

RAPPORT

Collaborative Traffic Management in Sweden

Current trends and a roadmap ahead



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Glossary

STA	Swedish Transport Administration
TM	Traffic Management
CTM	Collaborative Traffic Management
DIGG	Swedish agency for digital Government
E-sam	A program organizing digitalization among Swedish agencies
DATEX	Data exchange standard for exchanging traffic information between TMCs, traffic service providers, traffic operators and media
API	Application Programming Interface
OpenLR	Open standard for "procedures and formats for the encoding, transmission, and decoding of local data irrespective of the map" developed by TomTom.
XML	eXtensible Markup Language
NVDB	National road database. Information on all Swedish roads
NTS	National Traffic management System
Geofencing	Virtual perimeter for a real-world geographic area
TMC	Traffic Management Center
OEM	'Original Equipment Manufacturer', in the automotive industry used to describe a vehicle manufacturer
VMS	Variable Message Sign
MCS	Motorway Control System
ITS	Intelligent Transport System and services
TM 2.0	Multisector organizational innovation network launched 2014 by ERTICO
Extended vehicle	ISO 20077-1:2017 Road Vehicles. More information can be found at Car Data Facts , operated by ACEA
LV	Local road database used by municipalities for city roads
CEN	The European Committee for Standardization
UVAR	Urban Vehicle Access Regulation
TN-ITS	Ertico-driven platform for cooperation regarding exchange of information on changes in static road attributes.
CEF	Connecting Europe Facility funding large European implementation projects
VViS	VägVäderinformationsSystem – system for collection of road weather information via fixed sensors along the roads
FIFA	System for administration of road works on state roads in Sweden
ACEA	European Automobile Manufacturers' Association

LAIV	The new upcoming traffic management system in Sweden that will be used by all TMC:s – replacing NTS in 2022-2023
B2G, B2C, B2B	Business-to-Government, Business-to-Consumer, Business-to-Business

Sammanfattning

Med ökande trängsel på vägarna i och kring våra städer blir en pro-aktiv trafikledning allt viktigare. Trafikledningen måste ha förmågan att trafikstyra och att samarbeta med externa aktörer för att nå ut med trafikinformation till trafikanterna. Förare och resenärer är beroende av en mängd olika tjänster och informationskanaler för sin planering och ruttning av resor. Dessa inkluderar så väl privata som offentliga aktörer. Förmågor och ansvar är spridda över kommuner, Trafikverket, samt flera leverantörer av navigationstjänster. Lokala och statliga väghållare hanterar sammankopplade, men skilda delar av väginfrastrukturen med ibland motstridiga mål. Tjänsteleverantörer konkurrerar samtidigt på en öppen marknad genom att ge just deras kunder bättre navigation än konkurrenterna, vilket potentiellt kan leda till suboptimering av trafiksystemet som helhet.

Samverkande trafikledning, eller Collaborative Traffic Management (CTM), är ett koncept som försöker övervinna utmaningar med motstridiga mål genom att skapa lösningar som samtidigt gynnar medborgare (trafikanter och resenärer), privata tjänsteleverantörer och myndigheter. Konceptet, som föreslagits av TM2.0 testas nu i CEF projektet Socrates^{2.0} där flera piloter i Europa ingår. Det Svenska projektet Samverkande Trafikledning följer denna utveckling och relaterar den till trafikledning utifrån svenska förhållanden i syfte att införa alltmer samverkande trafikledning i Sverige de närmaste 5 åren.

För att skatta potentialen hos samverkan har nyttan med förbättrad väginformation till förare undersökts i en simulering. Det Tekniska Universitetet i Delft har en lång historik av trafikforskning och har anpassat en modell av en del av Stockholms infrastruktur där olika scenarier körts och visat på betydande förbättringar på systemnivå vid bättre tillgång till trafikinformation som är anpassad till plats, tid och aktuell trafiksituation.

Datadrivna affärsmodeller i trafikledningsområdet illustreras med hjälp av ett generellt ramverk för att beskriva verksamheter inom datahantering och analys, vilket tydligt visar att både privata och offentliga aktörer var för sig utför nyckelaktiviteter. Det nuvarande ramverket som används av Socrates^{2.0} diskuteras och en övergripande strategi för samverkande trafikledning föreslås. Där kombineras grundläggande koncept med analyskategorier från datadrivna affärsmodeller. Den föreslagna modellen har fokus på samverkan avseende antingen informationsdelning eller navigationsrådgivning, eller båda samtidigt, se bild nedan. Till sist relateras samverkande trafikledning till trender och pågående aktiviteter på Trafikverket och inom andra organisationer.

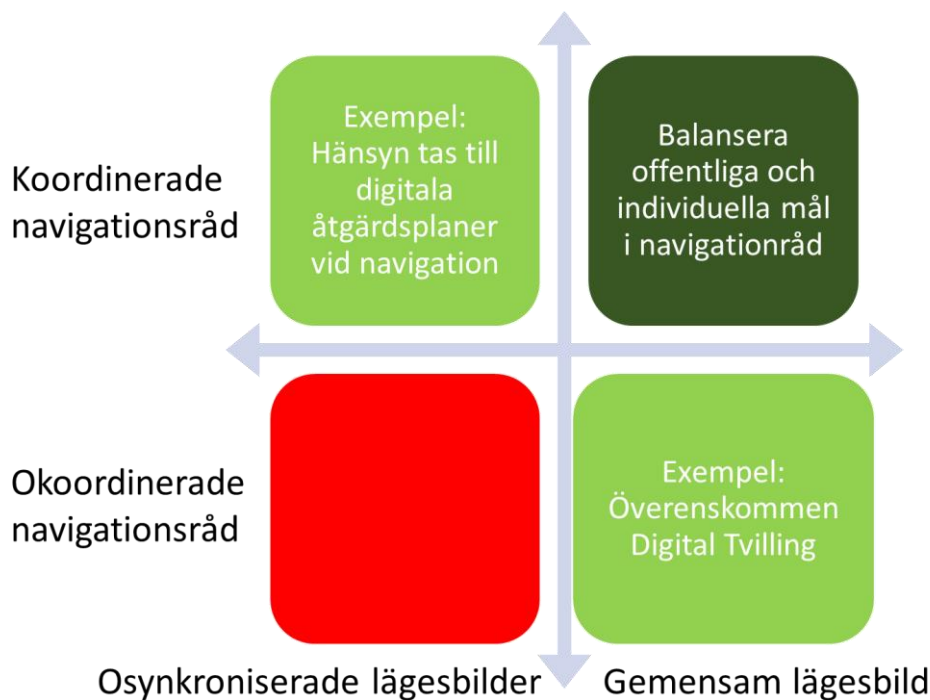


Figure 1: Samverkansmatris för Trafikledning

1.1. Rekommendationer

Sammanfattningsvis är långtgående samverkande trafikledning troligen inte möjlig inom de närmaste 3-5 åren. Men för att förbättra trafikledningen och förbereda för en gradvis utveckling mot samverkande trafikledning föreslås en färdplan med flera direkta åtgärder, många med början omedelbart eller i en snar framtid. Dessa inkluderar:

- 1) Trafikverket tar steg mot ett övergripande nationellt ansvar för utbyte av trafik- och transportrelaterade data med fokus på data som offentliga aktörer ansvarar för
- 2) Fortlöpande utvärdering av hela kedjan från datakälla till slutanvändning, vilket primärt inkluderar uppföljning och ständiga förbättringar av hur data registreras och mappas mellan system samt kvalitetssäkring och kvalitetsmärkning av data.
- 3) Över tid etablera överenskomna processer för dynamisk reglering via geofencing, vilket innebär att temporära trafikregler etableras utifrån trafikläge, händelser, väderlek, etc. och att dessa kommuniceras ut till trafikanter primärt via tjänsteleverantörer och fordonsleverantörer.
- 4) En tydlig strategi för datakanaler och format, som bygger på att nå så många trafikanter som möjligt. Det betyder att vi behöver anpassa kanaler och format till olika externa krav.
- 5) Detaljerat och förtydligt omledningsnät som kommuniceras ut till externa aktörer. Detta för att kunna utnyttja vägnätet mer optimalt samtidigt som oönskade omledningar undviks.
- 6) Förbättrat samarbete mellan offentliga aktörer, bl.a. för att komma överens om gemensamt omledningsvägnät och utnyttja vägnätet mer optimalt.
- 7) Etablera ett permanent svenskt forum för samverkande trafikledning med både offentliga och kommersiella aktörer som medlemmar. Detta i syfte att lyfta aktuella frågor och etablera långsiktiga samarbeten för att främja transportpolitiska mål.

8) Etablera KPI:er och SLA:er för datautbyte. Syftet är att vara överens om vad samarbeten innebär i form av data och kvalitet samt vad som är relevant att följa upp resultat utifrån. Primärt bör KPI:er mäta effekter i transportsystemet.

9) Förbättrade rutiner för platsangivelser. Problem med det som brukar kallas "Location referencig" har visat sig ge upphov till många brister i den trafikinformation som förmedlas till trafikanterna.

10) Inleda arbete mot en bilateralt delad situationsmedvetenhet, vilket innebär att tjänsteleverantörer delar med sig av vissa data till väghållaren (Trafikverket), så att väghållaren får en mer fullödig bild av trafiksituationen och kan fatta bättre beslut gällande trafikledningen. För att inte skada en kommersiell aktörs affärer är det viktigt att inte data från en kommersiell aktör läcker över till en annan utan att villkor för detta är avtalade.

11) Inleda arbete mot överenskomna navigationsråd, vilket innebär att väghållare och tjänsteleverantörer är överens om principer för navigation och omledning. Detta för att nyttja kapaciteten i vägnätet optimalt och för att undvika att leda trafik på oönskade och känsliga delar av vägnätet i onödan.

De flesta av ovanstående rekommendationer har i slutfasen av projektet konkretiserats i en utvecklingsplan för vägtrafikledningen och flera åtgärder är i en eller annan form redan påbörjade.

Övergripande risker och hinder som behöver lyftas upp i närtid:

- Lagstiftning som inte är anpassad för digitalisering och samverkan mellan offentliga och kommersiella aktörer.
- Säkerhetskrav som kan försvåra interaktion med externa aktörer. Säkerhetslösningar måste implementeras så att dessa inte hindrar digitalisering och effektivt informationsutbyte.
- Oklara, ineffektiva eller obefintliga affärsmodeller. Det är fundamentalt att säkerställa incitament för privata aktörer att delta i samarbeten genom att vara lyhörd för och anpassa samarbeten till långsiktigt hållbara affärsmodeller.

Summary

As urban congestion levels rise, a well-functioning traffic management is paramount. Drivers and travelers rely on a multitude of services and information channels for planning and routing journeys. These include private as well as public actors. Capabilities and responsibilities are both distributed among municipalities, the Swedish Transport Administration (STA) and several service providers. The local and national authorities each manage interconnected yet distinct parts of the road infrastructure with sometimes conflicting goals. Similarly, service providers compete by giving their customers better route guidance than the competitors, which could risk sub-optimizing the traffic system as a whole.

Collaborative Traffic Management (CTM) is a concept that strives to alleviate challenges of these conflicting goals by enabling a 'win-win-win' for citizens, private service providers and authorities alike. The concept proposed by the TM 2.0 forum is currently being tested in the Socrates^{2.0} project in several pilots across Europe. The Swedish project Samverkande Trafikledning follows these developments and relates them to the current Swedish traffic management practice to explore how CTM could be implemented in Sweden focusing on the 2025 time frame.

As a means of gauging the potential of CTM, the merits of improved information to road users is further explored in a simulation study of Stockholm performed by TU Delft, indicating substantial benefits of better traffic information and route guidance.

The data driven business models in the traffic management sector are illustrated using a generic framework focusing on data management and analytics, clearly illustrating that both private and public actors perform key business activities. The current Socrates^{2.0} framework is discussed and an overarching CTM strategy framework is proposed combining the CTM foundations with data driven business model analytics concepts, focusing on collaboration on either information sharing or routing advice or both and CTM is related to key trends and ongoing activities at the STA and other organizations.

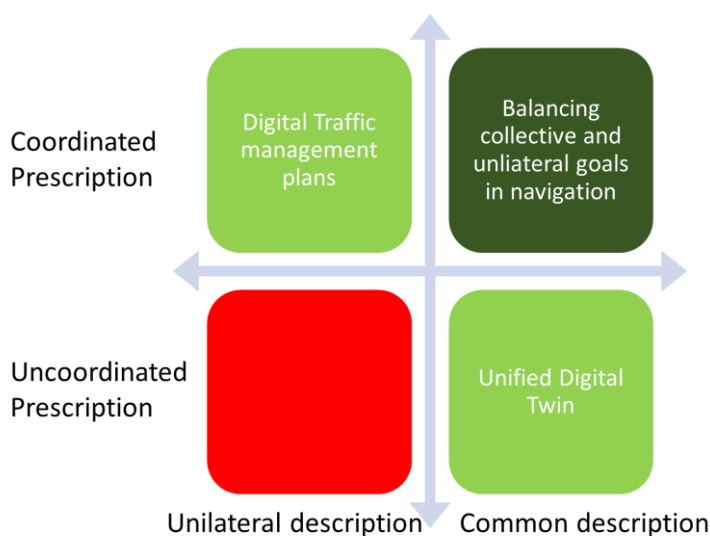


Figure 2: Collaboration level matrix of traffic management

Summing up, while complete CTM is most likely not within the near project time scope, to improve traffic management and prepare a gradual development towards CTM, a road map containing a set of direct actions is proposed for the very near future. These include 1) the STA moving towards national domain responsibility for traffic data, 2) continuous end-to-end assessment of data exchange and use, 3) establishing common processes for dynamic regulations via geofencing, 4) a clear data channel and format strategy, 5) detailed and clarified rerouting priorities, 6) improved public interagency coordination, 7) the setup of a permanent Swedish CTM forum with public and private members, 8) establishing KPI:s and SLA:s for data exchange, 9) improving location referencing practice and finally 10) initiating work towards a bilaterally shared situational awareness.

2 Introduction

2.1. Purpose and intended audience

This report aims to inform the implementation of a strategic framework for a future Swedish collaborative traffic management to further improve traffic management utilizing third party service providers more actively. This report is part of the project ‘Samverkande Trafikledning’ (‘Collaborative Traffic Management’), funded and led by the Swedish Transport Administration (STA)¹. Third party service providers are an important part of traffic management and this project aims to increase the level of cooperation between the public and private sector traffic management actors. The intended readership includes, but is not limited to, decision makers in the STA concerned with digitalization and/or traffic management, as well as decision makers at Swedish municipalities concerned with traffic management and planning. Additionally, it specifically concerns navigation service providers. Yet another audience is experts involved in applied research initiatives in related fields through such as industry consortia, think tanks or EU-funded projects.

2.2. Delimitations

The project covers the near future, 2025, and is geared towards both tactical and strategic actions to further collaborative traffic management practices in Sweden. Being focused on national strategies on traffic management, the project and report does have an STA focus, but the acceptance and involvement of key actors are necessary. The most important being the service providers and the municipalities. The project has focused on a number of major service providers and the two Swedish municipalities with advanced TMCs in collaboration – Stockholm and Gothenburg.

Decided by the steering committee, the project has the following scoping delimitations. First, no specific attention is given to the emergence of autonomous driving. It is reasoned that by the timespan covered by the project (2025), automated vehicles will not have significantly affected traffic. In addition, any effects that might be judged applicable would be highly speculative.

Second, no specific attention has been given to multimodal mobility management topics. The project recognizes that such sectoral coordination is an ongoing development across societies and that this includes some interesting overlaps but will exclusively focus on the practice of road traffic management.

On a general note, the project is derived from a desire on behalf of the STA to observe and learn from the Socrates^{2.0} project. Consequently, it will emphasize developments and conceptualizations in the Socrates^{2.0} project as well as related activities and networks such as e.g. the Traffic Management 2.0 forum. However, the Socrates^{2.0} project and Samverkande Trafikledning differs on key aspects. Most notably, the sizeable Socrates^{2.0} CEF-project collects a number of advanced CTM pilots across Europe and aims to facilitate and develop a set of guidelines to inform discrete CTM-implementations. The Samverkande Trafikledning project is far smaller and lacks the focus on pilot CTM-services. Instead it is focusing on analyzing the strategic capabilities of the STA to implement CTM. In this sense,

¹ STA was formed in April 2010 and took over some or all of the responsibilities of the former road administration, rail administration and a number of other public actors.

² <https://socrates2.org/>

Samverkande Trafikledning is more closely related to the work and output of the TM 2.0³ platform.

2.3. Contributors

The project would not have been possible without the participation of several organizations. The project has included numerous interviews and tours as well as meetings and workshops involving a key set of organizations and people. The STA has provided the funding and project scope and goal, more specifically, the Traffic department. The TMCs in Gothenburg and Stockholm has taken part through a number of key personnel in Gothenburg and Stockholm. INRIX, HERE and TomTom has taken part in activities and Google/Waze has been invited for comments. Stockholm and Gothenburg have participated in steering committee work and feedback. Michael L Sena as an independent consultant with deep knowledge in the telematics-sector has given the project very valuable feedback. Last but not least, the project has had repeated contact with the Socrates^{2.0} project as well as the TM 2.0 forum to discuss and compare results. In addition, the project has been discussed with the Swedish vehicle manufacturers, inter alia in relation to geofencing-initiatives in Sweden. As part of the project, TU Delft has evaluated the potential of enhanced traffic information in a simulation study based on a case on traffic disruptions in Stockholm. On behalf of the STA, RISE has facilitated and participated in all steps of the project process – from inception to finalizing.

2.4. Road Traffic Management

In Sweden, Traffic Management is a term used in a variety of businesses and transport modes. Rail operations would be unthinkable without a well-functioning centralized traffic management, modern air transport as well. However, in the road transport sector there are several public and private actors that perform what they define as traffic management. The result is a decentralized arena, with overlapping concerns and sometimes conflicts of interest. First, an important public actor is the police who have far reaching authority to perform tactical traffic management yet lacks mandate and capabilities for long term strategic traffic management. Further on there are private bus operators, haulers, public transport administrations, public transport operators, and taxi companies among many. All focus their attention on their fleets to ensure smooth operations using the means at their disposal. Besides the information services provided by the STA and municipalities, and the operations optimizations performed by private fleets, a number of private service providers cater for generic navigation support to end users and transport professionals alike. Providing fast and efficient routes for the individual user is their main service.

The former Swedish Road Administration (Vägverket) was a latecomer, relatively speaking. Here, the term traffic management appeared in connection with the so called ‘Dennis Agreement’ in Stockholm and the ‘Gothenburg Agreement’, both large investments in infrastructure. The formal starting point was a Governmental Investigation resulting in a report called SOU1996:186 “Transportinformatik för Sverige”. It focused on three main areas. First, a National Digital Road Data Base (leading to the implementation of the current NVDB). Second, a joint organization for Traffic Management – involving both national and local authorities (starting with Stockholm and Gothenburg), and third - integration of

³ The TM2.0 Innovation platform was launched in 2014 by ERTICO with 40 members from all ITS sectors to focus on new solutions for advanced interactive traffic management.

transport informatics in vehicles (this was the starting point of what became a long history of research collaboration between STA, private companies and research organizations).

In Europe, countries experiencing dense traffic and congestion, such as Germany, the Netherlands and Great Britain, have been at the forefront of advanced traffic management research and development. Sweden started a number of studies and minor tests but has largely done research in coordination with other nations at the EU level in initiatives such as PROMETHEUS, Drive and more recently Viking, EasyWay and Nordic Way.

In practice, modern Swedish traffic management started in Stockholm with a Traffic Management Center (TMC) supplying the main national road network with traffic information. In conjunction with the development of the traffic system Södra Länken 2004, the first co-operative Swedish Traffic Management Center was started. The STA and the City of Stockholm formalized an agreement in 2000, covering measures on a dedicated road net including both national and municipal roads. Later additions include cooperation on different levels together with police and emergency services to manage incidents and accidents and to minimize the negative effects of these types of events. However, so far, there are little in terms of specific legal instruments for Traffic Management in metropolitan areas. Legal frameworks providing guidance in some areas can be found in the Intelligent Transport System Directive and the delegated acts from the EU Commission (Europeiska kommissionen 2010/40/EU).

In essence, many activities associated with road traffic management such as route guidance and incident reporting are taking place in several places, both by public and private actors, with differing underlying logics and prioritizations. Already today, it is a reality that most of the drivers and travelers use services from commercial service providers as their main source of traffic information and route guidance. In order to use the current road infrastructure in a more efficient way the only option for a road operator today is to collaborate with the service providers. Summing up, there are several opportunities to enhance the collaboration between various public and private interests.

The structure of this report is as follows. First, a brief overview of the current management of traffic information at STA is given, followed by an account of a simulation of how improved information, including 3rd party service providers, could help reduce congestion. After this, a generic framework of data driven business models is used to briefly examine offerings, activities and revenue streams of the traffic information and navigation sector focusing on the Swedish market. Then follows an account of prior and ongoing European initiatives and strategies in the CTM area. Finally, several prioritized actions are presented in a roadmap for establishing CTM in Sweden.

2.5. Traffic management information in Sweden

Most modalities of transport are arguably more tightly supervised and guided than road transport. Roads are largely open for use by a vast number of private and professional actors utilizing various types of vehicles for various purposes. As long as traffic regulations are adhered to, there are no real limitations. Traffic management is largely confined to surveillance of a limited amount of road segments around major urban areas. Sweden is no exception and extensive TMCs exist in Gothenburg and Stockholm. Additionally, TMCs with more limited capabilities exist in Malmö and Gävle. While these have access to a limited amount of roadside installations to enact traffic *control* (e.g. variable signage and barriers at

crucial tunnel entrances), they do have an extensive amount of technologies and channels for traffic *information*.

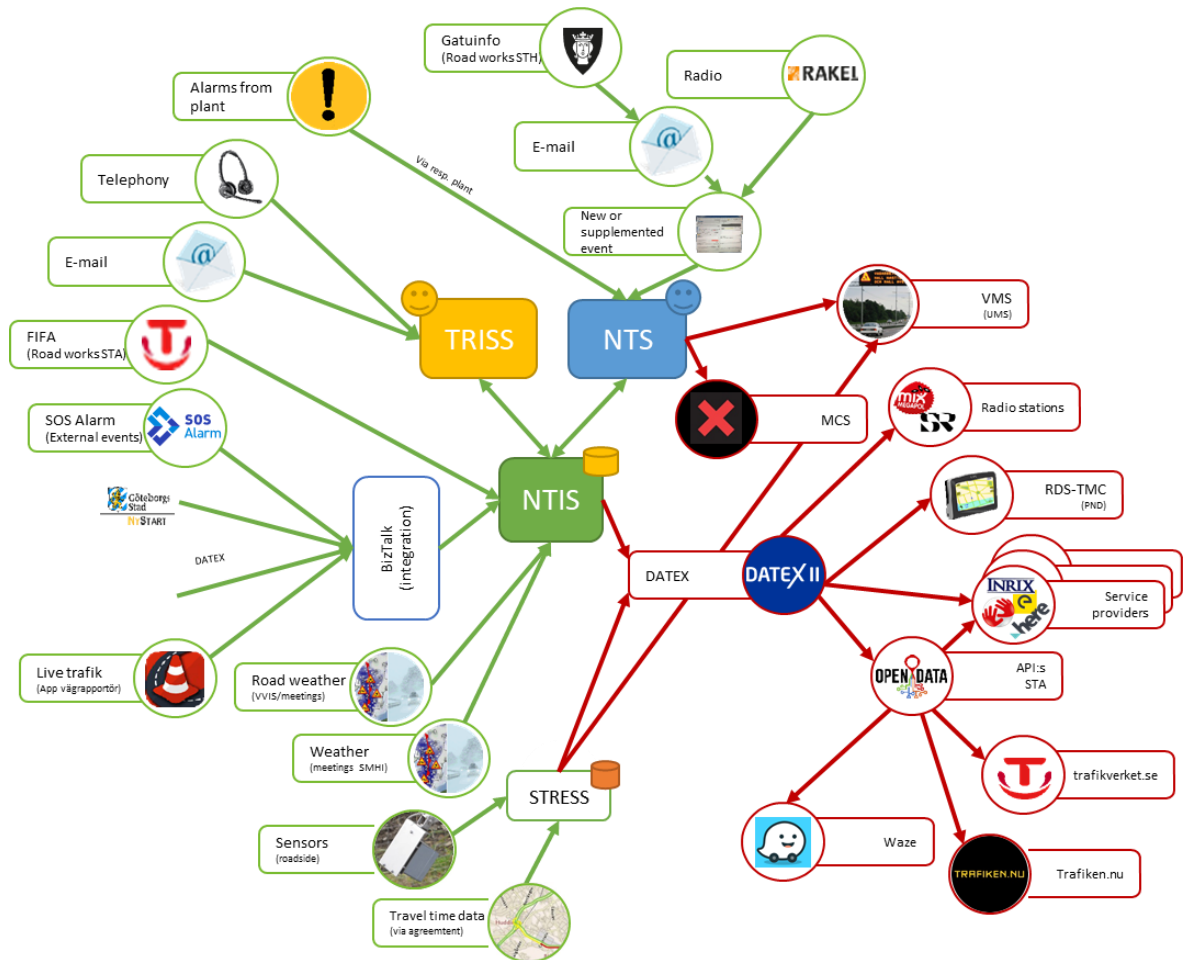


Figure 3: Traffic Information flows at Swedish TMCs

There is an extensive number of outbound channels and endpoints including VMS installations and the Trafiken.nu website operated by the STA. An important channel and user of traffic information is public and private radio.⁴

The Swedish traffic management process is facilitated by an extensive infrastructure of supporting digital systems. Through this, the STA caters for both in- and outbound streams of data and information. The current systems architecture revolves around the NTS system⁵ that acts as a decision support system for traffic managers, suggesting actions based on input on events. Actions are organized as a list of about 2 000 ‘action plans’ (‘åtgärdsplaner’) - chained actions that include traffic control measures and informing relevant stakeholders. The STA coordinates and facilitates several data management activities that involve municipalities to deliver certain types of data.

⁴ A much more extensive description of current Swedish TMC practice was made as part of the initial prestudy phase of the project.

⁵ NTS is the system view utilized by traffic managers at the TMCs. NTIS is the corresponding underlying database layer for traffic information.

Inbound include dynamic as well as static data, and digital as well as analogue channels. These include telephone calls or emails to TMCs from the public or media or other organizations. Roadworks are to be applied for and announced via a dedicated information system (FIFA). The information requirements on roadworks is regulated through TDOK 2017:0612 and FIFA is integrated with NTS. The distributed nature of reporting responsibilities (entrepreneurs, municipalities and STA all contribute parts) and the fact that it deals only with the entire length of the road work – not when it is actually creating disturbances, has made it difficult to present an accurate picture and there are local initiatives that intends to address this in e.g. Gothenburg via the 'Nystart' system. In addition to own measurements via roadside equipment, STA purchases travel time data from INRIX. VVIS supplies weather information from a large number of roadside weather stations across Sweden. Static road net data is supplied by the STA in cooperation with municipalities in the NVDB.

The STA has two main outbound digital traffic data channels – DATEX II, and an API. In addition, the STA has also adapted an outbound stream to conform to the proprietary Waze interface. The API is intended to be a more lightweight and manageable way for external service developers to access STA data, but is in practice utilizing DATEXII as an underlying information ontology. In total, STA acts as an access point to data on road net and topology, traffic regulations, road works, incidents, slippery road conditions, weather data, events and queues. Additionally, RDS-TMC is still provided. While the STA is relying on radio and service providers to a large degree, it also runs VMS-signs as well as a website – trafikenu-intended to inform drivers pre-planning.

There is an extensive number of outbound channels and endpoints including VMS installations. A DATEXII feed is utilized by a number of recipients including service providers as well as the Trafikenu website operated by the STA in cooperation with municipalities and public transport. An important channel and user of traffic information is public and private radio.⁶

The ability to digitally transmit a tactical traffic management intention to third party actors is a key aspect of the TM 2.0 preambles to CTM (see section 4.1). While the current version of DATEXII does provide for geolocation data by incorporating the defacto OpenLR standard, there are several alternative developments to geofencing standards. One of the oldest traffic management geofencing services, the Australian IAP, is the basis for the ISO 15638-14:2014 TARV-standard. This standard provides a reference architecture and 6 specified services. CEN has worked on a 'controlled zone' extension to DATEX II allowing for the transmission of geofencing information via this entrenched standard.

The EU project Socrates^{2.0} (see section 4.2) initially attempted to develop its own geofencing standard, following the directions from the TM 2.0 work – the 'TMex', construed as an extension to DATEX II. However, this work was not a part of the later activities of the Socrates^{2.0} project. Currently CEN TC 278 WG17 is developing METR, a DATEXII extension for management of electronic transport regulations. Finally, CEN has recently published the CEN/TS 17380:2019 standard, covering 'Controlled Zone' management for UVARs using C-ITS. Multiple research projects are currently taking place and Sweden has not yet chosen a specific means of expressing geofencing in the context of traffic management.

⁶ An extensive description of current Swedish TMC practice was made as part of the initial prestudy phase of the project.

2.6. Policy for Swedish Traffic Management

There are several national and regional regulations as well as public principles of governance that are of importance to the CTM area. As part of the EU, Sweden has incorporated the ITS directive and act into national legislation. The provision of safety related information is an important consequence of EU regulations that could affect the B2G relations, but the ramifications are not yet clear. The GDPR regulations could influence data services that depend on disclosing discrete user data sources, but many traffic services have not been affected thus far. The interpretation of the Swedish Public Access to Information act (Offentlighetsprincipen) has recently become the source of a debate. A strict interpretation of the legislation could mean that all traffic management information procured by public agency is made available to all. This is not how current agreements are configured and would make the price of such information services significantly higher.

Beyond legislation, several emerging topics have relevance to CTM. Currently no authority assumes the overall responsibility of national traffic and road net information management. Historically, this has created an ambivalence and reluctance to assume such responsibilities among involved actors. However, there are examples of collaborations, such as the NVDB, where the STA assumes a stewardship of the collaboration among all municipalities.

In the planning process, the STA operates according to a '4-step-principle'. This is designed to, if possible, prioritize cost effective trimming measures and ITS-services ahead of expensive new roads. However, it has been difficult to incorporate new digital services as part of solutions. Among the reasons is an experienced lack of easily quantifiable effects for novel services.

The STA has established a set of service levels to describe how different types of roads should be supported by traffic management and information.

Geofencing and UVARS are a strong current trend. Making traffic abide by regulations using digital fences has been available from a technological viewpoint for quite some time, but as the market is becoming saturated by connected vehicles, it has become steadily more feasible, and there have been pilot tests in e.g. Gothenburg where public transport buses were automatically reduced in speed over a sensitive bridge. There are currently standardization work ongoing at CEN building on pilot test experiences in e.g. a pilot performed in Oslo recently. The EU funded Reveal project⁷ is currently exploring the opportunities and challenges of using geofencing to manage traffic in cities.

⁷ <https://urbanaccessregulations.eu/public-authorities/reveal-project>

2.7. Simulating the effects of improved traffic information

Whereas traffic information and informing and guiding is key to traffic management, the merits of improved capabilities with regards to timely and complete information to drivers is by no means a foregone conclusion. To gauge the potential of improved processes, information quality and more extensive coverage, the project decided on a simulation of various levels of traffic information support.

With world leading competence in traffic information modelling, and prior experiences from researching preambles to the Socrates^{2.0} project, TU Delft was tasked with designing a simulation of various levels of traffic information access to gauge effects on traffic in a specific case. Real key cases were sought according to a set of criteria: Access to real traffic data for calibration; multiple roadside installations available; recurring disruptions; potentially significant traffic effects; potential for rerouting. The Södra Länken (The southern link) tunnel in Stockholm is an extensive complex that meets all these criteria.

Södra länken designated as national road 75 (Swedish: Riksväg 75), is a motorway in Sweden connecting Essingeleden (E4, E20), Stockholm with Värmdöleden (county road 222), Nacka. Södra länken is 6 kilometers in length, of which 4.5 kilometers are in tunnels. This makes it the third longest urban motorway tunnel in Europe. The tunnel is 2 lanes wide each way and 4 lanes including ramps at major junctions.

For fire safety reasons, queuing inside of the tunnel is to be avoided at all times. For this reason, entrances are regularly blocked for up to 15-20 minutes to reduce the congestion pressure. When closing the tunnel, rerouting is possible through the municipal capillary road network. At times this causes secondary congestion problems at key intersections. The study investigates the impact of route guidance on traffic flows on the network if entrances to the tunnel in the Södra Länken are closed due to congestion in the tunnel. The most common situation is that about 07.15 hrs. two entrances are closed for half an hour on average.

For this situation 8 scenarios were analyzed. Scenario 1 represents the current situation with normal traffic, no tunnel closure and no extra information. In scenario 2 the tunnel is closed, but traffic behaves as usual. In scenario 3 traffic reacts in the normal way to the tunnel closure, but without external information. So, all drivers make their own choice. VMS's are used in scenario 4, but they only give information about the situation. Scenario 5 is the same as 4, but now the VMS's give routing advice. In scenario 6 part of the route user receive extra information and a personal route advice via an in-car information service. Scenario 7 this information is improved for users with mobile devices and in scenario 8 all users receive the best information possible.

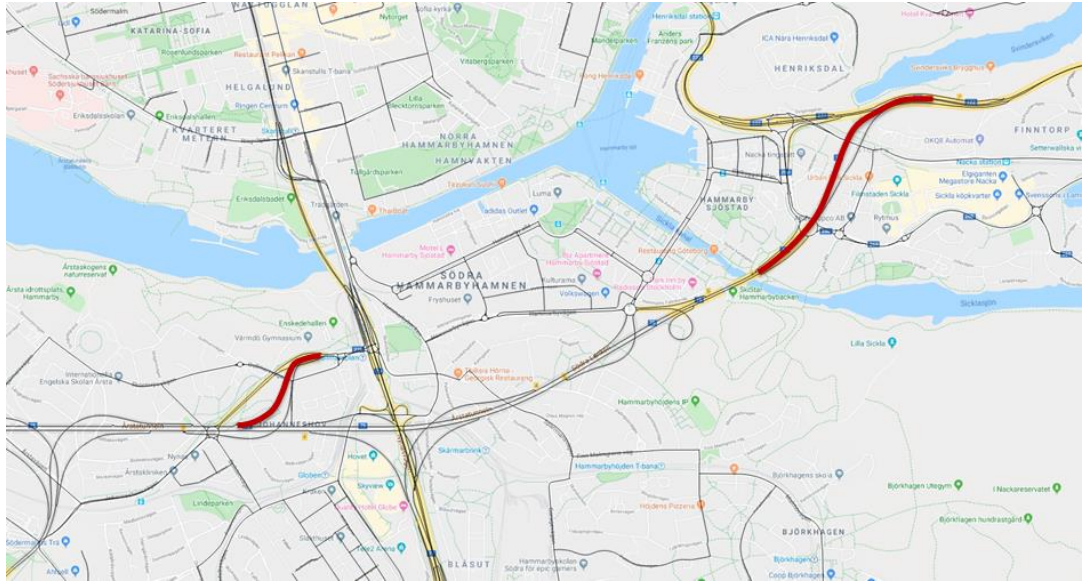


Figure 4: Closed entrances to the tunnel (red)

As seen above, in several scenarios VMS's are used to provide road users with information. Stockholm has various VMS's available (see www.traffiken.nu/stockholm), but only 4 of them are relevant for the study and used in the simulations.

According to the scenarios simulated, the effect of various levels of information in the Södra länken setting is as follows. If no information is given, drivers will try to find their own way and this is not the best option for the network as a whole. This individual search for alternate routes is in effect worse than the impact of the tunnel closure itself (3% extra delay). Moving on, giving information with variable message signs already improves the situation considerably (7% less delay), but informing road users personally and giving them a good route advice using navigation systems or mobile devices is better still and in this case, the total delay decreases with an extra 5% (12% in total). Improving the information also helps a lot. The best information for the group of users with navigation devices (about 60% of the traffic) gives in total 17% less delay than the situation without giving information and 11% less delay compared with the situation with information on VMS's. And giving this information to all users, instead of a certain group, improves the performance of the network with another 1% less delay.

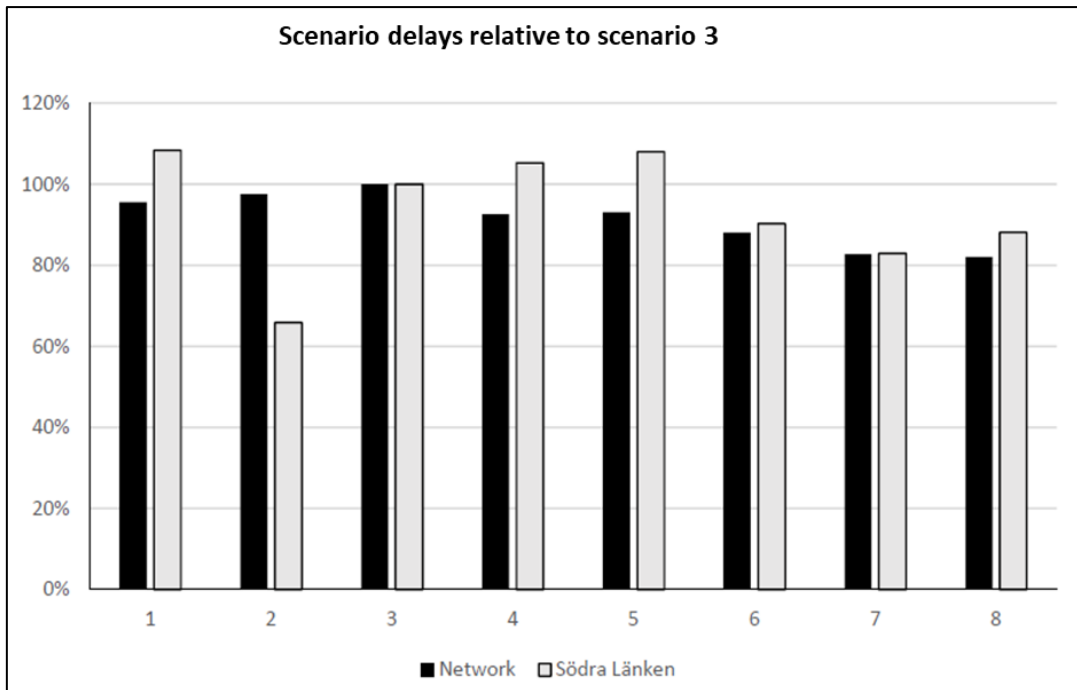


Figure 5: Relative results of the eight scenarios

Figure 4 shows the resulting delays for both network delay (black columns) and delays within the tunnel system itself (grey columns). A clear conclusion is that giving information is always better than no information and personalized information is even better. The best situation appears when everybody gets advice based on the traffic conditions in the whole network (scenario 7 and 8 in the figure). The results presented in this study are based on a number of assumptions. One of the assumptions is the duration of the closure. If this duration is increased from 30 minutes to 45 and 60 minutes, the results and the conclusions do not change.

The simulation utilizes the Marple model, developed by Delft, and a traffic model developed by Stockholm and the STA (Transmodeller) and calibrated using real traffic data. For a more detailed account of the simulation project, including assumptions and reflections on results, see the separate report on this (Taale 2020).

3 Data Driven Business Models in Traffic Management

As seen in the preceding introduction, the field of traffic management is dependent on a set of activities and components performed by various public and private actors. As in any data driven field, a collaborative traffic management ecosystem is characterized by a number of private and public actors performing value adding services on different levels. To gain an understanding of what these building blocks are and who are involved in them, the notion of business model is useful⁸.

There are several specific conceptualizations of business models in use, each with their specific emphasis from the single firm perspective towards ecosystems (El Sawy and Pereira 2013; Osterwalder and Pigneur 2010). On the ecosystem level, much can be gained by aligning with a 'keystone actor' to leverage e.g. its installed base (Selander et al. 2013).

In order to understand the specifics of these business models, we utilize an influential, comprehensive generic model for data driven business models (Hartmann et al. 2014). This model has been applied in a generic study of data driven business across a wide variety of sectors. It provides a comprehensive set of components that make up a business model and will be used to give an overview to the various activities and capabilities of a host of public and private actors in the traffic management sector, using the STA as the primary viewpoint.

⁸ Though business models are commonly used to discuss how private enterprise creates and captures value, several scholars use the term as a means to analyze how public organizations do the same, see e.g. (Ranerup et al. 2016)

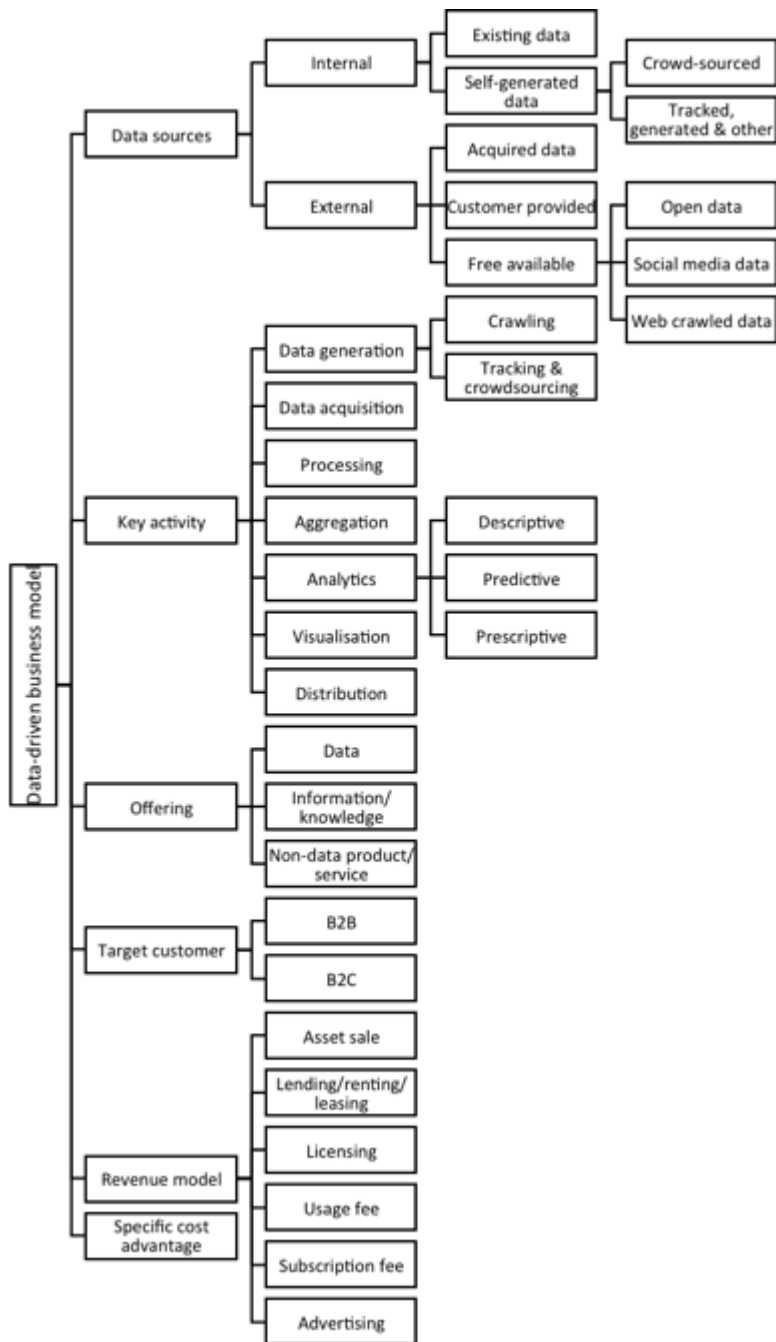


Figure 6: Morphological box of Data-driven Business Model components (Hartmann et al. 2014)

3.1. Data Sources

Starting from the top, a precondition for any data driven business model is data. There are several types of data available to the STA and various sources from which this data is collected. This is a rough approximation of the types of data of potential use to CTM. Some are in widespread use, others are available to only a few actors, and some are not well developed at this stage.

The STA are source of the following categories of data:

- **Road Infrastructure data**, such as road geometry, road width, road markings, height restrictions, functional road class, etc.
- **Traffic regulations** (static and time dependent), such as speed limit, one-way roads, in the future also dynamic regulations as geofencing zones triggered by air quality, etc.
- **Ongoing work** or disturbances on the roads, such as usual road works, road closures, detours, winter maintenance, etc.
- **What is visible** in the road network, such as information on static or dynamic signs, traffic signal info, and so on.

Examples of data primarily sourced from external actors but of interest for the road operator:

- Accidents and incidents
- Wrong-way driver
- Animal, people, obstacles, debris on the road
- Unmanaged blockage of the road
- Road conditions as slippery road
- Weather, visibility
- Travel times
- Queues
- Events

The above data is also provided from the STA when it is accepted according to terms and conditions agreed with the original provider of the data.

A digital representation of the road infrastructure is a key component in navigation services. The Swedish NVDB is managed by the STA and a collaborative effort between a number of authorities and municipalities. A functional road classification data set (Funktionell vägklass) is produced and maintained by the STA⁹ and this data is available as part of NVDB. The purpose of this is to facilitate an expedient shift of traffic flow from low to high grade roads. NVDB also contains road regulations such as speed limits. All roads are classified on a 0-9 scale where 0 is the highest priority.

For NVDB and other purposes, the STA has a process and metadata scheme, describing intended usage and general information along with a data product specification focusing on a number of data quality attributes.

Data on roadworks is a part of the DATEX stream available from STA. This data is generally reported by the entrepreneurs responsible for the construction activities. The input process is managed by municipalities together with the STA.

3.2. Key activities

The value adding processes contributed by the organization can be summarized by a set of key activities. The model lists a set of activities, each adding value to data. An actual data-driven business model can encompass any of a number of such key activities ranging from

⁹ https://www.trafikverket.se/STASefiler/Dataproduktspecifikationer/V%C3%A4gdata/DPS_E-G/1010funktionell_vagklass.pdf

data generation to distribution of either data or a refined analysis. For each key activity, prerequisite organizational capabilities and technologies are needed (see e.g. Klievink et al. 2017 for a comprehensive set of capabilities required to make the most of data driven innovation in the public sector).

3.2.1. Data generation and acquisition

Data generation refers to the process of creating data via some means. In the traffic domain there is a wealth of ways to generate useful data ranging from roadside ITS units to cellular information or floating car data. Although data needs to be generated to facilitate a data-driven business model, it is by no means evident who is responsible for any given data type. Moreover, the data generation activity is deemed critical and many actors collect their own data, such as via crowdsourcing the activities of their customers (e.g. Waze and other navigation services for user input and OEMs for telematics sensor input). In some cases, the sensors and data gathering resources are designed for the purpose. In other cases, the generating equipment is designed for a different primary task and can be reutilized for traffic analytics purposes. While some sources are available from several actors, they vary in geographic coverage and resolution. The pressure to compete with the best navigation system or to manage the traffic system in the most effective way leads actors to acquire new data sources to enable a refined analysis. The types of data acquired from external sources ranges from vehicle sensor and actuator data to weather data or free text in local reporting on e.g. roadworks. The cost structure varies accordingly from expensive detailed map data to crawling the web for unstructured text on traffic events.

3.2.2. Processing and Aggregating Data

Data ranges from raw sensor output to data synthesized and expressed in complex ontologies and API:s. In some cases data might require little in terms of refinement, whereas in many cases data is very difficult to interpret. Within the field of analytics, the terms Data Readiness Level is one way of describing the available data in terms of its usefulness and availability to fulfil a certain analytics task.

Most often, data needs to be combined with other data to enable efficient and effective analysis. For instance, ambiguous data might need to be combined with another type of source to improve overall quality. In traffic services this is a composite process with both automated and manual activities. As an example – a global service provider employs a substantial number of staff to perform manual editorial activities combining incomplete or ambiguous official data with acquired data from local news to improve the descriptions of road closures.

3.2.3. Analytics activities

Analytics is a core element in traffic management. The model describes three broad groups of activities within analytics: Descriptive, predictive and prescriptive analytics. For the purpose of collaborative traffic management, these can be contextualized as follows. A *descriptive* analysis intends to accurately determine and describe the current state of the traffic system. This is a key activity with all actors as a main purpose of all traffic management is generating concurrent ‘situational awareness’ of the current state of the traffic system. The exact configuration of the descriptive analysis output differs between actors according to the choice of design of critical algorithms and the quality and amount of data available. A *predictive* analysis means to accurately forecast a future state of the traffic system. Again, this is a key capability sought by most actors. This ranges from interpretations of effects of planned changes such as road works to advanced queue detection analysis. This is a field of growing importance and at the center stage of an

increasing interest in data driven traffic management among traffic management. Finally, *prescriptive* analytics seeks to accurately gauge the optimal action in a traffic situation. This ranges from adaptive route calculations for the individual drivers to a potential systemwide optimization of all partaking vehicles and passengers. Note that the term prescriptive is not necessarily to be understood as a forced action, although from the point of view of a TMC, this level of analytics could be coupled to traffic control measures of various kinds, such as geofencing mechanisms or roadside equipment. From the point of a navigation service provider, showing users the optimal route is the key offering and showing a better route than the competition is important.

3.2.4. Visualization

Most service providers provide a visualization of the historic, current or future traffic situation based on the analytics activities described above. They may focus on different types of visualization strategies depending on key user groups or data supply. For instance, the crowdsourced events is a key part of the Waze app user interface. Whereas the STA primarily displays its own events on trafiken.nu (although these are often fed by similar processes including phone calls from the public). The visualization of composite data reflecting operations is a sector in its own right and several vendors provide advanced concepts for displaying the traffic system situation to TMCs.

3.2.5. Distribution

Distribution is a key activity and is performed at all stages via APIs or similar methods. Raw, or processed data can be distributed for a fee or as Open data to improve sector efficiency (see e.g. the PSI directive). Refined information resulting from aggregation or analytics activities is transmitted from public sources via the DATEX II standard. More recently, the STA is supplying data via an API, designed to be a more lightweight means to access a selection of frequently requested data. The API is still based on the DATEX II specification as an underlying ontology. Recently, STA has developed a specific interface to the Google Waze service.

The STA is also acquiring data from external sources. The manner of distribution of such data is case specific. As an example, the STA together with the cities of Stockholm and Gothenburg purchase travel time data directly from INRIX. This data is made available to TMCs and used internally by the STA. Another example is the STA use of Waze. In this case, the STA has access to a 'dashboard' containing a number of relevant ready made analyzes of traffic data. However, the underlying data is not made available for aggregation or fusion with the STA.

3.2.6. Offering

In a data-driven business model, offerings can concern raw data, information and knowledge based on data and analysis, and services connected to managing and refining data, analysis, information, and any type of utility generated thereof. In the traffic management area, there are several types of offerings from various organizations:

- Selling IT-systems for Traffic management
- Operating traffic management (for public or private road owner)
- Fleet management systems provision
- Traffic control Tower operations
- Systems and services for traffic data aggregation and/or analysis

- Operating communications channels
- Operating gateways for aggregating and coordinating services

Most actors combine several offerings in their business model. In terms of raw data, STA generates long term traffic volumes using their Tindra-system and infrequent measurements at specific places. A more frequently updated data from the STA is weather data from the many stations provided via VViS. Although the distinction between raw data and refined information is to a degree a matter of context, private service providers generally prefer to supply more refined information and knowledge, using raw data as input for analysis to produce such information. As an example, INRIX currently supplies the STA with travel times estimates based on their collected raw data from telematics units on commercial terms. Another example is NIRA Dynamics who fuses road weather data with tire friction loss and other telematics data to produce services for e.g. road winter maintenance.

3.3. Target customers

The notion of target customer is quite complex in the public private field of TM and navigation services and many variants of business relationships exist side by side. First, as a public authority, STA together with local municipalities considers all citizens and organizations using the road network as customers in a government-to-customer relationship. The open public end-to-end Trafiken.nu web site thus serves everyone interested in the current traffic state.

However, as a provider of open traffic data, STA also caters private service providers in a government-to-business relationship. These service providers refine this data by combining it with other sources and providing proprietary analytics and providing end results to paying customers in a business-to-consumer relationship.

Additionally, they also provide public sector actors such as STA with their traffic data on a commercial basis in a business-to-government relationship. Finally, vehicle OEMs utilize service providers as a supplier of onboard navigation functionality and traffic information services in a business-to-business relationship.

3.4. Revenue model

In the case of private actors, they charge end-user customers, other businesses or public organizations for the use of data or analyses. Many if not most engage in business models utilizing more than one of these revenue models. The use of analyses or data is usually limited to a certain user or case, in order to prohibit a widespread use of a key data set. Purchasing data for open access is possible, but at a significant cost.

In the case of STA, the stated goal is an available, efficient and long term sustainable transport system considering traffic safety and environmental issues. In this way, the provision and acquisition of traffic data and traffic management is assumed to produce a utility to the users of the road traffic infrastructure. From a public perspective, the provision of open traffic data to third party service providers is a means to boost the reach and utility of that resource, instead of assuming a costly end-to-end service design and delivery role. However, the STA also retain some direct end-user informing capabilities through the trafiken.nu website.

This way of reasoning is also applicable to the procurement of data from private firms to enhance the capabilities of the Gothenburg and Stockholm TMCs. The service providers utilize a set of revenue streams. Mostly conforming to B2G, B2C or B2B licensing, subscription fees and/or advertising (for end-users).

4 Data Driven Businesses in Collaborative Traffic management

Collaborative traffic management requires a well-adapted technical infrastructure and organizing logic. The field is currently evolving and there are a number of new kinds of actors that offer platforms to manage collaborative traffic management of various scopes and abilities. Some representative examples are given below. Some fit the scope of traditional TMC, whereas others have a different origin and more limited applicability. Some target local government, some target businesses. Some target end-users, some provide B2B services.

4.1. CIP

The City Innovation Platform (CIP) is a set of B2G open source software components developed by Dutch firm Civity, designed to manage data and spur digital innovation in a city. It is intended as a facilitating layer connecting service providers to open data in an efficient manner.

A Data Market, to make all types of data available, according to licensing and pricing models and access rights determined by the provider of the data. In the Data Market's catalogue, data requests are accessed via standardized APIs (with associated tools).

The Data Management Framework is the core of the City Innovation Platform. Here, the collection, processing and storage of data (if necessary) is regulated. Much attention is paid to data quality, common data models and tools for the storage of open, linked and big data.

While CIP conforms to a B2G business model, providing authorities with a means to expose open data for innovation, they also pursue crowdsource data acquisition development, e.g. reporting services and crowd-sourced NOX-analysis suggesting a very wide scope of business activities. Civity and CIP has been very active on the EU-project scene and part of Swedish EU-research efforts.

4.2. Traffic Management as a Service

While much CTM focus has been on big cities, many small and medium-sized cities around the world also need improved traffic management. Historically, this has not been feasible, as building separate, traditional TMCs for all these cities is probably not the most feasible solution. As a response to this perceived need, the Traffic Management as a Service (TMaaS) project is developing a lightweight platform that offers citizens and local government's situational awareness focusing on multimodal mobility.

The TMaaS team's ultimate goal is to build an on demand modular solution, where users can build a customized tool by subscribing services. The initial pilot is in Ghent and end-user research has been carried out into what information citizens need and how they prefer to view it. Citizens will have access to a dashboard that they can adapt to their preferences and where they can follow-up the mobility items of interest to them. While the dashboard design principle demands some degree of end user adaptation and there is a two-sided platform connecting city and public transport with citizens, the TMaaS initiative is first and foremost

a lightweight end-to-end service approach targeting the same type of B2G market as traditional TMC-installations. Main activities include everything from data acquisition and aggregation to analytics. Having said this, it is important to note that this is a project that is yet to be finalized and that many issues are still to be resolved.

4.3. National Data Warehouse for traffic information

Whereas the STA purchase limited sets of data from the private sector, the Nationale Databank Wegverkeersgegevens (the National Data Warehouse for traffic information, NDW) has procured comprehensive sets of traffic data from several sources. Through the Dutch national data warehouse for road traffic information 9 public authorities maintain a shared database of road traffic information. The mutual collaboration among these public authorities as well as their contacts and contracts with the private sector have resulted in extensive high-quality traffic data with a high level of geographical coverage.

In 2014, NDW entered into a framework agreement with eleven private companies for the purchase of real-time traffic information. This provides a way for NDW to issue tenders that are completely customized according to the needs of the particular road authority. Since the public authorities have formed an alliance, they can use the economies of scale to buy at lower prices. The NDW partners can also decide to arrange for collecting the data themselves and then having it entered into the NDW database.

The NDW performs several data driven key activities with a focus on data acquisition, processing and aggregation but also analytics, distribution and visualization. Examples of the latter is a viewer to present the traffic data, and user-friendly reporting software to transform the data stored in the historical database into tables, maps and graphs. A crucial capability is data quality monitoring to ensure that data acquired is fit for purpose depending on its intended use in e.g. policy making or traffic management. 24/7 monitoring is coupled to a set of agreed procedures involving sources and there is a service desk managing malfunction reporting and support needs.

In terms of systems architecture, it is supplied and distributed among a number of private sector organizations all contracted by NDW. The high-quality information afforded by the aggregation of so many sources makes NDW a near full spectrum traffic information provider to public and private actors alike. Data is available as open data, meaning that it is available to third parties for reuse in their applications. For parties that require more services, NDW offers an Agreement on Mutual Data Provision and Services. Parties involved make record of mutual conformation to data and service deliveries to one another.

Beyond Business model activities, NDW also participates in National and international standardization agreements needed for the smooth exchange of information between various systems. NDW coordinates this aspect with other parties, participates in decision-making, and also contributes substantially to the development of standards. Once a new standard has to be introduced, NDW directs this process.

4.4. The Extended Vehicle concept and neutral server

While the most visible companies provide end-user navigation services, some have opted for a different approach. Otonomo is an Israeli telematics company that does not focus on end to end user services, but rather to build a two sided B2B market based on attracting both several OEMs and their car data as well as service developers who would otherwise struggle

to develop services with enough coverage. In a strict sense, Otonomo might not be a navigation service provider, but their business model, building on the ACEA Extended vehicle Neutral server concept, merits inclusion as an example of data driven business models that does not target analytics activities. Rather Otonomo strives to perfect data acquisition processing and aggregation to become a one-stop supplier of telematics data.

The neutral server initiative, sponsored by the European Automobile Manufacturers' Association (ACEA), is a joint effort to make automotive data available to third-party service providers in a safe and secure manner, without requiring those third parties to sign a contract directly with each automotive manufacturer. The neutral server initiative was announced in late 2016 and received critical support from the European Union, automotive OEMs, and other automotive industry stakeholders such as insurance companies, energy providers, and automotive maintenance services.

5 Collaboration models in traffic management

In the preceding sections, the traffic management sector has been found to depend on both public and private interests to share data and analyses, but always serving the most immediate goals according to their differing viewpoints and business models. Public actors strive to optimize the entire traffic systems while private actors compete by serving their customers superior routes. Growing congestion problems have for some time been a factor provoking an interest in improving public private collaboration in traffic management. The need for an overarching set of guiding design principles for collaborative traffic management has been a driving force in the project. This is rooted in the realization that traffic management agency is currently distributed between public entities in traditional traffic management centers, and navigation service providers where the latter is the drivers and travelers' main source for traffic information and route guidance.

On a surface level, both types of actors attempt to alleviate challenges rooted in congestion through the collection and distribution of information and analysis. However, a key difference concerns their differing *raison d'être*. Traditionally, traffic management centers have been erected by public authorities to ensure a smooth operation of the traffic flow on road infrastructure. The goal is societal in scope and funding is frequently provided by one of or a combination of state and municipality tax money. Service providers, on the other hand, serve paying customers or serve as a means of attracting user generated data to companies, or a combination of both. Competing on a global market, customer satisfaction regarding good quality advice and individual user travel speed is a key driver.

While the public goals of providing seamless infrastructure capability and private goals of individual navigation have developed largely in isolation, as congestion increases, it has become increasingly clear that a more involved relation is likely advantageous. While consolidating private and public goals for TM might seem advantageous, it is not very well understood how this can be accomplished in practice in a way that both sides can agree upon.

Both public agencies and private service providers collect and provide traffic information from a number of sources, internal as well as external, performs analysis and shares information via a number of channels to a number of users, both end-users in traffic and other organizations. In this highly complex and involved ecosystem, all actors are potentially interdependent in various ways. Any change towards a more comprehensive transparent dissemination of traffic data by e.g. public agencies needs to be compared to the potentially

negative effects on market attraction and the innovation capabilities provided by private navigation service providers. Vice versa, while satisfying customer demands for effective routes, route guidance should not compromise public goals by increasing traffic past sensitive areas or roads not capable of handling such loads. Collaborative traffic management is essentially about improving the efficiency of route guidance measures whilst managing this balance.

5.1. Traffic management 2.0

Managed by Ertico and launched in 2014, TM 2.0 is an 'Innovation platform' listing 40 members from all ITS sectors, with a focus on public TMCs, to discuss and promote new solutions for advanced interactive traffic management. TM 2.0 approaches the issue of collaborative traffic management from a societal utility perspective. While acknowledging private navigation firms, it is mostly concerned with a global road infrastructure viewpoint. TM 2.0 assumes a number of capability gaps in the form of lacking digital infrastructure components (European Commission 2017). These are:

1. Classification of roads including preferred routing alternatives
2. A geofencing mechanism, e.g. 'zone access control'
3. Actual Levels of Service for road network
4. 'Triggers' based on 1-3 above that decide when a specific Collaborative TM service should activate
5. A Common Operational Picture for the traffic system

A classification of roads needs to be done accordingly to network flow hierarchy; This tool should help road managers to present their views of the main road network hierarchy and the preferred routing alternatives. These may be useful for re-routing traffic over an area that is becoming saturated, using Green light optimized speed advisory (GLOSA), or targeted to specific road user groups, e.g. freight, electric vehicles or passenger transport.

A geo-fencing mechanism will specially help cities to translate their zoning urban planning into traffic management related data, preventing routing through residential areas or close to hospitals and schools. Service Providers can relate to these zones and apply virtual delays on top, so that the routing algorithm proposes an alternative way, more in line with the public's authority expectations. TM 2.0 assumes that this will align with the day 1.5 service 'Zone access control for urban areas' (Spoelstra 2017). The development of static zones is the first step, but dynamic zones, in location and time, will be used in the future.

Established network performance Levels of Service (LoS) is dependent on the nature of the road segments in question. This concept is related to classification, but it will be assessed under a combination of two more evident key performance indicators; Speed and Volume. These may be collected by roadside units, loops, or provided, Probe Vehicle Data by private entities.

A trigger is set globally based on **Classification, Geofencing and LoS** and when reached declares the need to engage a Cooperative Traffic Management Service, to maintain safe and efficient traffic conditions. The triggering conditions need to be commonly agreed upon, as Cooperative Traffic management services are the result of a combination of orchestrated actions, from specific actors.

Additionally, in order to make the orchestration of Cooperative Traffic Management Services possible, there is a need to develop a **Common Operational Picture (COP)** to provide the involved actors with a standard overview and regional context of a traffic situation. The COP will provide a visual interface, on top of a map, enabling the display of the appropriate traffic management related data, in accordance with the described building blocks layers. The COP can play a major role for re-routing services, for identifying the need of any additional measures or, for facilitating extra traffic on alternative routes, etc.

This list is useful for directing attention to what needs to be developed to utilize digitalization to improve current TM practice. However, it does not explain in any detail the nature of the proposed capabilities. It is also silent about the fundamental prioritization and weighing of priorities and resources and the interplay of public utility and private profits. These lines of question were further developed into an EU CEF project – Socrates^{2.0}.

5.2. SOCRATES^{2.0}

Retaining the overall purpose and goal of the TM 2.0 initiative, Socrates^{2.0} advocates the nature of private public collaboration as the key issue to achieve effective collaborative traffic management. This project is thus concerned with establishing a reference framework of collaboration. It does so by attempting to go beyond a mere ‘collection of ITS-pilot cases’ and pursuing a more ambitious goal of putting forward a full set of generic components and collaboration permutations to guide future CTM implementations. Socrates^{2.0} actual cases of advanced ITS service pilots as reference evaluations of the suitability of the derived conceptual collaborative framework. By necessity an overarching model capable of conveying a complex relationship between competing public and private entities at a glance will necessitate abstraction and this forms a limitation in terms of granularity. However, Socrates^{2.0} aims at providing a conceptual design framework capable of conveying a broad set of cases. Socrates^{2.0} use three key dimensions to describe cooperation: Level of commonality, Level of detail, and level of commitment. Level of commonality concerns the notion of a ‘common truth’ and whether such a thing exists in the case at hand and if so, to what degree. Common truth is rather broadly defined, with respects to what this entails in terms of levels of data transparency and service coordination. The granular description of what is actually shared is instead covered by the ‘level of detail’ construct. This is divided in four levels of increasingly strategic character. The first ‘situational’ level implies various

	• No joint approach • Exchange info	• Joint approach • Common insights	
	No coordinated services	No coordinated services	Coordinated services
Situational: status sensors, actuators	Monitoring with own instruments	Share data, jointly set up CSP and optional improve own monitoring	Joint development CSP and all agree to use it
Operational: actions, measures	Independent choice and deployment of measures	Share actions and measures and optional improve own measures and actions	Joint development, choose and deploy coordinated measures and actions
Tactical: approach, TM services, motivation	Independent development and choice of tactical approach	Share approach and motivation and possibly improve own approach and motivation	Joint development, choice and deployment of coordinated approach
Strategical: policy, priorities, objectives	Independent development and deploy of policy framework	Share policies and priors and possibly improve own policy and priors	Joint development and deployment of policies

Figure 7: Socrates^{2.0} cooperation matrix

alternatives to monitoring. The next two, ‘operational’ and ‘tactical’ concerns agency over choices and development of measures and ‘tactical approach’. The fourth and final, ‘strategic level’ concerns who develops priorities in e.g. policies and how. The last dimension covered by the cooperation matrix is the ‘level of commitment’. This is described as the existence or non-existence of ‘service coordination’.

The model, while informative, does present a very large number of permutations, all of which might be warranted, but this also carry the cost of complexity in interpretation and application. Additionally, although the framework provides for different levels of collaboration in the development of situational awareness and measures, it stays silent on how this can be achieved. This critique has been noted by the Socrates^{2.0} team who has explored ways of providing a more easily conveyed set of overarching design principles. One promising simplified way of achieving a unifying scope and design vision for collaborative traffic management has already been proposed and is currently under consideration.

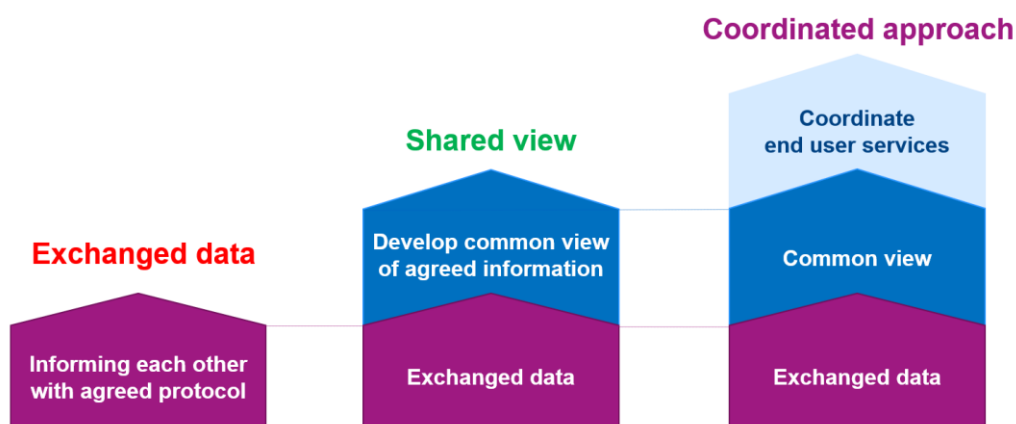


Figure 8: Socrates^{2.0} cooperation framework

It focuses on the key relation between public and private parties and provides three levels: exchanged data, shared view and coordinated end-user services. Data exchange is about agreeing on data formats and their interpretation, as per usual in interorganizational data exchange. The shared view is about developing a common understanding of the data shared. While the notion of common operational picture is not discarded, it is clear that the notion of sharing data with authorities and competitors is a highly sensitive and contentious issue, regardless of whether an independent actor is used as a trusted party. Furthermore, the actual interpretation of data, the core of the data driven business model of service providers, is even more sensitive. Socrates^{2.0} assumes that only when data exchange formats and a common understanding of shared data is achieved, coordination of end-user services can take place.

5.3. Swedish Collaborative Traffic management

Whereas the cooperation models from Socrates^{2.0} capture the sociotechnical design heuristics applicable to the development of a specific CTM-service well, the purpose of this project is rather to generate a strategic roadmap to reach the necessary capabilities for collaborative road traffic management in Sweden. In TM 2.0 and Socrates^{2.0}, CTM concerns collaboration in two core functions – situational awareness and route guidance. According

to this dichotomy, it is possible to share data and information creating a common situational awareness, whilst retaining the right to prescribe drivers routing advice individually. Alternatively, it is possible to coordinate route guidance to all drivers, whilst retaining actor-specific functions for generating a distributed situational awareness. The current situation could be described as largely (though not completely) non-collaborative concerning both awareness and guidance.

Using the core activities of data driven business models presented in the preceding data driven business model section, this project views CTM-services as a result of a value chain consisting of 1) data generation, 2) data acquisition, 3) data processing, 4) data aggregation, 5) data visualization, and 6) data distribution. As seen in previous sections, these activities can be configured involving varying number of actors in various business models. Though all activities are value adding to some degree, a key activity for most data driven business models, including CTM, is analytics. Currently multiple parties each utilizes their own value chain to perform their own data analysis. As detailed earlier, analytics can be further subdivided into 1) descriptive, 2) predictive and 3) prescriptive analytics.

For the purpose of CTM, this project has defined descriptive analysis as concerned with generating situational awareness, whereas prescriptive analysis concerns route guidance and active traffic management. Predictive analysis is more difficult to associate and could serve either situational awareness or prescriptive functions depending on how it is visualized and distributed¹⁰.

Focusing these dual end-user functions of data driven CTM: description (i.e. maps and road traffic information analysis and visualization) and prescription (i.e. decision support for direct route guidance and/or dynamic geofencing), this project has adopted a matrix to explore how the degree of collaboration shapes a future collaborative road traffic management ecosystem.

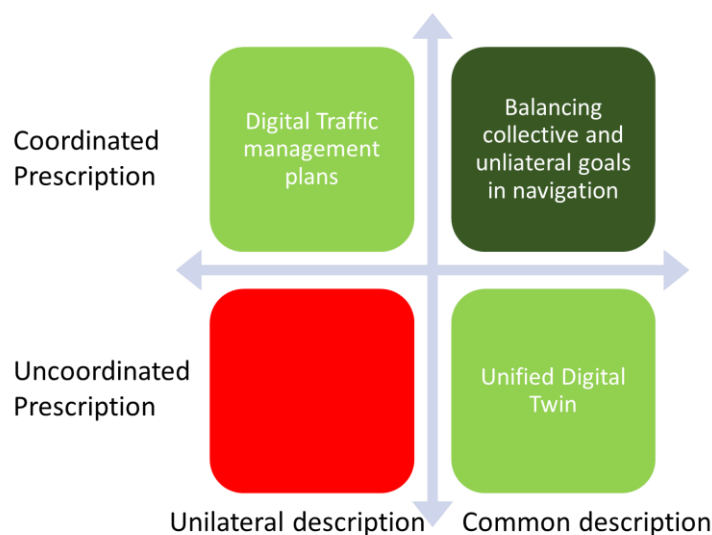


Figure 9: Collaboration level matrix of traffic management

¹⁰ While this report focuses on the 3 analytics categories used by one paper, there are many types of characterizations of analytics and many are fuzzy with considerable overlap in some instances and not easily distinguishable.

This framework allows for increasing levels of collaboration in terms of data sharing and understanding independent of the sharing of intentions. While in many cases these will coexist, as shown by e.g. the Socrates^{2.0} Amsterdam pilot, the sensitive nature of data sharing makes it a risky proposition to assume a dependence of substantial data sharing and understanding to design geofencing CTM service.

6 The Future of Swedish Traffic Management

6.1. Desired position and recommended actions

It is the stated ambition of STA to move towards a more involved and bilateral relationship with external providers of navigation services to achieve collective goals on a system level. However, considering the dual goals of on the one hand providing coordinated digital representations and on the other hand coordinating prescribed actions to drivers, there are likely several possible paths towards balancing collective and private goals of citizens, authorities and commercial actors. Actions coupled to improving collaboration in terms of data and visibility may be intrinsic to actions coupled to coordinated routing action (as shown in the implementation of the Socrates^{2.0} Amsterdam pilot) but need not be. Regardless of the causal structure of fundamental CTM elements, several immediate to short term actions are needed along both axes.

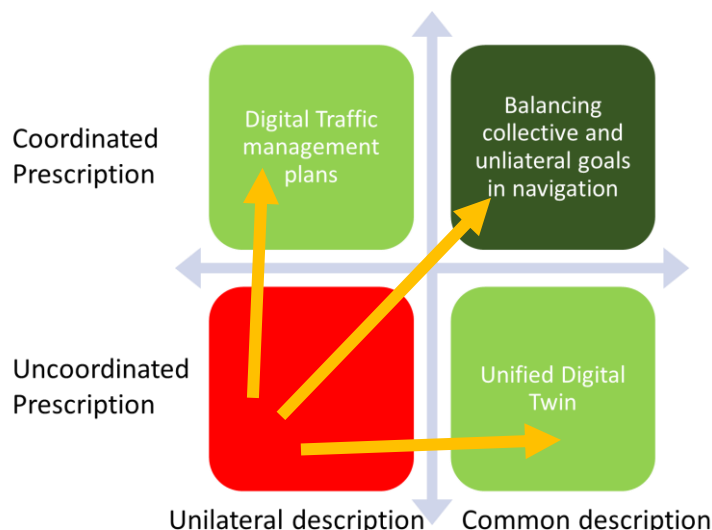


Figure 10: Collaboration level matrix from current situation

In the 2020 STA plan for traffic management, several activities have been prioritized that have close relationship with collaborative TM. The figure below describes how several key components synergize towards an increasingly collaborative TM.

First, based on the experiences as part of this project, external actors will likely require an improved perceived quality of the data provided by STA in order to give their customers the correct advice. (e.g. moving from simple coordinates for placing of text and symbols to more emphasis on navigation quality geolocation markup.) Additionally, a better coordinated public sector would greatly simplify their acquisition and utility of public traffic data.

Second, an increased data quality will facilitate an increasingly data driven TM practice. Beginning with decision support systems listing dynamically formed and ex ante evaluated

options at incidents or events, based on trigger levels, moving towards completely automated responses with minimal human involvement.

Third, increasingly detailed tactical actions increasingly utilize a host of external channels to convey recommendations to drivers.

Fourth, once in place, geofencing standards grant new opportunities to utilize external actors (vehicle OEMs and service providers) to act on advice or, indeed, regulations, e.g. recommended detours and corresponding sensitive routes to be avoided.

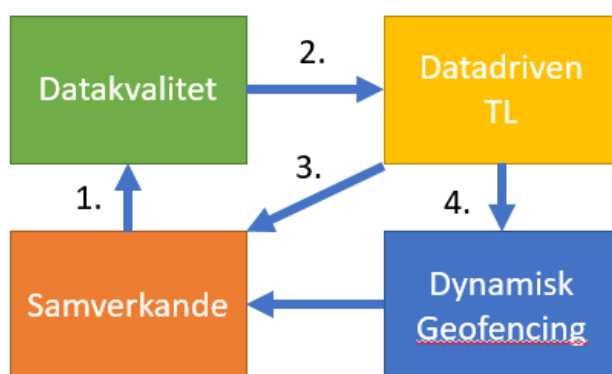


Figure 11: STA Strategic Traffic Management Development plan in relation to CTM development

The following recommended actions are a result of a collaborative effort among the project core team as well as external participation from Stockholm and Gothenburg city and interactions with service providers. Information gathered in a series of workshop served as a basis for the development of a number of recommended actions. In the following sections each such action is given a brief explanation followed by a list of main opportunities foreseen as a result of a successful implementation as well as risks associated with the challenge. Some general observations can be made. Many of the suggested actions span multiple actors both within STA and across organizational boundaries. Given the nature of CTM, this is to be expected, but several actions on a generic digitalization and strategic national level have been listed seeing as they will have a significant impact on the feasibility of establishing a CTM in Sweden.

6.2. Recommended actions 2020

6.2.1. STA as domain responsible for traffic data

Public data acquisition, governance and distribution lies at the heart of Collaborative TM. The issue and its opportunities and challenges are far greater than the scope of this roadmap. However, since this question is coupled to how CTM can or cannot be developed, it is included here. The issue of general responsibility for public data in the Swedish transport sector has been a topic of interest for some time as the STA has not assumed such a role, assuming it lies beyond its current duties. Whereas some coordination with other actors does take place (e.g. the NVDB governance process together with municipalities and the joint STA/Municipality TMCs in Gothenburg and Stockholm), a well-structured global role for managing public traffic data could provide clarity and resource pooling and avoid

duplicate efforts to provide public data. With this in mind, the STA is currently working towards assuming this role in Sweden.

STA is currently clarifying an intention to assume the role of national domain responsibility for public data in the transport sector (multimodal). STA – EVI is currently involved in dialogue with DIGG and E-sam who are coordinating nationwide digitalization domain responsibility.

STA will need to generate an estimate of the necessary internal and external capabilities and the funding to manage acquiring, governing and providing data within this scope, and the costs incurred. STA will utilize a shared resource (platform) and predefined patterns for secure and efficient data exchange with external parties. Managers at VO/CF (STA ‘Central function’) shall ensure that funds that are used for VO/CF-specific solutions for digital collaboration are instead diverted towards the shared platform.

STA Legal Matters will clarify the legal ramifications of participating in international collaboration projects involving data sharing and to suggest any necessary changes to accommodate such activities in the future. While the first steps towards a domain responsibility has been taken, the issues mentioned will likely require some time to resolve before this can have a notable effect on CTM and digitalization of TM in general. Meanwhile, while the issue of domain responsibility will likely have an effect on many of the other suggested actions, the descriptions of these do not presuppose a domain responsibility in effect.

Indeed, as exemplified by a currently ongoing initiative (‘NSöd’) to improve the management of road work information among municipalities and the STA, cross sectoral coordination seems underway.

Opportunities

- STA can assume complete responsibility for the entirety of Swedish public data for traffic in all modes, greatly simplifying strategic planning and interactions among public actors on this field.
- External actor could gain access to this comprehensive data resource, including data from all municipalities in a convenient manner.
- An improved common public operational picture will be more complete in depth and geographical coverage and more easily updated and maintained

Risks

- Currently, STA lacks the necessary resources to assume this responsibility
- The scope of this task is currently in need of clarification and balance between envisioned capabilities needs to be met by funding and other resources (platforms, competencies, funding etc.).
- There could be a goal conflict of interests and/or overlapping interests on the municipality level. As an example, several capabilities regarding dynamic geofencing are currently being explored by cities as part of e.g. their CIP-platforms including potentially diverging data formats and processes.

6.2.2. Continuous end-to-end assessment of data exchange and use

Although the STA provides much information free of charge through its DATEX II feed, there is a lack of knowledge about how this information is used. During 2019, a study on the

visualization of a number of actual events (road closed) has been conducted by the STA. The events were chosen arbitrarily, and output results were compared between the webservice Trafiken.nu and a number of commercial service providers. A preliminary analysis of the results shows a wide deviation with some services ignoring the road closed information sometimes and sometimes not with no obvious patterns. A formal dialogue has been initiated with service providers to discern what might have gone wrong and where. It is crucial that such a dialogue continues in a formal and structured manner to provide for continuous improvement. A dedicated STA resource should provide for securing:

- A structured recurring dialogue between STA and service providers
- Identifying where in the STA organization this work should be performed
- A structured diagnose of input and interpretation errors about actual events coupled to timed snapshots of DATEX II feeds
- Identifying and record keeping categories of errors according to e.g. types, source and consequence.
- Identifying possible improvement measures at all involved actors, including the STA, local government and service providers.
- Identify measurements and track status aiming for an improvement of STA data utility (internal KPI).

Opportunities

- Better utility of shared data
- An enabling step towards collaborative data practices
- A fast improvement

Risk

- Measures suggested should not unfairly help only certain actors. Any measures put in place must balance the need of the collective and keeping a level playing field.

6.2.3. Establish common processes for dynamic regulations via geofencing

STA should engage in a collaborative process to design and implement dynamic geofencing together with municipalities and private firms (e.g. fleet operators, OEMs and service providers). While there are several activities ongoing in Sweden, it is currently unclear how these should synergize. Among such initiatives, Gothenburg is testing local geofencing as part of their CIP. Stockholm is implementing similar concepts. Pertinent issues include legal, technical and market challenges.

The current Geofencing program orchestrated by CLOSER is an arena in which various actors meet and discuss these phenomena, though their current focus is static geofencing. The Policy Lab at Drive Sweden is currently investigating the implementation of position-based dynamic vehicle data access at accident sites together with RISE and VEONEER. General questions that need further research include:

- An unclear legal framework for dynamic regulation of traffic. Currently changes to regulations need to be communicated weeks ahead of activation. Can access management be allowed implemented as a digital-only service?
- How should enforcement of dynamic regulations be implemented? (e.g. direct control vs. informing)

- How should ‘triggers’ to activate or deactivate dynamic regulation be implemented and distributed in a robust and timely manner?
- What should be harmonized in terms of channels, formats and governance of dynamic geofencing?

Opportunities

- New tools for active traffic management targeting e.g. environment, traffic flow and access catering for the overarching goals of safety, environmental concerns, security and availability

Risks

- Complex causal relations in practice with conflicts of interest that might prove politically difficult to resolve
- Legal and business model ramifications for OEM:s to move towards active control
-

6.2.4. Channel and format strategy

Currently, STA use the DATEX II information standard for sharing data. While this is a multinational standard format, using it does not necessarily generate less interpretational ambiguity than a bilateral systems integration. For instance, STA and the Dutch National Datawarehouse for Traffic information have jointly together with TomTom developed an extension for OpenLR in DATEX II. However, besides DATEX II, STA also provides traffic data through their API. While these are roughly based on the DATEX II format, they achieve ease of use by sacrificing granularity. For instance, OpenLR is not currently available in the API. Additionally, STA has recently developed a specific proprietary interface towards Google Waze. In effect there are now three means to access STA traffic data, each with their own specific limitations and processes. While reaching more citizens with accurate traffic information and advice is always beneficial, there is always a cost associated with developing and maintaining integrations and interfaces. There is currently no strategic decision or guideline on when to pursue direct proprietary adaptations and when not to.

Opportunities

- Quickly reaching the most drivers

Risk

- Diverging channel formats risk propagating various versions of STA traffic data in various granularity
- Multiple interfaces could become costly to maintain over time

6.2.5. Clarify National and Local rerouting network priorities

Previous STA projects have developed a nationwide set of 850 national as well as local municipality reroutes for the prioritized network¹¹. Early 2018, data was still not displayed openly in NVDB due to a lack of formalized agreements on the STA-municipality level. To the knowledge of the authors of this report, a clarification of different road owners and other’s incentives and goals for rerouting is still needed. Roles and responsibilities are in

¹¹ Delrapport Omljedningsvägar 2017, Författare: Jonida Qureshi, Dokumentdatum: 2017-12-15

need also within STA as to who is responsible for developing, maintaining and putting rerouting data to use in with e.g. external actors. Focus should still be on the prioritized road network and the current national rerouting data in NVDB should be checked to ensure applicability and completeness for nationwide use beyond STA and extend to the city scope.

KPI:s for measuring the effects of rerouting should be developed by STA to facilitate efficiency- and follow up analysis of new digital rerouting services. Establish triggers for rerouting (Here, the current incident grading system used in e.g. Stockholm can be used as inspiration).

Opportunities:

- Enables optimal utilization of capacity relative to stated goals of road owners, including e.g. environmental, safety, or multimodal concerns.
- Enables rerouting farther away from problem situation and thus spreads the network risks

Risks:

- Competing interests and difficulties in negotiation between STA and municipalities could limit usefulness of result
- Could be somewhat demanding to establish and maintain.

6.2.6. Improve data coordination from municipality (LV) to national repository (NVDB)

There is a clear need for improved coordination between NVDB and the local road databases (LV), which is said to have several shortcomings resulting in long response times making NVDB less attractive as a go-to source for road data. This needs to be addressed whilst, optimally, reducing cost as well.

However, there will always be a need for specialized local data sources and formats catering for local user groups in and around specific municipalities. This is reflected in current practice including access to LV-APIs. The ongoing DIZ2 activity and Nordic Way III both address these issues.

Opportunities:

- A well-coordinated national/local data set are necessary for an improved rerouting management and a host of other issues.

Risks:

- Full automation of porting of data between LV and NVDB is likely difficult, adding cost

6.3. Recommended actions 2021

6.3.1. Collaborative TM Forum

Establish an arena managed by STA to gather all involved parties (Road authorities (local private and national), service providers, OEMs, important road users' organizations).

The forum would have an advisory role and promote sector wide agreements and guidelines. In terms of scope and responsibilities, the suggested dimensions of the "strategy table" as part of the Socrates^{2.0} framework serves as a good starting point. Suggested initial key topics

include; 1) The establishment of cross actor relevant KPIs for the traffic system, 2) agreed upon trigger levels for dedicated actions to e.g. reroute traffic, 3) the establishment of an agreed upon format for communicating such actions, 4) the establishment and follow up of data quality measures across the whole origin-end-use process, 5) facilitation of continuous interorganizational data sharing process improvement, 6) establishing cost-benefit analyses of CTM.

The exact nature of governance structure of such a forum lies beyond the scope of this roadmap, however, a lightweight overhead is likely adequate. STA should be coordinating and set up regular interactions a few times annually. It is recommended that STA set aside dedicated long-term resources to facilitate this, including enough manhours annually. Individual development projects coupled to the scope of the CTM Forum could be financed by partaking organizations in a case-by-case manner. The governance structure of the CTM Forum must reflect the nature of CTM, and decide early on how to resolve conflicts of interest, share cost and benefit and so on.

Opportunities

- An inclusive and open arena helps bring attention to the area
- Enable quick and concise feedback among parties
- System wide follow up on suggested CTM actions

Risks

- Potential conflicts of interests (e.g. STA/Municipality, public/private) could be difficult to resolve
- Risks that some important actors might choose not to partake based on unilateral strategy considerations and perceived interests

6.3.2. Clarify intentions on e.g. data availability and quality

Currently, there are no processes intended to ensure data quality and utility from a third party perspective at STA. The scope includes everything from data generation or acquisition at STA via analysis and distribution to actual results as part of third party CTM services. Preferably this action could be coupled an established CTM Forum as described above.

As a first step, a dialogue has been initiated between STA and four large multinational service providers¹². Based on experiences made in a continued effort along these lines, datasharing processes should be formalized and made measurable in terms of quality KPI:s (G2B and B2G). Once KPIs have been established, STA should consider promoting updated SLA:s with service providers specifying the responsibilities of both parties. A relevant starting point is the current STA data product specifications utilized by STA. However, as quality is in the eye of the beholder, care must be taken to ensure that these are effective and efficient for CTM-use, i.e. that external feedback is given attention by STA.

Opportunities

- Efficient and effective CTM through continuous improvement of G2B navigation data sharing practice

¹² Note that this is a first exploratory step to increase knowledge about how a set of service providers perceive and use STA data. Which service providers to include in a long term engagement and on what grounds is an important decision that needs to be made.

Risks

- Vague or unintentional SLA.s could very well set sub-optimizing incentives and become counter productive

6.4. Recommended Actions 2022

6.4.1. Increase information granularity

NVDB/NTS is too coarse for many current and near future purposes and does not utilize the granularity available in LV. This could likely be an obstacle considering the need to find a uniform information model to base CTM services on. The current integration process has shortcomings and in need of improvement. The ongoing implementation of the STA LAIV system needs to acknowledge and facilitate a city perspective as part of its requirements.

Opportunities

- Enables a one stop shop for G2B road network data relations.
- Enables smooth standardized implementations of future Geofencing services across Swedish municipalities

Risks

- A lengthy process to align interests, priorities and data formats could put a break on CTM innovation and diffusion velocity

6.4.2. Bilateral situational awareness

Currently, all actors create their own “operational awareness”. The data forming that operational pictures differ along multiple dimensions such as number of sources, types of sourcing, granularity and quality. This is driven by the presumption that end user navigation services quality benefit from the innovation pace inherent in an open competitive market. However, this also means that data access of any given organization is always incomplete, in comparison to the totality of relevant data on offer by all actors. What if this was not so? In theory, a common operational picture could be fed by all and grant all contributors with an enhanced view. While such a ‘common operational picture’ is an espoused vision of Socrates^{2.0}, this is most likely not feasible or desirable in a foreseeable future. The most compelling reason being that no private service provider could share business critical data and retain their competitive edge over time. Everyone else would instantly gain the shared information and a free riding problem would hamper the current competitive landscape to the point of irrelevance. Seeing as the retention of private sector innovation capacity is generally viewed as beneficent to TM in general and CTM in particular¹³, simple altruistic sharing is likely not a productive route.

¹³ A more involved reflection could likely be made here, but no actor, public or private, engaged during this project disputed the societal merits of a well-functioning market for innovative navigation services so this has been adopted as the stance of the project.

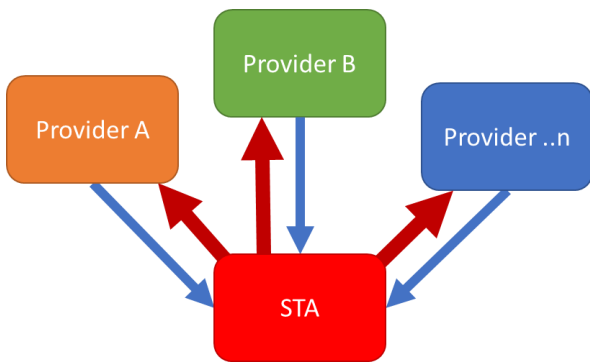


Figure 12: Business actor data for complete government data (Common Operational Picture)

However, some collaboration could still be fruitful. Although it is beyond the scope of this project to provide a detailed blueprint for such more limited exchanges, further investigations could have merit. A private service provider could likely supply part of its data to STA, and STA alone, assuming that the net gains merits this for all involved parties. One such possibility is using data as payment for taking part in an advanced CTM service in which STA has a coordinating role. The other variant is quite similar to how such exchanges are operated currently, when STA purchase access to e.g. travel time data from external providers. In either case care must be taken to ensure that data does not leak to third parties, competitors or others. While not constituting a common situational awareness, over time such exchanges would improve the overall situational awareness of the STA. Correspondingly, STA could provide data quality feedback based on its improved awareness, as long as it does not cause data leakage. Such processes and the technological platform that facilitates them would require strict access management principles and legally binding assurances that data be managed in a way that does not threaten the business integrity of service cum data providers. Additionally, each bilateral setup must be made so as to ensure neutrality and a balance in net gain between STA and any data contributor. The relative utility weights of data contributed, and improvements made between STA and the providers must be considered in each bilateral arrangement. Whether such an agreement is legally feasible or not would need further investigation.

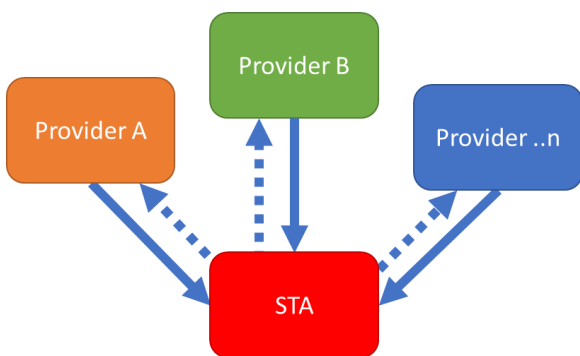


Figure 13: Business actor data for limited data and quality benefit (Bilateral Operational Pictures)
Opportunities:

- Gives STA greatly enhanced data set and awareness
- Grants STA a better picture of the specific benefits of various existing channels

- Makes it possible to compare different suppliers of data for quality improvement (see specific actions on Collaborative Traffic Management Forum, Development of SLAs, KPI:s etc.)

Risks:

- Service developers (or others) could very well be unwilling to share data regardless of proposed benefits, limitations and precautions for strategic competitive reasons.
- The willingness to contribute data is likely influenced by the current business model of the actors. Some actors work closely with STA delivering data and information, e.g. INRIX travel time data. While Google does have a specific program for G2B collaboration, their workflow is based around delivering end user TMC functionality, such as Dashboards, and not base data.
- The Swedish Public Access to Information and Secrecy Act¹⁴ stipulates that potentially all data received by a government entity is to be considered public and made available unless this compromises state security or other fundamental laws. If a government entity is not able to decide on any limitations to this principle for business purposes, it is highly unlikely that B2G data provision could ever work in any form other than as a result of direct legal measures.
- The Swedish laws on public procurement, and the corresponding EU legal framework, could make a data sharing scheme among heterogeneous actors and the government highly complex or impossible as it could be difficult to evaluate the contributions of specific actors against each other in a fair and neutral manner.

6.5. Conclusions

With increasing demands on urban traffic systems, system wide optimization is becoming an increasingly attractive proposition. However, as in most societies, the management of traffic has been spread among a host of public and private actors, each operating to their internal business logics and goals. Collaborative traffic management represents a way forward by aligning disparate interests. While several initiatives have been launched in a number of countries in recent years, the key concepts are still being developed. Additionally, there are several obstacles to overcome before Swedish CTM can be introduced in earnest. First, CTM must be introduced so as not to disrupt the innovation potential of the private sector. In particular, this means that full data sharing and common operational pictures will likely remain a challenging concept for years to come. Additionally, the STA needs to further develop or establish a set of key capabilities that needs to be put in place before moving towards the implementation of CTM. Several such actions are listed in this report. However, most of these actions carry immediate benefits. As an example, an increased level of communication with and feedback from service providers have already shown opportunities for improved data management practice at the STA that will have immediate effects on the utility of its data in external navigation services.

On a strategic level, by approaching CTM as a set of options to enhance collaboration on either description or prescription analytics or both, crucial first steps can be taken towards fully coordinated public private traffic management. Enabling a formalized dialogue with

¹⁴ A brief English text is available at <https://www.regeringen.se/informationsmaterial/2009/09/public-access-to-information-and-secrecy-act/>

key data and service providers is one important step in this direction ensuring commitment of both public and private actors for increased coordination of traffic management practices. Such collaboration will be a necessary prerequisite to future mobility management services.

6.6. Acknowledgements

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7 References

El Sawy, O. A., and Pereira, F. 2013. *Business Modelling in the Dynamic Digital Space: An Ecosystem Approach*. Springer.

European Commission. 2017 "C-Its Platform, Final Report Phase II"

Europeiska kommissionen. 2010/40/EU. "Europaparlamentets Och Rådets Direktiv 2010/40/Eu Av Den 7 Juli 2010 Om Ett Ramverk För Införande Av Intelligent Transportssystem På Vägtransportområdet Och För Gränssnitt Mot Andra Transportslag,").

Hartmann, P. M., Zaki, M., Feldmann, N., and Neely, A. 2014. "Big Data for Big Business? A Taxonomy of Data-Driven Business Models Used by Start-up Firms," *Cambridge Service Alliance*).

Klievink, B., Romijn, B.-J., Cunningham, S., and de Bruijn, H. 2017. "Big Data in the Public Sector: Uncertainties and Readiness," *Information Systems Frontiers* (19:2), pp. 267-283.

Osterwalder, A., and Pigneur, Y. 2010. "Business Model Generation,").

Ranerup, A., Henriksen, H. Z., and Hedman, J. 2016. "An Analysis of Business Models in Public Service Platforms," *Government Information Quarterly* (33:1), pp. 6-14.

Selander, L., Henfridsson, O., and Svahn, F. 2013. "Capability Search and Redeem across Digital Ecosystems," *Journal of Information Technology* (28:3), pp. 183-197.

Spoelstra, J., van Waes, F., Mann, M., Konstantinopoulou, L., Tzanidaki, J. . 2017. "Exchanging Traffic Management Plans between Traffic Management Centres and Service Providers in Traffic Management 2.0.," *In Proceedings 12th European Congress, Strasbourg. ERTICO (ITS Europe)*.).

Taale, H. 2020. "Cooperative Route Guidance - a Simulation Study for Stockholm," *Samverkande Trafikledning*).



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