# Freight Urban RoBOTic vehicle

## Reporting

### Project Information

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### Executive Summary:

Drilling in thick ice: lessons from the past
The project proposes novel concept architectures of light-duty, full-electrical vehicles for efficient sustainable urban freight transport and developed FURBOT, a vehicle prototype, that factually demonstrated the performances expected. The main paradigms of the new vehicle design are: energy efficiency, sustainability, mobility dexterity, modularity, intelligent automated driving and freight handling robotization. The design approach was oriented to harmonically integrate the new features into the vehicle architectures, based on the knowledge of advanced technologies in the field of the electric power supply and drive trains, in wheel motors, lightweight high strength materials, perceptual systems and intelligent controls. FURBOT presents new frame-platform structure, new efficient power supply and drive train layout including X-by wire transmission, new robotic tools for freights manipulation, new internal state sensorial/monitoring system and new perceptual/automated control functions. The vehicle architecture is conceived modularly. The payload is considered packaged in FURBOT boxes or ISO pallets. Attention has been paid to the modularity and standardization of components as well as to safety issues. A great effort has been devoted to improve the energy efficiency of the system by exploiting different aspects: a new power train layout integrated in the chassis; new battery and energy management system; last generation lightweight, direct drive electric motors; regenerative braking on the four driving wheels; reduced mass; attentive use of power addressed by the driver assistant or operating within the automated driving module. The FURBOT represents a transport agent that can be used by alone but that better exploits its power if used in a fleet offering a new sustainable and very adaptable (evolvable) urban freight transport system. Freight is directed to receivers, who could be commercial activities or consumers (e-commerce). In the proposed freight transport system, at the UDC, packages are consolidated into FURBOT boxes, according to their dimensions and to the receivers’ addresses. Each box is assigned to a temporary unloading bay and it is delivered there by a FURBOT vehicle. The receivers are in charge of collecting the packages in the unloading bays. A methodology to optimize the transport system performances has been proposed: it allows to assess: the number of boxes, their temporary unloading bays, the fleet dimension and the vehicle routing for a given scenario.

Project Context and Objectives:
In urban areas, freight is directed to receivers, who could be commercial activities or end consumers. Regarding freight directed to commercial activities, its transport depends on the production system. The increasing value of delivered products requires rapid transportation because companies want to reduce the interest costs bound up in store and inventories. There is the need to reduce store costs since store areas in urban centers are expensive. This leads to the Just-In-Time (JIT) delivery principle, which involves more frequent delivery of materials at the right time and at the right place in the production process. Regarding freight directed to end consumers, this is the result of on-line shopping. E-commerce enables businesses to sell their products and services directly to consumers without establishing a physical point of sale. While some products can be delivered digitally to households, most products purchased online ultimately must be transported to the end-users in the physical world. The receivers are often single people, especially students and time-poor professionals, who purchase products online but are not normally at home at daytime to accept deliveries. This increases the number of trips with a low load factor: 12% of deliveries have to be delivered a second time and 2% of the goods cannot be delivered (Visser, Nemoto, Browne 2014). An efficient, rapid and reliable delivery system is essential for gaining
In urban environments, the high fragmentation of demand (i.e. numerous independent retail outlets located in a city centre) combined with the fragmentation of supply (e.g. numerous wholesalers and other suppliers using their own vehicles to make just-in-time deliveries) results in a high number of urban freight transport trips with a low load factor of vehicles. These problems are further increased by e-commerce. The problems related to urban freight deliveries will become even more critical in the next future since on one hand urbanization will bring more consumers in urban areas; and on the other hand home deliveries will increase since e-commerce trend is growing despite the crisis.

Home delivery due to e-commerce has different aspects in common with city logistics. However hardly any of the providers of city logistics services considers that home delivery can be part of the city logistics concept. (Visser, Nemoto, Browne, 2014). Home delivery concerns both delivery within urban areas, relatively short distances per trip and in general with smaller freight vehicles, van or light trucks. Important differences between home deliveries and deliveries by city logistics are: the delivery size (one package versus more deliveries per address), the location of the address (residential address versus shopping center). The FURBOT project integrates deliveries due to e-commerce into the city logistics. The idea is to have specially designed modular boxes: we have two typologies of FURBOT boxes: A) boxes that contain packages for only one receiver: these are without compartments and could be used to ship a larger order to a shop and would be deposited very close-by and B) Multiboxes which internal space is divided into modular parcels: each parcel accommodates packages for one receiver, for instance private e-consumer, and would be deposited in a temporary unloading bay, where receivers are in charge of collecting their packages. For both the typologies, the box footprint has the euro-pallet dimension and the bottom parts of all the FURBOT boxes have the euro-pallet design in order to be operated with the standard movement and handling tools.

The FURBOT delivery system is therefore based on the pick-up point concept. New solutions based on the pick-up point concept (including Pick&Pay, Pack Stations and Bento Boxes) have been recently proposed for e-commerce deliveries in order to reduce the capillarity of last mile freight distribution, concentrating packages in fixed points and asking the receivers to collect them. This last aspect provides flexibility for recipients who recover their packages when they want.

Instead of considering fixed locations for the pick-up points, in the FURBOT transport system the number and the localizations of the pick-up points, where the Multiboxes are unloaded, are daily assessed by optimization according to the daily freight transport demand. This leads to two main consequences. Firstly, the distance the receivers have to walk for collecting their packages is minimized. Secondly, the impact of the FURBOT boxes on the land occupation is minimum, as the boxes are placed only where and when required. Moreover, the unloading of the FURBOT boxes in the temporary bay is automatic and this reduces dwell times.

The FURBOT delivery system is a cooperative freight system. Cooperative freight systems integrate the resources of the cooperating companies to optimize the economic benefits. The main benefits of the techniques are (1) properly increasing delivery trip loads; (2) reducing unnecessary trips, as well as pollution and costs; (3) reducing service area overlaps; (4) increasing service quality and company profits (Tseng et al. 2005). Cooperative freight systems need logistic platforms (UDC - Urban Distribution Centre) close to the city centre, within the freight village area. The goods are reorganized in the freight village...
before being delivered to the urban areas. This system can reduce the required number of vehicles used for delivery and handling. Cooperative freight systems are the ways which could be expected to solve urban freight transport problems.

In a number of areas, low emission zones are introduced, mostly shopping areas with city centres. This affects traditional urban freight transport. Trucks are banned in a number of residential areas. But there are no restrictions for lighter trucks and vans.

The FURBOT project proposes light duty full electrical vehicles for efficient sustainable urban freight transport and developed a FURBOT vehicle prototype to factually demonstrate its performances. The main paradigms of the new vehicle architectures design are: energy efficiency, usability, sustainability, modularity, mobility dexterity, intelligent automated driving and freight handling robotization.

It is clear that the modern reality requires a change of paradigm for goods delivery. A sustainable freight transport has to fulfil all the following objectives (Behrends et al., 2008):

• to ensure the accessibility to all categories of freight transport;
• to reduce air pollution, green house gas emissions, noise to levels without negative impacts on the health of the citizens or nature;
• to improve the resource- and energy-efficiency and cost-effectiveness of the transportation of goods, taking into account the external costs;
• to contribute to the enhancement of the attractiveness and quality of the urban environment, by avoiding accidents, minimising the use of land and without compromising the mobility of citizens.

To contribute to the solution of the societal needs, the project proposes the following main S&T objectives: A) the development of a radically novel vehicle: the dominant paradigms have been energy efficiency, low cost and high efficiency; B) a paradigm change in user service yielding an efficient organization of freight transport inside the city.

Project Results:

The project focuses on the development of a next generation urban freight transport vehicle, FURBOT, and a sustainable urban freight delivery system based on a fleet of FURBOT vehicles. The system will increase freight mobility inside cities, including restricted areas inaccessible to existing vehicles, while guaranteeing the safety of users and non-users and maintaining a negligible impact in terms of environmental and acoustic pollution and land occupation.

The scientific and technological (S&T) advances towards this goal which have been achieved in the project are: the design of vehicle architectures, the construction and street testing of one prototype FURBOT unit, and the development of a simulation/optimization environment for the logistics set-up and evaluation of different strategies to efficiently manage a FURBOT vehicle fleet for freight delivery in a given urban environment.

More precisely, the following major S&T objectives have been pursued.

A– The development of a radically novel vehicle. The dominant paradigms have been energy efficiency, low cost and high efficiency.

The vehicle comprises a chassis frame module with four suspensions, two wheel motors, steering; an outer body assembled over the body frame; two fork units, identical and coming with all services and
subcomponents (all modular as well); a driver cockpit comprising screens, stick, pedals.
A number of new-concept vehicle modules (sub-assemblies), considered critical for the adopted approach, have been developed. Novel, breakthrough solutions are proposed for the modules listed below.

Agile chassis-frame module
Great attention have been devoted to the optimization of the vehicle layout in order to increase the freight-payload to vehicle-weight ratio and improve crashworthiness. Tests have been performed in virtual environment before the manufacturing phase, and on-street real test site have been also performed for the prototype.
The FURBOT chassis has been designed in order to meet specific requirements: first of all, it must allow the transportation of two boxes, each weighting 450 kg (for a total load of 900 kg); moreover, it must be light if compared to the maximum load carried on board, to reduce as much as possible the total weight of the vehicle. Naturally, its mechanical resistance must be ensured during the driving for any possible scenario. The highest part of the volume is intended to host the load. The front side has been designed to allow the positioning of the seat for the driver and on the rear side the space for the allocation of the battery has been realized.
It is worthy to point out that the structure of the chassis is not symmetric with respect to the longitudinal axis (the driving direction). This is due to the fact that the loading takes place on the right side of the vehicle, so the left part turns out to be stiffer than the right one. This asymmetry is not an issue neither in terms of dynamical stability nor as for what concerns the mechanical integrity. Globally, the structure of the vehicle turns out to be compact and suitable for the circulation in urban environment. Compared to the maximum load which can be transported, the chassis turns out to be light: its total weight (without including the suspensions) is approximately 200 kg.
This novel architecture, characterised by a light-weight agile frame allows a better usability in urban environment and improves intrinsic stability and safety.

Adaptive robotic module
For improving the functionalities of the freight handling services, a new robotic device is developed and two of them are integrated in the platform of the vehicle. The architecture and design is especially suitable to the service tasks of cargo handling, with minimized mass and degrees of freedom, thus simplifying the control system and allowing for an intuitive Human Machine Interface (HMI). The box/pallet loading/unloading tasks are performed by moving the whole box/pallet to and from the chassis-frame, so this operation can be done very quickly. The main features of the robotic module are: (a) full flexibility and ability to handle (in particular load and unload) automatically the freight boxes; (b) automatic ability to determine the mass and inertial properties of the boxes (by reading the RFID tag) and to optimize accordingly the handling operations.

Innovative freight modules
The vehicle layout enables the transport of: the Euro pallet, the Multibox, the Solid box and the Isolated box. All the boxes have the bottom part equal to the bottom part of the Euro pallet. The Multibox, the Solid box and the Isolated box have been manufactured and the bottom part is made up of a welded frame structure made of aluminum profiles. The EURO pallet, the Solid box and the Isolated box contain freight addressed to only one receivers, for instance a commercial activity. The Multibox contains freight
addressed to many receivers, for instance e-shoppers. Details about the freight boxes are provided in the following.

The Multibox has 22 parcels, each one accommodates packages for one receiver and can be opened by an access code. The Multibox has a mirror-like arrangement; it consists of 11 parcels on each side. Section 1 includes parcels from No. 1 to 11, and Section 2 includes parcels from No. 12 to 22. Sheet metal boxes are inserted into the frame from both front ends. These provide the space for placing the packets. The side walls and the top wall of the Multibox are covered over and sealed by aluminum sheets. The front ends of the Multibox are provided with doors, swivel mounted on hinges. The individual parcels are provided with a skirting edge in the front which provides a sealing area when the door is closed. On the inside of the door there is a lock placed under a cover. From the front view the Multibox is divided into a top, middle and bottom section. The top section is made up of three identical parcels with dimensions 300x340x370 mm. Two of these can be joined into one by removing the flexible partition. This will make a parcel sized 300x700x370 mm. The middle section is made up of four identical parcels with dimensions 140x450x370 mm and a space with the control panel. This space also holds the battery, the control system and the Multibox electrics. The bottom section is made up of four identical parcels with dimensions 440x540x370 mm. By removing the flexible partitions it is possible to join pairs of parcels horizontally. This will result in having two parcels sized 440x1110x370 mm.

A relevant terminal is appointed to each section. The two terminals are used for the communication of the receiver with the control system. The terminal consists of a digital LCD display and a keyboard. The keyboard is determined for entering the access code. The display is determined for displaying the relevant text messages.

After entering the correct access code the control system issues the command for opening of the relevant parcel. The relevant electromagnetic locks are released for the time necessary to open the door. Following collection of the packet the receiver pushes the door shut and the door is again blocked by the spring in the latch.

The Solid box is manufactured from bent steel sheets welded into the required form. For purpose of increased toughness the sheets are reinforced on the side walls and on the bottom by extra pressing. In the top section the Solid box is provided with elements to be exploited for possible stacking of Solid boxes, or for handling of Solid boxes by a crane using chains or webbing slings.

The Isolated box is a solid steel box of construction similar to the Solid box, but provided with and internal jacket. The space between the internal jacket and the external steel box is filled with insulating material. On top of that the insulating box is equipped with an outer insulated cover with jacket-like construction that can be opened.

Clean and efficient power module

The FURBOT vehicle is electrically powered. The electrical power of the battery is divided in two ways: the control power for the control systems and the high power for the power systems. Each way must be protected by suitable fuses and activated by separated circuits with protections.

As battery voltage 96V was selected as a compromise to have reasonable amps in the power circuits for the given 15 kW max traction power and available motors and driver hardware on the market. As maximum power requirements were around 19kW and energy storage had to be 20kWh, we needed a battery system that would be able to provide 96V, 200A. The final decision was to use Lithium-polymer batteries. This technology is available at the market and has been tested for some years, having a good relation of specific energy and energy density and a higher specific power (W/Kg) than the Lithium-ion
batteries; they can deliver up to 2.5 times the power than a conventional lithium-ion battery. With this technology we could be able to store 20 kWh with peak power up to 40 kW.

The electrical architecture defines the way in which all components are connected in order to assure safety, power consumption and communication between all the modules. The first safety issue has to be the disconnection of the battery system. This feature has to be activated in case of a critical error such as a crash or a battery failure. It is done by a main relay, managed directly from the Battery Management System than can activate this option with its own inputs or with some messages from external systems. Once any of these signals has been activated the entire system disconnected and a hardware reestablishment of the system is needed. The second safety issue regards mobile parts. In case of emergency related to the movement of the Furbot as a malfunction in traction motors, the forklift system or any other situation, an emergency relay is activated, disconnecting all the mobile parts and high current devices. The control system of the Furbot will be still working in order to determine the error and to be able to reset the system or solve the problem.

The BMS consists on a single PCB with a CAN communication node to send information about the battery system and to receive information about the overall situation of Furbot. It also has LIN communication with the balancing system to receive information about cell packs status. An overall summary of BMS features follows.

The balancing system is the responsible for the equalization of charge of the cells in the battery packs. The Furbot balancing system can perform both active balancing and passive balancing.

The packaging of the power system consists in a closed box, installed at the back of the Furbot. Due to its high volume and weight, it has to have a proper structure for maintenance services. The box can be extracted and opened to access to the cells and circuitry in case.

A datalogger is developed. It is an independent hardware that collects all the information from CANBus and stores all the information in a non-volatile memory. With the data collected from all the devices in the Furbot, a study about performance and use of the vehicle can be done. The datalogger will include an accelerometer, inclinometer and temperature sensor that, along with the information from the power system (current, voltage, etc.) could determine power needs and autonomy depending on the usage of the vehicle (slope, speed, acceleration).

Driver assistant module and automated driving

Driver assistance systems have been developed in the FURBOT project: they concerns: localization, emergency braking and parking and manoeuvring assistance. The vehicle could be driven in two different control modes called “driving” and “parking” modes. The “driving” mode is used to move from one place to another quickly, while the “parking” mode allows a precise and smooth control of the vehicle, necessary, for instance, during a parking manoeuvre. Indeed, the maximum speed is limited according to the specific mode: in the “driving” mode is 22 km/h, while in the “parking” one is 5 km/h. The driver interacts with the vehicle in a different way depending on the chosen control mode. In the “driving” mode, the driver uses the right pedal for the throttle, the left one for the brake and the joystick for the steering. The brake is in two levels: for the first 50% span it brakes electrical, and for the rest it brakes on the hydraulics. Instead, in the “parking” mode, the driver uses the joystick both for the throttle, brake and steering. The left pedal could be still used as brake and emergency brake like in the “driving” mode.

The FURBOT vehicle is provided with automated assistance during the box loading-unloading process. Specifically it consists of: (1) Identification of the box using perception assistance (2) Localization of the vehicle with respect to the freight box, (3) Planning of the trajectory to approach to the box (4) Finally a
routine to load the box is performed. During the automated handling of the box, the safety responsibility goes to the system; the goal is therefore to ensure safety during any automation stage by using obstacle detection algorithm.

Special attention has been given to the obstacle detection and tracking, as well as the collision risk assessment. In order to help the driver to accomplish his mission, a precise localization is provided with a basic GPS, as well as a map of the environment. This map-matching function is a part of the assistance systems that is displayed and provided by the graphical HMI dedicated to the driver that has been specifically designed.

Body embedded sensorial system:
the Furbot vehicle is equipped with many sensors, in order to perceive its environment and to localize itself. A communication antenna allows the communication with the supervisor, a GPS provides the approximate absolute vehicle localization, a camera allows environment monitoring, two lasers, proximity sensors and an odometer allows box and obstacles detection, good positioning regarding box position and orientation and speed estimation. RFID allows box identification.

Laser impacts are segmented in order to detect objects and they are projected on the image to inform the driver (via HMI). The fusion of data coming from the camera and laser sensors implies the use of a very precise calibration process.

B – A paradigm change in user service yielding an efficient organization of freight transport inside the city.
An optimization methodology has been developed for reducing the FURBOT delivery system overall cost. Every day the proposed methodology allows to assess which are the number of Multiboxes, the fleet dimension, the Multibox consolidation and the FURBOT vehicle routing that minimize the system cost, given the actual freight transport demand, the road network and the delivery time window. The daily system cost $S$ has two components: the user cost and the operator cost. The daily user cost is a function of the overall distance travelled by receivers in a day to collect their packages at the unloading bays. The daily operative cost is a function of the overall distance travelled by FURBOT vehicles in a day, of the fleet dimension and of the number of boxes. Simulated Annealing (SA) resulted suitable for approaching the problem. The methodology has been published in: Cepolina E.M. Farina A.,"A new urban freight distribution scheme and an optimization methodology for reducing its overall cost",2015, European Transport Research Review, Volume 7, Issue 1, 2015.

The methodology recalls two subroutines:
1. A subroutine to resolve the Multibox consolidation problem (Problem 1).
2. A subroutine for consolidating the FURBOT vehicles with boxes and for routing each FURBOT vehicle (Problem 2).

Problem 1: Multibox consolidation
The problem we face with is the daily clustering of the packages at the UDC into a given number of Multiboxes. To each cluster, and therefore to each Multibox, an address is assigned, which is the “centre” position of the addresses of the packages within the cluster. Among all the possible clusters we select the ones that minimize the distances the receivers have to walk for collecting their packages (and therefore the distances from the addresses of the packages to the cluster centre). The cluster centre will be the unloading bay of the box. Actually, each urban area has a list of possible places that can be used as unloading bays. These places should be accessible from the FURBOT vehicle and the receivers, and the
impact of the FURBOT box, temporary placed there, on pedestrian flows and vehicular flows, should be minimum. We have other constraints to our problem, one is related to the box capacity and another is related to the maximum distance the receivers can walk (in order to collect their packages in the box). The procedure has been published in: Cepolina E.M. “The packages clustering optimisation in the logistics of the last mile freight distribution”, 2016, Int. J. Simulation and Process Modelling, in press.

Problem 2: the FURBOT vehicle routing problem

Once the boxes have been consolidated in a UDC, all the boxes have an assigned unloading place that is the unloading bay, in case of a Multibox, or the commercial activity’s address in case of EURO pallet, Solid box or Isolated box. Each FURBOT vehicle has a capacity equal to 2 boxes. The problem is to decide which boxes should be loaded on a given FURBOT vehicle, taking into account the position of their unloading places. For each vehicle, then we have to assign the order for the stops (which box should be unloaded first) and a route from the UDC to the first stop, from the first stop to the second stop and from the second stop to the destination UDC. The goal is to optimize the travel time related to the delivery trips, from which the number of required FURBOT vehicles depends, since the freight delivery should be completed in a given time window. This problem has been faced considering two cases:

1. the case of only one UDC: in this case, the FURBOT trips are round trips. The FURBOT vehicle routing can be formalized as the Capacitated Vehicle Routing Problem (CVRP), with some modifications, and Genetic Algorithm is used to get the optimization solution. The procedure could be applied also to the case of multiple UDCs with independent fleets and independent freight transport demand (shipping companies work disjointly). The procedure has been presented at Transportation Research Arena, 2014 and has been published in: ISTE: Volume 2 - Towards Innovative Freight and Logistics, Coordinated by: Corinne Blanquart, Uwe Clause, Bernard Jacob.

2. the case of multiple UDCs with independent freight demand and a shared fleet. The peculiarity is that the vehicle trip does not necessarily end at the same departure UDC. Therefore, the trip may begin at an UDC and end at another. This could be highly important because for example vehicles could have a too low battery level to reach the origin UDC, or there could be a balancing issue related to the necessity of a vehicle at an UDC with a lack of vehicles. The procedure has been described in: Cepolina E.M. Farina A.,"A multi-UDC freight transport system involving electric vehicles: an optimization methodology for vehicle routing and its application to a case study", Case Studies on Transport Policy, in press.

Potential Impact:

POTENTIAL IMPACT
The project contributes towards the following societal and economic impacts.

Social impacts

Increased energy efficiency
A great effort was spent in improving energy efficiency both at the level of vehicle and at the level of freight delivery system. As it concerns the vehicle, long drive tests have been done to verify the battery life. The vehicle could drive up to 60 km with a full battery charge, when no loading/unloading operation was performed. On average, for one kilometer travel, the battery level decreases of from 0.6 to 1 percent, while for one loading/unloading operation a 0.5 percent was consumed.
Increased system efficiency
As it concerns the delivery system, the system performances are expressed in terms of: the average load factor of FURBOT boxes, the maximum and the average distances walked by customers to collect their packages and the reduction in the number of trips necessary to perform the delivery operations. The average load factors of Multiboxes in all the simulated scenarios (Genoa historical city centre and old Barreiro) are higher than 90%. Because the load factor of FURBOT vehicles is almost always equal to 1 as they always carry two boxes, it is the boxes load factor that should be compared with that of vans currently performing freight distribution in urban city centers. The average load factors resulting from simulation are good since recent regulations of load factors recommend a load factor of at least 70% (by weight or volume).

The number of required trips per day with the FURBOT system results, by simulation, lower than the current number of daily accesses of freight vehicles to the historical city centres and no empty running occur.
The maximum distance walked by customers results between 300-400 metres and the average distance is lower than 50 metres for the simulated scenarios.
The space occupancy of FURBOT boxes is also acceptable.
As a result, the FURBOT system highly improves the freight delivery in the considered scenarios.

Enhance transport safety
Transport safety is one of the main issue of these vehicles developed to share urban areas with cars, bicycles and pedestrians. The perceptual and communication systems of the vehicle, the intrinsic stable structure and low velocity are a good basis for safety.

Commercial activity expansion in urban zones
FURBOT gives the opportunity to expand commercial activities in urban zones that are not accessible to traditional freight duty vehicles, including historical centres and green areas without introducing noise and pollution due to emissions, by integrating them well via urban freight transport networks served by FURBOT fleets.

Reduction of CO2, pollutant emissions and noise at least in compliance with EU legislation.
As FURBOT vehicles are electrically powered, the degree of pollution related to freight distribution is relevantly decreased.

Economic impacts
• the FURBOT vehicle will allow the European industries, included SMEs, to gain competitiveness in the market of electric and intelligent vehicles;
• thanks to the modular approach adopted, the new modules such as the adaptive loading device, intelligent driving interface, new power module, can be commercialised stand-alone and can be integrated into future generations of vehicles, maybe scaled in size, or other applications such as warehouses and stores indoor services for reinforcing the competitiveness of the European automotive and transport industry;
• FURBOT concept will also benefit the industrial transportation logistics area that accounts for 400 M€/year (World Robotics, IFR). This promising market is requesting ever more units for the transport of...
smaller freight amounts; moreover the environment these units will work with, will be less and less structured requiring more sensors and intelligence on board. This area has been also considered for exploitation.

- the technology developed will have larger applications, e.g.: - autonomous delivery of parcels based on destination address or garbage collection inside urban areas as well as inside hospitals and campus areas. These applications are in line with the city of the future. The multidisciplinary approach to design will give advantage to European manufacturers in the markets of the future.

Impact on employment

FURBOT results will give business opportunities to European companies of the transport sector creating qualified employment opportunities for production, selling and maintenance of the new electric vehicles. The promotion of this vehicle production will also stimulate the supplier of electrical motors, power store/supply units and related components to invest in human resources in order to offer new green higher efficiency products.

Further employment return will apply to companies that will manage the urban transport services.

MAIN DISSEMINATION ACTIVITIES AND EXPLOITATION OF RESULTS

The overall aim of the dissemination activities was to facilitate the introduction the FURBOT vehicle and of the FURBOT boxes into the mass market as well as to promote the FURBOT transport system in a high number of municipalities.

With workshop formats the exploitation relevant to target groups are directly addressed. Urban freight transport involves many different stakeholders, both those within the urban area that are not directly involved in the freight transport movements (city authorities, residents, tourists/visitors) and the actors in the supply chain. The latter can be categorized according to the demand for goods (receivers), the supply of goods (shippers or producers) and finally the transport of goods (transport operators).

In FURBOT the following sub-groups of stakeholders have been considered and have been invited in the final demo workshop that explained the FURBOT results and benefits to them:

- Receivers: this group includes commercial activities in urban areas and end consumers: for instance e-shoppers resident in urban areas. They need to experience the advantages of the FURBOT freight delivery system, paying attention to cost-benefit relation and to the possibility of receiving rewards. Commercial activities will receive their pallets close to the commercial activity place whilst receivers of small packages will be asked to collect their packages in the FURBOT Multibox in the daily assessed unloading bay, which location minimize the distance the receivers have to cover. With the FURBOT transport system receivers will have a time window for collecting goods addressed to them. The advantage is that they are free to choose the time, within the time window, for collecting their packages and that their packages are unloaded as close as possible to them.

- Transport operators: have a rather rational perspective on the evaluation of the technology as they will primarily try to optimize the cost benefit ratio. Automation during loading/unloading stages, driver assistance, the FURBOT Human Machine Interface help in making the FURBOT vehicle more attractive. Thus, this target group has a special interest in all technologies involved in the FURBOT vehicle.

- City authorities/politicians: they should be more interested on the urban freight transport impact: on the environment, on the land occupation and on the traffic flows. While diversity in the retail sector provided by small and medium sized independent retail outlets offers greater choice for consumers and can be seen as related to the urban freight transport, the location of retail outlets has an immediate impact on the urban traffic flow.
providing wider benefits to society, economies of scale in the provision of freight transport services in all sectors tend to lead to inefficiency in distribution in urban areas: low load factors and empty running; a high number of deliveries made to individual premises within a given time period; long dwell times at loading and unloading points. The innovative FURBOT urban freight distribution scheme aims at reducing the externalities connected with the freight delivery process: it is aimed at reducing the capillarity of last mile freight distribution, concentrating packages in bays and asking the receivers to collect them; it makes use of small electric vans, which have been specifically designed to limit the space occupancy as much as possible and which have been specifically designed with a high level of automation that allows to short the dwell times at loading and unloading points. The show cases of the final demo workshop perfectly illustrated the FURBOT advancements to the press representatives for wide media coverage.

The final demo workshop has been organized on two days in Barreiro, close to Lisbon, Portugal. On the 21st January 2016 a press conference in the Forum Barreiro shopping mall has been organized mainly for the stakeholders involved in urban freight transport: logistic companies, municipalities, the FURBOT EAP, transport engineers, partners involved in other eu projects in the field of electric mobility and freight transport. The main results of the project have been presented as well as the simulation results of the FURBOT freight delivery system in the old area of Barreiro and in the historical city centre in Genoa (Italy). After the conference the FURBOT vehicle and the FURBOT boxes have been presented to the invited stakeholders. A training activity has been performed in that occasion; the training was related to the FURBOT vehicle prototype driving and to the loading/unloading operations. On the 24th January 2016 the FURBOT vehicle and the FURBOT boxes have been presented to the general public in Barreiro, close to the market place. In this occasion many citizens have been trained in driving the FURBOT vehicle and have been instructed on the usage of the Multibox, including the access with PIN codes. All the partners are interested to exploit FURBOT after an industrialization process.

List of Websites:
http://www.furbot.eu/

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