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Sustainable Urban Consolidation CentrES for conStruction

Intervention models and impacts report

Version 1.0

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Executive summary

SUCCESS chose to target the construction industry as a sector with a major impact on city logistics which has an un-exploited potential of improvement as regards the efficiency of trips associated with the delivery of goods, waste and service in EU cities. The project aims at answering the challenges pinpointed by the European Commission and in particular at improving the understanding of urban freight transport and introducing more resource-efficient, more environmentally-friendly, safer and seamless supply chain innovations.

Deliverable D6.2 is part of WP6 ("Replicability and take up") which aims at demonstrating the potential of the solutions developed by SUCCESS to be replicated and transferred to other contexts. This deliverable defines the foundations for identifying an intervention model with the objective to give to local authorities and construction companies a toolkit to start considering how to make the construction logistics and supply chain more efficient. The deliverable is closely linked to the deliverable D6.3 *Road map for the uptake of the SUCCESS solution* which later prioritizes the measures described in this document with regards to the objectives of the organization.

The proposed approach is the following: an initial assessment measures the complexity of a construction project to support the definition of the intervention model which is mostly appropriate for that construction project. The complexity of each project is assessed along two primary dimensions:

- Urban complexity – related to the accessibility of the specific urban area where the site is located.
- Site complexity – related to the features of the construction site itself.

The two dimensions include 22 variables, each evaluated on a 4-point rating scale. An urban – site complexity matrix (logistics profile matrix) supports the decision maker in ranking construction projects: depending on the complexity, the decision maker (a construction company or a local authority) will decide what resources need to be allocated to adequately manage the complexity of the site.

The SUCCESS team identified 75 measures to improve the logistics and supply chain management in the construction. Some of them are described in detail in *D6.1 Report on good practices in the EU and USA*. The measures were mapped against the assessment variables so that the assessment guides the decision maker in identifying the most relevant measures for her own situation and preparing an action plan.

An interactive tool is currently under development to support the overall decision making process. The tool will support the characterisation of the logistics profile of a given construction project and propose the most adapted measures.

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1 Introduction to intervention models

This chapter introduces the concept of intervention models.

1.1 Definition

An intervention model can be defined as *a set of measures that were deemed most relevant to improve the logistics and supply chain management of a given construction project*.

1.2 Target

The intervention model gives tools to both local authorities and construction companies to start reflecting on how to make the construction logistics and supply chain more efficient. The assessing tool should have a global vision of the situation it evaluates and be aware of the construction activities and the local context to provide good quality results.

1.3 Objectives

The final objective of defining intervention models is proposing measures so that the persons in charge can better face the logistics challenges of the construction project.

For example, a construction site which has very limited available space and is located in a congested area may require a clear and effective strategy to reduce the negative externalities caused by its logistics. On the other hand, a construction site located in a new urban area may require a less proactive and costly set of mitigating actions.

1.4 Framework

The definition of the intervention model follows a two-step approach (Figure 1 Intervention model framework).

In the first step, the complexity of the urban area and of the construction site is evaluated to determine the logistics profile of the construction site (low, moderate and high priority). This step determines which projects should receive highest priority with the portfolio of evaluated projects. In our proposal, projects categorised as high priority should receive more attention in the second step.

In the second step, a list of relevant measures is proposed based on the overall complexity of the project. Finally, the decision maker is guided in the preparation of an action plan with a selection of the most appropriate measures to face the project complexity. This final step will be the object of *D6.3 Road map for the uptake of the SUCCESS solution*.

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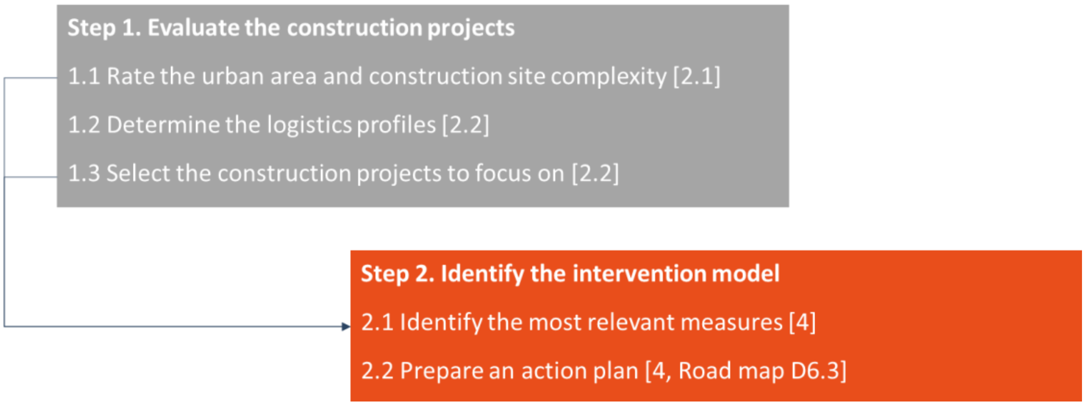

Figure 1 Intervention model framework

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2 Classification of the construction projects

In this chapter, the complexity of the urban area and the construction site is evaluated to determine the logistics profile of a construction project (low, moderate and high priority).

2.1 Evaluate the logistics profile of the construction project

Two dimensions were identified to evaluate the complexity of the construction project: the complexity of the construction site itself and the complexity of the urban area surrounding the construction site.

The *urban area* dimension addresses the complexity of a set of variables related to the accessibility of the construction site.

The *construction site* dimension looks at the complexity of a set of variables related to the construction site itself.

A group of six experts from the logistics and construction sectors identified together the main variables which characterize the complexity of a construction project. The list of variables was identified based on the learning experience from past projects (LaMiLo Interreg NWE IVB, construction projects: House of BioHealth, Eco² and Royal Grace…) and SUCCESS project.

Section 2.1.1 *Rating process* details the rating process common to all variables.

Sections 2.1.2 *Urban area dimension* and 2.1.3 *Construction site dimension* describe the list of variables associated with their specific rating scale.

2.1.1 Rating process

For each variable, different levels of complexity were identified by the experts' group, to be further used for assessment. The rating of each variable is either evidence-based or perception-based. Indeed, some variables, such as turnover, can be rated in numerical terms. Others, such as city logistics regulation, can only be rated by the judgement of the assessor.

Each variable is rated using a common 4-point rating scale (Table 1 Rating scale). The users can adapt the list and the associated scale to their own context. The global evaluation of the variables' score determines the rating of the dimension. When all the ratings related to a dimension have been identified, the assessor combines the results and calculates the average of the dimension (Table 2 An example of rating). Using these ratings, the assessor can determine the level of complexity achieved for one dimension.

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1- Slightly complex
2- Moderately complex
3- Very complex
4- Extremely complex

Table 1 Rating scale

The complexity of the construction project is evaluated against the full range of variables for both the urban area and construction site dimensions as described below. The overall project rating is composed of two scores. The complexity of the construction project is then mapped against the two scores. During this phase, the assessor collects all relevant information enabling her to determine with a high level of confidence the level of complexity of each dimension.

Urban dimension

Variable	*Rating*
Site location	1
Neighbourhood's environmental sensitivity	3
Regulation	4
Maturity level of local authorities	1
Exposure to air pollution and traffic noise	2
Congestion	1
Topology	4
Topography	*Don't know*
Construction activity	1
Average	**2,125**

Site dimension

Variable	*Rating*
Turnover	3
Building size	3
Storage capacity	3
Time pressure	4
Subcontractors	4
Site access	3
Delivery areas	3
Handling equipment	4
Certification	1
Logistics strategy	3
Scope of the project	2
Construction's intended usage	2
Change in project scope	4
Average	**3**

Table 2 An example of rating

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2.1.2 Urban area dimension

Due to the increasing urbanization (*World Urbanization Propects*, 2014), the need for new or renovated constructions is growing and results in an increase of urban freight transport operations related to the sector. Every day in cities, vehicles enter and travel in congested urban areas to provide building materials to construction sites and to take away waste materials for disposal. A significant proportion of construction activity takes place in cities. According to Dablanc (Dablanc, 2009), building materials can make up to 30% of the weight carried across cities in growing urban areas. For city dwellers, all these activities go hand in hand with pollution, traffic congestion, noise, damaged infrastructure and, ultimately, a compromised quality of life.

Assessing the complexity of the urban area where a construction project takes place is thus really important to understand the challenges the project is facing. The *urban area* dimension addresses here the complexity of a set of variables mainly related to the accessibility of the construction site.

2.1.2.1 Site location

The item refers to the location of the construction site in the city.

A high proportion of construction activity takes place in cities. The difficulty to access a construction site in a city depends highly on the size of the city and on the location of the site within the city. The traffic conditions are specific to each city and each city area however we consider that the traffic conditions are usually worst in a large city than in a small city and in the city centre than in the suburbs to simplify the profiling. Unfavourable traffic conditions will increase travel time and delays.

Score	Measure	Comments
1	in the suburbs of a small city	The construction site is located in the suburbs of a small city.
2	in the centre of a small city OR in the suburbs of a medium city	The construction site is located in the centre of a small city OR in the suburbs of a medium city.
3	in the suburbs of a large city OR in the centre of a medium city	The construction site is located in the suburbs of a large city OR in the centre of a medium city.
4	in the centre of a large city	The construction site is located in the centre of a large city.

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Additional comments:
The size of cities is based on the OECD definition (Redefining Urban: A New Way to Measure Metropolitan Areas, OECD Publishing, 2012). Small cities are defined as small urban areas, with population between 50,000 and 200,000. Medium cities are defined as medium-sized urban areas, with population between 200,000 and 500,000. Large cities are defined as metropolitan areas, with population above 500,000.

2.1.2.2 Neighbourhood's environmental sensitivity

The item refers to the neighbourhood's environmental sensitivity.

The construction site generates noise, pollution, dust, visual nuisance and could have a negative impact on the vegetal elements, street furniture and the economic attractiveness of the area. To address these issues, the construction site can undertake a series of actions (e.g. wheel cleaning, fence…).

Score	Measure	Comments
1	low	The urban area is not sensitive to a construction activity. The construction site doesn't have to undertake actions to limit the nuisances. e.g. industrial area of a city
2	moderate	The urban area is somehow sensitive to a construction activity. The construction site has to undertake one or more action(s) to limit the nuisances. e.g. suburbs
3	high	The urban area is sensitive to a construction activity. The construction site has to undertake several actions to limit the nuisances. e.g. residential area
4	very high	The urban area is very sensitive to a construction activity. The construction site has to continuously undertake several actions to limit the nuisances.

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		e.g. touristic area with historical, heritage or cultural value

2.1.2.3 *Regulation*

The item refers to the level of constraint that regulatory and fiscal measures that the local authority implements for the urban freight transport.

Local authorities are in charge of traffic and parking regulations, including all regulations that relate to delivery vehicles. In that context, local authorities implement regulatory and fiscal measures to improve the existing urban goods distribution system. Congestion, air pollution, noise, road damage and accidents among others, are considered the most important nuisances of urban freight transport. Policies regulating the latter aim to ensure economic growth and at the same time address the negative impacts of urban freight transport on the environment and society.

Score	Measure	Comments
1	low	Regulations slightly constrain freight activities in the city. e.g. height limitation
2	moderate	Regulations moderately constrain freight activities in the city. e.g. restriction on unloading zones
3	high	Regulations highly constrain freight activities in the city. e.g. time-window regulations
4	very high	Regulations severely constrain freight activities in the city. e.g. very strict time-window regulations, congestion charge

2.1.2.4 *Maturity level of local authorities*

The item refers to the organizational maturity of the local authorities.

The organizational maturity level of the local authorities should positively influence their intervention to reduce the negative impacts of the construction logistics. Cities where coordination of policies between sectors (transport, safety,

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environment, construction, land use) exists make easier to implement actions and are open to test new solutions.

Score	Measure	Comments
1	extremely mature	The local authority is used to implementing measures to limit nuisances related to the construction transport and is proactive in proposing solutions. e.g. cities which propose dematerialised contact points are usually extremely mature
2	moderately mature	The local authority is used to implementing measures to limit nuisances related to the construction transport. e.g. a single contact point, an e-form for each service
3	slightly mature	The local authority is somewhat used to implementing measures to limit nuisances related to the construction transport. e.g. several contact points
4	not at all mature	The local authority is absolutely not used to implementing measures to limit nuisances related to the construction transport. e.g. lack of a clear contact point

2.1.2.5 Exposure to air pollution and traffic noise

The item refers to the city pollution exposure.

Urban air pollution and urban noise are major factors that can degrade quality of life in cities. With the growth of urban areas, the total emissions and noise from road traffic have risen significantly and exceed regularly the quality standards. As urban air and noise quality declines, the risk of strokes, heart diseases, lung cancer, and respiratory diseases increases for the people who live in cities centres. Because road traffic is responsible for both noise and air pollution, high polluted cities will tend to implement actions to limit transport movements including for the construction sector.

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Score	Measure	Comments
1	low	The city is slightly affected by the exposure to air pollution and traffic noise
2	moderate	The city is moderately affected by the exposure to air pollution and traffic noise
3	high	The city is highly affected by the exposure to air pollution and traffic noise
4	very high	The city is extremely affected by the exposure to air pollution and traffic noise

2.1.2.6 Congestion

The item refers to the level of congestion in the city.

Traffic congestion has a great impact on the economy of a city. Road congestion in the EU is often located in and around urban areas and costs nearly €100 billion every year, or 1% of the EU's GDP (European Commission, 2013). A survey reveals that almost three-quarters of European citizens believe that road congestion (76%) is an important urban problem (European Commission, 2013).

Whereas construction vehicles account for a significant proportion of congestion, traffic congestion tends to increase delays in the construction, vehicle operating costs, collision probability and pollutants' emissions. To prevent delays, the delivery vehicles can arrive up to an hour early, necessitating the vehicle to either park outside the site or "kill time" in driving in the neighbourhoods consequently adding to congestion and environmental pollution. Traffic congestion is a widely recognized factor in transport's cost. Transportation costs can amount to 10-20% of the overall construction cost (Building Research Establishment and Department of Trade and Industry, 2003).

Score	Measure	Comments
1	low	Low congestion, driving speed is not reduced i.e. the average driving speed is close to the speed limit
2	moderate	Moderate congestion, speed is somewhat reduced i.e. the average driving speed is under the speed limit
3	high	High congestion, speed is reduced with frequent drops in speed i.e. the average driving speed is far under the speed limit

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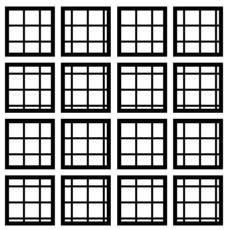
4	very high	Very high congestion, speed is reduced and travel time is unpredictable i.e. the average driving speed is nearly zero

2.1.2.7 *Topology*

The item refers to the organization of the roads in a city.

The roads' pattern is mainly determined by the natural terrain (see also next item: topography), the work of urban designers and the changing needs of the inhabitants. Cities can display any of the three basic patterns (grid plan, concentric zone, irregular) or their combinations. The road pattern greatly affects the mobility in a city. Delivering in narrow streets or streets with acute angles seems difficult with heavy rigid vehicles whereas turning in wide streets and boulevards with such vehicles is easier.

Score	Measure	Comments
1	grid plan	The streets mainly run at right angles to each other, forming a regular grid. e.g. most U.S. cities, urban expansion of Valencia, Barcelona (Eixample district), cities rebuilt after wars (le Havre), cities founded by ancient Greek and roman civilizations such as Turin's old neighbourhoods 
2	concentric zone	The city is made up of neighbourhoods shaped like rings that circle around a central business district. To increase mobility and traffic flow, societies often add concentric loops or rings to larger radial patterns. e.g. Paris

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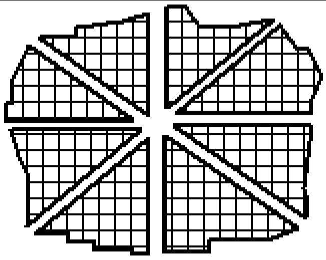
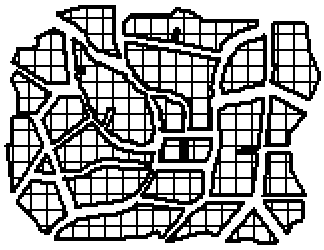
		
3	irregular	The city includes blocks with no regular pattern. e.g. Luxembourg 
4	irregular and narrow streets	The city includes blocks with no regular patterns and where vehicles can hardly circulate. e.g. City centre and historic neighbourhoods of Valencia (like Ruzafa), City centre of Barcelona, City centre of medieval fortified cities, pedestrian city centres

2.1.2.8 Topography

The item refers to the relief of the land.

Topography has a direct impact on the energy consumption, emissions and manoeuvrability of delivery vehicles. While an unfavourable topography characterised by a steep slope will increase road emissions and make vehicles manoeuvrability more complex, a favourable topography with a flat terrain will improve vehicle performance.

Score	Measure	Comments
1	very flat	The land is very flat. e.g. Valencia, Verona, London, Amsterdam, Berlin, Brussels, Bruges, Copenhagen

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2	flat	The land is relatively flat. e.g. Paris
3	moderate	The city is characterised by medium slopes. e.g. Luxembourg
4	steep	The city is characterised by valleys and hills. e.g. Toledo, San Francisco
Additional comments: Some websites give indications on the topography of the cities. http://en-au.topographic-map.com http://www.floodmap.net		

2.1.2.9 *Construction activity*

The item refers to the number of construction sites in the neighbourhoods.

The volume of construction activities in the neighbourhoods has a direct impact on the evaluated construction site. The neighbourhoods can be considered as the street of the construction site and the adjacent streets. Indeed, an area with several construction sites will tend to increase the congestion with additional vehicles and to reduce road capacity with fewer available lanes or closed sections. However, the presence of other construction sites can be an opportunity to mutualise efforts in implementing solutions such as a Construction Consolidation Centre (CCC) since its running costs could be more easily absorbed.

Score	Measure	Comments
1	none	There is no other construction site in the neighbourhoods.
2	1 small	There is another small construction site in the neighbourhoods.
3	1 large OR several small	There is another large construction site or there are several small construction sites in the neighbourhoods.
4	several large	There are several large construction sites in the neighbourhoods

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Additional comments: A construction site with a turnover below 20M€ or with a gross floor area below 10.000 m² is considered as a small construction site. A construction site with a turnover above 20M€ or with a gross floor area above 10.000 m² is considered as a large construction site.

2.1.3 Construction site dimension

Scarcity of construction site space imposes important challenges for contractors in planning material supply which can represent 40% of the project's budget and site logistics (Sullivan et al., 2011). The main contractor has a limited vision of the supply chain due to the wide variety of actors: each sub-contractor is responsible for ordering needed materials but cannot schedule the deliveries on site independently. Thus the stakeholders have to synchronise with the main contractor for scheduling their material deliveries on the site.

Assessing the characteristics of the construction site is thus really important to understand the challenges the project is facing. The *construction site* dimension looks here at the complexity of a set of variables related to the construction site itself. It should ideally be considered under a set of variables described below.

2.1.3.1 Turnover

The item refers to the turnover the site generates.

The higher the turnover of the construction project, the greater the potential for absorbing the logistics costs.

Score	Measure	Comments
1	< 20 M€	No comment
2	between 20 and 50 M€	No comment
3	between 50 and 100 M€	No comment
4	> 100 M€	No comment

2.1.3.2 Building size

The item refers to the gross floor area.

Scale of activities varies from major construction sites to very small development projects. The size of the building gives a rough estimation of the volume of materials that need to be brought to the construction site. Because of the size of

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the project, large buildings require more materials and thus the delivery and collection of large quantities of goods resulting in considerable freight activity.

Score	Measure	Comments
1	< 10.000 m²	No comment
2	between 10.000 and 25.000 m²	No comment
3	between 25.000 and 50.000 m²	No comment
4	> 50.000 m²	No comment
Additional comment: The gross floor area is the sum of the area of all floors of a building measured from the external faces of the external walls.		

2.1.3.3 *Storage capacity*

The item refers to the availability of space on the site to store materials.

Limited available space on site results in manual handling, double-handling (loss of productivity) and increases safety and health risks and potentially damaged materials.

Score	Measure	Comments
1	< 0.3	The ratio is below 0.3. There is space on the site.
2	between 0.3 and 0.7 and storage not fragmented or located on the same level	The ratio is between 0.3 and 0.7. Space is limited on the site but the storage capacity is located on the same level.
3	between 0.3 and 0.7 and storage fragmented or located on different levels	The ratio is between 0.3 and 0.7. Space is limited on the site and the storage capacity is fragmented on different levels.
4	> 0.7	The ratio is above 0.7. Space is extremely limited on the site.
Additional comments:		

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Ratio of the building footprint (expressed in m²) to the site surface area (expressed in m²). The ratio is associated with the fragmentation of the free space.

2.1.3.4 *Time pressure*

The item refers to the amount of time available to complete the development project.

The necessity to reduce costs induces reduced delays and thus increases time pressure forcing the construction sector to accomplish a lot within a limited period of time. Construction operations often face time constraints that influence the execution of activities. A better coordination between the operators becomes necessary to avoid delays in the project schedule which may result in penalties if deadlines are missed.

Score	Measure	Comments
1	< 500 m²/month	The ratio is below 500 m²/month. The development project is slightly time-constrained
2	between 500 and 1.000 m²/month	The ratio is between 500 and 1.000 m²/month. The development project is moderately time-constrained
3	between 1.000 and 2.000 m²/month	The ratio is between 1.000 and 2.000 m²/month. The development project is highly time-constrained
4	> 2.000 m²/month	The ratio is above 2.000 m²/month. The development project is extremely time-constrained
Additional comments: Ratio of the gross floor area (expressed in m²) to the duration of the project (expressed in month).		

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2.1.3.5 *Subcontractors*

The item refers to the subcontractors' relationship determined by the collaboration history and the fragmentation of the subcontractors' chain.

The role of the main contractor often involves managing subcontractors to ensure that they understand the project requirements and that whilst working on site they comply with any rules or procedures that are implemented, including management of deliveries, storage and distribution of materials and management of waste. Logistically, this places a great deal of pressure on the main contractor to manage the project's resources efficiently. Effective coordination is essential to avoid waste and non-value-adding activities. The more subcontractors working on the site, the more complex their coordination will be. Established relationships with subcontractor teams are a key advantage to work efficiently. The longer the collaboration with the teams exist, the easier will be to provide the coordination of their activities.

Score	Measure	Comments
1	few known subcontractors	The main contractor manages few subcontractors he is used to working with.
2	many known subcontractors	The main contractor manages many subcontractors he is used to working with.
3	few unknown subcontractors	The main contractor manages few subcontractors he is not used to working with.
4	many unknown subcontractors	The main contractor manages many subcontractors he is not used to working with.

2.1.3.6 *Site access*

The item refers to the accessibility of the site to supply and remove materials.

The nature of the construction site layout impacts the management of materials. With many urban confined-site environments, the location of the site entrance or the site itself can be an issue. One of the primary functions of the entrance and exit gates is to provide suppliers an access to enter and leave the site. The accessibility of the site will not only impact the site's productivity but also the traffic and safety conditions outside the site.

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Score	Measure	Comments
1	several entrance and exit gates	Multiple accesses allow the vehicles to enter and leave the site.
2	1 entrance and 1 exit gate	Vehicles do not cross each other at site access.
3	1 entrance/exit and possibility for a U-turn on site	Vehicles use the same access point to enter and leave the site.
4	1 entrance/exit and no possibility for a U-turn on site	Vehicles must enter or leave in reverse.

2.1.3.7 *Delivery areas*

The item refers to the number of delivery areas used by the construction site.

It is important to avoid bottlenecks as trucks arrive on site to access delivery areas. The nature of the site usually limits the number, size and location of the delivery areas. The number of delivery areas is related to the site's accessibility.

Score	Measure	Comments
1	several	Several delivery areas are available on the site or there is a lot of space on the site that can be used as an ad-hoc delivery area.
2	1 fixed	One delivery area remains available throughout the entire project duration.
3	1 temporary	One delivery area remains available but its location changes as the project progresses. Space can be rent/requested to the local authority for a limited period.
4	none	There is no delivery area available, the unloading should be done directly from the street.

2.1.3.8 *Handling equipment*

The item refers to the type and number of handling equipment used to bring the materials from the delivery vehicle to the point of use.

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Unloading and handling of materials have largely rested with the subcontractors who procured them. The main contractor may share handling equipment with their subcontractors particularly for important handling equipment like cranes. Suppliers can also provide their own equipment e.g. using vehicles equipped with an on-board crane. Offloading of materials should take place as close as possible to the point of use. When it is possible, the use of the crane is preferred over other lifting equipment to save time.

Score	Measure	Comments
1	1 crane on site OR no crane but not needed	One crane is available to handle materials directly from the truck to the roof of the building or into floors via an access platform. OR no crane is needed on the site (horizontal building)
2	several cranes	Several cranes are available to handle materials directly from the truck to the roof of the building or into floors via an access platform.
3	mobile cranes, forklift, lift on site	Equipment are limited on site and multiple handlings are required to bring materials to the final point of use. Forklifts are problematic when unloading from the street as they may cause obstructions to other road users and pedestrians. Lifts require additional resources.
4	only handling equipment of the suppliers (on their trucks)	Suppliers provide their own equipment to unload the truck (such as on-board cranes or forklifts).

2.1.3.9 Certification

The item refers to the labelling scheme that a building intends to meet.

Several international environmental certifications systems for designing and erecting sustainable buildings exist. The most popular are HQE™ (High Quality Environmental), BREEAM® (Building Research Establishment Environmental Assessment Method) and LEED® (Leadership in Energy and Environmental Design). Meeting the requirements of these certification systems implies a reduction of natural resources' consumption. Among the list of requirements, some are related to the transport of materials from the suppliers to the

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construction site and more particularly to the emissions related to the transport, others are related to the management of waste. These certification systems imply a better coordination of the logistics activities to ensure traceability during the audit process.

Score	Measure	Comments
1	none	The building doesn't intend to reach a labelling scheme.
2	one with certification	The building aims at the certification of one labelling scheme.
3	several without certification	The building aims at reaching several labelling schemes without applying for a certification.
4	several with certification	The building aims at the concurrent certification of several labelling schemes.

2.1.3.10 Logistics strategy

The item refers to the services the main contractor offers to their subcontractors to support certain activities.

The construction sector has recognised the need for centralised logistics to support certain activities such as facilitating deliveries, waste collection… Such strategy could potentially result in cost savings.

Score	Measure	Comments
1	completely centralised	The main contractor completely centralises the logistics resources (human, equipment and services).
2	mostly centralised	The main contractor mostly centralises the logistics resources (human, equipment and services).
3	somewhat centralised	The main contractor slightly centralises the logistics resources (human, equipment and services).
4	not at all centralised	The main contractor doesn't centralise at all the logistics resources (human, equipment and services) and lets the subcontractors manage logistics at their own level.

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2.1.3.11 *Scope of the project*

The item refers to the nature of the construction activities.

The construction sector generates a substantial proportion of all waste outputs. It accounts for 25-30% of waste generated in the EU (European Commission, 2016). To address this environmental problem, relevant authorities increase legislation and landfill tax.

Development projects including demolition or renovation activities generate de facto more waste and require more coordination to manage collection schedules and waste containers.

Score	Measure	Comments
1	construction	The development project includes only construction activities
2	renovation	The development project includes only renovation activities
3	demolition and construction	The development project includes demolition and construction activities
4	demolition and renovation	The development project includes demolition and renovation activities

2.1.3.12 *Construction's intended usage*

The item refers to the intended usage of the development project.

Development projects can either provide only one function (single-use) such as office, housing, retail, medical or any combination of more than one function within the same building or development area (mixed-use).

A mixed-use construction implies a larger array of construction techniques and methods. Because of the physical complexity and the need for integrating multiple uses, these projects result generally in longer development times and construction costs. They require to comply with different building codes for each use, adding to the complications, costs, and the time required to build the project.

Even in a single-use project, different levels of complexity exist. Some single-use projects may have more site requirements than others and thus require more coordination. Some single-use projects are easier to complete because they have less constraints on space while others may require more coordination because a lot of special construction techniques are required.

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Score	Measure	Comments
1	single-use	The building integrates a single usage with a low need for coordination. e.g. shop, warehouse, sports hall
2	single-use with high level of design complexity	The building integrates a single usage with a moderate need for coordination. e.g. office, residential buildings
3	single-use including special techniques OR mixed-used including up to 3 uses	The building integrates a single usage or blends up to 3 usages with a high need for coordination.
4	mixed-use including at least 3 uses	The building blends at least 3 usages which requires a high need for coordination. e.g. hospital

2.1.3.13 Change in the project scope

The item refers to the ambiguity of the project scope or the probability for a change.

Change requests and late definition of requirements generally affect the budget and the schedule of the project. They depend on the nature of the project and the customer. For example, in mixed-use development projects, the multiple stakeholders in charge of planning and executing the project make the decision-making process more complex than in single-use development projects where only one expert is in charge of all facets. In that context, the project scope can be completely defined quite late in the project.

Score	Measure	Comments
1	extremely unlikely	Change in the project scope is extremely unlikely. E.g. needs clearly identified, early selection of the materials, standardised building.
2	unlikely	Change in the project scope is unlikely.

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3	likely	Change in the project scope is likely.
4	extremely likely	Change in the project scope is extremely likely. E.g. needs not clearly identified, late selection of the materials, high probability to change the scope, unique architectural design.

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2.1.4 Conclusion

The illustrated evaluation based on the two dimensions and their variables reflects the logistics complexity profile of the construction project. It is in our opinion a rapid and efficient method for establishing priorities and drafting an action plan (intervention model). The evaluation does not need to be revisited during the project's life cycle but has to be done once at the earliest stage of the project (during the planning phase). The table below summarizes all the variables of the two dimensions with their specific rating scale.

Urban dimension

Variable	*Slightly complex (1)*	*Moderately complex (2)*	*Very complex (3)*	*Extremely complex (4)*
Site location	in the suburbs of a small city	in the centre of a small city OR in the suburbs of a medium city	in the suburbs of a large city OR in the centre of a medium city	in the centre of a large city
Neighbourhood's environmental sensitivity	not needed	one-shot solution	one solution to apply continuously	several solutions to apply continuously
Regulation	low	moderate	high	very high
Maturity level of local authorities	extremely mature	moderately mature	slightly mature	not at all mature
Exposure to air pollution and traffic noise	low	moderate	high	very high
Congestion	low	moderate	high	very high
Topology	grid plan	Concentric zone/ring model	Irregular	Irregular and narrow streets
Topography	very flat	flat	moderate	steep
Construction activity	none	1 small	1 large OR several small	several large

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Site dimension

Variable	*Slightly complex (1)*	*Moderately complex (2)*	*Very complex (3)*	*Extremely complex (4)*
Turnover	< 20 M€	between 20 and 50 M€	between 50 and 100 M€	> 100 M€
Building size	< 10.000 m²	between 10.000 and 25.000 m²	between 25.000 and 50.000 m²	> 50.000 m²
Storage capacity	< 0,3	between 0,3 and 0,7 and storage not fragmented or located on the same level	between 0,3 and 0,7 and storage fragmented or located on different levels	> 0,7
Time pressure	< 500 m²/month	between 500 and 1.000 m²/month	between 1.000 and 2.000 m²/month	> 2.000 m²/month
Subcontractors	few known subcontractors	many known subcontractors	few unknown subcontractors	many unknown subcontractors
Site access	several entrance and exit gates	1 entrance and 1 exit gate	1 entrance/exit and possibility for a U-turn on site	1 entrance/exit and no possibility for a U-turn on site
Delivery areas	several	1 fixed	1 temporary	none
Handling equipment	1 crane on site OR no crane but not needed	several cranes	mobile cranes, forklift, lift on site	only handling equipment of the suppliers (on their trucks)
Certification	none	one with certification	several without certification	several with certification

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Logistics strategy	completely centralised	mostly centralised	somewhat centralised	not at all centralised
Scope of the project	construction	renovation	demolition and construction	demolition and renovation
Construction's intended usage	single-use	single-use with high level of design complexity	single-use including special techniques mixed-used including up to 3 uses	mixed-use including at least 3 uses
Change in project scope	extremely unlikely	unlikely	likely	extremely likely

Table 3 Variable rating

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2.2 Mapping the logistics profile of a construction project

The logistics profile matrix uses the combination of urban complexity and construction complexity scores of each project and ranks them for easier handling of the projects. It is graphically represented on a matrix to increase the visibility of the project's global complexity. The logistics profile matrix helps to determine what kind of action plan each construction project needs. It is important to understand the priority of each project in terms of logistics as it allows the construction company or the local authority to appreciate the relative importance of each project and decide what resources they will allocate to managing that complexity.

This step leads to rating the overall logistics profile of the construction site as low, moderate, or high priority (Figure 2). The projects are classified into three distinct categories:

Low priority: Construction projects which benefit from very good conditions on the construction site and accessibility to the site. The projects that fall in this category do not need proactive actions since such actions would offer little benefit. The added value of improving logistics for this category is low.

Moderate priority: Construction projects which are somehow constrained by either the site itself or the surrounding urban area. Investment should be intermediate for projects falling in this category since the added value of improving logistics for this category is moderate.

High priority: Construction projects which are highly constrained by the site itself and are located in a constrained urban area. The added value of improving logistics for this category is the highest. An action plan to reduce the negative externalities should target primarily construction projects in this category since they offer the greatest benefit.

Following the rating defined in the previous sections, the logistics profile matrix uses a 4x4 matrix (with urban and site complexity rated as "Slightly", "Moderately", "Very" and "Extremely" complex).

A sample of the logistics profile matrix is given below for reference (Figure 2). It shows the complexity of five construction projects. The size of the point is proportional to the turnover of the project. The assessor should here focus her efforts on projects falling in the "high priority" category and having the higher turnover.

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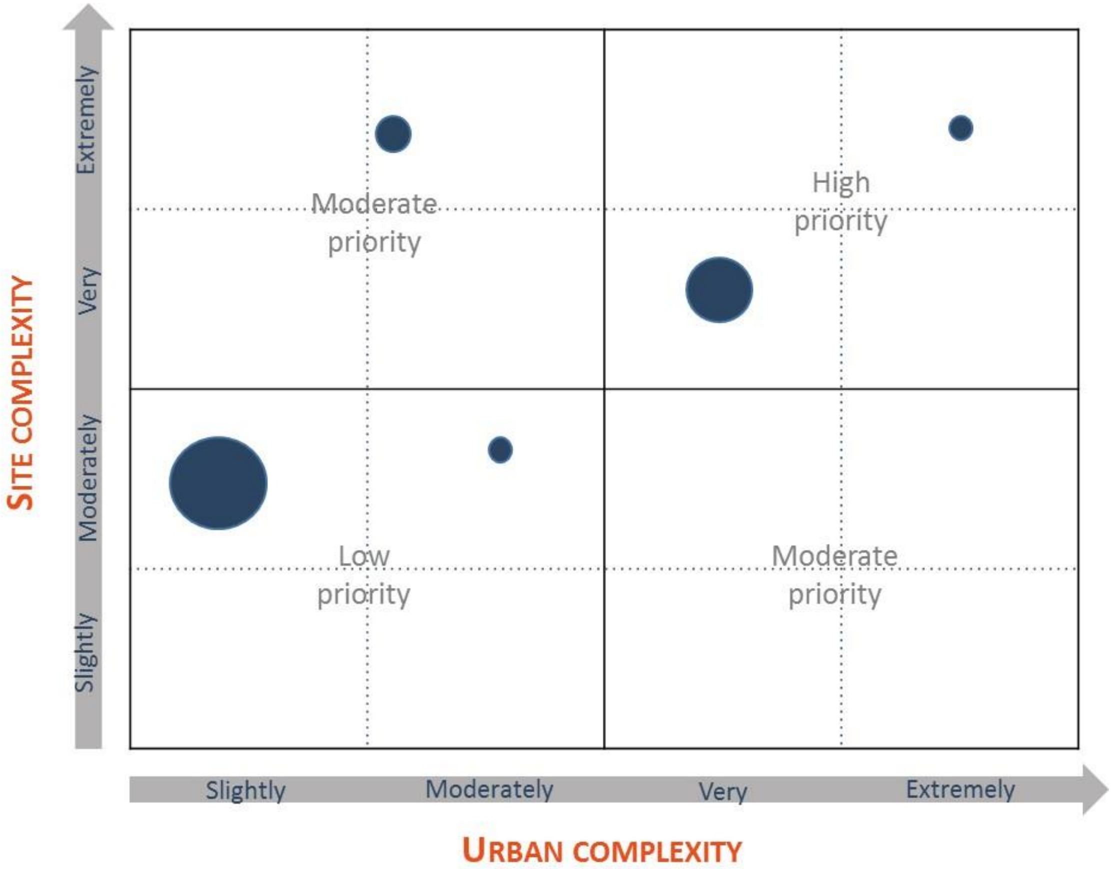

Figure 2 Logistics profile matrix

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3 Intervention models

This chapter presents a list of measures to improve the logistics and supply chain management in the construction sector and the steps to select the most appropriate ones to face a project's complexity.

3.1 List of measures

This section describes measures to mitigate the logistics complexity of a construction project. The measures are classified according to the nature of the objective they refer to. We identified four objectives, which were divided in sub-objectives where necessary (see Figure 3 The measures' underlying objectives' tree)

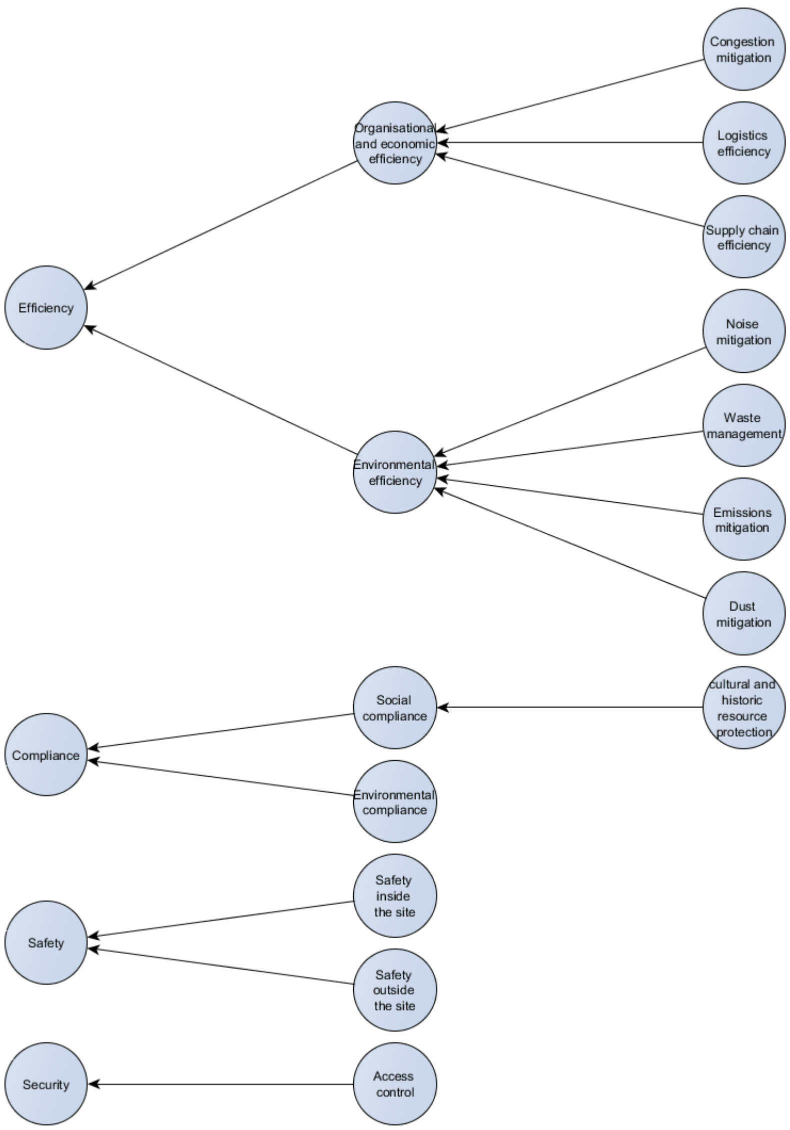

Figure 3 The measures' underlying objectives' tree

Measures listed hereafter address at least one and possibly several objectives.

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3.1.1 List of measures for the 'Efficiency' objective

Scarcity of construction site space in urban areas imposes serious challenges for contractors in planning material supply and site logistics. Such limitations result in crowded exterior space, lower productivity, and higher costs for material's procurement.

The measures described hereafter aim at increasing productivity and avoiding wasting materials, energy, time, and money to deliver to the site and build the construction.

3.1.1.1 Delivery windows

Define the most appropriate period(s) for planning deliveries (ideally off-peak period(s)) leading to less congestion, less emissions and improved safety.

3.1.1.2 Delivery area booking system

Use a dedicated software to let hauliers book a slot for their deliveries, thus smoothing the deliveries all along the operating hours of the construction site.

See Good Practice *IT2 - Delivery area booking system* in deliverable D6.1 for further details and examples.

3.1.1.3 Delivery schedule

Agree in advance with the hauliers the arrival time of most if not all deliveries to the construction site. This aims at avoiding congestion resulting from idle trucks waiting inside the site, at the entry or in the surroundings of the site.

3.1.1.4 BIM

Heavily use BIM models instead of plans to exchange additional information among stakeholders of the construction. In particular, the use of 4D or 5D BIM can help to forecast schedules of materials' demand per week or day and to organise daily site logistics.

See Good Practice *IT5 - BIM for construction logistics* in deliverable D6.1 for further details and examples.

3.1.1.5 Last planner system

Engage the main stakeholders in a collaborative scheduling of the project. It results in a more reliable work planning and thus in improved flow management. In fact requirements in material and equipment depend largely on work planning.

NB: Planning of construction activities is crucial for logistics because logistics activities should ensure that resources (materials, equipment, and people) are at the right time, place, quantity and quality to carry out the related activities.

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Consequently, the most important input for logistics is the work plan. Considering the increasing complexity of construction projects on the technical aspects as well as the number and diversity of the involved stakeholders, traditional ways of scheduling activities become increasingly difficult to use.

3.1.1.6 Logistics team

A specific team dedicated to the improvement of the support actions on site and requiring the collaboration among different stakeholders, such as the coordination of material flows for all the sub-contractors.

See Good Practice *LO1 - Logistics team* in deliverable D6.1 for further details and examples.

3.1.1.7 Waste management team

Engage a specific team dedicated to the management of waste among all stakeholders and share among those its operational costs.

3.1.1.8 Scaffolding tower

Use scaffoldings as an ad-hoc way to build additional material storage locations on the construction site that could be more secure and closer to the material final point of use.

See Good Practice *LO5 - Scaffolding tower* in deliverable D6.1 for further details and examples.

3.1.1.9 Authorisation to use public space for storage / delivery

Get authorisations from local authorities to use public space nearby the construction site as a temporary additional storage or delivery area for the site.

3.1.1.10 Defects management software

Use dedicated software and or devices (tablets, drones…) to track defects in the construction site and follow their resolution.

See Good Practice *IT3 - Defect management* in deliverable D6.1 for further details and examples.

3.1.1.11 Site logistics plan

Draw accurately the locations of points of entrance, access routes, emergency routes, staging areas for delivery /storage / waste / equipment, crane / lift / scaffolds, temporary traffic signal controls, worker and pedestrian crossings, barriers / fence, temporary accommodation for workers such as toilets, locker rooms, offices and parking.

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See Good Practice *PO6 – Safety, Health and Environmental Program* in deliverable D6.1 for further details and examples.

This measure includes the following sub-measure

- Housekeeping plan
  Set-up and control measures for the orderly storage and movement of materials from the point of entry to exit. The plan includes but is not limited to the appropriate storage and/or protection of all new and waste materials (with a storage area demarcation for example), the continued maintenance of clear access (with clear demarcation of the walkways for example), the maintenance of all temporary facilities and the cleaning of work areas from waste.

3.1.1.12 Material handling

Use either building specific equipment (crane, mobile cranes) or alternative material handling equipment (lift) on site. Manage the sharing of handling equipment for material handling among contractors and sub-contractors on the site.

3.1.1.13 Sourcing software

Use dedicated software to select suppliers or sub-contractors of a construction project according to multiple criteria. Keep track record of suppliers' and sub-contractors' capabilities and performance for further reuse in next projects. Keep record of sourcing decisions for any further usage or request. (See Good Practice *IT1 - Sourcing Software* in deliverable D6.1 for further details and examples)

3.1.1.14 Framework agreement

Define framework agreements with qualified suppliers to avoid performing a full sourcing analysis and decision at each new construction project. Renew such agreements on a regular basis.

See Good Practice *SC2 - Framework Agreement* in deliverable D6.1 for further details and examples.

3.1.1.15 RFID

Use Radio-Frequency technologies to identify and locate more quickly and more conveniently material and equipment on the construction site.

See Good Practice *IT4 - Radio-Frequency Identification* in deliverable D6.1 for further details and examples.

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3.1.1.16 *Routes plan*

Define plans of recommended or allowed routes to access, deliver to and/or leave the construction site. Communicate these plans to hauliers and get their commitment to comply with such plans.

This measure includes the measure Approved routes plan (cf. 3.1.2.6).

3.1.1.17 *Consolidation*

Organise group deliveries of disparate materials to reduce the number of vehicles delivering to the site(s) and increase the load rate of delivery vehicles.

This measure includes the following sub-measure

- Construction Consolidation Centre
  Potentially, set-up a dedicated infrastructure and organisation to perform such consolidation for a single construction site or for several sites.
  See Good Practice *SC1 - Construction Consolidation Centre* in deliverable D6.1 for further details and examples.

3.1.1.18 *Pre-fabrication*

Use pre-fabricated materials rather than raw materials in order to speed up the construction process and potentially lower the need of storage space on the construction site. Note that the use of pre-fabricated materials can require more trips than the use of raw materials and possibly the pre-fabricated elements can require heavier and less manoeuvrable trucks.

3.1.1.19 *Reuse demolition waste*

In case of projects including demolition activities, the reuse of demolition waste as raw material reduces the need of hauling both waste and new material on the site.

See Good Practice *LO6 - Construction & Demolition Waste Manual* in deliverable D6.1 for further details and examples.

3.1.1.20 *Construction Logistics Plan*

Define during the planning process for the construction work how the project will be run and managed to improve freight vehicles' movement to and from construction sites in delivering construction materials and removing waste in a safe, efficient and environmentally friendly way.

See Good Practice PO1 – *Construction Logistics Plan* in deliverable D6.1 for further details and examples

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3.1.1.21 *Planning*

Estimate the correct amount of materials and equipment needed for a specific activity.

This measure includes the following sub-measures

- Delivery schedule (cf. 3.1.1.3)
- Delivery area booking system (cf. 3.1.1.2)
- Just In Time deliveries: Receive goods only as they are needed in the production process, thereby reduce inventory costs.
  See Good Practice *SC4 – Just-In-Time delivery* in deliverable D6.1 for further details and examples.

3.1.1.22 *PIEK Labelling for equipment and vehicles*

Use of noise-reduced certified equipment and vehicles for material hauling and handling on site in order to reduce noise disturbance and possibly extend the site operations hours in quiet periods (nights and week-ends).

3.1.1.23 *Roads / paths sealing*

Use techniques and equipment to reduce the spread of dusts during vehicles' operations on roads or paths of the construction site. Among available techniques, we suggest the regular compression of roads and paths or the use of coating substances (asphalt, concrete) on dusty roads and paths.

3.1.1.24 *Dust suppressing agent spraying*

Spray a non-hazardous and biodegradable agent on any source of dust on the construction site (e.g. on a heap of sand).

See Good Practice *PO6 – Safety, Health and Environmental Program* in deliverable D6.1 for further details and examples.

3.1.1.25 *Physical containment of fugitive dust*

Use techniques and equipment to reduce the spread of dust during construction activities or during material transport or storage. It refers mainly to the use of a tarpaulin (a type of waterproof cloth) covering the cargo of the truck, the construction materials on the site or the building.

See Good Practice *PO6 – Safety, Health and Environmental Program* in deliverable D6.1 for further details and examples.

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3.1.1.26 *Wheel washing of all construction non-road and motor vehicles leaving the site*

Set-up appropriate equipment to remove dirt from the wheels of vehicles leaving the site. Such equipment can be a water pool or a pit in which wheels get washed or a dry wheel-cleaning zone just before the site's exit.

3.1.1.27 *Road cleaning*

Plan the use of dedicated equipment to clean roads whenever operations or activities generate dirtiness on public roads outside the construction site. Set-up appropriate measures and duties as needed: e.g. monitoring of roads' dirtiness, roads' cleaning schedule …

3.1.1.28 *Centralisation of waste collection*

Centralise the collection of waste [at a single place on the construction site / by a single/dedicated team on the site] in order to ensure that waste management is carried out properly and in compliance with site requirements.

See Good Practice *LO6 - Construction & Demolition Waste Manual* in deliverable D6.1 for further details and examples.

3.1.2 List of measures for the 'Compliance' objective

The measures described hereafter aim at improving the capacity and capability of construction sites to comply with legal and extra-legal regulations that could be in place in the environment nearby the site. Among others, such regulations may be related to historical, cultural or world heritage, or environmental preservation. Therefore, the solutions proposed below are dealing with the visual attractiveness of the building site, the restoration and reseed of the disturbed areas immediately after the construction, the covering of the building or scaffoldings with canvas to reduce the visual, acoustic and physical impact of construction activities on the surrounding environment.

3.1.2.1 *Building canvas*

Use (printed/decorated) canvas on scaffoldings in order to reduce the visual, acoustic and physical impact of construction activities on the surrounding environment.

3.1.2.2 *Decorated fence*

Decorate the fence used to protect the construction site in such a way that the construction site is better visually integrated in its local environment.

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3.1.2.3 Street furniture and vegetal protections

Protect street furniture and vegetation nearby the construction site from possible damages due to vehicles or equipment operations (in particular during material deliveries).

3.1.2.4 Recordkeeping and reporting damages, injuries and illnesses

Set-up procedures to keep records of damages, injuries and illnesses attributable to logistics operations on the construction site and report such events to the appropriate stakeholders.

3.1.2.5 Fleet operator label

Set-up a voluntary accreditation scheme such as FORS (Fleet Operator Recognition Scheme) to recognise efforts that vehicle operators are providing in terms of safety, efficiency and environmental protection.

3.1.2.6 Approved routes plan

Define plans of allowed routes to access, deliver and or leave the construction site. Communicate these plans to hauliers and get their commitment to comply with such plans.

3.1.2.7 Emission mitigation plan

Establish on-road vehicle (i.e., diesel trucks) staging zones for the off-loading and loading of materials to and from the construction site to minimize the impact of pollutants from diesel engines and vehicles on the general public.

Set-up policies restricting the idling time of non-road and on-road vehicles.

See Good Practice *PO6 – Safety, Health and Environmental Program* in deliverable D6.1 for further details and examples.

3.1.2.8 Dust control plan

Set-up controls and implement mitigation measures to reduce at all times dust particulate dispersions generated by work activities such as demolition, earth moving …

See Good Practice *PO6 – Safety, Health and Environmental Program* in deliverable D6.1 for further details and examples.

3.1.3 List of measures for the 'Safety' objective

Movement of heavy construction vehicles and moving materials create important risks of accidents for workers and road users. These accidents, as well as their social and financial cost, can be avoided by adequate measures.

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The measures described hereafter aim at improving construction workers' safety and more globally road users' safety beyond the site.

3.1.3.1 *Traffic light to make insertion in traffic safety*

Set-up traffic light(s) at the exit point(s) of the construction site to ease the insertion of vehicles leaving the site in the traffic flow.

See Good Practice *LO2 – Access management* in deliverable D6.1 for further details and examples.

3.1.3.2 *Blind mirror at the entry/exit gate*

Set-up a mirror at each entry or exit gate(s) of the construction site to ease drivers' visibility of the traffic when entering or leaving the site.

3.1.3.3 *Manoeuvring guide*

Communicate and train stakeholders to a common set of gestures to communicate visually with vehicles' drivers on site.

3.1.3.4 *Speed limits inside the construction site*

Set speed limits and potentially control procedures inside the construction site to reduce risks of damages and the spread of dust.

3.1.3.5 *Speed limits outside the construction site*

Set speed limits and potentially controls outside the construction site to reduce risks of accidents with construction vehicles entering and leaving the site and to ease the insertion of these vehicles within the traffic flow.

3.1.3.6 *Approved routes plan*

Cf. 3.1.2.6.

3.1.3.7 *CLOCS*

Set-up part or all of the measures of the UK's CLOCS certification to ensure the safety of road users such as cyclists with regards to construction vehicles.

This measure includes the following sub-measures

- *Recordkeeping and reporting damages, injuries and illnesses*
  Capture, investigate and analyse road traffic collision, incidents and near-misses information that result or could result in injury or damage to vehicles and property.
- *Side under-run protection*

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Equip construction vehicles with under-run protection devices to protect road users such as pedestrians and cyclists from slipping sideways under the wheels of trucks and trailers.

- *Warning signage*
  Equip construction vehicles with prominent signage to visually warn other road users not to get too close to the vehicle.
- *Blind spot minimisation*
  Equip construction vehicles with devices such as mirrors, cameras and audible alerts to eliminate or minimise front, side and rear blind-spots.
- *Vehicle manoeuvring warnings*
  Equip construction vehicles with enhanced audible means to warn other road users of a vehicle's left manoeuvre.

See Good Practice *PO4 - Road safety (CLOCS)* in deliverable D6.1 for further details and examples.

3.1.3.8 Construction Logistics Plan

Cf. 3.1.1.20.

3.1.3.9 Exit barrier

Force vehicles leaving the construction site to stop at the exit of the site, in order to ensure a smooth insertion in the traffic flow and the detection of pedestrians / cyclists etc. around the site exit.

3.1.3.10 Site logistics plan

Cf. 3.1.1.11.

3.1.3.11 Recordkeeping and reporting damages, injuries and illnesses

Cf. 3.1.3.7.

3.1.3.12 Entry Barrier

Reduce the risk for pedestrians and vehicles to inadvertently enter the site and get harmed due to unstable construction, loose material or debris.

3.1.4 List of measures for the 'Security' objective

Construction sites are easy targets for thieves. Materials, especially copper and other metals and small equipment are their main targets. The need to replace missing tools, equipment and materials can cause a huge loss of revenue and productivity if the missing materials and equipment delay the project.

The measures described hereafter aim at protecting materials and equipment against theft and damage.

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3.1.4.1 *Fence*

Control the access to the construction site and delimit the perimeter of the secured site.

3.1.4.2 *Secure area*

Permit to store tools, equipment and materials in a securely-locked outbuilding such as:

- A storage container
- A closed room on site

See Good Practice LO4 – *Secure area* in deliverable D6.1 for further details and examples.

3.1.4.3 *Entry barrier*

Control the arrival of any kind of vehicle on the construction site to ensure that only allowed material or equipment enters the site (cf. 3.1.3.12 for additional purpose).

3.1.4.4 *Exit barrier*

Control the departure of any kind of vehicle on the construction site to ensure that material or equipment leave the site with adequate authorisation (cf. 3.1.3.9 for additional purpose).

3.1.4.5 *Site guarding*

Check, thanks to one or more dedicated person(s), the access authorisation of trucks as well as react to any kind of security breach occurring on the construction site. NB: This measure is usually applied only to check if people are authorised to enter the site.

3.1.4.6 *Entry / Exit gate*

Control the entrance as well as the departure of both trucks and humans on the construction site. It could be combined with the use of a RFID reader in order to track RFID tags all along their lifecycle.

3.1.5 Measures overview

The Figure 4 below provides an overall picture of the Relationships between measures and previously defined objectives.

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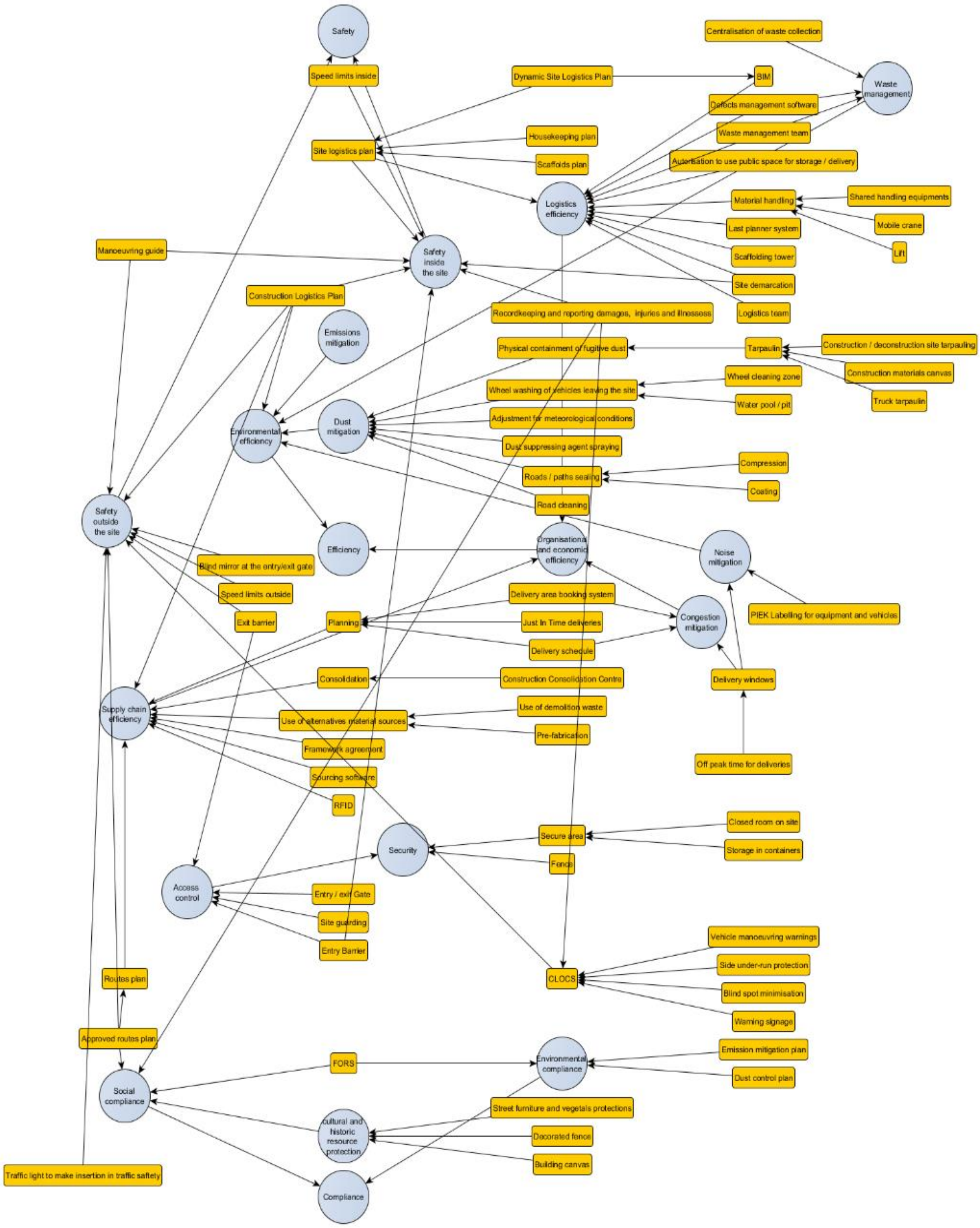

Figure 4 Relationships between measures and previously defined objectives

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3.2 Identifying the most relevant measures

Among the list of measures detailed in the previous sections, only a subset is relevant to address the complexity of a specific construction site. The measures have been mapped against the variables identified in the previous chapter. Some variables may be more determinant than others to qualify a measure. The table below presents the mapping between the variables and the measures. It specifies the rating a variable needs to achieve to make the measure relevant. In other words the table can be read as: *if variable (in first column) scores at the level indicated in the cell, then the implementation of the measure (in first row) might be relevant to reduce the complexity.*

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Variable	Approved routes plan	Authorisation to use public space for storage / delivery	BIM	Blind mirror at the entry/exit gate	Building canvas	Centralisation of waste collection	CLOCS	Consolidation
Site location	>=3	<=3					>=3	>=3
Neighbourhood's environmental sensitivity	4				>=3			>=3
Regulation								4
Maturity level of local authorities	1	<=2					<=2	<=2
Exposure to air pollution and traffic noise	>=3				>=3			
Congestion	>=3	<=2						4
Topology	>=3			>=3			4	
Topography	4			4				
Construction activity	>=3							>=3
Turnover			4			>=2		>=3
Building size								
Storage capacity		4	>=3			>=3		4
Time pressure								4
Subcontractors						2;4		
Site access				<=3				
Delivery areas		>=3	1;3					
Handling equipment			2					
Certification			2;4					2;4
Logistics strategy	1					<=2		1
Scope of the project								
Construction's intended usage								>=2
Change in project scope								<=2

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Variable	Construction Logistics Plan	Decorated fence	Defects management software	Delivery area booking system	Delivery schedule	Delivery windows	Dust control plan	Dust suppressing agent spraying
Site location					>=3	>=3	>=3	>=3
Neighbourhood’s environmental sensitivity		>=3		>=3		>=3	>=3	>=3
Regulation	>=3			4	>=3			
Maturity level of local authorities	<=3					<=2	1	
Exposure to air pollution and traffic noise	>=3					>=3	4	>=3
Congestion	>=3			>=3	>=3			
Topology	>=3							
Topography								
Construction activity								
Turnover								
Building size			>=3	>=2	>=3			
Storage capacity					>=2			
Time pressure				>=3	>=3			
Subcontractors			>=2					
Site access					4			
Delivery areas								
Handling equipment				<=3	<=3			
Certification							2;4	2;4
Logistics strategy				<=3				
Scope of the project								
Construction’s intended usage								
Change in project scope								

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Variable	Emission mitigation plan	Entry Barrier	Exit barrier	FORS	Framework agreement	Just In time deliveries	Last planner system	Logistics team	Manoeuvring guide
Site location									
Neighbourhood’s environmental sensitivity	>=3	4	4			<=3			
Regulation				4					
Maturity level of local authorities	1			1					
Exposure to air pollution and traffic noise	4					<=3			
Congestion						<=3			
Topology		4	4						
Topography									
Construction activity									
Turnover								>=2	
Building size					>=3			>=2	
Storage capacity		4			4	4		>=3	
Time pressure					>=3		>=2	>=2	
Subcontractors		2;4	2;4				2;4	2;4	
Site access									4
Delivery areas									
Handling equipment								<=2	
Certification				2;4					
Logistics strategy	1	4	4			<=3	>=3	<=2	<=2
Scope of the project									
Construction’s intended usage							>=2		
Change in project scope					>=3		>=3		

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Variable	Material handling	Physical containment of fugitive dust	PIEK Labelling for equipment and vehicles	Pre-fabrication	Recordkeeping and reporting damages, injuries and illnesses	RFID	Road cleaning
Site location		>=3					>=3
Neighbourhood's environmental sensitivity		>=3	>=3				>=3
Regulation					>=3		>=3
Maturity level of local authorities					1		<=3
Exposure to air pollution and traffic noise		>=3	>=3				
Congestion				<=2			
Topology				<=3			
Topography							
Construction activity			>=3				
Turnover	>=2					>=3	
Building size	2;4					>=3	
Storage capacity				>=2		>=3	4
Time pressure				>=3		4	
Subcontractors							
Site access							
Delivery areas							
Handling equipment	4						
Certification		2;4	2;4		2;4		2;4
Logistics strategy	<=3					<=2	
Scope of the project							
Construction's intended usage							
Change in project scope				1			

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Variable	Site guarding	Site logistics plan	Speed limits inside	Speed limits outside	Street furniture and vegetal protections	Traffic light to make insertion in traffic safety	Use of demolition waste
Site location				>=3			
Neighbourhood's environmental sensitivity	4			4	>=3		
Regulation					>=3		
Maturity level of local authorities				<=2		<=2	
Exposure to air pollution and traffic noise				>=3			
Congestion				>=3		>=3	>=3
Topology				4			
Topography						>=3	
Construction activity				>=3			>=3
Turnover	>=3						
Building size							
Storage capacity	>=2	>=3	1				
Time pressure							
Subcontractors		2;4					
Site access	>=2	1	<=2			<=3	
Delivery areas		1					
Handling equipment							
Certification							2;4
Logistics strategy							
Scope of the project							>=3
Construction's intended usage							
Change in project scope							

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Variable	Waste management team	Wheel washing of Vehicles leaving the site
Site location		>=3
Neighbourhood's environmental sensitivity		>=3
Regulation	4	>=3
Maturity level of local authorities		<=3
Exposure to air pollution and traffic noise		
Congestion		>=3
Topology		
Topography		
Construction activity		
Turnover	>=2	
Building size	>=3	
Storage capacity	>=3	
Time pressure		
Subcontractors	2;4	
Site access		>=2
Delivery areas		
Handling equipment		
Certification	2;4	
Logistics strategy	<=2	
Scope of the project	>=2	
Construction's intended usage		
Change in project scope		

Table 4 Relation between the variables and the measures

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3.3 Preparing an action plan

An action plan is designed early during the planning phase. It integrates one or a combination of measures which should have been selected among the relevant measures identified in the previous section. Any given profile category identified in section *2.2 Mapping the logistics profile of a construction project* could necessitate a set of suitable actions.

The action plan must be appropriate in terms of its cost and time-effectiveness for reaching the challenges the construction project is facing. Because some actions can target similar impacts, we strongly suggest to carefully evaluate the estimated efforts in terms of cost, time and difficulty before selecting the most suitable measure(s).

The table below presents the estimated efforts to implement and run each measure in terms of cost, time and difficulty:

- Cost: How much does it cost to implement and run the measure?
- Time: How long does it take to implement and run the measure?
- Difficulty: How difficult is it to implement and run the measure?

The criteria are evaluated on a three point scale:

Low (green) Medium (orange) High (red)

Measure	Cost	Time	Difficulty
Approved routes plan	Low	Low	Low
Authorisation to use public space for storage / delivery	Medium	Low	Medium
BIM	High	High	High
Blind mirror at the entry/exit gate(s)	Low	Low	Low
Blind spot minimisation	Low	Medium	Low
Building canvas	Medium	Medium	Medium
Centralisation of waste collection	Medium	Medium	Low
CLOCS	Medium	Low	Medium
Closed room	Low	Low	Low
Coating	Medium	Medium	Medium
Compression	Low	Low	Medium
Consolidation	Medium	Medium	Medium
Construction / deconstruction site tarpauling	Medium	Medium	Medium
Construction Consolidation Centre	High	High	High
Construction Logistics Plan	Low	Medium	Medium

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Measure	Cost	Time	Difficulty
Construction materials canvas	Green	Green	Green
Decorated fence	Orange	Green	Green
Defects management software	Orange	Orange	Orange
Delivery area booking system	Orange	Orange	Orange
Delivery schedule	Green	Orange	Green
Delivery windows	Green	Orange	Orange
Dust control plan	Green	Green	Green
Dynamic Site Logistics Plan	Green	Red	Red
Emission mitigation plan	Green	Green	Green
Entry / exit Gate	Green	Green	Green
Entry Barrier	Orange	Green	Green
Exit barrier	Orange	Green	Green
FORS	Orange	Orange	Orange
Framework agreement	Green	Orange	Red
Housekeeping plan	Green	Green	Red
Just In Time deliveries	Green	Orange	Orange
Last planner system	Green	Orange	Red
Lift	Red	Green	Orange
Logistics team	Red	Green	Orange
Manoeuvring guide	Green	Green	Green
Mobile crane	Red	Orange	Green
Off peak time for deliveries	Orange	Green	Orange
Physical containment of fugitive dust	Green	Green	Green
PIEK Labelling for equipment and vehicles	Orange	Green	Green
Planning	Orange	Orange	Orange
Pre-fabrication	Orange	Green	Orange
Recordkeeping and reporting damages, injuries and illnesses	Green	Green	Green
RFID	Orange	Orange	Red
Road cleaning	Green	Green	Green
Roads / paths sealing	Orange	Green	Orange
Routes plan	Green	Green	Green
Scaffolding tower	Orange	Green	Green
Secure area	Orange	Green	Green
Shared handling equipment	Green	Orange	Red
Side under-run protection	Green	Orange	Green

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Measure	Cost	Time	Difficulty
Site demarcation	green	green	green
Site guarding	red	green	green
Site logistics plan	green	green	green
Sourcing software	orange	green	orange
Speed limits inside	green	green	green
Speed limits outside	green	green	orange
Spraying of a (non-hazardous, biodegradable) dust suppressing agent	green	green	orange
Storage in containers	orange	green	green
Street furniture and vegetal protections	green	green	green
Tarpaulin	green	green	green
Traffic light to make insertion in traffic safety	orange	green	red
Truck tarpaulin	green	green	green
Use of demolition waste	green	orange	orange
Vehicle manoeuvring warnings	orange	green	green
Warning signage	green	green	green
Waste management team	red	green	orange
Water pool / pit	green	green	green
Wheel cleaning zone	green	green	green
Wheel washing of all construction Non-Road and Motor Vehicles leaving the site.	green	green	green

Table 5 List of measures (example)

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Conclusion

Good logistics and supply chain management of a construction project has to ensure that the right materials are delivered to the site at the right time, to the right place, in the right condition and in the right quantity.

Several factors can make a construction site more complex to supply than others. Depending on the nature of its complexity, different actions should be applied to address the challenges that each specific construction site is facing.

This deliverable proposes an evaluation framework to assess the logistics profile of any given construction project in an urban area.

In a more advanced version of the definition of the intervention model, several improvements to support its usability should be proposed taking into account the return of experience. These improvements should concern additional guidance to rate the variables, an updated list of variables, an updated or recalibrated rating scale and an extended list of measures. This deliverable is one of the first steps that the SUCCESS project attempts to enable the replicability and take up of its findings to non-partner construction companies and cities.

In order to make it even more usable, we plan to release before the end of the project an interactive tool to support end users in the definition of the intervention model and of the associated road map as described in this deliverable.

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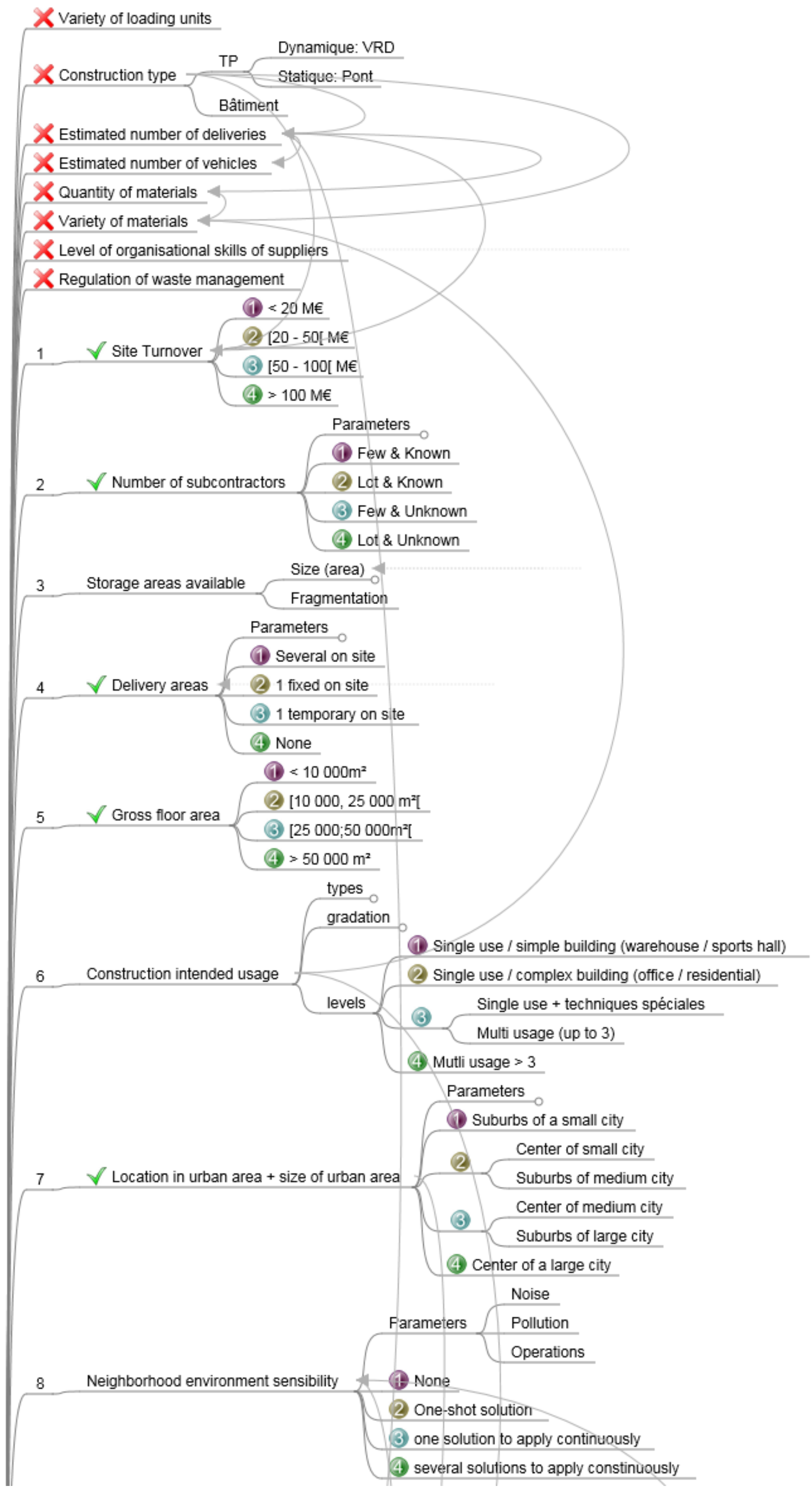
Annexes

Mind mapping to identify the list of variables



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Evaluation of the SUCCESS pilots

For the purpose of testing the evaluation framework, the complexity of the four construction projects was evaluated. The results reflect the reality but some inconsistencies could exist and the construction companies will later validate the ratings attributed to their site.

Urban dimension

Variable	*FR*	*LU*	*IT*	*SP*
Site location	4	2	2	3
Neighbourhood's environmental sensitivity	4	3	3	1
Regulation	3	2	NA	2
Maturity level of local authorities	NA	1	NA	NA
Exposure to air pollution and traffic noise	4	2	4	2
Congestion	4	3	2	3
Topography	1	3	1	1
Topology	2	3	2	1
Construction activity	3	3	1	3
Average	***3,1***	***2,4***	***2,1***	***1,8***

France

Site location: the construction site is located in the city centre of a large city.

Neighbourhood's environmental sensitivity: with the proximity of street furniture/trees to protect and the presence of prestigious buildings around, the urban area is extremely sensitive to the construction site.

Regulation: the regulation places heavy restrictions on the construction activities.

Maturity level of local authorities: no data was available during the evaluation.

Exposure to air pollution and traffic noise: the exposure in the district is very high.

Congestion: the traffic is extremely congested in Paris (it ranks 10 out of 1,064 cities in the INRIX 2016 Scorecard index (INRIX, 2016)).

Topography: the district and the access route are very flat.

Topology: Paris applied a concentric zone pattern.

Construction activity: there are several small and large constructions around.

Luxembourg

Site location: the construction site is located in a residential area in the suburbs of a medium city.

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Neighbourhood's environmental sensitivity: with the close proximity of residential buildings, the urban area is highly sensitive to the construction site.

Regulation: the regulation restricts moderately the construction activities.

Maturity level of local authorities: the city of Luxembourg is extremely mature in managing construction activities (e.g. the forms are dematerialised on their website).

Exposure to air pollution and traffic noise: the exposure in the district is moderate.

Congestion: the traffic is highly congested in Luxembourg (it ranks 134 out of 1,064 cities in the INRIX 2016 Scorecard index (INRIX, 2016)).

Topography: the site is located in a valley.

Topology: because of the relief, streets are irregular in Luxembourg.

Construction activity: there are several small and large constructions around.

Italy

Site location: the construction site is located in the suburbs of a medium.

Neighbourhood's environmental sensitivity: with the close proximity of the other buildings of the hospitals, the urban area is highly sensitive to the construction site.

Regulation: no data was available during the evaluation.

Maturity level of local authorities: no data was available during the evaluation.

Exposure to air pollution and traffic noise: the exposure in the district is very high.

Congestion: the traffic is moderately congested in Verona (it ranks 807 out of 1,064 cities in the INRIX 2016 Scorecard index (INRIX, 2016)).

Topography: the district and the access route are very flat.

Topology: Verona follows a concentric pattern.

Construction activity: there is no construction activity around.

Spain

Site location: the construction site is located in the city centre of a medium city.

Neighbourhood's environmental sensitivity: the urban area is almost not sensitive to the construction site.

Regulation: the regulation restricts moderately the construction activities.

Maturity level of local authorities: no data was available during the evaluation.

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Exposure to air pollution and traffic noise: the exposure in the district is moderate.

Congestion: the traffic is highly congested in Valencia (it ranks 221 out of 1,064 cities in the INRIX 2016 Scorecard index (INRIX, 2016)).

Topography: the district and the access route are very flat.

Topology: Valencia consists of a grid of streets.

Construction activity: there are several small and large constructions around.

Site dimension

Variable	*FR*	*LU*	*IT*	*SP*
Turnover	4	2	3	1
Building size	4	2	3	1
Storage capacity	4	3	2	1
Time pressure	4	2	3	1
Subcontractors	4	3	4	3
Site access	1	4	2	2
Delivery areas	1	3	2	1
Handling equipment	2	2	2	1
Certification	4	1	2	1
Logistics strategy	1	1	3	4
Scope of the project	4	4	3	2
Construction's intended usage	4	3	4	1
Change in project scope	3	3	2	4
Average	***3,1***	***2,5***	***2,7***	***1,8***

Table 6 Rating of the SUCCESS pilots

France

Turnover: 230 M€

Building size: 55,475 m²

Storage capacity: (building footprint/surface area) 13,000 / 14,400 = 0.9

Time pressure: (gross floor area / project duration) 55,475 / 24 = 2,311

Subcontractors: the main contractor manages a lot of subcontractors he is not used to work with.

Site access: there are two entrance gates and two exit gates.

Delivery areas: there are two delivery areas.

Handling equipment: two cranes are available to handle materials directly from the truck.

Certification: the building aims at the concurrent certification of several labelling schemes (BBC and HQE).

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Logistics strategy: the main contractor provides a logistics team for the waste management and shares the handling equipment, thus the logistics is completely centralised.

Scope of the project: the building should be refurbished keeping the architecture dating back to the 1930's.

Construction's intended usage: the site offers workplaces (considered as one use), an auditorium (considered as one use), a sports hall (considered as one use), a restaurant (considered as one use), a childcare centre (considered as one use) and parking spaces.

Change in the project scope: some requirements had to be defined during the renovation of this historic building.

Luxembourg

Turnover: 20.8 M€

Building size: 11,400 m²

Storage capacity: (building footprint/surface area) 3,132 / 6,796 = 0.46. The storage is fragmented on different levels and locations because of the nature of the relief and the design of the buildings.

Time pressure: (gross floor area / project duration) 11,400 / 23 = 496 (rounded to the nearest 10)

Subcontractors: the main contractor manages few subcontractors he is not used to work with.

Site access: there is only one entrance/exit gate with no possibility for drivers to do a U-turn in the site.

Delivery areas: there is a temporary delivery area which changes over time.

Handling equipment: Two cranes are available to handle materials directly from the truck.

Certification: the building doesn't intend to reach a labelling scheme.

Logistics strategy: the main contractor provides a logistics team for the waste management and shares the handling equipment, thus the logistics is completely centralised.

Scope of the project: some buildings have been refurbished respecting the architectural and industrial heritage.

Construction's intended usage: the site offers residential units (considered as one use), office spaces (considered as one use), shops (considered as one use), a public square and parking spaces.

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Changes in project scope: some requirements are not clearly defined by the property developer and the residents will select their materials after purchasing the apartment.

Italy

Turnover: 126 M€

Building size: 44,034 m²

Storage capacity: (building footprint/surface area) 7,339 / 16,891 = 0.43. Since there is only one building, the storage is not fragmented.

Time pressure: (gross floor area / project duration) 44,034 / 29 = 1,518

Subcontractors: the main contractor manages a lot of subcontractors he is not used to work with.

Site access: there are one entrance gate and one exit gate.

Delivery areas: there is one fixed delivery area.

Handling equipment: Two cranes are available to handle materials directly from the truck.

Certification: the building aims at the certification of one labelling scheme.

Logistics strategy: the logistics is somehow centralised with a check at the entrance of the site.

Scope of the project: the existing infrastructure has been demolished before erecting a new building.

Construction's intended usage: the site offers hospital facilities including surgery rooms (considered as one use), patient rooms (considered as one use), restaurant (considered as one use) and other specific infrastructures to equip medical rooms. Because the technics are more important than a traditional building, the rating is higher.

Changes in project scope: the requirements of the non-standardised building are defined.

Spain

Turnover: 15.8 M€

Building size: 7,772 m²

Storage capacity: (building footprint/surface area) 7,515 / 78,470 = 0.096

Time pressure: (gross floor area / project duration) 7,772 / 24 = 323

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 633338.

Subcontractors: the main contractor manages few subcontractors he is not used to work with.

Site access: there are one entrance gate and one exit gate.

Delivery areas: there is plenty of space to use as a delivery area.

Handling equipment: no crane is needed on the site. When needed, the subcontractor uses a mobile crane.

Certification: the building doesn't intend to reach a labelling scheme.

Logistics strategy: there is only one company working on the site, thus the logistics is not centralised.

Scope of the project: the buildings will be renovated.

Construction's intended usage: the site offers a park area (considered as one use).

Changes in project scope: the final destination (i.e. destination) of the building has not yet been identified.

SUCCESS pilots logistics profile

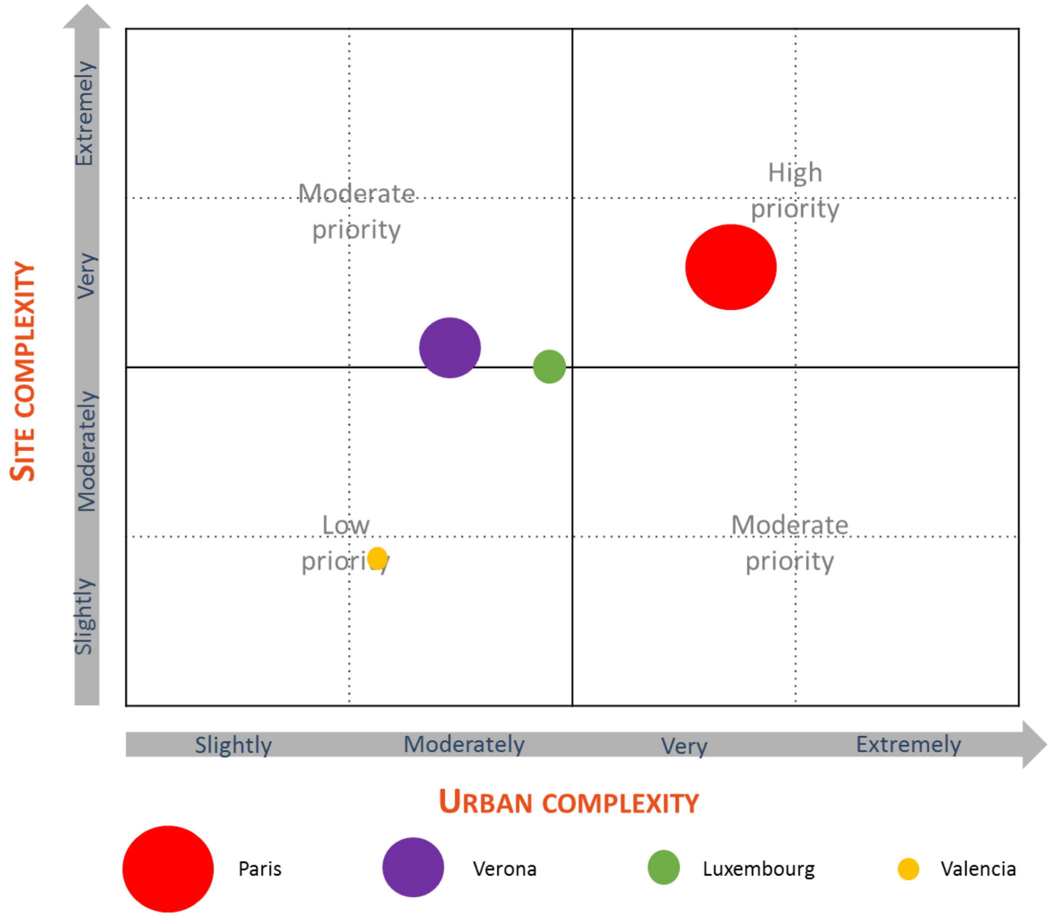

Figure 5 SUCCESS pilots logistics profile matrix

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 633338.

Applied to the four construction projects monitored by SUCCESS, the framework compares their relative complexity (Figure 5 SUCCESS pilots logistics profile matrix). The Paris site is the most complex construction project. The projects in Verona and Luxembourg have a similar ranking with less complex construction sites and urban areas. The Valencia site seems to be the less complex one.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 633338.

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