# Multi-actor participatory decision-making in urban construction logistics

**Author(s)**
Macharis, C.; Kin, B.; Balm, S.H.; Ploos van Amstel, W.

**Publication date**
2016

**Document Version**
Author accepted manuscript (AAM)

**Published in**
Transportation Research Record: Journal of the Transportation Research Board



**Citation for published version (APA):**
Macharis, C., Kin, B., Balm, S. H., & Ploos van Amstel, W. (2016). Multi-actor participatory decision-making in urban construction logistics. *Transportation Research Record: Journal of the Transportation Research Board*, *16*(2337), 83-90.

# MULTI-ACTOR PARTICIPATORY DECISION-MAKING IN URBAN CONSTRUCTION LOGISTICS

**Cathy Macharis, Corresponding Author**
MOBI
Vrije Universiteit Brussel
Pleinlaan 2, 1050 Brussels, Belgium
Tel: +32-2-6292286; Fax: +32-2-6292060; Email: cathy.macharis@vub.ac.be

**Bram Kin**
MOBI
Vrije Universiteit Brussel
Pleinlaan 2, 1050 Brussels, Belgium
Tel: +32-2-6292411; Fax: +32-2-6292060; Email: bram.kin@vub.ac.be

**Susanne Balm**
Amsterdam University of Applied Sciences
Weesperzijde 190, 1097 DZ Amsterdam, The Netherlands
Tel: +31-6-21157771; Email: s.h.balm@hva.nl

**Walther Ploos van Amstel**
Amsterdam University of Applied Sciences
Weesperzijde 190, 1097 DZ Amsterdam, The Netherlands
Tel: +31-6-10081090; Email: w.ploosvanamstel@hva.nl

Word count: 6234 words text + 5 tables/figures x 250 words (each) = 7484 Words

Submission Date **26/10/2015**

**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

# INTRODUCTION

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

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

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

**Example of different - often contradictive - 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 $CO_2$ 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.

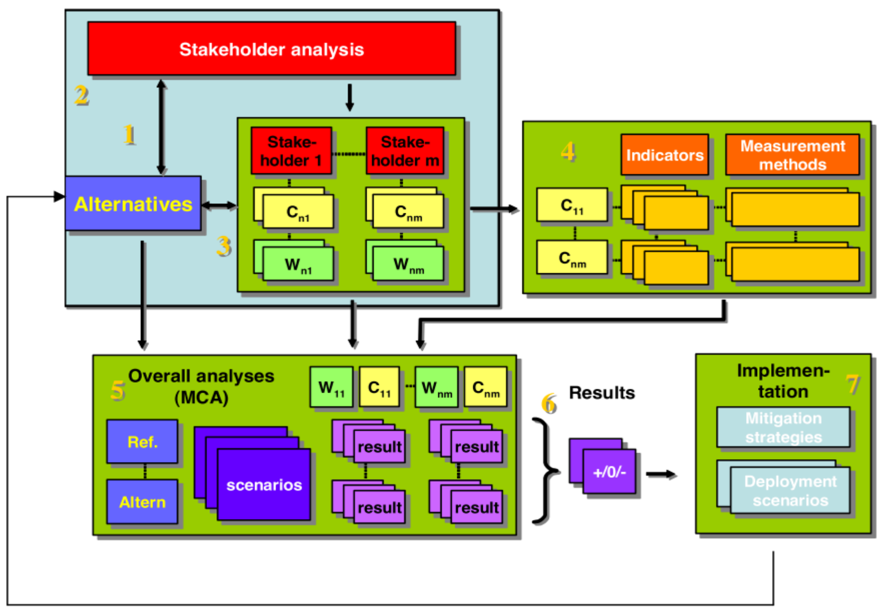


**FIGURE 1 The Multi-Actor Multi-Criteria Analysis (*31*).**

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

## CASE / SOFTWARE DEMONSTRATION

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

### Case

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

### Alternatives

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

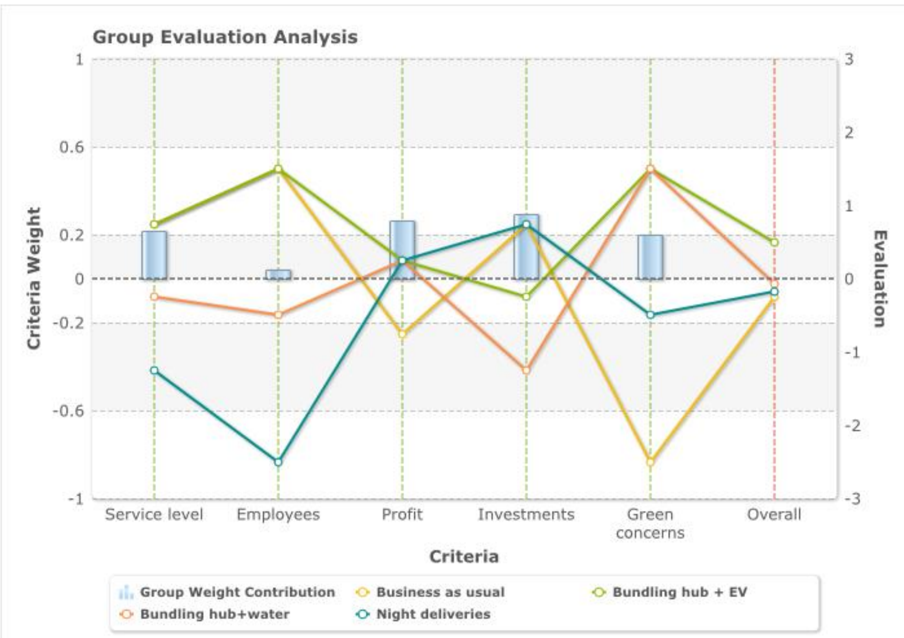


**FIGURE 3 Uni-actor view logistics service provider.**

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.

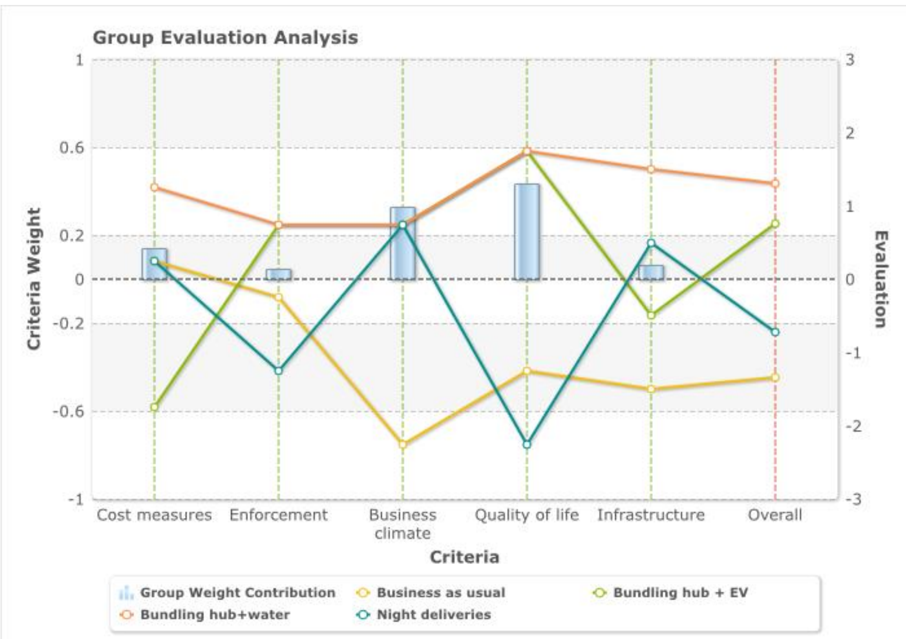


**FIGURE 4 Uni-actor view municipality.**

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

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

## CONCLUSION

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

## REFERENCES


1. Verlinde, S. *Promising but challenging urban freight transport solutions : freight flow consolidation and off-hour deliveries*. Vrije Universiteit Brussel, Universiteit Gent, 2015.
2. Lindholm, M. Urban freight transport from a local authority perspective – a literature review. *European Transport / Trasporti Europei*, Issue 54, Paper 3, 2013, pp. 1–37.
3. Dablanc, L. Goods transport in large European cities: Difficult to organize, difficult to modernize. *Transportation Research Part A*, Vol. 41, No. 3, 2007, pp. 280–285.
4. MDS Transmodal. *DG MOVE European Commission: Study on Urban Freight Transport*, 2012.
5. Quak, H. *Sustainability of Urban Freight Transport. Retail distribution and Local Regulations in Cities*. Erasmus University Rotterdam, 2008.
6. Dablanc, L., and J.-P. Rodrigue. City Logistics : Towards a Global Typology. In *Transport Research Arena 2014*, Paris.
7. van Rooijen, T., and H. Quak. City Logistics in the European CIVITAS Initiative. *Procedia - Social and Behavioral Sciences*, 2014, Vol. 125, pp. 312–325.
8. CBS. *Helft Europees wegvervoer bouwgerelateerd*, 2014. Available from: http://www.cbs.nl/nl-NL/menu/themas/verkeer-vervoer/publicaties/artikelen/archief/2014/2014-helft-wegvervoer-eu-bouw-2012-art.htm. Accessed July 27, 2015.
9. Browne, M., J. Allen, T. Nemoto, and J. Visser. Light goods vehicles in urban areas. In *Procedia Social and Behavioral Sciences*, Vol. 2, 2010, pp. 5911–5919.
10. Diziain, D., C. Ripert, and L. Dablanc. How can we Bring Logistics Back into Cities? The Case of Paris Metropolitan Area. *Procedia - Social and Behavioral Sciences*, Vol. 39, 2012, pp. 267–281.
11. Yuan, H. A SWOT analysis of successful construction waste management. *Journal of Cleaner Production*, Vol. 39, 2013, pp. 1–8.
12. Gilchrist, A., and E. Allouche. Quantification of social costs associated with construction projects: state-of-the-art review. *Tunneling and Underground Space Technology*, Vol. 20, No. 1, 2005, pp. 89-104.
13. Landqvist, M., and A. Rowland. Stakeholder requirements affecting urban freight transportation to and from construction sites in the city. Gothenburg: Master Thesis, Chalmers University of Technlogy, 2014.
14. Quak, H. J., S. A. W. Klerks, S. Aa, D. A. de Ree, W. Ploos van Amstel, and S.A. Merriënboer. *Bouwlogistieke oplossingen voor binnenstedelijk bouwen*. Publication No. TNO-060-DTM-2011-02965. TNO, 2011.
15. van Merrienboer, S. *Best Practices in Bouwlogistiek.* TNO, Delft, 2013.
16. Lindholm, M., and S. Behrends. Challenges in urban freight transport planning – a review in the Baltic Sea Region. *Journal of Transport Geography*, Vol. 22, 2012, pp. 129–136.

17. Cherrett, T., J. Allen, F. McLeod, S. Maynard, A. Hickford, and M. Browne. Understanding urban freight activity – key issues for freight planning. *Journal of Transport Geography*, Vol. 24, 2012, pp. 22–32.
18. Mok, K. Y., G. Q. Shen and J. Yang. Stakeholder management studies in mega construction projects: A review and future directions. *International Journal of Project Management*, Vol. 33, No. 2, 2015, pp. 446–457.
19. Muñuzuri, J., J. Larrañeta, L. Onieva, and P. Cortés. Solutions applicable by local administrations for urban logistics improvement. *Cities*, Vol. 22, No. 1, 2005, pp. 15–28.
20. Diziain, D., E. Taniguchi, and L. Dablanc. Urban Logistics by Rail and Waterways in France and Japan. *Procedia - Social and Behavioral Sciences*, Vol. 125, 2014, pp. 159–170.
21. Mommens, K, and C. Macharis. Location Analysis for the Modal Shift of Palletized Building Materials. *Journal of Transport Geography*, Vol. 34, 2014, pp. 44–53.
22. Browne, M., J. Allen, T. Nemoto, D. Patier, and J. Visser. Reducing Social and Environmental Impacts of Urban Freight Transport: A Review of Some Major Cities. *Procedia - Social and Behavioral Sciences*, Vol. 39, 2012, pp. 19–33.
23. Transport for London. *Construction Logistics Plans*. Available from: https://tfl.gov.uk/info-for/freight/planning/construction-logistics-plans. Accessed July 15, 2015.
24. Sullivan, G., S. Barthorpe, and S. Robbins. *Managing construction logistics*. Chicester, Wiley-Blackwell & Sons, 2011.
25. Browne, M., M. Sweet, A. Woodburn, and J. Allen. *Urban Freight Consolidation Centres. Final Report*, 2005.
26. Lebeau, P., S. Verlinde, and C. Macharis. How Authorities can support Urban Consolidation Centres ? A Review of the Best Practices. In *NECTAR Cluster 3: City Logistics and Sustainable Freight Transport Workshop*, Algarve, 2015.
27. Ballantyne, E. E. F., M. Lindholm, and A. Whiteing. A comparative study of urban freight transport planning: addressing stakeholder needs. *Journal of Transport Geography*, Vol. 32, 2013, pp. 93–101.
28. Reed, M. S. Stakeholder participation for environmental management: A literature review. *Biological Conservation*, Vol. 141, No. 10, 2008, pp. 2417–2431.
29. Macharis, C. The importance of stakeholder analysis in freight transport. *European Transport / Trasporti Europei*, Issue 25-26, 2005, pp. 114–126.
30. Macharis, C. *Strategische modellering voor intermodale terminals: Socio-economische evaluatie van de locatie van binnenvaart/weg terminals in Vlaanderen.* Vrije Universiteit Brussel, 2000.
31. Macharis, C., L. Turcksin, and K. Lebeau. Multi actor multi criteria analysis (MAMCA) as a tool to support sustainable decisions: State of use. *Decision Support Systems*, Vol. 54, No. 1, 2012, pp. 610–620.
32. STRAIGHTSOL. *Deliverable 5.4. Final evaluation of all STRAIGHTSOL city distribution concepts by use of the MAMCA*. Brussels, 2014.
33. Vermote, L., C. Macharis, and K. Putman. A road network for freight transport in Flanders: Multi-actor multi-criteria assessment of alternative ring ways. *Sustainability*, Vol. 5, No. 10, 2013, pp. 4222-4246.
34. Behrends, S. *Urban freight transport sustainability. The interaction of urban freight and intermodal transport*. Chalmers University of Technology, 2011.

35. Macharis, C., and L. Milan. Transition through dialogue: A stakeholder based decision process for cities: The case of city distribution. *Habitat International*, Vol. 45, 2015, pp. 82–91.
36. MAMCA. www.MAMCA.be. Accessed May 13, 2015.