ISTITUTO DI DIRITTO DELLA NAVIGAZIONE
Sezione del Dipartimento di scienze giuridiche della Sapienza, Università di Roma
I.S.DI.T. — ISTITUTO PER LO STUDIO DEL DIRITTO DEI TRASPORTI
ANNO XXXIII - N. 2-3

DIRITTO DEI TRASPORTI 2020

EDIZIONI AV

ISSN 1123-5802

I.S.DI.T.

Istituto per lo Studio del Diritto dei Trasporti

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Dal 2019 la rivista Diritto dei Trasporti sarà edita in formato elettronico e sarà disponibile gratuitamente *on line* sul sito *www.dirittodeitrasporti.it*.

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Annate arretrate 1992-2018:	Italia	€	105,00
	Estero	€	130,00
Singolo fascicolo arretrato 1992-2018:		€	50,00
CD indici generali 1988/2009 (per gli abbonati):		€	55,00
CD indici generali 1988/2009 (per i non abbonati):		€	120,00

Pagamenti tramite bonifico bancario Banco di Sardegna S.p.A. Sede di Cagliari IBAN IT 89 F 01015 04800 000000035089 per l'estero codice BIC/SWIFT BPMOIT22 oppure sul c/c postale n. 16720096 entrambi a Edizioni AV di Antonino Valveri

Rivista quadrimestrale. Le richieste di fascicoli e gli eventuali reclami per mancato ricevimento vanno indirizzati all'amministrazione presso

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Direttore responsabile: Leopoldo Tullio

Redazione: rivista@isdit.it

Sito web: www.dirittodeitrasporti.it

Registrazione Tribunale di Cagliari n. 2 dell'8 gennaio 1992

Finito di comporre nel mese di gennaio 2021

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AUTONOMOUS VEHICLES IN SMART ROADS: AN INTEGRATED MANAGEMENT SYSTEM FOR ROAD CIRCULATION

Cinzia Ingratoci

The current liability regulation in the case of damages related to vehicle circulation is focused on the culpable behaviour of the driver and the legal status of the vehicle's owner. While in the case of automatic vehicles, which operate under monitoring of a «supervisor» on board, it is possible to apply the general liability paradigm, autonomous vehicles will be completely different as they do not have a driver/supervisor on board, requested to be ready to intervene at all times. For this reason, the adequacy of the current liability paradigm in governing these new phenomena is questioned. Learning lessons from highly technological transport systems (such as maritime and air transport) preventive measures aimed to maintain the risk of the overall system at an acceptable level include a safety oversight structure, as well as the implementation of traffic monitoring and management systems that assume a pivotal role with respect to safety, efficiency and environmental results. In view of the implementation of AV on public roads, full traffic situation awareness is probably the best solution to create safer, more efficient and environmentally friendly road traffic.

1. *Autonomous driverless vehicles: a definition* — Automation is at the core of scientific and cultural debate in this era and is of particular interest in the legal sector due to some very complex regulatory profiles, involving ethical, economic and social issues (1). Once again, transport law provides a

(1) For a picture of the advantages of smart and autonomous mobility see T. Casadei, G. Zanetti, *Tra dilemmi etici e potenzialità concrete: le sfide dell'autonomous driving*, in *Smart roads e driverless cars: tra diritto, tecnologie, etica pubblica*, edited by S.

field of experimentation for legal solutions adequate to support original and innovative human experiences (2).

Legal issues concerning technologically sophisticated vehicles relate to the level of automation.

The existing regulatory experience on vehicle circulation is focused on the behaviour of an agent (i.e. the driver), which can be oriented by a rule to obtain a safe result. If the agent does not comply with the rule or, in any case, if results expected from the precautionary rule are not achieved and some damage occurs, the agent is liable (3).

Currently, many new car models incorporate advanced driver-assistance systems that are part of autonomous vehicle (AV) technology, such as forward collision warning, automatic emergency braking, pedestrian automatic emergency braking, adaptive lighting, adaptive cruise control, lane departure warnings, rear-view video systems, and rear cross-traffic alerts.

All these items support the driver, giving him/her information, which is useful for safety, but which does not substitute the driver in the responsibility for vehicle circulation.

According to the classification outlined by the US National Highway Transport Safety Administration (NHTSA) in 2016, we can distinguish five levels of automation (4):

Scagliarini, Torino, 2019, 41 ff.; S. Vantin, *Automobili a guida autonoma: un'inedita opportunità per le persone con disabilità fisiche*, ivi, 55 ff.; L. Butti, *Auto a guida autonoma: sviluppo tecnologico, aspetti legali e etici, impatto ambientale*, in *Riv. giur. ambiente* 2016, 435-452.

(2) For an updated general framework on this subject see *L'automazione nei trasporti marittimi, aerei e terrestri*, Special Number of this Review, 1/2019.

(3) A. Davola, R. Pardolesi, *In viaggio col robot: verso nuovi orizzonti della r.c. auto (driverless)*?, in *Danno e responsabilità* 5/2017, 619-629; S. Scagliarini, *Smart road e driverless car nella legge di bilancio: opportunità e rischi di una attività economica «indirizzata e coordinata a fini sociali»*, in *Quaderni cost*. 2/2018, 497-500; C. Severoni, *Prime considerazioni su un possibile inquadramento giuridico e sul regime di responsabilità nella conduzione dei veicoli a guida autonoma*, in *this Review* 2/2018, 340 ff.; D. Cerini, *Dal decreto smart roads in avanti: ridisegnare responsabilità e soluzioni assicurative*, in *Danno e resp*. 4/2018, 401, and therein L. Butti, I. Rigo Tronconi, *Decreto smart road quali profili di sicurezza*? On the Infrastructure and Transport Ministerial Decree of 28 February 2018, n. 70, «Smart Road» decree, see page 7, note 21, in this paper.

(4) USA Department of Transportation — National Highway Traffic Safety Administration -NHTSA, *Guide lines for the development and deployment of driverless vehicles*, September 2016. See also *Reference document with definitions of Automated Driving* (WP.29) and the *General Principles for developing a UN Regulation on automated vehicles*, ONU, *Economic and Social Council*, 23 April 2018, *World Forum for Harmo-*

1. Level one indicates solutions for driver assistance. The vehicle can assist the driver with some functions, such as adaptive cruise control etc.;

2. Level two indicates partial automation, which is a common situation where technology assists the driver, taking vehicle control in a few limited situations (lane centring). The driver has to monitor the vehicle and be ready to intervene;

3. Level three indicates «conditional automation» that concerns some driving modes, but with overall control and monitoring of the environment by the driver;

4. Level four means high automation for many driving modes when the vehicle is able to steer, brake, accelerate etc., but usually it cannot undertake dynamic decisions;

5. Level five is full automation for all driving modes.

In this case, we can use the concept of autonomous or driverless vehicle.

Level O indicates that there is no automation: the driver performs all operating tasks at all times.

Following the definition of self-driving car (included in some foreign legislation, such as that adopted in California) ([5]), AVs are vehicles «with the capability to self-drive without being actively controlled or monitored by human operators», where the «operator» is the person who engages the te-

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nization of Vehicle Regulations. See also M.C. GAETA, *Automazione e responsabilità civile automobilistica*, in *Resp. civ. previdenza* 2016, 1717.

([5]) For a general overview, see J. S. BRODSKY, *Autonomous Vehicle Regulation: How an Uncertain Legal Landscape May Hit the Brakes on Self-Driving Cars,* in *Berkeley Technology Law Journal*, vol. 31, *Annual Review* 2016, 851-878; D. A. CRANE, K. D. LOGUE, B. C. PILZ, *A Survey of Legal Issues arising from the Deployment of Autonomous and Connected Vehicles*, 23 Mich. *Telecom. & Tech. L. Rev*. 191 (2017); M. ROE, *Who's Driving That Car: An Analysis of Regulatory and Potential Liability Frameworks for Driverless Cars*, *Boston College Law Review* 60, no. 1 (2019) 317-348. A self-driving car traveled the public roads of a city without any human driver in November 2017, for the first time in Arizona. This was announced by Waymo, a Google-Alphabet group project, which is engaged in the development of self-driving cars, starting its driverless test on public roads in Phoenix, AZ. Three Waymo cars (Chrysler Pacifica brand) with five passengers on board, but no drivers, took a long tour of the American city in normal traffic conditions: pedestrians crossing the street, red traffic lights and normal car traffic with human drivers. Uber had also been testing driverless cars for a long time, until it was involved in an accident (the death of a woman who was crossing a dark street, just off the pedestrian crossing in Tempe, Arizona, on March 18, 2018) which resulted in a temporary interruption of tests. Apple is engaged in tests for autonomous driving in California on the roads of New Jersey. For an overview see Italian National Insurance Association (ANIA), *Smart roads, veicoli connessi ed autonomi. Mobilità e assicurazione nel prossimo futuro: Rc auto o Rc prodotti*?, Discussion paper, October 2017, on *www.ania.it*.

chnology, regardless of if he/she is physically present in the vehicle or not, while it is engaged (6).

Thus, following this definition, any AV is automated, driving itself without any human intervention, but automated vehicles are not necessarily autonomous, as technology in automated vehicles may only be adopted up to a certain level, not fully.

Implementation of AV constitutes a project of general interest with the number of benefits it can provide for accident reduction, implementation of a more inclusive mobility system, reduction of polluting emissions and congestion in urban areas. These targets can be achieved provided that the regulatory framework reference, in which autonomous vehicles will operate, is able to support their utility by preventing negative effects (for example, in terms of privacy violations) (7) and adequately managing conflicts (8), with special reference to damage and liability effects.

One of the main legal problems precisely concerns the identification of the person who is liable in the event that an AV does something wrong or crashes.

According to the Italian civil code (art. 2054), the driver (as well as the owner of the vehicle), is strictly liable for damages toward victims resulting from circulation. He can be released from liability by demonstrating that he has done everything possible to avoid the damage, or that the damage derives from the imprudence of a third party or an unpredictable and unavoidable external cause (9). In the case of a driverless car, the owner could re-

(6) The definition of driver contained in the Canada legislation is interesting in that it refers to the person that «causes the autonomous vehicle to engage, regardless of whether the person is physically present in the vehicle while it is engaged». Also according to Japan legislation vehicles must be able to be stopped remotely. On this subject see I. Ferrari, *Analisi comparata in tema di responsabilità civile legata alla circolazione dei veicoli a guida autonoma* in *Smart roads e driverless cars,* cit., 97 ff.

(7) N. Miniscalco, *Smart area, circolazione dei veicoli autonomi e protezione dei dati personali*, in *Smart roads e driverless cars,* cit., 27 ff.; M.C. Gaeta, *La protezione dei dati personali nell'Internet of things: l'esempio dei veicoli autonomi*, in *Diritto dell'informazione e dell'informatica* 1/2018, 147-179.

(8) Emad Abdel Rahim Dahiyat, *From Science Fiction to Reality: How will the Law Adapt to SelfDriving Vehicles?*, in *Journal of Arts and Humanities*, Vol. 07, Issue 09, 2018, 34-43; A. Taeihagh, H. Si Min Lim (2019) *Governing autonomous vehicles: emerging responses for safety, liability, privacy, cybersecurity, and industry risks,* in *Transport Reviews*, 103-128.

(9) According to the Italian Cass. Court, 9 March 2004, n. 4754, liability of the driver and the owner is joint and objective (art. 2054, comma 3, Italian civil code), except for damages due to unforeseeable circumstances or force majeure and for da-

main the only person liable (as well as legal user, or buyer with reserved domain agreement or the lessee in the leasing agreement according to art. 91 of Italian road code) according to art. 2054, comma 3, Italian civil code, following the same paradigm in liability for damage caused by goods subjected to human control or supervision, albeit with some deviations.

The vehicle manufacturer can be held responsible too for eventual damage caused by defects based on the rules set out by the consumer code ([10]) and related EU legislation ([11]).

Thus, the presence of automation does not impact in itself on the legal paradigm of liability for damage resulting from road circulation: in the case of driver assistance devices (level 1 and 2), which operate in limited situations for a very short time under monitoring of a «supervisor» on board, it is possible to apply the general rules.

Fully automated vehicles will be completely different, as they do not have a driver/supervisor on board, nor people requested to be ready to intervene or alert at all times ([12]), but just users on board. These considerations give rise to very important questions on the adequacy of current law paradigms in governing these new phenomena, also in the presence of the declaration of the National Highway Transportation Safety Administration (NHTSA) that Self Driving Systems are considered as the «driver» for liabilities purposes.

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mage suffered by damaging person. P. Trimarchi, *La responsabilità civile: atti illeciti, rischio, danno*, Milano, 2017; M.C. Gaeta, *Automazione e responsabilità civile automobilistica*, in *Resp. civ. e previdenza* 2016, 1718-1750; D. Cerini, *Dal decreto "Smart roads" in avanti: ridisegnare responsabilità e soluzioni assicurative*, in *Danno e responsabilità* 2018, 4, 401-409; S. Pollastrelli, *Driverless cars: i nuovi confini della responsabilità civile automobilistica e prospettive di riforma*, in *La decisione nel prisma dell'intelligenza artificiale* (E. Calzolaio editor), Bologna, 2020, 109 ff.

([10]) According to the Italian Supreme Court strict liability of the driver or car owner does not exclude the liability of the manufacturer: Cass. 9 Mach 2004 No. 4754 in *Mass. Giust. Civ*. 2004, 3. On this argument see I. Ferrari, *Analisi comparata in tema di responsabilità civile* cit., 102; S. Pollastrelli, *op. cit*., 113 ss., also for more bibliographic references.

([11]) T. Liivak, *Libility of a Manufacturer of Fully Autonomous and Connected Vehicles under the Product Liability Directive,* in *International Comparative Jurisprudence* (2018) Vol. 4, Issue 2, 178-189.

([12]) For this reason, according to scholars «legislation should introduce an irrefutable presumption of a defect in a highly or fully automated vehicle that causes an accident, unless the manufacturer can prove that the autonomous vehicle functionality was not the cause of the accident»: V. Ilková, A. Ilka *Legal Aspects of Autonomous Vehicles — an Overview*", Proceedings of the 2017, 21[St.] International Conference on Process Control (PC) Strbské Pleso, Slovakia (2017) June 6-9. See also S. Pollastrelli, *op. cit*., 117.

Assigning liability for damages deriving from vehicle circulation to driverless car users is in contrast with the paradigm based on the connection between behaviour (wilful misconduct, gross fault and/or negligence) and an adverse event; this paradigm foresees the possibility of an agent intervening in the causative process of the event ([13]). In the case of an AV, liability would be connected to the simple use of the vehicle for involvement in the event. On the other hand, it has also been observed that levelling any responsibility on the manufacturer could interfere with the development of driverless mobility ([14]).

The issue on «who is liable in the event of an accident with an AV?» is not the topic of this paper. I will just mention that there are different doctrinal positions that — considering the Self Driving System as a driver — attribute liability to the developer of technology or the product manufacturer, without prejudice to the position of the owner who, as in the case of manned vehicles, maintains a generic duty of care concerning the use of the vehicle and has to prevent damage that may derive from it ([15]).

In the case of a sub-standard product, manufacturer's liability has also been proposed ([16]). On the contrary, the intervention of a public fund could be foreseen in the presence of damage caused by vehicles that comply with standard safety requirements ([17]).

The debate is ongoing, but all agree that AVs probably need *ad hoc* legislation ([18]).

([13]) The user would still be considered as a third party according to art. 2054 Italian civil code: M.M. Comenale Pinto, E.G. Rosafio, R*esponsabilità civile per la circolazione degli autoveicoli a conduzione autonoma. Dal grande fratello al grande conducente*, in this Review 1/2019, 395.

([14]) G.E. Marchant, R.A. Lindor, *The coming collision between autonomous vehicles and the liability system* in *Santa Clara Law Review* 52, 2 (2012), 1321-1340.

([15]) In an attempt to identify the person responsible, in the case of driverless vehicles, the person who owns the car, as owner or builder, has to be considered as responsible. On this argument, see G.E. Marchant, R.A. Lindor, *The Coming Collision between Autonomous Vehicles and the Liability System*, in 52 *Santa Clara L. Rev*. 1321, 1340 (2012); W.J. Kohler, A.C. Taylor, *Current Law and Potential Legal Issues Pertaining to Automated, Autonomous and Connected Vehicles*, 31, *Santa Clara Computer & High Tech. L.J.* 99, 138 (2014); F. Douma, S.A. Palodichuk, *Criminal Liability Issues Created by Autonomous Vehicles*, in 52, *Santa Clara L. Rev*., 1157, 1170 (2012).

([16]) S. Pollastrelli, *op. cit*., 113 ff.

([17]) A. Davola, R. Pardolesi, *In viaggio col robot*, cit., 629.

([18]) A. Herd, *R2DFord: Autonomous Vehicles and the legal implication of varying liabilities structures*, in *Faulkner Law Review*, 29, 2013, 58. The A. explains that in the case of driverless vehicles, it is difficult to prove manufacturer liability, using the tra-

Deployment of autonomous vehicles on public roads push the system to provide a new paradigm to assign civil liability for damages resulting from vehicle circulation, compared to the model based on driver's liability.

A possible scenario could involve the configurability of a model of strict liability of software producers and (possibly) of the car owner (probably different from the user, with a corporate structure capable of bearing the inherent risk in the new model of circulation, guaranteeing against this same risk — an ad hoc form of insurance); at the same time, some interesting indications derive from the current legislation on experimentation on smart roads ([19]).

I would like to emphasize that the presence of AVs on public roads, which interact with traditional users, makes road traffic a highly complex system, similar to the aviation and maritime sectors ([20]), characterized by unknown risks due to new technology, to higher levels of real time information sharing and to the high number of independent interactions between different operators.

It is obvious that safety of the overall system cannot be entrusted to single driver diligence, or to the reliability of a single artificial intelligence system, but rather depends on a fully integrated «Cooperative Driving Architecture», carefully designed and managed, that includes autonomous vehicles, technological resources, smart-infrastructures and a sharing information network between all components.

Thus, the topic is — who manages the overall risk related to the deployment of AV on public roads?

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ditional test of customer expectations and risk-utility. As outlined by scholars, «the two most common tests a Court will use when determining if a product is defective are "consumer expectation" and "risk-utility" tests». "Consumer expectation" determines if the danger "is greater than an ordinary consumer would expect when using the product in a reasonably foreseeable manner". In the *Bresnahan* v. *Chrysler Corp.*, on the contrary, the Court concluded that, although consumers did not understand how autonomous technology works, they reasonable develop expectations on safety features, as the main buying motif. The "risk-benefit test" is founded on evaluation if "the harm posed by the product could have been reduced or avoided by the adoption of a reasonable alternative design". Also this test is of difficult application, as there are different designs for autonomous cars. See law-case at p. 45 ff. and, for the application of maritime and aviation liability rules, p. 51 ff.

([19]) On the new dimension of mobility, organized as shared mobility with a general delegation of management services to the "manager" outside the vehicle, see F. LEALI, L. CHIANTONE, *Un ambiente urbano per la sperimentazione di soluzioni innovative per la mobilità*, in *Smart roads e driverless cars*, cit., 1 ff.; D. CERINI, *Dal decreto Smart roads in avanti: ridisegnare responsabilità e soluzioni assicurative*, in *Danno e responsabilità* 4, 2018, 401 ff.

([20]) M.M. COMENALE PINTO, E.G. ROSAFIO, *op. cit.*, 397 ff.

Looking at the current regulatory framework, a suggestion for a possible solution might be found in the Italian regulations, albeit transitory, contained in the Infrastructure and Transport Ministerial Decree of 28 February 2018, on «Implementing methods and legal instruments for road testing of smart road and connected and automatic driving solutions» ([21]), i.e. «Smart road decree». The Italian decree allows an experimental use of AV on public roads on the condition, above all, of the implementation of a Road Traffic Control architecture to manage risks connected with the circulation of autonomous vehicles, both for preventive safety aims, but also as an element that can contribute to defining a new liability paradigm, aimed at sharing the negative effects of a general interest innovation.

As highly technological complex systems, aviation and maritime sectors are governed by a set of rules on safety, setting preventive measures to maintain the risk of the overall system at an acceptable level; the model includes an oversight structure (to ensure that individuals and organizations performing an activity comply with safety-related laws and regulations) as well as the implementation of traffic management and monitoring services, which assume a pivotal role with respect to safety, efficiency and environmental results.

The liability paradigm adopted in highly complex and technological systems includes, first, a strict liability regime (and mandatory insurance) for the operators, with the aim to compensate damages also in the case of unexpected and unstoppable events or where it is not possible (or extremely difficult) to prove fault or negligent behaviours; second a model of culpable liability — usually including slight negligence — for the agent who is called on to manage the traffic and guarantee overall safety oversight.

As we know, safety oversight forms part of the safety regulatory process aimed at ensuring that applicable safety regulatory requirements are met, also implementing monitoring services. Unless prescribed otherwise by international legislation, safety oversight in the aviation (and maritime) sector is a national responsibility.

Thus, the aviation (and maritime) experience suggests finding safety solutions and liability paradigms improving traffic management and monitoring systems to deal with complex issues that can stem from the implementation of AV circulation.

The air traffic control (ATC) service, especially for unmanned aerial vehicles could represent a viable tool from which regulators and lawmakers

([21]) Infrastructure and Transport Ministerial Decree of 28 February 2018, in Italian Official Journal, 18 April 2018, No. 90.

may find the way to ensure safety in AV road traffic — especially in city centres and crowded areas.

The aim of this paper is to attempt an evaluation of possible application — from a legal perspective — of ATC architecture and principles to a future AV Traffic Control.

2. *Autonomous vehicle regulatory framework* — With a view to deployment of AVs, implementation of a regulatory framework to maintain an acceptable level of risk for different users of the road is required. It includes the traditional function of vehicle registration, managing driver licensing and regulation of insurance.

From a general point of view, the attraction of AVs for consumers comes from the promise that they will be safer and more accessible to reduced mobility users than conventional vehicles.

Experimentation on autonomous cars has already been authorized in many States of America for over a decade ([22]), but the main issue remains the allocation of responsibility to manage relevant risk between different parties: owners, operators, passengers, manufacturers.

AV developers are pursuing different strategies and technologies in their systems ([23]).

These differences make it difficult to compare vehicle safety across companies and to foresee fixed technical specifications, so as to lay the basis for a regulation of competition in this sector. In any case, States are urgently requested to review the existing legislation, in the part in which it relies on the human driver for diligence in behaviour, as well as duty of crash reporting or insurance charges, etc. ([24]).

([22]) Cfr. L. Mc Christian, R. Corbett, *Regulatory issues related to Autonomous vehicles* (2016), in *Journal of insurance regulation,* 3, 1590.

([23]) Tecla, Google and, in the EU, Audi, Mercedes are considered independent developers that are not manufacturers.

([24]) The 1968 United Nation Vienna Convention on Road Traffic, of 8 November 1968 (in United Nation, Treaty Series, vol. 1042), requires that every vehicle has a driver on board. According to Art. 8 on «drivers», every moving vehicle or combination of vehicles shall have a driver. Every driver shall possess the necessary physical and mental ability and be in a fit physical and mental condition to drive. Every driver of a power-driven vehicle shall possess the knowledge and skill necessary for driving the vehicle; however, this requirement shall not be a bar to driving practice by learner-drivers in conformity with domestic legislation. Every driver shall at all times be able to control his vehicle, according to new comma 5-*bis*. The on-board systems that affect the driving of the vehicle are considered to comply with § 5 of this article and

The ongoing EU agenda is focused on smart automated mobility, above all on the adoption of common rules at a European level ([25]), based on the idea that different regulations will not allow the marketing of vehicles, as it would be nearly impossible for auto manufacturers to comply with them all ([26]).

Starting from the legal framework of Directive 2010/40/EU on Intelligent Transport Systems (ITS) ([27]), a phase of construction of fully integrated and

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with the first paragraph of article 13 if they comply with the provisions on construction, assembly and use set forth in international legal instruments relating to wheeled vehicles and the equipment and components assembled and/or used on them. On-board systems that affect the driving of the vehicle and do not comply with the aforementioned provisions on construction, assembly and use are considered to comply with § 5 of this article and the first paragraph of article 13 if they can be neutralized or deactivated by the driver. According to Art. 13, first paragraph, every driver of a vehicle shall in all circumstances have his vehicle under control so as to be able to exercise due and proper care and to be at all times in a position to perform all manoeuvres required of him. The *National Highway Transportation Safety Administration* (NHTSA) said that «Self Driving Systems» are considered as the «driver» for liabilities purposes.

([25]) EU Ministers of Transport, at an informal meeting on 15 April 2016, signed a declaration concerning cooperation in the field of autonomous driving (Declaration of Amsterdam on cooperation in the field of connected and automated driving). According to the Declaration of Amsterdam, the EU Ministers, together with all the stakeholders, defined a common agenda to pursue and further develop a set of shared objectives, for the introduction of connected and automated cars by 2019. The main issues to be analysed are: the creation of a harmonized legislative framework at EU and international level (legal framework); the analysis of issues related to the use of public and private personal data (privacy and data protection), with the identification and definition of the responsibilities of the subjects involved; the mechanism of interoperability of services and systems between vehicle and vehicle (so-called V2V) and between Vehicle and Communication Infrastructures (V2 Infrastructure communication).

([26]) EC Communication *"On the road to automated mobility: An EU strategy for mobility of the future"*, Brussels 17 May 2018, 283 final.

([27]) Dir. 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport. The priority actions identified concern: first of all the elaboration and use of specifications and norms relating to information services: a) on multimodal mobility; b) traffic in real time; c) free communication to users, if possible, of minimum traffic information related to road safety; d) harmonized provision of an interoperable electronic emergency call service (e-Call) throughout the European Union; e) implementation of information services related to safe parking areas for heavy vehicles and commercial vehicles; f) reservation services for safe parking areas for heavy goods vehicles and commercial vehicles. The European Commission has issued the Delegated Regulations 962/2015, 886/2013, 305/2013 and 885/2013, which contain the details of specifications to be adopted for points b., c., d. and e. respectively.

innovative infrastructures has been launched: in the European vision, an autonomous driving system has become ever more a «network architecture» which includes self-driving cars, platforms for connecting and smart roads, to provide essential services, above all storing, processing and spreading information.

Smart Roads are the most important element of the EU Cooperative ITS (C-ITS) plan ([28]), as they establish the technological ecosystem that allows interoperability with new generation vehicles, for the provision of innovative services for users — intermediate and final — and adequate levels of safety through continuous knowledge of vehicle behaviour.

Thus, smart roads could become a milestone for the gradual replacement of the driver's role with innovative driving technologies, as a «mediator between vehicle» and context, using information coming from both the internal environment (vehicle) and the external environment (traffic, weather) and processing it to maintain risk at an acceptable level ([29]).

It is important to clarify that at this *test phase*, legislation of Member States that admits experimental circulation of automated vehicles, requires a supervisor on board, who is in turn requested to intervene in the case of danger. For instance, driverless vehicles can be tested in the UK providing that a test driver is on board and assumes responsibility for safe operations. The same solution is foreseen in German legislation ([30]).

([28]) On 30th November 2016, the European Commission adopted a «European Strategy on Cooperative Intelligent Transport Systems (C-ITS)», a milestone initiative towards cooperative, connected and automated mobility. The objective of the C-ITS Strategy is to facilitate the convergence of investments and regulatory frameworks across the EU, to see deployment of mature C-ITS services in 2019 and beyond. This includes the adoption of the appropriate legal framework at EU level by 2018 to ensure legal certainty for public and private investors, the availability of EU funding for projects, the continuation of the C-ITS Platform process as well as international cooperation with other main regions of the world on all aspects related to cooperative, connected and automated vehicles. It also involves continuous coordination, in a learning-by-doing approach, with the C-ROADS platform, which gathers real-life deployment activities in Member States.

([29]) According to the concept, the AI must be built on knowledge that can derive from an information system partly based on a road-side sensors network and partly based on other sources, including vehicles capable of collecting information through sensors and forwarding it (updated) either directly back to the road (or other vehicles) or to a third party from which the road procures information.

([30]) See M.G. LOSANO, *Il progetto di legge tedesco sull'auto a guida automatizzata*, in *Diritto dell'informazione e dell'informatica* 1/2017, 1 ff. For a picture of the national regulations adopted in Germany, the United Kingdom, France and the United States, as well as in Italy, see A. DI ROSA, *Il legal framework internazionale ed europeo*, in

Italy has recently allowed experimentation on automated vehicles with the enactment of the «Smart Road decree», aimed at creating a digitized road system capable of making vehicles and infrastructures interoperable through V2X (vehicles to everything technology) ([31]).

The reference discipline for road circulation in Italy is established by legislative decree No. 285, 30 April 1992. After a long delay in starting with the digital revolution and experimentation of AVs, on December 27th, 2017, l. No. 205 (Art. 1, § 72) ([32]) allocated funding to make national infrastructures — included in the TEN-T network and the National Integrated Transport System (SNIT), as well as all highways — digital and connected (Smart-Roads) ([33]). This rule sets the legal basis for the detailed administrative regulation, implemented with the so called «Smart Road» decree on «Implementing methods and legal instruments for road testing of smart road and connected and automatic driving solutions».

The «Smart Road» decree defines a vehicle with autonomous driving as «a vehicle equipped with technologies capable of adopting and implementing driving behaviours without the active intervention of the driver in certain road areas and defined external conditions» (art. 1, let. f).

Smart Roads e driverless cars: tra diritto, tecnologie, etica pubblica, cit. 65 ff., 69; S. Pollastrelli, *op. cit*., 111 ff.; M.M. Comenale Pinto, E.G. Rosafio, *op. cit*., 379 ff., 396; M. Ferrazzano, *Dai veicoli a guida umana alle autonomous cars. Aspetti tecnici e giuridici, questioni etiche e prospettive per l'informatica forense*, Torino 2019.

([31]) The document drafts the «system architecture» characteristics, where innovative technologies for smart mobility are inserted, identifying the basic elements in an open and comprehensive dimension. The system architecture is composed of some enabling structures (platforms) which form the backbone on which different functions are based. The architecture is qualified as «enabling» as it supports different categories of functions and services, and it is considered «open» because it is not managed by a predetermined supplier but can be made available to third parties for the development of new commercial utilities under market conditions. Platforms are based on the connectivity of people and vehicles, open data, big data and the Internet of Things: see *Italian Ministry of Infrastructure and Transport, Functional Standards for Smart Roads, Position Paper* 22 June 2016.

([32]) See Italian law, No. 22/2012, implementing Dir. 2010/40/EU.

([33]) Exchange of information between driverless vehicles and infrastructure, pedestrians and devices is made possible by impressive technological development and by financing of equipment and facilities for high-rate data communication, WIFI hotspots, connection services for IT and traffic and weather detection systems. The costs are borne by the concessionaire of the infrastructure, the service or the manager. On this subject see S. Scagliarini, *Smart roads e driverless car nella legge di bilancio: opportunità e rischi per un'attività economica «indirizzata e coordinata a fini sociali»* in *Quaderni costituzionali* 2/2018, 497-500.

A vehicle equipped with one or more driver assistance systems, which requires continuous active participation by the driver in driving activity, according to this legislation is not considered an autonomous driving system. It should be noted, however, that in the Italian decree, the distinction is not clear regarding the difference between «automatic» (Level 4) and «autonomous» (Level 5).

Automatic driving technologies include various types of sensors, software for processing data coming from these sensors and software for the interpretation of traffic situations, learning software, software to make driving decisions and to implement them (art. 1, let. g).

The autonomous mode is where automatic driving technologies are inserted and assume «full control» of the vehicle.

The decree allows the experimentation of autonomous driving vehicles on public roads, subject to a specific procedure that involves different subjects such as the National Transport Authority, bodies authorized to experiment (manufacturer, independent developers such as universities and research institutes), and infrastructure managers, called to issue an authorization for experimentation on roads under their competence ([34]).

To obtain authorization for experimentation, producers must demonstrate that they have respected all precautionary rules as outlined in the Ministerial Decree ([35]). Vehicles are registered and identified by a special symbol.

During the testing phase, the authorization holder must fulfil a set of obligations: he must identify interaction between the vehicle and external obstacles, identify risks associated with use of the vehicle and illustrate the countermeasures put in place to the competent authority; install protections to prevent unauthorized access to the system; and satisfy the insurance obligation.

The authorization holder has also the obligation to report all anomalies that have involved the driverless system ([36]). In a future phase of commer-

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([34]) S. Scagliarini, *La sperimentazione su strada pubblica*, in *Smart road e driverless cars*, cit., 18 ff.

([35]) An Observatory is also established with the functions referred to in art. 20

([36]) Authorization includes the list of vehicles for which the experimentation is permitted, the accredited supervisors (the ability of which to manage the situation has been verified). Road surfaces and permitted weather conditions are also indicated. If the applicant for the authorization is an independent experimenter, the manufacturer's authorization is required to guarantee congruence between software and car model in use. On problems related to this authorization, with reference to the application of EU competitiveness rules, see *Italian Antitrust Authority,* opinion AS 1556 of 19 December 2018, in *Boll*. 2/2019.

cial use, the position (and responsibility) of the authorization holder will, probably, be on the owners of driverless vehicles or commercial users.

Provision of a manufacturer's authorization is a legal consequence of the complex structure of the driving system that, on an operational level, includes software, hardware and a human element as well as the interconnection tool between them, also if external to the vehicle.

According to the above-mentioned decree, experimental circulation requires a supervisor on board at all times. This is «the occupant of the vehicle who has always to be able to take control [...] regardless of the degree of automation, at any time the need arises [...] and that, therefore, is responsible for the circulation of the vehicle». When he/she takes command, in manual mode, he is the driver (art. 1, let. j), but he is responsible for the vehicle both in automatic and manual mode (art. 10, § 2).

A Smart Road is road infrastructure in which a transformation process has been completed, aimed at introducing platforms for observation and traffic monitoring, data and information processing models, advanced services to be provided to infrastructure managers, public administration and road final users (art. 2). Thus, the road is «smart» if, and to the extent that, it provides ITS mobility services, failing which it would be a «simple road».

The aim of this transformation is to implement a «tried and tested system» able to acquire knowledge of traffic flows, for safety purposes, traffic management and interoperability, providing priority services according to EU legislation ([37]): using V2I technology, the cooperative system can provide information, but also safety-useful services to on-board devices or to users' smart phones, in real time. Starting from predictive navigation solutions, it is possible to provide a broader set of services, such as dangerous goods monitoring and management of traffic flow.

Therefore, the «tried and tested system» is an entire set which includes the vehicle with automatic driving (authorized for experimentation), a supervisor and all systems that contribute to the experimentation «including monitoring systems, registration and systems of communication and interaction with the supervisor» (art. 1, let. k).

At the same time, we can conclude that the core mission of the «smart road manager» is to guarantee these ITS mobility services, which allow to consider him/her as a service provider ([38]).

([37]) Defined in the delegated regulation in force since 31 December 2019.

([38]) Manager guarantees the efficiency of V2I, I2I and V2X communication, as well as services to users starting from interoperability of the C-Road and C-ITS sta-

These functions are an expression of the planning authority of the administration, able to create (economic) utilities from a regulatory structure, which conditions and directs users' choices, rather than preserving and supporting them.

Briefly, the reference point of the regulation system is the smart road, as an infrastructure capable of monitoring the traffic flow by communicating with the vehicle according to the functional specifications indicated in the annex to the Smart road decree.

3. *Traffic management system for mixed road traffic* — As mentioned above, communication between vehicles, infrastructures and other users is considered of pivotal importance to improve safety of autonomous driving vehicles, where they will integrate with traditional road users. For this reason, connectivity and cooperation are considered prerequisites for secure automation and represent the first investment made by those States that have started experimentation.

According to the provision of the Italian Smart Road decree, the key to success of the system is to get «superior situational awareness».

Thus, the implementation of driverless vehicles poses, above all, a problem of regulation, not only with regard to the use of these vehicles on public roads ([39]), but also for the identification of a figure who has the duty of care for the overall efficiency of the Autonomous Driving System, being responsible for safety oversight.

Given that the possibility of a collision is very low in a reliable autonomous driving system, i.e. Level 5, the implementation of AVs suggests that, in the near future, safety risk assessments will depend on factors (such as cyber security and computer failure) that have a marginal impact in liability today.

From an operative perspective, AVs should be capable of self-learning rather than merely following instructions. They are programmed to make

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tions, guaranteed by compliance with technical specifications set at the EU level. Cooperative services are based on an open-access network that allows a relationship between all operators, guaranteeing data security and interchangeability.

([39]) On March 23, 2016, the amendment to art. 8 of the Vienna Convention (5-*bis*), which allows control of the vehicle to be entrusted to a computerized system, entered into force. On this subject see A. Di Rosa, *Il legal framework internazionale ed europeo*, *loc. cit.;* for profiles inherent to the protection of personal data see M.C. Gaeta, *La protezione dei dati personali nell'Internet of Things* in *Fonti dell'informazione e dell'informatica*, II, 1 February 2018, 147.

autonomous decisions according to their experience, so their actions are not always completely predictable by their users ([40]).

Programming AVs to comply with all laws and regulations regarding the rules of the road is simple; on the contrary, unpredictable events, where driving technology does not have all the knowledge to make a choice, could occur especially in the case of the coexistence of different driving models and users: the software may not have the full capacity, by itself, to manage unforeseen elements to support a decision regarding safety that deviates from the predetermined rules of driving: for instance, where it is better to disregard the precautionary rules set up in the system (software) to get a safer result (or reduce the danger) in the case of a totally unexpected event ([41]).

In some way, the confirmative power of technology, by preventing the choice to comply with or to violate rules, shifts the ethical responsibility on to the programmers and software developers and remits the responsibility to fix the measure of acceptable risk to the political level ([42]).

Even in the current testing phase, a supervisor on board is required to intervene up to the limit of unforeseeable circumstances or force majeure. Therefore, damages that fall into these areas could be ascribed to software manufacturers, who would respond for the risk coming from unknown technology, or even to the vehicle manufacturer, who is also involved in the commercial operation.

Nevertheless, in these cases, it is not easy to conclude that it was the technology that failed, because actually, the technology probably worked cor-

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([40]) Sensors collect data about the car's surrounding and pass these data to the driver's computer that combines these data with any incoming information from networks. This analyses all those data and decides what action to take: this becomes an instruction to the competent component. On this argument see E.A. RAHIM DAHIYAT, *From Science Fiction to Reality: How will the law adapt to self-driving vehicles*? cit., 34-43.

([41]) The ethical dilemma arose from the impossibility for machines to make choices supported by conscience and awareness, but only optional choices on a cognitive basis according to a preset program following the correct/incorrect alternative and not the right/wrong one: R. BRIGHI, S. ZULLO, *Filosofia del diritto e nuove tecnologie. Prospettive di ricerca tra teoria e pratica*, Aracne, Roma, 2015. Automatic driver decision-making mechanisms are essential when an AV is interacting with situations that request specific decisions and collision is not avoidable. For the special issues concerning liabilities coming from the e behavior of the AV in emergency situations: see S. LI, H. ZHANG, S. WANG, P. LI AND Y. LIAO, *Ethical and Legal Dilemma of Autonomous Vehicles: Study on Driving Decision- Making Model under the Emergency Situation of Red-Light Running Behaviors*, in *Electronics* (2018) 7, 264.

([42]) F. DE VANNA, *Autonomous driving e questione della responsabilità: alcuni nodi teorici*, in *Smart roads e driverless cars,* cit. 82.

rectly, nor can we use the culpable omission formula to find a liable entity, as it is quite hard to argue that technology can have a duty to do everything possible to prevent the event.

Future accidents will probably improve the awareness of the system every time. In any case, having full traffic-situation awareness is undoubtedly the best solution to create — as soon as possible — safer, more efficient and environmentally friendly traffic.

As we know, traffic management has long existed also in road traffic in a basic way (traffic lights on city streets), but the development and implementation of sophisticated integrated applications based on Intelligent Transport Systems (ITS) has expanded the scope and possible results of this function.

In other words, while increased safety remains the core aim, nowadays, traffic control includes managing transport networks more effectively to better organize the use of infrastructure, provide a reliable service to the end user and reduce negative environmental effects.

In the case of AVs, smart infrastructures can monitor traffic by dialoguing with users and can integrate mobility management platforms to provide services for deviation of flows in the event of accidents, intervene on average speeds to prevent congestion and give suggestions of itineraries and lanes (re-routing), dynamic administration of accesses, supplies, and parking ([43]).

The abovementioned rules concerning the testing phase of automatic vehicles do not provide clear obligations and responsibilities for a monitoring traffic service, or a proper «road traffic control system». From them, however, indications can be drawn about where the law is going.

According to the Italian Smart Road decree, the list of «minimum services» that the manager of Smart-Roads (empowered with V2I communications) must provide consists of the basic elements of a traffic monitoring system including the collection, processing and distribution of traffic data ([44]).

([43]) Smart roads are divided into different types and classes according to the level of automation and are marked by a logo indicated in the *Decree of the General Director of Information and Statistics Systems Direction* (*Ministry of Infrastructure and Transport*) of 4 May 2018 http://www.mit.gov.it/comunicazione/news/smart-road-smart-mobility-mezzi-stradali/mit-operativo-osservatorio-tecnico-di-supporto.

([44]) For Type I Smart Roads these features include: a) Warning on the presence of stopped vehicles or slowed traffic in the segment following the current position; b) Warning on an abnormal density of vehicles under emergency braking in the segment following the current mileage; c) Arrival of an emergency vehicle and the estimated time for its arrival; d) Repetition of road signs on the vehicle; e) Repetition of speed

It is important to clarify that the manager of the infrastructure (where an experiment is being carried out) must issue an express authorization for the activity. This is because during the tests the manager is requested to ensure the efficiency of the cooperative systems and make all collected data available for the authorization holder, as well as give information to the users on possible experiments, through official communication channels or appropriate traffic signals ([45]).

Infrastructure management must provide services related to road safety applications (e.g. temporary provisions and rules, warnings, emergency management, etc.), traffic control, maintenance of infrastructures and superstructures (including traffic rules), monitoring of respect of the rules of circulation and of the use of infrastructures, as well as the preparation of data for issuing and collection of fines, application of tariffs and tolls and their collection. Infrastructure managers also provide traffic information directly to their users. To this end, they integrate conventional systems (variable message panels, radio and TV bulletins, web, etc.) with the new direct vehicle communication systems (V2I), using the appropriate platform ([46]).

Utilities connected to smart road/driverless car mobility start from performance analysis (as emerges from historical data on circulation efficiency, safety data, and data on infrastructure functionality) to perform traffic forecasts, identify possible management strategies, simulate the consequences and define coordinated and publicized intervention scenarios. These utilities are at the basis of new performance of operational management of traffic and parking, leading to decision making for traffic management, as well as surveillance, sanctions and security services (which may include enforcement regarding the payment of tolls in free flow mode).

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limits on board the vehicle. For Type II and Type I Smart Roads, these functions include: a) Warning on the presence of construction sites; b) Warning of a traffic rule violation (e.g.: driving on the opposite carriageway, driving on lane in reverse gear, etc.); c) Suggested route deviations due to the propagation of shock waves backwards; d) Collection of information from probe vehicles specifically equipped and used by infrastructure manager.

([45]) This assumption generates a significant amount of data, which must be open and usable. The operator must comply with the existing regulations (EU and national) and arrange a data storage, research and processing platform based on modern technologies that makes searching, processing and data transfer simple and effective, both for internal use (services for the manager), and for use by third parties with access rights.

([46]) First authorization to test driverless cars on public roads in Italy was issued by the Ministry of Transport on 7 May 2019 and concerns specified streets in Turin. The tests were conducted by VisLab, a startup that manufactures self-driving vehicles.

In synthesis, Smart Road represents the core element of this implementation, allowing authorities, operators and users to have better awareness of the overall traffic situation.

Thus, the driverless experience depends on the external environment with which data exchange underlying the driving decisions takes place, according to a predefined algorithm. The car makes choices regardless of will, in the proper sense, but is also immune from internal conditioning or evaluation errors, except in the case of technical failure: if everything works correctly, therefore, choices are attributable to the "context", or better to whoever manages it (data provider) rather than to the user (vehicle).

In conclusion, regulation related to the implementation of driverless circulation seems to indicate the smart road manager as the person responsible for the implementation of network platform services, as a reference point for safety of automated road traffic system, entrusting him/her with a duty of oversight ([47]).

4. *The relevance of a road traffic management system: lessons learned from air transport* — It would thus seem clear that a platform for the governance of AVs is an important means for solving future problems of traffic management in modern cities ([48]).

([47]) Services that managers must provide include: a) collection, processing and distribution of data on traffic and structural safety; b) elaboration of information content for different uses (according to methods established by legislation applicable to data providers. Access to the content provider system must take place according to open data rules); c) preparation of information services usable for end users.

([48]) A joint public-private project (June 2017) was aimed at defining and proposing a traffic control cloud for automated vehicles with interfaces to vehicles, road authorities and city authorities, along with the associated information flows for connected vehicles. In addition, the project proposed solutions on required services including traffic control and information sharing. The partnership included Volvo Cars, Ericsson, Carmenta, Trafikverket, and the City of Gothenburg. «The system is composed of a Central Traffic Control (CTC) cloud, a number of OEM (Original Equipment Manufacturer)-clouds and external data sources. The CTC Cloud is assumed to be a Public or a Public Private Partnership instance that can serve any number of OEM clouds by aggregating all data of interest. Also here there is a Traffic Controller that monitors the situation (on the different certified roads) and with automation support that can trigger alerts to the OEM clouds if there is an event». In The Volvo Cars *Drive Me* project vehicles are aimed at Level 4 automation; if the vehicle cannot manage the situation it will go to a safe stop or make a controlled handover to the driver. Automatic Driver is allowed on a carefully mapped set of road segments but not under severe weather or traffic conditions. When the vehicle is in Autonomous Driving mode, Volvo Cars takes the responsibility and, so, it must be able to allow or revoke the Autonomous Driver in real time.

Complete deployment of AV requires a safe system and probably also a Common Centre (cloud) in which all information transferred from AVs can be assessed and evaluated to enhance safety in real-time operations ([49]).

Sharing of information between different service providers and road users, to provide remote assistance and control in a safe, reliable way becomes more and more essential.

But, what vision can we have of this road management network architecture? To try and answer to this question it might be useful to turn now to the aviation sector, to see what can be adapted from there to apply to road traffic control.

Advanced traffic control systems, more and more based on sophisticated control apparatus, have been implemented from the beginning of civil aviation activities as a service (air traffic control — ATC) to provide infrastructural aid for navigation, which was essential for the development of air transport under State responsibility.

Due to the characteristics of flight, ATC is fully implemented and continuously updated, from a technological and regulatory point of view, in the aviation sector.

Apart from the current use of ATC for manned air vehicles, application with new technology, e.g. AI and Machine Learning on aviation, has now become of vital importance ([50]).

The ongoing work of International institutions and the EU towards the definition of an air traffic control function that allows the safe use of drones is of particular interest for our purposes.

The U-Space project, developed by SESAR (Single European Sky ATM Research) Joint Undertaking, and launched in 2015-2016, does not represent a «passive» airspace, dedicated only to drones, but rather a set of services that will allow the drones to operate safely below 150 meters (500 feet) through an Automated traffic control system ([51]).

([49]) On 12 December 2016, Member States and the Commission officially launched the C-Roads Platform, an open platform to link C-ITS activities, develop and share technical specifications and test systems interoperability.

([50]) *European Union Aviation Safety Agency*, *Artificial Intelligence Roadmap*. *A human-centric approach to AI in aviation*, February 2020, on easa.europa.eu.

([51]) Defined by the basic Reg. (EU) 2018/1139 of 4 July 2018, art. 55, 56, 57 and 58, as supplemented by delegated Reg. (EU) 2019/945 and execution Reg. (EU) 2019/947. According to art. 56, § 7 of the basic regulation, Member States «shall ensure that information regarding the registration of unmanned aircraft and unmanned aircraft operators subject to the registration requirement […] is stored in harmonized national digital registration systems and interoperable. Member States may access and exchange

ATC for remotely piloted vehicles will be regulated autonomously through the Unmanned Aerial Vehicles Traffic Management platform (UTM). The technology used aims to ensure the safety of the flight of drones beyond visual line-of-sight (BVLOS) (that is when the remote piloting station can only make use of the technological equipment to display any changes in the scenario). The use of this space is based on sharing information on air operations in real time and follows its own rules, being separate, albeit interoperable, from that of manned vehicles.

The system can furnish four basic services (information, registration, electrical identification and identification of no-flight zones with an automatic ban on access — geo-fencing). The research is aimed at enabling computer planning of flights, real-time location and access to dynamic information capable of realizing a flight reorganization (2020).

During flight, the drone can exit its predetermined route to avoid obstacles or to comply with indications that it receives in real time, for example, because a certain area is subjected to geo-fencing. The drone is however always detectable because it continuously transmits its identifying signal. Enhanced services, such as operations in complex and widely populated areas, can be implemented (urban air mobility).

All control centres involved in flight management are able to simultaneously view the trajectory of the monitored vehicles, improving flow through the System Wide Information Management (SWIM) aeronautical information exchange network.

The philosophy behind the system is that the rules to be applied depend on the level of risk of each operation, even if carried out with the same machine ([52]).

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this information through the directory referred to in Article 74» The provision states that in cooperation with the Commission and the competent national authorities, the Aviation Safety Agency establishes and maintains a repository of information necessary to ensure effective cooperation between the EASA and the competent national authorities in relation to the execution of the tasks related to the certification, supervision and application of the rules of the regulation. The cornerstones of the SESAR system are: the network operation plan, an operational plan that ensures a common vision on the situation of the airspace; the complete integration of airport activities in air traffic management; the trajectory management service; new methods of aircraft separation to increase safety, capacity and efficiency of the system; system-level data management (SWIM, System-Wide Information Management), which will allow all subjects involved in air traffic management to be connected, allowing them to share data; controllers and pilots will be assisted by new automatic functions to facilitate their workload and manage complex decision-making processes. See *Report of the WISE Persons Group on the future of Single European Sky*, April 2019, on sesarju.eu website.

([52]) We can distinguish open (a) specific (b) and certified (c) operations. Specific operations allow drone flight (of any weight) Beyond Visual Line of Sight (BVLOS) at

For implementation of unmanned aerial vehicle (UAV) traffic control systems, Enav S.p.a. ([53]), has developed a D-flight platform that will allow BVLOS operations thanks to the interconnection of information, geo-location systems, etc. The usefulness of the platform is not only related to the identification of drones from a remote location ([54]), but also to the management of integration in the air space used by general aviation.

The main benefits of the system are: registration and identification of drones, planning (the user plans activities safely thanks to the information available in both a static and dynamic context), monitoring (real-time control of all UAVs operating in flight interaction with users, sending of alerts), and self-separation (supported by users in maintaining separation between drones, fixed and mobile obstacles, and reserved areas).

Even though the benefit of having a Central Traffic Control (CTC) Platform that provides collaborative situational awareness is clear also in AV road circulation, the responsibility for operating the CTC remains to be further investigated.

It may be useful to look at the solutions already tested in air transport, where the use of automatic driver assistance systems has long been widespread.

At this stage of legislation, it seems that the reference point for the implementation of a Central Control Platform, to provide information and assistance services in a specific road segment, could be the Road Manager, by himself or contracting with independent providers.

According to a project developed by a public-private partnership in 2017, the architecture for a road traffic control system could consist of a CTC cloud, a number of original equipment manufacturer (OEM)-clouds and external data sources. The CTC Cloud is assumed to be a Public or a Public-Private Partnership enterprise that can serve any number of OEM clouds by aggregating all data of interest. A Traffic Controller monitors the situation and can trigger alerts to the OEM clouds if there is an event, with

all altitudes. The other types of flight are called VLOS (Visual Line of Sight) and EVLOS (Extended Visual Line of Sight). Certified operations are those concerning drones used in transport services (of people and/or dangerous goods) or whose flights overfly people assemblies or take place in other particularly risk situations. The risk of an activity is assessed with the Specific Operation Risk Assessment (SORA) method, which allows definition of the level of risk in progress and an adjustment of the related rules, including intervention in the event of an emergency.

([53]) Italian Enav S.p.a. "Ente Nazionale dell'Assistenza al volo" (Air Traffic Managemen Body).

([54]) The drone is equipped with «*Electronic Identification and Geoawarness*» able to block vehicle access in certain areas.

automation support. Sensors and other apparatus send information flows from cars to the cloud and, through to the CTC platform, information back again in a useful form to improve general situational awareness for users and authorities.

From an organizational point of view, it might be better to arrange a "federated network" of CTCs that can interact and cover adjacent areas (cities or nations) or even the same area (public and private roads). Different access points in different countries can handle the possibility of different providers for the same type of services in different areas: we can find the same architecture in the Common Information Sharing environment (CISE), aimed at sharing information between authorities, qualified users and EU institutions to improve maritime use awareness and surveillance ([55]).

However, the exchange of V2X data entails an excess of information for drivers and greater risks for security and privacy.

What about liabilities?

We have already mentioned that, according to the existing paradigm in liability, the person who knows and, therefore, can govern certain risks, is responsible for it.

An analysis of case-law concerning air transport shows that in the event of an accident, judges establish guiltiness of the pilot in command, even in the case of the event probably being caused by a malfunctioning autopilot ([56]); this is because the pilot in command has to supervise at all time and the automatic pilot is considered a mere driver assistance apparatus. From a legal point of view, this solution can be extended also to remote pilot stations of drones which, under the Italian navigation code, are considered as aircraft.

Also in the case of an accident concerning drones, the person responsible for flight behaviour is still the pilot from a remote location (Issue Italian «Ente Nazionale Aviazione Civile»- ENAC Regulation No. 2 of 16 July 2015,

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([55]) A common information-sharing environment (CISE) is currently being developed jointly by the European Commission and EU/EEA members with the support of relevant agencies such as Frontex, EMSA (European Maritime Safety Agency) and the EFCA (European Fisheries Agency): see EC Communication on «Integrating Maritime Surveillance» COM (2010) 584 fin.

([56]) According to *Belger* v. *Moore* case, the equipment was intended to assist the pilot, not take over his responsibility for the aircraft: see A. Hera, *R2DFord: Autonomous vehicles and the legal implication of varying liability structures*, in *Faulkner Law Review* 29, 58 (2013), 40. The same solution, as Hera refers, in *Richiardson* v. *Bombardier*, Inc. 2005, U.*S. District Court*, and in the *Korean Air Lines Disaster*, 156, F.R.D. The A. refers also to the same treatment in cases involving boating accidents where the auto-pilot system was in use.

Revision 3 on 24 March 2017), but it is important to underline that the intervention of the UTM system, providing information able to allow the «Air Traffic controller» to coordinate and integrate traffic, could result in liability of the operator for fault or gross negligence (57).

Scholars correctly outlined that a driverless vehicle is not simply an automatic vehicle, but an autonomous vehicle, that means it is able «to make decisions and is expected to be fully engaged from the start of the trip until its destination» (58).

If this is true, the perspective from which we would like to examine the issue is different: the diffusion of remotely piloted aerial vehicles, the expected integration of these into spaces used by civil aviation and, above all, the use of these vehicles for the development of an Aerial Urban Mobility, make the two scenarios comparable from the viewpoint we have chosen, namely that of traffic regulation and management. Italian jurisprudence identifies the duty of the air traffic controller to give indications and information to the pilot in command even if not required by him (59); sophisticated avionics on board and the proper functioning of this instrument at the moment of the event does not exempt the traffic control operator from informing the pilot of any dangers or mistakes (60).

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(57) On July 1, 2019, the *European Drone Regulation* came into force, which provides for uniform rules in all Member States. The ENAC ATM — 09 Circular, in force since 1 July 2019, indicates criteria for the use of airspace by Remotely Piloted Aircraft (RPA), foreseeing specific «respect» areas to protect general aviation use zones. The system is still based on separation rather than coordination, with an assessment of the risk of a single operation based on the perspective of the operator, according to the model in use for maritime traffic control.

(58) A. Hera, *R2DFord: Autonomous vehicles and the legal implication of varying liability structures*, cit., 58.

(59) In Italian case law, the first ruling stating the expansion of ATC functions concerns the proceedings for the incident to a DC9 of ATI which crashed into Mount «Nieddu», near Cagliari (Sardinia, Italy), on the night between 13 and 14 December 1979. In that case, according to the judge's reasoning, the traffic control officer in service should have actively intervened in many different ways: by prohibiting the visual flight requested by the pilot in command; providing information on the relevant flight deviation from the predetermined route; communicating safety warnings in relation to the concrete danger of collision with obstacles on the ground. See *Criminal Court* of Cagliari, Section I, 23 June 1982; *Court of Appeal* of Cagliari, Criminal Section, 21 February 1984; *Criminal Court of Cassation*, 12 April 1985, n. 635.

(60) In line with this approach, we can refer to the verdicts that concluded the process of the Linate air disaster of 8 October 2001 (*Criminal Court of Cassation* 22614/2008, Linate Disaster), and the first- and second- degree sentences pronounced by the *Court* of Cagliari for the plane crash of 24 February 2004 (Capo Gallo Disa-

5. *Conclusion* — Traffic control is a critical element in the safe and efficient operation of any transportation system. Operational procedures and physical devices (e.g., signs, markings, and lights) are the components of any traffic control system, that — in a traditional way — is organized around the figure of the operator: a driver (or pedestrian) in a roadway system, a pilot in aviation or maritime systems.

Today, traffic is the result of the behaviour of a large number of operators who collectively must make consistent decisions so that systems work safely and efficiently. Traffic management services, both in maritime and in air navigation, have the task of assisting a pilot in command who is the subject responsible for navigational safety by law.

It must be said that, due to the complexity of maritime and air transport systems and to the inherent risk level, a gradual shift has been recorded of the guarantee positions inherent to vehicle safety and navigation from the driver to the subject who — in certain circumstances — appears better able to be aware of the traffic as a whole, as a typical element of risk, looking at all concurrent circumstances and external conditions.

The capacity of totally automated systems to make decisions in the presence of situations for which there is no reference «algorithm», or in the case of an ethics dilemma, appears more complex. In this sense, it seems that the Italian Smart Road decree clearly indicates the legislative intention to implement regulatory models able to limit the risk of unknown technology.

The examined legislation — even if relating to the simple experimental phase — foresees a sort of «"human" second-level precautionary mechanism», in the on-board supervisor, and also in the Smart-Road manager.

Thus, the on-board supervisor is a figure that will disappear, unless the (future) tested driverless technology asks to equip each driverless car with a remote manager (or imagine entrusting this function to a passenger!).

The figure that will acquire a growing level of control over the general system seems to be the network manager (who could be the Smart-Road manager or an independent provider), already capable of intervening with rational choices based on an overall view of the information transmitted by the «vehicle-infrastructure» system.

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ster). According to the Court ruling, liability of the ATC personnel arises from their capability to prevent the event, as they were entrusted to managing the related risks: see *Criminal Court of Cassation* No. 7291, 14 February 2003 (Villafranca Disaster); *Criminal Court of Cassation*, IV, 19 March 2013 No. 26239, 17, Capo Gallo Disaster; *Criminal Court of Cassation* No. 38343 of 24 April 2014.

As in the cooperative traffic management plan in ATM, the Central Traffic Control platform provides solutions for optimising network planning through collaborative processes involving all actors and continuous information sharing.

In synthesis, the safety of driverless mobility depends on the organized connection of all groups of operators, such as suppliers and users of information, and on a traffic management architecture that entrusts the smart infrastructure manager with a duty of care in relation to specific and/or anomalous behaviours of the vehicle.

Smart road management represents the unifying element of the system, as it includes smart and traditional users; it also constitutes the umpteenth application of a model of public intervention which is usual in the transport sector, focused on the discipline of access and use of infrastructure, also for the purpose of regulating services, security and competition in the market.

This is the direction of the safety regulatory system in the modes of transport briefly compared: creating a virtual space, delimited by a function which defines an architecture of services and utilities, dedicated to traffic management in function of safety, environmental purpose and efficiency in using resources, but not just for safety.

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Tel. (segr. e fax) 070/ 27 26 22
nel mese di gennaio 2021