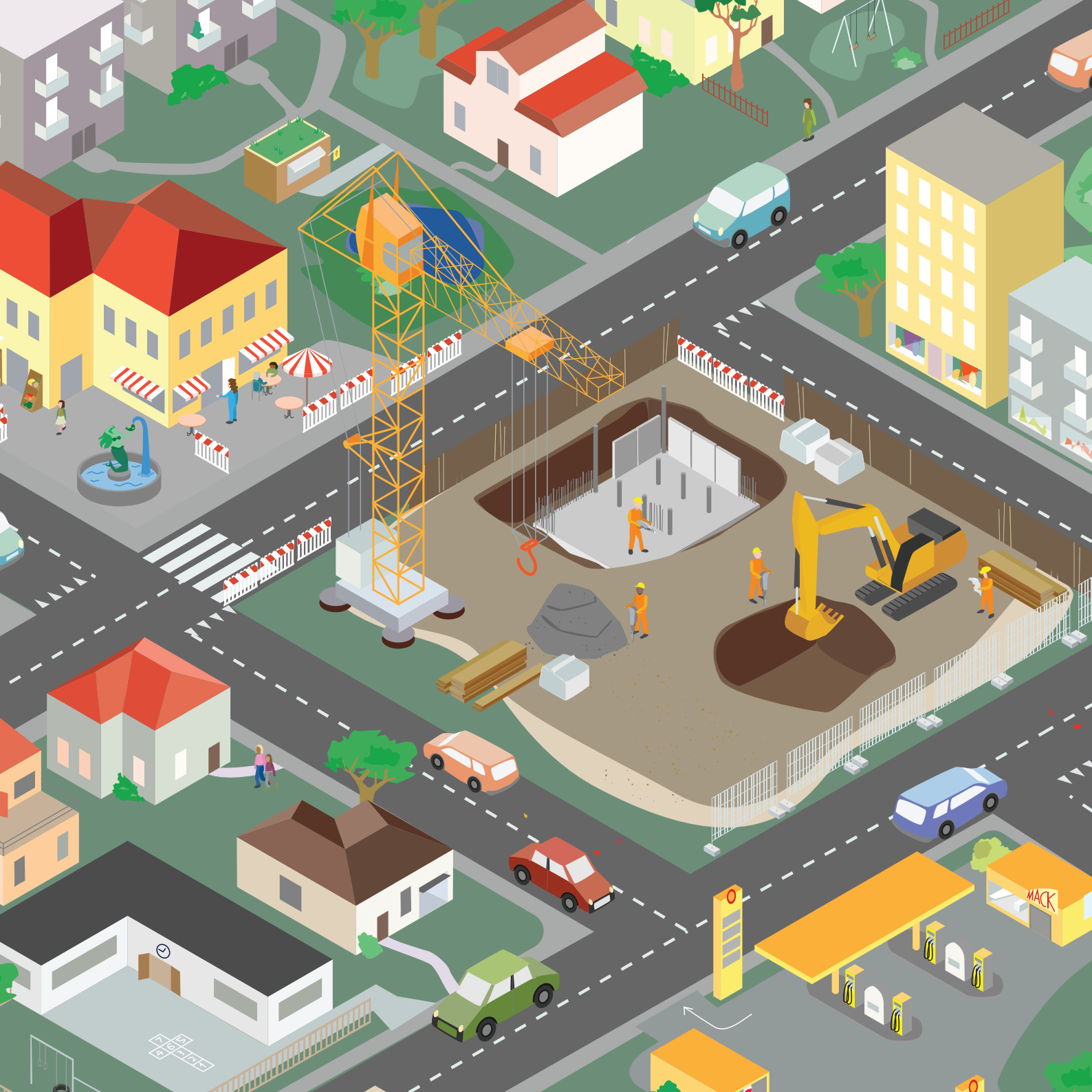

SMART CONSTRUCTION LOGISTICS



Smart construction logistics



SMART CONSTRUCTION LOGISTICS



Smart construction logistics



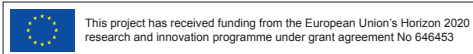
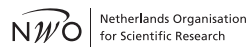
Smart construction logistics

The CIVIC project is a collaboration between



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INTRODUCTION

The growth in urban population and economic upturn is leading to higher demand for construction, repair and renovation works in cities. Houses, public utilities, retail spaces, offices and infrastructure need to adapt to cope with the increasing number of residents and visitors, urban functions and changing standards. Construction projects contribute to more attractive, sustainable and economically viable urban areas once they are finished. However, transport activities related to construction works have negative impacts on the surrounding community if not handled appropriately. It is estimated that 15 to 20 percent of heavy goods vehicles in cities are related to construction, and 30 to 40 percent of light commercial vans [1]. In the cities studied in the CIVIC project, construction-related transport was found to be one of the biggest challenges to improving sustainability. Smarter, cleaner and safer construction logistics solutions in urban areas are needed for environmental, societal and economic reasons. However, in many European cities and metropolitan areas the sense of urgency is not evident or a lack of knowledge is creating passivity.

The goal of the CIVIC project is to facilitate and support efficient, sustainable and broadly endorsed transport to, from and around urban construction sites that minimises disruption in the surrounding community, improves construction productivity and optimises energy efficiency. The CIVIC project found that the

impact of construction works on mobility and livability of a city was only a very limited part of the urban planning in the cities studied: Amsterdam, Vienna, Brussels, Stockholm and Gothenburg. The studied cities focused on large-scale infrastructure projects such as building motorways, railway stations and underground train systems or development projects, for example, whole new city areas. It is not only these large projects that need to be considered focusing on the impact of construction related transports. Additionally, there are many small-scale development projects in cities with a combination of different official and private actors. Contractors and developers/clients are displaying increasing interest in construction logistics since research shows that improved construction logistics can improve the productivity of a construction project by about 30 percent. Construction companies using innovative logistics concepts see less congestion around the sites and improved productivity and road safety. Thus, there is a need to align public planning coordinating construction projects with traffic planning in order to manage city infrastructure bottlenecks.

The ultimate goal is coordinated planning between the public partner of construction projects and the private construction contractors and developers on the necessary measures for mobility, livability and road safety in the city.

This handbook has been developed for local governments, clients, developers, contractors, or any other actor that can influence logistics planning and the set-up of construction projects. It can help local governments collaborating with private partners to realise more sustainable, and safer, construction works with less inconvenience and cleaner air. In addition, it can help clients, developers and contractors to ensure smooth and efficient construction operations. Hence, sustainable construction logistics could be a future deal-breaker.

The handbook first provides a description of the challenges of urban construction logistics and the governance of construction logistics. Secondly, it presents the Smart Governance Concept developed under the CIVIC project, combining different tools to improve construction logistics and its governance.

This concept can be applied on two levels: the city level and the project level. On a city level, a sense of shared ownership and urgency should be created to optimise construction logistics on the project level. This is the first step of the concept. Steps 2 to 6 outline different tools and methods for the development of a solution: in step 2, a conceptual solution is required to create a common understanding of the prerequisites for the specific project and possible methods for organising logistics. Step 3 entails the different instruments, policies and guidelines that are needed for creating the formal conditions for the solution. In step 4, the specific stakeholders are involved to

identify important criteria that influence the selection of the final solution. Step 5 then aims to select the final solution by providing cost calculations and traffic optimisation models. Step 6 entails the collection of data and follow-ups of KPIs. The final step 7 regards the evaluation of the different projects that feed back into the continuous development process of the optimisation of construction logistics at a city level. This final step is presented together with step 1 since these both concern the city level.

The Smart Governance Concept should be part of development/construction projects from the very beginning, meaning from the planning phase.

CURRENT STATE OF URBAN CONSTRUCTION LOGISTICS

PART 1

Current state of urban construction logistics

PART 1.1

Challenges of urban construction logistics

PART 1.2

Challenges in governance

PART 1.3

Examples of current governance of construction logistics in four European cities

PART 2

CONCLUSION

REFERENCES

This first part of the handbook describes the current state of construction logistics. 1.1 deals with the challenges of construction logistics – the specific characteristics of construction logistics that cause negative effects. 1.2 focuses specifically on the challenges in governance and the barriers found in processes of decisionmaking that have a negative impact on construction logistics in cities. In 1.3, the four different cases studied in the CIVIC project are described in terms of their current state of governance of construction logistics.

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PART 1.1 CHALLENGES OF URBAN CONSTRUCTION LOGISTICS

Each construction project demands a multitude of materials and resources that need to be delivered on-time, to the correct location on site and according to the rules as set by site management. The scope of construction logistics concerns all supply and disposal shipments of materials, equipment and personnel to and from the construction site, in addition to the efficient and effective planning and control of these resources at the construction site.

Construction work has some distinctive characteristics that influence the logistics:

1. Each construction site requires a new logistics setup since the location is unique and temporary.
2. Construction sites are material intensive and are supplied on an irregular basis depending on the construction phase (first concrete, last furniture).
3. Activities should be performed in sequence and if one activity is delayed, all the following activities

will also be delayed. Therefore, construction materials should be delivered to the contractors at a construction site at the right time and in precisely coordinated numbers.

4. Another distinctive character is the fragmented nature of the construction industry. There are many construction companies, suppliers and logistics service providers working in different temporary construction consortia. This leads to different ways of working and various ways of managing data.

Consequently, this results in a high number and inefficient use of vehicles to and from the construction sites thus impacting congestion, emissions, noise, use of public space, traffic safety, and damage to buildings and infrastructure due to the size of the vehicles and the heavy loads. In addition, the lack of planning and coordination among private and public actors in construction projects gives rise to four main problems causing negative effects for various stakeholders:

Current challenges of construction logistics

1. ***Unclear division of responsibilities between site and supply chain.*** This causes negative effects such as congestion around construction sites since vehicles are often unable to be unloaded and loaded immediately upon arrival. Instead, they should wait for further instructions before being directed to the right location on site.
2. ***An inefficient supply chain.*** Incoming transports are not coordinated due to a lack of data and supply chain planning, and an unnecessary high number of transport movements are sent to the site. Furthermore, contractors experience low delivery performance and thereby lack materials and resources when needed, which hinders the progress of the project and generates express transports, thus further increasing the number of transports close to the construction site.
3. ***Inefficient logistics on site.*** Lack of control at the construction site and inferior planning lead to material losses and extra costs, as well as hazards for workers at site. Furthermore, even more transports are generated to replace the lost materials, as will trucks with low fill rates due to small shipments.
4. ***Lack of coordination between construction project and society,*** by which we mean all parties related to the construction project. The surrounding society impacts the construction site in the form of the residents and shop owners close to the construction site and share, for example, streets and parking with the construction activities. The stakeholders will also affect the construction site through shared utilities such as water, electricity and heating. The emergency services also have demands regarding the construction site as they require access to the site and the surrounding activities. When this is not adequately coordinated, there are clashes that affect the productivity at site and citizens due to congestion, lack of space, safety issues and delays. For example, the lack of planning regarding how personnel are to travel to the site creates competition regarding parking spaces and generates unnecessary traffic that could have been avoided by coordinating public transport.



PART 1.2 CHALLENGES IN GOVERNANCE

The process of governing construction logistics is particularly difficult due to the fragmented nature of the construction industry. Not only is the supply chain fragmented, but there are also different public departments involved in the decision-making processes regarding construction projects and logistics.

Governance is here defined as “the art of overcoming barriers through organising collective action” [2]. Governance range from the traditional model of decision-making by formal institutions to processes of decision-making within more horizontal networks, in which the actor constellation changes from one dominant actor to multiple actors [3]. The fragmented nature of the construction industry and the number of different stakeholders involved reduces the role of one dominant actor, and requires joint action from both the public and private sector.

In this part, we identify current barriers in the decision-making process that hinder the optimisation of construction logistics. In part 2, we identify how collective action can be organised to overcome these barriers. The barriers are categorised following the model of behavioural change, indicating the relation between the different barriers and how one barrier leads to another [4].

Awareness:

There is a lack of awareness of the need and existence of ‘good’ construction logistics. A certain level of awareness is needed to start developing a better understanding of innovation in construction logistics, as well as willingness and ability to change.

Understanding:

To change construction logistics, the decision maker needs to understand what the change requires and what it entails. However, there is a certain degree of uncertainty about the potential of construction logistics because of the lack of information about innovations in construction logistics and what the effects are in terms of costs, efficiency, societal and environmental benefits (as described in 1.1).

Willingness:

The willingness and intrinsic motivation for innovation in construction logistics is constrained by the fact that there are conflicting goals and values between public (societal interest) and private (commercial interest) parties, but also among different municipal departments and different private parties (contractors and sub-contractors). For example, it is important for the

municipal department of land to obtain the highest price for the land and thus the requirements for construction logistics are kept to a minimum.

Ability:

The ability to change construction logistics – and implement innovative solutions – can be constrained by the lack of financial or human resources, not obtaining the necessary permits or limited supply of specific physical resources, such as low emissions vehicles. This hinders implementation in contracts.

Implementation:

Implementation is hindered due to a lack of cement of construction logistics at the municipal level and a lack of demand on a customer level. In addition, supply chain partners are involved in the process too late. For instance, the supplier is involved in the process when everything has already been decided (construction methods, materials used, etc.) and thus is unable to be innovative in its supply chain strategy.

These different barriers, combined with the intrinsic fragmented nature of the construction industry, all contribute to a more general lack of coordination and consequently a lack of shared sense of ownership of construction logistics.

The Smart Governance Concept is explained step by step in Part 2, demonstrating tools and methods to overcome these barriers, starting first with a strategy to mobilise joint action to create the shared sense of ownership needed to improve current governance models.

PART 1.3 EXAMPLES OF CURRENT GOVERNANCE OF CONSTRUCTION LOGISTICS IN FOUR EUROPEAN CITIES

This part presents four different cases of construction logistics governance in Stockholm (Sweden), Vienna (Austria), Brussels (Belgium), and Amsterdam (the Netherlands) to illustrate the present state of governance.

Stockholm:

Use of a construction logistics centre

This case illustrates the development of a city area in Stockholm, Norra Djurgårdsstaden. The city of Stockholm sets the conditions for the construction logistics by applying a clear environmental vision to the project, including goals for transport to the site and accessibility issues. A logistics coordinator (LC) was appointed to manage and coordinate all logistics activities to the site. This includes operating a construction logistics centre (CLC) that all contractors on the site are required to use. Furthermore, the LC also offers contractors additional services related to materials handling on site. All shipments are to go through the CLC for intermediate storage except volumes/items above 5 m³, which are directly shipped to contractors' sites. In cases of direct shipments, specified unloading zones are appointed that are to be cleared within two hours after unloading. Consequently, no storing of materials is allowed close to sites. The LC also coordinates and manages waste handling, fences and gates. Each contractor

is responsible for logistics planning, whereby all shipments need to be booked in the LC's IT system and cleared by LC. Each contractor manages materials handling and resources on their site independently.

Vienna:

Use of logistics coordination

This case concerns the construction of a new city area in Vienna, Seestadt Aspern. The city of Vienna governs parts of the process with an EIA (environmental impact assessment), specifying such issues as social concerns, noise, ground water, animals, flowers, air quality. EIAs were introduced by the European Commission to ensure that the environmental implications of decisions are taken into consideration, thus limiting negative environmental effects. (European Commission. Environmental Assessment. http://ec.europa.eu/environment/eia/index_en.htm). An EIA is mandatory for all large projects in Vienna. In this specific case, the EIA also required that an overall logistics coordinator (LC) was to be appointed to ensure that the logistics activities did not negatively affect the construction work. Examples of tasks handled by the LC are: logistics centre for material storage, temporary construction roads, loading zones, areas for storage of equipment, gravel processing for excavation material and a concrete plant on the construction site. The LC also coordinates and

checks that guidelines are fulfilled by using sensors and gates, plans the number of truck movements to and from the public transport network and at site through a check-point. Although the LC is responsible for coordinating deliveries to the construction site, each contractor can act independently regarding material handling on site as long as it follows the EIA's and LC's regulations. As a result, each contractor manages their own equipment for material handling (lifts, fork lifts, load carriers, cranes, etc).

Brussels:

Focus on mobility

This case covers the extension of tramline 94 in Brussels, a project initiated by the Regional Government of Brussels. For this public transport infrastructure project, the responsible Department for Mobility establishes the overall requirements for the contract called "Cahier des charges," which also serve as the basis for the open tendering procedures. Stakeholders, including businesses, stores, local residents and a school, were consulted but the public instances have the final say. The planning of construction work and material requirements are imposed on the contractor by the contract (Cahier des charges). Nevertheless, logistics requirements do not appear in the contract so the main contractors decide on logistics issues and perform the daily operations in cooperation with their sub-contractors. Focus of the authorities in Brussels seems to be placed more on mobility issues like, for example, guaranteeing accessibility of the area for such stakeholders as citizens and shop owners, than

specifically on reducing the impact of construction logistics. To summarise, there is no centralised logistics planning or coordination, and instead each contractor manages logistics to and on site independently by interacting with their respective sub-contractors.

Amsterdam:

City-wide coordination of construction projects

Three different construction projects provided input to the Amsterdam case. In Amsterdam, an alliance of different (local) governmental departments concerned with the public space ("coördinatieinstelling") monitors the number of projects taking place at the same time and combines projects or adjusts planning schedules when needed. The "coördinatieinstelling" uses different instruments to govern the process of construction logistics. A construction logistics proposal needs to be included in the proposal from contractors in order to be awarded a tender. When the tender is awarded, the selected contractor needs to specify the construction logistics proposal into a concrete plan. This plan needs to be approved by the municipality to receive a permit to work in and use the public space. Hence, contractors are responsible for the planning of construction logistics and are also responsible for informing and coordinating logistics related issues with their sub-contractors. Most often the project manager of the main contractor is in charge of construction logistics planning. Since contractors try to "be the best" at logistics when applying for tenders, innovative logistics measures often come from the contractors in this process.

PART 2

Smart Governance Concept

CITY LEVEL

Steps 1 and 7

Create a sense of urgency through collaborative governance

PROJECT LEVEL

Step 2

Develop a conceptual solution

Step 3

Policy, guidelines and agreements

Step 4

Stakeholder involvement
Type of stakeholders
Stakeholder criteria
MAMCA tool

Step 5

Select a solution
Optimisation of two scenarios
and traffic flows
Cost calculation of construction
logistics solutions

Step 6

Measuring impact and follow-up

CONCLUSION

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SMART GOVERNANCE CONCEPT

Following the current state of construction logistics (1.1) and its governance (1.2) on a more general level and more specifically in the four cities that are part of the CIVIC project (1.3), we now present the Smart Governance Concept.

A process of seven steps – including different tools of stakeholder involvement, logistics solutions concepts, traffic optimisation models, cost calculations and KPIs for follow up – with which we hope to provide guidelines and tools for optimising construction logistics.



In order to make construction logistics solutions 'come to life' in a city, the CIVIC project developed the Smart Governance Concept. This concept is a process of seven steps including different tools of stakeholder involvement, logistics solutions concepts, traffic optimisation models, cost calculations and KPIs for follow-up. The steps of the Smart Governance Concept have been developed in cooperation with companies and municipalities. The different tools used in the steps have been developed based on the different cases in the project. The Smart Governance Concept can be used both on a city/municipality level covering the total number of developments project in the next few years within a certain geographic area or it can be used as a tool by developers and contractors in a development project. The co-creation process facilitated by the Smart Governance Concept should be initiated at an early stage in the construction project, when there is still scope to assess the potential impact of alternative construction logistics and mobility-related solutions on the criteria of the different stakeholder groups so that the most appropriate can be selected.

The steps in the Smart Governance Concept are to be executed on two levels: steps 1 and 7 take place on the city level and steps 2-6 on the project level. This is to allow for feedback between the goals and effects in the development project, and the goals and effects on an overall city level. Firstly, the steps and their relationships are introduced below to provide an overview of the process and its relationship to the construction process, see figure 1. Secondly, the steps and the tools to be used are described in more detail.

Step 1 involves establishing all-embracing visions and guiding principles of construction logistics that relate to all types of stakeholders affected by the transports to, from and around the construction sites in the city/area. Therefore, it is important during this step to involve many different types of stakeholders to identify the goals from a broad perspective. Thereafter, step 7 should be used to obtain feedback from the same stakeholders to create a continuous development process. Accordingly, steps 1 and 7 should be annual processes.

Steps 2 to 6 are to be followed in each construction or development project. In step 2, conceptual solutions adapted to the demands of the specific projects are to be developed based on the decisions regarding visions and guiding principles in step 1. The goal of step 2 is to create a common understanding of the prerequisites for the specific project and possible ways of organising construction logistics, that is, the conceptual solutions. Step 3 establishes the conceptual solution input for the formulation of policies, guidelines and agreements to be used in the specific project. The project-specific stakeholders are involved in step 4 to obtain their input regarding the important criteria and the conceptual solutions that they prefer. The purpose of step 5 is to select the solution to be set up by providing a cost estimation and assessing the impact of the conceptual solutions on traffic. Step 6 involves collecting data during the use of the solution and afterwards and following up KPIs. Naturally, this should have been decided before the solution is tendered and created.

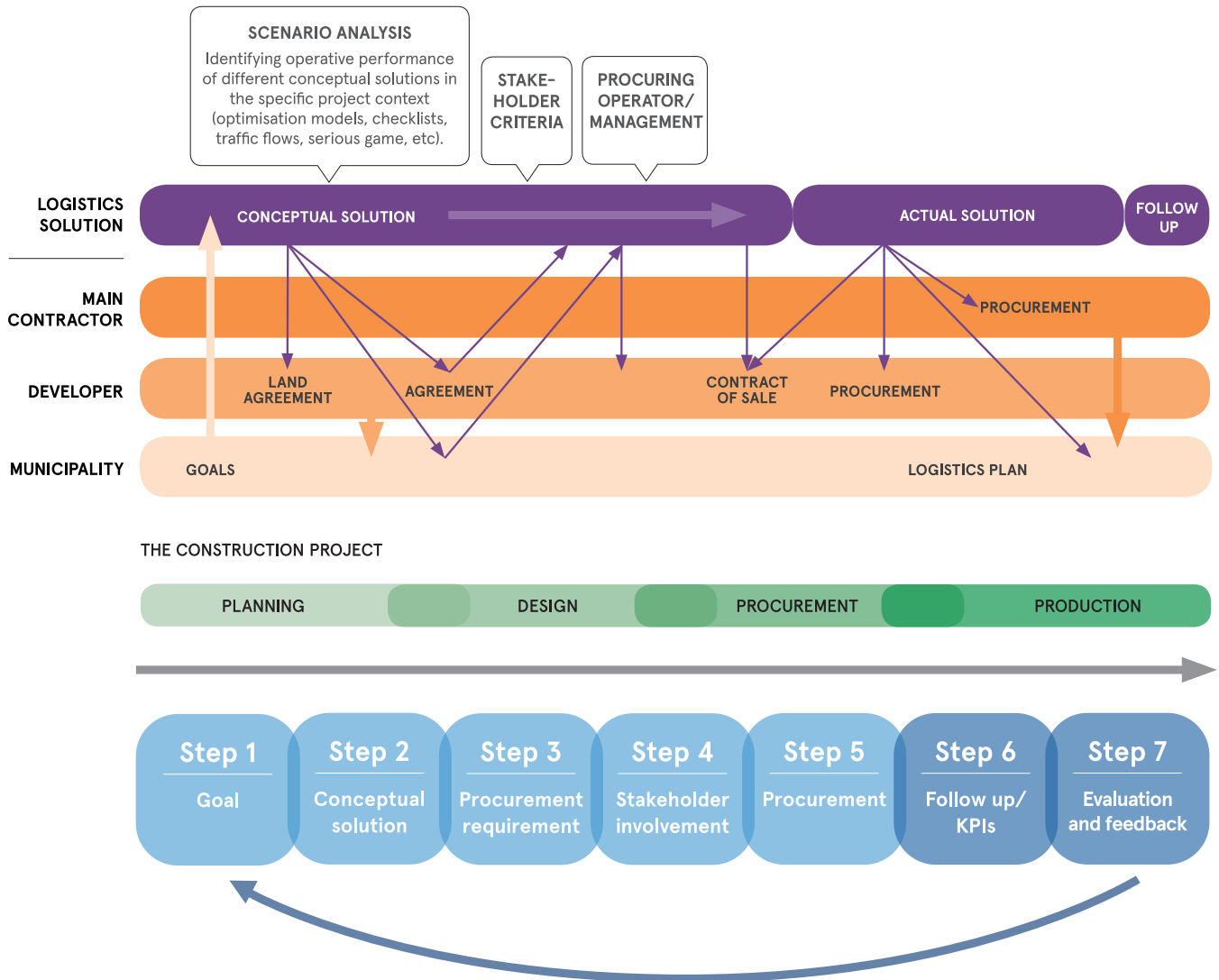


Figure 1 - Smart Governance Concept

STEPS 1 AND 7: CREATE A SENSE OF URGENCY THROUGH COLLABORATIVE GOVERNANCE

The lack of a sense of urgency at the strategic level is one of the most profound barriers for improved construction logistics identified in the project. These barriers result in the creation of additional barriers in the decision-making processes (see part 1). A sense of urgency may be felt among individuals, but it is important to obtain a shared understanding of what good construction logistics entails and how it can be achieved. In the four cities studied we saw that a general vision on 'good construction logistics' does not exist - although Stockholm is currently developing one - and thus in most cases guidelines for construction logistics are project-based.

Accordingly, the first step in the Smart Governance Concept is to create a shared vision of good construction logistics that is then developed into project goals. As such, step 1 should be carried out at the city level as part of the area planning. We have seen from the different cases in Amsterdam, Brussels and Sweden that this vision is needed to be able to define more specific requirements at the project level. This long-term vision should make specific goals on efficiency, sustainability, safety and inconvenience more explicit.

Collaborative governance

To create a sense of urgency, the different stakeholders along the construction supply chain should collaborate to jointly define problems, work together

on potential solutions and take steps to execute the shared purpose of the collaboration. In doing so, a sense of shared ownership of construction logistics can be created among all stakeholders involved in construction logistics (see figure 4). The strategy of collaborative governance is an iterative and long-term process [5] since collaborative governance is about stakeholder involvement. One method to support this is the Multi-Actor Multi-Criteria Analysis (MAMCA) (described in more detail in step 4) as a practical tool to establish both the drivers for collaboration and the four components of collaboration dynamics presented below.

To start the collaboration, drivers for collaboration are needed [5]. These are:

- **Leadership:** The first essential driver refers to the presence of an identified leader who is in a position to initiate and help secure resources and support for the collaboration. In the case of construction logistics, this is often the public administration or the developer.
- **Incentives:** This can be either internal or external drivers for collaborative action that encourage leaders and participants to engage together. These incentives can be found in the challenges described earlier in part 1.
- **Interdependence:** This is a broadly recognised precondition for collaborative action. The different

stakeholders are interdependent in the sense that they are unable to realise good construction logistics solutions on their own.

- **Uncertainty:** This is about how to manage a problem and its solution is related to interdependence: because of the uncertainty of the problem and the solution needed, parties need each other to avoid taking too much risk.

Once the collaboration process has started, collaboration dynamics keep the process moving. Collaboration dynamics is based on four interrelated components [5]:

1. **Face-to-face dialogue**, the “thick communication” allowed by direct dialogue is necessary for stakeholders to identify opportunities for mutual gain and reach consensus.
2. **Trust building** is a continuous and time consuming process that requires longterm commitment. However, it is necessary to achieve collaborative outcomes since trust forms the basis of mutual understanding.

3. **Shared motivation**, trust forms the basis of mutual understanding, which refers to the ability to understand and respect the positions and interests of others even when one might not agree.
4. **Capacity for joint action** recognises the importance of formal and informal rules and protocols, institutional design and other structural dimensions for ongoing collaboration.

Continuous feedback

These four components work together in an interactive and iterative way to produce collaborative actions. Collaborative actions can be perceived as interventions or experiments. These actions can lead to outcomes (i.e. results on the ground) and potential adaptation (the transformation of a complex situation or issue). Evaluation and feedback of the actions lead to a better understanding of the problem at hand and provide feedback into the potential solutions and change of the governance structures. These moments of evaluation and reflection are essential throughout the smart governance concept and thus comprise step 7.

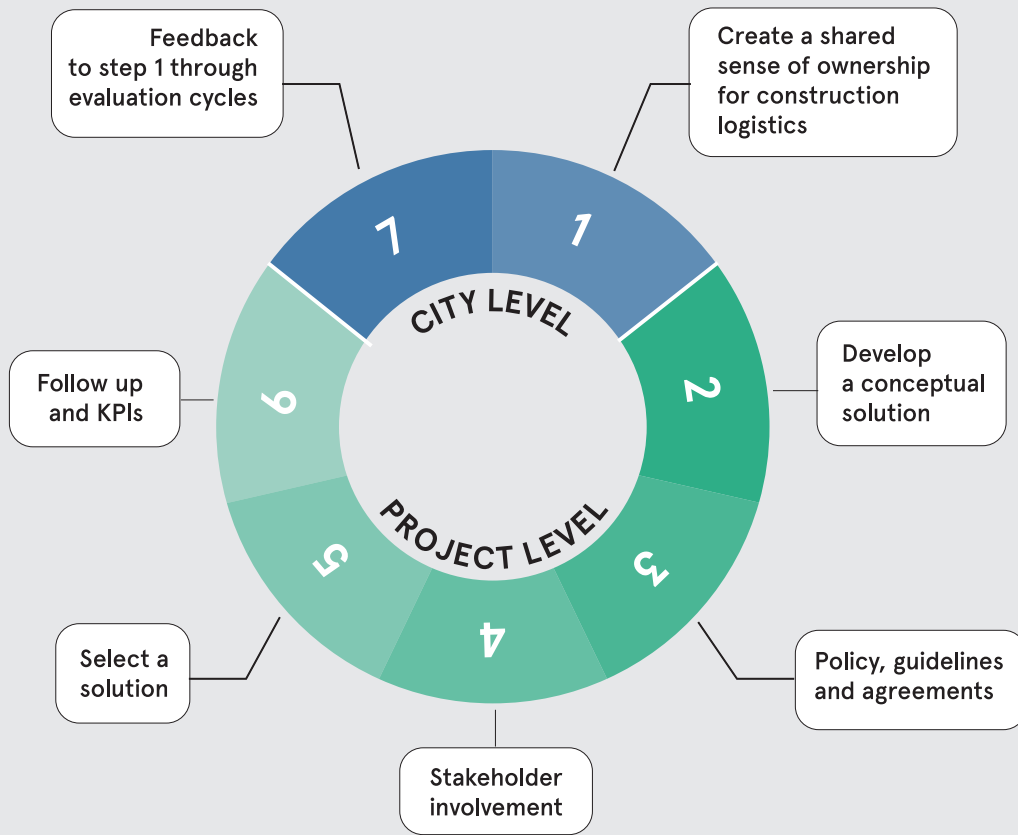


Figure 2 – Smart Governance Concept - a continuous development in seven steps

STEP 2: DEVELOP A CONCEPTUAL SOLUTION

This step focuses on the development of one or several conceptual solutions for solving the construction logistics in the specific project. Which solutions are suitable depends on the project context, such as type of project (hospital, city development, infrastructure or a single house), time span, location and geography (access roads, congestion within the area, possibilities of inter-modality, that is, closeness to railroads and waterways), disturbance sensitivity of the surrounding society in the form of schools, hospital wards, shops etc.

The first element presented is how to identify the type and scope of the logistics solution to be used. The activities and sub-activities to be included in the solution are presented in Appendix 3.

The different hierarchical decision levels in construction logistics (strategic, tactical and operational) are then to be presented and explained. In order to implement and optimise a logistics solution, planning and decision making from earlier stages of the project are to be aligned at a strategic level to the execution at the operational level in procurement and production.

Determining the type and scope of the solution

The overall aim of construction logistics is to improve the material and resource delivery process. Depending

on the organisation of the construction logistics solution, the solution can solve different problems in different parts of the construction supply chain. Construction logistics can play six different roles in improving the construction work and supply chains [6], [7], [8].

Role 1: Establish clear interfaces between supply chain and construction site

Role 2: Increase supply chain efficiency

Role 3: Increase site efficiency

Role 4: Transfer value-adding activities

Role 5: Integrate the construction site with the supply chain

Role 6: Coordinate with the neighbourhood

Different actors have different goals for the solution and as a result what roles the solution should play. The municipality/administration focuses on the city as a whole with the goal of increasing road safety and reducing inconvenience and pollution and thus prefer to decrease the number of transports around the construction site, i.e. role 2 and role 5.

Developers focus on their development area and like to have an as efficient construction process as possible to shorten the time before they can start receiving payback on their investment, and also reduced inconvenience for their customers already living or working there, such as parking spaces and accessibility to shops, i.e. role 1, role 2, role 3 and role 6.

The main contractors focus on their construction site and also like a construction process that functions and is as efficient as possible, i.e. role 3, role 4 and role 6. Different types and scopes of logistics solutions will be chosen due to these various goals and preferred roles.

Based on an extensive study of construction solutions used in Sweden, we have identified three areas of logistics activities that a con-

struction logistics solution needs to include: transports, site, and planning and organisation. The more activities included in the solution (see figure 3), the more general the solution, and the more roles can be encompassed. However, the cost of the solution will also increase, and a larger budget to control and manage the solution is required. Furthermore, awareness should be raised that construction logistics solutions are not universal, and instead they should be adapted to the unique context of the project and its settings.

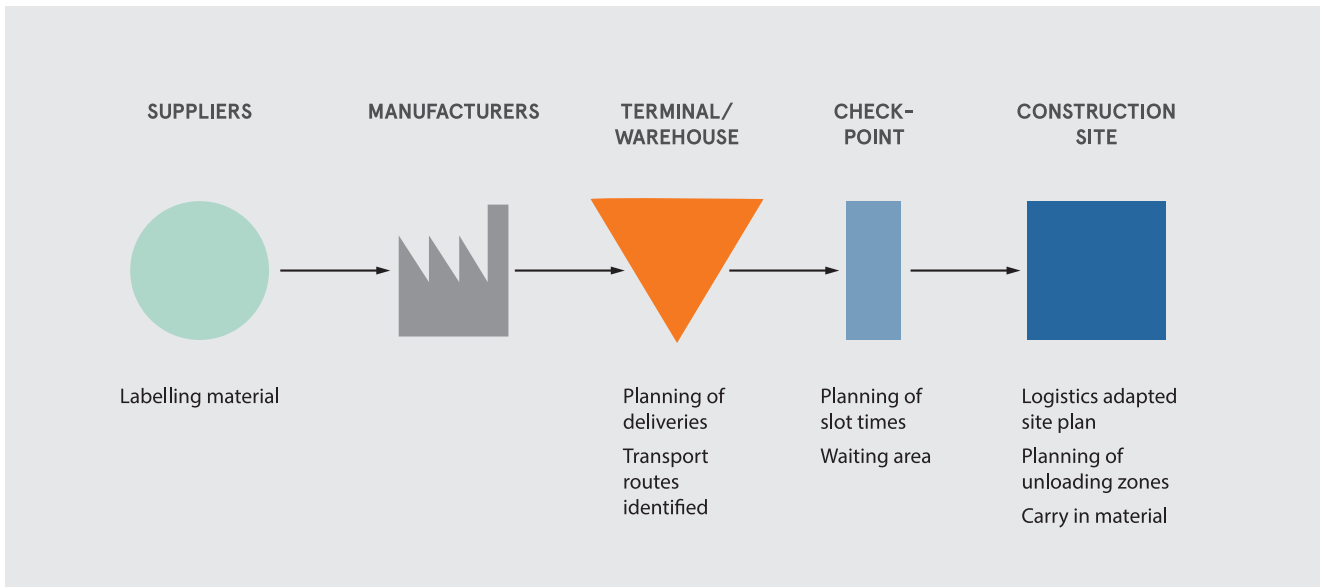


Figure 3 - A construction logistics solution

Different levels of decision making

Three levels of decision-making can be distinguished:

Strategic level

The scope of strategic decisions is long term and is aimed at providing visions and guiding principles for smarter and cleaner construction logistics. On the strategic level, decisions can be made by different entities such as the city council, the administration or the municipality. It is important that decision makers recognise their leading role in defining criteria for quality of life, accessibility, safety, communication with stakeholders, and aligning the planning between major construction works in the city with traffic planning. Tools supporting the alignment are planning tools (goods flow models, traffic models, urban strategy models), generic guidelines for construction logistics and urban freight, facilitating construction hubs providing ITS data for transport planning. Generic project guidelines are formulated in the land agreement.

Tactical level

The scope of tactical decisions is medium term (at the overall project level). At the tactical level, the aim is to establish a sound design and planning the logistics supporting a project (or several nearby projects).

Coordination through guidelines and instruments is crucial in this phase. This means adequately planning the execution of the construction works: efficiently, on time and sustainably with construction methods, collaboration, on-site logistics and transport systems that include such decisions as what mode to use, i.e. water and/or road and whether construction consolidation centres are to be established. This could be performed by a logistics coordinator (public-private and/or private). Communication with stakeholders is critical at this stage and could be carried out by both public and private actors. A full list of the logistics activities that can be included in the design of the solution and their relation to different goals from the strategic level are presented in Appendix 3. MAMCA is a tool to support the involvement of multiple actors, which is described further in step 4.

Operational level

The scope of operational decisions is short term and aimed at the day-to-day coordination of different material flows, for example, crane planning, warehousing, delivery time slots and pre-positioning zones. The aim of operational monitoring and enforcement is to monitor the actual safety, livability and mobility and demand that partners comply if necessary. Communication about the construction activities (often in real time) with stakeholders is critical at this stage and can be carried out by both public and private actors.

STEP 3: POLICY, GUIDELINES AND AGREEMENTS

After developing the conceptual solution in step 2, it is essential to identify the different instruments available to create the (formal) conditions for the development of the final solution, such as policies, guidelines and agreements. It is important that policies stating the vision of the city and developers are developed early on in a project or even before, mainly at a strategic level. Guidelines on how to carry out the work are mainly prepared at the tactical and operational level. To ensure that the policies and guidelines have an impact they are to be included in the agreements and cover all three levels. These instruments are country and city specific, which is why they are presented here as examples in Sweden, Vienna, Amsterdam and Brussels, although they can be used as inspiration in other contexts.

Sweden

- **Policies:** The environment is primarily impacted through the number of transports. Stockholm, for example, uses environmental zones and off-peak deliveries to deal with this. Regarding efficiency, the county of Östergötland had a policy of no disruptions to ambulance transportation when the hospital in Linköping was renovated.
- **Guidelines:** To affect the number of transports, different routings in Stockholm were permitted depending on the fill-rate. A high fill-rate allows for direct deliveries, while a low fill-rate must be

routed via a CLC. To increase efficiency, guidelines relating to planning are used, i.e. deliveries must be planned three to five days in advance otherwise extra costs are incurred or the storage in the warehouse is free for 14 days after which costs are incurred. Other guidelines that can be established are to demand a logistics plan or vehicles used and number of deliveries) in the environmental plan of the construction project.

- **Agreements:** Firstly, it is important to state that a construction logistics solution will already be included in the Land agreement (Markanvisningsavtal), and also in the following Collaboration agreement (Samverkansavtal), Development agreement (Exploateringsavtal) and the Purchasing agreement (Köpeavtal). The more details about the solution that can be added, the easier it is for the users to make preparations by making calculations and agreements with their sub-suppliers.

Brussels

- **Policies:** The Strategic Road Freight plan of Brussels Capital Region has only a limited explicit focus on construction logistics transport, and expresses a preference for 1) making more use of inland waterway transport via the inland port of Brussels and 2) reducing the impact of building sites on mobility. Environmental aspects of construction logistics are mainly impacted

- indirectly by changes in urban mobility policies such as the enlargement of the pedestrian zone in the city centre (2016), the introduction of a Low-Emission Zone in Brussels (2018) and the existing noise legislation (which prohibits evening and night operations, unless exceptions are granted for works for which the duration of significant impacts needs to be minimised). At the national level, which is also applicable to Brussels as stipulated by the European directive on the interoperability of European Electronic Toll Service (EETS), Belgium implemented a road pricing scheme for Heavy-Goods Vehicles (HGV), resulting in on-board units with GPS logging for taxation. HGVs also comprise construction vehicles, but no information on the intended use of this type of vehicle is currently available. No limit on the number of permitted transports has currently been set.
- Guidelines: There is no structural procedure for integrating logistics requirements in public tendering procedures, although very sporadically ad-hoc targets for an intermodal share of transports to and from building sites close to the port are included. In general, from an operational viewpoint, new construction activities are to be communicated to the Directory Coordination of Building Sites (DCB) to assess and minimise the impact of building sites on urban mobility.
 - Agreements: Trial initiatives to stimulate intermodal transport of palletised construction material by using the inland port of Brussels are starting to be developed. However, ideas for construction consolidation centres are only at the design

stage at the moment. Different types of incentives and, if necessary, adjustments to regulatory tools (building permits, environmental permit, etc.) are being carried out to stimulate more sustainable construction logistics. Communication on construction sites by the Cell Communication of the Brussels Regional Public Service for Mobility should pay specific attention to freight transport impacts. In the future, the idea is to appoint a separate unit that will be responsible for the preparation, follow-up and control of very large construction sites.

Vienna

- Policies: The environment is mainly impacted through the number of transports. An environmental impact assessment was performed for Seestadt Aspern that stated that a maximum number of transports per day must not be exceeded.
- Guidelines: To impact the number of transports, overall site organisation, the management of transport logistics and trip data acquisition and environmental assistance for the Seestadt Aspern urban development project were analysed. The logistic area was prepared and managed by a construction logistics and environmental management agency, which coordinated and checked the primary guidelines and objectives by holding regular meetings and conducting site visits.
- Agreements: Based on current contractual regulations, the single construction project organised

its internal responsibilities by itself (as normal for construction sites). Before starting the construction phase each single construction project provided information about internal responsibility (organisational structure, standard procedures, contact data, etc.) to the construction logistics and environmental management agency.

Amsterdam

- Policies: The city's urban freight plan (2016) stated that the City of Amsterdam will develop guidelines for construction logistics. There are no formal guidelines for tendering for sustainable construction logistics.
- Guidelines: The City of Amsterdam coordinates its larger construction projects in the so-called "coördinatiebureau", an alliance of different (local) governmental organizations concerned with the public space (including emergency services). Construction projects that work in or have an effect on public space need to register their projects in the "coördinatiebureau". Public services (for example, public transportation, water services, etc.) are notified and they decide whether they want to combine their activities with the construction project. The "coördinatiebureau" includes different instruments (regarding accessibility, liveability, safety and communication, in Dutch "BLVC") to govern the process of construction logistics. "BLVC scans" are conducted by the municipality and are used to analyse the impacts of construction works (including utilities) and to align different construction projects by using time windows. The focus is on the area

and on accessibility. BLVC frameworks are developed by the municipality (specifically the department for engineering) and draw up specific BLVC guidelines, which are included into the tender. This can be for the development of an area or the development of a single project. A BLVC framework is required for every larger project. The project manager of the contractor responds to these frameworks with a more detailed BLVC plan. An

approved BLVC plan is a prerequisite to receive the WIOR permit for construction in the public or use the public space for construction activities. The measures from the BLVC plan are legally binding and are used as guideline for law-enforcement

- Agreements: The "bouwenvolp" (the development agreement) is an agreement between the municipality and the developer in which the municipality draws up a document with the desired construction programme, volume, building-boundaries and price.

Construction logistics are managed by two permits: the construction permit (WABO) and the WIOR permit (Werken In Openbare Ruimte). Many construction elements that impact construction logistics are governed by the construction permit. In order to obtain a construction permit, the contractor/principal needs to submit a large amount of information, including construction drawings and engineering drawings. The WIOR permit is necessary when the construction project needs to use public space. The contractor needs to submit a BLVC plan to obtain this WIOR permit. Without a WIOR permit, it is not possible to perform work in a public space.

STEP 4: STAKEHOLDER INVOLVEMENT

As projects enter the construction phase, indirect stakeholders are often suddenly confronted with sometimes significant impacts. In current practice, there is limited space for bottom-up participation and conflict mediation with these impacted indirect stakeholders. This limited or late stakeholder involvement can, however, lead to conflicts during construction production and result in significantly negative impacts on time and costs. The CIVIC project suggests that stakeholders are involved at an early stage. This allows stakeholders to be presented with alternative solutions (the conceptual solutions developed in step 2) when they still can influence the decision on which solutions to implement.

To organise communication and collaboration between stakeholders, it is important to have a clear understanding of the different stakeholders involved in construction logistics and the issues that they consider to be important (the criteria) in relation to construction logistics. Firstly, the various stakeholders identify the different criteria that they consider to be important. Secondly, a tool for stakeholder involvement is presented.

Type of stakeholders

Construction projects typically involve many direct and indirect stakeholders with different, and sometimes conflicting, interests. For example:

- Contractors: aim to carry out the project as efficiently as possible and care about deliveries being made on time, safety for their workers and efficacy of the construction project.
- Municipalities: care about their citizens, and therefore demand solutions that decrease congestion, accidents, noise and pollution.
- Local business and institutions: care about their customers (shop-owners, patients, tenants, etc.) and support solutions that reduce inconvenience, such as lack of parking, noise and congestion.

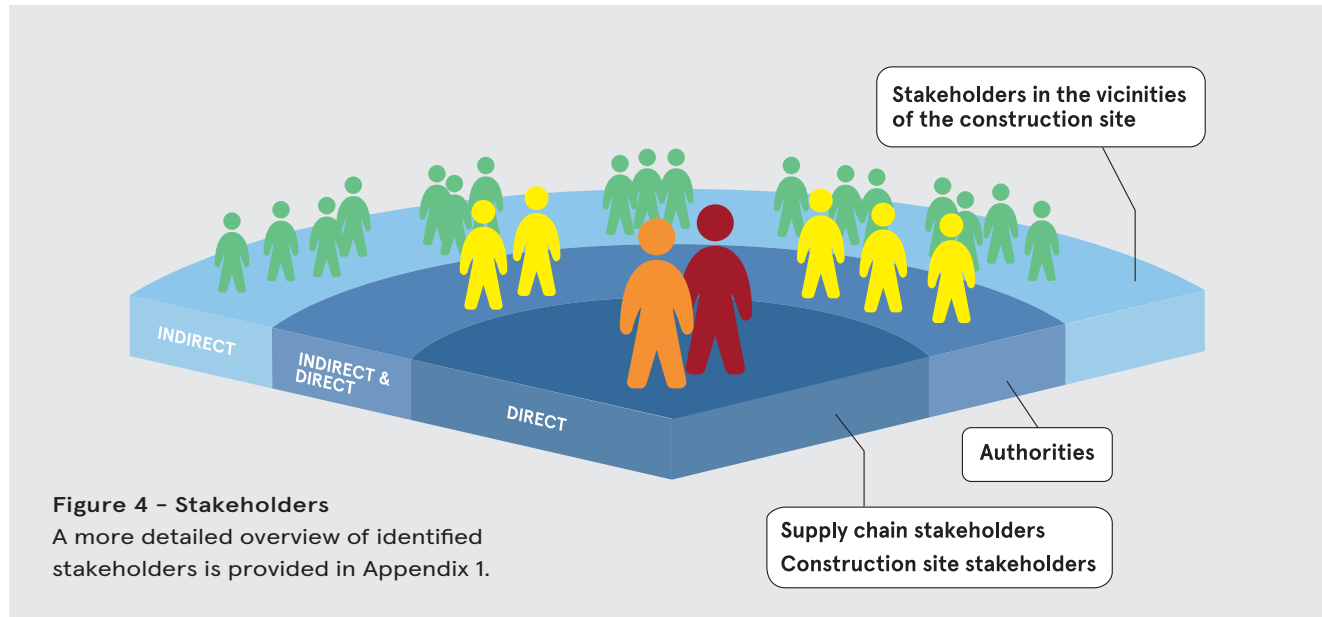
Stakeholders can be divided into direct and indirect stakeholders:

- Direct stakeholders are economic actors related to the construction project that are directly involved in the project's decision-making process (for example, commissioner, (sub)contractors, suppliers)
- Indirect stakeholders are societal actors affected by the construction activities in a significant way (for example, residents, infrastructure users, local companies) that are not directly related to the construction project and are traditionally therefore only involved in the decision-making process in an indirect and/or ad-hoc way. CIVIC aims to integrate these actors more structurally in the decision-making process.

Depending on the type of project (private or public), au-

thorities can be more an indirect or direct stakeholder.

An example of identified direct and indirect stakeholders in a construction context is shown in figure 4.



Stakeholder criteria

As illustrated above, different stakeholders can have similar but also very different priorities. Accordingly, the identification of the relevant criteria for each stakeholder group, and the weight they attribute to these criteria, is a key step in CIVIC.

Three impact categories were identified in CIVIC:

- **Economical:** examples of criteria include the transportation costs, profitability of operations and the viability of the investment. They are

usually the most important category for the direct stakeholders.

- **Environmental:** criteria such as greenhouse gas emissions, air and soil pollution and noise are often high on the list of certain interest groups (NGOs) or local residents.
- **Social:** criteria such as traffic safety, labour conditions, security and attractiveness of the area are often the dominant issues for (local) governments and public bodies.

MAMCA TOOL

To support the involvement of multiple actors with multiple criteria, CIVIC applied the Multi-Actor Multi-Criteria Analysis (MAMCA), which is a methodology for evaluating different policy measures and explicitly taking into account different stakeholders' opinions.

The MAMCA methodology [10], developed at Vrije Universiteit Brussel, allows for all stakeholder concerns to be taken into consideration at an early stage, and facilitates the analysis of the impact of potential solutions on individual stakeholder level. This enables stakeholders to make better informed decisions and supports them to engage in defining solutions that are both more sustainable and have a broader acceptance base. Such an approach can create win-win situations for all stakeholders by simultaneously alleviating burdens for local community members and optimising efficiency in operations for contractors, logistics service providers (LSPs) and transport companies. The MAMCA methodology has already proven its usefulness in several transport-related decision problems [11].

The MAMCA consists of two main phases, with four and three steps, respectively:

A. ANALYTICAL PHASE – GATHER ALL NECESSARY INFORMATION TO PERFORM THE ANALYSIS

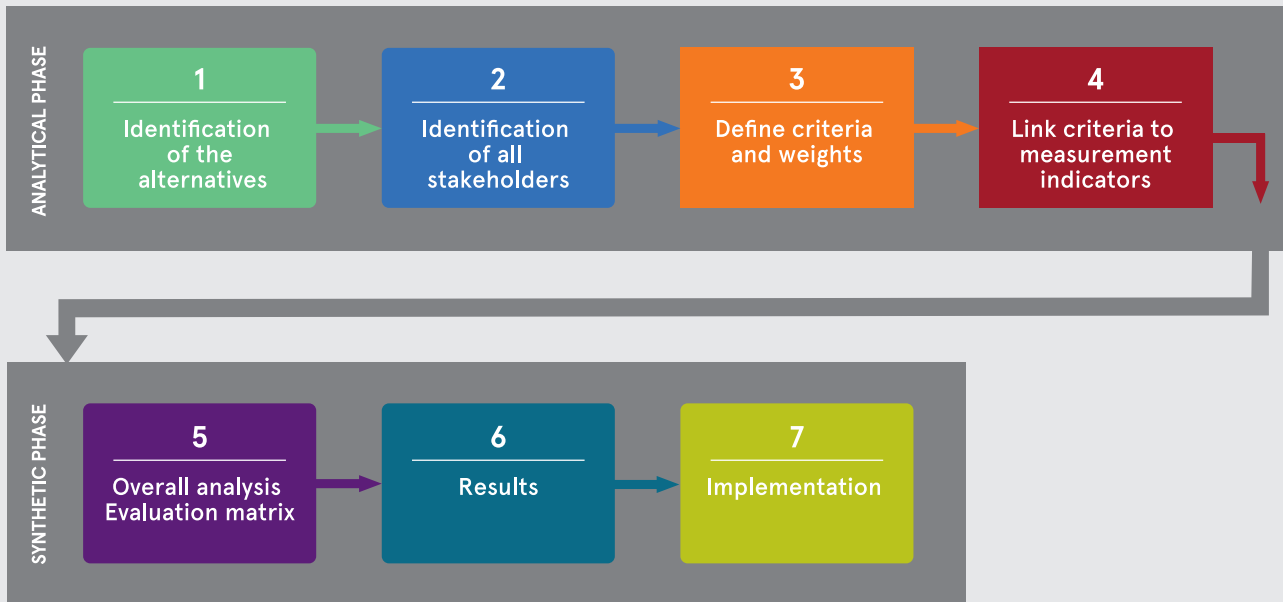
1. Problem definition and identification of the alternatives that need to be taken into account (such as different construction logistics solutions).
2. Identification of all the relevant stakeholders and their objectives.
3. Translation of objectives into criteria and assessment of the importance of each criterion at stakeholder level by weighing the different criteria (different stakeholder groups might have different but partially overlapping criteria, with specific weights per criteria).
4. Linking one or more measurable indicators to each criterion in order to evaluate each alternative with regard to a given criterion. Indicators can be either quantitative or qualitative, depending on the criterion (e.g. "gram of CO₂ emitted per ton transported" to measure impact of each alternative on the criterion of "climate change").

B. SYNTHETIC PHASE – ACTUAL ANALYSIS

5. Aggregation of the information of the previous steps into an evaluation matrix.
6. Generation of actual results by using a Multi Criteria Analysis methodology. This step analy-

ses the advantages and disadvantages of every alternative for every stakeholder. Based on this analysis, alternatives might be adapted to increase stakeholders' acceptance.

7. Actual implementation of the result (often linked to the policy-making level).



The MAMCA methodology is facilitated through an online decision-making platform which provides an interactive method to weigh stakeholders' objectives, evaluate options and provide easy-to-understand visualisations of evaluation outcomes.

STEP 5: SELECT A SOLUTION

This step focuses on selecting the logistics solution to be set up by analysing the most appropriate solution for the specific project. This decision should be based on the conceptual solutions developed in step 2 and the stakeholder analysis in step 4. The conceptual solutions are further developed based on input from the stakeholder analysis so as to ensure a solution that satisfies as many criteria as possible. However, it should be noted that there is never going to be a solution that satisfies all parties since there are inherent trade-offs between stakeholder criteria. Step 5 provides input for the decision of the exact solution to be used by assessing the impact of the different conceptual solutions developed in step 2. The assessment is based on the impact on the traffic flow and the cost impact of the solutions. The tools to use for assessing the impacts are described in this section. First how optimisation tools can be used to plan and assess the impact on the traffic flow of a construction project. Secondly, a tool based on activity-based costing (ABC) for calculating the cost of using a logistics solution is presented.

Optimisation of two scenarios and traffic flows

Planning construction logistics helps to enable smooth construction works in an efficient and sustainable system. Planning ahead of time is essential to finish

construction tasks on time, while exploiting benefits of cooperation between the stakeholders involved. Two scenarios are presented to illustrate how cooperation and coordination can help make cities more attractive even during periods of heavy construction.

Figure 5 presents the number of transports related to construction activities in a large development area. All construction sites in the area need to be considered by applying a holistic approach. Material deliveries can be bundled using construction consolidation centres outside the city, and several construction sites can be supplied at the same time. With an inter-connected real-time data system, delivery tours are coordinated, and the required material is supplied to the right place at the right time. Resources are optimally used and traffic and emissions on site are reduced. Planning enables a better distribution of delivery trips according to construction schedules and helps to avoid congestion and periods of down-time.

In the *first scenario*, represented by the blue line in figure 5, the schedules of the different construction sites are not harmonised – all construction activities start at the same time, resulting in inefficient delivery operations. Thus, the maximum number of allowed transports, the red line (50 trips), is significantly exceeded (by a maximum of almost 100 trips),

Cost calculation of construction logistics solutions

When new solutions for construction logistics are developed, uncertainty exists about the level and allocation of costs and benefits, risks, and responsibilities. An activity-based costing (ABC) approach can be used [12] to make construction logistics costs visible. ABC is a cost accounting technique that highlights the relationships between activities and resource consumption [13], [14] and assigns both direct and indirect costs to each activity and in the long run also the profitability of serving a certain customer [15]. ABC analysis follows a seven-step process [16], [14] as outlined below.

1. Determine the process of interest and set system boundaries
2. Break down the chosen processes into activities
3. Identify the resources consumed in these activities
4. Identify cost drivers for the activities
5. Gather cost data
6. Allocate costs to the activities
7. Analyse the cost information from a total cost perspective

Figure 7 presents the cost calculation for using a construction logistics centre. The supply process of such a solution comprises the transport from the supplier's loading bay to the construction site via a construction logistics solution or directly, materials

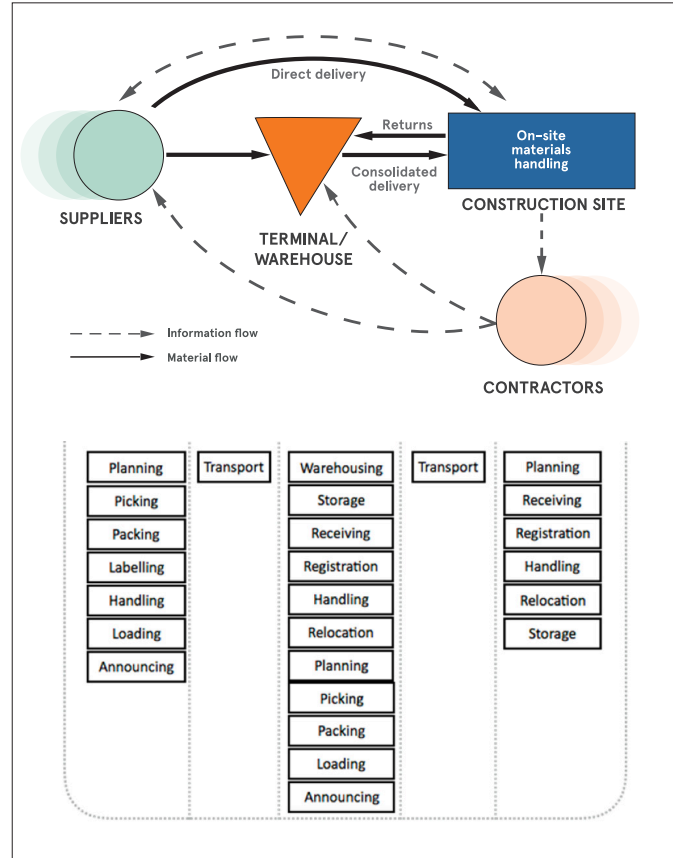


Figure 6 - Activity-based costing approach

handling in warehouses and terminals, and the actual warehousing. This overall logistics process is divided into four sub-processes: direct transport to site, transport to construction logistics centre, operations within the centre, transport from the construction

logistics centre. These sub-processes are broken down into their corresponding activities. From this, resources used and cost drivers can be identified and managed. The cost of utilising a construction logistics solution (CL) can thus be formulated as in figure 7.

A requirement for a reliable construction logistics calculation model is a cross-company insight into processes and activities regarding the logistics of construction materials, equipment, and labour as well as insight into the productivity of construction processes. The cost equations (1 – 5) defined below

combined with the detailed breakdown can be used to gain a greater insight into the composition of the costs associated with the solution. Furthermore, it can be used as a tool to continuously improve the operations of the setup by analysing the identified cost drivers to determine whether the prices per activity need to be updated.

To formulate a valid construction logistics calculation model, it is necessary to obtain reliable information from partners in the construction supply chain. This cost information is a result of operational activities. To analyse the data required, it is therefore necessary to know and share which indicators are important to track.

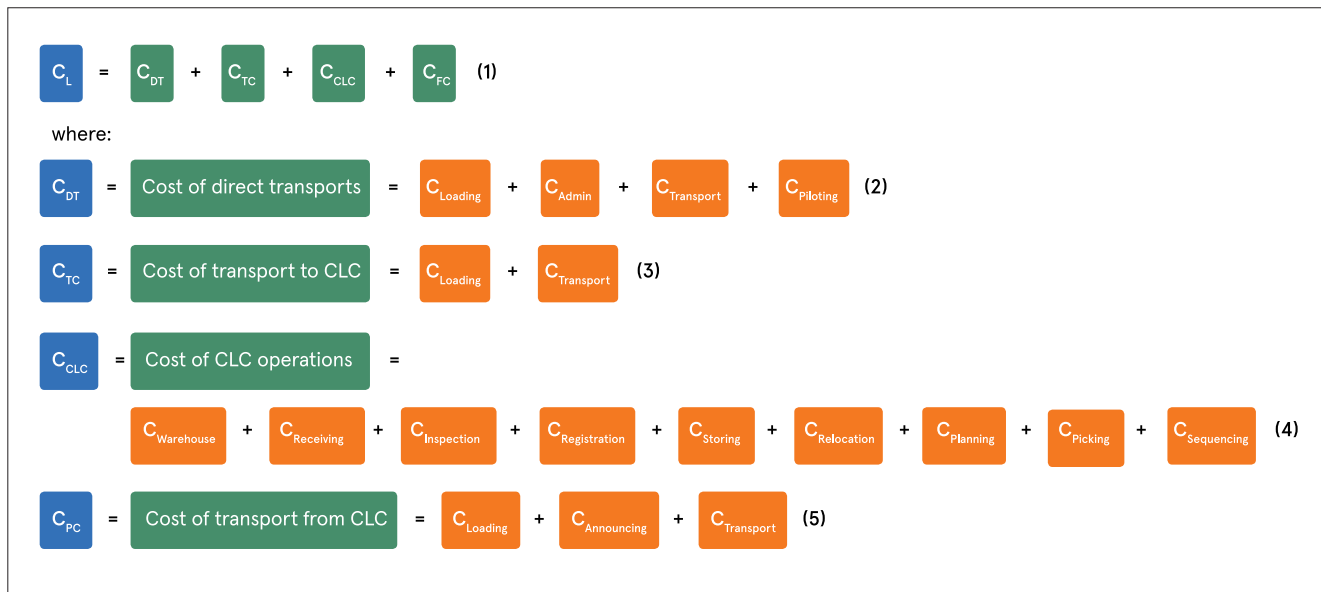
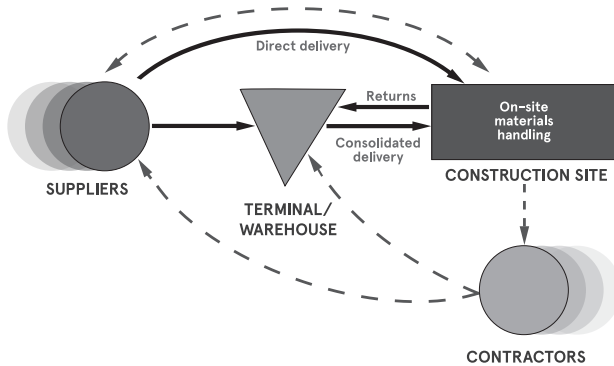


Figure 7 - Cost calculation

STEP 6: MEASURING IMPACT AND FOLLOW-UP



The solution should be implemented by identifying a logistics provider, but it has also to be followed up by measuring KPIs and be adapted when new projects, new phases of projects, supplementary projects, etc. arise. KPIs are used to follow up and measure the impact of applied solutions. To ensure that the improvements have the intended effects, the KPIs should follow the main activities of the ABC

	TRANSPORT KPIs	WAREHOUSING KPIs	HANDLING KPIs
INDIVIDUAL PRJOECTS	Number of transports on time in relation to the total number of transports	Average number of days that deliveries are stored on site	Number of times pallet are moved at site
			Number of loadings and unloadings at site versus the warehouse
			Number of unloadings at site in relation to total deliveries
DEVELOPMENT AREA	Number of non-planned vehicle entries and exits in relation to the total number of vehicle entries and exits	Average m ² usage of the warehouse in relation to the total warehouse m ²	Total number of unloadings and movements
	Number of heavy vehicles in relation to the total number of vehicles		

Figure 8 - Examples of different KPIs

calculation in step 5. Accordingly, the KPIs discussed here are related to the processes of transportation, warehousing, and handling.

Furthermore, it is important in urban development projects that the processes are measured at two levels: the individual project level and the whole development area. The individual project level is important for highlighting the well-performing projects in the development area and continuously improving the projects. The whole development area is important for measuring the impact of the development project on society and to obtain data for comparison with other development projects. The economic, environmental and societal criteria, presented in Appendix 2 and discussed in step 4, are to be considered in defining KPIs.

An important part of all follow-ups is to obtain reliable data. It is important to log data in order to secure reliable data after implementation and during use. To ensure that the right data is logged, a decision must be made before implementation on which type of data to log and the reasons for logging it. This decision is to be based on the KPIs used. Some examples of how to log data are presented below:

1. Data from existing IT systems, such as transportation management systems, warehouse management systems or enterprise resource systems. The studies conducted in the CIVIC project show that there is a lack in data in these systems due to fragmentation in the construction industry and no tradition of saving data.
2. Obtain new IT systems specifically for data collection for construction logistics. These can be IT systems that focus on communication between stakeholders (such as KYP) and IT systems that focus on warehouse management, transportation and emissions (such as ILIPS). These systems are currently being used, but the study shows that there is a shortage of reliable quantitative data due to industry fragmentation and no tradition of saving data.
3. Processing sensor technologies, such as air, noise and movement sensors to assess the impact of the solution on the vicinity. The study shows that sensor technologies are not used in practice due to the purchasing costs and data processing capacities, in particular the costs of gateways. The costs of the sensors itself are low.
4. Manual collection, by construction employees or hired personnel. However, this is costly and time consuming and is only possible for a limited time. It means that data always comes as a sample and is thus difficult to generalise.

PART 1

PART 2

CONCLUSION

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CONCLUSION AND FUTURE WORK

The CIVIC handbook presents the Smart Governance Concept of construction logistics that provides tools to accomplish coordinated planning between public and private actors in major construction projects. The goal is to improve mobility, liveability and road safety in the city. Construction logistics should be part of both the agenda of major construction projects and future city planning. Sustainable construction logistics starts in future city planning.

However, knowledge about construction logistics must first be improved. This is the reason that the CIVIC project developed a construction logistics game. The game is a playful and informative way to aid understanding of the need and importance for collaboration between different stakeholders in order to accomplish successful construction logistics and thus decrease the number of transports around construction sites. The result will be both an increase in the efficiency of construction work and a reduction in negative effects for third parties.

This CIVIC handbook is not the end of a journey; it is the beginning of a new journey. With this handbook we hope to raise awareness of urban construction logistics and innovative construction logistics solutions among both public administrations and private actors. We hope that this handbook can help these actors when they establish their own Smart Governance Concept processes of construction logistics and adapt them to the specific context in which they operate. By doing so they can make construction logistics part of the daily agenda of construction projects.

Based on the work behind this handbook we see several challenges for future research:

- Link construction plans with traffic models to identify areas of congestion before project are initiated.
 - Increase digital monitoring and enforcement of construction transports and develop control towers to optimally route the transport.
 - Develop new business and cost models on how to make construction logistics solutions profitable and gain acceptance among the supply chain partners in the construction industry.
- Stimulate collaboration between public and private actors regarding construction logistics and increase information sharing.
 - Include logistics factors in construction agreements and plans.
 - Stimulate knowledge of logistics planning and control in public and private construction actors.
 - Increase data collection of construction transport flows to build up a dataset of the impact of construction logistics.
 - Improve execution of logistics concepts such as hubs, runners and waterway transport.
 - Increase stakeholder involvement in construction logistics planning by further developing the MAMCA method and playing the developed construction logistics game with different stakeholders to raise awareness of the importance of collaboration.

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APPENDIX 2

APPENDIX 3

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APPENDIX 1

List of stakeholders

The table below presents an extended list of stake-holders to consider for construction projects.

Different type of stakeholders

Project-related, direct	Directly involved in the decision-making process of the project
Construction companies	
Suppliers	
Logistics service providers	
Client	
Project-related, indirect	Do not directly participate in the decision-making process
Landowners	
Infrastructure providers and operators	
Local urban planning (infrastructure)	
Authorities	
Residents in area	
Public institutions in area	
Businesses in area	
Users of infrastructure	
Road	
Bikes and pedestrians	
Public transport	
Visitors and customers	
General public (opinion)	
Local politicians	

APPENDIX 2 Stakeholder criteria

Economic criteria

Enforcement costs	Costs to ensure other parties comply with rules in the transport system and/or legislation during the construction works
Viability of investment	Positive return on investment. For example, the investment in mobility or safety measures should result in more (efficient) work in the long term
Profitable operations	Objective to generate a profit by providing logistic or transport services during the construction works
Transportation costs	The costs of transporting construction materials and/or personnel during the project
Adaptation costs	Financial costs due to mobility impacts caused by the construction site (for example, detours, parking)
Impact of construction works on transport infrastructure use	Impact of infrastructure works on the efficiency of a transport system, in terms of average speed level, congestion and connectivity and the impact on parking
Quality and reliability of deliveries of construction materials	The punctuality and the percentage of damage-free delivery of goods (from shipper and recipient perspective)

Environmental criteria

Air pollution	Impact of construction works on local air quality. The main air pollutants considered in urban areas are sulphur dioxide (SO ₂), nitrogen dioxide (NO ₂) and particulate matter (PM2.5 and PM10)
Climate change	Impact of construction works on greenhouse gas emissions CO ₂ (global impact)
Noise pollution	Sound level caused by human activities, including transport, during construction projects
Vibration	Impact of vibrations during construction works on the surrounding built-up environment, which can cause significant damage
Water pollution	Impact of construction projects on water quality since construction may pollute water flows and affect volume and velocity
Biodiversity	Impact of construction works on an area of nature in the vicinity

Societal criteria

Labour conditions	Labour conditions for employees during construction works (from the perspective of each stakeholder)
Social and political acceptance by citizens of impacts generated	Level of ease for stakeholders to comply with the authorities' rules and regulations during construction works
Business climate during construction works	Attractiveness of the area in terms of business opportunities
Attractiveness	Impact of construction works on the attractiveness of the urban environment, defined as the recreational facilities in and around the construction zone
Security of construction material goods during construction works	Probability of construction materials being lost or stolen while being transported to, or stored on, the construction site
Traffic safety impacts	Traffic accidents during transport of goods and people to, from and within the site, as well as accidents caused by the changes in transport infrastructure at the site

APPENDIX 3

Construction logistics activities

This appendix presents the logistics activities within the three areas of 1) planning and organisation, 2) transportation and 3) site. The logistics activities are also divided into sub-activities and the aim of and the role to which the activities relate are presented.

Role 1: Establish clear interfaces between supply chain and construction site

Role 2: Increase supply chain efficiency

Role 3: Increase site efficiency

Role 4: Transfer value-adding activities

Role 5: Integrate the construction site into the supply chain

Role 6: Coordination with local stakeholders

1. Planning and organisation

LOGISTICS ACTIVITY	SUB-ACTIVITY	AIM	ROLE
Coordination meetings in project		Share information about future events	3
		Coordinate with other activities	6
Organisation	Own budget	Control and influence	3, 6
	Representation in the project management	Control and influence	3, 6
	Work safety responsibility	Control and influence	3, 6
	Logistics managers within projects	Improved coordination and planning	3, 6
Planning system		Possibility to share resources	3
		Share unloading zones	3
		Share information about future events	3
		Control deliveries	1, 2, 5
Business model	Financing	Share cost and benefits equally	

2. Transport

LOGISTICS ACTIVITY	SUB-ACTIVITY	AIM	ROLE
Logistics adapted site plan	Access roads	Decreased risk of clashes between activities in the projects	1, 2, 6
	Marked areas for material storage	Improved utilisation of space	3
	Unloading zones	Decreased risk of clashes between activities in the projects	3
	Site establishment	Improved utilisation of space	3
	Construction production order	Decreased risk of projects disturbing each other	1, 3
Parking		Less inconvenience for surrounding society	6
External coordination	Coordination with other construction work in the city	Less inconvenience for surrounding society	6
	Coordination with public transport	Less inconvenience for surrounding society	
	Information to people living and working in the area	Less inconvenience for surrounding society	6
Bicyclists and pedestrians		Decrease risk of accidents and improve accessibility	6
Rescue services		Accessibility	6
Public transport		Decrease risk of accidents and improve accessibility	6
Checkpoint	Fencing	Controlled access	1
	Coordination of signs and information material	Clear communication	
	Waiting area	Controlled queues	1
		JIT	1
Terminal with storage possibilities	Tent/space	Consolidation	2
	Personnel	JIT	1

3. Site

LOGISTICS ACTIVITY	SUB-ACTIVITY	AIM	ROLE
Waste and recycling	Coordinated collection	Consolidation and fewer transports	2, 3
Site huts	Common area		3
Cranes and other machinery	Rental		3
Deliveries on site to floor	Materials labelling	Less unnecessary movements	3
		Direct deliveries to usage space	3
		Controlled deliveries	2
	On-site materials handling	Materials transported directly to place of installation	3
	Marked areas	Less unnecessary movements	3
Boundary protection and ID coordination	Joint	Coordinated delivery arrivals	1



A brochure produced by CLOSER at Lindholmen Science Park.
The illustrations on pages 2, 9 and 46 are a production of Jackie Forzelius.
Gothenburg, Sweden 2018.

CIVIC aims to increase understanding among stakeholders on how to improve construction logistics. CIVIC explores how public authorities can support implementation of smart solutions.

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Smart construction logistics