In this study, we looked at two successful test sites (or ecosystems, as we call them), to find out the cornerstones needed to make test sites both suitable and long-lasting.

Although the benchmarked ecosystems for cooperative mobility and automated driving are quite different, the results of interviews and desk work revealed many similarities when it comes to preconditions for establishing and maintaining those ecosystems (see Figure 3). Firstly, in both cases, everything seems to rest on national agendas that highlight the digitalization of transport as one of the most important future focus area. Because it is extremely difficult or even impossible to know beforehand where the development is going to lead, setting up a fixed roadmap – such as making required political decisions or required future investments – for cooperative mobility cannot be done either. Therefore, public support and enabling in conjunction with the national agenda and strategy can be considered as the second main pillar on which the other preconditions are relying. Generally, public support and enabling means, of course, monetary support – mainly via national and international funding instruments – but the main thing is enabling pilots and creating a culture of experiments and collaboration. Pilots make it possible to get some information about the impacts of new technology and refine the vision based on this increased knowledge (i.e., verification and validation). Simultaneously, the public funding also attracts private investments in test environments and facilities and hence enables the emergence of business activities around the subject.

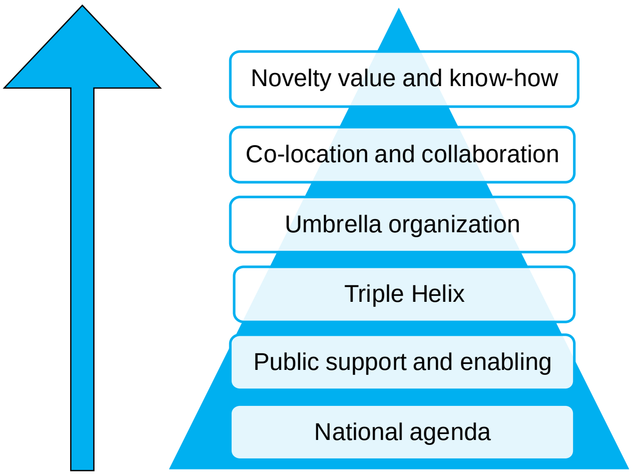

Figure 3 – Preconditions for setting up the test site

Cooperative mobility and automated driving are broad and complex issues that cannot be solved separately. Because of that, widespread collaboration throughout the supply chain is needed. In the context of emerging and cross-cutting themes (e.g. cooperative mobility and automated driving), the triple helix approach is crucial to ensure the inclusion of views, perspectives, know-how, potential possibilities and requirements of different stakeholders. In both of the observed cases, one of the most interesting findings was the coordination and facilitation of the triple helix collaboration, which was taken care of by umbrella organizations (DITCM in the Netherlands, and Test Site Sweden and Drive Sweden programs in Sweden). Especially neutrality without own business interest was seen as essential to ensure impartiality. Naturally, the partners can better focus on their core competencies when they do not have to think about things like coordination, marketing and commercialization of the test site.

It should be noted that some of the test facilities are not commercially accessible to all until the "internal" R&D projects carried out by the official test site partners (e.g., DITCM partners) are finished. After these projects, open and commercial facilities are vital for these ecosystems at least for the following reasons: 1) private and commercial income becomes more important in the future when the share of public funding is decreasing, 2) part of the invested money can be recovered when the facilities are used by 3rd parties, 3) commercial income enables additional investments in the test facilities, and 4) openness and accessibility ensure the permanence of the test site which ultimately attracts new participants to join in the ecosystem.

The inherent competitive advantage together with know-how is the last but not the least of the cornerstones. It rests on the fact that there is no point to develop everything at every test site: the greatest benefits come through specialization that takes niches, novelty, local assets and know-how into account. One way to ensure this is to develop solutions that solve real-life problems and help the society. For example, due to traffic congestion and high traffic volumes, traffic management is a natural focus area for the Dutch ecosystem. The Swedish ecosystem, on the other hand, is concentrating on safety issues since safety has always been what Swedish automotive industry has been known for.

As shown by the examined ecosystems, technology and equipment is not the most important success factor. Rather, success is more about collaboration, exploitation of ecosystem competencies, potential competitive advantages and mutual objectives (i.e. a national agenda). Technology is just a tool that enables the development and deployment. In the future, the emergence of new ecosystems in different countries will be worth studying.

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