Multi-actor participatory decision-making in urban construction logistics

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1 **MULTI-ACTOR PARTICIPATORY DECISION-MAKING IN URBAN**
2 **CONSTRUCTION LOGISTICS**

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ABSTRACT

Construction is required to create more attractive, sustainable and economically viable urban areas. However, transportation of construction related goods and personnel potentially cause negative impacts. A lack of early and accurate information on how the construction site and goods will be organized can lead to disputes and disruptions that harm the construction work and the surrounding community. This paper presents a method for the evaluation of alternative construction logistics measures in a multi-actor participatory setting. The method (MAMCA-software) has been demonstrated in a role-playing setting with 20 students at the Amsterdam University of Applied Sciences.

Keywords: Urban construction logistics, Stakeholder involvement, MAMCA

1 INTRODUCTION

2 When it comes to freight flows in urban areas, transport to and from construction sites often gets
3 less attention and is a less studied (1). Construction deliveries are therefore also termed as
4 “hidden” logistics by Lindholm (2). This is remarkable because urban population growth has
5 led to an increased demand for construction, repair and renovation works in cities. Houses,
6 public utilities, retail spaces, offices and infrastructure need to adapt in order to cope with the
7 increasing amount of residents and visitors, urban functions and changing standards. The
8 construction projects contribute to more attractive, sustainable and economically viable urban
9 areas once they are finished, such as improved accessibility, functionality and energy efficiency.
10 However, construction related transport activities, if not dealt with in a comprehensive manner,
11 are causing severe negative impacts on the surrounding community. In line with the movement
12 of goods in urban areas, transport to and from construction sites causes negative effects such as
13 air pollution, noise pollution, negative impact upon road safety and a contribution to congestion
14 (3; 4; 5). However, compared to the movement of consumer goods, deliveries to construction
15 sites have some distinctive characteristics.

16 Construction sites, albeit differing in their size, are overall material intensive and
17 supplied on an irregular basis (6). For instance, for the reconstruction of the railway station in
18 Utrecht in the Netherlands, it has been estimated that at the peak of the works, 250 trucks were
19 driving towards the site every day (7). According to European transport data half of European
20 road transportation is related to construction materials (8). This puts a severe constraint upon the
21 livability of the surrounding area, especially because construction sites are often located in
22 sensitive areas such as pedestrian zones and historical city centers. Because it also concerns
23 heavy goods vehicles, additional nuisance is caused. Construction material is often heavy which
24 necessitates large vehicles. Not only the size of those vehicles, but especially when they are
25 loaded, damage to infrastructure can be considerable compared to other – lighter – freight
26 vehicles (4; 9). Research by students in Amsterdam in 2011 shows that 18% of heavy goods
27 vehicles are related to construction, and 43% of cargo vans (excluding construction waste).
28 Another distinctive character is the fragmented nature of the construction industry. Consequently
29 this leads to the movement of a relatively high number non-optimized freight vehicles to and
30 from these sites. Additionally, congestion around construction sites can increase substantially
31 because of waiting times for vehicles to be (un)loaded (4). Personnel are also moving towards
32 the construction sites every day, which causes additional flows. At the same time these sites
33 produce a lot of waste and outgoing flows should therefore not be neglected (10; 11). Although
34 in this way transportation related to construction sites causes negative effects for the society and
35 the environment, there is principally a large potential gain for the stakeholders directly involved
36 in a construction project (e.g., logistics service provider, building contractor). Due to congestion
37 and non-optimized flows, improved construction logistics could save between 10 and 30% of
38 project costs (4). Altogether, the transportation of goods and personnel to, from and around
39 urban construction sites, cause social, economic and environmental problems:

- 40 • *Social*: construction related transport leads to nuisance in terms of noise, physical
41 hindrance and safety issues, and annoyances from the occupation of parking space.
- 42 • *Economic*: inefficient planning of resources, material and personnel, leads to
43 unnecessary costs and construction delays. Construction materials have a low value density.
44 Therefore transportation costs are an important part of total construction costs. Road closures
45 during construction works often lead to reduced income for surrounding businesses (e.g., shops
46 and restaurants) and traffic delays.

• *Environmental*: construction related transport is carried out with heavy and/or old polluting vehicles that emit harmful emissions and due to inefficient planning often spent long time idling.

All the above problems result in a societal challenge; *how to keep the construction site surrounding community a livable and acceptable place to work, life and visit while improving energy efficiency and productivity of construction projects at the same time?* The solution needs to be found both in the construction and logistics processes itself as well as in the management of people; the expectations and criteria of the various stakeholders. The first concerns challenges regarding the optimization of resource planning in a dynamic setting, while the latter concerns challenges of transparency, communication and engagement. Both are complicated considering the high density and sensitive environment of urban construction sites and the amount of stakeholders involved, with often contradictory criteria (see textbox).

Example of different - often contradictory - criteria

Public authority: “no heavy vehicles allowed in the city after 11am”

Client: “there is no space available for inventory on site”

Contractor: “I need to start at 7am to manage all the transport within the time window”

Employees: “I want to travel to work before traffic gets congested”

Logistics service provider: “I want to optimize my trip to multiple destinations”

School: “Our kids need to travel to school safely and it has to be quiet after 8.30am”

Resident: “I do not want to wake up by traffic noise”

This paper presents a method for the evaluation of alternative construction logistics measures in a multi-actor participatory setting. The method has been demonstrated in a role-playing setting with 20 students at the Amsterdam University of Applied Sciences. The next section first elaborates on the literature study with regard to making construction logistics more sustainable. Hereafter, the third section elaborates on the methodology – the multi-actor multi-criteria analysis (MAMCA) – which allows taking different stakeholders and their respective objectives into account with regard to different alternatives which possibly mitigate the negative effects of construction logistics. This is followed by the case study concerning planned construction works in the city of Amsterdam. The results are presented and discussed in ‘analysis and results’ which is followed by the conclusion.

STATE OF THE ART

In the past years, strategic research has led to increased understanding of construction logistics processes. For example Gilchrist (12) has clearly described the issues that are often encountered around urban construction. Stakeholder specific requirements have been identified, by among others Landqvist and Rowland (13). Also, possible measures and strategies to optimize construction related transport have been proposed by Quak (14) and van Merrienboer (15). However, the process used for determining the effectiveness of measures from a multi-actor perspective, has not been subject of research before. This process is of relevance as measures may have positive effects for one stakeholder, while having negative, unexpected effects for another. Early accurate insight into the consequences for, and from construction related transport needs have to be obtained and discussed in order to avoid disputes and disruptions harming the construction work and the surrounding community. In the past, urban freight transport in general

has been neglected by city planners (16). Only recently more attention has been given to it due to the effects on mobility and the quality of life (17). Despite the increasing attention for urban freight transport, certain movements of goods including construction mostly remain neglected (2). Although stakeholders are increasingly involved in construction projects, it merely applies to the project itself and transport receives little or no attention (18).

As elaborated above, there is an enormous potential to make construction logistics more sustainable whereby attention should be paid to the three aspects of sustainability (i.e., economic, environmental and social) (5). In this light different measures have been implemented with the aim to make urban freight transport more sustainable. Measures include, amongst others, time windows, weight and size restrictions, low emission zones, congestion charging schemes, urban consolidation centers, night deliveries and the deployment of cargobikes (5; 19). However, due to its nature construction logistics demands for tailored solutions. For instance, a solution with clean vehicles such as cargobikes or small EV's is limited because of the low payload. At the same time construction sites only cause intensive transport flows temporarily. There are nevertheless some measures specifically targeting more efficient and sustainable construction logistics. The potential of transport of construction materials towards urban areas by using water- and railways has been studied in France, Belgium and Japan (20; 21). In this way congestion can (partly) be avoided, whereas the use of barge or train leads to fewer emitted pollutants. A construction logistics plan (CLP) has been implemented by Transport for London (22) and in Utrecht (7). CLP's provide a framework to manage different types of freight vehicle movements to and from construction sites better (23). The most broadly trialled measure with regard to construction sites are consolidation centers (24). In line with a regular urban consolidation center (UCC), the purpose is to bundle goods from outside the city by cross-docking them for subsequent deliveries. Herewith efficiency of deliveries can be increased which leads to a higher load factor, less vehicles and fewer vehicle kilometers (24; 25). Consolidation centers either serve a certain area such as a city center or are site-specific. With regard to the latter several construction consolidation centers have been used to serve specific sites whereby the use of the consolidation center was made compulsory by the manager of the construction site to better control the movement of vehicles (26). Projects that included the temporary use of consolidating construction deliveries are terminal 5 at Heathrow Airport, the rebuilding of the Potsdamer Platz in Berlin and Hammarby in Stockholm (24; 25). The London Construction Consolidation Centre (LCCC) served four major construction sites and eliminated the use of articulated vehicles while simultaneously the use of vans was significantly reduced due to the increased efficiency. In total it was estimated that the LCCC contributed to a vehicle reduction to the four sites of 60 to 70% which resulted in a reduction of 70-80% of CO₂ emissions (22).

However, while implementing different measures, authorities often do not pay enough attention to the transport sector itself. Depending on the measure, this can lead to even more complicated deliveries. As a result there is insufficient attention for economic sustainability (27). Altogether this demands for a more comprehensive stakeholder involvement when it comes to making construction logistics more sustainable. The simultaneous importance and difficulty of including different stakeholders in the decision-making process has been raised by several authors (e.g., 2; 28; 29). The multi-actor multi-criteria analysis (MAMCA) developed by Macharis (29; 30) provides a structured approach to include different stakeholders early in the decision-making process with regard to the simultaneous evaluation of alternative policy measures, scenarios or technologies. The MAMCA allows evaluating the impact of different measures with regard to the criteria of different stakeholders. It is therefore very well suited to

complex decision-making processes where many stakeholders from several areas and backgrounds with different interests are involved. It can be used for many applications and has principally been used for transport-related decision-making problems (for an overview see 31). It has been used for several real decision-making problems (e.g., 32; 33). The next section elaborates on the methodology.

METHODOLOGY

The MAMCA is an extension of existing multi-criteria decision analysis (MCDA) methods which allows taking quantitative as well as qualitative information into account. Whereas traditional MCDA methods have a common value tree for all stakeholders, the MAMCA allows the evaluation based on a separate value tree for each stakeholder. In this way decision-makers and experts can evaluate different policy measures with regard to the criteria of different stakeholders. Stakeholders are explicitly included in the analysis and the decision-making process. They get an insight in the impact of measures on their own criteria as well as on those of others (31). The MAMCA consists of seven steps and is illustrated in Figure 1. In this section each step is briefly elaborated.

FIGURE 1 The Multi-Actor Multi-Criteria Analysis (31).

During the first step of the MAMCA the problem as well as some alternatives is identified. The alternatives can be policy measures as mentioned in the previous section (e.g., LCCC). Next to the different alternatives, there is a business as usual (BAU) alternative representing the current situation. Subsequently there is a stakeholder analysis. Stakeholders are those actors who affect a problem as well as those who are being affected by it (29). Within the city context, the most commonly identified stakeholders are the receivers, shippers, logistics service providers (LSP's), local authorities and citizens (5; 34; 35). The list is, however, not predetermined, and depends on the decision-making problem. In the same step the objectives of the stakeholders are identified. This is done based on literature and consultation with the involved stakeholders. Hereafter the objectives are translated into criteria and the stakeholders

1 themselves attach weights to them by using the Analytical Hierarchy Process (AHP) pairwise
2 comparison. The fourth step couples one or more measurable indicators to each criterion which
3 allows evaluating each criterion with regard to the different alternatives. This is done in step five
4 by aggregation in an evaluation matrix and can be done by the stakeholders or by experts.
5 Different group decision support systems are available (e.g., PROMETHEE, AHP, ELECTRE,
6 see 31). Step six involves the visualization of the results in a uni- and multi-actor view whereby
7 different visualizations are possible; e.g., criteria contribution chart, GAIA (geometrical analysis
8 for interactive aid) plane view. A sensitivity analysis can be conducted to examine the robustness
9 of the results. Finally, the results provide input for a structured discussion as it becomes clear to
10 what extent each alternative contributes to the criteria of the different stakeholders (31). Recently
11 software has been developed to allow the simultaneous evaluation of different policy measures in
12 a multi-actor setting (36). The software allows to set-up a project including alternatives, to create
13 relevant stakeholders for the project, and attach criteria to these groups. This has been applied to
14 a real case concerning construction logistics in Amsterdam, whereby students are actively
15 involved in the role of the different stakeholders.

16 **CASE / SOFTWARE DEMONSTRATION**

17 The MAMCA software has been demonstrated for construction logistics with 20 students at the
18 Amsterdam University of Applied Sciences (AUAS). The case is an actual construction project
19 of the university campus, planned for end 2015-2018. During the software demonstration in May
20 2015, the construction project was still in the tender phase in which the logistics would be used
21 as part of the most economically advantageous tender (MEAT) approach. In the next paragraphs
22 we discuss the construction project in more detail, the alternative solutions to make the transport
23 to the building site more efficient and sustainable, and the stakeholder groups to which the
24 students were assigned.

26 **Case**

27 The AUAS is building a new campus building for 28.000 students in the inner city of
28 Amsterdam, called the Conradhuis. Sustainability is important for AUAS and, in line with that,
29 the organization aims to build the most sustainable campus of the Netherlands. However, the
30 construction project is complex for several reasons. First, the location of the construction site,
31 which is near the Amstel River, is next to a very busy intersection (Marnixstraat/Wibautstraat).
32 During construction works part of the campus is already operational with many students and
33 employees coming and going. There is barely any space for holding stock of construction
34 materials on site. Moreover, the construction site is within the environmental zone of Amsterdam.
35 Next, the construction site is surrounded by campus buildings and student apartments that are
36 already in use. This means that there are many citizens, cyclists and pedestrians around the site.
37 Recently, the University of Amsterdam (UvA), a close partner of AUAS, has experienced several
38 disputes with local residents during construction works, which led to delays and negative PR.
39 The AUAS recognizes the importance of a multi-actor-multi criteria approach.

41 **Alternatives**

42 Based on an analysis of the local situation, stakeholder consultation and the literature, three
43 possible alternatives were identified in close collaboration with experts involved in the project
44 and presented to the students. First, the business as usual (BAU) represents the situation in which
45

no action is taken meaning that freight vehicles arrive and depart irregularly during the day, leading to fragmented deliveries. The three potential logistics solutions are:

- Night deliveries: goods are delivered with trucks at night (before morning peak hours);
- Bundling hub + Electric vehicles (EV): imposing a central delivery address at the city border, after which goods are consolidated and delivered with electric freight vehicles to the construction site;
- Bundling hub + Waterway: imposing a central delivery address at the city border, after which goods are consolidated and delivered by waterway transport near the construction site.

Stakeholder groups

Five stakeholder groups as well as their objectives are identified as being involved in the project. The objectives are based on the local situation as well as a literature review focusing on city (construction) logistics (32). The five stakeholder groups are: LSP, supplier (construction wholesale), building contractor (receiver), citizens and municipality. The students were assigned to these groups and asked to project themselves into the stakeholder's position and objectives. To help them, they were informed about the various possible criteria of each stakeholder group. For example, citizens desire a certain maximum noise level, public space (for example to park the car, or for children to play) and traffic safety. Suppliers and builders want to deliver/receive a high level of service with low transport costs. LSP's aim for profitable operations and satisfied employees. The municipality wants to have an attractive environment for citizens and companies, with little enforcement. An overview of all the criteria per stakeholder group is presented in Table 1.

ANALYSIS AND RESULTS

Criteria weights

The students, alias specific stakeholders, were first asked to give weights to their criteria by using the pairwise comparison method (1 to 9 scale, AHP). Each group contained four students who discussed on the attribution of the weights to the criteria. The table below shows the weights of the respective criteria. Per stakeholder group the sum of the weights is 1. The weights already give a first insight where the preferences of the different stakeholders are with regard to their criteria.

The LSP attributes an almost equal importance to four of its criteria except employee satisfaction. For the supplier, the quality of the service and quality of the pick-ups are by far more important than its other two criteria, green concerns and transportation costs. Especially with regard to the latter this is remarkable. In line with this, the building contractor attaches more importance to convenient deliveries and security than to the costs of transportation and green concerns. Next, the municipality values the quality of life of its citizens and an attractive business climate as most important, whereas the weights attached to the other three criteria are relatively low. Finally, the citizens find traffic safety the most important, followed by public space.

TABLE 1 Stakeholders groups with their weighted criteria

Stakeholder group	Criterion	Criterion definition	Weight
Logistics service provider (LSP)	High service level	Receiver and supplier satisfaction	0.21
	Employee satisfaction	Employees are satisfied with their work and working environment	0.04
	Profitable operations	Making profit by providing logistics services	0.26
	Viability of investment	A positive return on investment	0.29
	Green concerns	Positive attitude towards environmental impact	0.20
Supplier	High service level	Receiver satisfaction	0.31
	Quality of pick-ups	Punctual and secure pick-ups with no damage	0.52
	Transportation costs	Low costs for transportation	0.05
	Green concerns	Positive attitude towards environmental impact	0.12
Building contractor (receiver)	Convenient high level deliveries	Deliveries that do not compromise the receiver operations	0.42
	Transportation costs	Low costs to receive goods	0.08
	Security	Security of goods, less thefts	0.40
	Green concerns	Positive attitude towards environmental impact	0.10
Municipality	Quality of life	Attractive environment for citizens	0.43
	Positive business climate	Attractive environment for companies	0.32
	Infrastructure	Optimal use of existing infrastructure	0.06
	Cost measures	Low costs to implement measures	0.14
	Enforcement	Easiness of compliance	0.04
Citizens	Traffic safety	Positive impact on traffic safety	0.34
	Air quality	Reduce emissions of NOx and PM	0.04
	Public space	Attractive environment	0.27
	Accessibility	Reduce freight transport, less congestion	0.20
	Noise nuisance	Reduce noise nuisance	0.15

Evaluation of alternatives

The evaluation of the alternatives was executed by the students, still in their stakeholder group. Within such a workshop setting, this is a good way to come directly to results, but keeping in mind that this impact analysis of the alternatives on the criteria is based on their perception of the situation and not based on objective research. For the evaluation the PROMETHEE method is used. For each alternative every stakeholder group evaluated to what extent BAU and the three alternatives contributed to each criterion. The evaluation scale used is qualitative (very negative, negative, neutral, positive, very positive). In the results this is visualized in the figures in a quantitative way whereby -2 represents very negative, -1 negative, 0 neutral, +1 positive and +2

very positive. During the final discussion, each stakeholder group elucidated on the reason why they attributed the weights in the way they did as well as a clarification of the evaluation of the alternatives.

Multi-actor perspective

The MAMCA-analysis leads to a multi-actor view on the three alternatives and BAU. The results are shown in Figure 2 below. On the x-axis the different stakeholder groups are displayed. The y-axis, ranging from -1.8 to 1.8 shows the evaluation scale. This represents the (qualitative) evaluation scale as used for the evaluation of the different alternatives with regard to the criteria (step 5; see previous section). The colored lines in the figure represent the alternatives whereby the location on the vertical dotted line corresponds to the evaluation score for the respective stakeholder group.

FIGURE 2 Multi-actor view with alternatives.

The first observation that can be made from this figure is that the current situation (BAU) contributes for almost all stakeholders the least to their criteria. Only for the supplier, the alternative with the bundling hub and the water contributes slightly less to its criteria. From this first observation a tentative conclusion can be drawn that every way of delivering the construction site is an improvement vis-à-vis BAU. By looking at the different uni-actor perspectives, the contribution of BAU with regard to each criterion can be explained in more detail (see next section). Apart from this there are, however, differences between the contributions of the alternatives to the criteria of the different stakeholders. Deliveries during the night are for none of the stakeholders the alternative that contributes most to their criteria. With regard to the other two alternatives, bundling with EV's contributes by far the most to the criteria of both the LSP and the supplier. Similarly bundling but by making use of the available waterways contributes most to the criteria of the building contractor, the citizens and the municipality. Especially for the latter both bundling alternatives contribute relatively well to its criteria. From this first analysis it becomes clear that bundling deliveries provides a good alternative to regular deliveries since it contributes well to the criteria of all the stakeholders.

There is, however, a difference when it comes to the transport mode for carrying out the subsequent consolidated deliveries. A closer look at the different uni-actor views shows in more detail how each alternative contributes to the different criteria of each stakeholder.

Uni-actor perspectives

In this paragraph the uni-actor perspectives of the LSP and the municipality are elaborated in more detail. As shown in Figure 2, only the bundling with EV's contributes relatively well to the criteria of the LSP. A more detailed view of the criteria is shown in Figure 3. The x-axis represents the different criteria. The colored lines in the figure show the alternatives, whereas the bars indicate the weights that were given to the respective criteria by this stakeholder group. The criteria weight (0-1) is shown on the left side of the y-axis and the evaluation score on the right side. The score of each alternative is a calculation of the separate scores of each alternative to the criterion, based on the defined PROMETHEE parameters.

FIGURE 3 Uni-actor view logistics service provider.

The bundling hub with EV's contributes the most to all criteria except for the criterion on the viability of investment. The reason for this – as explained by the students – is that a LSP has to invest in EV's for delivering the construction site whereas it is difficult to recoup this investment. In addition, the LSP expects additional costs for the consolidation center. The same reasoning applies to the bundling with last mile deliveries by water whereby the LSP also considers the extra costs of deliveries by barge. At the same time both alternatives contribute the most to green concerns as it is expected that more efficient deliveries due to bundling and subsequently using cleaner transport has a positive impact on the environment. BAU contributes the least to this criterion. When it comes to the profitability of operations, the three alternatives score equally higher than BAU. The reason is that the LSP assumes that the tender is won when a cleaner alternative is provided to regular inefficient deliveries by trucks. The current situation as well as the bundling with EV's both contribute relatively well to the high service level as well

as employee satisfaction. With regard to the latter the explanation is that the employees are truck drivers and in those two alternatives they can execute their job. This partly ceases with deliveries via the waterway, whereas deliveries during the night are not preferred. The high service level is attributed well for BAU and the EV's because the LSP expects that it is able to maintain its service level with regular last mile deliveries with trucks during working hours. Night deliveries only contribute the most to the viability of investment because together with BAU the current fleet can be used.

The LSP is only one of the three so-called 'economic' stakeholders directly involved in the project. The two other stakeholder groups, the citizens and the municipality are more indirectly involved. With regard to the latter an active role can be played in different ways. For instance, the municipality can introduce restrictions and leave it to the other stakeholders how to supply the construction site. It can also support more optimal deliveries by for instance providing subsidies or a consolidation hub (26). In this workshop the alternatives and the position of each stakeholder groups were, however, not specified to such a detailed extent and it was left to the students to fill in the details. During the final discussion they had the opportunity to clarify this. The uni-actor view of the municipality is shown in Figure 4.

FIGURE 4 Uni-actor view municipality.

Both bundling alternatives contribute the most to the criteria of the municipality. Especially the use of waterways contributes to each separate criterion. By using the waterway for last mile deliveries, no construction materials are transported at all via urban roads. As a result this positively impacts the criterion on infrastructure (accessibility). With regard to the quality of life and the business climate, there is limited air pollution, no impact upon road safety and no noise nuisance because of the deliveries to and from the construction site which makes the city more attractive for both citizens and companies. Finally, because the roads are avoided no measures have to be implemented to make city distribution more sustainable and consequently there are no costs. The other bundling alternative with consolidated deliveries by EV's

1 contributes equally to the criteria on the business climate and the quality of life. Regarding the
2 infrastructure, however, EV's – although efficiently loaded – still compose a part of road traffic.
3 This alternative contributes the least to the cost of measures since the municipality assumes that
4 subsidies have to be provided for the EV's which makes it relatively expensive. Night deliveries
5 contribute less to the criteria which is mainly because it contributes the least to the criterion with
6 the highest weight, quality of life. The reason for this low score is the expected noise nuisance
7 during the night which negatively affects the citizens' night rest. The low contribution to the
8 criterion on enforcement is because special permits to allow deliveries during the night have to
9 be issued. Regarding infrastructure, it is expected that avoidance of deliveries during the day
10 alleviates congestion. Therefore this alternative scores relatively well here. Overall, BAU
11 contributes the least to the criteria since inefficient deliveries with (heavy) vehicles negatively
12 impact the accessibility, quality of life and business climate. At the same time, no specific
13 measures are implemented for these deliveries and as a consequence it contributes in a positive
14 way to the criteria of enforcement and costs of measures.

15 The more detailed descriptions of two different stakeholders show how the uni-actor view
16 explains the results behind the overall multi-actor perspective. This provides more insight in the
17 reasoning of the stakeholders. As elaborated above, it depends to a large extent how detailed the
18 alternatives are presented. In this workshop the choice was to leave the interpretation of the
19 alternatives to a large extent to the students. For example, it matters whether the municipality
20 subsidizes the bundling hub or not because it can severely influence the contribution of the
21 alternatives to the criteria of the LSP. Even more as subsequent consolidated deliveries are
22 carried out by a UCC operator and the LSP is only delivering from the supplier to the
23 consolidation hub. In line with this it matters what kind of stakeholder each group is; for
24 example, is the municipality proactive, reactive or does it take no role in the project at all.
25 Additionally, depending on the project, other stakeholders could be added, for instance a UCC
26 operator.

27 28 **CONCLUSION**

29 Despite the negative impacts and consequently the high potential to make it more optimal for
30 different stakeholders, construction logistics in urban areas is often neglected. In this paper the
31 MAMCA methodology is applied on a real construction project in a fictive setting with students
32 to show how the objectives of stakeholders with different interests can be incorporated with
33 regard to the evaluation of different alternatives. The alternatives are constructed in such a way
34 that they can potentially contribute to more sustainable construction logistics. To what extent
35 they contribute to the different objectives of the stakeholders becomes clear through the analysis
36 in a workshop. The MAMCA methodology allows the incorporation of the different points of
37 view of different stakeholders in the analysis. The methodology gives insight in the importance
38 stakeholders attach to their objectives by allowing them to weigh criteria. This already leads to a
39 better understanding by the stakeholders of where their priorities are, but more importantly,
40 where those of the other stakeholders are. The same applies to the eventual evaluation of the
41 different alternatives. In this way complex decision-making processes in which different interests
42 are involved are structured. The results structure the discussion and provide input for possible
43 future implementation. The MAMCA software allows setting up a specific project which can be
44 executed with actual stakeholders in a workshop. The MAMCA can be used to support real
45 decisions. In this way it can influence decisions that have to be made by a certain stakeholders
46 such as the authorities. With the MAMCA software the effectiveness of the proposed measures

can be analyzed and taken into account. The MAMCA software furthermore allows for ex-post or ex-ante evaluations, but also to increase awareness among stakeholders. The latter was the aim of the workshop with the students in an educational setting. By involving the students in this way it helps them to take up different points of view and above all to make clear how difficult decisions in different fields such as transport are when diverging interests are involved. Similar workshops can be set up with the real stakeholders, which allow for further insights in the impact of the methodology.

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