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Towards advanced transport for the urban environment

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Executive Summary

In the future, cities will need of integrated traffic solutions, which provide a more effective organisation of urban transport and require mobility in an efficient, safe and economic way. The goal of the CityMobil project is to achieve these solutions.

In the first subproject of CityMobil, concepts and tools which are developed in the project will be validated and demonstrated in a number of different European cities. Therefore three large-scale demonstrators have been chosen which will present real implementations of innovative transport concepts.

Besides the three large demonstrators, a number of small demonstrations and temporarily showcases will be organised in a handful of European cities in order to demonstrate to audiences and authorities what automated transport could look like in practice and to demonstrate and evaluate certain aspects of this technology.

The showcase vehicles, being fully automated vehicles on the one hand and dual mode vehicles on the other hand, will be developed within the project and brought to a suitable site in a small number of cities.

This deliverable describes the safety assessment process as executed on the November 9th 2009 and February 8th 2010 for the second Advanced City Car showcase, to be organised in Orta San Giulio (IT) in May 2010. The analysis was carried out by representatives of the CityMobil project, responsible for the CityMobil showcases and representatives of the city of Orta, responsible for this event, during one of the preparatory meetings. The document briefly describes the Risk Reduction Method as the used method for this safety assessment. For a more extensive description see [1]. Subsequently the hardware and the system is described, finally the trajectory used for the showcase is described and illustrated. The results of the Risk Reduction Method are reflected in the Risk Indicator tables, dealing with the various aspects such as the built-up area, the potential users and traffic, the vehicles and hardware and the specific conditions of the environment.

Concluding, a number of recommendations for the operation are given. The overall conclusion is that after having taken care of the recommendations the operation of the Orta San Giulio showcase will be safe and no serious incidents are to be expected.

1 GENERAL

1.1 Introduction

The purpose of this document is to introduce the Risk Reduction Method as a suitable and practical method for a simplified safety analysis for showcases and small demonstrations. The Risk Reduction Method was developed in the years 2002/2003 within the framework of the CyberMove [1] project, a European project in the 5th framework program of the European Union.

As an illustration of the method a safety analysis of the Orta San Giulio Showcase has been executed. In principle a safety analysis using the Risk Reduction Method will be carried out on all of the CityMobil showcases and small demonstrations. The Orta San Giulio showcase will be executed in May 2010. The site was visited and assessed on the November 9th 2009 and February 8 2010; the results are in chapter 2 of this document

1.2 The Risk Reduction method

The purpose of the Risk Reduction Method is to establish the safety risks related to the implementation of an automated transport system in an urban environment. The Risk Reduction Method is not meant to be a comprehensive safety analysis method. The intention is to have an indication of safety risks in a very early stage of the planning process. A different, much more extensive procedure exists for the complete safety and certification process needed when an automated transport system is implemented in a city [2].

The simplicity of the Risk Reduction Method makes it excellently suited for the analysis of the safety implications of short duration showcases and demonstrations. The method is used for the first time to establish safety implications of the showcases and small demonstrations carried out in the CityMobil project, an integrated project in the 6th framework of the EU. (www.citymobil-project.eu).

The method analyses risk factors following various angles of view of the showcase setting such as the built-up area, the potential users and trespassers, objects in the neighbourhood, specific conditions of the environment and the used vehicles and hardware. Per aspect a number of general indicators are listed in tables. By a simple expert assessment as to whether or not a certain risk factor is relevant, the seriousness of the risk can be estimated and measures to mitigate the risk can be proposed. The risk is expressed in likelihood of occurrence of an event and the severity of the effect. Where appropriate a further technical analysis will be carried out, for instance to establish the effectiveness of braking systems or obstacle detection systems.

Information about the site and the system can be found in the second chapter of this document. This chapter also contains the risk reduction tables and the results of the analysis in the shape of a list of recommendations that need attention in order to guarantee the safety of the showcase. A formal written reaction on these issues from the parties responsible for the showcase is required.

2 SAFETY RECOMMENDATIONS FOR THE ORTA SAN GIULIO SHOWCASE

This chapter contains the safety analysis of the Orta San Giulio showcase. First there is a general description of the system, a general description of the site and a number of photos, drawings and maps. The following paragraph contains the Risk Indicator Tables. These tables contain a number of general indicators. During the analysis a decision is made as to whether or not these indicators are applicable and if they are, what their influence is. The final paragraph contains a number of recommendations to improve the safety of the showcase. These recommendations are the result of the analysis. They should be followed in order to be assured of an acceptable level of safety.

2.1 General description of the transport system

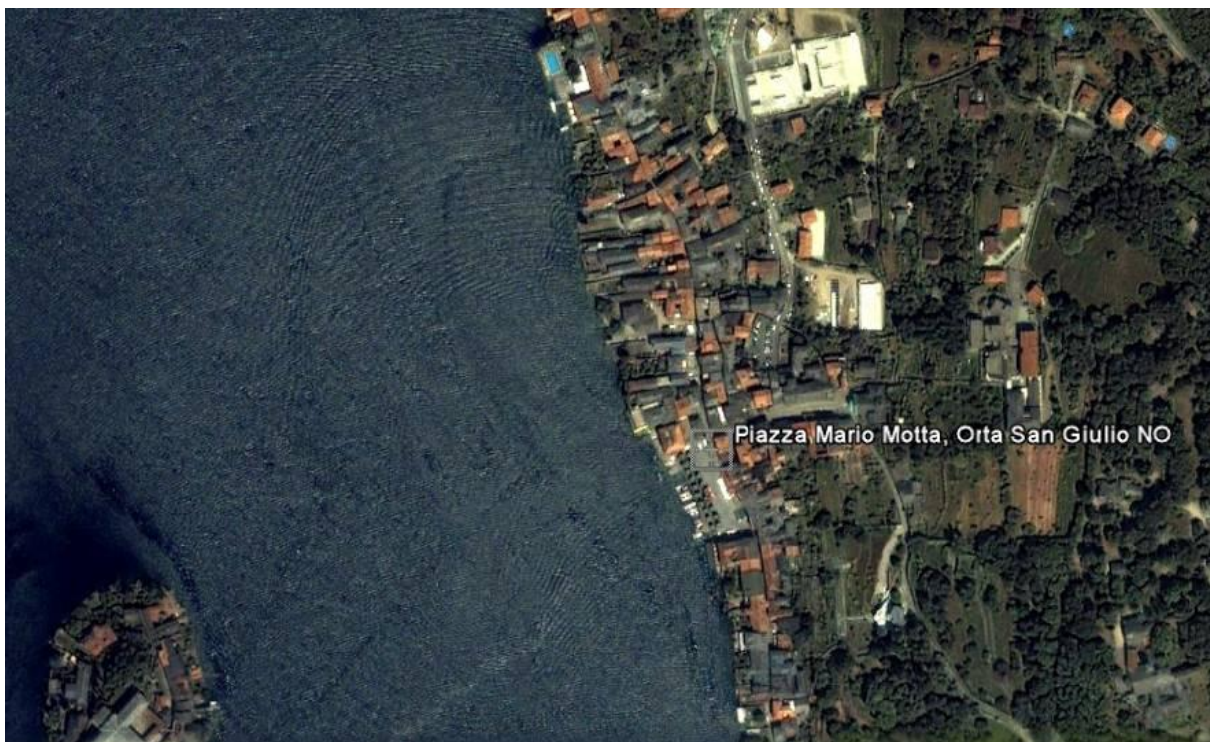
Table 2-1 : Information about the CityMobil Advanced City car (FIAT Panda) hardware

INFORMATION ABOUT THE TRANSPORT SYSTEM	
Vehicles	
Description	FIAT Panda
Specifications	
Mass	1200 Kg
Maximum speed	100 Kmh
Brakes	
Type	Normal production
Specifications	Controlled by a modified Can message
Propulsion	
Type	Electrical
Specifications	<ul style="list-style-type: none"> • 15 kW rated power • 30 kW peak power • 122 Nm peak torque • 2200 rpm base speed
Obstacle detection system	
Type	Laser radar
Specifications	SICK rotating laser
Communication system	
Present?	No
Central control system	
Present?	yes
Type	Compact Rio
Specifications	
Emergency switches	
Present?	Yes
Type	Contact and remote
Specifications	Contact- Inside the vehicle, between the driver and the passenger seats. Contacts on the doors also stop automatically the vehicle. Remote: two types, emergency (cut electric power to the motor) stop (make a request to the control system to stop the vehicle).
Specific safety measures	
Doors present	Yes, car stop if a door is opened, cannot go in automatic mode if a door is open.
Door locks present	Normal production
Specific safety remarks	
Risks	
Other?	

2.2 General description of the site

The site for the Orta San Giulio showcase is a place in the center of the city. People can reach this place only walking or taking a small tourist bus, that leaves every hour. Only residents could enter by car, normally in the morning for freight distribution. However the City Authority will forbid vehicle circulation during the showcase, from 11:00 to 17:00. Bicycles could reach the area but are not commonly used.

Figure 2-1: View of the test site location in Orta San Giulio

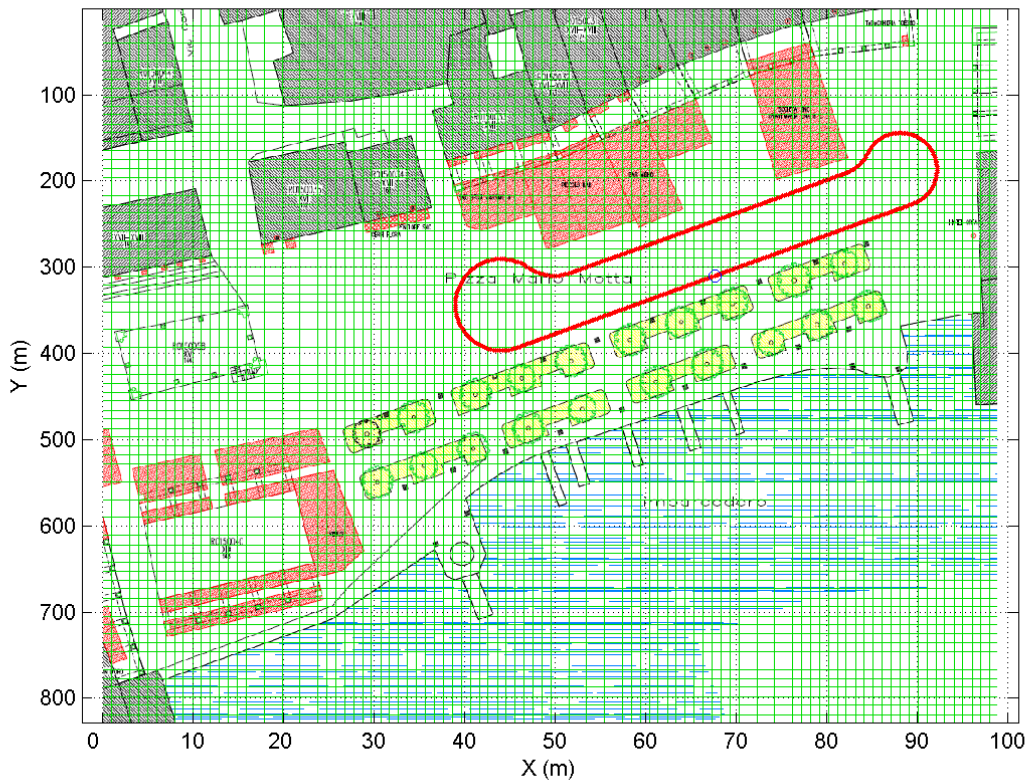


The showcase is in a very busy area. The Piazza Motta is the hystorical centre of Orta and there is also the location to get boats to visit the beautiful San Giulio isle, in front of it . The showcase will start operating at 11.00, since before vehicle could circulate fro freight distribution. The place is very crowded all the day, with only a pause during lunch time (13:00-14:00).

Figure 2-2: View of Piazza Motta



Figure 2-3: View of the showcase path



2.3 Photo's, drawings and maps

Figure 2-4: Advanced City Cars (FIAT Panda)



Figure 2-3: Showcase path (1)



Figure 2-4: Showcase path (2)



2.4 Risk Indicator Tables

The risk indicator tables used in this document are directly taken from the description of the risk reduction method in reference [1]. No changes were made for this particular application.

Table 2-2: Built-up area

Type of build-up area	Risks for users	Applicable
Living	Number of houses/inhabitants: more inhabitants is higher likelihood of incidents	-
	Playing children are weak implies higher impact of incidents	-
	Playing children are not aware of the risks implies higher likelihood of incidents	-
	Animals are not aware of the risks implies higher likelihood of incidents	-
Home for elderly	Elderly are weak implies higher impact of incidents	-
	Elderly move slowly and therefore they may be not able to avoid a collision; implies higher likelihood of incidents	-
Recreation, Nature, Park, Tourism, Amusement park, Airport	Visitors are not familiar with the traffic situation, people aren't paying attention to the Cybernetic Transport System and people are not aware of the risks: implies higher likelihood of incidents	1
	(Playing) children are weak implies higher impact of incidents	-
	(Playing) children are not aware of the risks implies higher likelihood of incidents	2
	Animals are not aware of the risks implies higher likelihood of incidents	-
Offices	Commuters cause crowded peak hours, implies higher likelihood of incidents	-
Schools / kindergarten	(Playing) children are weak implies higher impact of incidents	-
	(Playing) children are not aware of the risks, implies higher likelihood of incidents	-
	Crowded peak hours, implies higher likelihood of incidents	-
Sport area, Events	Visitors are not familiar with the traffic situation, people aren't paying attention to the Cybernetic Transport System and they are not aware of the risks, implies higher likelihood of incidents	-
	Peak of number of visitors at the end of a match or event, implies higher likelihood of incidents	-
Hospitals	Rushing ambulances, implies higher likelihood of incidents	-
Parking	Peak of number of visitors, implies higher likelihood of incidents	-

Remarks:

1	A large majority of the tourist visiting Orta have to cross the place to take a boat for the San Giulio isle.
2	Often parents leave children to play freely all over the place, since the place is almost close to traffic

Table 2-3: Potential Users, trespassers and other traffic

Risk profile	Risk subject/type of environment	Risks for users of the environment	Applicable
Potential users of the Cybernetic Transport System	Number of users	Peak intensities (high peak intensities will cause longer waiting times and a higher number of waiting people) implies higher likelihood of incidents	1
	Characteristics of the users	Are they aware or unaware (animals, playing kids) (unaware is higher likelihood of dangerous situations) Are they patient or impatient (impatient is more likelihood of dangerous situations because they may be entering the track) Are they fast or slow moving (fast moving is more difficult to avoid a collision) Are they weak or strong (weak is higher impact of incidents)	2
	Origins and destinations of the users, routes of the users	What route will they take from origin to destination? Will they cross the track of the Cybernetic Transport System? Is the straight line connection crossing the track of the Cybernetic Transport System? If the shortest route is crossing the track there is a greater likelihood that users will enter the track; implies a greater likelihood of encounters. The fewer crosswalks, the larger the detour and the greater the likelihood that people will cross the track at a place where it isn't allowed. If the distance between origin and destination is not too far, users will enter the track if they have to wait too long for the next cybercar. Higher likelihood of incidents	-
	...		-
Trespassers	Number of trespassers	more trespassers is a higher likelihood that someone enters the track is higher likelihood of incidents	3
	Characteristics of the trespassers	Are the aware or unaware (animals, playing kids) (unaware is higher likelihood of dangerous situations) are they patient or impatient (impatient is greater likelihood of dangerous situations) are they fast or slow moving (fast moving is more difficult to avoid a collision) are they weak or strong (weak is higher impact of incidents)	-
	..		-
Other traffic on the same track	Cybernetic Transport System	See risk profile for Cybernetic Transport System	-
	Pedestrians	Slow and weak road-users implies easy to detect, but higher impact of incidents	-
	Bikes	Slow and weak road-users implies easy to detect, higher impact of incidents	-
	Cars	Fast road-users implies difficult to detect, high impact on Cybernetic Transport System, both in likelihood and severity	-

	Lorries	Fast and strong road-users implies difficult to detect, high impact on Cybernetic Transport System, both in likelihood and severity	-
Other traffic on the same track	Rail traffic	Fast and strong road-users without maneuvering capabilities	-
	...		-
Other traffic crossing the Cybernetic Transport System track	Number of crossings	The more crossings, the greater the likelihood of incidents	4
	Type of crossings	grade crossing or road over road crossing, unguarded or guarded implies influence on the likelihood of incidents (encounters)	-
	Number of cybercars	The more cybercars the smaller the time period between two cybercars = smaller gap to cross	-
	Amount of traffic	The more traffic crossing on the Cybernetic Transport System track, the greater the likelihood of incidents	-
	Type of traffic	Are they aware or unaware (animals, playing kids) (unaware is higher likelihood of dangerous situations) are they patient or impatient (impatient is more likelihood of dangerous situations) are they fast or slow moving (fast moving is more difficult to avoid a collision) are they weak or strong (weak is higher impact of incidents)	-

Remarks:

1	In particular during week end the location is very crowded
2	Since there are public transport leaving from the location, people could be in a hurry to get the boat or the bus.
3	Trepassing could not be completely avoided
4	One small bus is crossing the area every hour

Table 2-4: Objects in the neighborhood

Risk profile	Risk subject	Risks	Applicable
Objects in the neighborhood	Power pylon and power transmission line	Electric magnetic fields, danger of electric shock	-
	Industry	Processes can be dangerous	-
	Buildings	Effect on navigation, communication, and obstacle detection	-
	Tunnels	Effect on navigation and communication	-
	Flyover	Obstacle, Falling objects	-
	Ditches, canals, rivers	Water near the track, drowning danger, natural barrier	-
	Trees	Falling branches, objects on track	-
	Mountains	Falling objects, natural barrier	-

Remarks:

Table 2-5: Specific conditions of the environment

Risk profile	Risk subject	Risks	Applicable
Weather conditions	Heavy wind	Extreme wind forces on vehicles → effect on stability and driving behavior of vehicles. More steering deviation of the cybercar due to wind load. Change of behavior of other traffic.	-
	Extreme cold	Effect on components of the Cybernetic Transport System	-
	Extreme heat	Effect on components of the Cybernetic Transport System	-
	Snow	Slippery track, poor visibility. Cybernetic Transport System can not brake accurately due to slippery road.	-
	Freezing rain	Slippery track, poor visibility. Cybernetic Transport System can not brake accurately due to slippery road.	-
	Heavy rain	Slippery track, water on the track, reflection of light, poor visibility	1
	Fog	Poor visibility	-
Natural phenomena	Earthquake	Disturbance of the track, falling obstacles	-
	Flooding	Water on the track	-
	Lightning	Effect of Electric magnetic fields on the vehicle, lightning stroke	-
Lighting conditions	Dark area	People do not see the Cybernetic Transport System properly	-

Remarks:

1	In case of heavy rain the showcase will be stopped, to avoid risks on this electric prototype vehicles

Table 2-6: Risk profile of the vehicles and hardware:

Risk profile	Risk subject	Risk effect	Applicable
Advanced City Car	Speed	Higher speed means more reaction time needed, higher speed in combination with higher mass means more energy and can result in more damage by collision	1
	Deceleration Jerk	Increase in the deceleration jerk will be dangerous for passengers inside, especially if standing	-
	Acceleration	Higher acceleration means more difficult to anticipate by other users of the environment	-
	Ability to maneuver	The ability to maneuver gives the ability to prevent collisions, a lot of change in maneuvers means more difficult to anticipate by other road-users	-
	Mass	Higher speed in combination with higher mass means more energy can result in more damage by collision	-
	Obstacle detection and Collision avoidance	A good obstacle detection system and collision avoidance system will prevent collisions with obstacles and other road-users	2
	Number of passengers in vehicle	More people do not necessarily raise the likelihood of anything to happen, but surely this raises the severity of anything that occurs because of the impact it might have on more people	-
	Sitting or standing passengers	Standing passengers can fall	-
	Dimensions L, B H	Free space needed for the vehicle, bigger dimensions can make a vehicle more visible	-
	Navigation	Accurate navigation results in less room needed on the track and less steering errors	-

Remarks:

1	The maximum speed of the vehicles during the showcase is 10 km/h, lower in the curves
2	The existing collision avoidance sensor has to be complemented by human control from the internal of the vehicle and also external (surveillance people)

Table 2-7: Risk profile of the embedded control system

Risk profile	Risk subject	Risk effect	Applicable
Control System	Communication	Loss of communication can result in a standstill -> the Cybercar becomes an obstacle. Cybernetic Transport System communication can interfere with other systems in the environment. Depending on the power and frequency of the communication system.	-
	Accuracy		1
	Traffic management	Slow down ability of vehicles at dangerous spots like crossings, stops and dangerous curves -> positive for safety	-
	Fleet management		
	Total number of passengers a day	The number of people possibly involved in an incident with the system	-
	Type of passengers	Tourists with luggage, students, commuters	-
	Number of vehicles	More vehicles mean a more complex system	-
	Number of vehicle types	More types of vehicles mean a more complex system	-

Remarks:

1	In case of mistake in the path following, the vehicle could go outside the area

Table 2-8: Risk profile of the track

Risk profile	Risk subject	Risk effect	Applicable
Track	Type of passengers	Tourists with luggage, students, commuters	-
	Number of vehicles	More vehicles mean a more complex system	-
	Number of vehicle types	More types of vehicles mean a more complex system	-
	Stops	The design of the stop affects the safety, e.g.: The placement of a stop Free stops along the track	-
	Navigation	Accurate navigation results in less room needed on the track and fewer steering errors	-
	Communication	Loss of communication can result in a standstill of cybercars. Cybernetic Transport System communication can interfere with other systems in the environment. Depending on the power and frequency of the communication system.	-
	Infrastructure	The dimensions of the track → maneuvering area The pavement of the track → special pavement for Cybercar to keep other road users from the track.	2
	Crossings	Design of crossings affects the safety, e.g.: Crossings with bars or only signaling	-
	Fences	Physical barriers to prevent people to enter the track	1
Shelters		-	

Remarks:

1	Fences have to be used all around the track to avoid people crossing the track
2	Manoeuvring area is small, vehicle have to be pushed towards their limits (minimal curvature radius)

2.5 Conclusions and recommendations

Conclusions:

The method as described appeared to be useful and practical when applying on the Orta San Giulio showcase. The recommendations below are partly the results of the analysis as presented in the risk indicator tables, but also on the discussion with the various stakeholders that was the basis for completing the tables.

Recommendations:

1. In order to avoid contact between vehicles and the public, all the following situations should be valid at all times:
 - 1.1 There will be always a CityMobil operator sitting in the driver place, able to take the control of the vehicle in any moment.
 - 1.2 All vehicles should be provided with an adequate obstacle detection system that stops the vehicle before an impact can take place.
 - 1.3 There should be someone monitoring each vehicle at all times, with a remote control to stop the system.
2. The responsible operator should stop the showcase if the area is too crowded to be able to control the system.
3. People crossing the area should be avoided. All operators, inside and outside the vehicles, have a radio to be warned of any authorised crossing
4. In case of authorised vehicle crossing, for example police, local bus, school bus, showcase operations have to be stopped temporary.
5. To avoid people crossing the track, fences should be distributed all around the manoeuvring area, it is advisable to have signs directing people which way to take for their different destinations.
6. In the case of heavy rain, poor visibility or fog the system will be stopped
7. The speed at curves should be lowered

3 REFERENCES

- [1] CyberMove project: Deliverable 3.2: Safe sites and systems: J.P. van Dijke and M.M. Janse. October 2004.
- [2] CityMobil deliverable 2.5.1: Certification procedures for automated transport systems. J.P. van Dijke e.a. . November 2007.