The Notion of Defectiveness Applied to Autonomous Vehicles: The Need for New Liability Bases for Artificial Intelligence

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Abstract: Both the US and the EU product liability regimes are based on the notion of defectiveness of the product. However, in the case of damages caused by autonomous vehicles, such notion proves to be profoundly inadequate for consumer protection. In fact, from the European perspective, the defectiveness of a product is assessed through the so-called consumer expectation test, according to which a product is defective when it does not provide the safety a person is entitled to expect. However, such approach is inadequate in the context of autonomous vehicles as it leads to unreasonably high safety expectations. By contrast, the US product liability doctrine adopts the so-called risk-utility test, according to which a product is defective if the foreseeable risks of harm could have been reduced or avoided by the adoption of a reasonable alternative design. Such approach is nonetheless undesirable as it links safety to market forces. This article aims at analyzing in comparative perspective the current legislation concerning damages caused by autonomous systems, with a view to devising new possible solutions and alternative approaches to product liability for Artificial Intelligence.

Keywords: Product liability; Artificial intelligence; Autonomous vehicles; defectiveness; Safety standards.

1. *Introduction*

"How can Artificial Intelligence be defective?"[1]. The question was raised after a series of crashes, involving Tesla vehicles, occurred in the United States, some of which resulted in fatal casualties[2]. Since then, the uncertainty over the liability regime applicable to autonomous vehicles has tackled the full deployment of such technology[3], while the debate around the adequacy of the traditional liability rules is still far from reaching a unanimous conclusion[4]. In fact, the US Department of Transportation has been ever since enquiring into the safety-related issues of autonomous driving technology[5]. On the same wavelength, the European Commission has appointed in 2018 a group of experts to assess whether the current Directive 374/85 concerning liability for defective products (hereinafter the Product Liability Directive) is still fit-for-purpose in the new digital era[6]. Pending the

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1. See Jean-Sébastien Borghetti, *How Can Artificial Intelligence Be Defective?* in Sebastian Lohsse, Reiner Schulze and Dirk Staudenmayer (ed.), *Liability for Artificial Intelligence and the Internet of Things: Münster Colloquia on EU Law and the Digital Economy IV* (Hart Publishing 2019).

2. See European Commission, *Commission Staff Working Document Accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Maximising the Benefits of Articificial Intelligence for Europe* (2018) SWD/2018/137 final at 14.

3. See European Parliament, *Resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics*, 2015/2103 (INL).

4. See Paulius Cerka, Jurgita Grigiene and Gintare Sirbikyte, *Liability for Damages Caused by Artificial Intelligence*, 31 Computer Law and Security Review 376, 383 (2015).

5. See National Highway Traffic Safety Administration, *Federal Automated Vehicle Policy: Accelerating the Next Revolution in Roadway Safety* (United States Department of Transportation, September 2016), available at https://www.hsdl.org/?abstract&did=795644 (last visited August 30, 2020). See also National Highway Traffic Safety Administration, *Automated Vehicles for Safety* (United States Department of Transportation, 2018), available at https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety (last visited August 30, 2020).

6. See *Expert Group on liability and new technologies (E03592)* (March 9, 2018), available at https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.

issuance of the final report including the guidelines for the adaptation of applicable rules to the new technological development, this article aims at outlining some preliminary considerations regarding the safety of autonomous vehicles.

Going back to the opening question, autonomous vehicles will represent an important employment of Artificial Intelligence *latu sensu* available for consumer use. Therefore, it is important to understand why – beyond benefits in term of overall increased safety[7] – an intrinsic risk of crashes and damages may remain. Needless to delve at this point into the strictly technical functioning of an AI-embedded product, it suffices to say that the features of autonomy and machine-learning may lead to unpredictable behaviours that have not been anticipated in the software programme, thus causing accidents or damages[8]. This is due to the fact that autonomous driving technology relies on machine-learning capabilities, which – by definition – do not run on if-then programming rules but change their behavior according to their experience or, in other words, the processed data taken from the environment[9].

Therefore, given the nature of AI algorithms that adapt to new situations, autonomous vehicles raise important questions in terms of foreseeability and reliability[10], possibly challenging the very core of the

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7. European Commission, *Commission Staff Working Document* SWD/2018/137 final at 14 (cited in note 2). On the environmental benefits of autonomous driving, see also Peng Liu, Yanijao Ma and Yaqing Zuo, *Self-Driving Vehicles: Are People Willing to Trade Risks for Environmental Benefits?,* 125 Transportation Research Part A: Policy and Practice 139 (2019).

8. See Esther Engelhard and Roeland de Bruin, *Liability for Damage Caused by Autonomous Vehicles* at 5 (Eleven International Publishing, Utrecht, 2018). See also T.S., *Why Uber's Self-Driving Car Killed a Pedestrian – The Economist Explains* (The Economist, May 29, 2018), available at https://www.economist.com/the-economist-explains/2018/05/29/why-ubers-self-driving-car-killed-a-pedestrian (last visited August 30, 2020).

9. On the functioning of autonomous vehicles, see Alexander Hars, *Top Misconceptions of Autonomous Cars and Self Driving Vehicles* (Driverless Car Market Watch, June 24, 2015), available at https://www.driverless-future.com/?page_id=774 (last visited August 30, 2020). See also Kevin Funkhouser, *Paving the Road Ahead: Autonomous Vehicles, Products Liability, and the Need for a New Approach*, 1 Utah L Rev 437 (2013).

10. See Borghetti, *How Can Artificial Intelligence Be Defective?* at 67 (cited in note 1).

product liability regime in the event of a crash[11]. Consumers, thus, may face great challenges when required to prove that the vehicle was defective, which may jeopardize their right to receive a compensation[12].

In order to address such issue more thoroughly, this article adopts a comparative approach between the EU Product Liability Directive and the equivalent US Restatement (Third) of Torts[13], on the ground that the US and the EU face similar concerns related to autonomous vehicles within the frame of strict liability for defective products. A comparative analysis of the notion of defectiveness shall provide a two-tier perspective on the issue of applying traditional liability rules to autonomous vehicles. While the European legislation relies on the so-called consumer-expectation test, the US regime adopts a more market-related risk-utility test. The final goal of this article is to assess the adequacy of both approaches to product liability in the new context of Artificial Intelligence.

Since the current liability regimes will prove their shortcoming when applied to fully autonomous vehicles, it will be conclusively argued that new legal bases are needed for the future of Artificial Intelligence. In order to inquire into new alternative and complementary solutions to the notion of defectiveness, this article will first analyze the role of harmonised technical standards in identifying the legitimate, i.e., objective, safety expectations. Such preliminary approach shall lead to increased social acceptance of products incorporated with machine-learning capabilities and, gradually shifting from the current state-of-the-art of autonomous driving technology, shall pave the way for further deployment of fully autonomous vehicles.

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11. See Daily Wuyts, *The Product Liability Directive – More than Two Decades of Defective Products in Europe*, 5 Journal of European Tort Law 1, 10 (2014).

12. European Commission, *Commission Staff Working Document Evaluation of Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products*, accompanying the document *Report from the Commission to the European Parliament, the Council and the European Economic and Social Committee on the Application of the Council Directive on the approximation of the laws, regulations, and administrative provisions of the Member States concerning liability for defective products (85/374/EEC)*, SWD/2018/157 at 3.

13. See, for example, Geraint Howells and Mark Mildred, *Is European Products Liability More Protective than the Restatement (Third) of Torts: Products Liability*, 65 Tenn L Rev 985 (1998).

2. *Product Liability in Comparative Perspective*

From the European perspective, the wording of Article 6 of the Product Liability Directive links the notion of defectiveness to the notion of safety: "a product is defective when it does not provide the safety which a person is entitled to expect". The Directive, therefore, opts for the so-called consumer-expectation test, according to which the product is defective when it breaches the legitimate safety expectations of the public at large[14]. The degree of safety is therefore a matter of social acceptance[15].

The legitimacy of safety expectations, however, is assessed on a case-by-case basis and it entails a certain degree of judicial discretion[16]. It is the judge's *nobile officium* to establish which degree of safety the consumers are entitled to expect[17], although in accordance with the circumstances listed at Article 6 of the Directive (namely, the presentation of the product, the use to which it could reasonably be expected to be put, and the time it was put into circulation). Needless to say, the vagueness of such circumstances, which are expected to establish the standard of safety[18], reflect a certain lack of objectivity[19] that may lead to excessive judicial discretion[20].

By contrast, US doctrine introduces different standards of defectiveness in relation to different types of defects, namely manufacturing, design and warning defects[21]. For the sake of simplification, it may be anticipated that, within the tripartite distinction of possible

14. See Geraint Howells, *Defect in English Law – Lessons for the Harmonisation of European Product Liability* in Duncan Fairgreve (ed.), *Product Liability in Comparative Perspective* 141 (Cambridge University Press, 2005).

15. See Hans Claudius Taschner, *Product Liability: Basic Problems in a Comparative Law Perspective* in Fairgrieve (ed.), *Product Liability in Comparative Perspective* 159 (cited in note 14).

16. Duncan Fairgrieve, Geraint Howells and Marcus Pilgerstorfer, *The Product Liability Directive: Time to Get Soft?*, 4 Journal of European Tort Law 1, 6 (2013).

17. See Taschner, *Product Liability* at 159 (cited in note 15).

18. See Geraint Howells, *Comparative Product Liability* 36 (Dartmouth Publishing Company 1993).

19. See Taschner, *Product Liability* at 159 (cited in note 15).

20. See Cristina Amato, *Product Liability and Product Security: Present and Future*, in Lohsse, Schulze and Staudenmayer (ed.), *Liability for Artificial Intelligence and the Internet of Things* 78 (cited in note 1).

21. Restatement (Third) of Torts: Products Liability §2 (1998).

defects[22], manufacturing defects are the least likely to pose problems in relation to autonomous cars, since such defects usually concern hardware components, the defectiveness of which is usually caused by quality-control problems[23]. Therefore, since manufacturing defects in most cases do not implicate the software and the algorithm that execute the driving tasks, there is plausibly almost no legal uncertainty as to the allocation of liability.

For the scope and purpose of this article, therefore, only design defects are concerned, in relation to which the safety of the product is analyzed through the so-called risk-utility test: a product is defective if the foreseeable risks of harm could have been reduced or avoided by the adoption of a reasonable alternative design, without unduly impairing its utility[24]. In other words, a product is considered defective if the cost of eliminating a particular hazard is less than the resulting safety benefits[25].

The two approaches differ in the sense that, while the EU's concept of risk is entirely associated with the safety of the product, from the US perspective the risk is balanced with the product utility, as well as the probability of damage and the economic capacity of the producer to avoid damages without incurring into overly burdensome costs[26]. However, it has been rightly pointed out that whether the producer possesses sufficient financial resources for an alternative safer design should not be relevant while assessing the defectiveness of a product[27].

On the contrary, the Product Liability Directive does not require proof of fault. This is confirmed by Article 4 of the Product Liability Directive, which only requires three elements to establish liability: damage, defect and causation. Moreover, in assessing the defect of the product, Article 6 of the Directive refers only to safety, whereas the

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22. Namely, manufacturing, design and warning defect according to Restatement Third of Torts. See Giulio Ponzanelli, *Antologia Sull'American Tort Law* (ETS Editrice 1992).

23. See Mark A. Geistfeld, *A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation*, 105 Cal L Rev 1611, 1636 (2017).

24. See *A and Others v. National Blood Authority and another*, EWHC QB 446 (2001).

25. Fairgrieve, Howells and Pilgerstorfer, *The Product Liability Directive* at 7 (cited in note 16).

26. See Taschner, *Product Liability* at 159 (cited in note 15).

27. See *id.* at 160.

possibility that the damage could be foreseen and avoided, taken into consideration by the risk-utility analysis, is entirely irrelevant since the qualification of the properties of the product hinge upon the safety expectations of the public at large and not upon the design adopted by the manufacturer[28]. Thus, the safety standard is not absolute, but rather linked to the risks the society as a whole is willing to accept[29].

Nonetheless, it is worth noting that judges, while carrying out the delicate task of establishing which safety expectations are *legitimate*, inevitably experience an overlap between product liability and product safety legislation: the former specifically concerns compensation for damages caused by defective products, whereas the latter refers to the kinds of products which should be (safely) put on the market[30]. As some scholars have pointed out: "the primary function of product liability is to compensate for any damage, and its influence on the level of safety is indirect and incomplete"[31]. Thus, European and national courts should pay heed and draw a demarcation line between product liability and product safety in order to reduce judicial discretion[32].

Ultimately, it must be pointed out that in an age of increasing technicality and complexity, courtrooms may not be an appropriate venue to decide whether the safety expectations of the public at large are legitimate or not. This holds true particularly with regard to AI, where proving the defect entails high costs of expert evidence, information asymmetry and a considerable degree of IT expertise[33]. In fact, judges may lack the appropriate skills and knowledge to address issues arising from new technologies, and furthermore they are more concerned with the individual facts of the case at hand rather than the systemic consequences of their decisions[34]. Therefore, it is questionable whether the courts are a proper body to take product safety decisions for the society as a whole.

28. See Taschner, *Product Liability* at 160-161 (cited in note 15).

29. An example of harmful products, the risks of which are nonetheless accepted by the public, therefore considered non defective, are tobacco products and alcoholic beverages.

30. See Howells, *Comparative Product Liability* at 6 (cited in note 18).

31. See Christian Jeorges, *Product Safety, Product Safety Policy and Product Safety Law*, 6 Hanse Law Review 117, 132 (2010).

32. See Amato, *Product Liability and Product Security* at 79 (cited in note 20).

33. See *ibid.*

34. See Howells, *Comparative Product Liability* at 6 (cited in note 18).

3. *The Notion of Defectiveness Applied to Autonomous Vehicles*

3.1. *Five Levels of Vehicle Autonomy*

There are multiple levels of vehicle autonomy, based on the reliance of the vehicle on the human driver's intervention in specific situations, and *vice versa* the degree to which the human driver relies on the so-called Driver-Assistance Systems (DAS). The following paragraph briefly describes the six levels of a progressive autonomous driving, as identified by the Society of Automotive Engineers (SAE)[35].

Level zero simply consists in conventional vehicles without any computer driving assistance whatsoever[36]. The first and second levels entail partial automation of certain functions, like acceleration and automatic emergency braking systems, introduced around the 2000s[37]. The third level – the one currently available for consumers – allows the automated system to both conduct some of the driving tasks and monitor the driving environment, e.g., cruise control and lane keeping. At this stage, however, the human driver must be ready to take back control, if necessary; therefore, it can be regarded as the *autopilot mode*[38]. Vehicles with this stage of autonomy can be regarded

35. See *SAE International Releases Updated Visual Chart for Its "Levels of Driving Automation" Standard for Self-Driving Vehicles*, (SAE International, December 11, 2018), available at https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-"levels-of-driving-automation"-standard-for-self-driving-vehicles (last visited August 30, 2020).

36. The first level of autonomy was incorporated in conventional vehicles around the 1970s and it was meant to help drivers perform certain driving tasks in order to increase safety: cruise control, antilock braking systems (ABS), stability control and parking-assistance systems are a few examples. See Klaus Bengler, et al., *Three Decades of Driver Assistance Systems: Review and Future Perspectives*, 6 IEEE Intelligent Transportation Systems Magazine 6, 8 (2014).

37. The automated system can actually perform some driving tasks, while the human driver continues to monitor the driving environment and performs the remaining driving tasks.

38. See David C. Viadeck, *Machines without Principals: Liability Rules and Artificial Intelligence*, 89 Wash L Rev 117, 121 (2014) stating: "Autopilot devices perform a relatively simple set of tasks. For instance, autopilots keep the plane or vessel on a course determined by the pilots by controlling for minor variations in winds and currents, but generally without reference to other traffic. For that reason, pilots have a duty to remain vigilant-while the machine may have the controls, the pilots are responsible for monitoring other traffic and ensuring that the autopilot is working correctly".

as *semi-autonomous*, according to some scholars[39]. It is worth mentioning that a possibility to switch from the automated driving mode to the conventional one and *vice versa* may pose new safety problems based on the possible over-reliance of the driver on the DAS[40].

The fourth level consists in the ability to perform all driving tasks, without need for the human driver to take control. However, this kind of autonomous system can operate only in certain environments and under certain conditions, depending, for example, on the weather, lighting, time of the day or traffic conditions. These limitations are precisely what distinguishes this level from the following, the fifth, at which the vehicle reaches full autonomy without any human intervention. The fourth level is currently the state of art of the *driverless cars technology* and it is being tested in relatively safe contexts such as shuttles in college campuses[41].

The depiction of the five levels above helps us draw a distinction between levels 1-2 of DAS, at which the human driver is primarily responsible for monitoring the external environment, and levels 3-5, at which such task is performed, although with different degrees of autonomy, by the system itself. In the latter case, the system can be regarded as a *highly automated vehicle* (HAV)[42]. The higher degree of autonomy is a result of a combination of hardware and software, both

39. See Thierry Bellet, et al., *From Semi to Fully Autonomous Vehicles: New Emerging Risks and Ethico-Legal Challenges for Human-Machine Interactions*, 63 Transportation Research Part F: Traffic Psychology and Behaviour, 153 (2019).

40. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1625 (cited in note 23). Level 3 of automation according to SAE creates an interface between the automated driving mode and the conventional one, allowing the human driver to switch from one mode to the other. The risk associated with the use of this technology is the possible over-reliance of the user on the autopilot mode. Such a case is reported to have caused the death of a Tesla-owner. See also Rachel Abrams and Annalyn Kurtz, *Joshua Brown, Who Died in Self-Driving Accident, Tested Limits of His Tesla* (The New York Times, July 1, 2016), available at https://www.nytimes.com/2016/07/02/business/joshua-brown-technology-enthusiast-tested-the-limits-of-his-tesla.html (last visited April, 18 2020).

41. See MET Staff, *Local Motors Debuts Autonomous Shuttle on California Campus Metro Magazine* (Metro Magazine March 4, 2019), available at https://www.metro-magazine.com/mobility/news/733255/local-motors-debuts-autonomous-shuttle-on-california-campus (last visited August 30, 2020).

42. See National Highway Traffic Safety Administration, *Federal Automated Vehicles Policy: Accelerating the Next Revolution In Roadway Safety* at 10 (cited in note 5).

remote and on-board, that perform the driving tasks and monitor the external environment. Being an implementation of the Internet of Things for transportation, autonomous vehicles rely on the same technology, i.e., a wide range of sensors, actuators, embedded computers with machine learning[43] capabilities and communicating technologies to enable a better perception of the external conditions and facilitate independent decision making[44]. Furthermore, specifically concerning HAVs, that is covering levels 3-5, an important step towards a fully autonomous driving experience will be the creation of an interconnected autonomous fleet of vehicles[45].

At this point, it is safe to say that Artificial Intelligence and more specifically machine learning play a major role in determining the degree of autonomy of a driverless car. It is clear that what differentiates conventional vehicles from autonomous vehicles is the decision-making process. In the former, human drivers monitor the environment and determine how the vehicle responds to it by performing the necessary driving tasks, whereas in the latter the computer makes its decisions based on data collected by its sensors[46]. Therefore, here the

43. Machine learning is a data-driven form of Artificial Intelligence that enables the systems to continuously adapt or change the algorithm based on newly acquired information in order to perform the tasks in the most efficient and safe way. See Hars, *Top Misconceptions of Autonomous Cars and Self Driving Vehicles* (cited in note 9).

44. It is important to understand the functioning of an autonomous vehicle, which can be briefly explained using the concept of 'module' or 'unit' to describe the computer system. In an oversimplified description, taking as an example a Google driverless car, the first is the perception module, which collects information from the sensors and identifies objects in the surroundings. An essential component of this module is the so-called rotating Light Detection and Ranging (LiDar), located on the roof. In conjunction with cameras that spot features such as lane markings, road signs and traffic lights, and radars that measure the speed of nearby objects, the LiDar detects the surroundings of the car and creates a three-dimensional schematic. Wheels are equipped with position estimators to locate the vehicle within the surroundings. The second is the prediction module: a sophisticated computer processes real-time data to forecast how the surrounding objects will behave in the following seconds, while the third module analyzes these predictions to determine how the vehicle should respond and safely interact with the environment. See Kevin Funkhouser, *Paving the Road Ahead: Autonomous Vehicles, Products Liability, and the Need for a New Approach*, 1 Utah L Rev 437 (2013).

45. See Klaus Bengler, et al., *Three Decades of Driver Assistance Systems* at 20 (cited in note 36).

46. *See ibid.*

central role is played by the algorithm that allows the vehicle to adapt to rapidly changing and unpredictable road conditions.

The autonomous DAS technologies reduce risk either by providing additional information to a human driver or by assuming temporary control of the vehicle[47]. This will become possible because of machine learning algorithms that analyze examples of safe driving and automatically generate core patterns that translate to effective driving[48].

While lower levels of DAS do not pose particular problems to the allocation of liability, the question is different in the case of HAVs: a higher degree of automation determines a shift in the role of the user, who increasingly relies on the operations performed by the system itself, albeit with some variations in the case of semi-autonomous and fully autonomous vehicles. This is where traditional rules of liability are truly challenged.

3.2. *The Inadequacy of both the Consumer-Expectation and the Risk-utility Test When Applied to Autonomous Vehicles*

3.2.1. *Consumer–Expectation Test*

When it comes to autonomous vehicles, both the consumer-expectations and the risk-utility tests have their shortcomings. A starting point would be analyzing the "reasonable safety expectations" of consumers towards the so-called driverless cars: consumers often expect a higher level of safety and reliability from this new driving technology. A whole different issue, however, is the reasonableness of such safety expectations.

From the logical premise that an ordinary consumer does not expect a product to malfunction, any situation in which an autonomous vehicle, although used in reasonably foreseeable circumstances[49], crashes, frustrates such expectations and consequently triggers

47. See *id.* at 154 (cited in note 36).

48. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1644 (cited in note 23). For this reason, Waymo, Google's self-driving car, has driven millions of kilometres on public roads with test drivers in order to collect data and *learn* from different traffic situations.

49. See Borghetti, *How Can Artificial Intelligence Be Defective?* at 67 (cited in note 1).

manufacturer's liability for any product malfunction. This is the so-called *malfunction doctrine* under the US tort law[50].

However, as autonomous vehicles increasingly become available to the public and their machine-learning capacities make them more protected from risk[51], the safety expectations of consumers will change accordingly[52]. In fact, the promise of increased safety in the performance of autonomous vehicles will generate exceptionally demanding expectations of safety. This will eventually result in the manufacturer being held liable for virtually *all* crashes[53], which creates excessive liability costs that will plausibly obstruct the full deployment of this potentially life-saving technology[54].

In order to prevent the risk of holding the manufacturer liable for any possible cause of crash, the safety expectations of the public must be leveled to the associated acceptable risk of the deployment of such technology, to the extent that the latter represent a benchmark for the assessment of new risks[55]. Hence, the manufacturer can avoid liability for crashes under the malfunction doctrine by fulfilling the duty to warn the consumer about the inherent and foreseeable risks of crashes[56]. As a matter of fact, warnings do shape consumers' safety expectations[57]. This holds particularly true for semi-autonomous vehicles, i.e.,

50. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1639 (cited in note 23).

51. See Cadie Thompson, *Why Driverless Cars Will Be Safer Than Human Drivers* (Business Insider November 21, 2016), available at https://it.businessinsider.com/why-driverless-cars-will-be-safer-than-human-drivers-2016-11/?r=US&IR=T (last visited August 30, 2020).

52. On how difficult is to shape consumer expectations with regard to complex products, such as automobiles, see Funkhouser, *Paving the Road Ahead* at 450 (cited in note 9).

53. See Geistfeld, *A Roadmap for Autonomous Vehicle* at 1639 (cited in note 23).

54. See Lora Kolodny and Katie Schoolov, *Self-driving cars were supposed to be here already — here's why they aren't and when they should arrive* (CNBC November 30, 2019), available at https://www.cnbc.com/2019/11/30/self-driving-cars-were-supposed-to-be-here-already-heres-whats-next.html (last visited August 30, 2020).

55. See Herbert Zech, *Liability for Autonomous Systems: Tackling Specific Risks of Modern IT*, in Lohsse, Schulze and Staudenmayer (ed), *Liability for Artificial Intelligence and the Internet of Things* 193, 194 (cited in note 1).

56. *See ibid.*

57. See Bernhard A. Koch, *Product Liability 2.0 – Mere Update or New Version?*, in Lohsse, Schulze and Staudenmayer (ed.), *Liability for Artificial Intelligence and the Internet of Things* 108 (cited in note 1).

level 3 of autonomy according to SAE, where manufacturer's liability certainly depends on the adequacy of instructions and warnings about the risks associated with the use of this technology[58].

Although such warnings and instructions may contribute to the reasonableness of the safety expectations under the consumer-expectation test, they do not necessarily eliminate or mitigate the risk of harm. Due to the fact that "instructions and warnings may be ineffective because users of the product may not be adequately reached, may be likely to be inattentive, or may be insufficiently motivated to follow the instructions or heed the warnings", the manufacturer has also the duty to adopt a reasonably safe and fault-tolerant design[59]. Failing to do so will subject the manufacturer to tort liability in the case of physical harm resulting from the use of the product[60].

However, in the gradual development from semi-autonomy to higher degrees of autonomy[61], the main technologically – as well as legally – disruptive feature is the shift in control from the user to the operational system of the vehicle[62]: fully autonomous vehicles are not controlled by a human driver but by an algorithm developed and installed into the vehicle by its manufacturer[63]. In this sense, the user will be regarded as a passenger who has no control over its functioning: therefore, it is regarded by some that the *behavior* of the car is in the hands of the manufacturer[64].

In this context, warnings only help establish consumers' minimum safety expectations of the actual performance of the product, which is

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58. For instance, the manufacturer must clearly point out that the autopilot mode is an assist feature that requires the driver to keep his hands on the steering wheel or that in certain conditions such as rain or fog, when the system operates less safely than a human driver, the driver is required to take over. See also Ryan Abbott, *The Reasonable Computer: Disrupting the Paradigm of Tort Liability*, 86 Geo Wash L Rev 1, 27 (2018). See also Chris Ziegler, *Tesla's own Autopilot warnings outlined deadly crash scenario*, (The Verge June 30, 2016), at https://www.theverge.com/2016/6/30/12073240/tesla-autopilot-warnings-fatal-crash (last visited August 30, 2020).

59. Restatement (Third) of Torts: Products Liability §2 (1998).

60. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1627 (cited in note 23).

61. Levels 4 and 5 according to SAE.

62. See Cerka, Grigiene and Sirbikyte, *Liability for Damages Caused* at 381 (cited in note 4).

63. See Gerhart Wagner, *Robot Liability*, in Lohsse, Schulze and Staudenmayer (eds), *Liability for Artificial Intelligence and the Internet of Things* 38 (cited in note 1).

64. See *ibid*.

different from the more demanding expectation of how the product should otherwise perform[65]: this is an assessment of a risk-utility nature over unreasonable unsafety of the design at hand and on whether an alternative design would provide higher safety levels.

3.2.1. *Risk–Utility Test*

Under the risk-utility test, as anticipated, the product is defective if it is possible to identify an alternative design that would have avoided the accident in question, provided that the accident costs – that would have been averted by the added safety feature – exceed the added costs of the alternative design[66]. From such a premise, a possible consequence of rigidly applying the risk-utility test to the rules that guide the machine-learning of an autonomous vehicle is that the manufacturer will almost always be held liable in the cost-benefit argument, in the aftermath of an accident, there will almost be a safer alternative design.[67]

Furthermore, in the case of fully autonomous vehicles, the risk-utility assessment must be carried out with respect to the algorithm that operates the vehicle. Machine-learning capabilities have in fact critical implications for how the risk-utility test applies to the design or programming of an algorithm that operates a driverless car[68]. This is mainly due to a misconception regarding how operating algorithms are programmed. Self-driving cars functioning, in fact, is not based on a series of pre-defined if-then rules as conventional software, but rather uses machine-learning algorithms that are *trained* to drive through analysis of safe- driving examples[69]. Relying on previous driving experience, an autonomous vehicle adapts its own algorithm to new situations in order to optimise the performance of the driving

65. See *id.* at 1641-1642 (for instance, the warning that a car does not have an airbag will not defeat the reasonable expectation of safety. Therefore, the plaintiff can allege the frustration of the ordinary consumer's expectations by proving that the omission of the airbag constitutes an unreasonably unsafe design).

66. See Wagner, *Liability for Artificial Intelligence and the Internet of Things* at 43 (cited in note 63).

67. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1644 (cited in note 23).

68. See *id.* at 1645.

69. See Hars, *Driverless Car Market Watch* (cited in note 9).

task, whereas the risk-utility test sees coding simply as a set of rules that constrain or guide machine learning[70].

Hence, the way of applying such risk-utility analysis to autonomous vehicles still leaves much room for debate[71] and it certainly entails an inquiry into software programming and the recourse to technical experts[72]. One way is to compare a product's risks with the benefits associated with its deployment. However conceptually logical it may sound, such an interpretation suffers from an over simplistic view that risks and benefits of autonomous driving are of the same nature, and therefore measurable and comparable[73].

Another way to do this is comparing other existing products of the same nature in order to assess their respective performance: the terms for comparison may regard an actual pre-existing or a hypothetical product, using the well-known alternative design test[74]. The comparison between performances of different algorithms, as well as between the algorithm and a human driver, although theoretically conceivable, will most likely lead to flawed and unfair conclusions.

For instance, the first logically suggested comparison is between the outcome of the algorithm on the one hand, and a reasonable human driver on the other hand. Despite the fact that autonomous driving is expected to decrease the number of road accidents by eliminating human error, collisions will happen regardless. Nonetheless, the critical point is that the pool of accidents that an autonomous vehicle may cause will be not the same as the pool of accidents a reasonable human driver is unable to avoid[75]. Therefore, not only is this *reasonable human driver test* fundamentally pointless[76], but it is also misleading in the sense that whenever the driverless car causes an accident, which a

70. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1645 (cited in note 23).

71. See Borghetti, *How Can Artificial Intelligence Be Defective?* at 68 (cited in note 1).

72. See Wagner, *Liability for Artificial Intelligence and the Internet of Things* at 43 (cited in note 63).

73. See Borghetti, *How Can Artificial Intelligence De Defective?* at 68 (cited in note 1).

74. *See ibid.*

75. See Wagner, *Liability for Artificial Intelligence and the Internet of Things* at 44 (cited in note 63).

76. See Borghetti, *How Can Artificial Intelligence Be Defective*? at 69 (cited in note 1).

reasonable human driver would have been able to avoid, the algorithm would be found defective[77].

Secondly, two algorithms might be compared with one another. As though one assesses the existence of human fault or negligence, one could compare the performance of an algorithm with the performance of another algorithm in the same circumstances[78]. This approach is also conceptually flawed, because, besides the fact that driving algorithms do not follow the same reasoning as human beings, in order to assess the defectiveness of an algorithm, the comparison between two algorithms has to take into account not the performance in a specific situation but the overall results of the two algorithms[79]. In other words, as the machine-learning process involves the analysis and processing of sets of data provided not by the single vehicle, but rather by the whole fleet of vehicles, designed by the same manufacturer, the assessment of the performance of the algorithm is system-oriented[80]: one must address the issue of the design defect with respect to the entire system of vehicle operated by the same algorithm[81].

However, this *optimal algorithm test* still poses difficulties in identifying an alternative safer design by comparing the algorithm under evaluation to other algorithms of different manufacturers: the algorithm that caused the accident will always be found defective whenever there is another algorithm on the market that would have avoided that particular accident[82]. Moreover, even by assessing the overall performance of any fleet of autonomous vehicles operated by the same algorithm, this test will lead to the unfair result that only the safest algorithm on the market is not found defective: needless to delve into the consequences that such a conclusion may cause on the competitiveness on the market between manufacturers of autonomous vehicles[83].

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77. See Wagner, *Liability for Artificial Intelligence and the Internet of Things* at 44 (cited in note 63).

78. See Borghetti, *How Can Artificial Intelligence Be Defective?* at 69 (cited in note 1).

79. See *ibid.*

80. See Wagner, *Liability for Artificial Intelligence and the Internet of Things* at 44 (cited in note 63).

81. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1645 (cited in note 23).

82. See Wagner, *Liability for Artificial Intelligence and the Internet of Things* at 45 (cited in note 63).

83. See *ibid.*

In conclusion, it can be stated that the central point of both the consumer-expectation test and the risk-utility test is the safety of an autonomous vehicle. At this point, it is clear that this parameter mainly depends on the adequacy of pre-market testing, i.e., the amount of driving experience that the driverless car has gained prior to its introduction to the market, rather than the set of rules that constrain or guide the machine-learning process itself[84]. The requisite amount of pre-market testing is not only an empirical question[85], but has also policy implications: it may pave the way for the adoption of safety standards of autonomous vehicles.

The above considerations allow to conclude that neither the consumer-expectation test nor the risk-utility test provide a convincing answer on how an algorithm should be found defective if such approaches are not specifically addressed to autonomous vehicles, which leads to the ultimate question whether the concept of defectiveness, which is regarded as the core of the product liability, is fundamentally inadequate to be applied to Artificial Intelligence[86].

4. *The role of Harmonised Technical Standards in Identifying the Legitimate Safety Expectations*

Having analyzed the shortcomings of the consumer-expectation test[87], lest there be a doubt, a risk-utility approach is nonetheless undesirable and does not provide a more satisfactory answer as it ties safety implications to market forces[88]. Although markets can bring about an optimum allocation of resources, such result can be achieved only under certain circumstances and conditions that are difficult to be guaranteed in practice: it is particularly true in the case of rational

84. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1646 (cited in note 23).

85. See *ibid.*

86. See Borghetti, *How Can Artificial Intelligence Be Defective?* at 71 (cited in note 1).

87. See Howells, *Comparative Product Liability* at 11 (cited in note 18) (consumers, as it is argued, do not have the data with which to form accurate expectations. This is especially true where the product involves complex technology about which the consumer can have little or no detailed understanding).

88. See Jeorges, *Product Safety, Product Safety Policy* at 125 (cited in note 31).

consumers' safety expectations, which would require perfect information symmetry for an economically rational decision[89].

It has also been remarked that a more effective and rational way to develop product liability is to separate the claims for compensation and product safety requirements[90], the latter being more properly established by legislative tools, so that it becomes a matter of public policy through either State authorities or independent agencies[91]. Otherwise, as long as the manufacturer does not have to comply with a specific safety level, while consumers may be responsible for the definition of their own safety interests, the safety standard will remain a function of supply and demand decisions[92]. Since product safety is a matter of social protection, it cannot be unilaterally determined by manufacturers or judges[93], making legislative intervention more appropriate.

There is a need for objective safety standards which represent the state-of-the-art of mass production so that the social expectations are reduced to a sustainable and shared notion of safety[94]. Such objective standards of safety, in the light of the aforementioned considerations, can be achieved through harmonised technical standards.

For instance, in the EU, products manufactured in conformity with harmonised technical standards are presumed to conform to the essential requirements established by the Directives[95]. This constitutes an important link between product safety and product liability: in particular, Article 7(d) of the Product Liability Directive exempts the manufacturer from liability if "the defect is due to compliance of the product with mandatory regulations issued by the public authorities".

However, it is important to remind that compliance with such requirements is not mandatory: it means that the producers have free choice whether to manufacture in conformity with the standards or

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89. See Roksana Moore, *Standardisation: A Tool for Addressing Market Failure within the Software Industry*, 29 Computer Law and Security Review 413, 417 (2013).

90. See Howells, *Comparative Product Liability* at 6 (cited in note 18).

91. See Jeorges, *Product Safety, Product Safety Policy and Product Safety Law* at 125 (cited in note 31).

92. See *ibid.*

93. See Amato, *Product Liability and Product Security* at 89 (cited in note 20).

94. See *id.* at 91.

95. Annex II of Council Resolution of 7 May 1985.

not, but in this event, they must prove that their products conform to the essential requirements of the relevant Directive. Therefore, it is of the key importance to establish the relationship between compliance with technical standards and assessment of the defectiveness of the product in the light of Article 7(d) of the Product Liability Directive. It would also have meaningful consequences on the burden of proof imposed on the consumer, since the use of presumptions is allowed as long as they are based on elements that are serious, specific and consistent[96].

At this point, two scenarios can be envisaged. First, non-compliance with harmonised technical standards, even though there is compliance with general and special mandatory rules, excludes the presumption of conformity with the essential requirements of the General Product Safety Directive, therefore the product is presumed to be defective[97]; thus, the burden of proving compliance or other causes of harm, for instance misuse or unavoidable risk, lies on the producer[98].

In this case, the presumption of defectiveness operates in the way that the producer cannot rely on Article 7(d) of the Product Liability Directive. However, judges maintain their discretionary power to deem the product as reasonably safe, taking into account all the circumstances listed in Article 6 of the Directive[99], but their discretionary power does not eventuate into an arbitrary judgement as a legitimate safety expectation of the public at large converges into the objective harmonised technical standards.

Second, the diametrically opposed situation is compliance with harmonised technical standards that accounts for the presumption of conformity with essential requirements. Thus, the producer may trigger the defence of Article 7(d) to exclude liability. However, it is worth pointing out that harmonised technical standards represent the minimum safety requirements. Hence, it is conceivable that the victim may rebut the presumption of conformity by proving the defectiveness of

96. See C-621/15, *N. W and Others v Sanofi Pasteur MSD SNC and Others,* para 28-29.

97. European Commission, *Commission Notice The 'Blue Guide' on the implementation of EU products rules 2016,* C/2016/1958 at 40.

98. See Amato, *Product Liability and Product Security* at 90 (cited in note 20).

99. See *id.* at 91.

the product in the specific circumstances when the damage occurred. Therefore, judges may employ their discretionary power to assess the higher social expectations of safety or other technical standards beyond the minimum standard the product has been compliant with[100].

From the analysis above, it is clear that compliance (or even non-compliance) with harmonized technical standards allows for a more objective and less discretionary assessment of the defectiveness of a product carried out by the judiciary. By coordinating product liability with product safety rules, judges are able to objectivize the safety expectations of the public at large, ranging from a minimum level of harmonized technical standardization to the actual level to be expected in the particular situation when a damage occurs[101]. The overall result is that safer products are placed on the market[102].

In the context of modern technology, where the burden of proof is deemed problematic for consumers, particularly with regard to AI[103], it is conceivable that adopting harmonized technical standard for AI offers a great deal of certainty[104]. Although it is not within the scope of this research to enquire into possible methods of the adoption of harmonized technical standards for AI[105] – which is no easy task due to machine-learning capacities and autonomous behavior – it is nonetheless possible to identify certain principles underlying safety standards for algorithms.

The first step is the identification of (known) risks associated with AI: it is necessary to identify which risks are unavoidable, which must be eliminated at all costs and which must be reduced through design

100. See *id.* at 92.

101. See, for example, Christian Jeorges and Hans-W. Micklitz, *The Need to Supplement the New Approach to Technical Harmonization and Standards by a Coherent European Product Safety Policy*, 6 Hanse Law Review 351 (2010).

102. See Lori A. Weber, *Bad Bytes: The Application of Strict Products Liability to Computer Software*, 66 St. John's L. Rev 469, 485 (1992).

103. See Jan-Peter Kleinhans, *Internet of Insecure Things* 14 (Stiftung Neue Verantwortung, December 2017), available at https://www.stiftung-nv.de/sites/default/files/internet_of_insecure_things.pdf (last visited November 11, 2020).

104. See Zech, *Liability for Autonomous Systems* at 192 (cited in note 55).

105. European Commission, *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: Artificial Intelligence for Europ*e, COM/2018/237 final at 237.

requirements. This way, as some scholars point out "[t]he alignment of corresponding decisions to technical standards specifying general safety duties is equivalent to setting a threshold value establishing the extent of permissible risks in general terms"[106]. Secondly, technical safety legislation must provide for an allocation of responsibilities matching the complexity of the normative assessment of hazards[107].

For the practical implementation of such method, as far as autonomous vehicles are concerned, one may consider testing the algorithm of a driverless vehicle in order to identify risks and behavioral response to the environment[108]. The algorithm's efficiency can be tested through a test harness which consists also of the data used to train the autonomous system[109]. Without delving into the technicalities of this operation, the result of the test will show how algorithms perform and learn in various circumstances. It gives an indication of the adequacy of the programming and of the data provided and sets the safety expectations related to the performance of the autonomous system[110].

Moreover, it can be stated that harmonized standards will mostly depend on the amount of pre-market testing, i.e. the distance expressed in total amount of kilometers the vehicle has covered before being put on the market. On the same line, the US NHTSA regulations confirmed the need for regulatory action in order to design and implement new standards based on rigorous testing[111]. Besides uncovering programming errors and bugs that may cause the vehicle to malfunction, extensive pre-market testing improves the safety performance

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106. See Jeorges, *Product Safety, Product Safety Policy and Product Safety Law* at 129 (cited in note 31).

107. See *id.* at 130.

108. See *ibid.*

109. See Woodrow Barfield, *Liability for Autonomous and Artificially Intelligent Robots,* 9 Paladyn Journal of Behavioral Robotics 194, 201 (2018), claiming that in software testing, a test harness or automated test framework is a collection of software and test data configured to test a program unit by running it under varying conditions and monitoring its behavior and outputs. The goal of the test harness is to be able to quickly and consistently test algorithms against a fair representation of the problem being solved.

110. See Tom Michael Gasser, *Legal Issues of Driver Assistance Systems and Autonomous Driving,* in Azim Eskandarian (ed) *Handbook of Intelligent Vehicles* 1519, 1528 (Springer, 2012).

111. National Highway Traffic Safety Administration, *Federal Automated Vehicles Policy* (cited in note 5).

of the vehicle through machine-learning[112]. Certainly, errors cannot be entirely avoided even in the ordinary machine world, therefore a low-enough margin of error may be sufficient to establish that the autonomous system is reasonably safe[113].

Although certain risks may not be initially discovered and may become evident after the product had been put into circulation, standardization bodies and authorities may impose follow-up actions once the product already enters the market[114]. Follow-up market controls serve two important redistributive purposes[115]: which t result in both assuring the possibility to withdraw unsafe products and also to impose on the producer the obligation to release periodical updates and patches so that the product maintains its compliance with the essential safety requirements[116].

However, the criticism against the harmonized standards derives from the slowness of their development and adoption, which allegedly does not keep pace with technological development[117]. Nonetheless, their role in establishing the standard of safety is undeniable and must be interpreted along with strict liability rules. Injured parties still have legal grounds under product liability law for their claims.

In conclusion, an extensive product liability regime for new technologies should entail the adoption of harmonized technical standards as means for establishing the state-of-the-art of mass production[118]. The convergence between product liability and product safety shall lead to an objective (minimum) safety standard that reflects the expectations of the public at large. As a consequence, the discretionary power of the judiciary will not result in arbitrary decisions over the defectiveness of the product since the judicial assessment is based

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112. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1678 (cited in note 23).

113. See Zech, *Liability for Autonomous Systems* at 192 (cited in note 55).

114. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1681 (cited in note 23).

115. See Jeorges, *Product Safety, Product Safety Policy and Product Safety Law* at 132 (cited in note 31).

116. See *ibid*. See also Alan Butler, *Products Liability and the Internet of (Insecure) Things: Should Manufacturers Be Liable for Damage Caused by Hacked Devices?*, 50 U Mich J L Ref 913, 928 (2017).

117. See Gerald Spindler, *User Liability and Strict Liability in the Internet of Things and for Robots*, in Lohsse., Schulze and Staudenmayer (eds.), *Liability for Artificial Intelligence and the Internet of Things* 136 (cited in note 1)

118. See Amato, *Product Liability and Product Security* at 91 (cited in note 20).

on the presumption of conformity (or non-conformity) with the essential safety requirements set by regulatory powers.

5. *Conclusion*

In the case of fully autonomous AI-enabled products, the Product Liability Directive may however not be sufficient. As the control over the driving performance shifts entirely from the driver to the algorithm of the vehicle [119], so does liability towards the manufacturer of the vehicle: the liability of manufacturers will increase in size and importance, while the users' behavior will proportionately decrease in relevance[120].

Further analysis will be needed to assess the impact of such provisions on the initial rollout of AI-enabled vehicles. The results of such analysis will also determine the best strategies to lead the process, from social acceptance to the initial stage of regulation of AI. As for this moment, some tentative considerations are nonetheless possible.

In the previous subsections, the important role of harmonized technical standards has been described with respect to the fundamental link between product liability and product safety. Thus, it is safe to argue that certification bodies, pre-market testing of algorithms, classification according to risks will maintain their relevance with regard to the future deployment of fully autonomous systems. However, it can also be argued that technical harmonization tools will have to keep the pace with technological progress. Although it exceeds the scope of this research, it can be argued that the use of Blockchain[121] will have a significant impact on the transparency of and reliance on AI[122]. Data acquired through the Blockchain could be used by judges for making liability decisions and may be crucial to insurance companies to attribute liability[123].

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119. See Wagner, *Liability for Artificial Intelligence* at 38 (cited in note 63).

120. See Cerka, Grigiene and Sirbikyte, *Liability for Damages Caused* at 383 (cited in note 4).

121. See Scott Ruoti et al., *Blockchain Technology: What Is It Good For?*, 63 Communications of the ACM 46 (2019).

122. See *ibid.*

123. See *ibid.*

In conclusion, the legal debate around the applicability of the Product Liability Directive to fully autonomous systems proves that the road ahead is far from certain, and it will most likely entail a profound revision of the current product liability rules in order to meet the specific technical features of this ground-breaking technology. Notwithstanding the difficulties in outlining a comprehensive liability regime, AI is a transformative technology that may bring significant benefits in terms of overall increased safety. As such, at least during the initial deployment of AI-enabled products, a certain degree of legal uncertainty is inexorable, therefore this rollout must be encouraged through regulatory and legislative tools, able to create social acceptance[124].

Surely enough, from the lessons taught by currently employed semi-autonomous vehicles, mandatory insurance will play a central role, as it guarantees that victims are compensated[125]. The increasing liability of manufacturers of autonomous vehicles will result in an increased demand of insurance coverage in order to prevent insolvency[126]. Although, it is vital that insurance is supported by a clear liability regime, otherwise the costs of uncertain liability will result in increased insurance premiums[127].

In the remote case there is no insurance coverage for certain situations or there are limitations imposed on liability, compensation funds that fill the gaps of compulsory insurance systems can be a viable solution[128]. Financial contributions to compensation funds may derive from manufacturers, programmers, owners or users of automatic

124. See European Parliament, *Resolution of 16 February 2017* (cited in note 3).

125. See Maurice Schellekens, *Self-Driving Cars and the Chilling Effect of Liability Law,* 31 Computer Law and Security Review 506 (2015).

126. See Georg Borges, *New Liability Concepts: the Potential of Insurance and Compensation Funds* in Lohsse, Schulze and Staudenmayer (eds), *Liability for Artificial Intelligence and the Internet of Things* 156 (2018).

127. See Geistfeld, *A Roadmap for Autonomous Vehicles* at 1618 (cited in note 23) (however, it is doubtful that "requiring disclosure of the annual, risk-adjusted insurance premium would give manufacturers a sufficient incentive to further improve the vehicle's safety performance in order to reduce the premium and enhance the vehicle's competitiveness within the market" as stated in *id.* at 1683. Such an assumption derives from an economic analysis of liability law. On the contrary, insurance premium may not be specifically matched to risks). See also Jeorges, *Product Safety, Product Safety Policy and Product Safety Law* at 129 (cited in note 31).

128. See European Parliament, *Commission on Civil Law Rules on Robotics* (cited in note 3).

vehicles who, in exchange for the contribution, benefit from limited liability. Accordingly, compensation funds have great potential in the transformation process as they may both close liability gaps[129] and increase social acceptance of AI[130].

129. See Funkhouser, *Driverless Car Market Watch* at 461 (cited in note 9).

130. See Borges, *New Liability Concepts* at 160 (cited in note 126) (this accounts for the fact that the transformation costs are not certain due to unpredictable amount of damages caused by the introduction of fully autonomous systems. "However, the necessity to avoid chilling effects whilst not burdening injured parties with the cost of the transformation process" can be addressed through the "introduction of limits on liability in order [to] facilitate insurance and avoid chilling effects. Compensation funds could be use in such situations to close gaps in liability").