ACCELERATE

Project no 2015-04851 within the Strategic Effort “Big Automotive Data Analytics” (BADA), pertaining to “Effektiva och Uppkopplade Transportsystem” (EUTS)
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FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently

there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**
For more information: www.vinnova.se/ffi

1. Executive summary

The main objective of the ACCELERATE project was to develop and demonstrate new technologies for the aggregation, spatio-temporal modelling and visualization of vast amounts of vehicle and transport data flows, provided by the ever-increasing fleets of connected vehicles. The Big Data and AI algorithms developed in the project, and the joint know-how developed and exchanged between the partners in the project, have put Scania in particular – but also the Swedish vehicle industry in general – in a much better position to exploit such data, with improved Big Data capabilities, and with a concrete and extensible test-bed which can be (and already has been) used for a range of demonstrations of customer utility.

A major contributing factor in the project's ability to "ACCELERATE" and achieve such conclusive results in a relatively short time frame, was that the goals of the project were already initially very clear, and that both project partners contributed complementary technology, data, algorithms and know-how, which were shared and developed further in the project.

The resulting proof-of-concept test bed, which has been made a part of Scania's transport management demonstration environment, features robust, high-performance algorithms for geo-temporal modelling of massive quantities of connected vehicle data, with an interactive visualization interface illustrating several cases of utility for the vehicle industry and its customers.

Demonstrations of results and knowledge sharing is done within the project and between project partners. In addition, demonstration of project results and sharing of knowledge will be offered to representatives from all BADA projects and partners of BADA projects at a shared project exchange event, currently under planning by BADA1 project management and scheduled to spring 2017 (date to be set).

The platform developed by the ACCELERATE project will also, as originally planned, be utilized in follow-up activities. Veridict and Scania are both participating in partnerships formed around the KTH research centre ITRL, and consortiums and projects are under formation where activities derived from ACCELERATE project results will be utilized in a transport related research arena in the Stockholm region. The ongoing discussions also include potential testing activities together with public transport customer, for shared knowledge build-up understanding potential benefits from Real-Time Data Analytics platforms utilizing AI.

2. Background

In 2015, Scania and Veridict identified the potential for joint R&D with the goal of combining Veridict's AI-based traffic modelling algorithms and technology platforms with real traffic and vehicle meta-data emanating from Scania's efforts in the area of connected vehicles and service offerings based on data science. One purpose of such a collaboration would be to advance state of the art in spatio-temporal modelling and interactive visualisation, another would be knowledge exchange and sharing, and a third would be to set up a persistent, scalable and extendible test bed with potential for future prototyping, application development and use case demonstrations.

To these ends, ACCELERATE was specified as a relatively short but concentrated and intensive joint collaboration project, to set up both a technical environment and a mutual knowledge-base with potential to become the pre-cursor to several follow-up projects and also complement and enrich Scania's other activities in the area of big data analytics, e.g. its participation in FFI's BADA1 project.

3. Objective

ACCELERATE has worked towards several goals. In retrospect, three of the most important ones were the following.

1. A general goal of the project has been to develop a **re-usable test** bed for real-time, massively scalable, spatio-temporal modelling and interactive visualization of connected traffic and transport movements. The general *purpose* of this is for Scania and other vehicle manufacturers remove the "data bottleneck" by acquiring the **capability of exploiting** and making use of the rapidly growing data flows from connected vehicle fleets on a global scale.
2. Another goal was to combine Scania's **proprietary vehicle data with open data**, with one *purpose* being to apply **predictive analytics** to past, present and future spatio-temporal modelling, and another to integrate, combine, visualize and interact with different types of transportation-relevant **points of interest** (POI) from a variety of sources.
3. A third goal was to acquire the **largest data sets** ever possible early on to be used for development and testing of AI-based spatio-temporal algorithms, including their

scalability, with the *purpose* of providing a fully working proof-of-concept implementation applied to large amounts of **actual Scania vehicle-centric data**, with demonstrations of aggregation, filtering, analysis and multi-modal interactive interfaces to exploit the massive data flows.

4. Project realization

4.1 Work packages

The project was organized in three work packages, each with a dedicated work package leader, responsible for the completion of tasks within the package. WP1 encompassed project management and business development, WP2 was devoted to system development, and WP3 dealt with demonstration and testing.

4.2 Development and project phases

Already at the outset of the project, Veridict had developed algorithms and technology for large-scale map-centric traffic modelling and visualization, tested and demonstrated primarily with public transport data. At the same time, due to activities in the field of data science applications on connected vehicle data, Scania was in a similarly good position for the two partners to move forward at considerable speed within the project.

Development work was therefore carried out in a number of relatively short consecutive sprints, leading to successive refinements and allowing for early demo, testing and requirements re-specification, decided jointly by Scania and Veridict.

The project's 12-month life span can be seen as largely divided in three (partially overlapping) phases:

Phase 1 focussed on acquiring as large amounts as possible of data, including both open and licensed public transport data, transport authority meta-data, global national road network data. The bulk of the effort was then spent on using these extremely large data sources to develop and "stress test" a spatio-temporal modelling framework fulfilling quite extreme Big Data- and performance-related requirements, in a way so that the resulting model could as easily be applied to completely unplanned transports as to more scheduled traffic, in order to cover applications both in the areas of goods and people transport. Several knowledge transfer workshops were also arranged early on.
Phase 2 aimed at surveying, selecting and integrating Scania's proprietary data with open and public data, and on modelling it in one and the same spatio-temporal framework. To this end, a development environment was also made available at Scania.

Phase 3, involved selecting, developing and communicating demonstration scenarios, both internally within Scania and the Volkswagen group, and also prepared such permanent standing demonstrations to the FFI community and other Scania partners, to be held after the project, to illustrate the combined customer utility obtained by using real data from real traffic in several use cases.

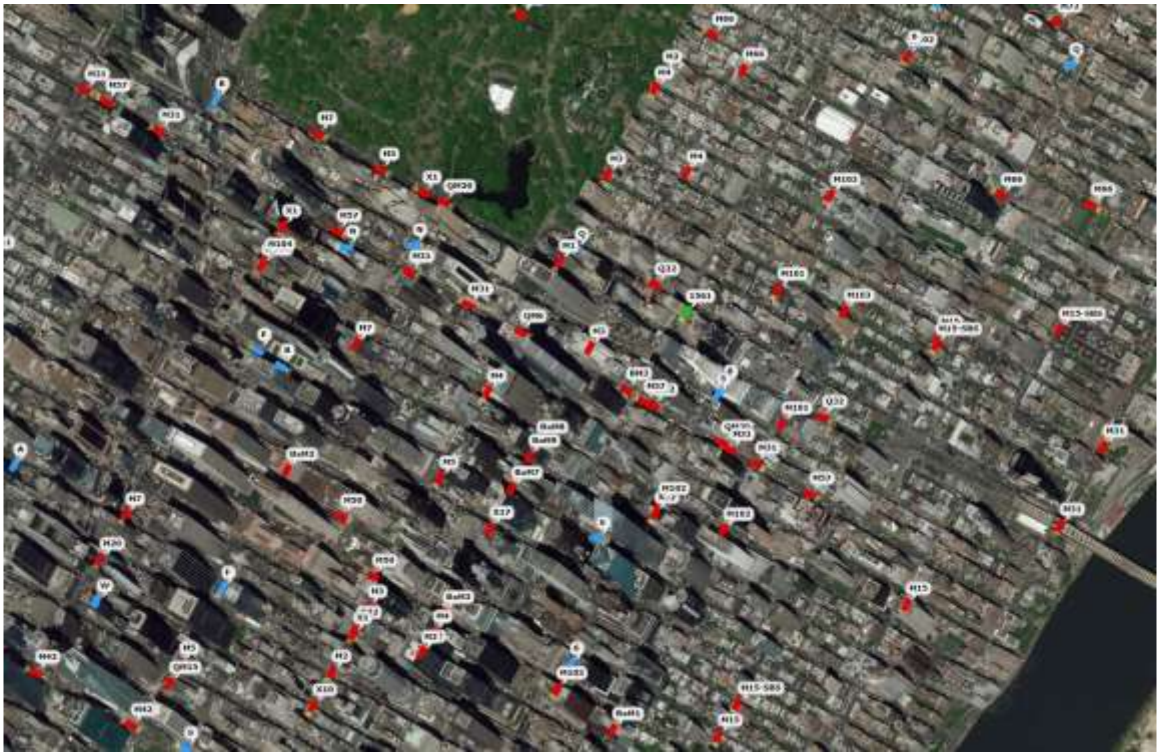

Figure 1. Public transport vehicles in urban environment.

5. Results and deliverables

With respect to the three goals stated in the "**Error! Reference source not found.**" section, the following results have been achieved and the corresponding deliverables have been supplied.

A **proof-of-concept** (POC) was developed, demonstrating large-scale, global, spatio-temporal modelling of massive amounts of transport data, ranging from completely unplanned transports to relatively well-planned traffic but with real-time alterations and updates. The model was refined to integrate partial spatio-temporal information with GIS data regarding routes and road network data, to model actual driving trajectories. Other aspects regarding the variety and veracity of different data sources also required compensatory algorithms to be developed, e.g. regarding positioning data with highly varying update intervals and latency. Predictive analytics were applied to allow the model to render both historic, concurrent and future traffic movements, in up to 20 times real time. The number of individual data sources was already initially in the order of 10^3 – 10^4, and the number of total handled "trips" in the model, as a consequence, in the order of 10^6 – 10^7.

Particular and unique features of the model, which – both in isolation but especially when considered together – set it apart from other known attempts at this type of spatio-temporal modelling, are, among others:

1. ***Interactive visualization*** of all the above-mentioned transport and traffic data, while still allowing *zoom levels* from a top-of-the world perspective down to a few meters (or less), while still calculating all vehicle movements of the active model, with no computational problems.
2. A ***split-up of the model*** in a client-server architecture, where technology-neutral clients are lightweight enough to run on the vast majority of today's smartphones and tablets, and which allows for extremely simple integration of the ***client software as a plug-in*** or embedded in customer code, web sites or apps. To this end, a specific API was developed for both internal and external use, using a special development environment which was also made available.
3. Said split-up allows the spatio-temporal modelling to take place on the server side, minimizing the amount of computation and allowing re-use of computed model data. This in turn means that the system solution is ***massively scalable*** in terms of number of ***users*** and numbers of ***requests***, with no computational penalties on either side of the system. This also makes the solution resilient to the typical usage patterns where massive service usage is localized in space and time, often as a result of delays or disruptions in the public transport network[1].
4. Individual ***modelling and interaction*** capabilities for large amounts of ***meta-data***, either specific to vehicles, routes or trips, and/or geographically anchored ***points of interest (POI)***, e.g. traffic CCTV cameras, and road condition monitoring.

Large-scale OEM vehicle data

A substantial amount of scrambled Scania vehicle data was subsequently integrated into the spatio-temporal model. The sheer volume of this data required novel algorithms for data reduction to be developed, and the data also had to be re-structured algorithmically to adapt it to the object structure of the spatio-temporal model in a non-trivial way. The end result was that both open public transport data and OEM vehicle data feeds co-exist and are modelled in one and the same spatio-temporal visualization framework.

A sample of visualization of the OEM vehicle data is shown in Figure 2.

[1] Such usage patterns are in fact quite similar to the so-called Distributed Denial-Of-Service (DDoS) attacks, which increasingly often affect high-profile web sites

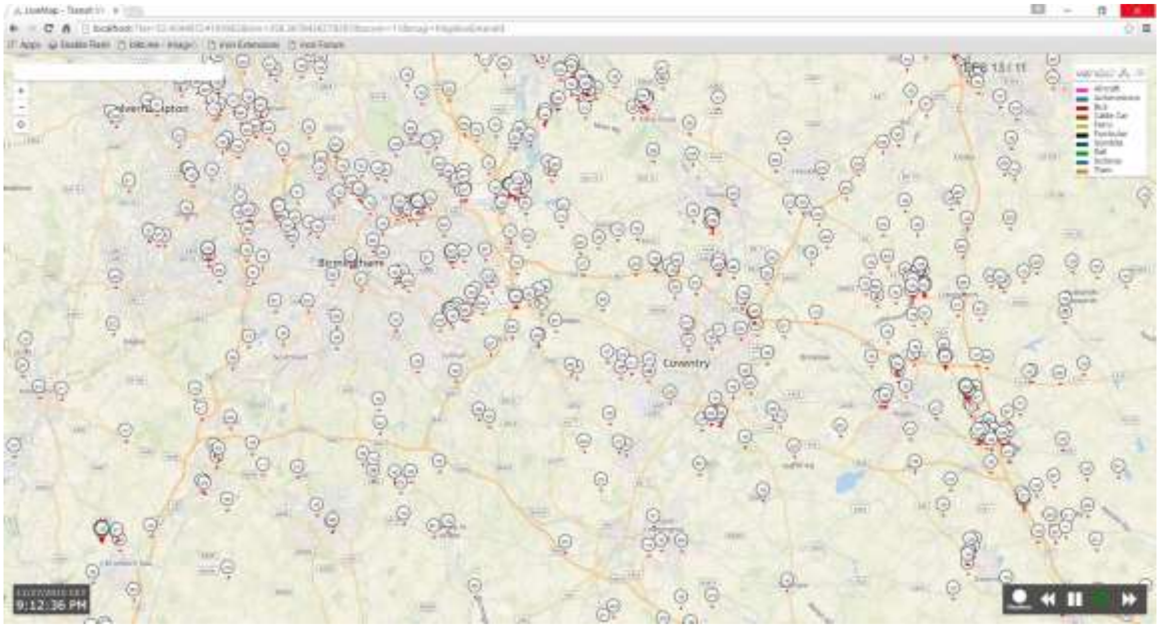

Figure 2. Example of OEM transport and traffic data

This is a ***key deliverable*** in the project, since it demonstrates the potential for ***cross-integration of open data with data from OEM's or their customers***. Live demonstrations using this set-up illustrate how both proprietary and open data on vehicle movements can be combined and also used in fusion with other, "static" data, e.g. POI's.

The ***use-cases*** produced includes the following separate system deliverables to be demonstrated outside the project:

- Global fleet-analysis scenario using a rich set of vehicle sensor data from +100k connected Scania vehicles world-wide.
- Real-time global fleet-tracker scenario showing movements and vehicle meta-data from hundreds of thousands of vehicles from +10k external data sources world-wide.
- Semantic relations and query demonstration showing how NLP-based queries can extract vital information from live traffic scenarios.
- Demonstration of GTS, Geo-Temporal Selection; how real-time AI analysis of multiple live vehicle trajectories can be applied in actual live traffic scenarios.

Another ***key deliverable*** is the ***knowledge transfer*** which has occurred both continuously throughout the project, in part through a series of formal as well as less formal ***workshops*** and ***meetings*** and ***hands-on*** joint ***work sessions***, and in part also through ***data and technology exchange.*** Thanks to the model split-up mentioned above, a ***development environment*** was ***made available and installed*** at Scania's Data Science R&D lab, to allow for further development and integration towards other data, platforms and systems in both this and in future projects. In the present project, this environment was used primarily during **Phase 3** when the visualization functionality was first loosely integrated in Scania's data portal, and later more tightly coupled by using the API's provided within the development environment previously provided.

5.1 Delivery to FFI-goals

The specific goals of the FFI Strategic Effort "Big Automotive Data Analytics" are described in the Programme Description (VINNOVA, 2015). They all combine to contribute to the over-arching FFI goals of reducing environmental impact, further lowering the number of traffic-related injuries and fatalities, and of improved competitiveness in an international perspective. One obstacle, clearly identified in the Programme Description, is the bottleneck between the massive generation of data from connected vehicles, and integration of such data streams into platforms for further analysis, application and business utility generation.

The ACCELERATE project has specifically directed its effort to solving a severely aggravated version of this problem, namely how to import and model colossal amounts of *real-time* streaming data across such a bottleneck, and make the data useful for the vehicle industry and its customers, by virtue of interactive visualization. The technical solutions achieved by the project reach clearly beyond what was expected at the outset of the project, with far larger data volumes being handled, and with scalability being proven to an extent which should make the overall results immediately useful to both the project partners, to other FFI partners, and, in general, to actors in the ITS and vehicle industry.

5.1.1. Contributions to the transport industry

A proof-of-concept (POC) was developed, demonstrating full-scale, spatio-temporal modelling of all globally available public transport movements, with no limits regarding the number of simultaneous users or requests. This has a range of immediate as well as indirect implications regarding potential services offered by OEM's such as Scania to their customers. Just as the project itself shows, this will contribute to strengthening international competitiveness not only for OEM's but can also be expected to do so for collaborating innovative AI/IT companies in the area of connected vehicle/ITS solutions.

5.1.2. Contributions to reduced environmental impact and improved transport efficiency

The potential for on-line monitoring at a fleet level of not only past vehicle movements, but also actual, current movements and – by virtue of predictive analytics – future trajectories opens up for a number of efficiency-improving and fuel-saving actions and services based on resource-sharing, outlier monitoring, driver feedback and education etc.

Several such use cases were demonstrated (by example) towards the end of the project, both internally and externally.

In the area of goods transport, a whole range of customer and business cases were identified, including several directed towards routing optimization and maintenance cost and equipment wear reductions by combining views of supply and demand regarding vehicle service and maintenance with actual transport trajectories. Such optimization across fleets would be just one example of a completely novel type of service which an OEM could offer to its customers, based on the technology and know-how developed in ACCELERATE.

For public transport, ACCELERATE's visualization technology is useful both at the back-end side, for traffic monitoring and control with PTA's and PTO's, but it can be equally useful for communication, planning, interaction and (eventually) ticketing on the passenger side, where it can provide a culture-universal, easy-to-use interface to public transport wherever you are. This could be vital in making public transport more attractive and accessible globally for the benefit of the environment.

5.1.3. Contributions to academia and transport industry R&D

The algorithms and technical solutions developed in the project lie well beyond state-of-the-art in a number of respects, especially in the fields of real-time spatio-temporal modelling, agent-based big data handling and visualization technology. Several of these results are currently being published for the benefit of the international scientific community.

6. Dissemination and publications

6.1 Knowledge and results dissemination

6.1.1. Partner dissemination

Results from the project has been visible on Veridict's corporate web sites. Veridict has continuously made open data versions of the map technology available for public demo and use via their corporate web site, www.veridict.com. Results from the projects have also been disseminated by participation at Smart Products for Automated Transportation Conference (Zürich, Sept 2016) and ITS World Congress (Melbourne, Oct 2016).

Scania has integrated the Veridict infrastructure into a prototype version of its Fleet Management system, thus learning about the functionality, API-s and usage of Veridict solutions as an integration partner. Scania have spent time at the Veridict development site on a regular basis, beside project meetings and other direct project related work, in order to accelerate information exchange and knowledge sharing.

A number of demo use-cases has been developed, use-cases that has been selected to drive knowledge build-up in relevant technology areas.

The projects demonstration environment has been integrated as a component into the Scania laboratory for general HMI-related research targeting transport management. This a Virtual Reality (VR)-based simulation environment, where different control room scenarios can be emulated. In this environment concepts and solutions from the ACCELERATE project can be used.

6.1.2. Internal and public presentations

Several demo scenarios were selected where live public transport data was combined with proprietary POI data, and vice versa.

Scania internal demo
The demo scenarios have been demonstrated internally within Scania.
An additional Scania-internal demonstration event is scheduled to march 2017.

BADA program demo
The project managers of all BADA-funded projects have met and presented each project to each other.
Demonstration of project results and sharing of knowledge will also be offered to representatives from all BADA projects and partners of BADA projects at a shared project conference, currently under planning by BADA1 project management and scheduled to spring 2017 (date to be set).

Scania Research day
The project will be presented, including demonstrations, at Scania Research Day 2017. Scania Research Day is a yearly event where all Scania research is presented for a large internal audience as well as specially invited important research partners, including for example VW Group Research.

Relation to other external partners
Besides the specific knowledge transfer and potential cross-fertilization within the BADA-program, specific attention has been on initiation of follow-up projects involving a broader set of research partners. This has been an aim for the project from the start, and in order to address this, the following members where part of the project steering board/advisory board:

- Dr. Peter Georén – Director of Integrated Transport Research Lab (ITRL), KTH.

- Dr. Elena Fersman - Research Manager, Advanced Decision Support and Knowledge Management, Ericsson Research, *as well as* Adjunct Professor in Cyber-Physical Systems, KTH
- Andreas Höglund, Scania - Leader of technology package (AP2) in BADA1-project from Scanias side.

The project steering board/advisory board has been demonstrated the project results on several occasions and a specific workshop has been held within the steering group where potential follow-up projects was identified. The result from the workshop is now included in ongoing discussions, with the aim that the platform developed by the ACCELERATE project should be utilized in follow-up activities. Thus Veridict and Scania are both participating in partnerships formed around the KTH research centre ITRL, and ITRL is leading the consortiums and projects under formation where activities derived from ACCELERATE project results should be utilized. This is planned to take place in a transport related research arena in the Stockholm region, like Connected Mobility Arena, Test Site Stockholm and Digital Demo Stockholm.

The ongoing discussions also include potential testing activities together with Scania customers in the public transport area, for shared knowledge build-up understanding potential benefits from Real-Time Data Analytics platforms utilizing AI in public transport.

6.2 Publications

Seward A, Lindström A, Seward A (2016). *Geo-temporal selection – a white paper on applications and ramifications of live transit.* Available at http/www.veridict.com/GTS-01.pdf

6.3 Furthering of knowledge and results dissemination

There are several potential “drivers of change” in the projects immediate or indirect surroundings which could positively affect the take-up speed of the project’s results.

The project results are likely to be directly used internally at Scania in development projects. The participating unit, REIO, see potential at extending its service offering by including the project’s results in some of its operational analysis tools.

There are several activities in the main BADA1 project, where the ACCELERATE technology ties in, and discussions are on-going regarding a follow-up FFI project, where results from both projects will be combined and further developed in terms of increased Technology Readiness Levels.

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7. Conclusions and future research

The main objectives of the project were to apply a Big Data and AI approach to real OEM vehicle and transport data flows, with the purpose of providing the vehicle industry in general, and Scania in particular, with new capabilities for exploiting the ever-growing feeds of data from connected vehicle fleets, thus overcoming the data “bottleneck” problem.
The project was successful in developing robust, high-performance algorithms for spatio-temporal modelling of such OEM data, primarily as a direct result of the consortial make-up.

The platform developed by the ACCELERATE project will also, as originally planned, be utilized in follow-up activities. Veridict and Scania are both participating in partnerships formed around the KTH research centre ITRL, and consortiums and projects are under formation where activities derived from ACCELERATE project results will be utilized in a transport related research arena in the Stockholm region. The ongoing discussions also include potential testing activities together with public transport customer, for shared knowledge build-up understanding potential benefits from Real-Time Data Analytics platforms utilizing AI.

Figure 3. Example of real-time reachability analysis using Geo-Temporal Selection. Blue lines are incoming, red represent outgoing connections, following color conventions normally associated with blood streams.

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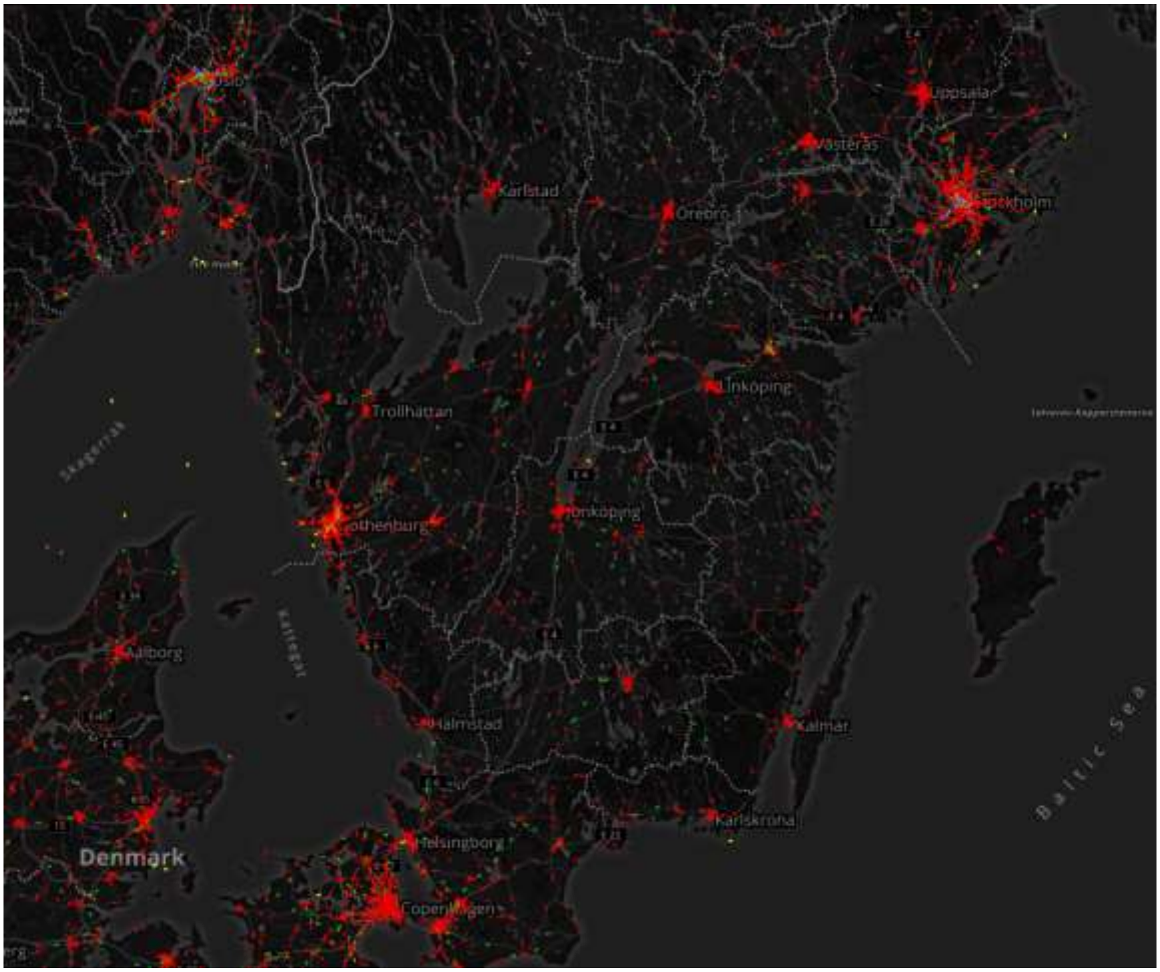

Figure 4. Public transport vehicles around the three Scandinavian capitals

8. Participating parties and contact person

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