# Deliverable Summary

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## Functional Use

The purpose of the present Deliverable is to give an overview of the efforts undertaken by the Municipality of Bologna (Mobility Department) in implementing an innovative ITS base system aimed to rationalise the freight distribution in the city centre and to make it more efficient and less pollutant.

The system is already active and a complete evaluation of the achievable benefits (both on field and desk simulation) has been presented.

Few private operators joined the system and findings and lesson learned about it can be found in 'lesson learned' chapter, where some recommendations on eventual replication in other cities have been given.

# Context and Purpose

The study and the works conducted in Bologna on the freight delivery scenario led to the deployment of a new freight distribution system, called 'Van Sharing', which aims at the rationalization of goods shipment in the city centre by means of vehicle routes optimization. The solution is mostly based on shipment orders' aggregation, which causes a relevant reduction of time spent/distance covered by a fleet of eco-friendly vans/lorries in the city centre, and therefore allows to significantly lower freight distribution environmental impact.

Today, freight distribution in the historical centre of Bologna is essentially provided by two main commercial categories: own account operators and third party operators.

| **Category** | **%** |
|---|---|
| Third party operators | 48,7% |
| Own account operators | 43,6% |
| Shopkeeper in LTZ | 5,7% |
| Sale representatives | 2,0% |

***Figure 1 – Scenario of freight distribution in Bologna - Limited Traffic Zone***

The own account operator has a delivery rate (number of loads delivered per time unit and per trip) and a saturation rate (capacity level used per vehicle) much lower than the third account operator, because of the lack of trip programming, just-in-time modality, no coordination and inefficiency.

In the framework of the most recent research on freight distribution in the city, a specific questionnaire addressed to freight operators showed that:

- more than 67% of the trips are achieved with a saturation factor lower than 25%;
- only 12% of the trips are achieved with a saturation factor higher than 50%;
- own account operators (i.e. small operators) have a halved delivery rate than third party operators (i.e. large companies).

Moreover small operators represent a relevant share (about 44%) of the freight operators.

While large companies are already equipped with structures, tools and innovative procedures to make more efficient their work, own account operators don't have the economic power to invest in such direction: first of all they are not able to provide themselves with physical big structures and innovative management instruments (as large companies do).

Therefore the delivery provided by own account operators (i.e. small operators) is affected by several negative aspects:

- no presence of transit point where to collect goods and consequently absence of loading dock;
- inefficient goods supplying;
- inefficient routing: the trip is substantially planned randomly depending on the demand of one/two customer retailers and on their instantaneous requests;

- trips do not take into account the actual traffic situation in the city. Drivers are not able to recognise routes that could be more efficient (considering also specific and critical events such as road yards, relevant traffic congestion events, road accidents,...) and delivery could suffer of relevant delay;
- loading bays are frequently taken up by other vehicles (other operators or even private vehicles) and operators are forced to use a less useful loading bay (e.g. another one too far away);
- just in time modality (no optimisation);
- single operators (or retailers) tend to create a strict relationship with single retailers (or operators). This cause often that two retailers located very closed each other are served by two different operators.

This represents a big problem especially in the city centre, due to its medieval architecture and consequently to its narrow streets and lack of space. As a result, in the city centre the mobility demand is larger than the mobility offer (i.e. road capacity, parking space).

Assumed that the mobility demand in the city centre cannot be reduced and the points of interest cannot be displaced outside, the solution is to implement a system capable of optimizing the mobility demand in the city centre through a better organisation of the distribution process in the urban area.

The measure '7.1 (BOL) City Freight Delivery Plan' is part of a general strategy deployed by the municipality, via the PGTU (Urban Traffic Plan), that aims to improve the road safety and mobility and to reduce pollution. The 'City Freight delivery Plan' (approved on 6th March 2006) is the key instrument through which the City of Bologna aimed at rationalising the freight delivery in the city area in order to decrease the number of km traveled while still providing the same services and to deploy 'cleaner' vehicles. The implementation of the Plan comprehended three stages:

- the introduction of faster procedures in the release of access permissions, new pricing policies and the enforcement of new policies related to the city centre access;
- the 'pay-to-access' LTZ area service;
- the 'Van Sharing' system that foresees to set up a 'technological transit point' meant to be a virtual IT platform for freight delivery.

The first two stages were already accomplished before the measure 7.1 implementation. The 'Van Sharing' has been introduced and evaluated thanks to the contribution of the measure.

An innovative aspect of the measure is the integration between road pricing policies and technological tools in order to optimise vehicles' movements. Specifically, the virtual IT platform introduced with the 'Van Sharing' is linked with the new Traffic Control Centre, called 'Cisium'.

Few words on 'Cisium' are necessary to complete the context overview.

Indeed, the Municipality of Bologna has recently completed a strong renewal of the Traffic Control Centre and an integration with the other ITS systems of the city, among which UTOPIA. This brought to a new Urban Traffic Management System, called 'Cisium', which primarily realises the following actions:

- Increase of the centralised traffic light intersection;
- Increase of the inductive loops, to cover a wider area;
- 5 travel time detection systems installed in private cars and connected to the Centre;
- Integration with the LTZ enforcement systems for traffic flow statistic acquirement;
- Integration with more traffic detection spots equipped by cameras (about 25 more cameras for traffic detection);
- Integration with real time control bus centre (AVM) for the bus travel time prediction;
- Integration with about 40 Video Message Signs (VMS) for dynamic traffic information providing.

The most important improvement achieved with 'Cisium' and integrated with the 'Van Sharing' platform is the opportunity to detect a deep and clear real time image of the traffic situation in the city, in terms of both road events and roads' level of service, with the storage of the current flows and the creation of a database of the different scenarios occurring in the road network. This database can be the main source for technical mobility planning as well as automatic high level prediction.

# Summary Contents

Due to the current goods' distribution conditions in the city, studies and analysis conducted by the Municipality of Bologna (in collaboration with Emilia-Romagna Region and the University of Bologna) showed that a good solution to cope with freight distribution issues would consist in the creation of a light-shape consortium made by a group of small operators to provide goods' delivery in the city centre. The implementation process has included the combination of the following elements:

1)the introduction of specific traffic management measures;

2) the "Van Sharing" system, a based IT platform linked to the new Traffic Control Centre owned by Bologna Municipality and called Cisium;

3) the "bookable loading bays" system, implemented and managed by ATC/TPER, the public-private company for Local Public Transport services in the city of Bologna.

1) Introduction of specific traffic management measures

To protect the city monumental attractiveness and also to improve urban air quality, the Municipality of Bologna introduced the Limited Traffic Zone (LTZ), which cover 3,20 $km^2$ and basically matches with the historical centre. The aim of the progressive introduction of traffic restrictions is to reconcile mobility demand with the low capacity of the mediaeval city centre (e.g. circulation and parking) which, in the past, has often led to so heavy congestion able to distort both architectural and environmental values and thus produce a very negative impact on the quality of life in the whole historic centre.

All streets giving access to the city centre and the main bus lanes are currently equipped with cameras in order to check if the vehicles accessing the city centre are authorised. The cameras are able to read car plates, check them with those contained in the database of authorised vehicles and, in case of violation, send transgressor's data to the Municipal Police Dept. which will issue a fine.

Inside the LTZ there is another area, called 'T zone', considered very important for public transport; in this area restrictions are higher than in LTZ and also here the

access is controlled by IT systems.

Beyond the access reduction of non-authorised vehicles, the deployment of these IT systems aims at the following 2 key goals: the improvement of Local Public Transport (LPT) and the introduction of pricing policies which will reduce existing access permissions as foreseen by the Freight City delivery Plan.


***Figure 2 – Enforcement system cameras in bus lanes and in the LTZ***

The scheme regulation settled and enforcement provided by ITS allows to put into practice specific strategy on urban mobility scenario, with specific measures involving lorries:

- payment of yearly delivery permits to LTZ: the permits, previously released for free and with no time limit to all operators, have been issued under the payment of a yearly subscription, which varies in relation to the pollution category of the vehicle (i.e. Euro category), and with a validity of 2 years;
- LTZ 'pay-to-access' ticket: tickets have been introduced to allow people, not otherwise entitled, to occasionally access the LTZ area. People can use two kind of tickets: daily ticket or a 4 days ticket (valid for 4 consecutive days). With the limit, for each month, up to only 3 daily tickets (or just one 4-day ticket) can be used for the same vehicle;
- access rules depending on pollution category: the access to the very inner city ('T' area), controlled by enforcing cameras, has been modulated on temporal windows depending on the pollution category of the vehicles. CNG, LPG and electric vehicles can enter the area in a temporal window that is triplicated compared to more pollutant non-Euro vehicles.

2) <u>The 'Van Sharing' system</u>

The Van Sharing platform is an advanced IT system made up by:

- a software platform for management of information regarding goods' shipments in the city centre (particularly in the LTZ). The main services offered by the SW platform are web services oriented to:

  - allow interested operators to register and join the consortium;

  - collect orders for shipment of freight (from pick-up point to delivery point);

- trace and track shipment status;

- monitor the fleets;

- monitor the traffic.

- an advanced travel planning engine, which can calculate optimal delivery routes to ship goods. Given a set of pickup & delivery services to be performed in a certain day, the planning engine calculates the optimal set of routes to accomplish all demand services of that day, in terms of minimization of vehicles circulating and route length. Time windows can be specified for each service, which can be fully detailed in terms of volume, weight and even number of parcels. The engine is designed to support optimization of goods packing and placing on the van/lorry, even though this facility is currently not active;
- 60 (in regime phase) On-Board Units, able to read barcodes and with navigation functionalities to allow real time, bi-directional communication between the Van Sharing Central and the vehicles, with the aim to achieving efficient operability, effective tracking of vehicle and monitoring of service progression;
- the Van Sharing platform can rely on a good level of integration with the road network status detection system provided by 'Cisium', that allows the travel planning engine to perform its task on the base of semi-real-time image made available by 'Cisium' every 5 minutes by means of DATEX protocol information, of the traffic status of the city with regards to:

  – key road events (e.g. road works);
  – roads' level of service, i.e. travel time per road segment, useful to calculate the minimal path.

  After receiving information from 'Cisium', the travel planning engine can calculate alternative delivery routes and send them dynamically to On-Board Units.

- finally, the platform is designed to be integrated with the bookable bays reservation system – described in the following section – providing guaranteed loading/unloading bays availability at presumed arrival time according to the shipment optimized plan (which, in turn, may be dynamically re-planned in case of substantial delays).

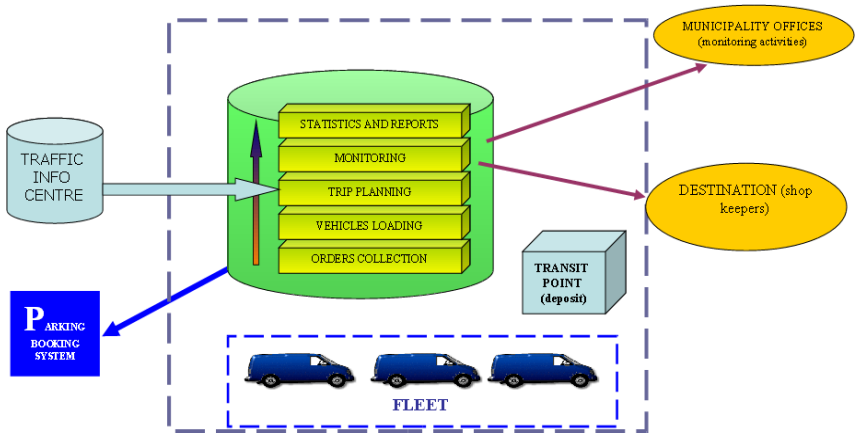


***Figure 3 – 'Van Sharing' architecture***

The Van Sharing system is already in place:

- the platform has been implemented and tested, including the travel planning engine which is active for a good extent of its functionalities;
- one logistic operator ensures the service is active to potential customers, although volumes are still kept very low until the end of the pilot phase. Service kick-off, though, has allowed extensive testing of the overall process and it verified the effectiveness of on-board units both at technological and functional level. All administrative documentation is already in place to allow more operators to join the consortium;
- integration with 'Cisium' is active, even though dynamic re-routing is used only in case of event detection (e.g. when the assigned route is blocked or strongly congested), even when this is reported directly by the drivers that operate on the field, while the road level of service input is still not used as input for the traffic planning engine based on the evidence that, in an historical city centre with narrow streets, the possibility to find alternative routes is relatively low;
- integration towards the bookable load/unload bay system, which takes the form of a web service allowing data exchanges between the two systems, has been developed.

The Van Sharing service is actually already being proposed to the market with a dedicated web-site already fully operative which presents the initiative in a clear and engaging manner and constitutes a link to register and access the service:

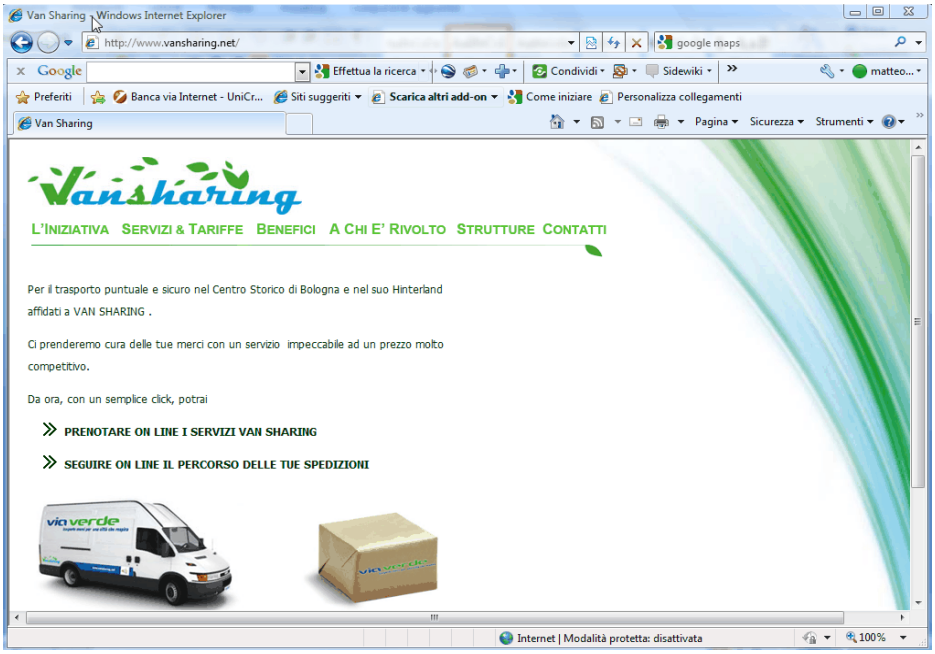


***Figure 4 – 'Opening screenshot of the Van Sharing web site***

3) <u>The 'bookable loading bays' system</u>

Bookable loading bays are being realized and made available to the Van Sharing platform by ATC, the public transport company of Bologna. Even if one of the main purposes of this initiative is to offer a service interface to the Van Sharing system to allow bays reservation to be fully integrated in Delivery Plans' elaboration performed by Van Sharing platform, due to a precise choice of the local political authorities, the software platform is open also to general registered users. This allows non-Van Sharing operators the opportunity to book a time slot for usage of the bays, provided that they are equipped with low environmental impact vehicles. As long as users are registered and have installed the identification RFID device on their vehicle, they can book parking slots accessing the system via web, SMS or call-centre.

The complete bookable bays system in regime phase will consists of:

- a Logistic Central, with responsibility to manage and operate the bookable bays system;
- a set of 14 load/unload bays, located in 12 strategic spots along the T zone, that have already been planned for implementation within a medium-to-short term, while current analysis is performed to allocate further bays up to a total of around 20 sites in the city centre restricted area. The objective is to cover the widest area subject to frequent load-unload activities with bays within maximum 300m walking distance. Up to date, two bays have been already equipped and made available for the system. In addition, 8 pull-in areas following the methodology of a specific French study have been selected for the introduction of the possibility to be booked in advance, for those companies which adhered to the Van Sharing Consortium: thanks to an algorithm, which considered different parameters such as the distance of the pull-in areas from the shops and the number of shops close to the area, this study assigned to every pull in area a 'preferability coefficient', used to identify the most useful pull in areas in Bologna. The first 8 pull in areas detected by this study, have been selected for the introduction of the possibility to be booked in advance, for those companies which adhered to the Van Sharing Consortium. The Municipality of Bologna is waiting for the authorization to install the booking stations in the historical centre from the Superintendence of the Cultural Heritage.
- RFID devices, that are assigned to logistic operators and general users following initial registration, to be installed on the vehicle (that must respect a series of low environmental impacts parameters) to allow its recognition when it occupies the loading bay area;
- a hardware recognition system per each bay, which allows entitled drivers to access the bay. The recognition system of a bay receives information regarding the bay reservation schedule via the GPRS network. Once the driver has entered the load/unload zone and has parked in the reserved bay, the recognition system UHF transponder identifies the RFID of the vehicle, thus confirming that the usage of the bay is authorized. Unauthorized use is discouraged at first with a warning; if the abuse persists, it is notified to traffic wardens via SMS.

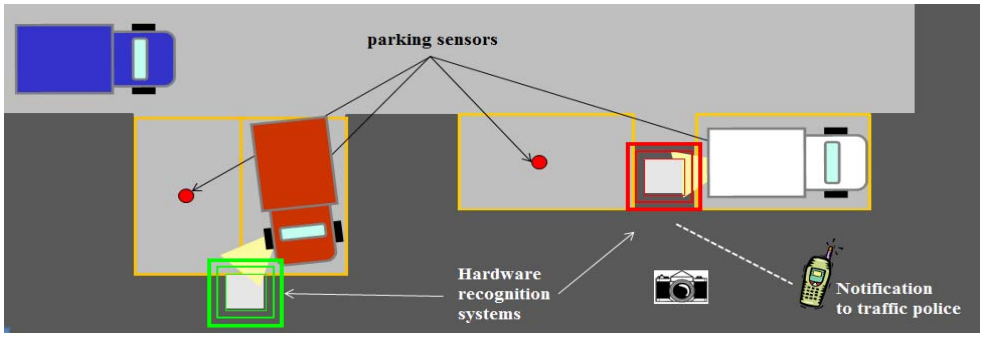

***Figure 5 – Operational principle of the hardware recognition system***


***Figures 6,7 – On road bookable loading bay***

***Figures 8,9 – The system recognise the vehicle and parking is allowed (left) or not (right)***

Within the CIVITAS MIMOSA project, under the measure '7.1 (BOL) City Freight Delivery Plan', some actions have been put into practice to support and improve the 'Van Sharing' system. In collaboration with the Optit company, an exhaustive RTD analysis field tests and simulations have been conducted to verify the effectiveness of the Van Sharing system and the benefits that could be derived from its full deployment.

It accounted for two different methodologies, which configured two separate tests.

**Test. 1**

Test 1 reported the experimental evidence of a practical field testing of the Van Sharing System. This test considered the actual case that took place in an ordinary day where a series of delivery orders were posted by three different medium-size operators (O1, O2, O3), subdivided in a each set of delivery orders (D1, D2, D3) for a total of 26 orders.

The case compared a 'before case', where three different operators perform independently their set of delivery orders (supported by a simple route optimization tool), with an 'after case' where the same set of orders is performed by Van Sharing vehicles, using the platform to conduct route planning. This experimentation was effectively demonstrating in a real case context the positive impacts of orders' aggregation and, in general, of vehicle routing optimization executed by Van Sharing travel planning engine, to accomplish the same deliveries, in terms of:

- overall time spent;
- overall distance traveled;
- number of accesses to the city centre.

In the case considered, all operators have the same headquarters; furthermore, there was a single picking point for all deliveries, located at the outskirts of the city of Bologna, that represents, de facto, a very relevant Transit Point in the Bolognese inter-modal network. For each route the first stop had to be at the picking point P, which happened to be the loading site for all of the 26 orders.

| route data | route $R_1$ | |
|---|---|---|
| overall distance travelled | 49,00 | km |
| whereof in the city centre | 12,80 | km |
| overall trip duration | 1h 23 | |
| whereof in the city centre | 0h 36 | |
| approximated total unload time | 0h 45 | |
| total shipment time | 2h 08 | |
| total time spent in the city centre | 1h 21 | |

***Figure 10 – Test 1: route planning* output**

The following table illustrates the results of comparison between before (three different operators perform independently) and after solutions (the same set of orders is performed by Van Sharing vehicles using the actual platform to conduct route planning). As expected, by reducing the number of shipment trips necessary to accomplish the entire orders set, have been obtained relevant reductions of overall trip

duration and overall covered distance. Furthermore, we also obtained some reduction in distance covered/time spent in the city centre.

| | | before case solution | after case solution | percentage comparison |
|---|---|---|---|---|
| number of accesses to the city centre | | 3 | 1 | -66,67% |
| overall distance travelled | km | 146,35 | 72,00 | -50,80% |
| whereof in the city centre | km | 37,75 | 35,80 | -5,17% |
| overall trip duration | | 4h 05 | 2h 28 | -39,59% |
| whereof in the city centre | | 1h 44 | 1h 41 | -2,88% |
| approximated total unload time | | 2h 10 | 2h 10 | |
| total shipment time | | 6h 15 | 4h 38 | -25,87% |
| total time spent in the city centre | | 3h 54 | 3h 51 | -1,28% |

***Figure 11 – Test 1: comparison between before and after solutions***

**Test 2**

Test 2 consisted in a desk simulation, supported by a generic route optimization tool, to account for a more complex mix of pick-up and delivery points and introducing van capacity constraints, which confirmed the benefits of freight flow aggregation. The simulation focused on a slightly more complete example, where more variables were considered, among which:

- the vans saturation levels;
- a wider range of operators, with two relatively structured operators ($BIG_1$ and $BIG_2$ owning storage facilities and vans of different capacities) and 3 smaller operators (A, B and C), whose vans had a more limited capacity and with no storage space (hence performing same-day-pickup-and-delivery shipments);
- a more heterogeneous mix of deliveries, pickup and pickup-and-delivery shipments had to be performed.

For each of the above mentioned operators, characterization were found for what concerns:

- the location of operational base;
- the shipments to perform, in terms of pickup location and delivery location addresses;
- the description of followed shipment route, in terms of:
    - route map;
    - route progress (visit order and load progress);
    - route analysis.

The following table underlines the differences occurred in test number two, between before case solution and after case solution with Van Sharing Platform optimization.

| | | before case solution | after case solution | percentage comparison |
|---|---|---|---|---|
| number of vehicles accessing the city centre | | 5 | 2 | -60,00% |
| overall distance travelled | km | 125,20 | 102,80 | -17,89% |
| whereof in the city centre | km | 33,55 | 23,50 | -29,96% |
| overall trip duration | | 3h 35 | 2h 42 | -24,65% |
| whereof in the city centre | | 1h 39 | 1h 05 | -34,34% |
| approx. total load/unload time | | 2h 40 | 2h 40 | |
| whereof in the city centre | | 1h 30 | 1h 30 | |
| total shipment time | | 6h 15 | 5h 22 | -14,13% |
| total time spent in the city centre | | 3h 09 | 2h 35 | -17,99% |

***Figure 12 – Test 2: comparison between before and after solutions***

From the two tests done by Bologna's Municipality the importance of a structured system which allows a more efficient service for delivery became clear. The results underlined how important the effects of a Technological Centre for the optimization of goods deliveries would be, allowing a reduction of 60% of number of vehicles accessing the city centre (66% in test one), of 25% of shipment time for the first simulation, of 14% in the second case and a sensible decrease of overall distance travelled.

# Lessons learned

The first results achieved showed much resistance among small operators to create a consortium. Indeed, the Consortium (that should comprehend freight operators and goods dealers) has seen few members joining. This problem is common also to other European cities that are trying to implement this kind of measures.

According to technicians from the Municipality and private operators feedback, the 'Van Sharing' system implementation registered a weak market impact till now for different reasons:

- from the small freight operators point of view, they were afraid to lose their market shares (because of the sharing of clients) and to lose revenues (the registered volumes don't optimize the vehicles capacity). Freight distribution operators were not attracted by the Consortium;
- from the potential customers (dealers) side, they incurred in bigger costs for deliveries in the start-up phase (+30%); this was because there was no critical mass, the minimum beyond which it was possible to obtain economic benefits;
- distrust toward the scheme proposed - the added value of the consortium was not well perceived whereas the current service performed by small operators was very flexible and appreciated. This was because the van sharing created transshipment points in order to optimize deliveries. The result was that the consortium caused a decrease of the kilometers traveled for every delivery to provide the same services but caused also less revenues for freight operators.

In short, the operators are reluctant to lose some of their autonomy, regardless of the economic advantages resulting from the Consortium.

The evaluation results didn't say that the measure was not appropriate or well-conceived, but only that the measure was not able to involve the operators in the participation to the Consortium. Despite the few adhesions to the Consortium, from a methodological and technical point of view the measure has correctly been implemented. The RTD tests showed that the technological transit point would work and would have good effects from the efficiency side that represented the objective of the intervention. But the market effects and the peoples/companies 'psychology' was overlooked when analysing the possible effects. Municipality of Bologna is currently coping with this problem in order to make clearer the benefits of the participation in the Consortium, following two integrated directions:

- further promotion of the new technologies and the new systems of rules: the efforts in communication and promotion are necessary in order to study the possibility of such a new technology, a new opportunity and a new plan for deliveries into the city center. That means an intense work of consultation of small freight operators in order to finalise economic agreements;
- new traffic management regulations: according to the guidelines provided by the new Mobility City Councilor, freight operators could be subject to new regulations in terms of access the city centre. Such measures will be introduced in the context of a new project in the pipeline to further extend the pedestrian areas in the city centre, whose guidelines have been presented to public last December 2011 ('Di nuovo in centro – In the city centre again' project). New restrictions for freight operators access to the centre are foreseen within this project, such as the possibility to circulate only in specific time slots and to pay more to access to the centre. A first implementation of the new policy has been introduced in May 2012:

during weekends and holidays, lorries can access and serve the very central ‘T’ area only for three hour in the very early morning.

In this sense the Van Sharing Platform should become more convenient and this could represent a good incentive to adhere to the consortium in the future.

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