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# Safe Integration of Fully Automated Road Transport Systems in Urban Environments: Basis for Missing Legal Framework

Andras Csepinszky, Gabriele Giustiniani, Carlos Holguin, Michel Parent,  
Maxime Flament, Adriano Alessandrini

► **To cite this version:**

Andras Csepinszky, Gabriele Giustiniani, Carlos Holguin, Michel Parent, Maxime Flament, et al.. Safe Integration of Fully Automated Road Transport Systems in Urban Environments: Basis for Missing Legal Framework. Transportation Research Record, 2015, 2489, pp.1. hal-01132714

**HAL Id: hal-01132714**

**<https://inria.hal.science/hal-01132714>**

Submitted on 20 Apr 2020

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1 **SAFE INTEGRATION OF FULLY AUTOMATED ROAD TRANSPORT SYSTEMS IN**  
2 **URBAN ENVIRONMENTS: THE BASIS FOR THE MISSING LEGAL FRAMEWORK**

3  
4 **Andras Csepinszky**

5 ERTICO – ITS Europe  
6 Avenue Louise 326  
7 B-1050 Brussels Belgium  
8 Tel: +32 Email: [a.csepinszky@mail.ertico.com](mailto:a.csepinszky@mail.ertico.com)

9  
10 **Gabriele Giustiniani**

11 IT - Ingegneria dei Trasporti  
12 Via Cavour, 256  
13 00185, Rome - Italy  
14 Tel: +39 64820350 E.mail: [g.giustiniani@itroma.com](mailto:g.giustiniani@itroma.com)

15  
16 **Carlos Holguin, Corresponding Author**

17 Research Centre for Transport and Logistics  
18 University of Rome "La Sapienza"  
19 Via Eudossiana, 18  
20 00184, Rome - Italy  
21 Tel: +39 06 44585148 Fax: +39 06 44585 Email: [carlos.holguin@ctl.uniroma1.it](mailto:carlos.holguin@ctl.uniroma1.it)

22  
23 **Michel Parent**

24 RITS Team  
25 INRIA  
26 BP 105 - 78153 Le Chesnay, France  
27 Tel: +33 1 3963 5593 Email: [michel.parent@cybercars.fr](mailto:michel.parent@cybercars.fr)

28  
29 **Maxime Flament**

30 ERTICO – ITS Europe  
31 Avenue Louise 326  
32 B-1050 Brussels Belgium  
33 Tel: +32 2 400 07 35 Email: [m.flament@mail.ertico.com](mailto:m.flament@mail.ertico.com)

34  
35 **Adriano Alessandrini,**

36 Research Centre for Transport and Logistics  
37 University of Rome "La Sapienza"  
38 Via Eudossiana, 18 - 00184 Rome - Italy  
39 Tel: +39 06 44585148 Fax+39 06 44585 Email: [adriano.alessandrini@uniroma1.it](mailto:adriano.alessandrini@uniroma1.it)

40  
41 Word count: 5,900 words text + 2 tables/figures x 250 words (each) = 6,400 words

42  
43 Submission Date: August 1<sup>st</sup> 2014

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## **ABSTRACT**

Automated road transport systems (ARTS) are transport systems based on the use of fully automated road vehicles controlled by a centralized fleet and infrastructure management system. ARTS are aimed (at least at the beginning) at supplementing mass transit in the last mile and are commercially available today. However, their deployment is limited to protected or special roads, while in urban areas, where these systems can be most beneficial, they cannot be implemented due to the absence of an adapted legal framework. The CityMobil2 project, financed by the European Commission, aims at removing (amongst others) the legal barriers that prevent the deployment of Automated road transport systems in urban areas, by developing a specific legal framework. Previous experiences based on risk assessment and Failure Mode and Criticality Analysis (FMECA) have demonstrated being acceptable to the National authorities. On this basis, the CityMobil2 project has started developing a methodology for the certification of fully Automated Road Transport Systems, aimed at guaranteeing an adequate level of safety. The certification framework has been developed at theoretical level, but during the next phases of the CityMobil2 project, it will be tested in real life conditions during the ARTS demonstrations that will be organized in several cities of Europe, in order to make of this methodology a major reference for a future legal framework.

*Keywords:* autonomous vehicles, cybercars, automated transportation, automated people movers (APM), certification, road safety

## 1 INTRODUCTION

2 Automated road transport systems (ARTS) are transport systems based on the use of fully  
3 automated road vehicles controlled by a centralized fleet management system, which also  
4 controls the vehicles' interaction with the infrastructure. ARTS allow providing scheduled,  
5 on-demand or door-to-door services on a specific road infrastructure that can be segregated,  
6 dedicated or shared with other road users. ARTS are aimed (at least at the beginning) to  
7 supplement mass transit in the last mile and are commercially available today. However, their  
8 deployment is limited to protected or special roads, while in urban areas, where these systems  
9 can be most beneficial (1), they cannot be implemented on the public road infrastructure due to  
10 the absence of a legal framework, which undermines the will of the local authorities and makes  
11 the systems costs' excessive. The CityMobil2 project, funded under the European Union's  
12 Seventh Framework Programme for Research (FP7), aims at removing the barriers that prevent  
13 the deployment of Automated road transport systems in urban areas in Europe.

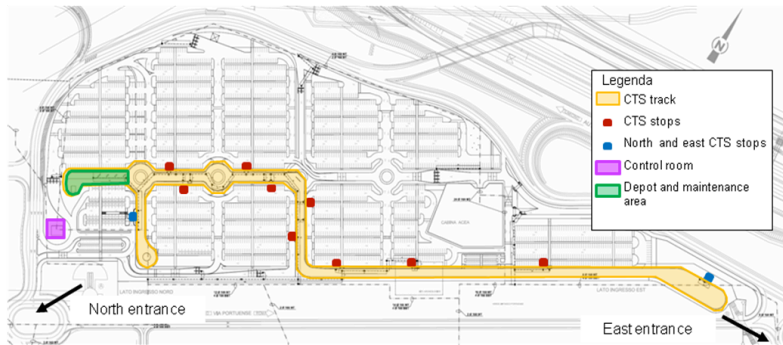
14 In order to tackle these barriers, CityMobil2 has two work areas. First, the project will carry out  
15 ARTS demonstrations in seven out of twelve cities, selected on the basis of feasibility studies  
16 made using a common methodology. These demonstrations can last up to 9 months. Second, the  
17 project will make studies on the overall impact of ARTS on the European economy. Finally, the  
18 project will study the specific legal barriers, in order to make a legal framework proposal for  
19 ARTS deployment in Europe, including the certification and homologation aspects. This paper  
20 presents the background, current results and expected outcomes of the legal framework study, in  
21 particular the certification procedure developed to certify Automated Road Transport Systems.  
22 This certification procedure will be tested during the large-scale demonstrations, set to start in  
23 the Autumn 2014, in order to refine the legal framework proposal.

### 24 **Previous experiences in the integration of Automated Road Transport Systems**

25 Since the late 1990's, the European Commission has funded several research projects on  
26 Automated road transport systems such as CyberCars, Cybercars-2, CyberMove, EDICT, among  
27 others. The last of these projects, CityMobil (2006-2011), aimed at developing and  
28 demonstrating concepts for advanced road vehicles, and new tools for managing the urban  
29 transport, in order to remove barriers in the way of large-scale introduction of automated  
30 transport systems. In the first sub-project of CityMobil (SP1), these advanced concepts and tools  
31 were validated and demonstrated in a number of different European cities under different  
32 circumstances. Two demonstrators of fully automated vehicles were implemented in Rome  
33 (Italy) and La Rochelle (France). The CityMobil2 legal framework builds upon the results and  
34 experience of these two demonstrations.

#### 35 *ARTS demonstration in Rome*

36  
37 The objective of the Rome demonstration was to implement a Cybernetic Transport System  
38 (CITIES – a former naming convention for Automated Road Transport Systems) based on  
39 cybercars, or fully automated road vehicles moving along a pre-defined trajectory, to connect the  
40 New Rome Exhibition with the main parking lot, in order to provide a permanent, on-demand  
41 service to the people reaching the Exhibition by car. The track had a length of about 1.6 km (two  
42 ways) and was totally segregated with a fence of about 1.2 m height. The surface was flat, in  
43 asphalt, and had 11 stops, two of them located close to the two main entrances of the Exhibition  
44 (Figure 1).  
45



1  
2 **Figure 1 Layout of the CTS route in the Rome demonstration**  
3

4 The overall system was made of the following subsystems:

- 5 • The cybercars (fully automated vehicles).
- 6 • The CTS control system.
- 7 • The track and stations.
- 8 • The user information system.

9 The implemented vehicle fleet was equipped with two different obstacle detection systems: a  
10 laser scanner and a bumper that activated an emergency stop in case of contact with an obstacle.  
11 The vehicles had a maximum capacity of 29 passengers, a maximum speed of 24 km/h and  
12 maximum acceleration and deceleration of  $1.2 \text{ m/s}^2$ , except for the emergency situations in which  
13 deceleration was greater. The stations' doors were controlled by the CTS control system, and  
14 opened only when a cybercar docked at the station.

15 The authority in charge of following the process and certifying the CTS was the General  
16 Direction of Local Public Transport of the Department for Transport, Navigation, Informatics  
17 and Statistic services of the Ministry of Infrastructure and Transport (MoT).

18 In order to define the overall certification approach, the meetings with MoT started in 2007. One  
19 of the first points discussed was the certification standard to follow. The possible frameworks  
20 were:

- 21 • To certify the single vehicle and not the CTS as a whole: This option was rejected  
22 because the Italian law (coherently with UN Vienna Convention applicable in Italy)  
23 required a person being in control and fully responsible for any consequences of the  
24 vehicle's movement.
- 25 • To certify the CTS as a whole using the EU Machinery Directive: it was concluded with  
26 the MoT that the Machinery Directive could not be applied to the transport of persons.
- 27 • To certify the CTS as a whole using railway certification standard (Standard EN50126  
28 "Railway applications - The specification and demonstration of Reliability, Availability,  
29 Maintainability and Safety").

30 After some discussions with MoT the selected standard was EN50126. The CTS was then  
31 considered as a driverless train with virtual rails. Since this standard limited the initial scope of  
32 providing an on-demand service, a step-by-step certification strategy was also agreed with the  
33 MoT, with very strict requirements in a first stage and further upgrades, once the CTS would  
34 obtain the initial certification. The steps agreed with the MoT were:

- 35 • 1st step. Totally segregated track with stop doors and shuttle service. At this stage no  
36 interaction between private vehicles (pedestrians included) and the cybercars, nor  
37 crossings between the cybercars themselves would be allowed.
- 38 • 2nd step. Totally segregated track with stops doors and on-demand service provided to  
39 the users (without overlapping of trajectories of cybercars moving in opposite directions),

1 as a horizontal lift. At this stage the user would arrive to the station and call a cybercar,  
2 and once on board, the user would select the destination.

- 3 • 3rd step. Totally segregated track, stop doors and on-demand service provided to the  
4 users. The only difference with the 2nd step is that overlapping between trajectories of  
5 cybercars moving in opposite directions, such in U-turn maneuvers, would be allowed.
- 6 • 4th step. Insertion of pedestrian crossings: At the last stage, pedestrian crossings would  
7 be inserted in the track.

8 The certification process to achieve the first step, in line with the EN50126, was the following:

- 9 1. The detailed design of the CTS would meet the basic requirements defined in step 1.
- 10 2. A Failure Mechanism Effects Criticality Analysis (FMECA) was to be applied by the  
11 CityMobil consortium on the detailed design.
- 12 3. If necessary, a review of the detailed design would be made according to the FMECA  
13 results.
- 14 4. The detailed design and FMECA report would be officially submitted to the MoT. The  
15 analysis by the MoT might result in an eventual request of clarifications or modifications  
16 to the detailed designs.
- 17 5. Once the detailed design was clear, the Interministerial Committee of MoT would  
18 provide a preliminary certification.
- 19 6. Implementation of the system on field.
- 20 7. A set of on field tests, defined by the MoT, to be executed on the CTS with positive  
21 results.
- 22 8. If the on field tests were positive, the MoT would provide a final certification and the  
23 CTS could open to the public.

24 The CTS detailed design was completed according to the 1st step requirements. These  
25 requirements had a strong impact on the Rome demonstration, since in a very early stage, the  
26 system should operate on reserved lanes, and fences and station doors were not foreseen.

27 The detailed design was finalized and delivered to MoT in July 2009, starting officially the  
28 certification procedure. The FMECA report was delivered to MoT in October 2009<sup>1</sup>.

29 After the delivery of these documents, the MoT started analyzing them deeply and an additional  
30 round of documents was provided to MoT in November 2009 and in May 2010. In total about  
31 2000 pages of official documents were produced.

32 After the documents delivery MoT finalized the analysis and, on the 13th of December 2010 the  
33 Interministerial committee of the MoT made a preliminary certification the system (“Nulla osta  
34 preliminare” in Italian), paving the way to the on-site tests foreseen in the points 6 and 7 of the  
35 certification process. Unfortunately, after 4 years of work on certification, because of financial  
36 problems, the Rome Demonstration project was stopped. However, the use of the EN 50126  
37 standard demonstrated an effective path for the certification of transport systems based on fully  
38 automated road vehicles.

### 39 *La Rochelle demonstration*

40 The city of La Rochelle has always shown a strong interest in the integration of fully automated  
41 road vehicles in the local public transport service. It hosted a fully demonstration in 2009 (2),  
42 and following its results, it also hosted a fully automated road transport service demonstration for  
43 three months in 2011 (3). In the latter, two fully automated vehicles were deployed on a track of  
44 around 1 Km. Unlike the Rome demonstration, the environment in La Rochelle was far more  
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<sup>1</sup> The results of this analysis are reported in the report “Safety Assessment of the Cybernetic Transport System for the Fiera di Roma”

1 complex, since the infrastructure where the system had to be deployed was a pedestrian street,  
2 with restricted access to the general motor vehicle traffic, but the track had several intersections  
3 with other public roads, one of which with intense motor vehicle traffic. However, the legal  
4 issues were similar, as there was no adapted legal framework under which the experiment could  
5 be carried out.

6  
7 Since the vehicles' maximum speed was under 25 km/h, they could not be considered as "motor  
8 vehicles" and therefore the "Road Code" was not applicable. The Machinery Directive, which  
9 has been applied for the transport of people in France, was not applicable either, as the system  
10 was to operate on public roads. The solution from the legal standpoint came through a local  
11 decree published by La Rochelle's Mayor. This decree provided a temporary permit for the  
12 system to operate, and defined the operational requirements that the system had to meet:

- 13 • The automated vehicles' speed was limited to 10 km/h;
- 14 • The automated vehicles had priority over other traffic in the crossings;
- 15 • An operator had to be on-board, in order to intervene in case of a problem;
- 16 • The system should be insured against damages to third parties;
- 17 • The vehicles were authorized to operate in other roads in manual mode only without  
18 passengers.

19 Besides these requirements, the CityMobil consortium, some of whose partners had already  
20 participated in similar experiments, carried out a risk reduction methodology (RRM). This RRM  
21 is a basic template that allows analyzing the environment in which the automated road transport  
22 system is deployed under the following characteristics:

- 23 • Built up area
- 24 • Potential users and trespassers
- 25 • Objects on the area
- 26 • Specific conditions of the environment
- 27 • Track

28 The RRM also considers the hazards raised by the vehicles, hardware, and the embedded control  
29 system. The resulting analysis of all the identified hazards allows identifying measures to reduce  
30 the risks or mitigate their impact (4). These measures are then used to refine the system's design  
31 or the system's operation procedures.

### 32 **Legal limitations for the deployment of Automated Road Transport Systems**

34 From the legal framework's perspective, the deployment of Automated Road Transport Systems  
35 has to consider three different level of regulation: international, national and local legal  
36 frameworks.

37 International conventions such as the 1949 Geneva Convention on Road safety (14) and the 1968  
38 Vienna Convention on Road Traffic (15) provide legal tools for national implementation but they  
39 are not globally accepted and ratified. The Geneva Convention was accepted by 95 states (16)  
40 and there is a European Agreement supplementing it (17). The Vienna Convention was designed  
41 to facilitate the international road traffic and to increase road safety by specifying standard traffic  
42 rules between the contracting parties. 70 countries ratified it. The Vienna convention imposes  
43 more extensive obligation on the driver of a vehicle stating in its Article 8 (1) "Every moving  
44 vehicle or combination of vehicles shall have a driver" and (5) "Every driver shall at all times be  
45 able to control his vehicle or to guide his animals". A sixth paragraph on distracted driving was  
46 added to the Convention's text in 2006. In 2014 a new clause was added to the Article 8, which  
47 refers to the technical regulations and includes a broad definition of "Driver Assistance

1 Systems".

2 At European level, the available EU directives provide guidance for the type approval of the  
3 motor vehicles (70/156/EEC (19), 2007/46/EC), for requirements and conformity assessment  
4 procedures of lifts (95/16/EC) (21), for requirements and conformity assessment procedures of  
5 industrial machinery (2006/42/EC) (22), for interoperability of the rail systems (2008/57/EC)  
6 (23) and for the deployment of Intelligent Transport Systems (2010/40/EU) (24).

7 In the member countries of the European Union there is no explicit legal regulation for  
8 Automated Road Transport Systems. The national legal frameworks implement the ratified  
9 international legal frameworks making the national regulation "compatible" with them, which  
10 may provide means of "exceptions" for the local authorities in the form of decrees. These can be  
11 considered as "backdoors" which provide the opportunity to temporarily deploy and test ARTS in  
12 some of the countries with more or less limitations.

13 The above legal conditions are all related to the authorization of the deployment of the ARTS.  
14 Today due to the above situation, the operation of ARTS has to be limited either by segregation  
15 of the itinerary of the vehicle or by the employment of a person on board of the vehicle who can  
16 intervene and stop the vehicle if necessary. The segregation of the vehicle itinerary from other  
17 motor vehicle traffic may be full physical segregation as it will be demonstrated by the  
18 CityMobil2 project in Finland and in Italy, or partial, as it will be demonstrated in France and  
19 Switzerland.

20 In addition of the purely authorization aspects of the ARTS deployment there are a number of  
21 legal issues. Liability issues remain one of the major questions concerning automated vehicles.  
22 Today the driver is held liable (criminal and civil) in case of an incident if no obvious product  
23 liability problem is revealed. Without a natural person in charge of driving the vehicle, the  
24 liability should be addressed but no legal regulation is available in the European countries to  
25 settle this issue. On the other hand, in order to settle the civil liability issue appropriate insurance  
26 law has to be adopted for the special case of ARTS operation. Thus part of the liability problem  
27 can be addressed today using case-to-case insurance coverage of the ARTS operations – but  
28 related European legal regulation would be helpful to address it. Anyway, the criminal liability  
29 of the ARTS operation cannot be solved using insurance measures. The only way today is the  
30 limitation of the ARTS operation as discussed above and the local ad-hoc authorization  
31 procedures, which evaluate the operational risks of the Automated Road Transport Systems at  
32 the site of the deployment.

33 Citymobil2 legal framework work package (26) has been investigating the above issues using a  
34 questionnaire, which was taken to the participating cities' authorities. The answers were  
35 classified and analysed in the project's deliverable D26.2 and some conclusions and  
36 recommendations proposed. The main concern of the participating city authorities was related to  
37 the liability issue – who is responsible in case of an incident/accident or damage. The second  
38 main issue was the lack of appropriate legal framework, which can be addressed by the above  
39 mentioned ad-hoc measures, segregation and/or an on-board driver. To limit the impacts of the  
40 concerns the authors proposed the following measures addressing some of the issues:

- 41 1. Distribution of disclaimers to the vehicle users (printed safety cards, visual, audible  
42 dissemination);
- 43 2. Specific contractual clauses between the cities and the vehicle manufacturers or system  
44 providers covering product liability issues;
- 45 3. Vehicle/system approval/certification;
- 46 4. Insurance to cover civil liability risks;
- 47 5. Training of the urser before using the vehicle;



- 1 6. Development/adoption a code of practice such as the ACEA ADAS Code of Practice
- 2 developed in the PreVENT project's RESPONSE 3 subproject;
- 3 7. Implementation of international, European and national standards – identification of gaps
- 4 and finally
- 5 8. Use of operational event data recorders (black boxes) on the vehicles to provide data
- 6 about events, incidents and accidents for further analysis.

7 These measures were used as basis for the CityMobil2 project to develop the legal framework  
8 proposal described in the next section.

### 9 **Scope of a legal framework proposal for Automated Road Transport Systems**

10 The development of the CityMobil2 legal framework proposal has two objectives. On one hand,  
11 it aims at assessing and certifying the demonstrations that will be implemented during the project  
12 timeframe, so that the ARTS demonstrations can be carried out safely. On the other hand, it aims  
13 at providing a basis for the definition of a Europe-wide process for certification of such systems.  
14 The approach is based on the proposal of two separate Directives, the instruments used by the  
15 European Union to harmonize national rules. The first Directive should aim at establishing a  
16 common legal framework concerning the approval procedure for automated road transport  
17 systems, their support infrastructure and subsystems. A second Directive shall provide a sound  
18 legal regime concerning the allocation of liability for civil and criminal damages caused by  
19 automated road vehicles. Preliminary discussions with the national transport authorities of  
20 different European countries revealed that it is preferred to deal with the civil and criminal  
21 liability at national level, while a system approval procedure at European level seemed more  
22 acceptable. Although both aspects are entrenched, the certification and homologation proposal  
23 has kept on progressing, since it responds to a more immediate requirement: the need to  
24 guarantee the safe deployment of the ARTS during the CityMobil2 demonstrations.

25  
26  
27 Building on the results of the Rome and La Rochelle's demonstrations in the CityMobil project,  
28 as well as other certification experiences for fully or partly automated transportation systems, the  
29 CityMobil2 legal framework Work Package identified the need for a combined approach based  
30 on the railway certification and on the road vehicle type approval processes. If on one hand, the  
31 railway approach guarantees very high safety standards and clear liabilities, on the other hand,  
32 the flexibility and modularity of the type approval for car regulations simplifies the process and  
33 the related costs. Therefore, it was decided to propose a certification and homologation process  
34 using the railway system approach, in which the system and all its components (including the  
35 automated vehicles, the physical road infrastructure on which the vehicles operate, the end-users  
36 information system, the fleet operator information system, the road-side sensor infrastructure,  
37 and the communication system that links these subsystems to a centralized Fleet and  
38 Infrastructure Supervision and Management System) are certified as a whole. However, the  
39 proposals differs from the existing railways certification legal framework, since it includes, if the  
40 infrastructure is not completely (physically) segregated, the consideration of risks linked to the  
41 roadside environment, including the presence of roadside objects and other road users. Besides  
42 this, unlike a complete system analysis made each time a new system is implemented, the  
43 CityMobil2 proposal consists in dividing the site in which an ARTS is implemented in several  
44 modules, or use cases, which present specific interaction situations between the road  
45 infrastructure, the ARTS subsystems, other road users and the physical environment surrounding  
46 the ARTS infrastructure. This approach is based on the risk reduction methodology developed  
47 and applied in previous projects, but provides a more in-depth risk analysis, and allows taking

1 advantage of the modularity of the type approval.  
2

3 To ensure that all subsystems are certified and operate together, the CityMobil2 proposal  
4 requires that the local authorities designate the road infrastructures where ARTS operate as, at  
5 least, dedicated to them (such as bus lanes). For a vehicle to be considered as part of an ARTS, it  
6 must be in permanent contact with the Fleet supervision and management system and obey to its  
7 instructions. This does not mean that ARTS are by definition public transport systems, and does  
8 not necessarily prevent manual vehicles from entering a dedicated ARTS lane nor forbids private  
9 ownership or use of the vehicle, but it means that such vehicles will need to obey specific rules  
10 while operating on the ARTS lane, set to ensure a much higher safety level.  
11

12 An example of such approach is provided by tramway regulations. In many European countries,  
13 tramways are not considered as road vehicles, but follow specific rules. However, these rules do  
14 not prevent cars from accessing or crossing the tramway infrastructure. From the technical point  
15 of view, this approach doesn't change much the conditions, but from the legal point of view it  
16 allows two important achievements: avoiding the application of the Vienna Convention, at the  
17 moment the most important legal barrier for the operation of automated road vehicles on public  
18 roads; and guarantees that the certification process, to assess all risks of using given vehicles on  
19 the given infrastructure, is applied, guaranteeing the achievement of an overall higher level of  
20 road safety. The certification process proposal will be tested and improved during the  
21 CityMobil2 ARTS demonstrations. This is why, at this early stage, no specific requirements or  
22 tests are included in the process, beyond those defined for the manufacturers that provide the  
23 Automated Road Transport Systems to the CityMobil2 project. These two very important  
24 elements will be defined based on the demonstrations activities. The following section presents  
25 in detail the certification that the proposed.  
26

## 27 **CERTIFICATION METHODOLOGY**

28 The proposed certification methodology is basically a “risk assessment and mitigation analysis”.  
29 The first step in the application of the risk assessment methodology is to identify, based on the  
30 preliminary system design of an ARTS (made at the city or local area level), a set of use cases.  
31 Several sets of components are used to describe each use case.  
32

### 33 **Use case analysis framework**

34 Use cases are specific interaction situations between the road infrastructure, the ARTS  
35 components, other road users and the physical environment that surrounds the ARTS  
36 infrastructure. Each of these elements is defined by several variables, which allow identifying  
37 and analysing in detail the associated hazards, in order to implement risk reduction or impact  
38 mitigation measures. Once a given ARTS manufacturer tests and demonstrates that its system  
39 meets the safety requirements necessary to manage a specific use case, such use case becomes  
40 certified, so that when the same situation repeats in a different site, the manufacturer will not  
41 have to follow a complete safety assessment and certification process of the whole site again.  
42 This modularity will allow the manufacturers to build a library of certified use cases, which can  
43 be extended progressively, only when they actually have to be implemented in a new site,  
44 drastically reducing the burden and costs of a complete safety assessment every time a new  
45 system is implemented. The proposed approach also guarantees that ARTS are deployed using  
46 railway-grade safety levels, and fosters competition between different manufacturers (or groups  
47 of subsystems manufacturers), who can implement different technological solutions and these

1 can evolve over time.

2  
3 Descriptions of the use case categories, including some examples, are provided below.

4  
5 **Frame layer** The frame layer describes the road infrastructure design, in terms of number of  
6 carriageways, lanes in those carriageways and driving direction of those lanes. It also describes  
7 the design of crossings, and the presence or not of sidewalks. Examples of frame layer elements  
8 are *single carriageway with two-way lanes per direction* and *X junction of single carriageways*  
9 *with one-direction lanes*.

10 **Scope layer** The scope layer describes the carriageway design conditioned by the geographic  
11 characteristics of the terrain, such as the *gradient* and the *design speed*.

12 **Vehicle movement** The vehicle movement category specifies all the possible automated vehicle  
13 movements in a given section of the infrastructure. Examples of vehicle movements are *cruise*  
14 (the period of time in which the vehicle moves the maximum posted speed) and *approach* (the  
15 period of time in which an ARTS vehicle approaches a crossing or a road section with a different  
16 segregation level and operates a transition in speed from the current section).

17 **Infrastructure differentiation level** The infrastructure differentiation level specifies the status  
18 of an ARTS lane (*shared, dedicated or segregated*) based on the elements present in the  
19 infrastructure that indicate this status to or prevent other road users' access to the said lane. For  
20 instance, *horizontal markings* or *walkways* indicate that an ARTS lane is dedicated, while  
21 *continues barriers* or *carriageway dividers* indicate that the infrastructure is segregated. These  
22 elements can also be used for the design of the infrastructure, in order to change its  
23 differentiation level.

24 **Regulation layer** The regulation layer contains the regulations elements that are defined by the  
25 road authorities. Such elements can be *crosswalks, stop signs, posted speed limits, etc.*

26 **ARTS users / Road users** This category groups the road users present in the surrounding  
27 environment where the ARTS is going to be implemented. It includes, for instance, *pedestrians*  
28 *cyclists* or *motor vehicle drivers*.

29 **Operation variables** Operation variables are environmental conditions that affect or change the  
30 normal system operation conditions to the ARTS operator. Examples of these variables include  
31 *rain fall, heavy wind, negative obstacles, etc.*

32  
33 The combination of the above mentioned categories and variables help describing in a very  
34 detailed form the environment where the Automated Road Transport System will be deployed.  
35 The number of other road users present (which can be determined by measurements or  
36 estimation), in combination with the physical environment surrounding the system, allows  
37 identifying the type of risks and to evaluate their possible impact and severity, in order to define  
38 mitigation measures such as modifications to the design of the surrounding environment or  
39 limitations to the speed of the vehicles. These measures are identified through the risk  
40 assessment and mitigation analysis presented in the next section.

#### 41 42 **Risk assessment and mitigation analysis**

43 The proposed certification methodology is basically a "risk assessment and mitigation analysis".

44 The process foresees the involvement of several stakeholders:

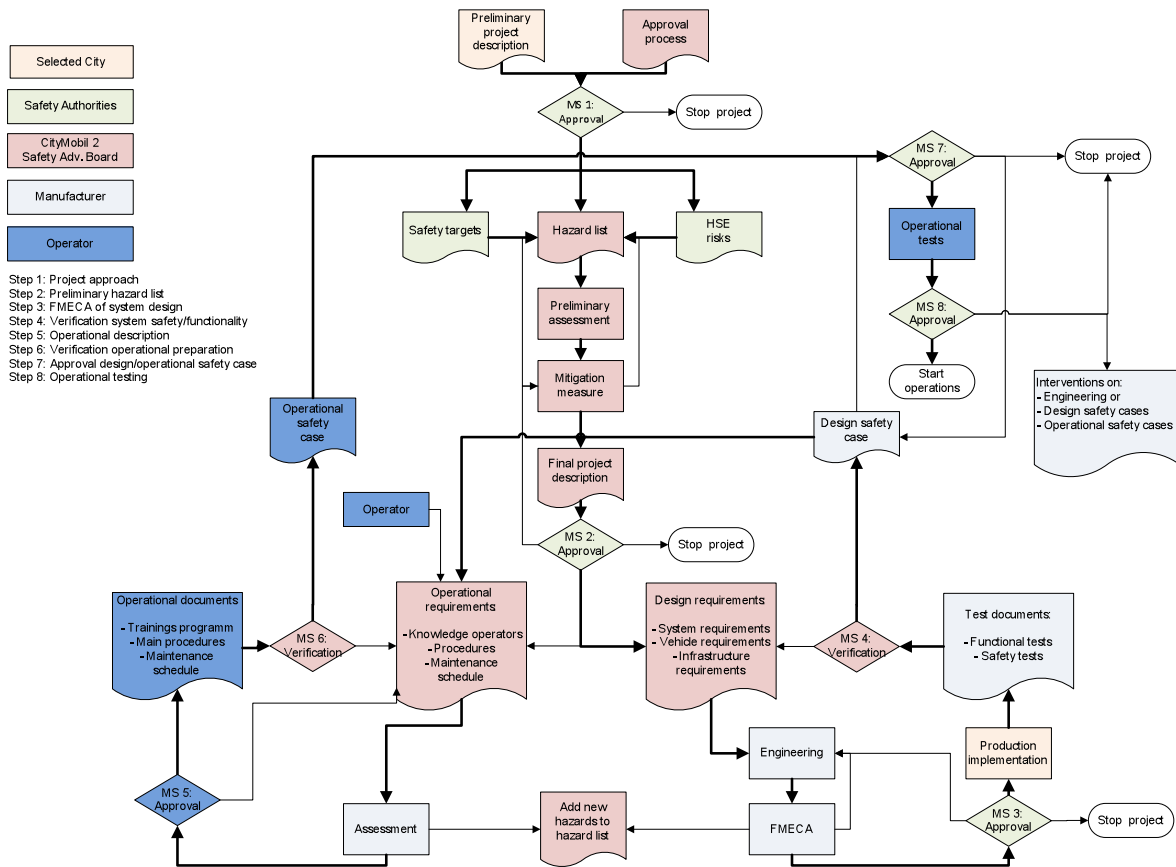
- 45 • A Safety Authority (SA), in charge of certifying the Demonstration at national or local  
46 level.
- 47 • The cities where the demonstration will be implemented.

- 1 • The CityMobil2 consortium, that will be represented by a high level independent expert;
- 2 • The ARTS Manufacturer.
- 3 • The Operator that will be in charge of operating and maintaining the ARTS during the
- 4 Demonstration.

5 One representative of each stakeholder will compose a Safety Advisory Board that will follow all  
 6 the certification process. The whole methodology is divided in 8 steps. Each step foresees a  
 7 series of activities to be carried out by the different stakeholders involved. To move from one  
 8 step to another, the approval of the step's outputs is expected to be provided by the SA or, when  
 9 not specifically requested by the local legal framework, by the Safety Advisory Board. The  
 10 following are the proposed steps:

- 11 1. Certification approach;
- 12 2. Preliminary hazard list;
- 13 3. FMECA of system design;
- 14 4. Verification of the system safety/functionality;
- 15 5. Operational description;
- 16 6. Verification operational preparation;
- 17 7. Approval of operational safety cases;
- 18 8. Operational testing.

19 An overview of the process is presented in Figure 2.



21 **Figure 2 - Overview of the certification process.**

22

## 1 **Discussion**

2 The legal framework and certification process proposed by CityMobil2 has strong and weak  
3 points. The first strength is that it was defined by experts from different member states with  
4 relevant knowledge of the legal frameworks available in their own countries. For this reason, it is  
5 very flexible and can easily be adapted to the local legal framework. Besides this, it is open,  
6 allowing its improvement with the results of the project. Finally if the use case approach  
7 demonstrates its effectiveness, will guarantee both modularity and repeatability of the results in  
8 all the MSs, avoiding a full certification process, and simplifying the deployment of automated  
9 road transport systems in different MSs.

10 On the other hand, there are several weaknesses. First of all, the process is still experimental and  
11 needs to be tested on the field. Secondly, requirements and tests have to be refined, and even if  
12 the project defined a series of requirements for the manufacturers providing the Automated Road  
13 Transport Systems for the demonstrations, this is still a new field where the previous experiences  
14 are either in contrast to the road or rail systems, each with more than 100 years of cumulated  
15 experience. This is why, at this stage, it was preferred to avoid defining requirements and tests  
16 beforehand. These two elements will be defined in the course of the project, based on the  
17 experiences and needs of the CityMobil2 demonstrations.

18

## 19 **CONCLUSIONS AND NEXT STEPS**

20 This paper presented the background, requirements and progress towards the definition of legal  
21 framework proposal for the deployment of Automated Road Transport Systems in Europe. While  
22 the proposed methodology for the certification of the system has certainly several weaknesses, it  
23 is based on a solid background, and has the advantage that it will be tested on real-life conditions  
24 during the CityMobil2 demonstrations. Currently, the analysis and the definition of the use cases  
25 is being applied in the site of La Rochelle, the first of the project's large-scale demonstrations,  
26 with the aim of demonstrating to the local and national authorities that the risk will be limited  
27 during the experimentation of the system, even if such demonstration isn't yet defined in an  
28 existing legal framework. The test of this certification methodology will allow to refine the  
29 process, discarding unnecessary elements and deepening those processes that can guarantee an  
30 adequate level of safety.

1  
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