On the deployment of WiFi-based road safety and efficiency services in Europe: opportunities for Telefónica

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***Abstract*—This paper presents the main facts and figures for the future deployment of road safety and efficiency services based on WiFi planned by the European Union, and outlines the opportunities for Telefónica in this field in terms of providing these services using its mobile network, and of providing value-added services using this future WiFi infrastructure on European roads and streets.**

I. Introduction

ROAD accidents in Europe account for over a million automobile accidents, with 40,000 dead persons per year (figures of 2005), 1,700,000 casualties and 160 billion Euros in economic damage. With the goal of halving the number of fatalities in road accidents by 2010, the European Union (EU) developed the concept of eSafety, which encompasses passive, active and cooperative safety systems. Besides safety, traffic efficiency is also a cornerstone in EU's Action Plan for the development of Intelligent Transport Systems (ITS) [1] because efficiency is a strong candidate to achieve 'green' transport, together with low-pollution engines.

These road safety and efficiency services will be provided using several communication technologies, which will involve vehicle-to-vehicle (V2V, also known as car-to-car) and vehicle-to-infrastructure (V2I) communications, as well as communications using future, specific roadside equipment, each of which is called Road-Side Units (RSU). These RSUs will form a network of hot spots, and will allow for vehicle-to-roadside (V2R) communications. Note that V2V is especially targeted for cooperative safety among cars, and that V2R is targeted for both cooperative safety and dissemination of traffic information in safety and efficiency scenarios. Typically, V2V and V2R communications are achieved using ad-hoc networks composed of vehicles and RSUs (Figure 1).

Since they are time-critical, road safety and efficiency services are expected to be provided using primarily V2V and V2R communications. These communications will be based on tailored WiFi technologies, as described in Section II. For simplicity, the services targeted for road safety and efficiency using WiFi will be called *WiFi-safety* in this paper. The main WiFi-safety services foreseen in Europe are local danger warning, cooperative danger warning and traffic information dissemination, e.g., the Cooperative Intersection Collision Avoidance Systems (CICAS). In particular, the Car-to-Car Communication Consortium (C2C-CC) considers four safety services in its architecture and proof-of-concept trials: approaching emergency vehicle, roadwork, stationary vehicle and intersection safety. Figure 2 illustrates a safety service.

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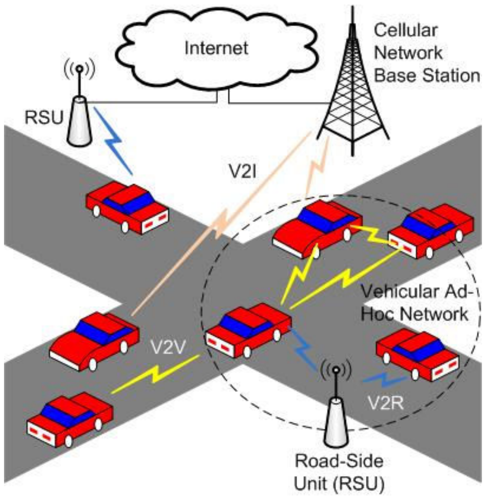

Figure 1. Communication scenarios for road safety and efficiency

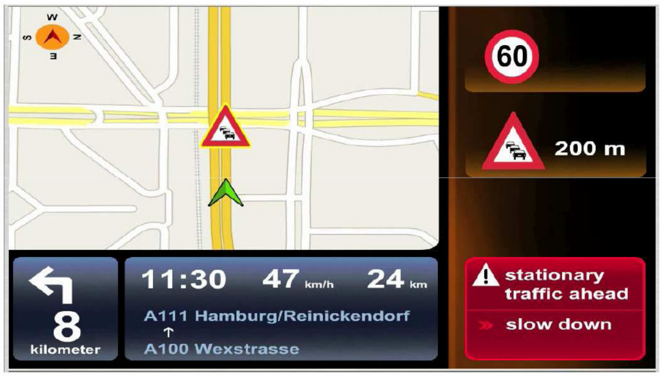

Figure 2. Example of road safety service: traffic ahead

II. Standardization and Regulation of WiFi-Safety

There are a number of regulation activities regarding WiFi-safety. Worldwide, the spectrum regulation for a specific band devoted to road safety and efficiency services is progressing. This band is in the 5.9-GHz spectrum for Dedicated Short-Range Communications (DSRC). The communication protocol for this DSRC is being standardized by the Institute of Electrical and Electronics Engineers (IEEE). This protocol, known as Wireless Access in Vehicular Environments (WAVE) [2], is an addendum (p) to the 802.11 family of standards (www.ieee802.org/11/), best known as WiFi.

In Europe, besides the IEEE, standardization and regulation efforts are driven by the C2C-CC[1], the Communications Architecture for Land Mobile (CALM) working group of the International Organization for Standardization and of the International Telecommunications Union, and the ITS technical committee of the European Telecommunications Standards Institute (ETSI TC ITS), created in late 2007.

The C2C-CC groups vehicle manufactures and automotive equipment suppliers with a threefold mission: to create and establish an open European industry standard for V2V communication systems based on WiFi components and to guarantee European-wide inter-vehicle operability; to enable the development of active and cooperative safety applications by specifying, prototyping and demonstrating this V2V system; to push the harmonization of V2V communication standards worldwide, and to develop realistic deployment strategies and business models to speed up the market penetration. Besides, through the Pre-Drive C2X project[2], the C2C-CC is estimating the impact on traffic safety and mobility of cooperative systems for road safety and efficiency.

CALM[3] is an international initiative to define and standardize a set of wireless communication protocols and air interfaces for a variety of scenarios in ITS spanning multiple communication modes and transmission methods (e.g., WiFi, cellular). These scenarios include road safety and efficiency.

The ETSI TC ITS receives inputs from relevant European players and initiatives, such as the eSafety Forum and the COMeSafety action. Established in 2003 by the Commission, the eSafety Forum[4] is a joint platform involving all road safety stakeholders. Its general objective is to promote and monitor the implementation of the recommendations identified by the eSafety working group and to support the development, deployment and use of eSafety systems. COMeSafety[5] integrates and harmonizes the use of communication technologies for road safety and efficiency addressed in major European R&D projects, such as CVIS[6], COOPERS[7] or SAFESPOT[8]. COMeSafety has developed a framework that will be standardized through ETSI TC ITS (see Section III.B).

A. The IEEE 802.11p protocol

In August 2008, the royalty-free spectrum for ITS systems and services dealing with safety and efficiency was allocated in Europe: 30 MHz at the 5.9-GHz band (5.875GHz – 5.905GHz). The communication protocol to be used in this spectrum is WAVE, which is composed by the layers depicted in Figure 3. At the physical layer (PHY), a 10-MHz channel with IEEE 802.11 p [2]. At the Medium Access Control (MAC) layer, basic IEEE 802.11 MAC with Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) and the MAC extension as defined in IEEE P1609.4. In the upper layers, IEEE 1609.x standards will be implemented, e.g., [3].

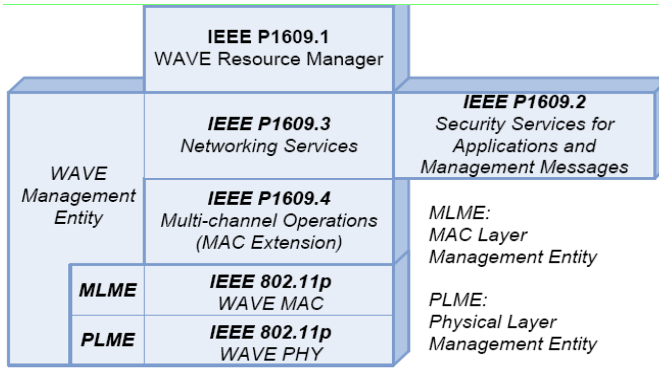

Figure 3. Layers of WAVE (IEEE 802.11p in PHY and MAC)

It has been demonstrated through simulations that WAVE works well with 100% penetration rate in both low and high density scenarios, in terms of V2R and V2V communications [4]. Some of the WiFi-safety services tested are related to periodical information exchange among neighboring vehicles, and message propagation. However, with a low penetration rate, the vehicular ad-hoc network suffers from the well-known 'fragmented network' problem. In other words, the end-to-end delay and the message propagation depend on the network density and market penetration rate.

III. Opportunities for the Mobile Operator

Road safety and traffic efficiency services are envisioned as 'WiFi services', which may be seen as a threat by network operators. The rationale behind this is twofold: no clear business case for the operation of roadside WiFi hotspots (so-called RSUs), which may leave mobile network operators (MNO) out, not only for safety and efficiency services but also for possible future value-added services (VAS) using the RSU infrastructure that is to be deployed. Then, safety and efficiency services are perceived by most users as public information, i.e., free of charge like current road information services, such as Internet sites by Traffic Authorities (e.g., http://infocar.dgt.es), RDS-TMC radio information or variable information panels on highways. In this context, here we outline two opportunities for Telefónica as an MNO, which are being explored in R&D projects led by MNOs.

A. Provision of safety services using the mobile network

CoCar is a German-funded project that is investigating V2V and V2I using cellular mobile communication technologies. The consortium of the project is composed of Ericsson (project leader), Vodafone, Daimler, MAN and Volkswagen. The CoCar system, depicted in Figure 4, combines cellular technologies such as GPRS, UMTS, HSxPA or LTE to achieve sufficient coverage, increase data rate and capacity and improve latency, and with these features be able to provide services related to road safety and to infotainment, i.e., information and entertainment VAS for drivers and passengers, and for travelers in general.

[1] C2C-CC, www.car-to-car.org.
[2] Pre-Drive C2X, www.pre-drive-c2x.eu.
[3] ISO TC204 WG16 CALM, www.isotc204wg16.org.
[4] eSafety, www.esafetysupport.org/en/esafety_activities/esafety_forum/.
[5] COMeSafety, www.comesafety.org.
[6] CVIS, www.cvisproject.org.
[7] COOPERS, www.coopers-ip.eu.
[8] SAFESPOT, www.safespot-eu.org.

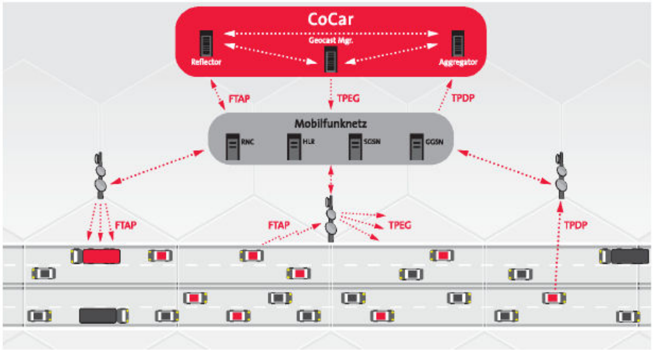

Figure 4. Road safety and efficiency services using the mobile network

The results of the CoCar project [4] show that the mobile network infrastructure ensures timely message dissemination throughout large areas. Besides, the mobile broadcast enables efficient message dissemination for many-user scenarios. Finally, end-to-end delays of below 500 ms can be achieved using in today's UMTS networks, although they cannot be guaranteed. Table 1 summarizes these results, and compares them with the performance of future WAVE networks. The advantages are highlighted in light grey, while the weaknesses are marked in italics. CoCar pinpoints that a solution to future road safety and efficiency services, which would also allow for the provision of other VAS, such as entertainment, would be a hybrid system in the user terminal. In this solution, the terminal would have a shared application module that would integrate parallel WiFi and cellular communication modules. This way, users would have the infrastructure support from cellular systems, which are already installed, and from future WAVE-based communications for time-critical applications.

	Cellular (UMTS)	V2V (WAVE)
Network infrastructure	Infrastructure-based system	Infrastructure-less system, although some services require support from the infrastructure
	Infrastructure ready	*No infrastructure deployed in Europe yet*
Communication range	Broad	*Ad-hoc network, single-hop distance 300-1000m*
System capacity	*Inference limited system, with limited resource of each cell*	Scalable, adaptive ad-hoc network
Processing and network delay	*Minimum end-to-end delay around 100 ms (HSDPA) for local hazard warning services, not guaranteed*	Minimum end-to-end delay < 100 ms for local hazard warning services, guaranteed
	Delay performance of long-distance communication independent of penetration rate	*Without RSU support, the delay performance of long-distance communication depends on the penetration rate*
Cost	*Licensed spectrum*	Royalty-free spectrum
	Mature network, with bounded capex and opex	*High cost to deploy and maintain the RSUs*
Security and anonymity	Centralized	Distributed protocol relying on infrastructure

Table 1. Cellular vs WAVE comparison for safety and efficiency [4]

Besides this possible hybrid solution, the time frame allows for the provisioning of safety- and efficiency-related services using only V2I, i.e., cellular technologies. According to its last Plan [1], the European Union will evaluate the performance and deployment strategies of cooperative systems relying on intelligent infrastructure, i.e., RSUs, in the period 2010-2013. The specifications for infrastructure communication (called I2I) will be defined in 2010; those for V2R in 2011, and V2V communications will be specified in 2013. Hence, until V2R systems are deployed, MNOs have a window of opportunity to offer safety and efficiency services through their mobile networks, and at the same time start offering mobile-based 'geographic' VAS beyond safety and efficiency services.

B. Provision of Internet access through the RSUs

StreetInfo2Me is a seedbed project funded by Telefónica's Corporate Innovation Program (CIP 2008-2009) that explores the architecture and use of RSUs for future VAS, beyond safety and efficiency, and demonstrates the feasibility of these WiFi-based VAS through a testbed, located in the Madrid premises of Telefónica I+D. StreetInfo2Me integrates know-how of Telefónica I+D's Networked Vehicles Division and of European and Spanish R&D projects in which Telefónica I+D is prime and participant, namely SAFESPOT, MARTA[9] and m:Vía[10]. One of the outcomes of StreetInfo2Me is a proposal to particularize the ITS Reference Station Architecture.

Issued by COMeSafety in October 2008 and now under study in ETSI TC ITS and Pre-Drive C2X, this reference architecture [5] harmonizes the modules of an RSU and an in-car system, understood as 'nodes' in a cooperative system. This architecture contemplates six modules, all compliant with the CALM architecture. The core modules are Applications, Facilities, Network and Transport, and Access Technologies, which are complemented with the Management and Security modules. Figure 5 illustrates the particularization of the ITS Reference Architecture proposed in StreetInfo2Me for a RSU. In the Access Technologies module, five interfaces are identified to reflect the services that can be provided:

- INT1: safety and efficiency (WAVE frequency band and protocol). Note that this interface has not been developed in the StreetInfo2Me project due to the unavailability of commercial WAVE cards.
- INT2: geo-VAS and Internet access (using 'conventional' WiFi and most probably single-hop for universal access).
- INT3: connection to backbone systems, typically through a fiber-optics or radio link.
- INT4: connection to legacy systems, e.g., traffic cameras.
- INT5: connection to a wireless sensor network.

Note that in the Network and Transport Module, an element to handle Sensor Networks has been introduced as a possible extension to [5]. This module uses INT5 to gather information about wireless sensors spread around the RSU. In the StreetInfo2Me project, this module is based on a ZigBee gateway. Note also that the elements depicted in gray in Figure 5 (Applications module) reflect the services that are not believed to be the core of Telefónica's business, and hence

[9] MARTA, www.cenitmarta.org.
[10] m:Vía, www.mvia.es.

would be provided by third parties. In fact, StreetInfo2Me considers two main value-added services: Urban Traffic Efficiency services, as defined in [5] and possibly integrating mobility patterns inferred from cellular network users, and high-speed Internet access, using INT2. To this respect, [6] demonstrates experimentally the feasibility of 'conventional' WiFi (i.e., 802.11a/b/g) for vehicular environments, and this can be translated into the fact that both users in vehicles and in-car systems could benefit from WiFi hot spots along the roads as a complement to broadband mobile Internet access.

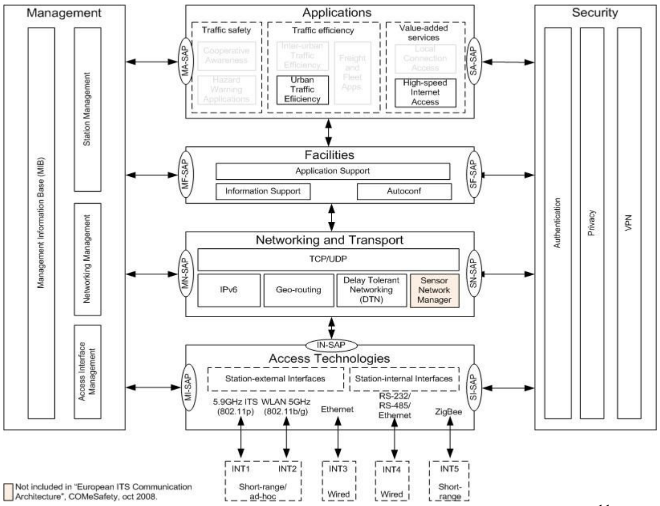

Figure 5. RSU architecture for Internet access compliant with [5][11]

IV. A WINNING STRATEGY FOR TELEFÓNICA

The history and evolution of the automotive telematics sector has traditionally placed MNOs in the niche of connectivity provisioning for the ITS services that are offered by third parties ranging from car makers to aftermarket navigation providers. With the advent of V2V and V2R communications, this role of 'dumb pipe' runs the risk of decreasing, and even of disappearing, because WiFi for ITS applications (namely WAVE, or IEEE 802.11p) may cannibalize the use of cellular communications for future safety and efficiency services. Far from wanting that, the goal for any MNO is to leverage its cellular and core network infrastructure to provide services to mobile users. And road safety and efficiency services are no exception to this rule and neither are VAS for drivers and passengers. Given the current situation and perspectives in the ITS field, which have been described in Sections I and II, as well as the possibilities for MNOs to capture part of the ITS value chain described in Section III, this section proposes strategic actions to answer two key questions for Telefónica:

- What should Telefónica do to position cellular communications, including Long-Term Evolution (LTE), as the technology of choice for ITS services?
- What should Telefónica do to become part of the value chain of VAS for drivers and passengers (ITS services)?

A. Communication technologies for V2R

WAVE is the communication technology best positioned to access road safety and efficiency services. As described in Section II, spectrum has already been allocated for WAVE and the European ITS Plan [1] foresees the evaluation of this technology for V2R (and also V2V) communication. Besides, a set of standards are being developed to adapt the WiFi operation to the vehicular environment [2] [3]. In Europe, WAVE is based on three 10-MHz channels consisting of one control channel and two service channels in the 5.9 GHz band. Following the standardization in the US, the service channels (WiFi-safety) will probably be used for public safety and private services, while the control channel will be used as the reference channel to initially detect surrounding vehicles and establish all communication links. Thus, the control channel will periodically broadcast announcements of available application services, warning messages and safety status messages. Cellular technologies are only envisioned for V2I.

The characteristics of the WAVE spectrum (30 MHz with specific uses for each of the three channels, prioritizing road safety and efficiency services) makes WAVE difficult to use for VAS other than safety and efficiency. Besides, as described in Section III, vehicular ad-hoc networks based on WAVE will suffer from the well-known fragmentation problem for multi-hop communications in the first deployment stages of V2V and V2R systems, among other weaknesses (see Table 1). In this context, **cellular technologies have a clear window of opportunity to be exploited by MNOs**.

B. Timing and partnerships

Two aspects are key to provide safety and efficiency services using cellular technologies: timing and partnerships. The current European Plan for ITS [1] has allocated the period of 2010-2013 to develop and evaluate cooperative safety and efficiency systems. More precisely, the specifications for V2R communications are to be ready in 2011, and those for V2V in 2013. To be the first in the market, Telefónica has ***(A1)*** **a time window of 2-4 years to create, deploy and commercialize its first portfolio of safety and efficiency services** in Europe using its MNOs in Spain, UK, Germany, Ireland, Slovakia and the Czech Republic, and using roaming agreements in the remaining EU countries. In parallel, the European standard for automatic emergency calls, known as eCall [7], is expected to come into force in early 2011. This means that all new cars that will be sold in Europe right after the standard comes into force will have to integrate an eCall system, that is, an embedded black box with a GPS receiver and GSM connectivity. The current economic situation of the automotive sector, and the fact that both the signature of Memorandums of Understanding (MoU) by all EU-25 countries (e.g., France and UK have not signed the MoU yet) and the technical specifications of the eCall standard (the transmission of the eCall data call is a major stopper, with in-band modem and SMS solutions competing) is moving slowly will most probably delay the date in which the eCall standard will come into force. In other words, Telefónica has ***(A2)*** **another 2- to 4-year window of opportunity to offer pre-eCall emergency and assistance services**. Besides, even after all new cars are sold with an embedded eCall system, the market of second-hand cars and two-wheeled vehicles will be a green field for Telefónica to offer eCall-compliant or proprietary

[11] StreetInfo2Me uses IPv4 because IPv6 is not widely deployed.

solutions for emergency/assistance. Using cellular communications, Telefónica could complement this portfolio by **leveraging its machine-to-machine (M2M) VAS**.

As for partnerships, besides the associations and consortia of car makers and providers that deal with ITS issues, e.g., the C2C-CC, the most relevant consortium in the ITS sector is the European ITS Association. Under the name of ERTICO (www.ertico.com), this association is a multi-sector, public and private partnership pursuing the development and deployment of ITS systems and services. Among other issues, this means ERTICO helps build the European strategic agenda for ITS. It is worth noting that Telecom Italia can become a strong partner in 'ITS lobbying' activities because it is one of the few MNOs that participates actively in standardization and has long been a member of ERTICO. Through the Telefónica I+D-Telecom Italia Labs synergies program, strong contacts with the ITS & Logistics Department at Telecom Italia Labs have been established since 2008 to work together in this direction. In short, Telefónica should ***(A3)* become a member of ERTICO, and should lobby with Telecom Italia so that the viewpoint and interests of MNOs are considered in and by ERTICO, and hence in the strategic agenda for ITS**.

Finally, it is widely accepted that pan-European ITS services will only become a reality with the help and action of the EU. Through [1], the EU kicks off its leading role in establishing the basic conditions for a rapid yet coordinated deployment of ITS systems and services, which involves setting up a committee with representatives of the public and private interested parties, as well as establishing a clear roadmap. The mentioned committee will be a high-level transversal group that will coordinate the interested parties in ITS. Telefónica should ***(A4)* participate in this EU transversal committee**.

C.Standardization: be an influencer or an adopter

To provide both safety and efficiency services using cellular technologies, and services through WiFi (RSUs), another key action for Telefónica is to partake in standardization. In the 2009-2014 period, the European Union plans to define and issue a mandate for European organizations, e.g., ETSI, to develop harmonized standards and regulation about ITS systems and services, particularly about services involving cooperative systems (i.e., based on V2V, V2R and V2I communications). This mandate will be most probably influenced by the transversal committee mentioned before and will be coordinated, in terms of standardization, by the ETSI. Therefore, Telefónica should ***(A5)* participate actively in the ETSI TC ITS**. In fact, in the first workshop organized by this technical committee (February 2008), its chairman (Mr. Soren Hess), stressed that MNOs should become a player in the standardization efforts related to ITS systems and services, and in particular invited Telefónica to join the ETSI TC ITS.

V. Conclusion

Telefónica is in a good position to get a share of the future ITS market, not only of safety and efficiency services, but also VAS. In the last decade, transportation has been experiencing continuous growth in Europe (Figure 6), and in 2004 73.5% of transportation accounted for passenger vehicles, i.e., potential on-the-go VAS users. The use of passenger transport means in the EU-25, as a percentage of total passenger transport measured in passenger-kilometers, is estimated as 76.6% for private cars in 2010. Besides, the global logistics industry is estimated at roughly 5.4 trillion euro (13.8 % of the global GDP), which leads to annual logistics expenditure in Europe and North America of 1 trillion euro respectively[12]. **To get a share of this ITS market, Telefónica should start now by following the strategic actions *(A1)* to *(A5)* identified here.**

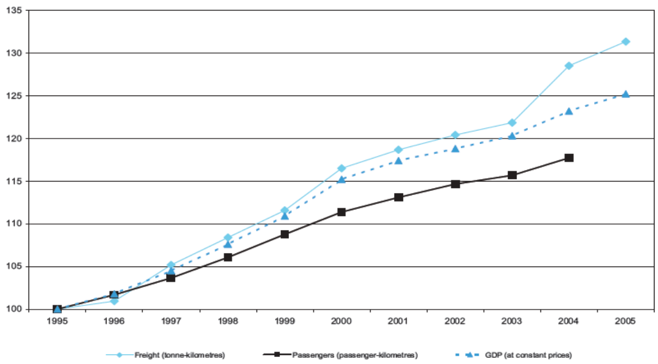

Figure 6. 1995-2005 evolution of transport in Europe[13]

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References

[1] COM(2008) 886 final, "Action Plan for the Deployment of Intelligent Transport Systems in Europe", December 16, 2008. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0886:FIN:EN:PDF

[2] P802.11p/D5.0, "IEEE Draft Standard for Information Technology -- Telecommunications and information exchange between systems -- Local and metropolitan area networks --Specific requirements -- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications Amendment 7: Wireless Access in Vehicular Environments", active unapproved standard, November 2008. http://ieeexplore.ieee.org/servlet/opac?punumber=4810961

[3] IEEE 1609.3™, "Trial-Use Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services", February 2007. http://ieeexplore.ieee.org/servlet/opac?punumber=4167672

[4] Y. Zang, B. Walke, S. Sories, G. Gehlen, "Towards a European Solution for Networked Cars-Integration of Car-to-Car Technology into Cellular Systems for Vehicular Communication in Europe", in IV Fully Networked Car Workshop, March 2009. http://www.itu.int/dms_pub/itu-t/oth/06/1B/T061B00000200201PDFE.pdf

[5] COMeSafety, "European ITS Communication Architecture. Overall Framework. Proof of Concept Implementation", October 2008. http://www.comesafety.org/fileadmin/uploads/architecture/COMeSafety_DEL_D31_EuropeanITSCommunicationArchitecture_v2.0.pdf

[6] A. Tufail, *et al.*, "An empirical study to analyze the feasibility of WIFI for VANETs", in Proc. 12th Int'l Conference on Computer Supported Cooperative Work in Design (CSCWD), 2008.

[7] eCall Driving Group, "Recommendations of the DG eCall for the introduction of the pan-European eCall", 2006. http://www.ecall.fi/Position_papers_DG_eCall_v2.pdf

[12] Source: COM(2006) 336 final, http://ec.europa.eu/transport/logistics/overview/doc/2006_06_28_communication_en.pdf

[13] Source: Directorate General (DG) Energy and Transport.