SMOOTh

SysteM Of Systems for sustainable urban gOods Transports

Public report

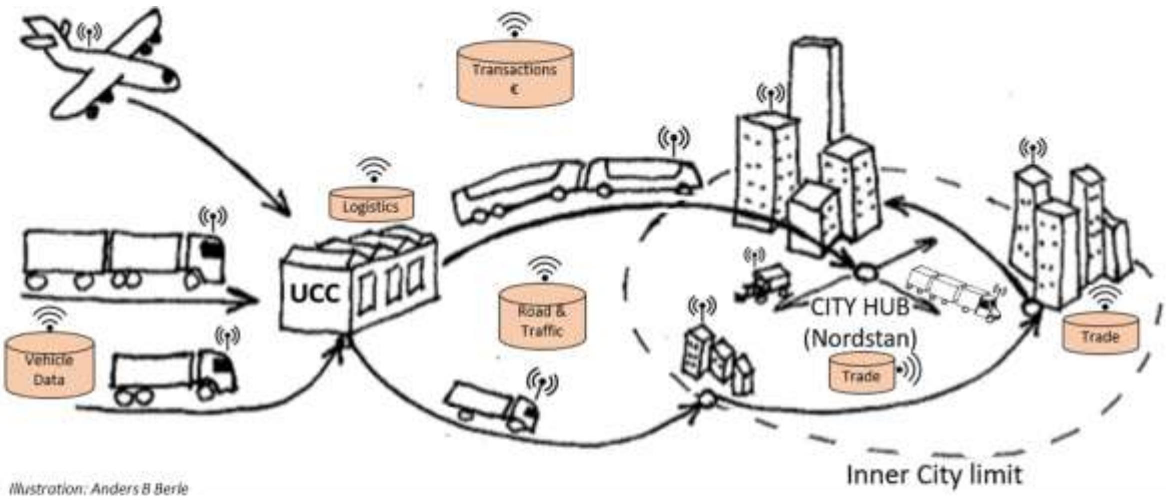

Figure 1: SMOOTh System of Systems in city logistics

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1 Summary

The currently fragmented nature of urban logistics results in a great number of freight movements by vans and small trucks characterized by high levels of empty runs, low energy efficiency, stop-and-go traffic patterns and long dwell times. As a consequence, urban areas lose in attractiveness due to road congestion, greenhouse gas emissions, poor air quality, noise pollution, as well as safety concerns. These concerns are heavily voiced by multiple stakeholders, including city shop owners and drivers, who all are in desperate need of solutions. A recent countermeasure is establishing Urban Consolidation Centres (UCC) in or close to the urban areas enabling the separation of trunk movements from local deliveries. This enables the use of larger, more efficient vehicles for the transport on urban access roads into and within the urban areas, and small electric vehicles or cargo bikes for deliveries in the more sensitive city centre environments, and thereby reducing congestion, emissions and noise, and improving safety for pedestrians and bicyclists.

However, many trials and projects on UCCs have failed due to costs associated with added handling, lack of system support and sustainable business model. Furthermore, much urban freight is already consolidated at the receiver or transport operator level (e.g. DHL, Schenker, Post Nord); and channeling these flows through a UCC would actually lead to detours and additional handlings increasing costs and environmental impacts. Having said this, studies of UCC initiatives (Urban Freight Consolidation Center by M. Browne, M. Sweet, A. Woodburn, J. Allen, 2005) show that consolidation hubs could actually reduce traffic movements and environmental impact if the right circumstances are there. However, it is important to have the right evaluation and control models in place. Furthermore, the UCC can be a good solution for a specific and clearly defined geographical area with delivery related problems, or in cases of large retail commercial development and major construction sites. The study also shows that the major potential beneficiaries would be e.g. transport operators making small multi-drop deliveries, and independent and small retail companies.

This pre-study identifies a very typical and generic case for city logistics. The selected system (Figure 1) in Gothenburg is a suitable case for studying urban freight System of Systems (SoS) development. The case will be used as a living lab, where solutions will be introduced step by step to evaluate the effects in real life business situations. The SoS consists of a UCC, the UCC to city-hub freight, road and traffic information systems, the shopping mall Nordstan serving as a city-hub as well as final delivery points at the shops, and finally the last-mile delivery system out from the city-hub. The SoS is supported by mobile on-line connected IT systems managing data from the included systems, including transactions. Our hypothesis is that this will enable design of a viable business model with fair sharing of the efficiency gains generated within the SoS, hence giving the incentive to enter into the SoS that will address the problems described at the top. It presents a case study of current logistics, as well as the potential of a multimodal micro hub solution. It presents the result of three multi-actor workshops in the form of four design scenarios and discusses them in terms of extant SoS literature.

The pre-study shows 30-40% vehicle kilometers (vkm) reduction potential by implementing a SoS for urban freight and advocates the development of a SoS demonstration and a structured methodology that can be applied beyond the case at hand. This could assist in building competence within Swedish industry as well as authorities, within the area of SoS for urban logistics and help find opportunities to commercialize the solutions developed.

2 Executive summary in Swedish

Den nuvarande fragmenterade karaktären av urban logistik resulterar i ett stort antal fraktrörelser med skåpbilar och små lastbilar vilka kännetecknas av höga nivåer av tomma körningar, låg energieffektivitet, stop-and-go-trafikmönster och långa vistider. Som en konsekvens förlorar stadsområden attraktivitet på grund av trafikstockningar, utsläpp av växthusgaser, dålig luftkvalitet, bullerförorening samt säkerhetsproblem. Dessa problem uppmärksammas nu väldigt mycket av många intressenter, inte minst av handeln och chaufförer, som är i trängande behov av lösningar. En ny motåtgärd är att inrätta Urban Consolidation Centers (UCC) i eller nära stadsområdena, vilket möjliggör separering av stamförflyttningar från lokala leveranser. Detta möjliggör användningen av större och effektivare fordon för transport på vägar till och inom stadsområdena, medan små elektriska fordon eller lastcyklar för leveranser i de mer känsliga stadsmiljöerna och därigenom minska överbelastning, utsläpp och buller, och förbättra säkerheten för fotgängare och cyklister.

Många försök och projekt på UCC har dock misslyckats på grund av kostnader i samband med extra hantering, brist på systemstöd och hållbar affärsmodell. Vidare konsolideras stor andel av stadsfrakt redan på mottagaren eller transportoperatörsnivå (t.ex. DHL, Schenker, Post Nord); och att kanalisering av dessa flöden genom en UCC faktiskt skulle leda till omvägar och ytterligare åtgärder som ökar kostnaderna och miljöpåverkan. Efter detta har studier av UCC-initiativ (Urban Freight Consolidation Center av M. Browne, M. Sweet, A. Woodburn, J. Allen, 2005) visat att konsolideringsnav kan faktiskt minska trafikrörelser och miljöpåverkan om de rätta omständigheterna finns. Det viktiga är dock att den rätta utvärderings- och styrmodellen är på plats. Vidare bör ett UCC ha ett specifikt och klart definierat geografiskt område med leveransrelaterade problem, stor detaljhandel och större byggarbetsplatser. Studien visar också att den potentiella nyttan skulle vara stor hos t.ex. transportföretag som gör små multidroppleveranser, samt oberoende och små detaljhandelsföretag.

Denna förstudie kartlägger ett mycket typiskt fall inom city-logistik. Det valda fallet (se fig 1) i Göteborg är ett mycket lämpligt fall för utveckling och applicering av city-logistik baserat på system av system (SoS). Det valda fallet kommer att användas som ett levande laboratorium, där lösningar utvecklas och införs stegvis för att utvärdera effekterna i verklig användning. Detta SoS består av konsolideringsterminal(er) (UCC), frakten mellan UCC och cityterminalen (city-hub Nordstan), väg- och trafikinformationssystem, köpcentret Nordstan som också utgör city-terminal, affärer och företag i innerstaden, samt leveranssystemen för utleverans från city-terminalen sista kilometern inom innerstaden. Detta SoS kommer att ha tillgång till mobil data on-line från de ingående delsystemen, inklusive transaktioner. Vår hypotes är att detta kommer att möjliggöra utveckling av en robust affärsmodell som fördelar effekiviseringsvinsterna rättvist, så att intresse väcks för att deltaga i detta SoS som då kan bidraga till att lösa den påvisade problemställningen. Rapporten visar en fallstudie av nuvarande logistik, liksom potentialen i en multimodal mikrohublösning. Vidare presenterar rapporten resultatet av tre workshopar, med deltaganade från flera organisationer, i form av fyra designscenarier och diskuterar dem i termer av existerande SoS-litteratur.

Förstudien visar en 30-40-procentig potential att reducera fordonskilometer genom att utveckla ett SoS för stadsfrakt och förespråkar utvecklingen av en SoS-demonstration och en strukturerad metod som kan tillämpas utöver det aktuella fallet. Detta kan bidraga till att bygga kompetens inom svensk industri samt myndigheter, inom området SoS för urban logistik och hjälpa till att hitta möjligheter att kommersialisera de utvecklade lösningarna.

3 Background

Goods movement is critical to everyday life. An efficient delivery of physical items is critical to the satisfaction of the customer, the success of individual businesses and the integration of the urban and the global economies. Today there is an immense amount of pressure placed upon the goods movement industry. Online sales are growing three times faster than traditional store sales and companies have shifted to just-in-time deliveries requiring more frequent and customized distribution systems that must operate within already congested and strained networks. At the same time, cities struggle to cope with bad air quality, congestion, lack of land/space, and unhealthy noise levels. Many cities around the world are starting to impose various regulations in order to minimize traffic and pollution, e.g. banning Diesel vehicles or time windows for goods deliveries. While electric vehicles could solve the emission & noise problems, it does not address the congestion problems. Congestion has increased during the past years, in part due to growth in transport demand, but also related to changes in city centre infrastructure and traffic patterns, fuelling a trend towards smaller goods transport vehicles with poor load capacity. As more street space is allocated to pedestrians, cyclists and public transit, city streets are increasingly becoming too narrow for regular trucks, and as a result urban freight distribution in cities primarily relies on smaller trucks that are roughly one-third the size of standard distribution vehicles.

As a response to these city challenges, society need to re-think how goods is transported in the urban area, what systems are needed, and how the systems should interact, in order to make goods deliveries more efficient with less external impact. Cities of today are based upon individual transports of goods categories. In order for cities to become attractive liveable places for people, tomorrow’s transports must include a higher degree of collective approach as a solution to achieve high fill rate and reduced vehicle movements. In a perfect world, vehicles are fully loaded both ways and delivery routes are optimized in order to minimize consumption and external impact. However, to move in this direction, key elements in the logistics chain needs to be connected digitally, as actors needs to collaborate, communicate and coordinate. There are several kinds of digital systems in use– embedded into vehicles and infrastructure as well as stationary back-office transport management systems, dealing with logistics processes and their effects. However, beyond the siloes collaborations among specific haulers, and within third party logistics and their customers, these are generally poorly integrated and the data within these systems are not easily accessed for e.g. city-level evaluation to inform reconfiguration of current logistics policies. Among challenges known and expected are: reluctance to allowing data transparency in an adversarial environment, integration of component systems with diverging information models and assumptions, diverse authentication and confidentiality levels and mechanisms, and asymmetric incentives for data sharing among heterogeneous actors including transport organizations, authorities, and transport customers (Andersson, Lindgren, & Henfridsson, 2008). While these challenges are crucial in SoS, logistics related SoS research has frequently overlooked or failed to overcome them (Sternberg & Andersson, 2014).

In this pre-study, we have investigated how a smart urban goods transport system could be structured in order to match on-demand end-to-end transportation to optimize the logistic chain with the vehicles as enablers for this kind of SoS. Gothenburg has been chosen as case study due to its exceptional situation with construction work the coming 20-30 years, which will require new ways of transporting goods. The shopping mall Nordstan with its about 200 organizations representing retails, restaurants, offices, real estates, technology companies etc., may have big impact regarding transformation and behaviour change. By measuring effects according to the UN sustainability goals and present results in the organizations’ Sustainability reports, there might be incentives for behaviour change on the demand side. A further important factor is that local regulations must support ambitions with relevant restrictions and incentives as well as development of physical solutions. At present, different cities are more or less proactive regarding regulations; they often have different sets of rules, which creates problems for carriers. Solutions and new systems must thus adopt a national and international perspective at all stages of the work.

4 Purpose, research questions and methodology

4.1 Purpose and research questions

The purpose of this pre-study is to investigate the feasibility of a smart urban goods transport system of systems, which reduces the traffic work associated with urban goods deliveries. As a result, this transport system should enable:

- a reduction of the negative impact on the surrounding environment and traffic systems.
- an increase of logistic efficiency (costs, time, quality, resource demand),
- higher city attractiveness (air quality, noise, traffic congestion)
- an efficient infrastructure for cargo loading/unloading.

To achieve the purpose of this study, the following research questions are designed:

RQ1: What goods distribution use cases have the potential to demonstrate an innovative and sustainable vehicle concept based on a SoS approach?

RQ2: What parameters and data sources are required for evaluating the effects of the use cases in terms of transport efficiency, resource utilization, congestion, safety, environment, human behaviour and resilience?

RQ3: How can a future SoS for urban logistics be designed from a sociotechnical perspective incorporating aspects of business models, technology options, behavioural change and transport policy making?

4.2 Methodology

The work in the project is organized in four work packages (one WP per RQ and one WP for project management.) The methods used in the different work packages are defined below.

WP1 Project management

Besides the administrative management of the project, the goal of this WP is to gather a consortium and develop a proposal for a complete project following this pre-study.

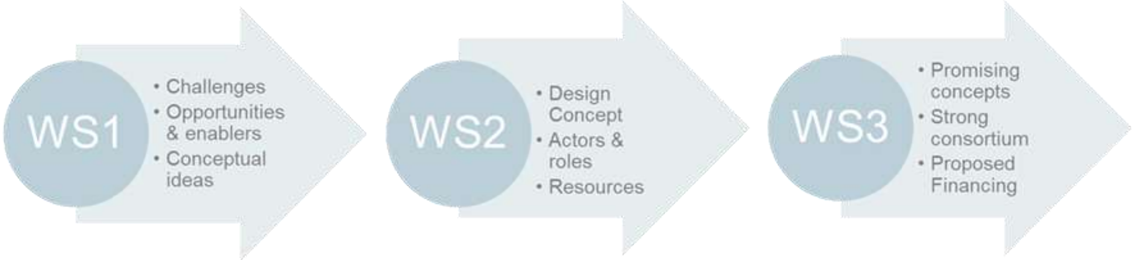
The methodology The SEVS Way[1] follows an open innovation approach, an inclusive process with multi-disciplinary teams participating in several result driven workshops. The Core Team performed some of the main activities together or by own work between the workshops.

The core team initiated the pre-study process with a desktop stakeholder analysis. The result was the basis for the invitation as well the start of building the consortium for the full project.

Three structured and result driven workshops (Figure 2) were performed including representatives from the municipality, vehicle manufacturers, logistics firms, carriers, IT companies, property owners, retailers and researchers specializing in environmental analysis, logistics and informatics. (About 20-25 persons attended each workshop).

[1] *The methodology is one of several result from an earlier FFI project; SEVS, Safe Efficient Vehicle Solutions (www.sevs.se)*

Figure 2: Three result driven workshops



Workshop 1:“Challenges/Difficult questions, Opportunities & enablers, Conceptual ideas”

Workshop 2:“Concepts Design”

Workshop 3:”Commitment & Financing”

The workshops followed the SEVS process and several SEVS tools were re-used. For instance, The Driving Force Model was re-used to identify and categorize the main challenges during the first workshop, (Figure 3).

Figure 3: The SEVS Driving Force Model

The Scenario cross (

References SEVS) in (Figure 4) is used mainly for discussions, analysis and communication of different types of SoS Design Spaces. In the SMOOTh project, different SoS approaches are divided into four Design Spaces, characterized by the level of Political proactiveness and by the level of Business proactiveness.

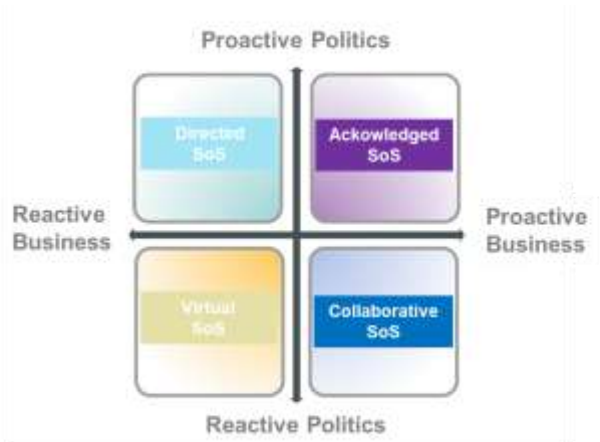


Figure 4: The Scenario Cross and SMOOTh’s Design Spaces

Regarding Model for assessment of logistical and sustainable effectiveness, we broadened the scope to include the customer/organization behaviours and incentives for changed business models. In the pre-study we did not specifically apply the UN's 17 SDG model to our own assessment model but in the next phase we will include and relate the assessment model to these goals.

Deliverables of this WP are 1) the project report, 2) a partner proposal for complete project & project description and 3) a strong Consortium.

WP2 Goods distribution use cases

The goal of this WP is to identify and to evaluate use cases to demonstrate an innovative sustainable vehicle concept and a SoS based transport system. The following methods were used:

- Meetings of the project core group
- Review of previous projects
- Interviews with relevant stakeholders, e.g. logistics companies, retailers, real estate owners, City of Gothenburg, and institutes and academia (e.g. Michael Browne Gothenburg University).

The deliverable of this WP is a definition of the selected use cases (as illustrated in Figure 1).

WP3 Parameters for evaluation of effects of the use cases

The goal of this WP was to develop an environmental assessment model for the use cases. This requires identifying the necessary parameters to measure and analyse in order to ensure an adequate evaluation. The methods used included theoretical work to develop the model and an empirical study to test and validate the model. In total, it included four steps:

1. Design a preliminary evaluation model for the context of the study based on previous evaluation models
2. Design a survey for collection of urban delivery data as input data for the model
3. Data collection using the survey (Traffic count in Nordstan, see details on method in Section 6.2)
4. Analyse the results, validating the model and the required input data

The deliverable this WP is an environmental assessment model for the use cases.

WP 4 Design scenarios for a future urban logistics system of systems

The goal of this WP is to provide a description of viable design scenarios for a future urban freight SoS.

There are unlimited numbers of Design Spaces[2] in the world, and **we do not have control** over any of these, not even Nordstan. The four SoS Design Spaces illustrates four extreme scenarios that gives guidance in the design of a specific SoS, given the political and business environment at hand.
The deliverable of this WP is a report conceptualizing viable design scenarios for future urban freight system of systems.

[2] *(A design space is the multidimensional combination and interaction of possible input variables and process parameters).*

5 Goal

The project produced the following deliverables reflecting the goals of this pre-study:

 Relevant use cases in the Gothenburg area (Deliverable of WP2, see results in Section 6.2)
 A model for assessment of logistical and sustainability effectiveness (WP3, Section 6.1)
 Scenarios for viable designs of business model, technology and policy (WP4, Section 6.4)
 State of the art study of SoS as applied to freight transport (WP4, 6.56.3)
 Findings and recommendations for main study including partners & financing (WP1, Section 6.4)

6 Results and goal fulfilment

6.1 Model for assessment of sustainable logistics.

One major driver of development of new city logistic solutions is to improve sustainability performance of the goods supply to business and individuals. An important task in the development process is thus to assess the contribution towards the goals and ambitions expressed by the key actors, e.g. city administration, property owners and transport companies. These goals have a focus on a liveable and attractive city environment, e.g. experience of safety in the street environment by less heavy traffic, clean air, reduced congestion/obstacles and low noise levels.

The suggested evaluation method follows the outline of the Life Cycle Assessment methodology with the following main parts:

- Technical description
- Functional unit
- Evaluation parameters
- System boundaries
- Data sources, uncertainties and data quality
- Method issues (e.g. allocation principles)

Technical description
The technical components making up the logistic/transport system under study is described and explained.

Functional unit
The result from the analysis is related to a unit describing the service produced/delivered by the investigated system.

Evaluation parameters
The main evaluation parameters connected to these goals can be categorized as outlines in Table 1 below.

Field	Parameter	Measurement data
Environmental performance	Use of energy	Total energy use Fossil energy use
	Emission of climate gases	Carbon dioxides – CO_2 Methane - CH_4

	Air quality	NOx Particulate Matter (PM2,5)
	Noise	Vehicle traffic noise (engine/tire/reverse warning signals)
		Cargo handling noise (loading/unloading)
Traffic system impacts	Congestion	Vehicle kilometres driven during peak hours, personal car equivalents
	Road safety/accidents	Incident per driven vehicle kilometres
Logistic indicators	Resource utilisation	Vehicle operating time, Cargo carrying capacity utilisation, transport work potential/realisation
	Efficiency	Transport work produced per engaged resource (vehicle, person, unit of energy, unit of CO2 emitted)
	Logistics cost	Direct cost per unit of cargo (per shipment, per pallet, per tonne etc.)
Socio-economic indicators	Environmental related	Air pollution
	Traffic related	Congestion costs (outside city centre, inside city centre)

Table 1: Evaluation Parameters

System boundaries
For each application of the methodology a number of system boundaries has to be set up and clarified. The following aspects must be covered:

Other services/products
Example: Other transport services produced simultaneous or in connection to the studied use case.

Technical systems
Example: Which parts of the technical systems engaged in the production of the logistic service under study to include in the investigation.

Geography
Example: Describe the geographical limits for environmental impacts to consider in the data collection.

Time
Example: Pre/Post ante or ongoing services.

Systems affected
Example: Limitations regarding the natural and social/human system affected by the negative environmental impacts.

Data sources, uncertainties and data quality
The impact on analysis and results from issues related to data selection and data issues are presented and implications on the study pointed out.

Method issues (e.g. allocation principles)
All method choices and/or alterations with potential impact on the study is presented and motivated.

6.2 Use Case Nordstan – Transport investigation

This pre-study identifies a very typical and generic case for city logistics. The selected system (see Figure 1) in Gothenburg is a suitable case for studying urban freight System of Systems (SoS) development. The case will be used as a living lab, where solutions will be introduced step by step to evaluate the effects in real life business situations. The SoS consists of a UCC, the UCC to city-hub freight, road and traffic information systems, the shopping mall Nordstan serving as a City Hub as well as final delivery points at the shops, and finally the last-mile delivery system out from the City Hub. The SoS is supported by mobile on-line connected IT systems managing data from the included systems, including transactions. Our hypothesis is that this will enable design of a viable business model with fair sharing of the efficiency gains generated within the SoS, hence giving the incentive to enter into the SoS that will address the problems described.

Nordstan is located in the centre of Gothenburg and it has a large underground logistic service area. The goods delivery system to the mall is today uncoordinated with a large number of actors calling to the service area with a multitude of vehicle types, all with varying efficiency in terms of cargo capacity utilisation. The potential for creating a more efficient transportation system was therefore considered large, why the project members decided to confirm this by a transport investigation.

The main question to answer by this investigation concerned the size of the potential to reduce the truck traffic to Nordstan through achieving larger goods consolidation prior to the transport to Nordstan. The investigation was thus not conducted using the full methodology suggested above for a logistics sustainability assessment. However, some questions regarding sustainability issues was included in the data acquisition in order to make some test calculations concerning further sustainability issues.

Research questions
The main question to answer was the potential to reduce the number of vehicle movements into the City Hub Nordstan logistics service area. The answer should include the fact that a large part of the trucks have several other stops planned on the same route why the logistics analysis were to include the entire vehicle route in the city centre, i.e. including pre and post traffic movements to and from Nordstan.
The potential for environmental improvements can be assessed as a consequence of the reduced number of truck arrivals at Nordstan (and its close vicinity). Each trip to Nordstan that is saved leads to a reduction of driven kilometres, which in turn leads to the following improvements:

- Energy: reduced fuel consumption
- Emissions to air: reduced engine emissions
- Congestion: reduced driven kilometres during peak hour
- Efficiency: Potential freight cost reduction

Scope and goal

The scope and goal is to develop a SoS based Smart Urban Mobility solution for city logistics. In order to assess the total potential the following aspects must be quantified:

- Total number of trucks arriving to Nordstan
- Planned pre stops: The number of planned delivery/pick up stops before arriving to Nordstan
- Planned post stops: The number of planned delivery/pick up stops after leaving Nordstan
- The number of the planned pre/post stops that takes place in the close vicinity of Nordstan, i.e. within the 'Vallgraven' city centre area.
- Amount of cargo loaded on the truck at terminal prior start of route
- Amount of goods delivered to Nordstan
- Amount of cargo delivered to the close vicinity of Nordstan.

The environmental benefits from a reduced number of truck arrivals to Nordstan (and its vicinity) can be assessed by knowledge of the following parameters:

- Location of the start of the route
- Driving route prior Nordstan
- Driving route after Nordstan
- Environmental performance of the vehicle (i.e. fuel type, fuel consumption and engine Euro class)

System boundaries in relation to the use case Nordstan.

The analysis is set within the following system boundaries:

- Technical: The assessment has a focus on the operations of the vehicle during the transport process. The data collection will be limited to the vehicles and not include upstream and downstream activities.
- Time: The assessment is based on ongoing traffic. Collected data reflects the present situation (fall 2018).
- Geography: The main data collection will concern activities and impacts on the local environment, local traffic and individuals directly exposed to the traffic. The exception will be the reporting of climate effects which have a global impact.
- Product cycle[3]: The investigated transports will in several cases be part of a transport route with multiple destinations, before, during and after the vehicle calls to the investigated destination point. We will thus have to relate to these transport tasks when assessing the potential for alternations to the present transport solution to Nordstan. The calculation is based on the total number of truck movements into the city centre that can be avoided by the investigated/suggested transport system.

Functional unit
The calculation is reported as an assessment for the entire transport work to Nordstan, and parts of, or all of, the other cargo with destinations within the central city.

Uncertainties and data quality
The main purpose of this limited study was to test the relevance of the use case and the evaluation model (ref chapter 5 and 6). A deeper study will be done in the planned main project after this pre-study.
The largest uncertainties in the study is introduced by the simplified questionnaire, which is limited in scope due to the short time available for the interviews. The information lacking is: detailed data on the cargo carried and delivered at each stop before and after Nordstan, the exact driving route, vehicle fuel type.

Potential analysis
The analysis was carried out as a field study combined with desktop analysis.
The aim with the field study was to gain knowledge and empirical data concerning the ongoing transport operations. A short survey was constructed with questions aimed to the drivers of the trucks entering Nordstan. The survey was conducted as an interview directly after arrival and

[3] A LCA-terminology which manage the transport scope from a system perspective.

when the driver started to unload the vehicle. A total of four persons manned the six out of eight loading bays at the Nordstan Logistical centre, thus not being able to approach all the drivers arriving (see below for details). A copy of the survey format is presented in appendix 1.
The survey was conducted in the morning of Tuesday 18th of September, between 06:00 and 09:30. A total of 34 trucks were approached and all drivers choose to participate. The traffic was a bit higher than average for the period, based on data from traffic counter installed at the entrance. The data on vehicle passages include all passages (including passenger cars), and during the time of the study did 128 vehicles enter Nordstan. The average morning traffic, during a five week period surrounding the September 18th, was 109 entrances. The average share of heavy vehicles during the time-period (06 – 09) was on average 43.5% during week 38. The estimated number of heavy vehicles entering Nordstan logistics area during the survey was thus 55 why, a total of 22 trucks were not included in the study. The reason for not including these trucks was a lack of personnel why a number of loading bays could not be attended at all times.

Analysis.

Vehicle fleet

The vehicle registration number of the trucks was used to extract information from the national vehicle registry. The following data was extracted: Euroclass, fuel type, Empty Weight and Total max weight. The cargo capacity was calculated as the difference between Max weight and empty weight. The following average data is calculated for the investigated trucks, see Table 2 below:

	Age	Length	Load capacity	Engine size
	(years)	(mm)	(kg)	(kW)
Average	4	8467	5309	164
Min	0	4878	484	75
Max	11	10100	15775	272

Table 2: Vehicle data for the fleet calling to Nordstan 2018-09-15.

All vehicles were operated with Diesel engines, and the analysis is based on the assumption that an average Swedish Diesel quality was used, i.e. MK1 diesel with a 19% (weight) mix of non-fossil components. The WTW (well to wheel) emission factor for this fuel mix is approximated to 2 kg/l.
The mix of trucks arriving at Nordstan showed to be modern with an average age of 4 years. This is also reflected in the composition of the environmental performance of the truck fleet, see Table 3 below:

Euroclass	Number of trucks
4	1
5	13
EEV	2
6	18

Table 3: Environmental class of the truck fleet arriving at Nordstan.

This composition of vehicles yields an average NOx emission factor of 2.8 grams per vehicle kilometre.

Starting point

The starting point stated by the driver was categorised into one out of eight sectors of the Greater Gothenburg area. Each sector was matched with a main access route going into Nordstan. A total of six main routes were identified and the traffic split was calculated (in brackets): E6N (56%), E20 (11%), RV40 (15%), Lundbyleden (4%), Oskarsleden (7%) and E45 (7%). We thus conclude that aver 90% of the traffic into Nordstan is using the almost 2 km long access route between Gullbergsvassmotet and Nordstan (Mårten Krakowleden).

Truck routes

The calculation of the potential to reduce the truck traffic to Nordstan has to consider the often complex transport routing for each truck. In the data collection were the drivers asked about the total stops planned for the route, i.e. number of delivery stops before and after the stop at Nordstan. The composition of the average route is stated in Table 4 below:

Stops prior to NS	Stops after NS	Totalt number of stops	of which takes place in or in the proximity of NS
2,1	6,9	9,8	4,8

Table 4: Average number of stops during a distribution route including the City Hub Nordstan (NS).

Only a smaller fraction (12%) of the trucks had Nordstan as their only stop. 21% of the trucks makes no further stops within the proximity of Nordstan (i.e. within the city centre, inside the 'moat'). These two categories are considered to be most easy to integrate in a consolidation project.

Cargo delivered

The amount of cargo unloaded in Nordstan was noted during the survey. The average amount of cargo unloaded is shown in Table 5 below.

	Goods delivered in the City Hub Nordstan		
	Pallets	Rolling pallets/cages	packages
Average, all deliveries	3,4	0,4	1,9
Average, for trucks with further stops after Nordstan	1,6	0,8	no data.
Average, for trucks Nordstan as its only stop	9,5	0	0

Table 5: Amount of cargo unloaded in the City Hub Nordstan.

Traffic reduction potential assessment

The idea behind the Urban Consolidation Centre (UCC) is to reduce the number of trucks needed in order to transport the cargo volumes to the City Hub Nordstan. The assessment is done for two specific use cases:

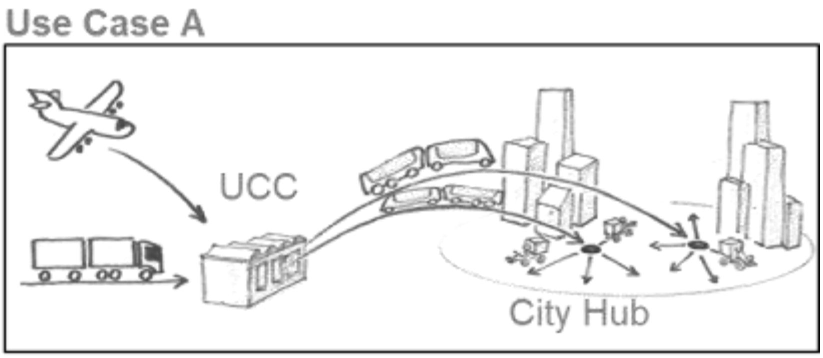


Figure 5: Use Case A

Use Case A (Figure 5): The Urban Consolidation Centre (UCC) is complemented by a City Hub in Nordstan. All cargo to Nordstan and the city centre is unloaded at the UCC. The consolidated cargo is then transported in electrical/non-emission vehicles from the UCC to the City Hub in Nordstan. The last mile delivery from the City Hub to consignees within the city centre is done by cargo bikes or small electrical trucks/road trains.

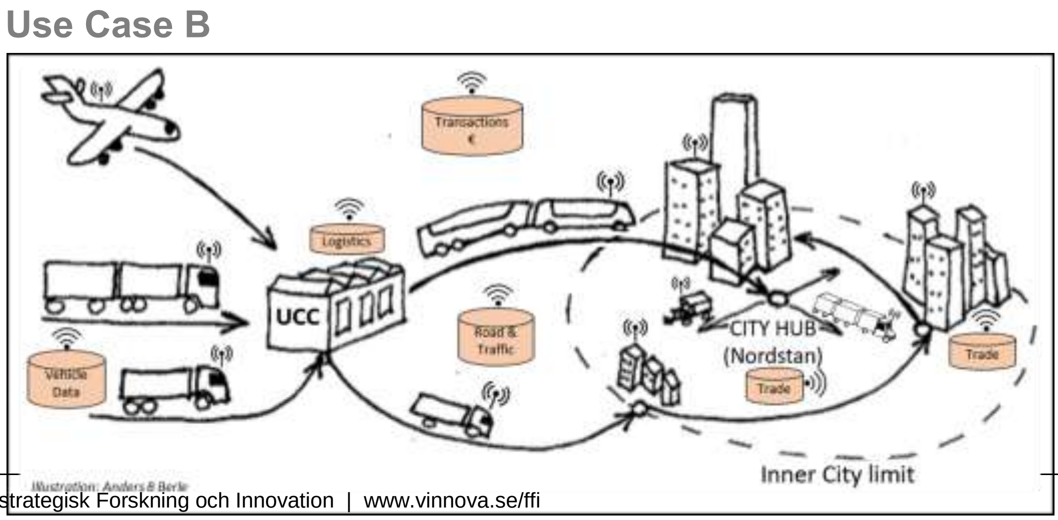


Figure 6: Use Case B

Use Case B (Figure 6)**:** The UCC, and the subsequent emission free transport into Nordstan, is used for all cargo to Nordstan and the cargo to receivers in the city centre transported on trucks with four or fewer planned stops in the city centre. Trucks with more planned stops in the city centre only unloads the cargo to Nordstan at the UCC and then proceeds into the city centre for the planned deliveries.

The assessment of both scenarios is made using the following methodology:

1. Calculate the total traffic work without UCC (i.e. sum of driving distances from all starting points to Nordstan). Calculate the share of this traffic work that takes place in the city centre.
2. Calculate the new total traffic work with a UCC (with driving distance from all starting points to the UCC plus consolidated truck traffic between the UCC and Nordstan). In Use Case A this is the total incoming traffic work. In Use Case B there will be fewer consolidated non-emission truck movements between the UCC and Nordstan, this since parts of the trucks still running their own distribution inside the city centre.
3. Calculate the traffic work for all trucks moving out of the city centre. We only include the driving distance within the city centre.
4. Assess the reductions of emissions of carbon dioxide (CO2) and nitrogen oxides (NOx), under the assumption that the trucks moving the consolidated goods are emission free (e.g. electrical).

Use Case A:
The calculations from Use Case A yielded the following results, (Table 6) below:

Weekly data	Traffic work Total (vkm)	City (vkm)	Emissions to air CO_2 (ttw) (kg)	NO_x total (kg)	NO_X city (kg)
Present	16 639	5 668	7 817	46	16
With consolidation terminal (Exportgatan) and city hub (Nordstan)	15 100	2 451	4 643	27	0
Reduction	-1 549 -9%	-3 217 -57%	-3 175 -41%	-19 -41%	-16 -100%

Table 6: Driving distance and emissions for Use Case A.

Details.
1. The total number of trucks arriving to Nordstan today: 790 per week. The total traffic work for the incoming traffic is today 16650 vkm per week, measured as driving distance from starting point to Nordstan. 5650 of these vkm takes place within the city centre.
2. The number of truck movements needed to move the goods from the UCC into Nordstan: 536 per week. This equals a reduction of one third of present traffic volume.
3. The total distance driven from starting points to the UCC (located at Exportgatan 13) is 9900 vkm/week. The total driving distance into Nordstan for the consolidated trucks are 4000 vkm/week and outbound (only considering the distance within the city) 1200 vkm/week. The total traffic work is thus 15100 vkm/week, of which 2450 vkm/week is produced in the city centre.
4. The following reductions are realised in Use Case A: Total driving distance: -1550 vkm/week. Reduced driving distance in the city area: 3200 vkm/week. The CO2 emissions are down by 40% (3,2 tonne/week) and the total NOx emissions are down by 40% (19 kg/week), of which 16 kg/week (out of a total emission of 16 kg/week, i.e. all NOx emitted) were removed from the central city area.

Use Case B

Background: The deliveries to Nordstan can be controlled by the property owner through their access control to the logistics area, to be used as a city hub, underneath the Nordstan shopping centre. Therefore, all transports with Nordstan as the only stop during the route (12% of the trucks) is assumed to be replaced by trips to the UCC. Further, the trucks with routes where the delivery to Nordstan with max four stops within the city centre (21% of the trucks) are assumed to be redirected to the UCC. The rest of the trucks have further stops planned within the city centre. It is likely that these trucks will make a trip into the city centre even if the cargo aimed for Nordstan is delivered at the UCC. A redirection of deliveries to Nordstan to the UCC is thus not likely to lead to a reduction of the (truck-) traffic work in the city centre area. Under the assumption that a new non-motorised distribution service is established with Nordstan as hub, a number of trucks are likely to choose to use this option. The benefit would be to avoid the trip into the centre city at the same time as a new cost would be introduced. Without any detailed knowledge regarding the costs and other conditions for the new service, the exact number of trucks reduced by this new option cannot be correctly calculated. We assume that deliveries with more than four deliveries in the city centre will find it worthwhile to make it into the city centre with the truck. The trucks with max four deliveries in the city centre are assumed to use the UCC in combination with the new emission free distribution service. This will concern a further 26% of the total deliveries to Nordstan. A total of 60% of the trucks delivering to Nordstan today will therefore not make it into the city centre at all with the UCC and new distribution service in place. The other 40% will deliver their goods to the UCC and then proceed into the city centre as usual, the only change being no stop at Nordstan during this route.

The calculations for Use Case B yielded the following result (Table 7) below:

Weekly data	Traffic work: Total (vkm)	City (vkm)	Emissions: CO_2 (kg)	NO_x (kg)	NO_X city (kg)
Present set up	16 639	5 668	7 817	46	16
With UCC (Exportgatan) and City Hub (Nordstan)	16 314	4 089	6 423	38	8
Reduction	-325	-1 579	-1 394	-8	-8
	-2%	-28%	-18%	-18%	-50%

Table 7: Driving distance and emissions for Use Case B.

Details

1. In this Use case is all goods with final destination in Nordstan consolidated at the UCC together with the cargo with destination within the central city area (within 'Vallgraven') transported on trucks routed to make 1-4 stops within the city centre. The number of truck movements needed to move this goods from the UCC into Nordstan: 311 trips per week. This equals a reduction of 60% of present traffic volume into Nordstan.
2. The total distance driven from starting points to the UCC (located at Exportgatan 13) is 9900 vkm/week. The total driving distance into Nordstan for the consolidated trucks are 2000 vkm/week, of which 620 within the city area, and outbound (only considering the distance within the city) 620 vkm/week. The trucks still making deliveries in the city centre (5 or more deliveries per truck) drive a total of 3800 vkm/week, of which 2850 vkm/week are driven within the city area. The total traffic work is thus 16300 vkm/week, of which 4100 vkm/week is driven in the city centre.
3. The following reductions are realised in Use case B: Total driving distance: -300 vkm/week. Reduced driving distance in the city area: 1600 vkm/week. The CO2 emissions are down by 18% (1400 kg/week) while the total NOx emissions are down by 18% (8 kg/week), all of which was reduced within the central city area. This reduction equals 50% of the NOx emissions from the present traffic.

Assessment of reduced environmental impact

In the pre-study assessment, we only measured a sub-set of parameters with available data, not a full-scale assessment. In the main project, we will consider several parameters.

The reduced environmental impact is strongly related to the reduction of the vehicle kilometres driven with trucks on the roads into Nordstan. The concept with an UCC leads to a change in the driving patterns for the deliveries. The route to Nordstan is replaced by a new trip to the UCC, why the location of this terminal will be decisive for the environmental benefit of the system.

The total impact in the greater traffic system is calculated by comparing the driving distance from each delivery point to the location of the UCC, and then add on the traffic between the UCC and Nordstan. The majority of the incoming transports were shown to originate from the Backa/Kärra area why the calculation was made for a theoretical location of the UCC at Exportgatan 13. This is in the south end of the Kärra/Backa area and close to the access routes to the central parts of the city.

The analysis showed a small decrease in the total driving distance, probably due to small/no distance saving for the majority of the cargo while a number of deliveries located on the south side of the city experienced increased driving distances.
The reason for the decrease in total traffic work (vkm) to be relatively small is related to the present location of the starting point of the different truck routes in combination with the location of the UCC and the Nordstan shopping centre. The layout of available infrastructure is the other main factor determining the total traffic work produced. The analysis has not looked into the potentials for future changes in these factors, however, all factors but the location of the Nordstan is prone to be undergoing small or large changes in the coming years. The potential for further reductions of the traffic work is thus anticipated as a logical consequence of the establishment of a new UCC. The position of the UCC, or UCCs, should be selected with great care.

Figure 7: Illustration from Workshop 1, by Afra Noubarzadeh.

Contribution to FFI goals:
Efficiency: Transportation should be fast and cost-effective, and there is thus a need to limit congestions and improve traffic flows. By a new effective feeding system with larger vehicles into the city centre, in combination with consolidated electrified last mile delivery, the number of small vehicles may be reduced (see Figure 1). Furthermore, if use of pure electrical vehicles the deliveries may be done during nights with less disturbing noise, if accepted by the customer.

The night deliveries as well as the reduction of smaller vans have the potential to reduce congestions. The potential will be further investigated in a main project.

Quality:
By use of a bike container system in combination with the electric small road trains (called "stadsleveransen"), in the city centre the delivery precision will be higher compared to using vans and trucks. Studies conducted by Velove shows that small goods deliveries by bike can double the capacity compared to vehicles during day time. Due to traffic jams in the city centre the delivery precision vary more for goods transport by vans/trucks compared to bikes since bikes have higher accessibility.

The initiative with electrical truck combined with bike and "stadsleveransen" will also reflect societal targets to deal with the side effects on transportation in order to make cities attractive and give citizens a high quality of life.

From the investigation in Nordstan we know that almost all drivers were frustrated due to the traffic jams in Gothenburg city. The SMOOTh project will have a positive impact also for the drivers since about 40% does not need to drive into the city centre and the drivers who still need, they will at least drive in less traffic.

Environment: The results from the investigations are presented above and shows that both congestions as well as emissions can be reduced by a wise combination of a UCC and a City Hub in Nordstan. This have both a global dimension, where the climate footprint of transportation needs to be reduced, and a local dimension, where the air quality and noise levels need improvement.

Safety: It is necessary to continue the reduction of transportation related accidents in city traffic. By eliminating the small vans, often parking on the streets or on the pavements, during the days and among many vulnerable road users, the risk of accidents will be reduced.

Resource usage: One of the scarce resources in a city is land, and it is desirable to minimize the usage for roads and parking. Energy and funding are also limited resources, which should not be spent more than necessarily on transportation and infrastructure. The underground street at Nordstan has huge capacity but is presently not at all used at its full capacity. A new City Hub in Nordstan, using the consolidated electrified last mile delivery systems, can free up public infrastructure and will be used for multiple purposes, and may even generate new business.

Economy: Due to e-commerce the goods transportation work increases day by day. Future smart urban mobility solutions will be quite different from today's, and will include new SoS based technologies, actors, and business models. In the pre-study we visited and interviewed "The Fitting Room", a hybrid temporary store in Nordstan. In this store, the customers can try, feel, look and buy the products but never bring any products from the store. Instead, the buying results in an e-commerce purchase order, which then delivers via e.g. pick-up point or a delivery directly to home. We have already in the pre-study learnt a lot about e-commerce but in the chosen use case of Nordstan, which includes organization and customer behaviour, e-commerce, hybrid stores, new business model, will result in a better understanding of the complex eco system that is under transformation. It is important to understand what will be the business effects on existing shops in an old shopping centre like Nordstan and in what way this influence the need of goods transportation. In the pre-study we have not been able to measure all the potential economy effects of implementing a City Hub in Nordstan. The analysis has reviled saving potentials based on consolidation. In order to realize these potentials a SoS based data sharing is needed, and to give incentives to actually share the data it is important to consider fair new business models, with the aim of implementing a sustainable transport solution; "Follow the data and follow the money".

New knowledge and ground-breaking results: IT and digitalization in general is an enabler of hybrid shops like "The Fitting Room" which is based upon a technical platform from the start-up company TouchTech. In the pre-study we were not able to inventory and analyse different societal sectors IT-systems, but in the strong consortium we managed to build during the pre-study, the innovation potential is probably very high by building a SoS, bottom up. The different stakeholders have a strong engagement to co-operate and to find new transport solutions and new business models based upon SoS. SoS solutions are needed in order to efficiently identify and realize the consolidation and efficiency improvement opportunities.

International dimension: In the pre-study we have initiated the work to develop a transformation model and a concept built on SoS, Urban Consolidation Centers with consolidated electrified feeding into a City Hub, and consolidated electrified last mile delivery. The selected use case is very generic and the concept can be transferred to other urban environments in the world, like Paris which is one of the reference cites. Many cities in the world has old shopping centres like Nordstan, and they need a transformation to be much more sustainable. By the SMOOTh pre-study a broad consortium have initiated a SoS based transformation process, which can be conceptualized to a service business and exported to other cities and thereby strengthening our international position.

6.3 State of the art study of SoS as applied to freight transport

SoS can be characterized as sociotechnical functionally and managerially independent components (Maier 1998) with more or less tightly coupled, well defined and controlled goals and behaviours (Sage and Cuppan 2001). Each constituent system comes with its own set of capabilities and limitations and designing a successful SoS rest on knowledge of the characteristics of its constituent systems' sociotechnical character. In the SMOOTh, context, the constituent systems are 1) politics and regulations, 2) public infrastructure and its management, 3) logistics, and 4) vehicle use and development. Each of these is given a brief introduction including related challenges.

First, research has shown that political decisions are frequently based on "guestimates" and partisan ideologically motivated negotiation behaviour rather than evidence from facts (Schneider and Ingram 1990). Without adequate information and evaluation, regulations with inadequate or even harmful effects remain. (Sterman 2006). Relevant and transparent information can enable a well anchored and robust policy process (Ostrom 1990). There are increasing opportunities for policymakers and civil servants to utilize data analysis to ground decisions on new or modified policies[4].

Second, road infrastructure is, as opposed to e.g. rail, largely unregulated with limited options for active traffic management with ITS (intelligent transportation systems). Swedish traffic management has a substantial number of digital systems to utilize via the NTS architecture (Nationellt Trafikledningssystem), however work is largely limited to informing and coordinating efforts to relieve disruptions. Several research areas are developing new capabilities, e.g. geofencing and vehicle access management[5] or utilizing connected traffic signals to optimize and prioritize traffic (as part of Nordic Way 2). As part of several ongoing initiatives, there is an ongoing effort to design a digital infrastructure for the transportation sector (Traffic management 2.0 (EU), C-ITS platform (EU), Digital infrastruktur för transportsystemet (SE), Drive Sweden (SE), Nordic Way 2.0(EU), Samverkande Trafikledning (Trafikverket) (SE), Socrates 2.0(EU)).

Third, digitalization of logistics has a long history, and numerous research initiatives have sought to address challenges of transparency and efficiency with the goal of achieving greater sustainability. Currently, the European Technology Platform on logistics[6] use the "physical internet" concept as a guiding vision for 2030-2050. The EU project Aeolix[7] aims to provide an open platform to facilitate information sharing between organizations in the transport industry.

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[4] *See e.g. the recent development of the multidisciplinary Data for Policy conference, http://dataforpolicy.org/ where computer scientists, analytics and political science discuss the latest findings.*

[5] (https://closer.lindholmen.se/node/62398

[6] *www.etp-logistics.eu*

[7] *http://aeolix.eu/aeolix-technology/*

However, in these and many other cases success in terms of large scale adoption has been limited as of yet.

Fourth, modern vehicles are becoming increasingly dependent on well-functioning and adaptable digital interfaces. The industry is currently moving from having seen digital services as just another component to be managed internally, to viewing the information produced by vehicles as a valuable component in other actors' business models. The ACEA neutral server concept (ACEA 2016) could be viewed as a response to an increasing pressure to utilize vehicle data in multiple contexts and individual actors are currently seeking new ways of organizing (such as the new Connectivity organization within Volvo Group) and new architectures for future automotive platforms (Magnusson et al. 2018).

There is a growing SoS-specific literature addressing transportation, however, as can be seen in (Axelsson and Nylander 2018) by far most deal with challenges of personal mobility and solutions to this, such as those grouped within the mobility-as-a-service (MaaS) concept. However, digitalization of logistics has a long history, and numerous research initiatives have sought to address challenges of transparency and efficiency with the goal of achieving greater sustainability. Since a comprehensive analysis of all such projects is out of scope of this part of the project, we will instead focus on a number of representative cases, i.e. current or historical cases that deal with a specific type of challenge in a specific way. Together, these cases point to a number of insights into what type of challenges an SoS for city logistics is likely to run into, and more importantly, some insights into significant success factors in applicable cases.

Currently, the European Technology Platform on logistics[8] use the "physical internet" concept as a guiding vision for 2030-2050. Here, the design metaphor of the internet is used to describe an open and self-regulating global freight system, including city logistics (Crainic and Montreuil 2016). Several years of research has resulted in a number of conceptual models, but there are no full-scale demonstrations or implementations as considerable challenges pertaining to incentives and business models remain.

The EU project Aeolix[9] aims to provide an open platform to facilitate information sharing between organizations in the transport industry. The project is in its final phase and a technical platform that realize some capabilities has been developed and tested, but clear incentives and business models remain to be developed. In sum, substantial research into completely decentralized and potentially disruptive digitalization of the freight transport sector has not been able to change the underlying business logic of logistics (Sternberg and Andersson 2014).

The Scutum project has addressed dangerous goods on public EU roads. Based on a number of initiatives and collaborations between member states and academia, dangerous goods monitoring concept based on EGNOS/EDAS was conceived as early as 2012[10]. This generated a technologically feasible architecture, and tests were performed successfully. However, due to scant attention given to cost benefit analysis, rapid wide spread adoption was difficult to achieve. Just recently, CEN has published an "interface control document" detailing how goods tracking could be implemented.[11]

The Australian "intelligent access protocol" (IAP)[12] aims at resolving similar issues, but with several important differences. Most importantly, IAP only intends to follow the vehicle, not the goods. The IAP is operated by the public TCA organization and implemented by telematics providers and employs tracking and geofencing via a telematics unit to ensure the registered vehicles compliancy. The IAP scheme is mainly targeting high mass vehicles and special vehicles (e.g. cranes etc.). This is deemed necessary due to the risks of catastrophic failure of bridges and wear and tear of roads. The IAP scheme is mandated for these vehicles. Since the cost benefit of operating these vehicle is greater than the cost of adopting the system, it has been a success. IAP was tested in Sweden as part of research into the feasibility of long trucks. The Australian implementation has been the basis of an ISO standard in which the architecture and related potential services are described.

There are several ongoing initiatives, not specifically targeting freight transport, but of importance to SMOOTh:

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[8] *www.etp-logistics.eu*

[9] *http://aeolix.eu/aeolix-technology/*

[10] *ftp://ftp.cen.eu/CEN/Sectors/List/ICT/CWAs/CWA16390.pdf*

[11] *ftp://ftp.cencenelec.eu/CEN/WhatWeDo/Fields/ICT/WS/CORE/CEN_WS_CORE_CWA_16390_publication_20180117.pdf*

[12] *https://www.nhvr.gov.au/road-access/access-management/intelligent-access-program-iap*

First, there is the already mentioned ongoing work in truck OEMs on next generation platform architecture. The focus is here on how trucks can be continuously adapted to shifting demands in their digital environment in a resource efficient way, inspired by layered service oriented architectures that could simplify and lower costs for implementation of C-ITS and logistics services. In essence, however, the scope here is that of adapting a constituent system to be able to interact with various, largely hypothetical, future SoS contexts.

Second, the SMOOTh context also relates to initiatives regarding generic ITS and Traffic management such as the ongoing Swedish ”Collaborative Traffic management” project, that collaborates with the CEF-project Socrates 2.0 to develop incentive structures for creating common operational picture of, and harmonizing routing information between authorities and service providers. The project also relates to current research on connected traffic signals in the Nordic Way 2[13] initiative and the “innovation cloud” work connected to Drive Sweden. In these settings, digital infrastructure and architecture is discussed on the one hand as a specific component of automation and C-ITS in several pilot studies, and on the other as a generic resource that could be used by as of yet unknown future services. Though there has been progress and more attention directed towards these issues lately, as of yet, there is no consensus on how such facilitating generic digital infrastructure should be designed, or, more importantly, funded beyond pilot tests.

Conclusions

To reiterate, while these cases show how digitalization is utilized to attempt to alleviate challenges of sub-optimization and transparency, information and process integration costs, and regulatory compliance and safety, they are not intended to form a comprehensive review of all such initiatives. However, it is likely that these cases are for the intents and purpose of this study, representative.

Axelsson and Nylander (2018) point to three challenges associated with SoS for generic mobility applications: complexity management, socio-technical effects, architecture and interoperability.

Regarding architecture and complexity, SoS-related transport applications are small in scale, developed, and operated in isolation. There is a lack of technological knowledge how to connect constituent systems in a SoS, e.g. in terms of information infrastructure, communication protocols, and the scalability of such solutions together with the distribution of responsibility across different stakeholders. Of the cases shown, the notable successes have all been straightforward and rather limited in scope from a technological point of view, while wide-open structures have struggled. However, the technological complexity is not the only attribute.

Regarding socio-technical effects, the Axelsson and Nylander (2018) conclude that there is a prevalence of technology driven concept development and that social and business critical issues are mostly ignored. This includes the willingness to change behaviours or business models including sharing data. This mostly means that actual implementation and adoption cannot take place, even though the SoS implementation might be technically sound.

In terms of sociotechnical complexity, the cases shown here differ substantially. Interestingly, most successful SoS implementations, such as IAP, have a relatively hierarchical approach coupled to a limited scope in which there is a capacity to cover costs. However, in several cases, hierarchy is disputed, which impedes adoption. Open, industry driven SoS implementations (see e.g. Dahmann and Baldwin 2008) within the freight sector are likely rare beyond the pilot stage as partnering organizations frequently struggle to find an acceptable governance and/or business model.

Indeed, the selection of cases presented implies that a “hierarchical” SoS approach (Maier 1998) seem more successful. A prime example of this is the Australian IAP implementation. However, as illustrated with the dangerous goods case, what constitutes a hierarchical context in a technological sense is only part of the puzzle. In many areas, hierarchy is contested and any SoS contrived by authorities must be prepared to be challenged on the grounds of cost effectiveness and business feasibility.

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[13] http://vejdirektoratet.dk/EN/roadsector/Nordicway/NordicWay1/Documents/NordicWay2_slides_Overall%20presentation_20180903.pdf

6.4 Scenarios for viable designs of business model, technology and policy

The SMOOTh project has partly been conducted according to The SEVS Way (see References 0). This means that we have worked according to an inclusive process, involvement of several stakeholdes and organizations, with the aim of building a strong team and consortium. The invitation to workshops and the selected interviews were based upon an initial stakeholder/customer analysis, which resulted in four main categories of Actors in Nordstan, see Table 8 below:

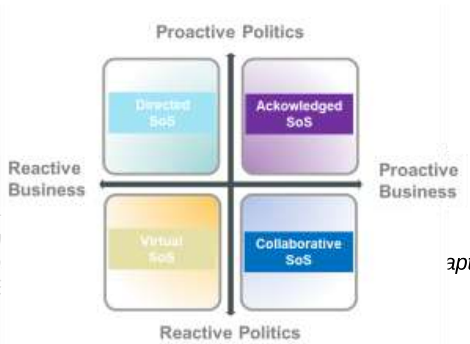
Shops (Corporate/Independent) • Retail goods in and out • Store materials (signs etc.) • Waste/cartoons • Offices material (paper, pencils etc.) • Bags	**Offices** • Flowers • Coffee • Fruit • Offices material (paper, pencils etc.) • Send and receive mail and packages
Restaurants (Corporate/Independent) • Groceries • Alcoholic beverages/Soda • Frozen products • Fruit and vegetables • Bred and dairy products • Waste	**Property owners** • Building materials • Craftsmen/inspections/services • Waste handling • Central post handling • Indirect material (toilet paper etc.)

Table 8: Stakeholder organizations in Nordstan

Three structured and result driven workshops were performed including representatives from the municipality, vehicle manufacturers, logistics firms, and researchers specializing in environmental analysis, logistics and informatics.

The process elucidated 78 challenges and opportunities related to the dimensions; economy and business models, social factors, physical planning, technological development, sustainability and political/regulative topics[14]. These were then inserted into a four by four-scenario model[15] based on the axes of political proactivity and business proactivity. This generated four contingency scenarios (Design Spaces), indicating what kinds of sustainability innovations was possible to achieve depending on the stance of regulators and business actors, (see Figure 8Figure 8: The SEVS Scenario cross, adapted to SoS below).

A taxonomy has evolved (proposed by Maier 1998, and extended by Dahmann & Baldwin 2008), which has been widely used to categorise SoS into four different types based on the degree of control exhibited[16]



[14] The SEVS Drivin
[15] The scenario cro ... apted to the SMOOTH project.
[16] Source: INCOSE

Figure 8: The SEVS Scenario cross, adapted to SoS and Maiers taxonomy

Scenario 1) *Incremental development.* Neither politicians or civil servants nor business actors act proactively. As a consequence, any SoS developed is constrained to existing roles and relations between systems. It can be construed as "Virtual" (Maier 1998). It lacks a clear overarching goal and governance and to a large degree resembles current bilateral integrations between systems. Although the low level of integration and lack of resources is a limiting factor, some innovations could still be put in place.

Scenario 2) *Business led development.* Business actors are proactive as they try to appeal to changing consumer behaviour and preference for sustainable options. But, since political actors and public institutions are passive, a SoS can only change roles and relations on a business level. This type of SoS could be viewed as "Collaborative" (Dahmann and Baldwin 2008). There is a goal, governance, and resources on the SoS-level, but a simultaneous lack of authority vis-à-vis the independent component systems who continue to follow their own goals with their own resources and can only be recommended to follow guidelines (de facto standard).

Scenario 3) *Political development.* Politicians and civil service act proactively using regulations to make a SoS possible. This SoS is used to enact new policies and regulations, analyse effects of policy and regulations, and adjust them in accordance with set goals. This type o SoS could be viewed as "Directed" (Maier 1998). It is centralized and authority controlled with clear goals. Component systems are still independent, but their development is to some degree determined by the SoS management, who can force necessary adjustments in component systems according to the overarching needs of the SoS.

Scenario 4) *Politics and business both proactive.* Business and civil service collaboratively determine goals and capabilities of the SoS. They manage it together towards common goals. Such a SoS could be viewed as "Acknowledge" (Maier 1998). Component systems participate on a voluntary basis to fulfil collective goals. A pure collaborative SoS has few central resources and all component systems are responsible for theirs. Adding higher complexity and far reaching requirements on SoS capabilities could lead to it becoming more of a "directed" SoS over time.

A conclusion from the pre-study is that a robust action plan for SoS development must consider stepwise implementation and plan for all scenarios, providing guidelines for various degrees of involvement, integrations and commitment from the various stakeholders and their constituent systems.

6.5 Uniqueness and topicality

Whereas the SoS discourse is now spreading to various sectors, most applications have been in public, mainly military contexts. While SoS methods for maturity assessment and development and strategy can likely be used in open contexts, there is a considerable lack of knowledge development on how an open market driven context affects the options available for SoS development. SMOOTh has in the pre-study initiated the work by putting the SoS in different Design Spaces and will continue to target this and provide such knowledge. The main reason for this is to be able to develop a generic SoS model which facilitates the implementation of a SMOOTh SoS concept in other cities around the world. The four Design Spaces represent different city environments, which in turn determine the SoS solution and the degree of system integration.

6.6 Findings and recommendations for main study including partners & financing

- The pre-study showed both an efficiency potential in the City Hub in Nordstan and the feeding connections at the UCC in Hisings Backa.
- During the pre-study and due to an inclusive process we have built a strong consortium with key stakeholders to initiate an implementation project; AB Volvo, Trafikkontoret

Gothenburg City, Rise, IVL, Nordstans Samfällighet, DHL, GLC, Velove, Pling, Best Transport and Trafikverket.

- The new consortium decided to apply for public funding for the full project via Vinnova/FFI/SoSSUM (the11th of December 2018) and committed to contribute by 52.2% in form of in-kind. The reason to apply for the full project, despite that the pre-study still had two months remaining, was to save lead-time and start the full project shortly after the pre-study was finished. However, the quality review at Vinnova had too many question marks to be able to recommend approval. The full project application was not approved, but recommended to be reviewed and updated after the pre-study had been completed. Then re-submitted to the June 11th closing.
- The main study was planned to start in March 2019 and end in March 2022, but is now delayed 7 months until October, if approved in the June 2019 application round. The total budget for the main study is about 20 000 000 SEK, see Table 9 below:

	Budget per participating part											Total budget/WP
	AB Volvo	Göteborg Stad	Rise	IVL	Velove	Pling	DHL	GLC	Best	Nordstans Samfällighet	Trafikverket	
WP1	*2 550 000*	*0*	*100 000*	*160 000*		*0*	*0*	*18 000*	*0*	*18 000*	*0*	*2 846 000*
WP2	*780 000*		*1 172 903*	*251 125*						*85 500*		*2 289 528*
WP3	*345 250*	*71 250*	*167 558*	*1 757 875*			*85 500*	*85 500*	*58 140*	*85 500*		*2 656 573*
WP4	*345 250*	*498 750*	*167 558*	*251 125*			*85 500*				*228 000*	*1 576 183*
WP5	*3 196 750*	*142 500*	*167 558*	*251 125*	*123 120*		*114 000*	*57 000*	*232 560*	*171 000*		*4 455 613*
WP6	*451 450*	*90 000*	*0*	*0*	*287 280*	*258 000*	*0*	*2 805 660*	*550 700*	*1 613 000*		*6 056 090*
Totalt	***7 668 700***	***802 500***	***1 775 575***	***2 671 250***	***410 400***	***258 000***	***285 000***	***2 966 160***	***841 400***	***1 973 000***	***228 000***	***19 879 985***

Table 9: Planned budget SMOOTh, an implementation project 2019-2022.

How has/will the project results be used and spread?	Marc with X	Comments
New knowledge with in the area	X	Urban Mobility and SoS
Spread to other advanced technical development projects	X	Input to main project application.
Transferred to other development projects		
Introduced to market		
Be used in pre-studies, regulations, Användas i utredningar/regelverk/ licening/ political descions	X	Guidance policymaking within local governments

The SMOOTh pre-study project has a related Volvo internal project in the Urban Mobility area. Paris is chosen as a reference city with similar transport needs and possible solutions. The SoS project module developed in the SMOOTh project in Gothenburg, may be transferred to other internal and external projects.

6.7 Publications

No publications have been released during the pre-study, but the SMOOTh project and some early results were presented at the SWESoS 2018 workshop in Linköping on November 22. The main purpose of the pre-study was to give input to a full project that has been applied for.

7 Conclusions and next phase research

The pre-study shows that there is a substantial potential to reduce environmental impact and increase logistics efficiency by implementing a SoS urban freight delivery system. To utilize this potential, the following further research is needed:

- Development of a model for scenario driven city-logistics SoS-development combining four constituent sociotechnical systems (logistics, infrastructure, vehicle development, and policy). This includes co-creating viable business models driving behavioural changes, and distributing the benefits realized by the optimization gains.
- Development of methods for analysis, evaluation and optimization of transport alternatives to avoid consolidating already optimized flows
- Development of processes for data driven policy in urban logistics
- Furthermore, there is a need to demonstrate SoS and digitalization in public authorities, businesses, political arenas, and research organizations through the active engagement of partners in the project and open seminars and presentations. There is a need to develop and demonstrate how the vehicles, physical and digital infrastructure and decision support and analytics can contribute to sustainable city logistics. This demonstration can be made in a sharp operational use-case with the Nordstan use case as a living lab, where there is a very high need of solving congestion and environmental challenges, which will motivate further research.

We therefore suggest establishing Nordstan as a living lab for innovative city logistics where stakeholders and technologies can generate and test new solutions, to support both research as well as dissemination and demonstration activities.

8 Participating partners and contact persons

The applicant partner organization in the pre-study were:
Volvo Group, (Project owner) Anders B Berle (Else-Marie Malmek)
IVL, Erik Fridell (Sönke Behrends, Sebastian Bäckström)
Rise, Kent Eric Lång (Magnus Andersson)
Göteborg Stad, Trafikkontoret, Malin B Andersson (Magnus Jäderberg)

Other participating organizations in 1-3 workshops were:
Nordstan Samfällighet, Magnus Zingmark
GLC, Bo Jonsson
Velove, Johan Erlandsson
Pling, Stina Johansson
DHL, Ulf Hammarberg
Best Transport, Niklas Knight (Niklas Falk)
Trafikverket, Hamid Zarghampour, (Magnus Palm)
Lindex, Maria Helmroth
Vasakronan, Kristina Post-Pettersson (Johan Lindström)
Inuse AB, Henrik Ernholm
Södahl & Partners, Björn Södahl
Closer, Lars-Göran Rosengren
Know IT, Christina Ceasar

Interviewed organizations:
Airmee AB, Julian Lee
Touchtech AB, Deniz Chaban
GU, Michael Browne

IBM, Mikael Haglund
Restaurant Prego, James Yuksel and employees
Elgiganten, Claes Tranell
Logicenter AB, Matthias Kettelhoit
Volvo Group, about 10 employees

The applicant partner organization in the next phase are:
By the 12th of December the below organizations committed to be partner in the next phase of SMOOTh. This was re-confirmed also for the updated application to be submitted by June 11th 2019.

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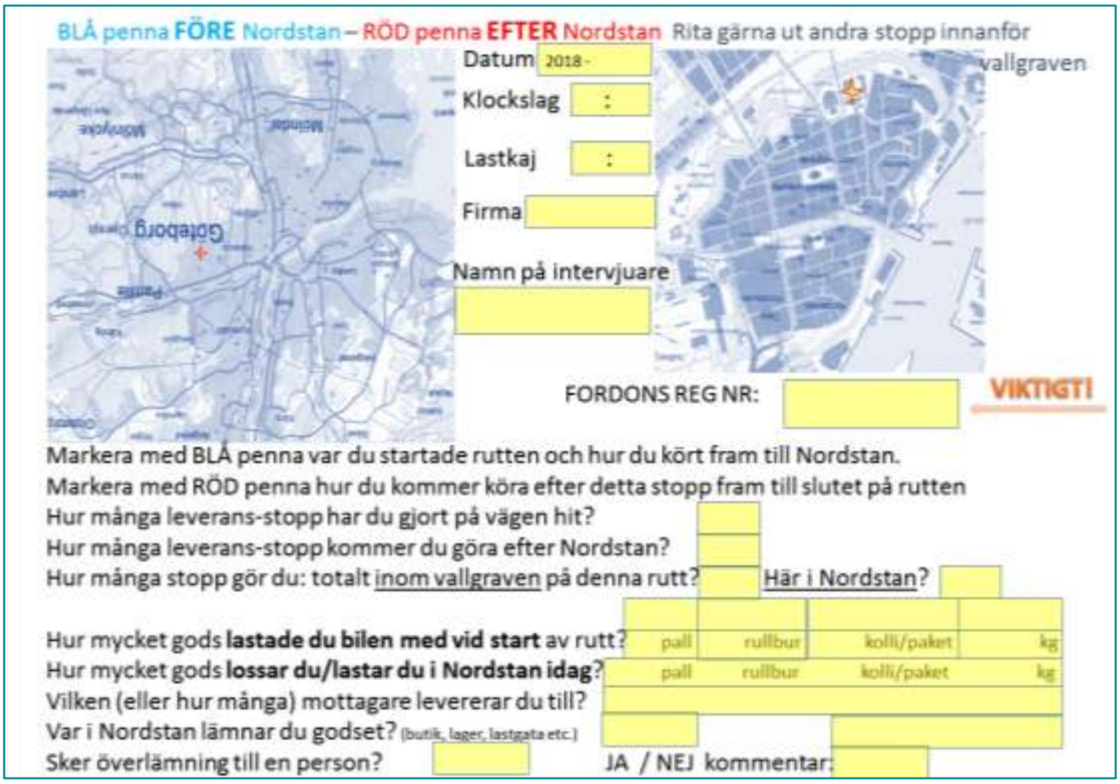
10 Appendix:

Appendix 1: Nordstan survey

The following format was used a support when making the interviews with the drivers making deliveries to Nordstan.



BLÅ penna **FÖRE** Nordstan – RÖD penna **EFTER** Nordstan Rita gärna ut andra stopp innanför vallgraven

Datum 2018-

Klockslag :

Lastkaj :

Firma

Namn på intervjuare

FORDONS REG NR: VIKTIGT!

Markera med BLÅ penna var du startade rutten och hur du kört fram till Nordstan.

Markera med RÖD penna hur du kommer köra efter detta stopp fram till slutet på rutten

Hur många leverans-stopp har du gjort på vägen hit?

Hur många leverans-stopp kommer du göra efter Nordstan?

Hur många stopp gör du: totalt inom vallgraven på denna rutt? Här i Nordstan?

Hur mycket gods **lastade du bilen med vid start** av rutt? pall rullbur kolli/paket kg

Hur mycket gods **lossar du/lastar du i Nordstan idag**? pall rullbur kolli/paket kg

Vilken (eller hur många) mottagare levererar du till?

Var i Nordstan lämnar du godset? (butik, lager, lastgata etc.)

Sker överlämning till en person? JA / NEJ kommentar:

Appendix 2: Scenario Result – Workshop 1

See separate file [Smooth_Scenarior-DesignSpaces,v1.1.pptx]