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Place-Based Innovation Ecosystems

*Volvo companies in
Gothenburg (Sweden)*

Gabriel Rissola (editor), Jens
Sörvik, Anna Zingmark and
Matilda Ardenfors

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Foreword

This research publication is part of a series on *Place-based innovation ecosystems* that was born in 2017 from a fruitful collaboration between the Committee of the Regions (CoR) and the Joint Research Centre of the European Commission (JRC) on promoting the importance of evidence-based policy development for regional and urban policymakers.

In particular, this case study focuses on the crucial role played by Volvo companies in the development of a vibrant innovation ecosystem rooted in the Gothenburg urban area (Sweden).

Gabriel Rissola (editor of JRC's *Place-based innovation ecosystems* series)

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Abstract

There is a revival in the automotive sector in West Sweden, whereby several new companies set around the vehicle industry are attracting fresh capital and expertise into the region. An increasingly dynamic entrepreneurial ecosystem is generating new innovation intermediaries who provide added-value functions. The emergence of these innovation intermediaries is being driven by political, market-related, socio-cultural, relational and technological factors. These include societal challenges and trends that drive political interest, such as environmental issues and climate change. There is also a political interest in adapting to globalisation, to secure regional competitiveness and resilience. New technology developments include the electrification of vehicles, automation and connected vehicles. This is driving an interest from industry and academia in attracting talent and securing competences. There is also a tradition and experience of collaboration in the region. Volvo Group (AB Volvo) and Volvo Cars are very interested in continuing to nurture the regional ecosystem, by attracting other companies to the region. Civil society is eventually involved in the innovation ecosystem as user of technology, where user behaviour is analysed as an input to development processes. A common view among respondents is that it should be the needs of the stakeholders to drive the setting-up of innovation support actors or collaborative projects. These initiatives should support not only single companies but also many actors in the system, and be conducive to collaborative activities.

Executive summary

In this case study the focus is on Gothenburg and the role of industry; in particular how AB Volvo and Volvo Cars influence the structure of the system and how these companies use the innovation ecosystem for their innovation work. The report also explores institutional and technological factors, and links to the regional smart specialisation strategy, that shape the innovation ecosystem. The report has a focus both on these companies and on interaction with the other actors. There is an emphasis on local and regional relationships, although relationships at national and global level are also portrayed. It also outlines a number of important innovation actors in the system: research institutes, testbeds, regional and municipal actors, research funding and other types of innovation intermediaries that support individual actors and foster collaborative efforts.

This report seeks to inform on the experiences from Gothenburg and to share experience with other regions, with the aim of supporting the development of their innovation ecosystem.

Key conclusions

The key success factors for the development of the innovation ecosystem in the Gothenburg urban area can be summarised as follows:

- 1) a long-standing highly-skilled human capital and research infrastructure,
- 2) a 'collaborative and solution-oriented culture' between stakeholders in Gothenburg and West Sweden,
- 3) dense formal and informal relationships between stakeholders and a high degree of working exchanges ('revolving doors') between actors,
- 4) existence of a strong enabling operating actor, the Lindholmen Science Park, providing good knowledge of the ecosystem and promoting trustful and fruitful relationships with all key actors,
- 5) a firm interest from the two key industry actors, AB Volvo and Volvo Cars, in developing the local innovation ecosystem by investing in and developing new technology collaboratively with other actors, and an interest in acquiring new knowledge and input from external actors,
- 6) committed regional and municipal governments, acting as mediators and facilitators and helping to enable opportunities when they arise,
- 7) government actors working with a long-term perspective to help the industry prepare for technology shifts, to ensure relevant competences and capabilities in the region,
- 8) funding for national and regional research and innovation (R&I) programmes, activities and facilities tailored to stakeholders' needs,
- 9) public interventions not targeting single companies but aiming to build up the ecosystem,
- 10) the flexible, stakeholder-defined and easy-to-access Strategic Vehicle Research and Innovation programme (FFI), which has made it attractive to locate R&I in the region,
- 11) an ability to attract strong international investors and partners, such as the Chinese company Geely, that continue to invest and locate additional functionalities in the ecosystem.

Main findings

There is a boom in the automotive sector in West Sweden, where several new companies have been started around the vehicle industry, and new capital and companies are locating to the region. The innovation ecosystem is also developing and adding new functions and intermediaries. Several factors are driving the emergence of innovation intermediaries: political, market-related, socio-cultural, relational and technological. These include societal challenges and trends that drive political interest, such as environmental issues and climate change. There is also a political interest in adapting to globalisation, to secure regional competitiveness and resilience. New technologies driving this development include the electrification of vehicles, automation and connected vehicles, which are raising interest from industry and academia in attracting talent and securing competences. There is also a tradition and experience of collaboration in the region. Rather than a single actor controlling the innovation ecosystem around the automotive industry in the Gothenburg area, there are a number of actors and agencies playing different roles.

The two Volvo companies (AB Volvo and Volvo Cars) are crucial actors because they invest in the development of new technology and build up skills that, through direct collaboration (with university actors such as Chalmers University of Technology, research institutes such as Research Institutes of Sweden - RISE, and suppliers) and other forms of spill-over, also benefit other actors in the system. The companies are training grounds for staff who spin out to new companies. There is also knowledge diffusion through informal networks between Volvo staff and actors in other companies, universities and innovation institutions. They are also very important customers for suppliers and important training grounds for them, as, if they can manage to supply the two Volvo companies, they can supply the rest of the industry.

AB Volvo is interested in acquiring new ideas, for both products and services, but also new working methods. The two Volvo companies have long-term collaborative relationships with the universities, in particular with Chalmers. These are in the form of both high-level agreements on the long-term design of education, and research projects. Volvo staff is also involved in projects and centres, and in seminars. It is mutually beneficial that the two Volvo companies get new and relevant ideas into their development processes, and the university can gain better understanding of industry needs and ensure that research questions are relevant. There is also a strong drive for the companies to secure talent recruitment and to ensure that future staff is trained and gains the right types of skills; and for the students, to get access to and connections with potential future employers.

AB Volvo foresees increased need for partnerships and collaboration with new actors such as start-ups, SMEs or industrial companies outside the automotive sector. They want to access the entrepreneurial spirit of small companies and enrich the innovation system. In this context, AB Volvo is interested in continuing to nurture the regional ecosystem, by attracting other companies to the region (both by requesting suppliers to locate to the region, and through the MobilityXlab, which is a way of attracting talent to the region), and through various forms of R&I initiatives that further strengthen the dynamics of the region.

The innovation ecosystem is a system with multi-level governance, where the two Volvo companies interact with the city and the region to develop the regional innovation ecosystem locally and to attract other types of funding and talent. They also work at national level for funding, and at EU and UN level for standards and for EU R&I programmes. For more long-term and complex issues, it is beneficial to raise issues such as standards and systems-oriented issues on a global scale.

Region Västra Götaland (VGR) finances thematic programmes linked to priority areas. The programmes are not detailed roadmaps, but broad guides to what funding will be provided. Beyond this, the region tries to be flexible and attentive to industry needs. Central to their efforts is Lindholmen Science Park, for which VGR has adopted informal responsibility for initiating and driving new collaborative projects. The science park is both project developer and a meeting place for reconciling interests between different stakeholders. For VGR, it is crucial to maintain constant dialogue with stakeholders in the industry, and they meet in many formal and informal settings. This type of mediating and facilitating role is perceived by VGR as their key role. VGR does not have any formal board or steering group for the transport programme but relies more on these interactions. The regional development strategy is adopted by the Regional Development Committee (Regionala Utvecklingsnämnden) and is politically anchored with the regional council. When it comes to the inclusion of civil society in this innovation ecosystem, this is more from the perspective of users of technology, where user behaviour is analysed as an input to development processes. A common view among respondents is that it should be the needs of the stakeholders that define the objectives for collaborative projects, new intermediaries and new innovation support activities. Innovation support should not target single companies, but build up several actors and the system, and also be conducive to collaborative activities.

Quick guide

This report starts by identifying a conceptual framework for implementing the study of concrete place-based innovation ecosystems. It continues with a presentation of the main local actors, presents 12 of these actors in depth, then goes on to carry out a cross-sectional analysis of contextual, regulatory and institutional enabling factors; governance model; quadruple helix model; consensus and commitment; strategic choices and vision for orchestration of the ecosystem; and actual and potential links with smart specialisation. The final chapter concludes the report.

1 INTRODUCTION

This publication is part of a series of case studies exploring place-based innovation ecosystem in various locations in Europe and beyond. The series maps out various innovation ecosystems in Europe, each time focusing on how a different helix of the quadruple helix model empowers the ecosystem, and on how the local ecosystem supports innovation and stimulates collaborative innovation.

The quadruple helix model is a development of the triple helix model. While the latter emphasises the role of interactions between universities, industries and governments, including new intermediary institutions such as technology transfer offices and science parks for innovation (Etzkowitz and Leydesdorff, 1995; Etzkowitz, 2008), the quadruple helix model adds a fourth component and emphasises the role of civil society and non-governmental organisations. Some also put the emphasis on user involvement, arguing that otherwise emerging technologies may not meet the demands and needs of society, and risk not being picked up (Carayannis and Campbell, 2009).

This case study is focused on Gothenburg and the role of industry in nurturing and leading an innovation ecosystem. In particular, it explores how AB Volvo and Volvo Cars influence the structure of the ecosystem and how these companies benefit from the innovation ecosystem for their innovation work. The report also explores institutional and technological factors and links to the regional smart specialisation strategy that shapes the innovation ecosystem. The report has a focus both on these companies and on interaction with the other helices. There is an emphasis on local and regional relationships, although relationships at national and global level are also portrayed. It also outlines a number of important innovation actors in the system, from research institutes, testbeds, regional and municipal actors, to research funding and other types of innovation intermediaries that support individual actors and also foster collaborative efforts.

This study aims to generate information and complementary insights on the role of industry as ‘orchestrator’ of a place-based innovation ecosystem. The other case studies in this series explore this role as played by an entrepreneurial university in Espoo, Finland; a technology park in Ljubljana, Slovenia; digital social innovation centres in Barcelona in Spain; and the municipality (in setting up innovation districts) in Boston, United States.

West Sweden and Gothenburg

The target area of this study is Gothenburg, Sweden’s second largest municipality (city: 570,000 inhabitants; metropolitan area: 1 million inhabitants) and, more broadly, the county of Västra Götaland (1.7 million inhabitants in 2017).

The region has a diversified business environment, two important sectors of which are automotive manufacturing and trade. The manufacturing industry has a significant presence in West Sweden ⁽¹⁾ compared to the country’s other metropolitan areas, and Västra Götaland is a centre of industry, trade and logistics that plays a central role for its economy (Business Region Göteborg, Region Halland and Västra Götalandsregionen, 2017).

Sweden is one of the countries with the highest proportion of research and development (R&D) expenditure as a share of GDP, and the majority of investments in R&D are made by industry. Average annual business expenditure on R&D in Västra Götaland over the period 2003–2013 was 4.1 %, which is well above the national average of 3.3 % and the EU-28 average of 1.9 %. There are several large multinational firms headquartered in the region, such as Volvo and AstraZeneca, but due to an increased share of foreign ownership, the region is relatively vulnerable to external decisions (OECD, 2018).

A number of national R&D innovation systems/cluster programmes are implemented in the region. According to the Regional Innovation Scoreboard (European Commission and Maastricht Economic and Social Research Institute on Innovation and Technology, 2017), West Sweden is ranked as a regional innovation leader and therefore has an innovation performance above the EU average.

¹ West Sweden is a statistical region at NUTS 2 level according to EU statistics. In Sweden there is no administrative body at NUTS 2 level, only at NUTS 3 level. However, some data is produced at NUTS 2 level. The main focus for this report is on the county of Västra Götaland (1.7 million inhabitants), but West Sweden also includes the county of Halland (300,000 inhabitants).

The innovation support structure consists of a variety of organisations and measures to support the development of innovations and business ideas, from the conceptual stage through to market launch. Many of the organisations work closely with higher education. In order to stimulate innovation, a number of science parks have been established through cooperation between public and private stakeholders. Science parks in Västra Götaland are dynamic hubs for innovation within thematic focus areas linked to the regional growth strategy VG2020 (Västra Götalandsregionen, 2013). They provide collaborative environments for joint research and innovation, entrepreneurship and support for start-ups and SMEs. The regional smart specialisation strategy was developed as part of the VG2020 process; during this process a number of priority areas were identified, one of these being sustainable transport (Västra Götalandsregionen, 2014).

Developments in the vehicle industry

In 2016, the automotive industry was Sweden's largest export industry, with a share of approximately 14 % of Swedish goods exports. Its share of Swedish industry investments was 21 %. The total industry working with vehicles and vessels in Sweden, which is somewhat larger than the automotive industry, made 21 % of all Swedish investments in R&D (data for 2015 from Swedish Statistics Office - SCB). Gothenburg's automotive industry has around 25,000 direct employees.

The region is home to original equipment manufacturers (OEMs) Volvo Cars, the Volvo Group and China Euro Vehicle Technology (CEVT), as well as major and specialist subcontractors and suppliers including SKF, Autoliv, Zenuity, Semcon, Ericsson, HCL and Brose. The region's large companies represent more than 60 % of Sweden's total investments in automotive R&D.

The automotive industry in Sweden is mainly built on three major vehicle manufacturers, with a supplier network largely based on orders and collaborations with these vehicle manufacturers. The heart of the Swedish automotive industry is in the Gothenburg region, where the entire vehicle production chain, test environments and high-level expertise are located.

An important key to the region's success in the automotive industry is the collaboration between enterprise, academia and the public sector. Lindholmen Science Park in Gothenburg channels such collaboration and acts as a platform for cross-disciplinary and cross-industry projects.

In Gothenburg there are also several platforms and arenas for development and testing. An asset for R&D is AstaZero, located just outside of Gothenburg. The facility is a full-scale test environment, where manufacturers, suppliers and academia can test and certify their products in different traffic environments and scenarios. A similar facility for electromobility is under development (pending EU approval). It will focus on research and testing for batteries, electric motors, power electronics and drivelines, as well as complete vehicles. The facility will serve as an arena for experimental collaborative work involving research institutes, universities, start-ups, SMEs and industry (large corporations).

Gothenburg's automotive industry is booming. Major companies are investing large sums in R&D and facilities, and strategic partnerships are being formed. The Chinese corporation Geely, for example, is developing a new 70,000 m² innovation centre. The Volvo Group is collaborating with private and public actors and testing entirely electric and emission-free buses in the city's public transport system. Meanwhile, Volvo Cars is moving forward with self-driving technology and is already testing prototype vehicles in real traffic on roads in Gothenburg.

2 CONCEPTUAL FRAMEWORK

The publication series to which this case study belongs explores the territorial dimensions of innovation by focusing on place-based innovation ecosystems. It explores contextual conditions, actors and collaborative efforts aiming to enable innovation. It explores connections to the concept of smart specialisation (European Commission, 2012; Foray, 2015), which is operationalised in Europe through regional research & innovation (R&I) strategies (RIS3). Smart specialisation builds on the economic strengths, collective intelligence and distinctive assets of a certain territory, involving — through an entrepreneurial discovery process (EDP) — a wide diversity of stakeholders to identify the strategic areas of intervention where innovation may flourish.

An analysis of a place-based innovation ecosystem needs to consider how actors in the innovation processes are empowered and interact in order for innovation to happen, how embedded local networks work and how they are facilitated, including spatial aspects such as proximity, and an analysis of the most prominent nodes in the network (Rissola et al, 2017): *'An innovation ecosystem consists of a group of local actors and dynamic processes, which together produce solutions to different challenges'* (Oksanen and Hautamäki, 2014). Innovation takes place in a precise location, which suggests that the physical proximity of innovation players is extremely important. It also means there are certain specific local conditions which, individually or in combination, make such an innovation ecosystem flourish.

Dynamic innovation ecosystems do not only support regional actors in their development; they also attract new companies, investments and talent (e.g. Cambridge, Amsterdam, Barcelona, Munich).

In this series, we have chosen to consider a range of factors influenced by the reference literature:

- core organisations:
 - leading industry actors, academia, universities and research institutes, public sector,
 - innovation support actors, such as science parks, incubators, technology transfer offices, venture capital, and various network organisations and associations;
- how these interact and link to smart specialisation;
- systemic conditions for collaboration, such as local culture and institutional framework;
- other political, market-related, socio-cultural, and technological factors.

While the overall conceptual framework for the series is defined in its first volume, each new case study refines it to allow for the peculiarities of the type of orchestrator or innovation process entrepreneur around which that case study revolves (entrepreneurial universities in Aalto, digital social innovation centres in Barcelona, etc.). The present case study explores the role of the two Volvo companies (AB Volvo and Volvo Cars) as large companies acting as core actors orchestrating the Gothenburg ecosystem. This requires a brief literature review to clarify concepts before proceeding with the case characterisation and analysis.

Invention is the first occurrence of an idea for a new product or process, while **innovation** happens when the invention is being put in place and starting to be used. Where an invention can take place in isolation, innovation by definition takes place in interaction. Innovation is about new technology integrated into social structures, such as firms and societies, meaning change. This challenges incumbent actors who are relying on established practices, tears down old structures and creates new ones; a process that the initiator of innovation studies, Joseph Schumpeter (1934), called 'creative destruction'. Historically, innovation has been seen as a linear process, where basic science generates new knowledge that is further refined by applied science and engineering, and then commercialised by an entrepreneur or a firm. However, the present perception is that innovation happens in a systemic fashion, where science is not the main driver of innovation, but just one component.

Ideas about dynamic places for innovation and economic growth were popularised and spread widely in policy circles in the 1990s, in particular through the concept of clusters (Porter, 1990), and in the innovation system literature, which emphasises that innovations occur in interaction between firms, and between firms and knowledge-exploring organisations such as universities and research institutes (Lundvall, 1992).

This builds upon a long tradition of economic theories addressing the role of externalities due to the co-location of economic actors active in a related economic field. What these theories have in common is that they describe local agglomerations as having a positive effect on company efficiency, innovation and

competitiveness, through creating externalities that reduce transaction costs and create opportunities for innovation (Malmberg and Power, 2006).

In general, it has been suggested that agglomerations create opportunities for innovation in five different ways (Sörvik, 2010).

1. Competition is tougher and more transparent, which drives firms to innovate more and in more productive ways.
2. There is knowledge spill-over, i.e. there are secrets of the trade that diffuse in the air, through labour rotation and informal contacts, which makes it easier to start new firms and to develop existing operations.
3. Specialisation occurs among labour and suppliers.
4. Co-locations provide opportunities for user-producer learning, which is an important input for companies' innovation activities.
5. Joint action: these are locations where it is easier for firms to collaborate in order to upgrade capabilities, goods and services and to undertake collaborative efforts, and appropriate locations for deliberative innovation policies.

Innovation is a process of association and combination, where it is very important to have knowledge of partners and of those holding different knowledge fragments that can be combined into new innovation (Arthur, 2010). Knowledge is also often tacit (Polanyi, 1962), which makes it hard to transfer as not all labour is mobile. Furthermore, there is not equal access to purveyors of knowledge; it can be easier to find relevant partners with whom to initiate collaboration processes within agglomerations (Nooteboom, 2006). Being located in a dense innovation system, where it is easier to find potential partners with knowledge and to set up collaborative endeavours, is therefore a competitive advantage. Due to the dense local market and the development of specialised suppliers, there are often complementary assets established which are necessary for taking knowledge to the market: knowledgeable investors; manufacturing, distribution and marketing channels; after-sales and technical services; complementary technologies; marketing and professional services, etc. (Teece, 1986). Others emphasise that local and external relationships seem to be complementary (Bathelt et al., 2004). More specifically, there is research suggesting that the importance of clusters depends on technology life cycles: clusters seem to matter more in early phases, where tacit knowledge is more important, but in more mature phases, knowledge and innovation are more dispersed (Audretsch and Feldman, 1996).

Operational approach

As previously mentioned, this mapping exercise is part of a wider effort to explore innovation ecosystems in various locations in Europe (Espoo in Finland; Ljubljana in Slovenia; Barcelona in Spain; Gothenburg in Sweden; Boston and Cambridge in the United States). In each of these locations, these studies discover how the regional system supports innovation and stimulates collaborative innovation among actors in the quadruple helix.

In each case there is a different focus: in Espoo, the study explored the role of entrepreneurial universities (Aalto) in driving innovation; in Barcelona, the role of open labs in increasing the involvement of citizens and users in community-led innovation; in Ljubljana, the role of the technological park in boosting the start-up ecosystem; in Boston and Cambridge, the role of their municipalities in setting up innovation districts. In Gothenburg, the interest is in understanding the role of industry and, in particular, how the two Volvo companies influence the structure of the system and make use of it for their own innovation work.

Therefore, this mapping focuses on the vehicle industry cluster around Gothenburg. All actors mapped are related to AB Volvo or Volvo Cars. There are local, regional, national and EU actors and connections, but they all relate to and are active in the Gothenburg urban area – and relate to Volvo in one way or another.

Consistent with the previous case studies, this report has been developed in three phases.

- (a) Initial scoping was carried out (based on desktop research and scoping interviews, generating a broad list of actors, a limited number of which were chosen for more in-depth interviews).
- (b) These interviews and some additional data were then summarised in a more detailed description of main actors and platforms.

- (c) A cross-sectional analysis of the material gathered in the first steps was performed, focusing on the enabling conditions, governance of the system, quadruple helix, links to smart specialisation and future steps.

3 ACTORS IN THE INNOVATION ECOSYSTEM

Findings from the first step in the process suggested that the Swedish automotive industry is concentrated in the Gothenburg region. Volvo Cars is the largest employer in the entire region, followed by Volvo Trucks. Gothenburg's automotive industry is one of the world's most knowledge-intensive, and the region is a strong centre for research and innovation (R&I) activities. Gothenburg has a rich innovation ecosystem, with various platforms and arenas for development and testing. The first step in the development of this report was to identify and characterise 36 actors who seemed to be the most relevant ones. These actors were identified through desktop research and initial scoping interviews with representatives from Region Västra Götaland and Volvo

The following is a list of major actors in the Gothenburg innovation ecosystem who are connected to Volvo. The list also includes a few actors who are located outside the region, but whose impact within the ecosystem was pointed out during the initial scoping interviews – notably R&I funding agencies and industry associations located in Stockholm. These actors are also displayed in two maps below, indicating their location.

The list of main actors below the maps follows the same typology. Actors and platforms that were considered to be central to the ecosystem were interviewed individually and are presented here in more details (indicated in bold letters below).

- Major automotive companies:
 - **Volvo Group (AB Volvo)**
 - **Volvo Cars**
 - CEVT
 - Geely Innovation Centre
 - NEVS (Trollhättan, northern Västra Götaland)
 - Autoliv (50 km east of Gothenburg)
 - Zenuity
- Universities and research institutes:
 - **Chalmers**
 - Gothenburg University
 - RISE
- Vocational training:
 - YH
 - Smarta fabriker project, Gothenburg Technical College
- Research Labs:
 - **SAFER (research centre for vehicle and traffic safety)**
 - CLOSER (Swedish arena for transport efficiency)
 - Swedish Electromobility Centre
 - Software Center
 - ChaseOn and GHz Centre
- Science Parks:
 - **Lindholmen Science Park (focuses on vehicles and ICT)**
- Incubation and accelerators:
 - **MobilityXlab**
 - Chalmers Ventures
 - Gothenburg University Ventures
- Test infrastructure:
 - **AstaZero** (full-scale test environment for future road safety, 50 km north east of Gothenburg)

- Awitar (Automotive Wireless Test and Research Facility, 50 km east of Gothenburg)
- ReVeRe (Research Vehicle Resource Lab)
- Reality Labs:
 - DriveMe
 - **ElectriCity**
- Networks/clusters/industry associations:
 - **Vehicle ICT Arena**
 - Drive Sweden
 - Test Site Sweden
 - Forum for transport innovation
 - BIL Sweden (trade organisation for the automotive industry, Stockholm)
 - Teknikföretagen (industry association, Stockholm)
- Regional and local government:
 - **Region Västra Götaland (VGR)**
 - Regional development (strategic support for vehicle industry and project funding)
 - Västtrafik (public transport)
 - **City of Gothenburg**
 - Business Region Göteborg
 - Traffic Office (participates in public transport projects)
- Research Funding:
 - **Vinnova (Sweden's innovation agency) – FFI (Stockholm)**
 - WASP (Wallenberg programme, funding vehicle research, Gothenburg and Linköping)
 - EU Horizon 2020 – Vinnova as national contact point (Stockholm)
 - EU ERDF – Swedish Agency for Economic and Regional Growth (Tillväxtverket) as regional managing authority (Stockholm and Gothenburg)

Figure 1. Map of key regional actors located in Gothenburg or nearby.

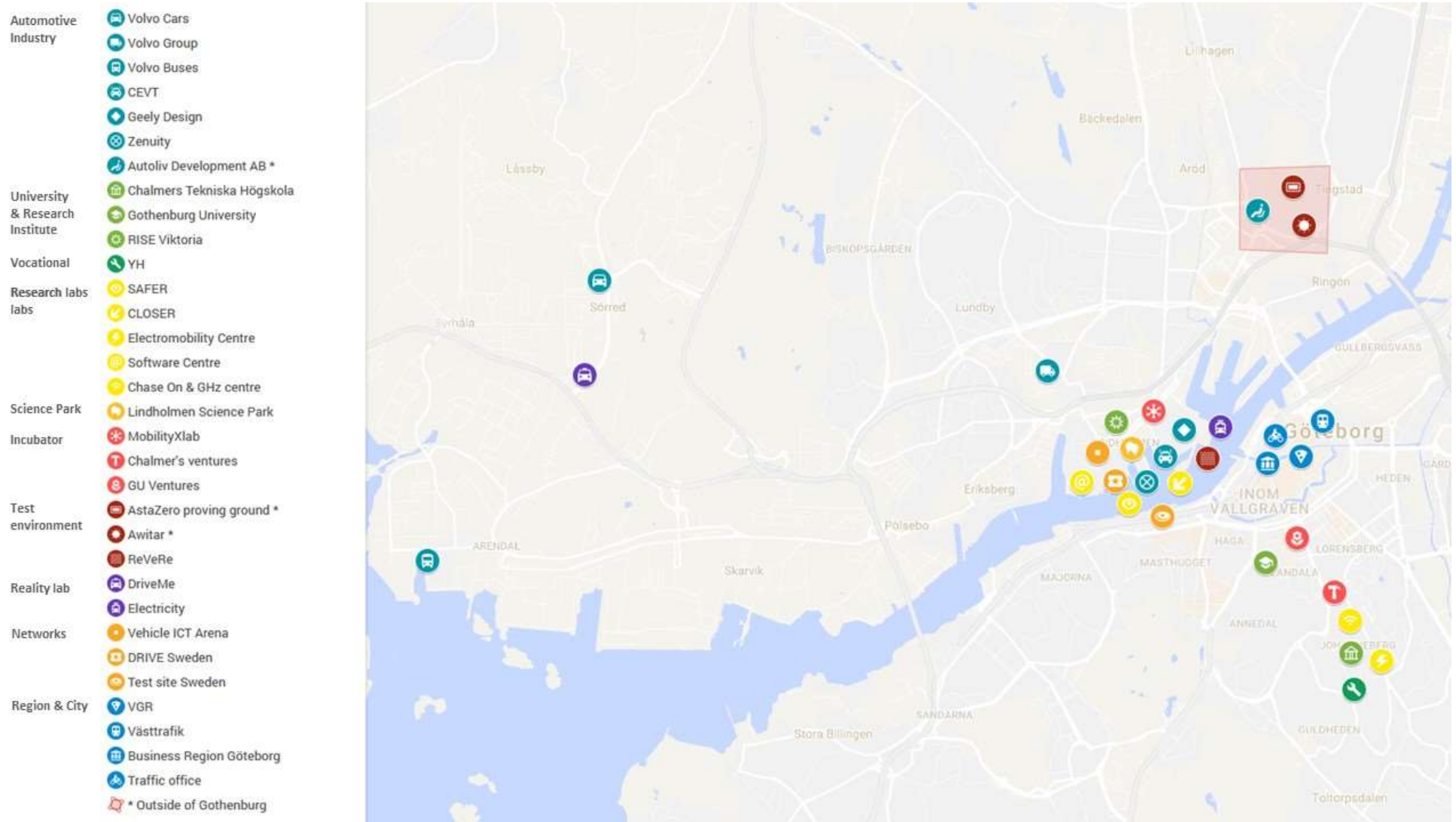
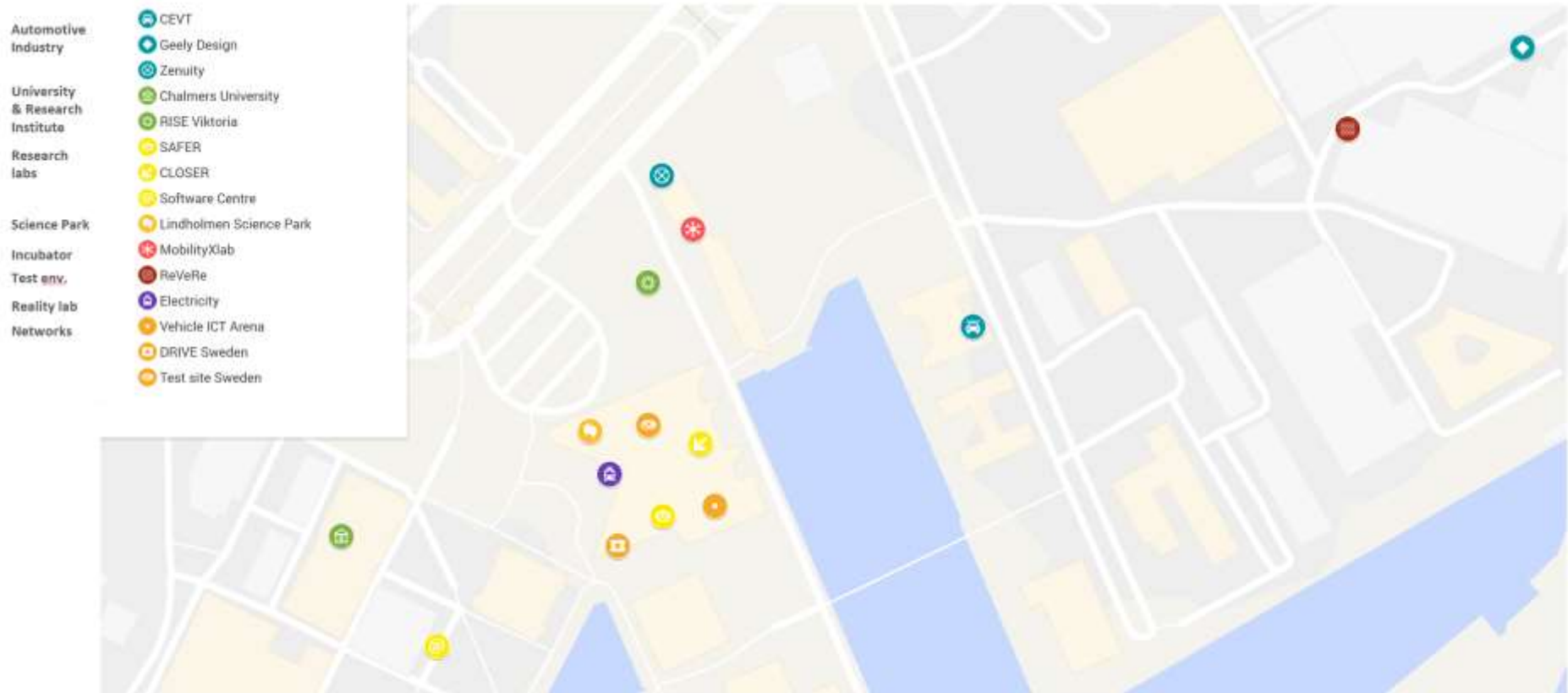


Figure 2. Map of key regional actors located around Lindholmen Science Park



After mapping Gothenburg's innovation ecosystem developed around the two Volvo companies, the actors and platforms in each category that were considered most relevant to the ecosystem were interviewed individually and are presented in more detail below.

3.1 Volvo Group (AB Volvo)

Volvo Group is a Swedish multinational manufacturing company headquartered in Gothenburg. Its main activities are the development, production, distribution and sale of trucks, buses and construction equipment, but it also supplies marine and industrial drive systems and financial services. It is currently the world's second largest manufacturer of heavy-duty trucks. Volvo Group employs around 95,000 people (about 25 % of them in Sweden), has production facilities in 18 countries, and sells its products on more than 190 markets (only 2-3 % of sales in Sweden).

Volvo was established in 1915 as a subsidiary of SKF, a ball bearing manufacturer. However, both the Volvo Group and Volvo Cars regard the rollout of the company's first car series, the Volvo ÖV 4, on 14 April 1927 as their beginning. The brand name Volvo was originally registered as a trademark in May 1911 with the intention to be used for a new series of SKF ball bearings. It means 'I roll' in Latin.

Automobile manufacturer Volvo Cars, also based in Gothenburg, was part of AB Volvo until 1999, when the car branch was sold to Ford Motor Company. Despite being legally separate companies, both AB Volvo and Volvo Cars share the same Volvo logo..

In the 1970s, Volvo and the French manufacturer Renault began to collaborate. In the 1990s, Renault and Volvo deepened their collaboration and both companies partnered in purchasing, R&D and quality control, while increasing their cross-ownership. Renault Véhicules Industriels (which included Mack Trucks, but not Renault's stake in Irisbus) was sold to Volvo in January 2001, and Volvo renamed it Renault Trucks in 2002. Renault also became AB Volvo's biggest shareholder, with a 19.9 % stake (in shares and voting rights), as part of the deal. In 2010 Renault sold their shares, leaving the Swedish industrial investment group Aktiebolaget Industrivärden as the largest shareholder, with 6.2 % of the share capital and 18.7 % of the voting rights.

In 2017 Volvo Cars' owner, the Chinese company Geely, became the largest Volvo shareholder by number of shares, displacing Industrivärden. However, Industrivärden retained more voting rights than Geely (Geely getting 15.8 %).

Volvo Group has acquired other heavy vehicle companies, but the major share of R&D (approximately 60 %) is still carried out in Gothenburg. Other major R&D sites are the main R&D locations of the companies acquired. The main R&D sites are located in Sweden, France and the United States. Rather than resulting from a strategic analysis of optimal locations for R&D around the world, this is where the company has historically run its operations.

Volvo Group perceives West Sweden as a beneficial location for R&D development, and over the past 10 years there has been a growing trend to locate to the area. They are positive about their location in the region and about the relationship with Region Västra Götaland. They use it as a basis for strategically important R&D activities, but also engage with Swedish national actors and R&I programmes, as well as EU activities.

Region Västra Götaland is a major strategic partner; for them, it is not mainly funding that is important, though they do see it as an important facilitator. The key is that the ideas for initiatives come from industry, and that there is then a fruitful collaboration with the Region and other innovation partners.

AB Volvo is interested in continuing to nurture the regional ecosystem, by attracting other companies to the region and through various forms of R&I initiatives that further strengthen the dynamics of the region. They want to sustain the current positive spiral of innovation activities being started in and locating to the region, which they believe will further strengthen Volvo Group.

Volvo Group is actively sustaining this concentration and exploring the possibility of opening it up and concentrating it even further. Currently, Volvo is mainly located in Lundby (a part of Gothenburg) and Lindholmen, where there are 6,000 staff. There are around a further 5,000 staff at other sites in Gothenburg that they want to relocate to the Lundby/Lindholmen area. Volvo is considering opening up their facilities, to make the sites more of a university campus than a closed industry area. Many of the activities that they foresee locating to the area relate to new technologies such as automation and connectivity. They want more actors to come in to this space to make it livelier; SMEs but also various service providers such as gyms and

restaurants. They hope this will facilitate collaboration with start-ups and SMEs, and make AB Volvo able to review and pick up new ideas more quickly. Final plans will be launched in March 2019. For this work, they are collaborating with the Region and the city in how to plan the area, and hope that the public actors can support SMEs and start-ups locating to this part of the city, with finding office space, financing and testing of ideas.

Also connected with this is the recently launched accelerator MobilityXlab. The idea is to support start-ups and SMEs that work primarily with software for automated driving, but also to structure the way these companies interact with the larger companies. The start-ups can provide new technologies, and there is also a hope that the larger companies may pick up new methods and innovative approaches developed by start-ups and SMEs. They can then help these companies through exploring the market potential of the new ideas and through mentoring by the larger companies' staff; if relationships work, they can also collaborate on new projects.

AB Volvo is positive about the many infrastructure and research centres that have been started over recent years, such as AstaZero, the test chamber for electromagnetic compatibility and for electromobility. A common factor for this is that Region Västra Götaland, together with Volvo and other industry actors, is mobilising a consortium of actors whereby the region can help in discussions with the national level to argue for locating activities to the region. Regional funds also help in initiating the process, but predominantly national funds finance the centres.

Another project highlighted by AB Volvo is the electric bus line, which is being tested in a live environment in the project ElectriCity. Volvo wants to support Gothenburg to develop into the electromobility capital of the world, and promote themselves and other local actors as the technology leaders in this domain. Volvo perceives a strong backing in this vision from both the city and the region.

However, when it comes to the important subject of establishing industry standards, the region is too small. For this, Volvo Group works through the standardisation bodies of the EU and the UN. AB Volvo has around 100 staff involved in different committees on this topic. For lobbying on national and EU-level policies, the region is of less importance.

Also in connection with this are various forms of research projects within Horizon 2020 (H2020), where they are collaborating with other leading industry actors. AB Volvo is the Swedish company that is participating in the most H2020 projects (around 20). These projects can both focus on carrying out detailed research, and create systems and shared practice. As an example, Volvo and Scania have shown by themselves that their trucks can carry out platooning (i.e. automatically connect and drive in a platoon, which is more fuel efficient); they are now collaborating with DAF and MAN on how to do this between vehicles from different companies. There is a need to establish a common language and for the vehicles to communicate wirelessly. If they succeed with this, they will create a de facto industry standard.

Volvo Group also has a venture capital company that can invest in these types of interesting companies. However, for the last few years AB Volvo has mainly been investing in US companies, often from California.

In envisioning the future, Volvo Group works with a 20-year to 30-year horizon; however, product plans are about eight years. As an example, their view of the future is one of multiple mobility solutions: there will be electric vehicles and hybrids, both for private use and trucks and buses, but for long distance it is likely liquid and gas-based fuels will remain. This forecasting is conducted within the company. They attend various conferences, are involved in technology parks and visit research institutes, where they pick up ideas to digest and synthesise internally. The Region is not involved in these types of process.

Work with regional actors focuses more on concrete matters such as establishing R&I facilities, and also ensuring that regional research institutes and academia are teaching and providing relevant competences, and carrying out relevant research projects. There are frequent contacts between AB Volvo staff and staff from academia and research institutes (mainly Chalmers), both in formal settings where AB Volvo staff are on the board of faculties and institutes, and in committees that oversee research and educational programmes. There are also many informal contacts, as Volvo staff and Chalmers staff have studied together.

AB Volvo also has an academic partner programme, which consists of universities with which it wants to have specific and close relationships. For this programme, 3 out of the 11 participants are located in West Sweden: Chalmers, Gothenburg University and the University College of Skövde.

AB Volvo are positive about collaborative initiatives with academia; problems can be solved more quickly and efficiently using new ideas and competences, and researchers can get access to the latest equipment and technology, as well as ensuring relevant research questions. In AB Volvo's view, for this type of collaboration to work it is important to define the partners' roles and rights, and how this can be licensed if necessary.

AB Volvo emphasises that the Strategic Vehicle Research and Innovation programme (FFI), managed by the Swedish innovation agency Vinnova, is of particular importance. AB Volvo argues that the programme has been an important factor for Volvo, increasing their share of research located in Sweden from 50 % to 60 %. They perceive the programme as useful for both industry and academia, and claim that many of the outputs from this programme have helped strengthen the industry and development in West Sweden.

Their view on smart specialisation is that it makes sense to build on regional strengths and continue to develop these. If there is no industry anchoring in the region, there is little possibility of success. However, they do not believe in overly detailed strategies, as there is a risk of these becoming simply PowerPoint documents. They consider it more important to establish good relationships, with the flexibility and competence to act when opportunities arise. A general overview plan, that sets a direction and intention, is a positive asset and can also be important for communicating intentions to external actors.

AB Volvo has a positive view of Region Västra Götaland (VGR). They perceive that they have common interests and the right tone in discussion between the partners, and that there is flexibility and directness in the relationship, making the process quicker and more agile. VGR can easily connect many actors capable of forming relevant groupings, as there is a lot of trust between the actors.

In this context, they are also positive about Lindholmen Science Park, which acts as a neutral broker and project manager, giving rise to many vehicle-related innovation initiatives. Their staff are skilled and knowledgeable about the industry and also well networked with the necessary actors.

In relation to other issues, AB Volvo also sees that the region and the city can take a role in helping to find housing for staff and future staff who locate to the region, and can also support talent attraction and skills development.

In brief, the Volvo Group:

- conducts collaborative research primarily under the Swedish FFI programme or Horizon 2020 (EU);
- uses the many testbeds available in West Sweden, in particular AstaZero and Awitar;
- participates in 'living labs' such as the ElectriCity project on fossil-free bus transport;
- has intensive collaboration with regional universities;
- collaborates with the Region, in order to sustain existing collaboration platforms or finance new ones;
- engages in new initiatives, such as the creation of an electromobility laboratory led by RISE (Research Institutes of Sweden) and Chalmers University, or a centre for research into artificial intelligence hosted by Lindholmen Science Park;
- foresees an increased need for partnerships and collaboration with new actors such as start-ups, SMEs or industrial companies outside of the automotive sector. A special 'innovation hub' for this purpose ('CampX') is under development and will be inaugurated during the first half of 2019.

3.2 Volvo Cars

Volvo Cars is a Swedish vehicle manufacturer headquartered in Torslanda, Gothenburg. It was part of AB Volvo until 1999, when it was sold to Ford Motor Company. Since 2010 the Geely Holding Group, a Chinese multinational automotive manufacturing company, owns it. Both AB Volvo and Volvo Cars share the Volvo logo and cooperate in running the Volvo Museum.

Volvo Cars manufactures and markets sport utility vehicles, estate cars, saloons and compact executive saloons. With approximately 2,300 local dealers in around 100 national sales companies worldwide, Volvo Cars' largest markets are China, the United States, Sweden and the other countries of the EU. Most of its worldwide employees are based in Sweden.

In 2015, Volvo sold more than half a million cars for the first time in its 89-year history. Volvo reported strong sales from all three core global regions.

In July 2017, the automaker announced that beginning in 2019, all its new models will include an electric motor in their powertrain. Implementation of the announcement could mean Volvo becoming the first manufacturer to end production of internal combustion-only vehicles, with all vehicles being hybrid or electric

powered. Volvo is also a proponent of autonomous vehicles. On 20 November 2017, Uber announced that it planned to buy up to 24,000 Volvo cars, designed to accept autonomous technology, between 2019 and 2021.

Volvo Cars has maintained and continued to build R&D capabilities in Gothenburg. The area around their R&D headquarters hosts 95 % of their entire R&D. They see it as a strength to have everything at close hand. It is easier to build competence and a mentality of urgency in the team when everyone is close.

The downside, as they see it, is that they are extremely dependent on the region's development for securing competence, through both attracting talent and developing skills. This is also dependent on having access to housing and schools.

The automotive industry in and around Gothenburg has grown strongly over the last decade. It is not only AB Volvo and Volvo Cars that are important players. CEVT has grown from 12 to 2,500 employees in four years, and the software supplier Zenuity, which is working on technologies for autonomous vehicles, now has around 700 employees in the region. Geely, which owns Volvo Cars and CEVT and is the major owner of AB Volvo, is preparing to set up another engineering office in Gothenburg. There are also many other suppliers.

At the same time, there is a change in the vehicle industry, whereby digitalisation is becoming increasingly important. The companies therefore need new types of skills and are increasingly recruiting and reskilling staff, with skills in software, data analytics and electronics engineering. This means they are competing with telecommunication industries for staff. So far, they have mainly recruited R&D staff to Gothenburg, but some small steps have been taken to move outside of the region, and this may continue if they do not manage to recruit more staff regionally.

There are a number of ongoing technological changes, such as digitalisation, electrification and autonomous vehicles. To adapt to these trends, Volvo Cars needs test environments to test the safety and functionality of the technologies in a secure environment. Together with other regional actors, they have initiated the establishment of research and test environments for these new technologies, such as the AstaZero test circuit where they can run large-scale tests without jeopardising the safety of others.

Volvo Cars is also running large-scale tests in Gothenburg city with autonomous vehicles, through the DriveMe project. This is exploring both functionalities that assist the driver and those where the car has control. The pilot is both testing user behaviour and demonstrating these new functionalities. This is a way of testing, in the public environment, what these technologies mean and how normal drivers can accept them (do they feel safe being around these vehicles?). DriveMe can be seen as a way firstly to pick up user feedback that can influence development, and then to showcase that the technology can work in a real environment. It is also a channel to show users that the technology exists and to build acceptance among citizens and future users of the technology.

Volvo has for a long time been focusing on building safe cars and to this end they have played an important role in the competence centre SAFER, which is hosted by Chalmers University. The centre is a place for roundtable discussion with key stakeholders on future needs, trends, traffic systems, their development, related risks and competence gaps that need investigation through research and from conceptual and regulatory angles. This then steers the research questions that the centre focuses on. Many of the research projects involve industry and research actors, as well as partners from the public sector. Gothenburg City and Traffic Office are involved in this centre. There is however no citizen involvement.

In these centres, Volvo Cars both participates through its own researchers (Industrial PhDs carrying out research in the centre) and supports the centre's researchers. The company benefits from collaboration and exchange with them and implements some of the research outcomes in its own cars.

Volvo Cars has both initiated centres and chosen to be a participant when asked by others. As an example, they have initiated a new centre focusing on additive manufacturing, together with Chalmers and the Royal Institute of Technology (Stockholm), and backed by Vinnova.

When it comes to defining their own research needs, Volvo Cars make a long-term analysis of their needs as a company and take that to the centres and then to other stakeholders, to find out what trends and needs they have in common with other partners and could address with them. However, there is not much funding in these centres; they are more appropriate for preliminary studies. If they then want to scale things up, they approach Vinnova's Strategic Vehicle Research and Innovation programme.

Volvo argues that the public investment in research is positive, in that it can speed up research processes and run more risky projects. As an example, new safety systems implemented in the new Volvo XC90 are a clear result of driving R&D faster through public investments.

Another advantage of working through the competence centres is that they can manage research projects. As an example, SAFER gets involved in H2020 projects, where Volvo can participate and benefit, without having to administer projects themselves. Volvo Cars is also active in its own right in H2020, where it participates in around 15 projects.

Vinnova's Strategic Vehicle Research and Innovation programme is easier and quicker. To get things started, Volvo gets together primarily with Chalmers to address specific research questions. However, when using EU funds, it is more a case of addressing long-term and complex issues, such as standards and systems, with many partners from many countries, as this is hard to do by themselves. Vinnova are also engaged in projects with the European Institute of Innovation and Technology (EIT).

Volvo Cars also participates in six of Vinnova's strategic innovation programmes. These programmes bring together key industry stakeholders and academia in triple-helix constellations to develop R&I programmes for different thematic areas. They are:

1. Drive Sweden (working on a transportation system for people and goods that makes use of automation, digitalisation and services);
2. Lightweight (gathering parties to spread the industrial application of lightweight technology through R&I);
3. Internet of Things (a national drive for Sweden to become a leader in the use of the Internet of Things; focus lies on solving societal challenges);
4. Production2030 (venture to create a national base of research, innovation and training for competitive Swedish production);
5. Graphen (with the objective of increasing the use of graphene in Swedish industry); and
6. Process industrial IT and automation (PiiA) (contributing to the development and use of automation and digitalisation within industry).

In terms of technology readiness levels (TRL), Volvo Cars handles TRL 6-8 itself as it wants to be in clear command of these levels as it gets close to the market, but it collaborates with others on the other levels, right down to TRL 1. As an example, it is in discussion with Chalmers University on how to carry out advance material research in the forthcoming European Spallation Source (ESS). They will not send their own engineers to Lund to do this research, but they will provide Chalmers with research questions they are interested in, that Chalmers will perform at the site. As an example, they are interested in multipurpose materials that can be located in the roof of the car but integrated into the material structure and that function as antennas, solar panels or sensors.

Regulations are important in the development of traffic solutions and self-driving cars, and these centres also work with seminars for industry actors and public officials to discuss matters related to this. They also create background papers and statistics in order to support decision-making.

However, they are not the main channels for lobbying; Volvo Cars itself has a dialogue with public actors to influence policy processes, nationally and internationally. The company also works through various forms of interest organisations, such as BIL Sweden representing the car industry in Sweden. Another important association it works through is Teknikföretagen, a reference group for R&D issues for technology companies in Sweden and an important industry organisation for the country that, for example, is putting together the industry view on the next EU Framework Programme for Research and Innovation (FP9). They work hard to ensure that issues that are relevant for Swedish industry are represented in the framework programmes.

For Volvo Cars, it is a sort of multi-level game, where many of the important strategic discussions happen at the global or national level. The regional level is important, but there are less funds and it is more about facilitation at this level. The regional actors are involved in the competence centres, support their establishment and play an important role in setting up the many innovation initiatives. As an example, the test facility AstaZero is important for the region; the region supports it in getting the right set-up and making it attractive for European actors to come and use it.

Volvo Cars has a long relationship with Region Västra Götaland and has been discussing the region's strategy on vehicles for 10 years. Volvo Cars is not part of any group in the region that co-develops any strategy, but they are in continuous discussions on the development of the industry.

For Volvo, the region and the city are important for establishing innovation platforms, but also for vocational training and talent attraction. Making the region attractive and keeping it relevant makes it easier for Volvo to recruit talent who may consider relocating to the region. Volvo Cars tries to find top talent internationally, but second-level staff is recruited locally. Volvo sees a need for students to come and study in the region and remain when they have finished, but it is also important to be able to attract international experts. They are also working on identifying potential staff among refugees who have arrived over the last few years, and then collaborating to address possible skills needs.

Volvo Cars is positive about collaboration on innovation, as it provides them with new ideas and possibilities for addressing complex issues. They see it as an advantage to be located in the region, where there are many platforms, many of the skills needed, and a habit of collaboration. They are positive about the neutral physical meeting spaces such as Lindholmen Science Park.

Recently they have set up the MobilityXlab, together with AB Volvo and Zenuity, to better interact with SMEs and start-ups. This is a way to scout for future technologies, but also to structure how they can collaborate with these smaller actors. They can help the start-up companies develop their products, and buy them if they may need them. In such a neutral arena, it becomes easier to sit down and discuss collaboration; bringing smaller companies into Volvo's facilities can be intimidating. There is also a setting where they have structures, with non-disclosure agreements and processes for how to manage intellectual property rights. In this setting, the large companies can also present needs and invite actors to come up with possible ideas for solutions. It is also a way to attract talent to the region. It is open not only to local companies, but globally, and indeed a number of international companies have joined the programme.

3.3 Other major automotive companies and key suppliers

CEVT (China Euro Vehicle Technology AB)

CEVT is a development centre for future cars of the Geely Group. CEVT covers all aspects of passenger car development – from the overall architecture, powertrain and drive line components, to top hat engineering as well as the vehicles' exterior design. CEVT currently employs some 2,000 people and is growing fast. It develops technology for the various brands of the owner group Geely, such as Geely, Volvo and Lynk & Co.

The company is located at Lindholmen Science Park in Gothenburg and in Hangzhou, China.

Geely Innovation Centre

The planned Geely Innovation Centre will be located at the Lindholmen Science Park in Gothenburg and will upon completion house CEVT, the Geely powertrain R&D centre, Geely Design Europe, Lynk & Co's international marketing, sales and services, as well as several key suppliers to Geely and serviced apartment facilities.

The new Geely Innovation Centre, with operations planned to start in 2020, will be wholly owned by the Zhejiang Geely Holding Group (ZGH) and operated by Geely Auto through a new Swedish holding company.

NEVS

National Electric Vehicle Sweden AB, abbreviated to NEVS, is a Swedish holding company that has acquired the assets of Saab from a bankruptcy estate in 2012. The company focuses on the development of electric vehicles.

Owners and management: National Modern Energy Holdings Ltd. (NME) is a British Virgin Islands-registered, Hong Kong-based holding company, which owns NEVS together with Japan-based Sun Investment LLC. Together, they own 43 %. Tianjin Binhai Hi-tech Industrial Development Area, (Tianjin BHIDA) owns 30 % and SRIT, a leading IT provider owned by the State Council Development Research Centre and the telecom giant China Unicom, owns 27 %.

Autoliv AB

Autoliv is the world's largest automotive safety supplier, with sales to all leading car manufacturers worldwide. Together with its joint ventures, Autoliv has over 70,000 employees in 27 countries, of whom 8,000 are involved in research, development and engineering. In addition, the company has 22 technical centres around the world, including 19 test tracks; more than any other automotive safety supplier. The group is among the biggest Tier 1 automotive suppliers in the world. Autoliv is incorporated in Delaware, United States, and headquartered in Stockholm, Sweden. It runs its business through two business segments: Passive Safety and Electronics.

The company develops, manufactures and markets passive safety systems (with an estimated market share of approximately 39 %) such as airbags, seatbelts, steering wheels and passive safety electronics; and active safety systems (with an estimated market share of approximately 25 %) including brake control systems, radar, night vision and camera vision systems. It also produces pedestrian protection systems. Passive safety systems are primarily meant to improve vehicle safety. The objective of active safety systems is to intervene before an imminent accident in order to avoid it completely or reduce its impact. Active safety products in Autoliv's portfolio include automotive radars, night driving assist, camera-based vision systems, brake controls and other active safety systems. Autoliv's radar sensors were notably used by Uber in their self-driving taxi pilot project in Pittsburgh, Pennsylvania.

In 2017, Autoliv and Volvo Cars formed Zenuity, a jointly owned company to develop the next generation of autonomous driving software.

In 2018, Autoliv began to focus on passive safety measures and spun out activities related to active safety in to the start-up company Veoneer.

Zenuity AB

Zenuity is a joint venture between Autoliv and Volvo Cars. The mission is to use the latest in ADAS/automated driving innovation to create robust and flexible solutions for automated driving technology. Founded in 2017, with headquarters in Gothenburg, offices in Germany and the United States, they have around 700 employees. Zenuity originates from the safety leaders of the automotive industry; while young as a company, they build on experienced industrial automotive solutions. They have a strong skillset from Tier 1 and OEM domain knowledge in sensors and vehicle control.

3.4 Region Västra Götaland

Region Västra Götaland (VGR) is one of Sweden's popularly elected counties (*Region*) with responsibility for healthcare, public transport growth and development matters. It is a relatively new entity, established in 1999. The Region works on regional development together with its 49 municipalities, trade and industry, and academia. In this area, the region works on communications and infrastructure, trade and industry, lifelong learning, and research and development.

Region Västra Götaland's Smart Specialisation Strategy (RIS3) is an integral part of the regional strategy for growth and development in Västra Götaland 2014-2020, also known as VG2020. The regional development strategy is adopted by the Regional Development Committee (Regionala Utvecklingsnämnden) and is politically anchored with the regional council.

The work complies with the six practical steps recommended in the European Smart Specialisation Platform guide. Industry, academia and civil society participated in a comprehensive dialogue in drafting the regional growth strategy VG2020, but there was no separate process for RIS3. The strategy is formally owned by the region and the municipalities, but the implementation is pursued in a broad partnership. Within R&I, collaborative initiatives (between academia, business and societal actors) are prioritised. The region has prioritised a few areas of strength and clusters where it supports R&I milieus, collaborative projects and test/demonstration.

Region Västra Götaland finances thematic programmes linked to priority areas, where regional stakeholders can seek funding for collaborative projects and R&I milieus, as well as testbeds and demonstration projects. These are:

- Sustainable Transportation
- Sustainable Energy and Bio-innovation

- Life Science
- Food production/Agriculture and Forestry
- Sustainable Maritime Industries
- Circular Fashion and Sustainable Interiors
- Cultural and Creative Industries

Region Västra Götaland is the Swedish region with the largest budget for regional development. They are also a top region for the endowment of strong regional actors, with which they also work closely. They see themselves as agile. Although they are the region with the most funds of their own, which gives them scope to act, the larger funds for innovation are at national level. Therefore, an important part of their work is trying to influence national agendas so that they serve the interests of VGR's regional actors. They aim to be knowledgeable about their region's areas of strength and have in-house experts in these domains. They work closely with institutes and academia, and with industry; there are direct dialogues with industry at various levels. They try not to become a stale bureaucracy, but to live and act in the system close to other actors, and to support actors and initiatives that have potential, and address and solve issues when they emerge. They try to work agilely in an ecosystem that they do not think they can steer or control, but can influence. As an example, they were approached by Volvo Cars who were interested in developing a new test environment, which eventually led to AstaZero; they supported it initially and other actors eventually took over.

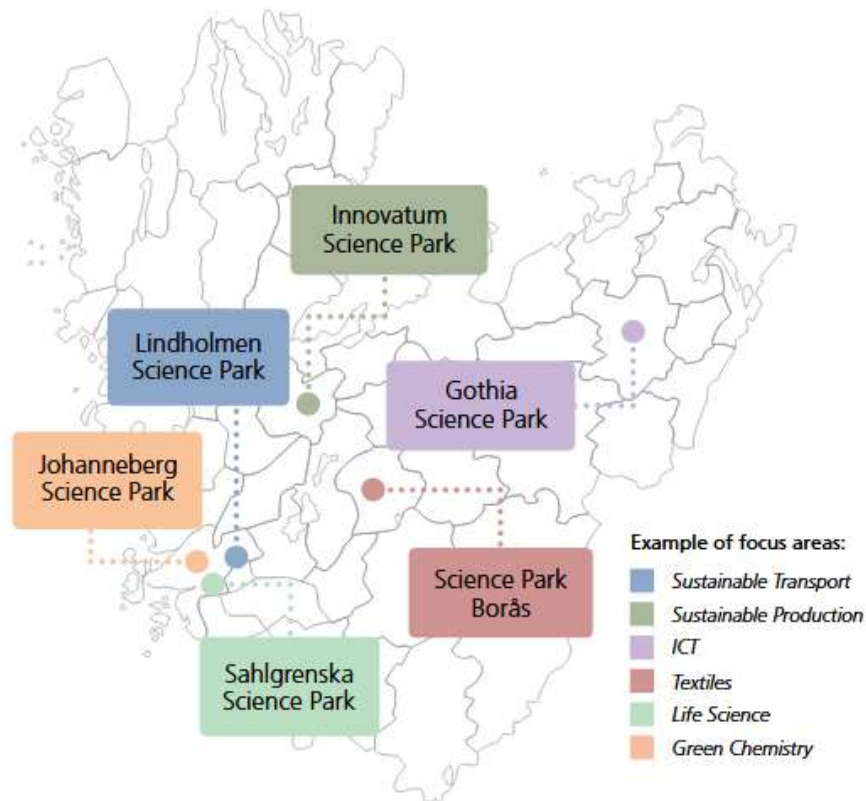
Region Västra Götaland has a collaborative agenda for their programme of work on sustainable transportation. However, there is no consensus and no specific board or reference group guiding their work in this area. The region can side with different partners in different circumstances depending on their analyses and perception of a specific problem or opportunity. Their programme is an expert product developed by the VGR staff. The staff participates in many regional and national level networks on the topic. Personnel also collaborate with various national level agencies. Therefore, the programme is an outcome of knowledge and input from being part of these forums. VGR is developing relationships with representatives from the key companies, at various levels (management level and line unit managers) and discusses strategies and projects. These include Volvo Group, Volvo Cars, Autoliv, Zenuity, and some SMEs.

Region Västra Götaland invests in science parks as part of its regional strategy for growth within the objective 'A leading knowledge region'. It hosts six science parks that play an important strategic role in the region's work with R&I. Science parks in Västra Götaland are dynamic hubs for innovation within thematic focus areas linked to the regional growth strategy VG2020. They provide collaborative environments for joint research and innovation, entrepreneurship and support for start-ups and SMEs. The six science parks are connected in a regional network, ensuring efficiency and synergies between them. The parks have focus areas which contribute to the regional smart specialisation strategy, as well as to societal challenges addressed for example in the regional climate strategy.

The science parks are settings that host various functions around R&I, where there is support both to start-ups, and also as initiators and hosts of various forms of collaborative efforts. In many cases they can be seen as delegated to take on the operative role of the regional development efforts (this is a type of informal arrangement), whereas the Region works more strategically. Lindholmen applies for funding for itself and for academic partners from the Region. The Region views the science parks as platforms that take greater responsibility than just developing and managing projects. As an example, the CEO of Lindholmen Science Park has a lot of respect in the industry and can talk with industry and academia as peers, which can facilitate and catalyse important processes. Region Västra Götaland can provide funds to support the initiation of projects, which then is leveraged from other funds, from the Energy Agency, Vinnova, etc. VGR also provides base funding for some collaborative efforts that in turn generate more projects, like SAFER, CLOSER, and VICTA.

All science parks are closely linked to the region's universities. Several of them, like Lindholmen, have started at classical industrial sites and in response to industrial structural change. They continue to play that role. A notable recent example is the importance of Innovatum Science Park in Trollhättan during the crisis of Saab Automobile and the local automotive industry.

Figure 3. Science Parks of Region Västra Götaland



Source: Västra Götalandsregion (2014), Smart Specialisation in Västra Götaland

In Västra Götaland county there is a long history of vehicle industry; it is also an important centre of Swedish industry and innovation policy tradition. Sweden has many engineering and technology companies, and the country has a long history of producing high technology and complex systems. From the public side, there is a tradition of R&I support as well as working with clusters and similar approaches. Traditionally, there have been close relationships between industry, academia and the public sector; with important sector programmes and competence centres, where industry and academia co-define research objectives. However, in comparison to other countries, Sweden has fewer specialised research institutes, although it is a target of the country's policy objectives to expand these; instead, universities have been undertaking a lot of applied research.

Swedish regional administrations (Region) are not particularly strong in the area of R&I. VGR is Sweden's strongest Region, but still relatively weak in comparison to the national state level, which is more important for R&I. The national level targets innovation support and sectoral support. As an example, VGR allocates EUR 2.5 million to the vehicle industry, whereas the Swedish government contributes EUR 50 million to the Strategic Vehicle Research and Innovation programme (FFI) alone, of which 70 % goes to Västra Götaland.

The Region and industry partners have a shared interest in developing the region. The big companies want R&I and headquarters to stay in the region. Sweden has a high number of multinational companies, and many others have left the country to set up their headquarters elsewhere. The Swedish home market is small, but Sweden is important for development. The Region is interested in supporting the industry to be prepared for technology shifts, so that it can stay competitive and grow in the region, facilitating that R&I, headquarters and manufacturing jobs remain in the region.

There is a concern that the OEMs that supply the car companies have not been developing as well as the leading companies. Therefore, the Region is investing in projects and activities that can get these companies ahead. The Region has identified that automation and electrification are key technological shifts in the industry and if knowledge can be developed around this, it can help the companies get ahead.

Now the drive system is changing, with smaller gearboxes and engines, and then electric units. This changes everything. Initially, Volvo handpicked suppliers outside Sweden that could deliver the technology needed but, for mass manufacturing, they want to have three to four different suppliers. Sweden's national level has been

quite slow to respond to this need. Therefore, industry and the Region joined forces to initiate ASSAR, an innovation centre that focuses on advanced manufacturing.

Although some companies are important, there are certain procedures that need to be followed and VGR cannot carry out activities that favour single companies, so it can take time to set up demonstration projects. The Region is struggling with how to support innovation. There has been a pendulum effect, where the public sector was working more closely with industry, then for a long time adopted a hands-off approach, and is now trying once again to work out how to collaborate. One of the respondents said it depends on how EU regulations are interpreted; some EU member states interpret that they can do more than Sweden has been doing lately. However, they are testing this out, describing it as stepping out on a frozen lake in order to find out how far one can go before the ice breaks.

Much of the traditional way of working is currently prevented by municipality law, procurement law and state aid regulation. Many of the ways that Sweden has been working to build up industry knowledge and competences is nowadays prohibited. These regulations restrict how partnerships can be formed. As an example, ElectriCity is a case close to the prohibited frontier. However, to achieve these types of project, VGR funds specific aspects, e.g. in ElectriCity they funded the testing of WiFi technology and not the buses, to take bus technology to the next level. For this project, there was an antenna company acting as project partner instead of Volvo. In addition, they use various forms of neutral brokers to manage projects (e.g. Lindholmen Science Park, institutes and academia).

VGR are involved in a number of projects, such as the ElectriCity project that demonstrates electric buses in the public transport system. There is the bus line 55, which runs fully electric buses, and seven hybrid buses running in electric mode. Other types of functions are being tested as well, for example connected vehicles and assisted driving. An example is geofencing, which reduces the possible speed limits of the bus, to 8 km per hour in certain areas, and is regulated through the cloud. They are in the process of adding projects on topics such as high-capacity transport (larger buses), and collaboration around trucks. There is also a project involving a self-driving electric bus.

The regional respondents argue that for them it is vital to have their own funds, going beyond national and EU regional development funds. This gives them manoeuvrability, which they can use to be flexible and close to regional stakeholders. Without any industry connection, there is no one that can pick up inventions and commercialise them. Also, projects should not be selected because they look good and give cheap political points, but should be based on facts and evidence and true regional needs and potentials. They recommend that others work bottom-up, not push things top-down. Furthermore, the respondents argue that they have had successful outcomes in their innovation initiatives because regional actors, both private and public, have been working with long-term commitment to processes, not expecting results from day one.

There is a point to being selective, and funding things where the regional funds add value; not funding things where there are already other types of support, and not spreading all things evenly to all actors and municipalities, where they will have no effect. At the same time, by targeting certain areas, they are helping to build accumulated capabilities over time.

Their funds are important, but so can be giving political support to actors and initiatives, even though political support and will can be double-edged. If projects are pushed and pressured, with many results expected in a short time, there is a risk of failure, as they may not be founded in the true needs and capabilities of a region. There may also be a waste of resources, and damage to relationships in the innovation ecosystem. As an example, regional politicians invested in a biogas plant; they wanted to spread this further to industry and get it to develop and set up more projects on this topic. However, industry sees limited market potential in the area and is still reluctant to engage. The respondents' recommendation is that there needs to be true stakeholder interest to begin activities. It quite often happens that regional actors see an opportunity to attract an establishment or research institute through a joint effort. This is something that the Region can respond to. At the same time, it is also important that projects deliver results that can be demonstrated at the political level. They need to be able to show that they have contributed and made a difference. This can be a challenge, as some projects work with 10-year to 20-year horizons but there may be a need to show results in a shorter time span.

There are quite a few opinionated voices asking the Region to be more vanguard and take a stronger lead in development issues. It is the view of the respondents that the Region is not well positioned to do this. It is mostly in healthcare and public transport that they can do this, as they are the service provider.

The respondents also argue that it is dangerous to go for a too regional approach. Most of the systems and sectors connected to the vehicle industry extend beyond single regions. As a single region or actor cannot

control the value chains, the Region needs to work flexibly and influence processes to its advantage, but also accept that these processes work in a commercial logic. It is key for Regions to have their own expertise and allow these processes to work long term.

A region needs to try to look to the future and anticipate future developments, and prepare itself to be an interesting location for industry in this coming future, so that there is a desire to locate to or remain in their region. As an example, VGR is part of a project to build up a strong competence centre around artificial intelligence in the region. There is a dialogue between regional stakeholders and the national level. Here, VGR tries to see what it can do to make this happen (e.g. they are exploring attracting a top specialist from Silicon Valley), and tries to isolate a piece of the package they can fund.

Another strong driving force in the region is Geely, which owns both Volvo Cars and large shares of Volvo Group. After their initial purchase of Volvo Cars, their presence has grown and they are setting up development offices in the region. In addition, the Chinese market is growing and playing an increasingly important role for the companies. They also invest in development, which the Region perceives as beneficial. At the same time, this growth creates a pressure to recruit, so one of the big issues now is skills supply.

There are various programmes related to secondary schools (AB Volvo is investing at this level to ensure skilled staff) and vocational training; the Volvo companies are also involved in this type of training.

There is also a programme being designed to reskill engineers to manage software engineering, born out of collaboration between seven technical universities. AB Volvo is interested in this and the Region is supporting the process. For many of the vehicle companies, the current drive is to have software engineers, but ideally also with training from and for the vehicle industry. Reskilling can therefore be an interesting approach.

3.5 City of Gothenburg

The City of Gothenburg is active in several ways that are interesting in this context.

Firstly, there is Business Region Göteborg (BRG), which works to create favourable conditions for trade and industry throughout the entire region by offering knowledge, contacts and arenas for collaboration. BRG is responsible for business development in the City of Gothenburg and represents thirteen municipalities of the region.

Gothenburg acts as a test arena for a number of projects, not least within the transport and automotive sector. BRG is often a collaborator in such projects; they identify companies' needs and gather actors from the private, public and academic sectors. Examples of projects where many actors are working together to bring ideas to fruition are Hyper Bus, ElectriCity and DriveMe.

BRG is also involved in talent attraction, through the Move to Gothenburg initiative. Access to human capital and talent is one of the main challenges in making use of the strong potential in West Sweden, and in securing the future wellbeing of citizens in the region. The shortage of qualified labour is already seen as the most serious obstacle to expansion for most companies. The prediction is that this shortage will continue. There is an increasing focus on the importance of attracting international labour, and several programmes have been launched to increase the attractiveness of the region. One example is a joint initiative within the framework of a regional platform, comprising stakeholders from the business community, academia, city and region, named Global Talent Gothenburg/West Sweden. The initiative aims to attract highly skilled international talent. The city has a strategic advisory group on industry issues, of which the two Volvo companies are members.

Gothenburg Traffic Office is of interest, as it is part of activities such as ElectriCity. Traffic Office activities range from strategic planning to practical implementation. There is a department working with development issues and international relations. The department matches their own development needs with those of external actors. In this department, there are various projects and cooperation on autonomous vehicles, as the City of Gothenburg is engaged in a broad cooperation with Volvo Cars, Chalmers, the Swedish Transport Administration, the Swedish Transport Agency and Autoliv. Within this platform, there are various R&I projects within autonomous and connected vehicles. Connected vehicles have become a major and important area. There is a great need for collaboration between actors and for harmonisation between different actors' solutions.

The department coordinates the municipality's involvement in DriveMe. The work includes the testing of autonomous vehicles in the ordinary traffic system. The Traffic Office is participating in DriveMe as a way to

develop the traffic system through the new technologies both in vehicles and in the city environment. The vision is a city that is designed for people, not for cars.

The Traffic Office is also involved in ElectriCity as a platform, as well as in other R&I projects financed by Vinnova, EU Horizon and CEES. There is also Drive Sweden, a national innovation programme financed by Vinnova, where the municipality is a partner. The Traffic Office is involved in various EU initiatives and interregional projects. Connected and autonomous vehicles are important issues for the municipality. There are several aspects where there is a need for cooperation on a European level for increased implementation of the technologies.

They communicate with various policy arenas at national and EU level, to ensure their interests as a city are respected. They are in general positive about the deployment of these types of technologies. Yet, other parts of the City may be less interested; with tight budgets, they may prioritise other issues. When they carry out projects, they try to ensure that they and the partners have a win-win solution. They are often also interested in running projects that are for not only the local level but can have effects on national or EU development agendas and that are something that neither actor could achieve on their own. They try to influence the development of the socio-technological system. This is a view that new technologies are situated in a socioeconomic context that influences the possibilities for them to break through, and that usually one actor alone cannot make things happen. For electrification, there is a need for new types of cars, places to charge cars, supply of electricity, new regulations, willingness to buy and invest in the new technology. It is a complex issue.

The respondent from the City of Gothenburg also believes that the two Volvo companies can see value in these collaborative projects where they do live tests in real environments; they can better understand the needs and requirements of users and customers, as these solutions are part of complex socio-technological systems. They have only in a few projects worked dedicatedly with a quadruple-helix perspective. But in the ones where they have, the impression is that it is important for it to be designed in a proper way, and for the questions to test with the actors involved to be properly defined from the beginning. It can be negative to engage in citizen dialogue and request feedback, if one does not eventually act upon the feedback. It can become counterproductive; instead of sending a message of being interested and willing to accept input, it sends quite the opposite.

This department has also seen a move from what they describe as challenge-driven innovation to more mission-driven innovation, where strong actors come together to solve an issue.

According to a respondent at the office, there is a win-win situation for them in working closely with AB Volvo and Volvo Cars. Around issues where the municipality - as well as Volvo - sees a need for development, it is easy to collaborate. The implementation of connected and autonomous vehicles is dependent on a broad range of perspectives, and collaboration between actors is often necessary. Cooperation often involves a link to the city's long-term strategies and to the vision of RiverCity Gothenburg (*Vision Älvstaden*), a large city development area in Gothenburg.

RiverCity is committed to building 25,000 apartments and 45,000 new workplaces simultaneously. At the same time, RiverCity has the aim of identifying and using new innovative solutions to create an inclusive, green and dynamic inner city. When working with AB Volvo and Volvo Cars, the initiative is taken from different actors depending on the project. Lindholmen Science Park is seen as a good and neutral coordinator for various cooperation projects.

In connection with smart specialisation, they work quite a lot with Lindholmen Science Park, which they perceive as being a central actor in many collaborative efforts in the area of transportation, as they have a secretariat and staff with competence to work on the issues.

The respondent is however a bit sceptical about some activities being carried out around innovation. He sees that there are a number of projects remaining at a meta-level and never reaching any kind of implementation. The projects remain talk shops that do not generate value for development. There is a particular danger where projects remain only with people with no budgets, no strategic decision-making power, and no responsibilities for implementation. He would prefer fewer projects, where he could see a 'mission-oriented' approach where a number of actors mobilise greater resources to achieve more large-scale implementation. At the moment the innovation system is fragmented, and a lot of people are living from the innovation system rather than pushing it to achieve concrete results. Thus, there is a need for more prioritisation, but also more effort and focus on deployment and implementation and becoming better at this.

The respondent believes that other regions could learn from there being a number of organisations in place that can facilitate collaboration. This is a basic pre-condition. In addition, the tone between actors is respectful and one of equal level, where the different actors respect each other's role in the system. It is not a hierarchical relationship. In some regions it is almost impossible to think about collaboration; there, the first steps may be to start small-scale in building trust. Therefore, it is impossible to jointly define the issue at hand, so that there is a common understanding of what kind of problems and possible solutions the different actors see that make them want to engage in the project, and be clear about what the different actors hope to achieve from the project.

3.6 Lindholmen Science Park

Lindholmen Science Park is specialised in intelligent mobility and transport systems, ICT, and modern media and design. It is a collaborative environment for research, innovation and education situated in the centre of Gothenburg.

The development of Lindholmen as a knowledge environment began during the 1990s. Thanks to joint efforts by public and private partners, the area began to develop. Today, there are 24 000 people, working in 400 companies (14,000), studying at Chalmers or Gothenburg University (9,000), attending six different secondary schools and vocational training, or living at Lindholmen.

Lindholmen Science Park runs many national and regional R&I programmes where collaborative projects between industry, public sector and academia are being developed. The transport and IT industries are major owners of the science park and, with their support and trust, the park has been able to act as a cluster node for activities within, for example, automation and vehicle ICT.

Lindholmen is one of six science parks in Västra Götaland. Together they form one of the most important features of the regional innovation system. Region Västra Götaland invests in the science parks as part of its regional strategy for growth. Science parks in Västra Götaland differ from many traditional science parks in Europe in having a much broader scope.

Lindholmen was set up to revitalise an abandoned shipyard area, but was kick-started by the establishment of Ericsson, which set up its second biggest research department in Sweden at Lindholmen. The Ericsson CEO saw the potential in the area and the project, but put pressure on the city and Chalmers to co-invest to build a cluster around the company. In this context, they formed the company Lindholmen to develop the area in 2000. The city had a property company, but not an organisation to develop innovation and collaboration.

In the beginning it was mainly focused on ICT and Ericsson, however over time, mobility has increased in importance and ICT is an important component in the vehicle industry.

The company is run not-for-profit, with the aim of delivering results other than financial. It is instrumental in the continued development of Lindholmen as an ecosystem. It does not own any buildings, have any financial resources of its own, or have any mandate or power.

The owners of Lindholmen are: City of Gothenburg, Business Region Göteborg, Chalmers, Ericsson, AB Volvo, Volvo Cars, TeliaSonera, Saab AB, Telenor Sverige AB and Toyota Material Handling. There are also strategic partnerships with Gothenburg University and the Traffic Office.

Lindholmen has a board with influential actors: leading politicians and opposition leaders, principals from the two universities, people from executive management teams and from the boards of Volvo and Ericsson. It has also had backing from a strong and tough mayor of the City of Gothenburg, which has helped it make brave decisions that have kept things going.

They have followed a strategy to attract large companies that can nurture smaller ones. In other locations, the early focus was on SMEs and start-ups. Here, they began with the big companies - Volvo, Ericsson, etc. By targeting them and getting them involved in projects and locating activities to Lindholmen, they got a momentum going, which subsequently also attracted the SMEs and start-ups. They are still close to the big companies, but at the same time have doors open to small companies.

They do not have their own incubators, but help these and other forms of business support actors to find offices at Lindholmen and act there. They run many dialogues with property companies and actors to match-make establishments. Companies do not want to communicate externally that they are coming before they do, but want to have informal contacts, which Lindholmen Science Park can help with.

One of the most important tasks is to support and strengthen the local innovation ecosystem. They work as an engine to set up collaborative efforts, and have a staff of 30 people who lead this. They can act as a neutral facilitator, to host collaborative effort. All these efforts originate from needs that they see and address; in the best case, they can meet both political and industry needs. As an example, they did all the groundwork for AstaZero. They do not have to locate the initiatives at Lindholmen, but have a positive attitude to that. The perception is that, if Lindholmen is helpful, the initiatives will locate there in the end. As examples, they work with Ericsson in Kista, and Saab in Linköping. They try to have a national perspective, saying that they want to lead and initiate national level projects. Therefore, they also spend time liaising with the ministries at national level. They recognise that they have a position, as they also get contacted by the ministry for guidance in different matters.

They have base funding from Region Västra Götaland, City of Gothenburg and the shareholders. They provide a long-term contribution to operations, but the base funding is not enough to operate 30 people. They therefore have second-level funding for programmes and arenas. To set up a programme, they need base funding for 3-4 years to dare to expand operations. On top of that, they do projects with mixed funds, EU, private and public funds.

Their main theme is mobility of people and goods, and their strength is their triple helix-based network. They have also managed to develop project management know-how in this area, which they can apply to new and upcoming projects.

Currently there is a lot of activity. It has been a 20-year process, where it was slower in the beginning but currently booming. They see a lot of activity in mobility, with strong actors like Volvo and Geely who are development oriented.

This is a period of disruption, with developments in connectivity, mobility and electrification. There is a need and urge to do something. Here, international - and in particular Chinese - capital is important. When Geely bought Volvo cars, the gears shifted. Three to four years after the initial purchase, Geely set-up an R&D centre for the entire group and decided to locate it at Lindholmen. This is CEVT, which initially aimed to have 200-300 staff and to develop small platforms for Geely and Volvo; however, it has grown and now has 2,000 staff in 14 buildings. They develop for Geely, Volvo Cars, and for Geely's new brand, Lynk & Co. The latter has 100 people in Lindholmen and 1,000 in China. Now Geely is also setting up the Geely Innovation Centre at Lindholmen, where they have purchased properties that can host 3,500 people.

There is a dense agglomeration of knowledge around Lindholmen and Gothenburg related to the automotive industry.

Lindholmen has also been key in initiating the project ElectriCity, a demonstration project for future transportation. Their role as an intermediary helps them understand needs and interests in the different helices of the triple helix, and means they can also identify possible projects and make them happen. In connection with ElectriCity, Lindholmen Science Park was in contact with Vinnova, the Swedish Transport Agency and involved in various discussions on future transportation. They perceived the need to develop electrified high-capacity public transport systems, and the benefit of building competencies around this. Lindholmen also had discussions with Scania and Volvo Group around electricity and public transport. They then had an informal meeting with the CEO of Volvo Group, to discuss and suggest setting up a demonstration project on electric public transport. They also argued that there are similar demonstrations in Los Angeles, so why not do something like this in Gothenburg. After a short time, Volvo Group came back and said they wanted to do the project and that they could contribute EUR 20 million. The public transport company for the city and the region were also interested and on board. Lindholmen was the driving force in initiating this, but later it was taken over by another team.

Currently, they are engaged in setting up a national centre for electric mobility, which will focus on electric drivelines. There are discussions with the Swedish government and CEVT; it is likely that the government will make a large investment. The Chinese companies are used to government subsidies and perceive it as favourable to work in the Gothenburg area, where there are various forms of innovation support available. However, in Sweden you cannot provide subsidies and support to one company only. The government can provide 50 % but the outcomes must benefit multiple actors. This centre has connections with CEVT, Volvo Cars, Scania, AB Volvo and RISE. It will most likely be RISE that will host the centre.

Lindholmen has a history of crisis, and their experiences are that they are a positive force both in good and bad times. When there was a crisis in nearby Trollhättan, they could help funnel funding to build operations, connect to work transition, and retrain people.

The two Volvo companies are extremely important for Lindholmen; both companies have a lot of staff and offices based there. They are visionary actors and drive collaborative efforts. Volvo Group has been more eager to use Lindholmen and to engage in processes; their products are closer to the public sector and they have been instrumental in Lindholmen's development. AB Volvo has also asked actors to locate to Lindholmen. For example, a Japanese company, which produces control units, got a deal to supply Volvo, who then requested them to be present close to their R&D and to locate to Lindholmen.

Before Lindholmen, Volvo worked directly with funding agencies. Now they have seen the beauty of working with Lindholmen - having a neutral agent to talk to the public sector.

The two Volvo companies have been fundamental in creating the ecosystem. This relates to the Lindholmen strategy of attracting large companies that can nurture others. Through the presence of these important companies, they attract other ones - suppliers and consultants, who in turn are interesting for other actors, and generate spin-offs and start-ups. It is the key to a dynamic environment. Even Scania, which traditionally has not been present in Gothenburg, has now located some people there and may expand further.

Due to their size, it can be challenging to find the right people in the two Volvo companies to go ahead with projects; especially so for SMEs that may not have the right entry points, but also sometimes for Lindholmen Science Park. Big companies also develop their bureaucracies and hierarchies, with their in-house politics between departments. Also, top management sees the need for change and transformation, but when these are large organisations with heavy and complex processes, it can take time for decisions to trickle down in the organisation.

3.7 Chalmers University

Chalmers University of Technology conducts research and offers education in technology, science, shipping and architecture. Founded in 1829, it has 13 departments, 10 300 full-time students and 3,100 employees. The university works both with fundamental research and with applied research to solve societal challenges. At Chalmers there are 2,300 researchers, instructors and doctoral students working closely with industry and the public sector in all research.

Chalmers works with Areas of Advance, which are challenge-driven thematic platforms for strategy and long-term collaboration. These challenges are often directly relevant to industry and society. Within these areas, there is a research infrastructure and several targeted centres, including Building Futures, Energy, Information and Communication Technology, Life Science Engineering, Materials Science, Nanoscience, Production, Transport, Basic Sciences, Five Star Campus, and Health Area of Advance.

Within Transport, there is research at Chalmers into Traffic Safety, Transport Efficiency and Sustainable Vehicle Technologies. The areas are further promoted in three cross-disciplinary themes: Electromobility, Autonomous transport and Transition to future transport systems. Volvo Cars and Volvo Group are two major collaboration partners within the Transport Area of Advance.

Within the Transport area, there is research infrastructure such as SEEL (Swedish Electric Transport Laboratory) – a testbed for electric mobility created jointly between RISE and Chalmers –, AstaZero – a full-scale test environment for future road safety –, ElectriCity – a live testbed for research and development of solutions for sustainable travel –, ReVeRe – Resource for Vehicle Research at Chalmers with a focus on self-driving vehicles, active safety and vehicle dynamics, and the VTI simulator.

ReVeRe is Chalmers laboratory focused on automotive-related research. The main research areas are self-driving vehicles, active safety and vehicle dynamics. In the lab, there are several vehicles which can be fitted with different types of sensors, equipment for data logging, communication technology and more. This allows the lab to provide a research platform for development and verification of theoretical models, algorithms and technologies, using real vehicles in real traffic environments.

Tests in different traffic environments are carried out in close cooperation with the test track AstaZero, where Chalmers is a partner. There is also an explicit aim to promote research between different scientific disciplines, and to increase collaboration between researchers from different universities and research institutes. The lab is available for undergraduate students and companies involved in research projects.

There are also centres at Chalmers related to the Transport Area of Advance, such as SAFER. SAFER is a centre of excellence for vehicle and traffic safety that conducts collaborative, interdisciplinary R&I to

eliminate fatalities and serious injuries in traffic. CLOSER is the arena for research, development and innovation within transport efficiency.

Chalmers also has an Innovation Office, created in 2011. This office provides professional support to individuals and to different research groups regarding innovation and utilisation. The innovation office provides advice regarding development of ideas, verification of needs and feasibility, utilisation strategies, patenting, licensing and collaboration with external parties.

According to a representative from the Innovation Office, there are long-term cooperation agreements and a strategic partnership between the Volvo companies and Chalmers, agreed between the CEOs and the president of Chalmers. The agreements are a way to structure the collaboration. The partnership promotes collaboration between Chalmers and the companies through research, competence provision, technological development and innovation.

There are various levels of collaboration between the university and the two Volvo companies. There are the high-level agreements between the CEOs and the president of Chalmers, where there is discussion on the long-term design of education and research projects. There is also involvement by Volvo staff in projects and centres and in seminars. The Volvo companies are obviously influential in the area of strength around transport, where they have a form of strategic partnership.

The agreements provide opportunities for industrial PhD students and adjunct researchers from the industry to access joint knowledge networks, research infrastructure and labs.

According to the Innovation Office, there is added value for the university from the agreements as well as for Volvo. The agreements also help in making roles and expectations clear to the parties involved. They feel the two Volvo companies see it as beneficial to get new ideas into their development processes, to be able to influence research agendas, and to give university staff better understanding of industry needs and see that research questions are relevant. Obviously, there is also a strong drive for the companies to secure talent recruitment and to ensure future staff is trained and gain the right types of skills; and for the students to get access to and connections with potential future employers.

Chalmers also has ongoing collaboration with public organisations such as Business Region Göteborg, the City of Gothenburg, Region Västra Götaland, the Swedish Energy Agency, the Swedish Transport Agency and RISE, and there are various types of involvement with the EU. The perception is that it is easy to collaborate in the region, and that there is good trust between the actors, with a clear policy of supporting and participating in collaboration.

This is also a recommendation from Chalmers to other regions, to try to develop these networks and maintain the dialogue that facilitates collaboration. They can see that even when there are competitors around the table, they manage to find areas where collaboration benefits all participants. The advantage in the Gothenburg region and around the vehicle industry is that they have a long tradition to build on. They can see that it is not as easy in other areas as in the transport area, but it is important to build trust, aim for long-term relationships, and coordinate activities by different actors – from industry, universities, research institutes, science parks, etc. Multi-level governance is also important; some issues can be dealt with regionally, others need to be raised and addressed in national or global alliances.

3.8 Other university and research organisations

Gothenburg University

The University of Gothenburg, with 37,000 students and 6,000 staff members, is one of the largest universities in the Nordic countries. With its eight faculties and 38 departments, the University of Gothenburg is one of the most wide-ranging and versatile universities in Sweden. Its eight faculties offer training in the Creative Arts; Social Sciences; Natural Sciences; Humanities; Education; Information Technology; Business, Economics and Law; and Health Sciences.

By itself or together with Chalmers, it hosts a number of the research labs in this mapping.

RISE (Research Institutes of Sweden)

RISE drives and supports innovation processes of all kinds, with facilities throughout Sweden and headquarters in West Sweden. They employ 2,700 people, 30 % of whom are PhDs. They manage over a

hundred testbeds and demonstration facilities that are open to businesses and higher education institutions. They are owners of and a partner in 60 % of Sweden's total test and demonstration environments. A large proportion of their customers are small and medium-sized companies who are responsible for approximately 30 % of the revenue.

One interesting institute is RISE Viktoria, which is dedicated to enabling sustainable mobility through the adoption of information and communication technology (ICT). RISE Viktoria is located at Lindholmen in Gothenburg.

3.9 Vocational training initiatives

YH – vocational

Higher Vocational Education (HVE) programmes come about as a response to labour market needs, and are delivered in close cooperation with employers and industry. The education providers are institutions or establishments such as universities, local authorities or private training companies. HVE are tailored to suit current needs. The range of programmes and specialisations therefore changes over time. New programmes start and old ones are discontinued as the labour market changes.

The business and organisations tied to HVE programmes take an active part in planning as well as delivering the programmes. Employers and industry representatives take part as members of the programmes' steering committees. They may also take part through giving lectures, joining in projects or by offering work placements. Most HVE programmes offer work placement. In HVE, work placement is referred to as LIA (*lärande i arbete* – learning in a work environment).

Smarta Fabriker and Gothenburg Technical College

The purpose and objectives of the Smarta Fabriker ('Smart Factories') project is to create a platform to disseminate knowledge on industrial digitalisation, to increase the attractiveness of technical studies and attract young people to want to work in industry. They have built two demonstrators with associated exhibitions: Universeum in Gothenburg, and Balthazar in Skövde. They will use the demonstrators in activities related to skills development and skills delivery in industrial digitalisation. This project is run by Gothenburg Technical College, which is a company jointly owned by AB Volvo, Volvo Cars and the City of Gothenburg. They jointly develop various courses and training for vocational training and secondary schooling.

3.10 SAFER

There are competence centres hosted at Chalmers University related to the Transport Area of Advance, such as SAFER. SAFER is a centre of excellence for vehicle and traffic safety that conducts collaborative, interdisciplinary research and innovation to eliminate fatalities and serious injuries in traffic.

SAFER is part of a larger societal project: the design and realisation of smart, sustainable transport systems in cities and beyond. SAFER's role is to be a thought leader in safe mobility, offering world-leading knowledge and project methodology. SAFER creates knowledge and value beyond what a single partner could achieve on its own.

Chalmers is the host for the centre, which has 34 partners from academia, industry and society. The partners in SAFER are Autoliv, Chalmers, City of Gothenburg, Combitech, Cycleurope, Folksam, Halmstad University, If, KTH, Lindholmen Science Park, NEVS, RISE, Scandinavian Automotive Suppliers, Scania, VTI, Swedish Transport Administration, Swedish Transport Agency, University of Gothenburg, Veoneer, Volvo Cars and Volvo Group.

The SAFER strategy is to take a holistic, system approach to traffic safety that covers people, vehicles and infrastructure. SAFER connects partners that individually are leaders in specific areas but together have a broader knowledge and resource base for addressing challenges in vehicle and traffic safety. By performing collaborative, multi-disciplinary research across organisational borders, new expertise and research facilities will be developed. New findings will also be implemented faster when all the different stakeholders can meet in a common environment.

The mission is achieved through collaborative research projects and by exploring new research. At SAFER, research is conducted within five areas: Systems for accident prevention, Road user behaviour, Human body

protection, Care and rescue, and Performance evaluation. There are also competence areas as a base for cross-disciplinary research. The competence areas are: Vehicle dynamics, Functional safety, Sensors and communication, Structures and materials, Human factors design, Road infrastructure, Behaviour in accident causation, Human monitoring, Driving simulator applications, Traffic systems, Biomechanics and protective systems, and Field data.

The mission is also achieved by providing an Open Innovation Arena in order to enhance innovation capability; provide prerequisites for creative research collaboration; inspire students, researchers and product developers; and disseminate results and knowledge to society.

SAFER should also work with international collaboration and exploit its potential to become a world leader in traffic safety, based on four cornerstones. The first cornerstone is to create identity and to communicate and attract international stakeholders, collaborative projects and funding. The second one is the shared research infrastructure that supports collaborative innovation projects. SAFER coordinates activities with a number of other research infrastructures, such as the full-scale automated driving laboratory ReVeRe, the safety proving ground AstaZero, and the databases of real-world data. The third cornerstone is SAFER acting as a thought leader and defining strategic research agendas based on different needs and trends. The fourth cornerstone is to create and share knowledge for innovation. This means making new knowledge and facts available, and creating and maintaining networks between industry, society and academia. Within this area also lies the role of trying to influence the international research agenda within safe mobility.

Since the launch of SAFER in 2006, around 300 projects within vehicle and traffic safety have been completed. SAFER is located at Lindholmen Science Park in Gothenburg.

The output of SAFER includes:

- a knowledge base that can address the full chain from investigating the causes and impacts of incidents and accidents, to developing preventive measures (technical as well as societal) and evaluating the impacts.
- world-leading data gathering for the analysis of naturalistic driving studies.
- NIC (Neck Injury Criterion), developed at SAFER, is an international standard, e.g. in the European New Car Assessment Programme (Euro NCAP). This has reduced injuries to the neck from traffic accidents, and is also being implemented in Autoliv and Volvo products.
- JALP! – the security app patent from a project on driver simulation combined with state-of-the-art neuroscience.
- increased awareness in China on child car safety, which has increased demand for Autoliv's products.
- research on risk from using mobile phones while driving, that has been used in policymaking and new guidelines for use of mobiles in traffic.
- Volvo Cars thanks SAFER for contributing to their car achieving the best rating in Euro NCAP (2015): 'One important success factor is our excellent research collaborations, where SAFER is an important asset. We value the contribution from this shared platform of broad safety competence'.
- supported researcher mobility between academia, industry, institutes and the public sector.
- new types of collaborations have been established and new projects have been initiated within the centre, in particular inter-disciplinary projects.
- new international partners, e.g. the French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR), University of Wisconsin, University of Michigan Transportation Research Institute (UMTRI) and Chemnitz Technical University.
- more than 600 publications (articles, conference papers, and reports) from projects at SAFER.
- many different conferences organised on related research areas.
- 35 PhDs, 47 licentiates and 20 adjunct professors.
- two partners and one patent application.

It has in a short time managed to become one of the world leaders in the area of naturalistic driving studies (NDS). As confirmation, SAFER has recently been awarded a prestigious project for NDS data analysis by the Strategic Highway Research Programme 2 (SHRP2) in the United States.

Key factors for success have been staying with the initial vision, with some needed adjustments and modifications over time. The vision is to seek both scientific excellence, and societal and partner benefits.

Another factor is that funding principles have been maintained intact, in that the board is fully responsible for the available funds and that these funds are used strategically to seek larger funds elsewhere.

SAFER has benefited from an increased interest in traffic safety; this is an important framework condition in order to succeed with automation, and for good quality of life in a modern city. It is also a target in the UN Global Goals.

Volvo Cars sees that it is fruitful to meet with partners with related interests in this type of centre, to address shared challenges, and to understand what may become future challenges from research, conceptual and regulatory angles.

3.11 Other incubators and accelerators

Chalmers Ventures

Since 1999, Chalmers Innovation has worked with over 200 projects and started more than 130 companies. Over 2,700 business ideas have been evaluated, which has led to the contribution of 1.5 billion private investments in start-ups. By 2011, the companies had a total turnover of SEK 558 million and 406 employees, which has led Chalmers Innovation to be Swedish leading idea investor and business developer. In 2015, Chalmers University of Technology decided to gather forces to strengthen, rationalise and scale up their entrepreneurship activities. SEK 300 million of investment capital was to be provided over a 10-year period, along with financing of operations, to bring forth more companies and newly established companies associated with Chalmers.

Gothenburg University Ventures

Since 1995, GU Ventures has supported projects and companies spawned by the University of Gothenburg. The company is wholly owned by the Swedish state and managed by the University of Gothenburg. They work in close collaboration with the Research and Innovation Office at Gothenburg University and with the Gothenburg innovation system, with partners such as Encubator, Chalmers Innovation and Sahlgrenska Science Park.

3.12 MobilityXlab

MobilityXlab is a platform and meeting place for innovation and new solutions for future mobility. MobilityXlab was founded by Ericsson, Volvo Cars, Volvo Group, Veoneer and Zenuity. In December 2017, CEVT also joined as a partner in MobilityXlab. The founders are global brands within mobility and connectivity and the purpose was to work more closely with start-up companies in order to strengthen competitiveness in the automotive industry.

The investment enables joint development of new technology as well as collaboration with smaller start-ups, whose ideas one wants to support and draw inspiration from. In this way, the companies aim to also stimulate development across the Swedish automotive cluster with the objective of increasing competitiveness in terms of tomorrow's transportation system.

MobilityXlab is hosted by Lindholmen Science Park with support from Vinnova and Region Västra Götaland. The staff are also employed by Lindholmen. The preparations to set up MobilityXlab were initiated when Zenuity located its headquarters at Lindholmen in 2017.

The organisation MobilityXlab is in its early phase of development, as it started up in 2017. According to interviews, the organisation works in an agile way, constantly developing its offerings, and activities are continuously evaluated. In the early phases, there has been work on how to define the vision of how to be a platform for future mobility.

MobilityXlab serves as a neutral broker between the different partners, to ensure all partners can benefit from the collaboration, and also aims to guarantee that people trust the processes and feel that they are gaining

from them. The idea behind it is that opening doors for other companies to access leading companies' networks, expertise and tools will spark new innovations, expand the horizon and push boundaries.

MobilityXlab offers young companies with pioneering ideas the opportunity to accelerate, through the opportunity to join strategic partnerships with the six founding companies within mobility and connectivity. The start-up company is allocated a contact person from one of the founding companies, who has the task of guiding and accessing the partners' competence, networks, tools and insights from leading subject matter experts, as well as free working space for a limited period of time. Joining the MobilityXlab means that the companies are included in the community and they receive the opportunity to collaborate with the larger companies for a six-month period.

MobilityXlab is regarded as a catalyst, initiator and facilitator of meetings. MobilityXlab should however not be regarded as an incubator. The target group is more mature start-up companies that have the ambition to strengthen their network and to obtain access to the larger companies. It is also a way to attract talent to the region. It is open not only to local companies, but globally, and indeed a number of international companies have joined the programme.

At MobilityXlab, various projects are initiated and various collaborative activities conducted. Artificial intelligence will be a focus area for MobilityXlab's next round of invitations to technology developers. Such focus, and how to address it, were co-developed with AI experts from the large companies.

When MobilityXlab works with a start-up company, there should be interest from at least two of the larger companies. The results expected from activities can differ between the larger companies. The result may be for the larger company to identify a need for competence, or it may be new innovations from start-up companies that can be brought in to the larger companies. MobilityXlab is initially financed for a three-year period. The expectations of the founders are to work closer with start-up companies and to have a platform for experimentation on future development. When it comes to designing new activities, the large companies are involved at an operational level in a process group comprised of innovation managers, which meets weekly. The process group prepares proposals for the steering group (with representatives from the larger companies).

MobilityXlab can function as a neutral platform for decision processes between the partners. Public authorities are involved as financiers, but not involved in projects. MobilityXlab is not yet part of any EU initiatives, but there are start-up companies at the arena that are involved in Horizon 2020 projects.

In the first round, three companies were selected. A second round was held in the first half of 2018, adding six more companies to the portfolio. These companies have a clearer focus on artificial intelligence.

The respondent from MobilityXlab sees the value in smart specialisation, where a region focuses on an area of strength and keeps developing this in order to raise the level of competitiveness. They see that their cluster has something unique that attracts companies from around the world. It is also important to collaborate with other actors. As an example, MobilityXlab is in contact with other groups – one connected with Saab – to share experiences, but is also exploring how to engage with Israel and Silicon Valley.

AB Volvo is interested in having a structured and simplified form of contact with SMEs and start-ups. In this lab, they have created a collaborative environment with a focus on software for autonomous vehicles. They wanted to increase opportunities for contact while making these easier to manage. Volvo wants to have new ideas and input. They also hope that, through their staff working with SMEs and start-ups, they will pick up new work practices and methods that may be more innovative, efficient and flexible. At the same time, they think they can help the SMEs and start-ups to quicker understand the market potential of their ideas, and also help them see how to develop and market their products to meet global requirements.

3.13 Other research labs

CLOSER

CLOSER is a project broker that began at a regional level and is now a national organisation. CLOSER is the Swedish arena for transport efficiency, a platform gathering actors from the business community, industry, universities, research institutes, cities, regions and government agencies. CLOSER is operated by Lindholmen Science Park. The platform initiates collaboration and projects for increased transport efficiency. Needs are identified among companies and agencies that could lead to demonstration projects and, in the long term, implementation (new solutions in transport). This enables new, innovative products and solutions that help the

transport industry and contribute to new solutions for the goods transport system which is to supply a sustainable society. They also contribute to research benefiting companies and society.

Swedish Electromobility Centre

The Swedish Electromobility Centre is a national centre of excellence for electric and hybrid vehicles and infrastructure. They unite Swedish e-mobility expertise, and are a node for interaction between academia, industry and society. They develop and optimise existing and future e-mobility solutions for energy-efficient and eco-friendly electric and hybrid vehicle concepts. Their research concerns the drivetrain with its components and control system as well as the infrastructure itself, communication between vehicles and the vehicle's ability to utilise the infrastructure. They promote knowledge building, networking and education, through conferences and workshops, courses for doctoral students and through their doctoral student network.

Software Center

At the Software Center, companies and universities work together to accelerate the adoption of novel approaches to software engineering. The cooperation between academia (Gothenburg University, Chalmers University of Technology, Linköping University, Malmö University and Mälardalen University) and ICT, vehicle and engineering companies (Axis Communications AB, Bosch, Ericsson AB, Grundfos Holding A/S, Jeppesen Systems AB, Qamcom, Saab AB, Siemens AG, Tetra Pak, Volvo Car Corporation, Volvo Truck Corporation) aims to create software engineering solutions needed by Swedish and Nordic industry. The Software Center opened officially in 2012.

The Software Center is hosted by the Department of Computer Science and Engineering, which is a joint department of Chalmers University of Technology and the University of Gothenburg. The research within the Software Center is driven by industry needs and is largely funded by the participating companies. The continuous exchange of knowledge is the basis of the interaction model used by the Software Center. Researchers and companies jointly determine which projects should be invested in, and there is frequent communication throughout the whole project.

GHz Centre & ChaseOn

The GigaHertz Centre (GHz Centre) is a 15-year agreement between Chalmers University of Technology, research institutes, company partners and Sweden's innovation agency Vinnova, to carry out R&I in wireless communication and sensor technologies. The GHz Centre is a competence centre partly funded by Vinnova. ChaseOn focuses on antenna systems. Given the diverse nature of the applications, antenna systems come in many different shapes and forms. ChaseOn gathers stakeholders from seemingly disparate application fields to continue building fundamental knowledge and solid competence in antenna systems. The GHz Centre and ChaseOn formed a joint consortium in 2016.

3.14 AstaZero

The name AstaZero refers to the Swedish parliament's vision for road safety, with zero dead or seriously injured in traffic ('Vision Zero'), and is the trademark of ASTA (Active Safety Test Area) AB, a company that operates a state-of-the-art testing ground specifically designed for developments in active traffic safety. New solutions are tested at AstaZero, which also assists collaboration and future development.

AstaZero is a full-scale test environment for future road safety; a testbed for automated transport systems that makes it possible to test advanced safety systems and their functions for all kinds of traffic and traffic situations. Its unique environments allow the construction of all types of scenarios for research, development and certification of future road safety systems, including autonomous vehicles and how to avoid collisions. Built upon the collaboration between academia, industry and the authorities, the AstaZero facility serves as an open, international platform for all interested stakeholders, such as vehicle manufacturers, suppliers, legislators, road agents, universities, and technical institutes from around the world.

AstaZero's starting point is that there was an understanding in the industry (AB Volvo and Volvo Cars) that new R&D and test possibilities were needed for the automotive industry. Historically, test environments had tested what happens with cars and engines after running for long periods of time and distances, or conducted

crash tests. However, in the new traffic environment with the emergence of electric, connected and autonomous vehicles, there was a need for new test environments.

Test Site Sweden conducted a pre-study in 2008, in which Volvo Cars also participated and initiated. In connection with the financial and automotive crisis, ownership was handed over to SP (now RISE) and Chalmers University of Technology, who formed a joint company, with a CEO from Volvo Cars. After the funding was agreed, construction of the site was started in 2011. AstaZero was inaugurated in 2014.

RISE and Chalmers are still owners of AstaZero; the partners are AB Volvo, Volvo Car Corporation, Scania, FFI, Autoliv, the Swedish Transport Administration, Region Västra Götaland, the City of Borås, the Swedish Agency for Economic and Regional Growth, and Test Site Sweden. There is financing from national agencies (research), Region Västra Götaland, the City of Borås and also EU structural funds. The two Volvo companies have also committed to purchase services on a stable level over a long period of time.

The core services that AstaZero provides include an environment to develop, test or certify new traffic safety solutions, enabling tests on all aspects of active safety in one place. They currently have four specific environments, shortly to be increased to seven. The test environment comprises a 5.7-km rural road lane; a city area with four districts of buildings, streets and crossing between streets; a multi-lane road; and a high-speed area for high-speed tests.

At AstaZero, it is possible to simulate pre-tests or early stages of research and development. There is also development of methods and test equipment and it is possible for companies and research institutes to use AstaZero as a demonstration facility, to test and verify concepts. AstaZero can host demonstrations and assist with product launches. Apart from being a test environment, AstaZero provides support in analysing and drawing conclusions from results, by supplying research engineers. Technicians may assist in testing, development and research projects. For this they use external consultants, which is also a way of raising the level of competences in the cluster and spreading knowledge on vehicle testing and development more widely.

The test site itself enables R&D in all possible areas related to active safety. Some examples of research areas at AstaZero are autonomous driving, communication systems (satellite GPS; vehicle-to-everything – V2X), protection of vulnerable road users, development of test targets and equipment, test methods for false positives (false alarms), creation of test scenarios, driver behaviour, new powertrains, crash contact point optimisation/integrated safety, and climate-related aspects. AstaZero conducts continuous research on how to improve the test tracks. Clients at AstaZero conduct their own R&D while using the test environments.

At AstaZero, there are various initiators of projects, including companies or a consortium of different actors (companies, universities, research institutes). Cooperation projects are financed by FFI (cooperation between national agencies and the automotive industry, financing research, innovation and development with a focus on climate, environment and security). When there are projects within FFI, it is mostly AstaZero that takes the initiative for collaboration.

Collaborative projects are rarely between two direct competitors. According to one respondent in this study, the added value of collaborative projects is often knowledge transfer between partners. Despite processes becoming more complicated in collaborative projects, new and unexpected learning may occur. The physical environment provides new insights and is important for creativity. According to responses obtained through this study, results from processes at AstaZero are often transferred into business processes in the automotive industry; the respondent says there are many features in new Volvo cars that have been enabled by testing at AstaZero.

Vinnova is a close partner, as research and innovation funding is channelled through the agency. On a regional level, Region Västra Götaland is also important. They appreciate the Region's support in that it helps them manage different application processes. The Region is flexible and easy to work with. AstaZero collaborates with several research and academic institutions such as RISE, Chalmers University of Technology, Royal Institute of Technology, Luleå University of Technology and Halmstad University. AstaZero is part of various EU initiatives, working groups, EU projects and research projects.

A key success factor for AstaZero has been the trust and social capital in the industry in the region. It has enabled the actors to come together and set up the facility. It is easy for them to hold a dialogue and collaborate. Furthermore, they try to be goal-oriented and to deliver value for the users of the facility according to set timelines. At the same time, they are a test and research environment and must be able to deal with uncertainties. However, this does not mean that they get stuck in circular discussions that do not move forward.

They involve citizen perspectives in their processes, but in different ways depending on the projects. In some cases, they have test persons involved who provide an input as citizens. At the same time, they are a testbed for the transport system as a totality, and there is an interest in understanding how future transport environments and cities can become more human-friendly. Human experience in cities has developed slowly and what exists is appreciated by many, but with the help of new vehicles, pods and drones, the environment can be improved. In order to achieve this, there is a need to test how new solutions can co-exist with humans. They have not yet hosted much of this type of R&D, but they are exploring how to work more with the traffic agency, transport agency and urban planners.

AstaZero sees as a trend that ecosystems are becoming more important, and big companies do not manage by themselves. Therefore, with smart specialisation is natural for regions to identify their areas of potential and focus their efforts on these.

3.15 Other testbeds

Awitar

Awitar (Automotive Wireless Test and Research Facility) is a stress test lab for full-size vehicles, for testing wireless communication systems and electromagnetic compatibility (EMC) for e.g. autonomous vehicles and active safety systems. The idea of Awitar is to provide a facility where vehicles can be tested in electromagnetic environments that can be controlled and repeated. An important part of the facility is the instrumentation for e.g. generating high field strengths, simulating complex wireless signals and creating a realistic environment for multi-sensor systems with radar, cameras, etc. The design and technology aspects have been developed in close cooperation with the Swedish automotive industry. The facility is designed to be able to handle cars, trucks and buses, as well as heavy construction machinery and other large heavy equipment.

ReVeRe

The Resource for Vehicle Research (ReVeRe) is an academic lab situated in a vehicle industry context, born from a collaboration between Chalmers, AB Volvo and Volvo Car Corporation, with funding from Region Västra Götaland. Inaugurated in 2015, it is co-located with Lindholmen Science Park. Its main objective is to enable ideas related to vehicles to develop into research and innovation, in particular within automated driving and collision avoidance. ReVeRe contains a research lab with resources – equipment, vehicles, and supporting personnel.

3.16 ElectriCity

ElectriCity is a cooperative venture that brings together 15 partners from industry, research and society, in the development and testing of solutions for next-generation sustainable public transport. The issues that are handled are: how to create preconditions for sustainable and attractive public transport, and what new opportunities arise for urban planning when noise and exhaust fumes disappear.

The partners involved work jointly to develop, test and demonstrate new solutions. Volvo Group is the initiator of ElectriCity and is responsible for development of the electrified vehicles and transport solutions used in the project. The background of ElectriCity is that the former CEO of AB Volvo had an ambition to support the development of Gothenburg and contacted the chair of the City of Gothenburg in 2013. Their discussions later resulted in the establishment of ElectriCity. Initially, it was the bus unit within the Volvo Group that was driving the project (Volvo Cars are not involved), which is a smaller unit. This has later moved to two other units, trucks and construction equipment.

Other partners involved in ElectriCity are: Region Västra Götaland (responsible for public transport in Västra Götaland and owner of Västtrafik), Västtrafik (the provider of public transport in the region), City of Gothenburg, Göteborg Energi (energy company for the residents of Gothenburg), Keolis (company that operates the buses in ElectriCity on behalf of Västtrafik), Chalmers University of Technology, the Swedish Energy Agency, Johanneberg Science Park, Lindholmen Science Park, Älvstranden Utveckling (city development area in Gothenburg), Akademiska hus (real estate company), Chalmersfastigheter (real estate company), and Ericsson.

A central part of ElectriCity is the testing and evaluation of electric bus operations. Since June 2015, electric buses have been operating the bus route 55, running between the two campuses of Chalmers University of Technology in Johanneberg and Lindholmen in Gothenburg. In June 2018, demonstration operations with electric articulated buses will be expanded to include part of route 16 (EL16).

The buses are powered by electricity from renewable resources, run quietly and are free from emissions. On board the buses, there are WiFi and facilities for charging mobile phones. As part of ElectriCity, there is also a platform for development and testing of products and services that can contribute to more attractive public transport, such as new bus stop solutions, traffic management systems and safety concepts, as well as systems for energy supply and energy storage.

There is also testing of new business models for sustainable mobility. The demonstration arena in ElectriCity features several projects that are linked to the collaborative joint venture. Companies that want to test products or services that can contribute to mobility and attractive public transport, can conduct testing activities at the demonstration arena. The test and demonstration project must be tested with at least one of the ElectriCity partners. The product or service may be something entirely new or it may be new in the context of sustainable mobility and attractive public transport. It must be possible to scale up the solution outside the arena. Two of the ElectriCity partners, the Swedish Energy Agency and Region Västra Götaland, are financing joint ElectriCity projects within their regular programme and financing tools. In addition, there are several research projects being run by researchers from Chalmers. Noise, the environment, safety, technology, behaviour and sustainability are some of the issues in focus. For example, one research project is evaluating buses and bus stops from the perspective of travellers and residents. Another project is investigating the situations that arise when a bus is used inside a building ('indoor bus stop'). Yet another project is focusing on the challenge of keeping noise levels low in the densified cities of the future. Chalmers has applied for research funding to investigate how the collaboration type/innovation management of ElectriCity supports the growth of attractive innovation environments in the region.

Partners may initiate projects that are suitable under the umbrella of ElectriCity. Other partners have a say in whether the projects should be taken on. Not all partners are part of all projects that are carried out under the umbrella; some are more interested in public transport, others in waste collection, charging technologies or noise pollution. The partners that work better in different circumstances do so. There is usually a lead partner and some other actors. It should be noted that there is little funding for the projects; the partners must organise their own funding. However, there are two partners that play more of a funding role: the Energy Agency and Region Västra Götaland.

Volvo is an important partner in the project; they were the ones who took the initiative, have invested most funds and carry out most projects. The impression from the project coordinators is that ElectriCity is a good project to showcase the solution, but also to test and learn new things. They feel that Volvo's understanding of their market, and various partners' needs and preconditions, increases through ElectriCity. Also, Volvo has many visitors who are interested in learning about the opportunities in the system, and this is a way of showcasing it in a structured way. They assess that there is at least one Volvo visitor per day. Furthermore, as they demonstrate new technologies publicly, it forces the development teams to sharpen up and deliver proper solutions.

Often, one of the partners in ElectriCity is responsible for a project. There are both main partners and project partners in ElectriCity. Main partners are representatives of the steering committee (City of Gothenburg, Volvo, Region Västra Götaland, Västtrafik, Ericsson and Chalmers). The steering group decides on expected deliverables from ElectriCity, the structure of the arena for demonstrations, goals, communication and accessibility. Not all actors are equally active, but all are engaged in some way in various projects. However, the project leaders try sometimes to have project partners pose questions and test them, rather than only coming up with ready-made solutions and testing them.

All participate because of their vested interests, but there are common interests and issues that can be aired and addressed through this forum. There are property developers who want to build future and sustainable cities, and want to solve the issues of shared spaces in a city environment. ElectriCity becomes a location to discuss ideas and how to solve potential conflicts of interest. There are regulatory and public policy angles, and this is a forum where these types of issue can be discussed in a less formal environment.

ElectriCity is based on a shared vision of sustainable transport, in which cities, regions, businesses and academic institutions develop working methods for research and demonstration projects, involving private and public sector actors and the academic world, and produce new scalable business models for sustainable

transport in cities. The current cooperation period will last until the end of 2018, but the intention is to continue until 2021.

So far, ElectriCity has resulted in a test route for fully electric and electric hybrid buses in the city of Gothenburg, with approximately 100,000 passengers per month. The test bus stops are both outdoors and indoors. Surveys show that the passengers are much more satisfied with bus route 55 than with other public transport systems in the city. Nine out of ten residents of Gothenburg know about ElectriCity and route 55. The project has shown that there is significant interest in future urban planning and electric public transport systems, in both Sweden and elsewhere. The project has attracted attention from the international media and has received many requests to take part in seminars and conferences. More than 100 delegations consisting of more than 5,500 people from all over the world have come to learn about ElectriCity. The visitors include customers, politicians, representatives of city authorities, ambassadors, ministers, members of royal families, research groups, students and public officials.

There are several research projects that have been carried out under the ElectriCity flag. These are carried out by the partners and coordinated by Chalmers. They include:

- (a) research from a user's perspective - how passengers, drivers and local residents perceive and interact with the new solutions;
- (b) indoor bus stop - focuses on maintaining a comfortable indoor environment and minimising the energy needed by the bus and the indoor bus stop;
- (c) controllable public soundscapes;
- (d) innovation leadership - a project which intends to systematise and package selected experiences and knowledge resulting from innovation activities, including experiences from ElectriCity;
- (e) innovation platform - access to digital data for research and for developing IT services; connecting charging stations to the electricity grid;
- (f) second-life batteries - bus batteries will be used to store solar energy from home solar panels;
- (g) a life cycle analysis study of the new transport solution; viii) the way in which the cooperation within ElectriCity functions;
- (h) a pre-study of the requirements for combining community planning, transport and housing; and
- (i) innovation competition - a research project in the field of open digital innovation.

Expected future results include continued demonstrations, testing and research. According to a representative of ElectriCity, the venture is a way for Volvo to contribute to the development of the City of Gothenburg, as it acts as a marketing tool, as well as a valuable tool when communicating the innovative aspects of the city.

ElectriCity contributes knowledge about the local market to property owners when building new districts of the city, to improve mobility solutions and show how shared solutions can improve the city environment. Göteborg Energi may use ElectriCity for testing; Västtrafik can learn about the preconditions for an electrified transport system. For the City of Gothenburg, ElectriCity is an arena where they can learn how to work with electrified transport and how this may affect city planning. According to the respondents in this study, ElectriCity can function as a neutral, freer arena for new ideas, balancing the needs from each partner organisation. ElectriCity is not part of any EU initiative, but some of the partners are.

Civil society is part of the project in that they are passengers and part of the environment. They have been subject to many studies and interviews. They are not co-creators in the project so far; there are some tentative ideas around this, but not yet been implemented.

The respondents indicate that a key success factor is having a neutral coordinator, who takes interest in the collaborative effort, cares about it, and bridges different vested interests. Secondly, it is important to move from discussing possible activities, to taking action. One also must accept that things can become messy, and that different parties may argue and have conflicts. This needs to be managed and overcome, but it is not a reason to avoid collaboration. For this reason, it is important to have a neutral party that can provide a bridge between the actors. One must also accept that some projects fail, and some succeed.

It is also important to keep expectations at a realistic level. This is similar to municipalities running citizen dialogue: the citizens can provide feedback, but should not expect that the municipality will do exactly as indicated in the feedback. Input is provided in a structured way. However, it is important to feed back to participants on the results of projects.

In ElectriCity, they perceive a danger with smart specialisation in that it can become too backward-looking and conservative if the focus is only on existing strengths. To succeed with smart specialisation, there is a need to be close to industry and build on collaboration with existing actors. It is important to test and demonstrate marketable solutions and not just carry out early research projects; there needs to be true market potential.

3.17 Other reality labs

DriveMe

DriveMe is the world's first large-scale pilot project in autonomous driving, where a large number of self-driving Volvo cars are being driven on public roads in Gothenburg. The groundbreaking project is a joint initiative involving Volvo Car Group, the Swedish Transport Administration, the Swedish Transport Agency, Lindholmen Science Park and the City of Gothenburg. DriveMe is backed by the Swedish government. The aim is to study the benefits to society of autonomous driving, and for Sweden and Volvo Cars to become leaders in sustainable mobility. The project started in 2014, with the first pilot cars launched on the streets of Gothenburg in 2017.

3.18 Vehicle ICT Arena

Vehicle ICT Arena (VICTA) ⁽²⁾ provides an open environment for innovation and maintenance of competence in automotive IT; it is part of Lindholmen Science Park. The arena is financed by a combination of public funds and membership fees. The initiative was taken by Volvo Cars in 2011, with the purpose of promoting competence development and innovation. An increasing part of innovation in the automotive industry is new software features, and there was a need to support the whole ecosystem around these issues. The founder believed that there was potential in building ecosystems and platforms involving smaller companies. Just as the PC and mobile phones are platforms on which many actors work, cars are perceived as being platforms or ecosystems that will allow many actors to create innovations. There is a need for collaboration to establish systems in which actors can support each other, to enhance each other's competitiveness. Volvo Cars invited actors to participate in pre-studies and discussions about the arena. The initiative was later handed over to Lindholmen Science Park.

The arena welcomes a variety of actors, such as newly established engineering firms, research institutes, universities and colleges, service providers and established suppliers to the automotive industry and automotive companies. One role is to support early ideas from research into early phases of innovation, and then to industrialisation. The arena offers an opportunity for the stakeholders to verify ideas technically in test environments. In the long term, VICTA builds the Swedish arena for automotive electronics. The ambition is to create an arena that is competitive on a global market.

The arena plays an important role between research and industry, where conceptual ideas can be taken through the early phases of innovation to industrialisation. Close collaboration with neighbouring arenas and centres of competence creates a strong ecosystem around the automotive industry.

The arena offers various types of meetings. Roundtable forums are organised, on a variety of strategical discussions. These are held between core and premium partners, for knowledge and information exchange. Innovation bazaars are larger networking meetings where actors meet, present research results, ideas and products, and discuss trends and consumer needs. An annual conference, Vehicle Electronics & Connected Services, is arranged with international speakers. The conference is regarded as an important meeting place for vehicle manufacturers and the supply chain.

Open innovation activities are arranged, as a way for larger companies to be introduced to new ideas, new products and service concepts outside the larger organisation. As a result, the larger companies then gain access to skills and creativity beyond their own company. The arena hosts innovation contests, in cooperation with vehicle manufacturers. The aim of these contests is to contribute to the development of new software-based features and services for the automotive industry, and to create an understanding of how management and processes in companies can be adapted. The vehicle companies invite third-party developers to contribute

² During the finalisation of this report, we learned that Vehicle ICT Arena had been discontinued.

to new software features. The format can be a 24-hour hackathon or a longer contest in which participants develop and submit their entries for evaluation. The host company for the innovation contest decides the subject area, conditions, competition rules and the jury. Only companies that are premium or associate members of VICTA can participate in the contest. In addition to owning the rights to their product, the participating companies also obtain the opportunity to showcase themselves and their expertise to the host company.

There are five core partners in VICTA: Veoneer (Autoliv was recently split; Veoneer is one part), Combitech, Ericsson, Volvo Cars and Volvo Group. There are also premium partners, such as: Alten, ArcCore, Business Region Göteborg, Chalmers University of Technology, Cybercom, Delphi, Halmstad University, HiQ, Kapsch, Microchip/SMSC Sweden, Pelagicore, QRtech, RISE, Semcon, Vector Informatic, VTI, and ÅF. There is also an option to be an associated partner of the arena.

Collaboration for innovation is frequently initiated by several of the actors or partners involved. Initiatives may later become projects. It is seen as important that one of the five core partners participates in the project.

The national initiative Wallenberg Artificial Intelligence, Autonomous Systems and Software Programme (WASP) acts as a complement and supporter of the arena. WASP supports strategically motivated basic research, education and faculty recruitment. The programme addresses research on AI and autonomous systems that act in collaboration with humans (adapting to their environment through sensors); information and knowledge; and forming intelligent systems of systems. Software is the main enabler in these systems and is an integrated research theme of the programme. Within WASP, there are also industrial PhD students (employed by a company and pursuing studies equivalent to at least half the time). WASP has invested in cooperation for autonomous vehicles.

According to one representative of VICTA, the added value of participation is being part of a collaborative initiative and finding partners. For core partners in the arena, one benefit is, as mentioned earlier, supporting the ecosystem and finding competence in order to be competitive on a global market, but also finding new innovations that can support their total offer. Results from the processes at the arena are transferred into business processes and production. Digitalisation is a major driver in the development, where the arena can play one part in the change process. In a longer-term perspective, the arena contributes to new knowledge and to long-term competence development.

They are engaged in processes where they involve users in innovation processes, foremost as drivers or car owners.

Region Västra Götaland was initially co-financing the arena and is now co-financing various R&I projects. The arena also collaborates with other cluster initiatives around the transport system and sustainable cities. Research organisations such as RISE, Chalmers University of Technology, Halmstad, Halmstad University and University of Skövde are all partners in the arena. VICTA is not part of any EU initiatives at present, but partners in the arena may be part of global initiatives.

VICTA has created many attractive meeting places, and contributed to competence supply through contributions to higher education, open innovation competitions, orchestration of collaborative projects and the setting up of testbeds. The meeting places include eight roundtable forums, which are half-day meetings with 30-40 participants for strategic discussions. The Innovation Bazaar, two half-day meetings per year with 150 visitors from 70-80 organisations, is an informal forum for Vinnova's FFI programme. It consists of presentations, mingling and organised matchmaking. They also collaborate with other actors at Lindholmen to set up large annual conferences, such as the Software Development Day.

They have set up an open innovation arena, where companies from the vehicle industry (Volvo Cars and Volvo Group) pose a challenge, and suppliers and software companies collaborate to address these challenges. The solutions have been systematised, and recommendations on how to address these challenges in future have been disseminated.

A key success factor for this initiative has been building on existing strengths around the automotive industry, and seeking out a niche in renewal, departing from existing networks and business relations and building this with new activities. They do not start from scratch. It is also important to work with long-term perspective and to have some kind of public co-finance, in particular for the facilitator's role.

In smart specialisation, VICTA perceives a need to be globally competitive, and focuses on the digitalisation of the automotive industry. There are three major trends: electrification, automation and the sharing economy. If the region's industry does not manage this shift, the region is vulnerable. VICTA believes it can support the

region's resilience by helping the regional companies embrace these new opportunities and spreading the knowledge to as many companies as possible. They are not trying to manage acute crisis (such as when Saab became bankrupt), but build more long-term competitiveness. They help the emergence of new companies, and diffuse knowledge to many regional companies. They also try to ensure that there is a regional voice in the knowledge development, so that this is not only foreign owners who set the direction. This is important with a regional cluster consisting of many regions, so that the region is not only dependent on one actor, who may leave or go bankrupt.

3.19 Other networks/clusters/industry associations

Drive Sweden

Drive Sweden is a national policy mechanism (strategic research programme) that delegates strategic planning to public-private interests. It coordinates Swedish research and innovation activities around mobility as a service. In 2015, Drive Sweden was selected as one of 17 strategic innovation programmes (SIPs) funded by Vinnova, the Swedish Research Council Formas and the Swedish Energy Agency. It is being operated by Lindholmen Science Park. Drive Sweden has developed an outlook showing what they want to achieve as a partnership by 2030. In order to achieve their vision of connected, autonomous, and shared mobility, a number of intermediary steps are outlined. Efforts in vehicle, mobility services and transport system research will be undertaken in an integrated manner that guarantees that Sweden's mobility of the future will be sustainable, safe and efficient, while also being attractive.

Test Site Sweden

Test Site Sweden is run as a programme at Lindholmen Science Park on behalf of Vinnova, with the task of developing test and demonstration environments in Sweden to support the development of sustainable transport systems, and to showcase them to other countries. Test Site Sweden started in autumn 2006, with the task of creating a demonstration and testing environment for products and services. Test Site Sweden now comprises two main areas: i) testbeds in the field of environmental engineering, on behalf of Vinnova - Test Site Sweden's role in this is to help Vinnova with calls for proposals and evaluations, and to be responsible for network activities; and ii) initiating and developing new test and demonstration environments for vehicles in order to support the development of sustainable transport systems.

BIL Sweden

BIL Sweden is the Swedish trade association for manufacturers and importers of cars, trucks and buses. Member companies account for around 99 % of new car sales in Sweden. The ACEA (Association des Constructeurs Européens d'Automobiles) and OICA (Organisation Internationale des Constructeurs d'Automobiles) are similar European organisations with which they work.

Teknikföretagen

Teknikföretagen (the Association of Swedish Engineering Industries) is an employers' organisation. They are present throughout Sweden and assist 3,900 engineering companies in labour law and industry issues. Teknikföretagen's mission is to strengthen the competitiveness of all member companies – large and small. They supply advice and support as an extension of a company's HR function. They influence and monitor decisions on labour law, environment, training and research in Stockholm and Brussels, and they work to encourage more young people to become engineers.

3.20 Vinnova - Strategic Vehicle Research and Innovation programme

Vinnova is Sweden's government agency for innovation, with a vision for Sweden to become a leading global player in research and innovation, and a country that is attractive for investment and entrepreneurship. Vinnova also aims to contribute to developing new solutions to major social challenges, such as the transition to a sustainable society or the challenges of an ageing population.

Each year Vinnova invests around SEK 3 billion in activities supporting innovation – both short-term innovation projects and research, and long-term strong R&I environments. An ambition is to stimulate

collaboration in Sweden and internationally, between companies, universities and other higher education institutions, public services, civil society and other actors. Vinnova provides financing in the early stages of innovation processes, as well as the opportunity for enterprises and organisations to experiment and test new ideas before they become profitable.

One of Vinnova's programmes is Strategic Vehicle Research and Innovation (FFI), a partnership programme run jointly by the Swedish state and Swedish automotive industry. The programme finances research, innovation and development related to the environment and safety. The programme's goal is to contribute to Vision Zero (no one killed through traffic accidents), reduced fossil fuel dependence, and increased Swedish competitiveness in a global market. The initiative involves research and development funding totalling around SEK 1 billion annually, almost half of which is public funds.

The overall goal of FFI is to:

- reduce the environmental impact of road transport;
- reduce the number of people injured and killed in traffic accidents;
- strengthen international competitiveness.

The programme is mainly focusing on research, with the aim of supporting and keeping research in Sweden. The programme is also important from a perspective of developing and providing competence. The greatest beneficiaries of funding are the research institutes and universities. The programme supports a range of activities within higher education, as well as financing postgraduates within academia and the research institutes. This skills development is an important factor, and the respondent from Vinnova thinks that this great concentration of skills in Gothenburg, and the commitment to continue developing these skills, is one reason for the great interest from the Chinese companies in locating to Gothenburg, e.g. CEVT and Geely Innovation Centre.

There is also a general (and historical) ambition of the Swedish state to keep employment in Sweden through partnering with the vehicle industry, which has an impact on Swedish industrial development in general. It is a large industry with many multiplier effects for other industries.

FFI has been running since 2009 and has no end date. FFI builds on previous vehicle research programmes where the state and industry have collaborated successfully since the beginning of the 1990s. These programmes came to an end around 2008, at the same time as the major financial and automotive crisis. At that time, it was decided to make a strategic and long-term effort.

From the programme preceding FFI (the Vehicle Research Programme FFP), the most important contribution was to maintain the competitiveness of the Swedish automotive industry by strengthening research expertise and absorption capacity, strengthening partnerships with universities and institutes, and strengthening internal competitiveness for the passenger car manufacturers within the foreign-owned groups. The entire FFP setup was an early success, as well as a trendsetting example of the triple helix format with broad official involvement, which: a) made it possible to factor in a number of public interests; and b) involved genuine user-controlled research and offered companies as well as research institutes something they needed (a win-win solution).

FFI builds on these experiences. FFI is based on a collaborative agreement and contract between the different parties. The board consists of members from both the state and the vehicle industry, with representatives from AB Volvo, Volvo Cars, Scania, FKG (the trade association for Scandinavian suppliers to the automotive industry), BIL Sweden, the Swedish Energy Agency and the Swedish Transport Administration. The secretariat of the FFI is located at Vinnova.

The activities within the programme are divided into five permanent areas and each is run by a separate plan. A larger part of the budget, approximately 75 %, is funding innovation projects within these five permanent areas:

- Energy and the Environment
- Road Safety and Automated Vehicles
- Electronics, Software and Communication
- Sustainable Production
- Efficient and Connected Transport Systems

Currently, FFI also has strategic focus areas with their own description, running alongside the five permanent areas. These are:

- Bicycles and Other Vehicles in a Safe and Smart Cooperation for a Sustainable Future
- Automotive Security and Privacy
- Complex Regulation
- Machine Learning

These constitute an opportunity for the board of FFI to strengthen a specific area with specific funding during a limited timeframe.

Vinnova's view on Volvo, and the regional actors surrounding Volvo, is described as collaborative and active. Volvo is described as taking an active role in both international EU programmes and national programmes.

Evaluations of FFI and its predecessor programmes say that Volvo is an example of how companies have a conscious strategy of using different programmes for different purposes. Participation in EU framework programmes is done in order to develop, jointly with other European vehicle companies, a long-term view of how technology is developing. Participation in the national programme is done to give better conditions for product development. Volvo also participates in a number of other Vinnova programmes in order to follow developments in other important and central knowledge domains: materials, manufacturing, etc. There have also been dedicated programmes and projects that have helped automotive industry to develop knowledge that has improved their competitiveness, such as funds for traffic safety that have helped Volvo and Autoliv to develop products that are competitive in international markets.

According to Volvo, this has contributed to developing and enhancing the innovation ecosystem. All actors know each other better; if there are good ideas to explore there are funds available, and also good opportunities to find and engage relevant partners.

Also, regional public actors such as the City of Gothenburg and Region Västra Götaland are described as mutually active. Region Västra Götaland is described to have a general attitude towards collaboration that generates good conditions for strong relationships. The collaboration between them and Volvo is described as based on mutual dependency, generating results that continuously strengthen the collaboration.

Evaluations show that the constructive cooperation between vehicle companies and their suppliers, authorities and academia has been rewarding for all actors involved. Among other things, it has led to the following:

- industry has increased ability to quickly absorb research results in its product development.
- public co-funding of projects has made companies able to take greater risks and focus on strategic areas with applications, with benefits that will only come in the longer term.
- companies have increased their skills by recruiting graduates with training as researchers.
- academia has developed competence in new research areas that are in demand.
- important innovation environments have developed, anchoring leading companies in Sweden.
- innovations have spread to other industries.
- by 2016, FFI had delivered 606 completed and 247 ongoing projects:
 - 131 PhDs, 148 Licentiate degrees and 728 graduation projects
 - 765 articles in scientific journals
 - 363 results introduced on the market
 - 290 results from projects used for policymaking.

3.21 Other research and innovation funding programmes

WASP

The Wallenberg Artificial Intelligence, Autonomous Systems and Software Programme (WASP) is a major national initiative for strategically motivated basic research, education and faculty recruitment in autonomous systems and software development. WASP is Sweden's largest-ever individual research programme, and provides a platform for academic research and education, fostering interaction with Sweden's leading technology companies. The programme addresses research on autonomous systems acting in collaboration with humans, adapting to their environment through sensors, information and knowledge, and forming intelligent systems of systems. The starting point for WASP is the combined existing world-leading competence in electrical engineering, computer engineering, and computer science at Sweden's four major ICT universities: Chalmers University of Technology, KTH Royal Institute of Technology, Linköping University, and Lund University. WASP will strengthen, expand, and renew the national competence through new strategic recruitments, a challenging research programme, a national graduate school, and collaboration with industry.

4 CASE ANALYSIS

A range and combination of factors is driving the development of the regional innovation ecosystem around the vehicle industry and Volvo in Gothenburg, such as political, market-related, socio-cultural, relational, academic and technological ones. These can be contextual, regulatory or institutional enabling factors.

There are several factors driving political interest and investments in intermediaries, and there are factors and relationships at different geographical and political levels that affect each other: influences from local, regional, national and international levels. There is no single actor governing the innovation ecosystem around the automotive industry in the Gothenburg area, but a number of actors and agencies that play different roles. However, regional actors have a number of shared interests, and collaborate in order to strengthen the development of the ecosystem and modify it. They use their own resources, but also draw upon available funding schemes.

There are a number of reasons for companies like Volvo to seek collaboration with other stakeholders in the form of triple and quadruple helixes. These include improving the sourcing of new knowledge, developing more relevant products and services, co-developing new standards, testing new technologies and building acceptance for them, and securing access to skilled and relevant labour. However, true quadruple-helix collaboration as described in literature (where industry, academia, public sector and civil society/NGOs are all involved in all steps of the development process) is not observed in this case. It may be easier to organise more equal quadruple-helix constellations when the core for collaboration is around communication or services, than complex and costly technology systems.

The innovation ecosystem in the Gothenburg area is the result of a decentralised process. It is not the outcome of a planned development strategy by one actor, but an evolutionary process through interaction between stakeholders. Key to this process was the trust and good relations between the actors, as well as a sensation of common interests. The work in Västra Götaland contains many components of a smart specialisation process. The Region did not rigorously follow the RIS3 guide nor any other methodology when developing strategy. Neither have they set up formal governance structures; the approach instead builds upon established informal relationships. In any case, here too the starting point for strategic planning remains the joint identification of interventions by stakeholders and the focusing of efforts on a number of priority areas.

This chapter outlines the various enabling factors for the system, how governance takes place, and the strategic directions.

4.1 Contextual enabling factors

On an overarching level, a number of societal challenges and trends are influencing the development of the regional innovation ecosystem. **Environmental considerations**, due to climate change, are one of the main drivers in the automotive sector pressing towards the adoption of new regulations and the allocation of public funding to invest into technologies and solutions geared to reduce the emission of pollutants. These include new, more energy-friendly technologies for personal vehicles, as well as new means for mass communication and public transport.

Traffic safety is another issue driving political interest. It is not only nationally motivated, but is also included in the 2030 Agenda for Sustainable Development (United Nations, 2015): ‘By 2020, halve the number of global deaths and injuries from road traffic accidents.’ (Sustainable Development Goal 3.6); ‘By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.’ (SDG 11.2). In Sweden, these goals influence both national and regional policies, e.g. the Swedish Innovation Agency uses Agenda 2030 as target objectives for how to invest in societally desirable activities.

Traffic safety has been a priority research topic in Sweden for years and substantial investments have been made, most notably in setting up the SAFER institute in Gothenburg, a world leading research centre on the topic. Since 1997, Sweden has been running ‘Vision Zero’³, a road traffic safety project aiming at achieving

³ https://en.wikipedia.org/wiki/Vision_Zero

a highway system with no fatalities or serious injuries involving road traffic. Vision Zero and other investments in traffic safety have supported the emergence of both new intermediary platforms and research institutes. They have also created knowledge that supports the competitiveness of Volvo in developing safe cars, but also companies like Autoliv who develop different products for safety in cars.

One key concern in the ongoing technological movement towards **autonomous vehicles** is safety. Can cars be left to drive themselves? Is it safe? Is it in fact safer? How does this interact with the rest of the traffic environment? Some of these issues have been addressed in the past within the various institutes and intermediaries in West Sweden. This past knowledge is now being updated to take into account an autonomous vehicle perspective, addressing issues such as the requirements for allowing self-driving vehicles, and how this can assist drivers to potentially make traffic environments safer. The government and industry have a joint interest in developing knowledge and solutions around this topic. This has been driving public investments in some of the intermediaries explored in this study, such as SAFER, AstaZero, DriveMe and ElectriCity.

Currently there are significant ongoing technology shifts, with the electrification of cars, autonomous driving and **connected vehicles** becoming realities; these are having an impact on the innovation ecosystem. Information and communication technologies (ICT) are profoundly changing how companies and societies operate. ICT is not just about changing some parts to being computerised; entire systems for product and service delivery are changing, and with them some actors and business models disappear, and new ones emerge. If a region is unlucky and has a strong focus on specific technology solutions that become outdated, they stand the risk of massive unemployment and economic decline (rust belts). At the same time, having the right investments can help a region to rise as a new global centre.

For the vehicle companies, there is a realisation that it is necessary to develop competences around these technologies. Even though regulation will not allow entirely autonomous vehicles in the traffic environment, there will be many circumstances where they can drive by themselves and there will be assisted driving functions. Even if not all vehicles will become entirely electrical in the short or medium-term, there will be hybrid parts with an electrical drivetrain combined with other types of technologies, and there will also be substantial numbers of fully electrical vehicles. Vehicles are also to an increasing degree becoming connected to various types of information and communication systems, for transport planning, traffic information, etc. Therefore, it is a requirement to have access to these technologies and to take a competitive stance.

Technologies in themselves are consisting of more sub-technologies and connecting with each other and between domains. So it is important to understand what happens in different domains and build upon other developments to produce technology. Many companies both scout for new technologies developed by others to include in their offer, and try to find new ways to trade knowledge.

Therefore, it is a competitive advantage for a company to be located in a setting where it can easily access skilled labour, suppliers with competitive innovations, important customers and providers of knowledge on e.g. advanced innovation ecosystems. Policymakers also want to support the growth of these types of competitive clusters. Furthermore, these clusters are connected in global value chains where certain regions increasingly specialise in different functions, but there is a need to collaborate and trade with other actors and suppliers to deliver offerings.

The companies and regions that can build a position in this will be part of global value chains. There are opportunities both for car manufacturers and for suppliers of technologies in this domain. There is recognition from the government that this will be key, and therefore there is an interest in supporting activities exploring these technologies and building competences and capabilities for them, but also in supporting Swedish companies to shift and take up technologies. In this there is a strong political will to support industry and societal actors to seek new solutions to deliver better services, but also to support industry to adapt and stay competitive, or support new actors who could become tomorrow's leaders. This is the rationale for the Strategic Vehicle Research Programme FFI, for example.

Digitalisation is another strong driver for the automotive industry. A key area that has been identified by actors in the Västra Götaland region is artificial intelligence. A large consortium of actors has come together to set-up an artificial intelligence (AI) centre, Data Factory & Arena, which will be hosted by Lindholmen Science Park. The funding is a mix of public and private money. Several research centres have also been set up, covering various digitalisation topics.

Another contextual factor is globalisation, which both increases competition and creates opportunities for new investments and new markets. In connection with this, there are however international trade rules on whether and how a country can support its industry (e.g. EU-based state aid and competition law, and World Trade

Organization agreements). From the government side, there is an interest in supporting industry in possible ways to stay competitive and keep high income jobs in Sweden, but also in attracting foreign investments to a region (e.g. Sweden's National Strategy for Sustainable Regional Growth and Attractiveness) ⁽⁴⁾. The expectancy is that using some tax money will secure high-income activities that will substantially offset the public investments and the taxes collected to do this. These strategies include support for strategic research and for clusters of competence, i.e. agglomerations of companies, research institutes and academia, concentrated in a certain field. These locations are attractive settings, as they support industrial competitiveness but can also attract foreign direct investment (FDI).

4.2 Regulatory and institutional enabling factors

Beyond the global context and the driving factors, there are also regulatory and institutional enabling factors. Innovation does not come about in isolation, but through interaction between individuals, within and between firms, and between firms and knowledge-exploring organisations, such as universities and research institutes, and also users, customers, regulators, public and private service providers (Edquist, 1997; Von Hippel, 2005). However, these interactions are affected by institutions and regulations that influence how interaction takes place (Hodgson, 2006). These include hard influences, such as regulation, but also softer ones such as culture, established practices, standards and norms; also various forms of policy systems that finance and facilitate interaction. This means that innovation processes are socially embedded. These factors also play out on different levels: some are local or regional; others national, European or global. Furthermore, these social structures both influence the behaviour of actors, and can be altered by agency of the actors (Hodgson, 2006).

What we have seen in this case is that there are also different types of actions at local, regional, national, European and global levels. The two Volvo companies have relationships on different levels, and interplay with different political interests at different levels, which has an effect on the innovation ecosystem and its development around the Gothenburg area. The two companies build certain types of consortia at EU and global levels, to influence the development of standards and de facto systems that fit their visions. In this context, they collaborate with other automotive companies in the EU Framework Programme for Research and Innovation (Horizon 2020), which funds, for example, the European Green Vehicles Initiative ⁽⁵⁾. They are also affected by national and EU-wide regulations, therefore engaging both in joint collaborative research to establish standards, and in influencing regulation through their own lobbying efforts and through lobby organisations such as Teknikföretagen and BIL Sweden. They collaborate at national level to develop knowledge for product development (in the Strategic Vehicle Research and Innovation Programme, FFI), and interact with city and region to develop the regional innovation system, test and showcase technologies, and build acceptance of new technology solutions.

The two Volvo companies and the innovation ecosystem benefit from the political interest in adapting to globalisation. In the economic crisis of 2008, which had a major impact on the automotive industry and led to major restructuring of the industry, resulting in the closing of one of Sweden's two large car manufacturers, Saab. This company had been struggling for a long period of time and its owners, GM, did not have the muscles to continue supporting the brand. A Dutch entrepreneur that did not manage to turn it around owned it for a short period. After this a consortia of Swedish and Chinese owners focused on creating an electrical car took over the assets. This company was called NEVS and the Saab brand was reused for other purposes, like fighter jets. NEVS was struggling until recently, before being resupplied with capital and forming a coalition with a Swedish electrical sports car company, located in Koenigsegg in the south of Sweden.

In the entire industry, there was substantial reduction in staff, the ownerships of Volvo changed, and there was great turmoil in this strategically important industry for Sweden. At the same time, other large Swedish companies reduced private R&D investments, e.g. in life science. In connection with this, the Swedish government raised the amount of funds going to R&I, and also those targeting strategic research areas (e.g. automated vehicles and transport systems), collaborative research, and research excellence (Swedish government, 2008). This raised the amount of funding going to the innovation ecosystem and its actors around the automotive industry in the Gothenburg area.

⁴ <https://www.government.se/information-material/2016/04/swedens-national-strategy-for-sustainable-regional-growth-and-attractiveness-20152020---short-version/>

⁵ <https://egvi.eu/>

In response to the financial crisis, Sweden increased innovation support for the vehicle industry via the FFI programme. As a result, around 70 % of this programme is channelled to West Sweden. The programme supports product development in industry, while at the same time building competence in intermediaries and knowledge institutions in Sweden. FFI is a successful programme that has led AB Volvo to increase the amount of R&D carried out in Sweden (from 50 % to 60 %).

In addition to this programme, other research funding is directed to universities and research institutes in West Sweden. It is worth mentioning some other important national R&I funding programmes targeting collaborative approaches, which have funded activities in the Gothenburg area that are of importance for the automotive industry. These include the Vinnova programmes VINN Excellence Centres/Competence Centres ⁽⁶⁾, Vinnväxt ⁽⁷⁾, and the Strategic Innovation Programmes ⁽⁸⁾, which among other things funds Drive Sweden ⁽⁹⁾.

Both the regional and local political levels are interested in promoting the regional industry and helping it stay competitive, and are therefore interested in supporting industry and consortia with academia in different ways. One is to support them to attract national and EU funds for different projects and institutions that can support the innovation ecosystem.

There is also a trend in industry and innovation policy to **support cluster organisations, platforms and research institutes** that can support knowledge-based growth among industry. These policy trends are also connected with a process of open innovation in industry. Global value chains that deliver products and services, and the technologies that they are building and building upon, are increasingly complex and include actors from many locations around the world. The all-encompassing Ford Motor Company, with its own rubber plantations and mines to provide primary goods for its cars, and its own sales organisations, no longer exists. There has been a long trend of companies focusing on core activities and connecting to other actors, both to produce their offerings (products and services) and to provide them. In this process, it is important to have some core unique competences, appropriate business models and connections to customers to stay competitive, but it is also key to have access to key inputs to be able to deliver offerings.

It is in this context that part of European Regional Development Funds should target these types of investments. Also, many regions and countries engage in policy activities supporting innovation and knowledge-based growth, as there is a consensus that this is a correct approach to supporting development. In addition, regions and cities both have some funds of their own, and try to leverage and attract national and EU funds to their region.

The city and region are interested in supporting the testing and showcasing of new technologies in real environments, to support innovation but also to identify new sustainable solutions in transport. In addition, the city is interested in learning about how to **design new urban areas** (also an interest for property owners), about better mobility solutions and how shared solutions can improve the city environment. The city has a specific unit that matches their own development needs with those of external actors. There are R&I projects within autonomous and connected vehicles. The Traffic Office participates in DriveMe as a way to develop the traffic system through the new technologies both in vehicles and in the city environment. The vision is a city that is designed for people, not for cars.

An important area of interaction in the innovation ecosystem between the two Volvo companies and the city is education and skilling of labour. Securing access to skilled labour is a key issue for the two companies, who are both interested in attracting international talent. In this, they collaborate with the city and the region in recruitment programmes, and also influence local services such as schools to be attractive to international experts. The two Volvo companies are also concerned that educational and vocational programmes train the right type of staff to meet their needs, and for this reason, they interact with the authorities to influence the curricula.

The technology shifts are also observed in the way that the car industry and its suppliers are looking for different types of skills and labour. There is a huge demand for software and electronics engineers. The vehicle industry is employing labour with this skill, but they have also developed programmes in conjunction with the unemployment agency to retrain staff to pick up these skills. The ideal staffs for the car industry are engineers who have training in mechanical engineering, and in software and electronics.

⁶ <https://www.vinnova.se/en/m/kompetenscentrum/>

⁷ <https://www.vinnova.se/globalassets/mikrosajter/vinnvaxt/dokument/vinnvaxt-a-programme-renewing.pdf>

⁸ <https://www.vinnova.se/en/m/strategic-innovation-programmes/>

⁹ <https://www.vinnova.se/en/m/strategic-innovation-programmes/drive-sweden/>

At the same time, there is a desire to have access to top talent when it comes to technology development, and one issue that has been raised by the car companies is how they can attract these talents to their region and secure access to them. One comment is that salary is not likely to be enough. Top talent wants to be part of an environment with other skilled people who can match them and also develop them. The Volvo companies want to support various types of centres of excellence that can attract top skilled people, but also support these R&I environments by giving them access to the latest types of technology and helping to formulate research programmes and questions that make research relevant.

A new and recent approach is the MobilityXlab, where the large companies are exploring how to better interact with SMEs and start-ups. This is a way to scout for future technologies, but also structure how they can collaborate with these smaller actors and build relationships with them.

Another important enabling factor is the cultural context, and the social capital and trust among actors in the region. There is a tradition and experience of collaboration in the region. The companies have collaborated with each other, and with academia and the public sector. There is experience of collaboration across sectors. There are also informal and formal networks between sectors – both through formal relationships, with Volvo staff being on institutional councils, etc., but also many informal ones, as many of the Volvo staff have studied together with Chalmers staff and participate in various platforms and networks where they interact due to shared interests. There seem to be a certain degree of revolving doors, where actors move back and forth between industry, academia and innovation support.

There is good collaboration between the Volvo companies and Chalmers, which seems to be mutually beneficial. This has been conducive to setting up research centres of excellence such as SAFER (on traffic safety) and CLOSER (on transport efficiency), which has generated knowledge to support innovation.

There is currently strong growth in the automotive cluster around the Gothenburg area, with growing employment, new start-ups and significant foreign direct investments, notably by the Chinese company Geely. Some of the respondents indicate that after Geely's takeover of Volvo Cars, they have grown increasingly satisfied with Volvo Cars as a company, and with Sweden and the Gothenburg region as innovation systems. They found Gothenburg a good location to do key research and innovation work for their entire group. They have set up more innovation centres and development companies in the region, and purchased large shares in AB Volvo, which could be seen as evidence of the strength of the area in innovation.

4.3 Formal governance model

Sweden's rate of investment in R&D of 3.25 % of GDP (2016) is high by international comparison. Of this, roughly two thirds stem from the private sector and the remaining third is publicly funded – mostly to fund the universities and to a minor extent public research institutes. The key governing documents for public sector R&I are the governmental research bill and energy research bill (both released every four years, most recently in 2016), and the national innovation strategy which was issued in 2012 and provides overall guidelines for Swedish innovation policy up to 2020 (Hallonsten and Slavcheva, 2018). Swedish public administration is characterised by relatively small government ministries, and larger agencies responsible for specific policy areas. In the R&I policy area, the Swedish Research Council and Vinnova are the most important agencies.

The research budget is dominated by institutional block grants to universities and colleges. The long-term trend is, however, that the importance of third party funding will increase. There has been a drive to promote university collaboration with other sectors, primarily business and public sector actors, but also civil society. This has turned universities towards a more entrepreneurial role. The 2016 research bill emphasised academic collaboration with society, partially in contrast to its predecessor bills whose focus was rather on strategic specialisation and promoting excellence in research (Hallonsten and Slavcheva, 2018). A parallel development to reshape the relatively small Swedish research institute sector was concluded in 2016, when three institute groups were merged into the larger RISE – Research Institutes of Sweden (Hallonsten and Slavcheva, 2018).

Then there are some regional and local funds directed towards R&I, which are at a much lower level than national funding. However, regional and local actors provide funding, co-funding, support and legitimacy for actors, and collaborative efforts in applying for national and EU funds to secure investments attracted to the region and to leverage available regional and local funds.

The West Sweden vehicle cluster is not the world's largest, but it is a complex weave of vehicle manufacturing, development and innovation, suppliers from different tiers, universities, research institutes, and innovation intermediaries that support innovation at various technology readiness levels (such as incubators, accelerators, testbeds and science parks). There are actors providing support to start-ups, incubation, acceleration, business advice and venture capital (e.g. Gothenburg University, Chalmers Innovation, ALMI, EEN, Connect GROW and MobilityXlab).

There is however no single actor that controls the innovation ecosystem around the automotive industry in the Gothenburg area, but a number of actors and agencies that play different roles. However, regional actors have a number of shared interests and collaborate in order to strengthen the development of the ecosystem and modify it. They use their own resources, but also draw upon available funding schemes.

There are a number of platforms that facilitate discussion among actors and can determine industry and societal needs, and that can play into the development of new platforms and joint initiatives to drive the long-term competitiveness of the industry in the regional setting (although this also has a national angle). In this ecosystem, **Lindholmen Science Park plays an important role as a mediator and meeting place**. They work deliberately through formal and informal contacts with stakeholders to formulate collaborative efforts; they initiate them with help of local, regional and industry funding, and then eventually leverage the projects with other sources such as national and EU funding. They are important in that they have this operative role in enhancing the development of the ecosystem, while the Region works more strategically.

There are also national initiatives that are important for dialogue at the Swedish national policy level and with the EU, such as Teknikföretagen and BIL Sweden. The Strategic Vehicle Research and Innovation programme (FFI) also appears to be an arena for determining R&I needs common to both industry and academia that supports these actors' needs, while being important for fostering collaborative links between stakeholders, and for formulating long-term development agendas.

The institutional representatives interviewed for this case study expressed a preference for a bottom-up approach to governance of the innovation ecosystem, in arguing that the needs of stakeholders should drive the setting up of innovation support actors or collaborative projects. These initiatives should support not only single companies, but many actors in the system, and be conducive to collaborative activities. They fear that setting up facilities top-down, to drive political ambitions that are not anchored in companies or academia, is not likely to generate results. This has been a guiding criterion for funding, expressed by the respondents from the region, the city and within the FFI. If this is not industry-driven and based on real regional industry needs, they will not proceed. The companies seem to be good at articulating their needs, but also serving as collaborative partners, providing both funding and manpower.

Region officials interviewed also indicated that they do not act on all opportunities made available from the national and EU levels. They perceive that there are many initiatives and not all are relevant for their innovation ecosystem. In particular, when an existing initiative seeks to continue by slightly redefining itself to fit the latest call for funding, they tend to stop supporting the initiative, as they perceive it as no longer fulfilling a need in the ecosystem and feel it should consequently be shut down.

There seems to be a shared interest among stakeholders in developing the innovation ecosystem, where the companies both work through public channels, but also sometimes **use their procuring power to influence suppliers to locate to the region**, e.g. AB Volvo has asked suppliers to relocate to the Gothenburg area in order to supply them.

It is clear that in the Gothenburg area, informal governance is possibly more important than formal governance. In Sweden, the phenomenon known as *Göteborgsandan* (Gothenburg spirit) is well-known. It was initially a description of the good collaborative climate between high-level representatives, and how close relationships and certain flexibility within bureaucracy made things happen. This has been conducive to setting up collaborative efforts in the region. In the past few years, there have been scandals related to the Gothenburg spirit (however, not in the vehicle industry setting), where it has been connected with not following regulatory procedures, and with bribes and corruption. These are two sides of the same coin, which must be handled carefully.

There is a need for platforms for discussion and deliberation, but these can't remain talk shops; they need to move to action. As one of the respondents (Peter Janevik) said, 'We cannot stay at circular discussions, but need to identify objectives and work towards that, even though goals and methods may need to change over time, and as many of these projects relate to exploratory work, the outcomes are not known from the beginning.' Also, certain collaborative set-ups may need to change over time, as reality changes; some partners may need to leave or others be added. Projects and the purpose of intermediaries need to be

understood in similar ways by the partners entering into them. However, there may be diverse expectations on what will be delivered for the actual benefit of different actors; despite different interests, vagueness about incentives and ambitions is not a factor for success.

It is a common observation by the respondents that other regions should try to foster a similar climate of positive dialogue between stakeholders as in the Gothenburg region, and support the long-term relationships between them. At the same time, the support that will be co-developed should not be geared towards individual companies as such, but develop the ecosystem, which will in turn benefit the industry and other partners. In this, it is important to set up platforms that can act as neutral brokers without vested interests, facilitate the dialogue between actors, initiate projects and also manage them. These brokers can support knowledge sharing and diffusion in the system. They can also help facilitate processes, especially where these are not conflict-free, as this can help overcome differences and try to foster a win-win solution in the longer term.

4.4 Quadruple helix model

There are a number of reasons for companies like Volvo to seek collaboration with other stakeholders in the form of triple and quadruple helices. These include improving the sourcing of new knowledge, developing more relevant products and services, co-developing new standards, testing new technologies and building acceptance of them, and securing access to skilled and relevant labour.

The two Volvos need to adapt to trends such as digitalisation, electrification and autonomous vehicles, and they are interested in taking leading positions in these domains. In order to do this, they can do partial research and development in-house, but there is also a need to collaborate with other actors to develop future standards on how vehicles will interact.

There is also a need to test and showcase products. Test environments such as AstaZero, where they can run large-scale tests without jeopardising the safety of others, are therefore important; as are DriveMe and ElectriCity, both of which enable testing of how the solutions function in real environments involving other actors from the traffic system. DriveMe is mostly a project to train algorithms based on huge amounts of data gathered from driving in the city environment. DriveMe is also a way to pick up user feedback that could influence development. Volvo Cars' DUX (Digital User Experience) Development Centre works together with Halmstad University in a project to run ethnographic studies to develop future solutions for self-driving cars.

DriveMe is also important for showcasing new solutions. It is a way of preparing citizens and users for these technologies and building acceptance. For Volvo Cars, it is also a way of showcasing and upgrading their brand from safe cars to safe autonomous cars, especially since there is doubt among consumers about whether this really works.

The two Volvo companies are positive about collaborative initiatives with academia; they see it as a way to solve problems more quickly and efficiently, using new ideas and competences. For researchers, it is a way to get access to the latest equipment, technology and funding, as well as ensuring relevant research questions. To make it work, it is important to define the different roles and rights of the partners, and a fair license scheme.

There are various levels of collaboration between the university and the two Volvo companies. There are the high-level agreements between the CEOs and the president, where there are discussions on the long-term design of education and research projects. There is also involvement by Volvo staff in projects and centres and in seminars. The Volvo companies are obviously influential in the area of strength around transport, where they have a form of strategic partnership. The agreements facilitate opportunities for industrial PhD students and adjunct researchers from the industry to access joint knowledge networks, research infrastructure and labs.

There is also a strong drive for the companies to secure talent recruitment and ensure that future staff is trained and gains the right types of skills from the universities. They are therefore interested in relationships with universities that can help secure this development.

As already explained, the Gothenburg innovation ecosystem is not controlled by one single actor, but is the outcome of many different stakeholders and their relationships and activities. Some actors are more important than others and influence it more, such as the city, the region, the universities and big industrial players.

With regard to quadruple helix versus triple helix, in the Gothenburg innovation ecosystem there are indeed a number of projects and processes where end-users, citizens and various specific interest groups are involved in development projects and influence them, speeding up development processes and improving the results. Both Chalmers University and Lindholmen Science Park organise a range of forms of quadruple-helix type activities. Chalmers does so mainly through various forms of seminars, but it is also involved in research projects in electricity, where it explores user behaviour. The team also includes the public transport office and companies that will take the risk of investing in the development of new technologies based on the project findings. In turn, Lindholmen Science Park organises various forms of workshops, innovation competitions and something called Innovation Bazaar, where they mobilise actors in the quadruple helix. Broad invitations are issued, but they tend to be accepted by the usual actors interested. It has generated results; for example, Region Västra Götaland participated in a development project where they tested mobility services. The outcome was a Mobility-as-a-Service (MaaS) company UbiGo⁽¹⁰⁾. Users participated in this project in a real way and the company was founded as a result. The service is now being used by the public transport companies of Gothenburg and Stockholm. There are similar examples in ICT and app development. Quite often in these processes, the interested parties and potential suppliers are already in the room.

However, these examples can probably not be considered true quadruple-helix projects or arenas. Typically, these processes are dominated by some actors, in particular those who invest resources and take risks related to the development of the projects. As an example, the UbiGo service is connected to a system that is developed and owned by VGR, in which they invest EUR 500 million per year. It is reasonable that they control and decide how potential third-party actors interact with their system.

This is also a fundamental issue in relation to quadruple helix. What is described as quadruple helix in the literature often struggles in real-life settings. Ensuring that any stakeholder is part of all steps of a project's development may make processes more costly, and there is no clear benefit from this participation that matches the costs. It is probably easier to organise more equal quadruple-helix constellations when the core for collaboration is more around communication or services. At the same time, these areas are quite often dependent on existing technology systems.

The reasons for expert systems reaching out to various interest groups in society have so far been to request feedback on how to invest and govern activities. This is of interest when an institution's reputation is at stake or it is hard to identify any kind of specific expertise. More open innovation approaches may fit well in identifying solutions to more complex or difficult problems, where there is a need for interaction between multiple actors in order to overcome them, rather than for the development of more specific technologies.

These types of consideration are addressed to some extent in urban planning and citizen dialogue, which are part of political processes in the Gothenburg area. As an example, this is important in the development of the new neighbourhood of Gothenburg that is being created by recuperating old industrial zones along the river – RiverCity⁽¹¹⁾. Here, broad and inclusive processes are being used to define living, infrastructure and transport needs. In addition, there are projects in the context of ElectriCity that explore these issues. To some extent, the city is analysing and dialoguing with citizens about future transport systems and urban planning, to design human-friendly cities and traffic environments. Output from these processes can be picked up by the city, the Region and public transport companies, but also by property owners. However, this is less about pure R&I issues, as user and citizen involvement is perceived to be more convenient in certain steps of development processes. Furthermore, these types of inclusive processes do not put all people in the room on an equal footing, although any participant in the process should be able to provide input and communicate. Indeed, inequalities in the provision of resources, risk and commitment to processes tend to be reproduced in decision-making. Likewise, some public processes and resources cannot be replaced by these networks, as there are democratic processes to manage them, and providing certain stakeholder groups with more influence in decision-making would lead to bypassing democratic processes.

The design of these types of projects and labs needs to be carefully considered, as it has also been argued that civil society involvements in complex technical projects are mostly top-down exercises in disguise (Joly and Kaufmann, 2008).

It is probably true that in the innovation ecosystem around transport in the Gothenburg area, there could be more initiatives of a quadruple-helix nature. However, it is necessary to be aware of when this is a suitable approach to reach out actors beyond the usual suspects while focusing on topics not purely technological in

¹⁰ <http://ubigo.se/>

¹¹ <http://alvstaden.goteborg.se/?lang=en>

nature but connected to a societal context and of a complex nature, where citizens and communities matter; or in collaborative efforts where collaboration by multiple stakeholders is needed, such as in safe traffic systems. At the same time, in doing so, not all actors should be involved in all parts of the process, and everyone involved needs to accept that some actors in the room will make more decisions.

4.5 Consensus and commitment

The innovation ecosystem in the Gothenburg area is a decentralised process, which develops progressively through the interaction between stakeholders. Key to this are trust and good relationships, and a sense of common interests. There is no single strategy that controls this process, but a meeting of many strategic interests by public, private and academic actors. There are a number of arenas for brokering the interests of the different actors, and for creating consensus and commitment; when it comes to the innovation support system, Lindholmen Science Park stands out, as does the Region.

The Region has its development strategy and as a subset the regional innovation strategy, which is an effort to support regional development and the growth of the transport industry and innovation in this industry. It is one form of arena for consensus and commitment. Another is the board of the Strategic Vehicle Research and Innovation programme, which is an important arena for collaboration between vehicle companies and representatives of national-level government.

The Region Västra Götaland Smart Specialisation Strategy (RIS3) is an integral part of the regional strategy for growth and development in Västra Götaland 2014-2020, also known as VG2020. Industry, academia and civil society participated in a comprehensive dialogue in the drafting of VG2020, but there was no separate process for RIS3. In this context, there was a type of quadruple helix in outlining the broader strategy. The strategy is formally owned by the region and the municipalities, but the implementation is pursued in a broad partnership. Within research and innovation, collaborative initiatives are prioritised. VGR finances thematic programmes linked to priority areas, where regional stakeholders can seek funding for collaborative projects and R&I milieus, as well as testbeds and demonstration projects. One of these is Sustainable Transportation.

VGR is the Swedish region that dedicates the most of its own funds to regional development, yet the larger funding sources for R&I are provided at national level, by the national agencies for R&I such as Vinnova, the Energy Agency, the Research Council and the Agency for Economic and Regional Growth. Therefore, an important part of the Region's work is trying to influence national agendas so that they serve the interests of the region's actors. They aim to be knowledgeable about their region's areas of strength, have in-house experts in these domains, and work closely with institutes and academia and with industry, embarking in direct dialogue with industry at various levels. Rather than becoming a stale bureaucracy, they try to live and act in the system close to other actors, support actors and initiatives that have potential, and address and solve issues when they emerge. They try to work agilely, in an ecosystem that they do not think they can steer or control, but can influence. As an example, they were approached by Volvo Cars who were interested in developing a new test environment, which eventually lead to AstaZero; they supported it initially and other actors eventually took over.

VGR has a collaborative agenda for their sustainable transportation programme. However, there is no consensus and no specific board or reference group that guides their work in this area. VGR has six science parks that play an important strategic role in the region's work with R&I. Lindholmen Science Park is the central actor in the sustainable transport area. The Region views the science park as a platform that takes greater responsibility than just developing and managing projects. As an example, the CEO of Lindholmen Science Park has a lot of respect in the industry and can talk with industry and academia actors as peers, which can facilitate and catalyse important processes. VGR can provide funds to support the initiation of projects, which then is leveraged from other funds like from Energy Agency, Vinnova, etc. Lindholmen Science Park is instrumental in the continued development of Lindholmen as an ecosystem. There are other intermediaries and activities with long-term perspectives building capabilities to meet future technology needs. There has been an evolution over time, and an upgrade in these efforts as focus changes in knowledge development. As an example, there was previously a strong focus on traffic safety and transport efficiency; now there is a realisation of needs related to electrification, autonomous vehicles and connected vehicles. With this, a need to develop new skills emerges and there are now efforts in, for example, electromobility and AI. The formation of constellations of new intermediaries and innovation-related platforms often builds upon previous constellations of actors, but modified and adapted for the new purposes, e.g. in these new efforts, actors with ICT skills are being added to the projects. However, they partly build upon previous relationships. The impression in this study is that triple-helix collaboration in the region seems to be conducive to organising relevant innovation intermediaries.

4.6 Strategic choices and vision for orchestration of the ecosystem

There is no single actor controlling the innovation ecosystem around the automotive industry in the Gothenburg area, but a number of actors and agencies that play different roles. The more important actors in the ecosystem include AB Volvo, Volvo Cars, Geely, Autoliv, Zenuity, Chalmers University of Technology, City of Gothenburg, Region Västra Götaland and Lindholmen Science Park.

Regional actors do however have a number of shared interests, and collaborate in order to strengthen the development of the ecosystem and modify it. They use their own resources, but also draw upon available funding schemes. The industry actors are influential in the themes explored by different centres, and also in indicating what innovation centres, testbeds, etc. are needed. They commit by purchasing services, and participate in collaborative projects. Industry defines the projects to be carried out; they come up with research ideas and researchers or PhD students from universities are then brought in to match those needs. It is rare that universities come up with the collaborative ideas, as the companies cannot work with projects which do not fit into their strategic needs; they do not have the staff or resources to do this (Fogelberg and Thorpenberg, 2012).

The role of the two Volvo companies in the innovation ecosystem can be seen as quasi-hierarchical relationships with the other actors (Sörvik, 2010). They can have a strong influence on the behaviour of other actors in the system, in particular suppliers who need to adapt to the practices of these companies; they can also urge suppliers to locate to the region. The two Volvo companies are at the same time important knowledge creators and diffusers of entrepreneurial and industry knowledge about the automotive industry. They are training grounds for staff that spins out to new companies, but knowledge also diffuses to suppliers about the requirements for selling to global value chains. The two Volvo companies also provide market channels and entry points for many suppliers. There is also knowledge diffusion through informal networks between Volvo staff and actors in other companies and innovation institutions. The staff also rotates between the organisations.

The dominant firms can increase flexibility, reduce risk and improve opportunities for acquiring new innovations, by engaging with suppliers, knowledge institutions and other innovation actors. Firms seek flexibility to meet a changing environment, by developing their core competences (Prahalad and Hamel, 1990) and by not locking resources into factories, R&D organisations and market organisations, but rather renting resources (Larsson et al., 1998). Many large firms are better equipped for incremental innovation, where there is stepwise perfection of offerings. Smaller firms can be better suited to responding to change; as they have fewer resources linked in to specific routines and knowledge-bases, it can be easier to change track. However, the smaller firm has fewer reserves to carry out change. Many firms have also started to seek external collaboration as a way of reducing risks, as the costs of not finding the right offer or missing the right standard are too high for a large firm (Chesbrough, 2003). However, there are also dangers for the weaker firm, which can end up in a position where another firm has power over it to the extent that the firm is totally dependent on the stronger party, which will also have control of the firm's future (Larsson et al., 1998).

AB Volvo is interested in acquiring new ideas for both products and services, but also new working methods. They want access to the entrepreneurial spirit of small companies. They are interested in picking up ideas from SMEs, testing them and possibly incorporating them into Volvo processes, creating in turn business opportunities for their partnering SMEs who can later supply other OEM companies.

In this context, AB Volvo is interested in continuing to nurture the regional ecosystem. They do this by attracting other companies to the region (both by requesting suppliers to locate there and through the MobilityXlab, which is a way of attracting talent there), and also through various forms of R&I initiatives that further strengthen the dynamics of the region. They want to sustain the current positive spiral of innovation activities being started in and locating to the region, which they believe will further strengthen Volvo Group. Volvo Group is actively sustaining this concentration and exploring the possibility to opening it up and concentrating it even further. Currently, Volvo Group is mainly located in Lundby (see map in D1) and Lindholmen. They want to relocate staff in Gothenburg to the Lundby/Lindholmen area and open closed areas, to make the sites more of a university campus. They want more actors to come in to this space to make it livelier; both SMEs and various service providers such as gyms and restaurants, and innovation support actors. They hope this will facilitate collaboration with start-ups and SMEs, and make AB Volvo able to review and pick up new ideas more quickly.

The city provides funding, but also live environments for testing, and land for new developments. The Region provides funding and legitimacy, and also helps consortia that communicate with the national level to access other funding sources. Chalmers and Gothenburg University host some of the centres and also bring skilled

researchers to the processes, with access to international links. They are knowledge hubs that create and disseminate knowledge in the innovation ecosystem. They also educate students at all levels, who are later picked up by the industry. Chalmers is an instrumental partner, and takes part in most of these collaborative efforts. It is involved, at local, regional, national and EU level, in projects related to the automotive industry, and partners with the two Volvo companies in various projects. It also hosts an incubator, has a venture capital company that can support start-ups, and hosts open innovation seminars. Furthermore, Lindholmen Science Park is central as a broker institution. It hosts a number of projects and centres related to innovation in the transport sector, with a long-term development perspective.

The relationships between the partners in the region seem to be of a long-term nature, as does the view on many of the innovation intermediaries. This is also argued as being an important factor for success, as it takes time to find the right operating procedures, and to reach out to actors and build trust.

Public funds are particularly a trigger for running long-term initiatives and coordinating actors, where there may be functions that do not benefit any particular actor in the short term as it is harder to break down separate costs and benefits. The latter is especially true for intermediary agents focusing more on SMEs. In these cases, some of the costs can be covered by membership fees, but public funds can give the long-term perspective that is needed.

The respondents from the public sector indicate that they are unsure about how to carry out activities at high technology readiness levels (TRL), as this conflicts with existing regulations, but that in some cases it could be desirable to do that. In some cases, they explore how they can do it and what roles to take. However, the respondents from the Volvo companies see less need for this, as they perceive work at those levels to involve more internal product development. It could be that having this type of high TRL innovation support would be beneficial for SMEs and that there is something missing in the innovation ecosystem as a result. One initiative that can partially overcome this is the MobilityXlab, which is driven quite heavily by the private actors to accelerate more mature SMEs to further develop concepts of strategic interest to the participating companies. MobilityXlab is a new way of attracting talent to the innovation ecosystem. It is not only about supporting local start-ups to grow, or for a company to locate an office to another agglomeration to be present there and pick up knowledge. This is a way to globally attract talented companies to the West Sweden region to work with the market leaders behind the initiative, and for these companies to get access to talent. At the same time, it will improve linkages in the innovation ecosystem.

However, an important role for public investments is to fund R&I activities that can prepare industry players for long-term changes. Here, it is important for regional actors to understand that companies in a region are not isolated systems, but are connected in global innovation systems. Our respondents urge that public sector innovation initiatives try to listen to industry needs in the long term and invest in these areas, where it is realistic that the companies will need to act. Policymakers should not see the industry as their instrument to carry out their vision, e.g. to be consumers of biogas produced by the public sector, if there is no other market potential for it. The public sector needs to try to understand global market shifts and help companies change their technologies to respond to these shifts more quickly, to support their competitiveness. It can also contribute to reducing fossil fuel use, in terms of electrification. The public sector is limited by state aid rules, and can mainly invest in pre-commercial initiatives; it is mostly large companies that have the time and resources to engage in these types of development processes. This is also the reason for the Region and national level to pay significant attention to the large original equipment manufacturers (OEMs). The drawback of this support is that it is pre-commercial and will take a long time before it reaches the market.

From a viewpoint of regional resilience, the Region should also be interested in developing the regional actors so they not depend on supplying one large local company and this being their only entry point to global value chains. They should of course benefit from the existence of globally competitive industry leaders, but encourage local suppliers to also approach other companies and in other locations; so that the system does not overly rely on the large anchor companies.

So far, actors in Västra Götaland have not made any detailed plans or roadmaps, within the regional context, for development of the area. This is developed more in the context of the FFI programme, and to some extent within Vinnova's Strategic Innovation Programmes. However, this is something that other regions may want to do, particularly regions with more funds (it should not however create too much rigidity and prevent needed flexibility and responsiveness).

Some of the respondents express scepticism about overly detailed plans. They perceive that, although strategies can be good for communication purposes, when it comes to actual operations there is a need for

flexibility. There are therefore trade-offs. They are of the opinion that plans should set out bases for work and long-term ambitions.

In Västra Götaland, the Region takes more of a facilitating, funding and strategic role, while activities of a more operational nature have been delegated to science parks. These are considered innovation support infrastructures that can both support start-ups and innovation, but also take roles in deliberating and taking the lead on collaborative efforts, serving as neutral grounds. They can also house the initiatives and help them communicate, and make existing efforts visible. The science park is an intermediary level between the region and projects. It gives more long-term perspectives to projects, as it can build on experiences gained through previous projects, even if they are now closed, and bring that to future ones.

4.7 Actual and potential links with RIS3

The respondents in this study argue that regional activities should build on and aim to develop existing capabilities, and foster excellence. The region should invest in areas where there are industry partners for co-development. If there are no industry partners, then it should not be done. However, actions should have longer-term perspective and also be transformative in nature, building capabilities to be prepared for technology needs and shifts.

This connects with smart specialisation and entrepreneurial discovery processes. The work in Västra Götaland contains many components of such a process, although they have not followed the RIS3 guide in developing their strategy, nor have they set up formal governance structures for their RIS3 or the transport area. It is built rather on informal relationships. However, the departure point is to identify interventions together with stakeholders, and efforts are concentrated on a number of prioritised areas. VGR and City of Gothenburg aim to be helpful, flexible and responsive, to facilitate opportunities identified by industry actors.

Not all regions will have world leading global companies like AB Volvo or Volvo Cars in their region, but the respondents emphasise the need to work with a group of existing industry actors with future potential, not try to set up initiatives in areas where there are no local carriers of the innovation support efforts. Depending on these needs, interventions and intermediaries may be aiming at different TRLs.

At the same time, a region has limited resources and capabilities and must prioritise what to invest in and with what to interact. Therefore, the respondents also emphasise a need to be selective about areas in which to intervene, and to try to focus on these and build a complex weave of innovation support mechanisms on many TRLs.

In many places around Europe, smart specialisation has not addressed competence development and supply. This is a key question in Västra Götaland, and this perspective should be integrated into smart specialisation work and public sector intervention in innovation ecosystems.

In addition, not all regions can have all-encompassing systems that develop all necessary technologies. In Västra Götaland, they are prioritising a number of technologies within the area (electrification, connectedness and autonomous driving). This is something that other regions can learn from. These niches will support existing industries, but can also help develop new ones, such as Zenuity and Veoneer in Västra Götaland, which deliver solutions within autonomous driving.

As these solutions are part of global value chains, regions are not isolated islands, and the same goes for industry and academia. It is important to identify what will be done at multiple governance levels (local, regional, national, European and global). But regions can support regional actors to benefit and influence what happens at other governance levels. However, there is a need to analyse and work with what happens elsewhere. This relates to how regulations and standards are established, in securing research funds and establishing industry systems and standards.

5 CONCLUSION

There is a boom in the automotive sector in the region. It has bounced back from the 2008 crisis and there is currently strong growth. Several new companies have started around the vehicle industry. Existing companies have grown, and in addition, Volvo's Chinese owner Geely is locating functions and new companies to the city, further strengthening the growth. Strong drivers here are the ongoing technology shifts with the electrification of vehicles, automation and connected vehicles. There is also a movement whereby vehicle companies are going deep into digitalisation, and companies are recruiting large numbers of staff with software skills and for electronic engineering.

Our respondents suggest that the interest in locating to the region is due both to the existence of skills and capabilities around these technology domains, and to policy programmes in Sweden that support the development of these skills and of new technology, in particular the Strategic Vehicle Research and Innovation programme.

There is also a realisation, at both national and regional political level, that the vehicle industry is important for Sweden and for West Sweden. There is also a political willingness to find ways to support the long-term competitiveness of this industry. The aims are to help the industry prepare for the technology shifts, ensure it has the relevant competences and capabilities to survive the global competition, and make the region attractive for foreign investments. Another reason is to support SMEs to raise productivity and become more competitive, and support start-ups around new technology and business concepts for the vehicle industry.

There is also a political interest in supporting the shift towards these new technologies, to access more environmentally friendly solutions, but also to develop safer traffic solutions, and solutions that contribute to more pleasant city environments, with less noise and pollution. Here, the political side wants to support innovations that can solve these types of societal challenges, while at the same time creating opportunities for Swedish industry.

There is no single actor controlling the innovation ecosystem around the automotive industry in the Gothenburg area, but a number of actors and agencies that play different roles. The more important actors in the ecosystem include AB Volvo, Volvo Cars, Geely, Autoliv, Zenuity, Chalmers University of Technology, City of Gothenburg, Region Västra Götaland and Lindholmen Science Park.

The role of the two Volvo companies in the innovation ecosystem can be seen as quasi-hierarchical relationships with the other actors. They can strongly influence the behaviour of other actors in the system. The two companies are very important customers for suppliers, and much of the Swedish automotive industry is built upon supplying them. They are also good training grounds for suppliers, as, if they can manage to supply the two Volvo companies, they can supply the rest of the industry.

The two Volvo companies are at the same time important knowledge creators and diffusers of entrepreneurial and industry knowledge for the automotive industry. They are the biggest investors in research and development for the automotive industry. All this both serves the two companies themselves and spills over to other actors in the industry. The companies are training grounds for staff that spins out to new companies, but knowledge also diffuses to suppliers about the requirements for selling to global value chains. There is also knowledge diffusion through informal networks between Volvo staff and actors in other companies and innovation institutions.

AB Volvo is interested in acquiring new ideas, for both products and services, but also new working methods. They have intensive collaboration with regional universities; the main programmes for this are the Swedish FFI programme and Horizon 2020 (EU). AB Volvo foresees increased need for partnerships and collaboration with new actors such as start-ups, SMEs or industrial companies outside the automotive sector. A special 'innovation hub' for this purpose ('CampX') is under development and will be inaugurated during the first half of 2019.

AB Volvo uses the many testbeds available in West Sweden (in particular AstaZero and Awitar), participates in 'living labs' such as the ElectricCity project, and collaborates with the Region to sustain existing collaboration platforms or finance new ones.

They want to access the entrepreneurial spirit of small companies and enrich the innovation system. In this context, AB Volvo is interested in continuing to nurture the regional ecosystem, by attracting other companies to the region (both by requesting suppliers to locate there, and through the MobilityXlab, which is a way of

attracting talent there) and through various forms of R&I initiatives that further strengthen the dynamics of the region.

In the region, there is a tradition of collaborating. The region is also of such a size that the relevant actors can and do know each other. There are formal relationships between city, region, national research funding agencies, traffic and energy agencies, universities, research institutes and industry actors. In addition, quite a few of the companies have emerged as spin outs of other companies, so there are also strong relationships between companies, due both to them being spin outs and them also functioning as suppliers.

Then there are many semi-formal and informal relationships, in that representatives know each other from having studied together, or sitting on same boards of various networks, or research institutes, etc. There is also a certain degree of revolving doors, where actors move between the helices of the triple helix. Former Volvo staff run innovation intermediaries, or move to the research world and then return. Researchers also work for the Region.

There is a realisation of common interests and that collaboration can mutually benefit the actors. Researchers can get access to test environments, new technology and funds, and co-define research questions to raise relevance of their work. For industry, it provides access to researchers' competences, specific projects developing knowledge that can serve as an input to their work, and new methods; it enables them to train their staff, but also ensure that future staff has the right skills. From the political side, they see that establishing these relationships can secure the competitiveness of the industry, solving societal challenges as well as building strength in academia and research institutes that can prepare the region to be attractive in meeting technology shifts.

The region has good links through the large companies that have sites in different parts of the world, e.g. AB Volvo has a network of international sites that carry out R&D; the research community also collaborates globally. Both academia and industry are involved in EU framework programmes, where AB Volvo is Sweden's foremost participant, and Volvo Cars is also a strong actor. Furthermore, with the Chinese firm Geely's takeover of Volvo Cars and subsequent investments in AB Volvo, the setting up of new companies (Lynk & Co), joint ventures CEVT and establishment of a development office at Geely Innovation Centre, there is an even stronger connection to the Chinese market and new opportunities for development and innovation in the region that will further drive the investment in innovation intermediaries.

When it comes to involvement of the fourth helix, in the context of Gothenburg, this has not been done such that civil society groups drive the regional strategy or setting-up of intermediaries. They have been involved in the design of the regional development strategy more broadly, identifying regional challenges and opportunities, and also in urban planning processes.

At the same time, there are several environments and activities designed to interact with users and citizens to learn how they react to new developments and solutions, at least one of which has led to the formation of a Mobility-as-a-Service company, UbiGo. In addition, the projects ElectriCity and DriveMe are, from the city perspective, a way to learn more for city planning. DriveMe is seen by Volvo as a way, initially, to pick up data to train algorithms for autonomous driving. It is also a way to get user feedback that can influence development. It is also a function to showcase that the technology can work in a real environment, and to build acceptance among citizens and future users of the technology.

When it comes to quadruple-helix collaboration for the development of more in-depth technology, it is more complicated; there are issues in relation to power asymmetries, investment burden, responsibilities and risk. Also, not all steps of development projects will benefit from having a quadruple-helix setup; it may simply delay and complicate development processes. A quadruple-helix approach is quite often used when an institution's reputation is at stake or it is hard to identify any kind of specific expertise. To some extent, these types of approaches may be also a good fit in identifying solutions to more complex or difficult problems, where there is a need for interaction between multiple actors in order to overcome them. It is probably easier to organise more equal quadruple-helix constellations when the core for collaboration is around communication or services, rather than technology development. User and citizen involvement fit into various steps in development processes, but are not necessarily needed in all steps.

These types of consideration are addressed to some extent in urban planning and citizen dialogue, e.g. in the development of the new neighbourhood, RiverCity⁽¹²⁾, and in ElectriCity. Here, broad and inclusive processes are being used to define living, infrastructure and transport needs. Output from these processes can be picked

¹² <http://alvstaden.goteborg.se/?lang=en>

up by the city, the Region and public transport companies, but also by property owners. However, these types of inclusive processes do not put all people in the room on an equal footing. All participants may provide input and communicate despite there is inequality in the provision of resources and commitment to processes. The citizens do not commit their own resources to materialise the projects; therefore, it is natural that those who commit and risk resources have more influence on the processes.

It is probably true that in the innovation ecosystem around transport in the Gothenburg area, there could be more initiatives of a quadruple-helix nature. However, before embarking on this type of setup, the project leader needs to reflect on whether this is a suitable approach for this project, and also not be restricted to the usual actors. Quadruple helix works better when the focus is on topics not purely technological in nature, but connected to a societal context, complex issues, or collaborative efforts where collaboration by multiple stakeholders is needed, such as in safe traffic systems. At the same time, in doing so, not all actors should be involved in all parts of the process, and everyone involved needs to accept that some actors in the room will make more decisions.

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