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Publishable Executive Summary

The purpose of this deliverable is to provide a single point of reference on the safety, regulatory and liability issues for operating robots in the European Union. The deliverable describes a state of the art and the well-known normative frameworks for assuring safety on the one hand and examines the regulatory and legal liability issues related to operating robots on the other.

We organised the report based on the required structure of the deliverable with taking into consideration the different robots technologies, as recognised at the European Union and international level.

This deliverable is closely related to other deliverables which describe the current state of the arts and normative framework from a different point of view. This review report is intended as a guiding document to be used by all project partners.

There is currently no single framework to regulate robotics technology in Europe. Different types of robots, depending on where they operate—which Member State and in the air, on land, or in the waters—may be subject to various existing laws or regulations on the international, European Union, Member State levels. The regulations include legal standards and industry guidelines on the robot technologies themselves and on the developers, manufacturers, suppliers, and operators that must be met before these new technologies can be legally and safely deployed. Specific types of robots are subject to different regulatory regimes, and depending on the type of the robot, the applicable regulations may be harmonised across Europe or differ in each Member State.

Current liability regimes on the EU and Member State levels govern the situations in which the humans associated with the robots are civilly liable for the damage they cause to property or injuries to persons. The appropriate legal regime could be fault-based, strict liability, or product liability depending on the particular circumstances. While existing laws are sufficient to address liability issues given the current state of the technology, further scientific advances that lead to increasingly sophisticated robots may raise problems on how to appropriately assign responsibility.

Introduction

RIMA network's domains of application are safety-critical because of both the things inspected and maintained (such as drinking water pipes, rail tunnels, and offshore platforms) and the things that are proposed to inspect and maintain them (such as drones, crawlers, and manipulator arms). Organisations developing technology in this domain will need to make rigorous efforts to ensure and assure its safety, to comply with relevant legislation, and to adequately manage the liability they have should something go wrong.

This report reviews legal frameworks for robotic infrastructure I&M, along with relevant standards and best practices in development, verification and assurance. It is an attempt to capture the best practices for achieving safety assurance, meeting existing regulatory standards, addressing legal risks, as well as dealing with potential liability issues. Within RIMA, it is delivered under Task 7.3 "Standardisation, assurance and certification; legislation and policy" in Work Package 7 – "Normative framework".

There are several challenges that need to be addressed when developing safety, assurance and regulation guidance for RIMA network of DIH:

- Standards and regulations can differ in diverse ways between different Member States.
- There is a great deal of existing knowledge on safety even before considering the knowledge specific to RIMA's domains. In this report we assume that the reader (or, at least, their organisation) is able to carry out basic safety assessments.
- The main issues which apply to industrial bodies concern the ability to the assure novel-use, novel-technology applications associated with new robotic solutions in RIMA's domains. This is especially important when robots are operated with a high level of autonomy. Based on the previous concepts, we urgently require new types of approaches that do not (solely) rely on this basic assumption (everything is defined at design time).

Naturally, there is a strong relationship between the safety standards that apply to robotics technology and the law. More specifically, this relates to regulations regarding safety standards, as well as potential liability issues that may arise in the event that robotic technology causes damage to property, humans, or both. The aim of this report is to outline the safety requirements that are currently in place. This is done with the intention of providing guidance on how to deal effectively with each step of the robot development process. This will allow for safe operation by limiting the potential for harm to be caused. The regulations that are discussed provide evidence of existing regimes which apply to robotic technology, as well as highlight gaps in the law as it is presently constituted.

The understanding of the existing regulatory framework is necessary in order to determine what are the next steps necessary to address the need for best practices and regulations specific to robotics in Inspection and Maintenance of Infrastructures. Robots operating in the RIMA domains raise specific issues and have particular risks that may not be relevant to robotics in general. Achieving safety, both through safety standards and regulatory standards, and understanding the allocation of liabilities specifically for RIMA application domains will facilitate regulatory and legal certainty.

In this report, we present our initial findings on the best practices for standardisation, assurance and certification, legislation, and policy for robots in RIMA application domains. Focus is placed on outlining best practices for robotic technologies which can operate in the air, on land, and at sea. For each of these forms of technology we have sought to provide the reader with useful information regarding safety, regulatory, and liability issues with a focus on RIMA application domains.

1 General Concepts

This section introduces the general concepts of regulation and legal liability. It first discusses the various ways the development and operation of robotics technology can be regulated to ensure safety standards are met. It then focuses on the liability regimes that can compensate victims of unsafe or malfunctioning robotics technology who suffer injury or property damage. The main types of liability regimes available in the Member States are fault-based and strict liability, with the product liability regime being a special type of strict liability.

1.1 Methods of Regulation

Regulations for robotics used for Inspection and Maintenance of infrastructures will ensure that robot technologies meet minimum requirements before they are deployed and used in society and also ensure that the individuals responsible for accidents resulting from the use of technology would be legally responsible for any damages caused.[1] These regulations will make certain that robots can operate safely for the sake of the individuals directly involved and also society as a whole that should not be forced to pay for the wrongdoings of the robotics companies, insofar as that is possible given the rapid pace of technological development.[2] While there may be numerous reasons for why regulations may be necessary, at this stage of the development of robotics technology for RIMA network, the overwhelming concern is likely the assurance that robots will work properly in the ways they are supposed to and people's safety are not unduly threatened for the sake of advances in technology.[3] Having a sound regulatory framework would instil confidence in the technologies and facilitate the further development and expansion of the use of robotic technologies for Inspection and Maintenance of Infrastructure.[4]

From a legal perspective, the two main ways to regulate technologies used for Inspection and Maintenance of Infrastructures addressed in RIMA network[5] are direct and indirect regulation. Direct legal regulation involves the robotic technologies meeting the approval requirements to be able to be used, whether in testing environments or in real life settings. Indirect legal regulation is effectuated through criminal and civil liabilities, the latter either being laws specifically designed for

[1] For suggested principles for the regulation of robots, see generally Margaret Boden, 'Principles of Robotics: Regulating Robots in the Real World' (2017) 29 Connection Science 124; Ronald Leenes et al, 'Regulatory Challenges of Robotics: Some Guidelines for Addressing Legal and Ethical Issues' (2017) 9 Law, Innovation and Technology 1; Michael Nagenborg et al, 'Ethical Regulations on Robotics in Europe' (2008) 22 AI & Society 349; Jacob Turner, *Robot Rules: Regulating Artificial Intelligence* (Palgrave MacMillan 2019).

[2] See generally Mark Fenwick, Wulf A Kaal and Erik PM Vermeulen, 'Regulation Tomorrow: What Happens When Technology Is Faster than the Law' (2017) 6 Am U Bus L Rev 561; Wulf A Kaal and Erik PM Vermeulen, 'How to Regulate Disruptive Innovation - From Facts to Data' (2017) 57 Jurimetrics 169.

[3] Other reasons include protecting vulnerable populations, allocating scarce resources, ensuring costs are borne by certain parties and not society as a whole, discouraging anti-competitive behaviour, and ensuring the continuance of basic, essential services. Robert Baldwin, Martin Cave and Martin Lodge, *Understanding Regulation: Theory, Strategy, and Practice* (OUP 2012) 24.

[4] https://www.bundesbank.de/en/press/speeches/confidence-through-regulation-711516

[5] Referred to as *RIMA technologies* in the rest of the document

the particular technology, or tort law or delict, which may incorporate or refer to industry standards and soft law such as the ISO or IEEE standards.[6] These laws can be passed by legislatures or be judge-made.[7]

Direct regulation of technologies used in I&M generally works by preventing accidents from occurring in the first place. Robots would have to meet requirements in order to be designed and used, including specifications of the technology and the qualifications of the operators. If an entity building the robot fails to meet the standards, it would be forbidden from putting the robot in operation. These regulatory measures may also have a post hoc effect where the operators or manufacturers may be sanctioned if it were determined that they deployed the robots without undergoing the approval process or received approval through providing erroneous information or otherwise did not meet the requisite standards. Depending on the country and specific regulatory framework, penalties could include monetary fines or reputational sanctions where the regulatory breaches are made public.[8]

Indirect regulations through criminal and civil liabilities would only come into play if an accident were to occur and it becomes necessary to determine whether the potential wrongdoer would be subject to any criminal or civil liability. Because the applicable laws are specific to each country, the details would differ for each situation. In general, the applicable law would be that of the jurisdiction in which the accident occurs, though it may also be possible for individuals to be charged in the jurisdiction in which they live. The potential criminal charges would also be different and depend on whether property was damaged, and if so, the amount of damage, and whether people were injured or killed. Depending on the particular circumstances, not only could the operator be subject to criminal liability, the designer, owner, or other individuals involved in the process of making the robotic technology a reality may also be potentially criminally liable. In general, for criminal liability to be found by the courts, there would probably have to be some type of maliciousness involved where the actions that led to the damage or injuries were the result of intentional acts or were due to the person's recklessness or gross negligence. In other words, the act must have resulted both from a criminal act and a mental state to commit that act.[9]

Civil liabilities have a much lower legal standard. If an accident were to occur whilst using the robotics technology, the operator, designer, owner, or other individuals involved in leading to the robot being deployed could be subject to civil liability if it were found that the technology did not meet the specific requirements to which they were subject, such as the training requirements for a drone operator. There could also be civil liabilities if it were found that the accident occurred due to negligence. In general, to show negligence, the court would have to find that the person did not meet the requisite standard of care, or duty. This standard of care is usually what a reasonable person in the particular situation would be expected to maintain, and in the realm of robots used in I&M, this standard could be industry guidance or best practices that are not independently binding.[10] These guidelines and best practices are usually called soft law, which, unlike legislation or case law,

[6] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 23.

[7] Marta Katarzyna Kolacz, Alberto Quintavalla and Orlin Yalnazov, 'Who Should Regulate Disruptive Technology (2019) 10 Eur J Risk Reg 4.

[8] See John Armour et al, 'Regulatory Sanctions and Reputational Damage in Financial Markets' (2017) 52 Journal of Financial and Quantitative Analysis 1429.

[9] For criminal liability issues, see generally Jeremy Horder, *Ashworth's Principles of Criminal Law* (OUP 9th edn 2019); Michael Bohlander, *Principles of German Criminal Law* (Hart 2008); Markus D Dubber and Tatjana Hörnle, *Criminal Law: A Comparative Approach* (OUP 2014).

[10] https://www.hg.org/legal-articles/what-is-the-relevance-of-industry-standards-under-the-law-36794

do not have any regulatory effect on their own because they are not laws made by state parties.[11] They nevertheless lead to compliance with certain standards because they 'create expectations about future conduct'[12] or acquire legally-binding force 'through acceptance as market requirements'[13] These soft law standards can be found by the court to be applicable in a case to determine civil liability, but they could also be incorporated into a contract, such as the one between the manufacturer of the robot and the user, and become an issue in a contractual dispute.

While it is unclear so far, it may be possible for courts or legislative bodies to determine that for robots for I&M, strict liability would be the standard for the determination of civil liabilities. For strict liability, negligence by the operator or manufacturer would not need to be shown as long as there is a defect with the robot and the defect caused the damage.[14] Determining whether there is a defect, again, could be aided by assessing whether industry standards were met, though this is not dispositive.[15] This means that the entities or individuals within them could be liable for monetary compensation even in the absence of fault. Product liability is a special case of strict liability. While criminal liability, fault-based civil liability, and strict liability laws may differ depending on the EU Member State, the EU Product Liability Directive 1985 harmonised the law on product liability throughout the EU.

Another way RIMA technologies could be regulated is through private regulation, especially through insurance contracts.[16] When an entity purchases insurance to cover risks arising from the trial and use of these technologies, the insurer is incentivised to reduce the risk because minimising losses would benefit both the insurer and the policyholder. Insurance, thus, plays the role of regulators of corporate behaviour by ensuring that basic safety standards are met.[17] In this regard, 'insurance policies are quite similar to statutes regulating the activity, expectations, and conceptions of insurers and policyholders'.[18] Some even argue that insurance companies are better regulators than the government because of their close working relationship with the insured.[19] Entities operating drones and trialling autonomous vehicles are required to purchase insurance to cover any losses, and through these insurance contracts, the insurer may require the companies to show evidence that all relevant regulations are met, or even to impose stricter standards of their own. Entities would abide by these contractual terms because failure to do so would mean they would not have insurance cover and consequently not be allowed to operate the robots.

1.2 European Union Directives

Various European Union Directives may be applicable to robots for infrastructure inspection and maintenance. The Directives all have different scopes, exclude different types of products or equipment, and have different purposes. This section introduces the Machinery Directive, the Radio Equipment Directive, and the Electromagnetic Compatibility Directive because all three are likely to

[11] Ryan Hagemann, Jennifer Huddleston Skees and Adam Thierer, 'Soft Law for Hard Problems: The Governance of Emerging Technologies in an Uncertain Future' (2018) 17 Colo Tech LJ 37. 46-49.
[12] Andrew T Guzman and Timothy L Meyer, 'International Soft Law' (2010) 2 Journal of Legal Analysis 171, 174.
[13] Naomi Roht-Arriaza, '"Soft Law" in a "Hybrid" Organization: The International Organization for Standardization' in Dinah Shelton (ed), *Commitment and Compliance: The Role of Non-Binding Norms in the International Legal System* (Oxford University Press 2000) 263–64.
[14] Directive 85/374/EEC Art 1.
[15] https://www.din.de/en/about-standards/standards-and-the-law/legal-significance-of-standards
[16] For a general discussion of private regulation of artificial intelligence, see Sonia K Katyal, 'Private Accountability in the Age of Artificial Intelligence' (2019) 66 UCLA L Rev 54.
[17] See Omri Ben-Shahar & Kyle D Logue, 'Outsourcing Regulation: How Insurance Reduces Moral Hazard' (2012) 111 Michigan Law Review 197, 217–28.
[18] Jeffrey W Stempel, 'The Insurance Policy as Statute' (2010) 41 McGeorge Law Review 203, 205-06.
[19] Jeffrey W Stempel, 'The Insurance Policy as Statute' (2010) 41 McGeorge Law Review 203, 228, 235–38.

be applicable to many different types of robotics technology, though it is important to remember that existing Directives may not be able to account for the rapid pace of technological advancements, and some robots may be excluded given the definitions used in the various Directives. Two more Directives, the Product Safety Directive and the Product Liability Directive, will be discussed in a later section.[20] It is unlikely they would apply as is in the commercial settings in which infrastructure inspection and maintenance robots operate given their focus on consumer protection. However, they are discussed because they offer safety standards and a liability regime for victim compensation that may be useful for robotics technology in general. They can serve as guidance and possible roadmaps for legal reform in the future to make similar measures applicable in the commercial robotics setting.

1.2.1 Machinery Directive

In general, robotics technology is likely to be regulated by the provisions of the Machinery Directive 2006/42/EC, which was first published in June 2006 and came into effect in December 2009. The purpose of the Directive is to protect the health and safety of persons in the EU from risks that may arise from the use of machinery.[21] The risks associated with machinery are usually high because of the ability of industrial robots to inflict serious injuries.[22] The Directive also guarantees the freedom of movement of products within the EU, as once a machinery is determined to be in conformity with the Directive, it can be put in the market or placed in service in any Member State without further restrictions.[23] This Directive is only applicable to machinery that are being placed in the EU for the first time.[24]

- *Scope of Directive*

According to the Directive, machinery is defined as:

> — an assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application,
> — an assembly referred to in the first indent, missing only the components to connect it on site or to sources of energy and motion,
> — an assembly referred to in the first and second indents, ready to be installed and able to function as it stands only if mounted on a means of transport, or installed in a building or a structure,
> — assemblies of machinery referred to in the first, second and third indents or partly completed machinery referred to in point (g) which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole,
> — an assembly of linked parts or components, at least one of which moves and which are joined together, intended for lifting loads and whose only power source is directly applied human effort;[25]

[20] See Section 1.4.
[21] Machinery Directive Article 4(1). The Directive's health and safety requirements are also meant to protect animals and the environment in certain cases.
[22] SP Gaskill and SRG Went, 'Safety Issues in Modern Applications of Robots' (1996) 53 Reliability Engineering & System Safety 301, 301.
[23] Machinery Directive Article 6.
[24] George A Ballas and Theodore J Konstantakopoulos, 'Greece Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 161.
[25] Machinery Directive Article 2(a).

Partly completed machinery are also governed by the Directive.[26] Partly completed machinery:

> means an assembly which is almost machinery but which cannot in itself perform a specific application. A drive system is partly completed machinery. Partly completed machinery is only intended to be incorporated into or assembled with other machinery or other partly completed machinery or equipment, thereby forming machinery to which this Directive applies.[27]

The Directive excludes its application to many products or equipment.[28] For example, the following are not within the purview of the Directive: 'safety components intended to be used as spare parts to replace identical components and supplied by the manufacturer of the original machinery', and 'machinery specially designed or put into service for nuclear purposes which, in the event of failure, may result in an emission of radioactivity'.[29]

More pertinent to robotics for infrastructure inspection and maintenance, it is generally agreed that robots in general are considered machinery.[30] There is little doubt that current industrial robots fall under the purview of the Machinery Directive. This is despite the fact that the word 'robot' does not appear in the Directive.[31] However, the Directive does explicitly exclude various forms of transportation that may impact its applicability to future robotics technology. The exclusions include agricultural and forestry tractors, four-wheeled vehicles designed for road use, two and three-wheeled vehicles, 'means of transport by air, on water and on rail networks' and 'seagoing vessels and mobile offshore units'.[32] The shared characteristic that leads to the exclusion of these systems is that they are designed to transport goods or people.[33]

As a result, '[m]achinery intended for use on rail networks that is not intended for the transport of persons and/or goods such as, for example, railbound machinery for the construction, maintenance and inspection of the rail track and structures, is also in the scope of the Machinery Directive'.[34] One scholar was initially unsure whether the Directive would apply to aerial drones but clearly advocated for its inclusion.[35] The *Guide to Application of the Machinery Directive* later suggested that drones that are not considered 'means of transport' are still covered by the Directive.[36] As will be discussed

[26] Machinery Directive Article 1(g). The Directive also applies to interchangeable equipment; safety components; lifting accessories; chains, ropes and webbing; removable mechanical transmission devices are also under the purview of the Machinery Directive. For definitions of these products, see Machinery Directive Article 2.
[27] Machinery Directive Article 2(g).
[28] Machinery Directive Article 1(2).
[29] Machinery Directive Article 1(2)(a)-(c).
[30] A Santosuosso, C Boscarato, F Caroleo, R Labruto and C Leroux, 'Robots, Market and Civil Liability: A European Perspective' (2012) IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication 1051, 1052.
[31] Marc Gallardo, 'Spain Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 308.
[32] Machinery Directive Article 1(2)(e)-(f).
[33] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 67-57.
[34] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 57.
[35] Guido Noto La Diega, 'Machine Rules. Of Drones, Robots, and the Info-Capitalist Society' (2016) 2 Italian LJ 367, 397.
[36] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 56-57.

later, aerial drones are also subject to Commission regulations specifically on drones.[37] The Machinery Directive's requirements on health and safety are generally applicable, but '[w]here those health and safety requirements are intrinsically linked to the safety of the flight', only the drone regulation would apply.[38]

Tractors that are covered by the Tractor Directive 2007/37/EC, which include wheeled tractors, track-laying tractors, trailers, and interchangeable towed equipment, are excluded from the Machinery Directive.[39] At the time the Machine Directive was first passed, it covered some risks related to tractors, but Regulation 167/2013 made it clear that tractors 'are completely excluded from the Machinery Directive'.[40] The machinery mounted or semi-mounted on tractors remain under the purview of the Machinery Directive.[41] It must also be noted that if the '"vehicle" is primarily designed for a task such that it does not meet the definition of an agricultural vehicle in Regulation (EU) No 167/2013', then the Machinery Directive still applies. Consequently, care must be taken to determine whether specific designs and models in the future are covered by the Machinery Directive or the Tractor Directive should they deviate from the industrial robots used today.

For cars and motorcycles, the exclusion is only applied to those that are designed to travel on roads, so off-road vehicles would still be subject to the Machinery Directive.[42] Vehicles used for an 'intra-enterprise setting' are also generally covered by the Directive.[43] With the exception of seagoing vessels and offshore units, the machinery on the vehicles must still abide by the Directive.[44] Such machinery includes 'loader cranes, tail-lifts, vehicle or trailer-mounted compressors, vehicle-mounted compaction systems, vehicle mounted concrete mixers, skip loaders, powered winches, tipper bodies and vehicle or trailer-mounted mobile elevating work platforms'.[45] The machinery installed on seagoing vessels and offshore units are not within the scope of the Directive because they are subject to international conventions.[46]

Due to the various exclusions, whether the Machinery Directive would be applicable to robots for infrastructure inspection and maintenance is a question without an overarching answer. The same water-borne robot that inspects bridges would be covered by the Machinery Directive if it is in a Member State's internal waters but would be excluded if it were operating in international waters. Aerial drones for infrastructure inspection and maintenance would likely be included in the Directive so long as they are not meant to transport goods or people and the health and safety requirements are not intrinsic to flight safety requirements. Land-based robots may or may not be subject to the Directive depending on how they are designed. If it moves on rails and is not meant for the transportation of people or goods, the Directive would apply. If it has wheels but is designed strictly to travel on roads and transport people or goods, it would not be within the Directive's scope, as

[37] See Section 2.1.
[38] COMMISSION DELEGATED REGULATION (EU) 2019/945 of 12 March 2019 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems Recital (6).
[39] Thomas Klindt et al, *The New EC Machinery Directive 2006* (Beuth Verlag 2007) 24.
[40] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 53.
[41] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 54.
[42] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 54-55.
[43] Thomas Klindt et al, *The New EC Machinery Directive 2006* (Beuth Verlag 2007) 25.
[44] Machinery Directive Article 1(2)(e)-(f).
[45] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 55.
[46] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 57.

other EU legislation, Council Directive 70/156/EEC or Directive 2002/24/EC, would apply. As for machinery mounted on top of such vehicles, with technological advancements, whether something is considered an integral part of the vehicle or mounted equipment could become hard to determine, making the applicability of the Directive less certain.

- *Obligations of Member States and Manufacturers*

The Directive requires Member States to ensure that machinery that are 'placed on the market and/or put into service' meet the requirements set forth in the Directive and 'does not endanger the health and safety of persons…when properly installed and maintained and used for its intended purpose or under reasonably foreseeable conditions'.[47] Annex I of the Directive contains the '[e]ssential health and safety requirements relating to the…design and construction of machinery' that manufacturers must meet.[48] These are mandatory provisions that must be followed.[49]

Annex I requires that '[m]achinery must be designed and constructed so that it is fitted for its function, and can be operated, adjusted and maintained without putting persons at risk' for the machinery's normal functions and misuse that is reasonably foreseeable.[50] Manufacturers must ensure that the machinery is designed and manufactured in ways that prevent abnormal use that could lead to danger.[51] The risk elimination must be for the machinery's lifetime, including 'the phases of transport, assembly, dismantling, disabling and scrapping'.[52] In taking measures to prevent risks, the following steps must be followed:

— eliminate or reduce risks as far as possible (inherently safe machinery design and construction),
— take the necessary protective measures in relation to risks that cannot be eliminated,
— inform users of the residual risks due to any shortcomings of the protective measures adopted, indicate whether any particular training is required and specify any need to provide personal protective equipment.[53]

Manufacturers must use materials that would not endanger the health and safety of people when constructing the machinery, and there must be internal and external lighting as appropriate to ensure safe operations, inspections, and maintenance.[54] The machinery must be made to be safely handled and transported, including being affixed with attachments for or shaped in ways compatible with lifting gear.[55] The health and safety of the person operating the machinery must also be considered. This includes ergonomic designs that minimise 'physical and psychological stress', ensuring the position of the operator is not subject to undue hazards such as exhaust gases, and stable seating for the operator if appropriate for the machinery.[56]

There are also health and safety requirements for the machinery's control systems, which should be designed and constructed so that:

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[47] Machinery Directive Article 4(1).
[48] Machinery Directive Annex I.
[49] Machinery Directive Annex I General Principles (3).
[50] Machinery Directive Annex I 1.1.2(a).
[51] Machinery Directive Annex I 1.1.2(c).
[52] Machinery Directive Annex I 1.1.2(a).
[53] Machinery Directive Annex I 1.1.2(b).
[54] Machinery Directive Annex I 1.1.3-1.1.4.
[55] Machinery Directive Annex I 1.1.5.
[56] Machinery Directive Annex I 1.1.6-1.1.8.

— they can withstand the intended operating stresses and external influences,
— a fault in the hardware or the software of the control system does not lead to hazardous situations,
— errors in the control system logic do not lead to hazardous situations,
— reasonably foreseeable human error during operation does not lead to hazardous situations.[57]
Additionally, control devices are to be:
— clearly visible and identifiable, using pictograms where appropriate,
— positioned in such a way as to be safely operated without hesitation or loss of time and without ambiguity,
— designed in such a way that the movement of the control device is consistent with its effect,
— located outside the danger zones, except where necessary for certain control devices such as an emergency stop or a teach pendant,
— positioned in such a way that their operation cannot cause additional risk,
— designed or protected in such a way that the desired effect, where a hazard is involved, can only be achieved by a deliberate action,
— made in such a way as to withstand foreseeable forces; particular attention must be paid to emergency stop devices liable to be subjected to considerable forces.[58]

The machinery also must be made in ways that would minimise the '[r]isk of loss of stability', '[r]isk of break-up during operation', '[r]isks due to falling or ejected objects', '[r]isks due to surfaces, edges or angles', '[r]isks related to combined machinery', '[r]isks related to variations in operating conditions', and '[r]isks related to moving parts'.[59] The 'protection against risks arising from moving parts' 'must be selected on the basis of the type of risk', and when the machinery is stopped, uncontrolled movement 'must be prevented or must be such that it does not present a hazard'.[60] Risks from other hazards such as the electric supply, static electricity, errors of fitting, extreme temperatures, fire, noise and radiation, must also be prevented.[61] The above are essential for all machinery, and Annex I also includes health and safety requirements for certain categories of machinery,[62] health and safety requirements associated with machinery mobility,[63] health and safety requirements to prevent 'hazards due to lifting operations',[64] health and safety requirements for machinery intended for underground work,[65] and health and safety requirements to guards against 'hazards due to the lifting of persons'.[66]

The Directive takes a risk-based approach rather than 'test[ing] for all possible dangerous faults'.[67] Consequently, a risk assessment as stipulated in Annex I must be performed by the manufacturer, and the design and construction must take into account this risk assessment.[68] The risk assessment and resulting actions must:

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[57] Machinery Directive Annex I 1.2.1.
[58] Machinery Directive Annex I 1.2.2.
[59] Machinery Directive Annex I 1.3.1.-1.3.7.
[60] Machinery Directive Annex I 1.3.8-1.3.9.
[61] Machinery Directive Annex I 1.5.
[62] Machinery Directive Annex I 2.
[63] Machinery Directive Annex I 3.
[64] Machinery Directive Annex I 4.
[65] Machinery Directive Annex I 5.
[66] Machinery Directive Annex I 6.
[67] SP Gaskill and SRG Went, 'Safety Issues in Modern Applications of Robots' (1996) 53 Reliability Engineering & System Safety 301, 307.
[68] Machinery Directive Annex I General Principles (1).

> — determine the limits of the machinery, which include the intended use and any reasonably foreseeable misuse thereof,
> — identify the hazards that can be generated by the machinery and the associated hazardous situations,
> — estimate the risks, taking into account the severity of the possible injury or damage to health and the probability of its occurrence,
> — evaluate the risks, with a view to determining whether risk reduction is required, in accordance with the objective of this Directive,
> — eliminate the hazards or reduce the risks associated with these hazards by application of protective measures, in the order of priority established in section 1.1.2(b).[69]

Though it is not a requirement to satisfy the requirements of the risk assessment, the UK government suggests that:

> the harmonised standard BS EN ISO 12100:2010 Safety of machinery - General principles for design - Risk assessment and risk reduction...provides fundamental guidance and an overall framework for designers making decisions during the development of machinery to enable them to design machines that are safe for their intended use.[70]

Conducting a risk assessment and reducing risks do not mean that all risks must be eliminated, so residual risk can be acceptable if the circumstances call for it.[71] Some machines are simply inherently dangerous.[72] Residual risks are risks 'to be controlled by the user based on information from the manufacturer contrary to the risks which have been eliminated by design measures and/or prevented based on safeguarding'.[73] The protective measures the user needs to take, which can be, for example, additional screens, protective gear, or operational restrictions to certain personnel, must be provided by the manufacturer.[74]

Manufacturers have the obligation to ensure the machinery is safe before putting it on the market or into service. First, it must 'ensure that it satisfies the relevant essential health and safety requirements set out in Annex I'.[75] So long as the machinery is 'manufactured in conformity with a harmonised standard, the references to which have been published in the *Official Journal of the European Union,* [it] shall be presumed to comply with the essential health and safety requirements covered by such a harmonised standard'.[76] These harmonised standards are developed by European

[69] Machinery Directive Annex I General Principles (1).
[70] https://www.hse.gov.uk/work-equipment-machinery/machinery-directive-essential-requirements.htm
[71] Gabriele Mazzini, 'A System of Governance for Artificial Intelligence through the Lens of Emerging Intersections between AI and EU Law' in Alberto de Franceschi and Reiner Schulze (eds), *Digital Revolution - New Challenges for Law: Data Protection, Artificial Intelligence, Smart Products, Blockchain Technology and Virtual Currencies* (Nomos 2019) 255.
[72] Thomas Gehring and Michael Kerler, 'Institutional Stimulation of Deliberative Decision-Making: Division of Labour, Deliberative Legitimacy and Technical Regulation in the European Single Market' (2008) 46 J Common Mkt Stud 1001, 1011.
[73] Torben Jespen, *Risk Assessments and Safe Machinery: Ensuring Compliance with the EU Directives* (Springer 2016) 52.
[74] Torben Jespen, *Risk Assessments and Safe Machinery: Ensuring Compliance with the EU Directives* (Springer 2016) 52-53.
[75] Machinery Directive Article 5(1)(a).
[76] Machinery Directive Article 7(2).

Standardisation Organisations.[77] The standards are highly technical and usually left to the private actors without intervention from Member States or the Commission.[78] The harmonised standards are divided into three types. 'A-type standards specify basic concepts, terminology and design principles applicable to all categories of machinery, and following these standards alone is 'not sufficient to ensure conformity with the relevant essential health and safety requirements of the Directive and therefore does not give a full presumption of conformity'.[79] 'B-type standards deal with specific aspects of machinery safety or specific types of safeguard that can be used across a wide range of categories of machinery' and its application confers a presumption of conformity if 'a technical solution specified by the B-type standard is adequate for the particular category or model of machinery concerned' or if it is for safety components placed on the market independently.[80] 'C-type standards provide specifications for a given category of machinery' and following the standard gives rise to a presumption of conformity.[81]

Examples of the standards that could be applicable to robots for infrastructure inspection and maintenance include:

- EN ISO 10218-1:2011: Robots and robotic devices - Safety requirements for industrial robots - Part 1: Robots (ISO 10218-1:2011)
- EN ISO 10218-2:2011: Robots and robotic devices - Safety requirements for industrial robots - Part 2: Robot systems and integration (ISO 10218- 2:2011).
- EN ISO 1525:1997 Safety of industrial trucks. Driverless trucks and their systems. (under revision, project published in 2018 as PR EN ISO 3691-4)
- EN 13020:2015: Road surface treatment machines - Safety requirements
- EN 13524:2003+A2:2014: Highway maintenance machines - Safety requirements
  EN 15997:2011/AC:2012: All terrain vehicles (ATVs - Quads) - Safety requirements and test methods[82]

Manufacturers can also choose to conform to the requirements without referring to these harmonised standards or only parts of them, but they must be able to show that their own standard 'provides a level of safety that is at least equivalent to that afforded by application of the specifications of the harmonised standard'.[83] The presumption provided by the private harmonised standards offers a level of certainty to the manufacturer.[84] However, it is rebuttable and can always be challenged should disputes arise.[85] This was confirmed in a 2007 European Court of Justice case.[86]

[77] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 75.

[78] Thomas Gehring and Michael Kerler, 'Institutional Stimulation of Deliberative Decision-Making: Division of Labour, Deliberative Legitimacy and Technical Regulation in the European Single Market' (2008) 46 J Common Mkt Stud 1001, 1012-13.

[79] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52017XC0609(03)&from=EN

[80] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52017XC0609(03)&from=EN

[81] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52017XC0609(03)&from=EN

[82] For a list of harmonised standards published in the Official Journal for the Machinery Directive, see https://ec.europa.eu/docsroom/documents/38570/attachments/1/translations/en/renditions/native.

[83] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 105.

[84] Eduard Fosch Villarongaa and Angelo Jr Goliab, 'Robots, Standards and the Law: Rivalries between Private Standards and Public Policymaking for Robot Governance' (2019) 35 Computer Law & Security Review 129, 133.

[85] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 105.

Second, manufacturers must compile and make available a technical file that 'demonstrate[s] that the machinery complies with the requirements' of the Machine Directive.[87] The technical file is meant to include all the documentation, most importantly the risk assessment, so they can be assessed by the national authority.[88] Third, the manufacturer must provide necessary information such as instructions.[89] These instructions are required to include information on health and safety.[90] They should also be 'accessible and readily understood' in order to be useful and effective.[91] Fourth, they must 'carry out the appropriate procedures for assessing conformity'.[92] To satisfy this requirement:

> the person carrying out the conformity assessment must have, or have access to the necessary means to verify the conformity of the machinery with the applicable health and safety requirements. The means may include, for example, access to the necessary qualified personnel who have knowledge of both the Machinery Directive and relevant standards, access to the necessary information, the competency and the equipment needed to carry out the necessary design checks, calculations, measurements, functional tests, strength tests, visual inspections and checks on information and instructions to ensure the conformity of the machinery with the relevant essential health and safety requirements.[93]

Fifth, manufacturers are required to 'draw up the EC declaration of conformity...and ensure that it accompanies the machinery',[94] and finally, manufacturers must 'affix the CE marking' as specified in the Machinery Directive.[95] The CE marking denotes that the manufacturer has ensured the machinery conforms to health and safety standards.[96] The marking 'shall consist of the initials "CE"' and 'shall be affixed to the machinery visibly, legibly and indelibly'.[97] In addition to the CE marking, the machinery must include other marking with the appropriate information 'usually specified in the relevant harmonised standards'.[98] All five of these steps are mandatory provisions that manufacturers must follow.[99]

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86 C-470/03 A.G.M.-COS.MET Srl v Suomen valtio, judgment of 17-04-2007, paragraphs 62-63: http://curia.europa.eu/juris/showPdf.jsf?text=&docid=63389&pageIndex=0&doclang=en&mode=lst&dir=&occ =first &part=1&cid=637359.

87 Machinery Directive Article 5(1)(b).

88 Torben Jespen, *Risk Assessments and Safe Machinery: Ensuring Compliance with the EU Directives* (Springer 2016) 39-40.

89 Machinery Directive Article 5(1)(c).

90 Torben Jespen, *Risk Assessments and Safe Machinery: Ensuring Compliance with the EU Directives* (Springer 2016) 49.

91 Liz Bluff, 'Safety in Machinery Design and Construction: Performance for Substantive Safety Outcomes' (August 1, 2014). Safety Science, 66 (2014), pp. 27-35; RegNet Research Paper No. 2014/41 <https://ssrn.com/abstract=2482169> 21.

92 Machinery Directive Article 5(1)(d).

93 European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 99.

94 Machinery Directive Article 5(1)(e).

95 Machinery Directive Article 5(1)(f).

96 A Santosuosso, C Boscarato, F Caroleo, R Labruto and C Leroux, 'Robots, Market and Civil Liability: A European Perspective' (2012) IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication 1051, 1053.

97 Machinery Directive Article 16(1)-(2).

98 Torben Jespen, *Risk Assessments and Safe Machinery: Ensuring Compliance with the EU Directives* (Springer 2016) 48.

99 João P Alves Pereira and Belén Granados, 'Portugal Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 260.

Member State authorities have the obligation of market surveillance to ensure that products are safe when or after they have entered the market.[100] This can be performed 'at any stage after the construction of the machinery is complete' and can be completed at 'the premises of manufacturers, importers, distributors, rental companies, in transit or at the external borders of the EU'.[101] While machinery with 'CE marking and accompanied by the EC declaration of conformity' is presumed to have conformed to the Directive, the power of market surveillance is an external check to the manufacturer's self-assessment and regulation.[102] If non-conformity is found, the national authority may order corrective measures be taken or forbid the use of the machinery altogether.[103]

The market surveillance must take into account the state of the art, meaning that although it may not 'be possible to meet the objectives set by [the Directive]…the machinery must, as far as possible, be designed and constructed with the purpose of approaching these objectives'.[104] When making this assessment, the authority must also take into account the intended use of the machinery and the reasonably foreseeable misuse, as 'certain kinds of misuse, whether intentional or unintentional, are predictable on the basis of experience of past use of the same type of machinery or of similar machinery, accident investigations and knowledge about human behaviour'.[105] Examples of misuse include 'loss of control of the machine by the operator' and 'behaviour resulting from pressures to keep machinery running in all circumstances'.[106] In addition to the market surveillance obligations of the Machinery Directive, Member States must also follow the market surveillance rules in Chapter III of the Regulation (EC) No 765/2008 if the former is silent on the issue.[107] Manufacturers of robotics technology should be aware of the measures Member State authorities can take in both the Directive and this regulation.

Member States have the ability to ensure that the machinery is made unavailable should there be violations of the Directive:

> Where a Member State ascertains that machinery covered by this Directive, bearing the CE marking, accompanied by the EC declaration of conformity and used in accordance with its intended purpose or under reasonably foreseeable conditions, is liable to endanger the health or safety of persons or, where appropriate, domestic animals or property or, where applicable, the environment, it shall take all appropriate measures to withdraw such machinery from the market, to prohibit the placing on the market and/or putting into service of such machinery or to restrict the free movement thereof.[108]

The Member State that takes this action must then inform the European Commission and other Member States the reason for the measure it has taken.[109]

[100] Machinery Directive Article 4(1).
[101] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 87.
[102] Machinery Directive Article 7(1).
[103] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 87.
[104] Machinery Directive Annex I General Principles (3).
[105] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 163.
[106] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 163.
[107] European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Guide to Application of the Machinery Directive 2006/42/EC (2.2 edn, October 2019) 85-86.
[108] Machinery Directive Article 11(1).
[109] Machinery Directive Article 11(2).

➢ *Applicability to New Technologies*

Whether the Machinery Directive is fit for purpose to regulate the health and safety of robotics for infrastructure maintenance and inspection is an open question, though it must be able to do so to fulfil its original and fundamental purpose.[110] It has been suggested that the Directive was meant to regulate health and safety in 'relatively well structured' industrial environments where the risks are able to be easily controlled.[111] With new and more complex technologies operating in 'less structured environments', the Directive may need to be amended.[112] The Directive's approach of minimising interactions between the machine and humans to reduce casualty is also one that may not be appropriate for artificial intelligence or robots for infrastructure inspection and maintenance that may necessarily encounter humans and operate in outdoor, uncontrolled environments.[113] The unpredictability of the behaviour of humans who are not part of the robotics operation while in relatively close proximity is an additional factor brought about by the new technologies.[114]

The European Commission conducted a public consultation on the Directive in 2016 which, in part, solicited opinions on 'its fitness-for-purpose to new technological developments'.[115] While 45% of the respondents answered 'to a large extent' on whether the Directive '[t]ook account sufficiently of new innovations and new technologies at the time' it was first implemented, only 29% answered the same way to the questions of whether it has been able to account for technological developments since then and 23% to the question of whether the Directive would be able to 'deal with new innovations and technologies over the next 10 years'.[116] For the latter two questions, 32% of the respondents answered 'to a moderate extent'.[117] In a 2017 report commissioned by the EC Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, the Technopolis Group found that a 'significant minority' of stakeholders in Member States would like to see the Machinery Directive revised to account for technological advances.[118] Specifically, new technologies in the 'areas of digitisation and robotics', including 'autonomous machines/systems, artificial intelligence, collaborative robotics, [and] mobile robotics' were mentioned as products that 'may not be well addressed by the Directive currently'.[119] The common characteristic of these machines is that

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110 See Gregory G Scott, 'Product Liability Laws in the European Community in 1992' (1992) 18 Wm Mitchell L Rev 357, 373.

111 Ronald Leenes and Federica Lucivero, 'Laws on Robots, Laws by Robots, Laws in Robots: Regulating Robot Behaviour by Design' (2014) 6 Law, Innovation and Technology 193, 201.

112 Ronald Leenes and Federica Lucivero, 'Laws on Robots, Laws by Robots, Laws in Robots: Regulating Robot Behaviour by Design' (2014) 6 Law, Innovation and Technology 193, 201.

113 Eduard Fosch-Villaronga and Michiel Heldeweg, '"Regulation, I Presume?" Said the Robot – Towards an Iterative Regulatory Process for Robot Governance' (2018) 34 Computer Law & Security Review 1258, 1261.

114 Ronald Leenes and Federica Lucivero, 'Laws on Robots, Laws by Robots, Laws in Robots: Regulating Robot Behaviour by Design' (2014) 6 Law, Innovation and Technology 193, 201-202.

115 https://ec.europa.eu/growth/content/public-consultation-evaluation-machinery-directive-200642ec-0_en

116 Summary report of the open public consultation on the Evaluation of the Machinery Directive 2006/42/EC, <https://ec.europa.eu/docsroom/documents/25462/attachments/1/translations/en/renditions/native> 3.

117 Summary report of the open public consultation on the Evaluation of the Machinery Directive 2006/42/EC, <https://ec.europa.eu/docsroom/documents/25462/attachments/1/translations/en/renditions/native> 3.

118 Paul Simmonds, Neil Brown and Maike Rentel, 'Evaluation of Directive 2006/42/EC on Machinery: Final Report' (September 2017) <https://ec.europa.eu/docsroom/documents/25661/attachments/1/translations/en/renditions/native> 112-13.

119 Paul Simmonds, Neil Brown and Maike Rentel, 'Evaluation of Directive 2006/42/EC on Machinery: Final Report' (September 2017) <https://ec.europa.eu/docsroom/documents/25661/attachments/1/translations/en/renditions/native> 48.

their operations and behaviours are governed by computer algorithms, like much of the robotics technology used for infrastructure inspection and maintenance.[120]

In a March 2017 meeting of the Machinery Directive 2006/42/EC Working Group, the applicability of the Directive to autonomous systems and artificial intelligence was first discussed. It was 'confirmed that it is necessary to clarify a whole range of aspects for robots, including a clearcut definition, in view of industrial evolution and the new concepts of robots, for the Machinery Directive to provide adequate requirements'.[121] It is evident that the EU is taking the applicability of the Directive to new technologies seriously. In the working document evaluating the 2016 survey responses, the European Commission noted the important of accounting for new technologies:

> These emerging digital technologies may not be inherently less safe than more traditional products whose risks are well addressed by the Machinery Directive, but their evolutionary and self-learning capabilities require attention in terms of safety.[122]

As a result, the European Commission is currently in the process of updating the Machinery Directive to take into account technological advances.[123] Feedback is closed, and the Commission is expected to release its proposal in the first quarter of 2021.[124] The Directive may be amended to better regulate the health and safety standards of autonomous robots, but in the meantime, manufacturers and operators of robotics technology should strive to meet the obligations of the Directive if the technology falls within its scope.[125]

1.2.2 Radio Equipment Directive

The Radio Equipment Directive 2014/53/EU 'establishes a regulatory framework for the making available on the market and putting into service in the Union of radio equipment'.[126] This is particularly important in the context of new technologies that are constantly connected to and in communication with each other. Not only do systems need to communicate with one another, users and the systems also need to communicate for certain types of robots to function properly. The Directive defines radio equipment as:

> an electrical or electronic product, which intentionally emits and/or receives radio waves for the purpose of radio communication and/or radiodetermination, or an electrical or electronic product which must be completed with an accessory, such as antenna, so as to intentionally emit and/or receive radio waves for the purpose of radio communication and/or radiodetermination;[127]

[120] See Marta Infantino and Weiwei Wang, 'Algorithmic Torts: A Prospective Comparative Overview' (2019) 28 Transnat'l L & Contemp Probs 309, 325-26.
[121] Minutes Meeting of the Machinery Directive 2006/42/EC Working Group, 29 March 2017, Charlemagne Building, Brussels <https://ec.europa.eu/docsroom/documents/38785/attachments/1/translations/en/renditions/native> 508.
[122] <https://ec.europa.eu/docsroom/documents/29232/attachments/1/translations/en/renditions/native> 29.
[123] https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-6426989/public-consultation_en#about-this-consultation
[124] https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-6426989_en
[125] Candido Garcia Molyneux and Rosa Oyarzabal, 'What Is a Robot (under EU Law)' (2018) 1 RAIL 11, 14.
[126] Radio Equipment Directive Article 1(1).
[127] Radio Equipment Directive Article 2(1).

Certain equipment are explicitly excluded and would not have to comply with the requirements of the Directive, including equipment used for public security, marine equipment, and airborne equipment.[128] However, 'electrical/radio equipment not intended for exclusive airborne use', drones in the open and specific category, and drones in the certified category 'if not intended to operate only on frequencies allocated by the Radio Regulations of the International Telecommunication Union for protected aeronautical use' are covered by the Directive if they are 'intended to emit and/or receive electromagnetic waves of frequencies below 3000 GHz for the purpose of radio communication and/or radiodetermination'.[129] This means that aerial robots for infrastructure inspection and maintenance, if they meet the above requirements, can be subject to the Directive.

The purpose of the Directive, per Article 3(1), is to ensure the 'health and safety of persons and of domestic animals and the protection of property', and radio equipment must be built with this aim in mind.[130] Article 3(1) also requires equipment to maintain 'an adequate level of electromagnetic compatibility' in compliance with the Electromagnetic Compatibility Directive discussed in the next section.[131] In addition, '[r]adio equipment shall be so constructed that it both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference', as Article 3(2) mandates.[132] Finally, Article 3(3) states:

> Radio equipment within certain categories or classes shall be so constructed that it complies with the following essential requirements:
> (a) radio equipment interworks with accessories, in particular with common chargers;
> (b) radio equipment interworks via networks with other radio equipment;
> (c) radio equipment can be connected to interfaces of the appropriate type throughout the Union;
> (d) radio equipment does not harm the network or its functioning nor misuse network resources, thereby causing an unacceptable degradation of service;
> (e) radio equipment incorporates safeguards to ensure that the personal data and privacy of the user and of the subscriber are protected;
> (f) radio equipment supports certain features ensuring protection from fraud;
> (g) radio equipment supports certain features ensuring access to emergency services;
> (h) radio equipment supports certain features in order to facilitate its use by users with a disability;
> (i) radio equipment supports certain features in order to ensure that software can only be loaded into the radio equipment where the compliance of the combination of the radio equipment and software has been demonstrated.[133]

Only when the equipment comports with these health and safety essential requirements can the manufacturer make them available on the market.[134] They can only be put into service and use when the equipment 'complied with this Directive when it is properly installed, maintained and used for its intended purpose'.[135] Compliance means that the equipment can then be moved freely within the EU.[136]

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[128] Guide to the Radio Equipment Directive 2014/53/EU (19 December 2018) 11-12.
[129] Guide to the Radio Equipment Directive 2014/53/EU (19 December 2018) 13.
[130] Radio Equipment Directive Article 3(1)(a).
[131] Radio Equipment Directive Article 3(1)(b).
[132] Radio Equipment Directive Article 3(2).
[133] Radio Equipment Directive Article 3(3).
[134] Radio Equipment Directive Article 6.
[135] Radio Equipment Directive Article 7.
[136] Radio Equipment Directive Article 9.

As with the Machinery Directive, compliance with harmonised standards published in the *Official Journal of the European Union* affords the presumption that the essential requirements are met.[137] The manufacturer is obligated to 'perform a conformity assessment of the radio equipment with a view to meeting the essential requirements'.[138] Demonstrating compliance with the essential requirements in Article 3(1) can be done through one of three ways:

(a) internal production control set out in Annex II;
(b) EU-type examination that is followed by the conformity to type based on internal production control set out in Annex III;
(c) conformity based on full quality assurance set out in Annex IV.[139]

For conformity to the essential requirements in Article 3(2) and (3), this can be done by the following procedures if a harmonised standard was used:

(a) internal production control set out in Annex II;
(b) EU-type examination that is followed by the conformity to type based on internal production control set out in Annex III;
(c) conformity based on full quality assurance set out in Annex IV.[140]

If no harmonised standards were referenced or if no relevant standards exist, conformity cannot be shown with internal production control, and one of the other two procedures must be used.[141] The internal control production control procedure set out in Annex II requires the manufacturer to self-regulate and ensure conformity. Technical documentation must be drafted, measures to ensure compliance during the manufacturing process must be taken, and CE marking and declaration of conformity must be prepared.[142] For the other procedures, an outside notified body would be involved to assess conformity.[143] This body is set up by the individual Member States.[144]

Designers and manufacturers of robots for infrastructure inspection and maintenance should be familiar with the requirements of the Radio Equipment Directive because it is likely these robots would need to communicate with each other and with users using equipment that would be subject to the Directive. However, some robots may be excluded by the Directive depending on their design, so evaluating the applicability of this Directive to various types of robots is an important first step to take with regard to new technologies.

1.2.3 Electromagnetic Compatibility Directive

The Electromagnetic Compatibility Directive 2014/30/EU 'regulates the electromagnetic compatibility of equipment'.[145] It main purposes is not health and safety; rather, it is concerned with compatibility.[146] This is important in the contexts of robotics technology to ensure that the robots

137 Radio Equipment Directive Article 16.
138 Radio Equipment Directive Article 17(1).
139 Radio Equipment Directive Article 17(2).
140 Radio Equipment Directive Article 17(3).
141 Radio Equipment Directive Article 17(4).
142 Radio Equipment Directive Annex II.
143 Radio Equipment Directive Annex III; Annex IV.
144 Radio Equipment Directive Article 23. For a list of the Member State notified bodies, see https://ec.europa.eu/growth/tools-databases/nando/index.cfm?fuseaction=directive.notifiedbody&dir_id=154428.
145 Electromagnetic Compatibility Directive Article 1.
146 March 2018 Guide for the EMCD (Directive 2014/30/EU) 8.

can operate properly in the electromagnetic environment without interference so that systems such as the GPS can function properly.[147]

The Directive is applied to 'equipment', which 'means any apparatus or fixed installation'.[148] Apparatus, in turn, 'means any finished appliance or combination thereof made available on the market as a single functional unit, intended for the end-user and liable to generate electromagnetic disturbance, or the performance of which is liable to be affected by such disturbance', whereas fixed installation 'means a particular combination of several types of apparatus and, where applicable, other devices, which are assembled, installed and intended to be used permanently at a predefined location'.[149] In other words, the Directive applies to 'a vast range of equipment encompassing electrical and electronic appliances, systems and installations'.[150] If the product 'does not contain electrical and/or electronic parts', it is not covered by the Directive.[151] Additionally, radio equipment, aeronautical products, inherently benign products, custom built evaluation kits, and equipment specifically covered by other legislation are excluded by the Directive.[152]

Equipment specifically covered by other legislation and thus not under the purview of the Electromagnetic Compatibility Directive include vehicles for road use, agricultural and forestry tractors, and vehicles with two or three wheels.[153] As a result, robots for infrastructure inspection and maintenance may or may not be covered by the Electromagnetic Compatibility Directive depending on how they are designed, and this must be determined on a case-by-case basis.

Member States are required to ensure that any equipment 'made available on the market and/or put into service' complies with the Directive.[154] Similarly, Member States cannot restrict the movement of equipment that do comply.[155] To comply with the Directive, the equipment must meet the following requirements set out in Annex I:

> Equipment shall be so designed and manufactured, having regard to the state of the art, as to ensure that:
>
> (a) the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended;
> (b) it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use.[156]

Additionally, '[a] fixed installation shall be installed applying good engineering practices and respecting the information on the intended use of its components, with a view to meeting the essential requirements set out [above]'.[157]

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[147] Eduard Fosch-Villaronga, *Robots, Healthcare, and the Law: Regulating Automation in Personal Care* (Routledge 2019) 87.
[148] Electromagnetic Compatibility Directive Article 2(1); Article 3(1)(1).
[149] Electromagnetic Compatibility Directive Articles 3(1)(2)-3(1)(3);
[150] March 2018 Guide for the EMCD (Directive 2014/30/EU) 8.
[151] March 2018 Guide for the EMCD (Directive 2014/30/EU) 12-13.
[152] March 2018 Guide for the EMCD (Directive 2014/30/EU) 13-18.
[153] March 2018 Guide for the EMCD (Directive 2014/30/EU) 14-18.
[154] Electromagnetic Compatibility Directive Article 4.
[155] Electromagnetic Compatibility Directive Article 5(1).
[156] Electromagnetic Compatibility Directive Annex I (1).
[157] Electromagnetic Compatibility Directive Annex I (2).

The manufacturer is the party that must ensure that the equipment or apparatus meets the above requirements.[158] If the equipment is 'in conformity with harmonised standards or parts thereof the references of which have been published in the *Official Journal of the European Union*', then there is a presumption that it is in conformity with the Directive's requirements.[159] For apparatus, '[c]ompliance…with the essential requirements set out in Annex I shall be demonstrated by means of either of the following conformity assessment procedures:

(a) internal production control set out in Annex II;
(b) EU type examination that is followed by Conformity to type based on internal production control set out in Annex III.[160]

Annex II requires the manufacturer to 'perform an electromagnetic compatibility assessment of the apparatus', which 'shall take into account all normal intended operating conditions'.[161] The manufacture must prepare technical documentation that 'make[s] it possible to assess the apparatus conformity to the relevant requirements, and shall include an adequate analysis and assessment of the risk(s)'.[162] During the manufacturing process, the manufacturer must take into account the technical documentation and ensure the essential requirements are met.[163] Finally, after meeting all of the above requirements, the manufacturer must affix a CE marking to the apparatus and draft a declaration of conformity.[164]

Annex III is a two-step process and states the following:

> 1. EU-type examination is the part of a conformity assessment procedure in which a notified body examines the technical design of an apparatus and verifies and attests that the technical design of the apparatus meets the essential requirements set out in point 1 of Annex I.
> 2. EU-type examination shall be carried out by assessment of the adequacy of the technical design of the apparatus through examination of the technical documentation referred to in point 3, without examination of a specimen (design type). It may be restricted to some aspects of the essential requirements as specified by the manufacturer or his authorised representative.[165]

After the examination by the notified body, the manufacturer 'ensures and declares that the apparatus concerned are in conformity with the type described in the EU-type examination certificate and satisfy the requirements of this Directive that apply to them'.[166] It is obligated to monitor compliance throughout the manufacturing process and to affix the CE marking and draft the declaration of compliance.[167]

The Electromagnetic Compatibility Directive is not concerned with health and safety, but compliance with it is equally important to ensure that robots for infrastructure inspection and maintenance can be manufactured and used in the EU and operate as intended. However, as noted in this section,

[158] Electromagnetic Compatibility Directive Article 7(1).
[159] Electromagnetic Compatibility Directive Article 13.
[160] Electromagnetic Compatibility Directive Article 14.
[161] Electromagnetic Compatibility Directive Annex II (2).
[162] Electromagnetic Compatibility Directive Annex II (3).
[163] Electromagnetic Compatibility Directive Annex II (4).
[164] Electromagnetic Compatibility Directive Annex II (5).
[165] Electromagnetic Compatibility Directive Annex III Part A.
[166] Electromagnetic Compatibility Directive Annex III Part B(1).
[167] Electromagnetic Compatibility Directive Annex III Part B(2)-(3).

whether the specific robotics technology would be covered by this Directive is a question that depends on the design of the robot and whether other directives are applicable.

1.3 Civil Liability Regimes

1.3.1 General issues

Like any technology, robotics can fail, be operated poorly, or be improperly maintained, which could result in bodily injuries or damages to property. When such situations occur, there must be ways to remedy the situation and compensate the victims for their loss. In general, this is done through the civil tort liability or delict regimes. Fundamentally, tort law, as used in common law jurisdictions is a mechanism to compensate victims of wrongdoing and vindicate their rights.[168] Delict is the functional equivalent in civil law countries.[169] While tort law developed haphazardly through the development of case law, delict law is generally a coherent set of rules in each jurisdiction that is 'the result of a long and characteristic process of generalization, systematization and abstraction'.[170] Unlike criminal law where a convicted defendant may be punished through imprisonment or criminal fines, compensation through monetary damages is the central principle in tort and delict law.[171] It can also be differentiated from contract law where, in general, there needs to be some type of prior contractual relationship between the parties and the aim is to 'protect specific expectations engendered by a binding promise'.[172] Damages, or compensation in contract law 'put the claimant in the position he would have been in had the contract been performed, whereas damages in torts put him in the position he would have been in had the tort not been committed'.[173]

- *Choice of Law and Jurisdiction*

Member States have different tort and delict laws, and where the litigation occurs and which law is applicable depends on the specific situation, such as where the robot causing the incident was used or where the manufacturer or supplier of the robotics technology conducts business. The Convention of 30 June 2005 on Choice of Court Agreements (Hague Convention) and Brussels Regulation (recast) govern jurisdiction. They are both for international civil cases, but if both parties are EU Member States, then the latter would apply.[174] Article 4(1) of the latter states 'persons domiciled in a Member State shall, whatever their nationality, be sued in the courts of that Member State'.[175] Companies are

[168] Michael A Jones, Anthony M Dugdale and Mark Simpson, *Clerk & Lindsell on Torts* (22nd edn 2017) para 1.11-1.12.
[169] Reinhard Zimmermann, *The Law of Obligations: Roman Foundations of the Civilian Tradition* (OUP 1996) 907.
[170] Reinhard Zimmermann, *The Law of Obligations: Roman Foundations of the Civilian Tradition* (OUP 1996) 907.
[171] W Edwin Peel and James Goudkamp, *Winfield & Jolowicz on Tort* (19th edn 2014) para 1-015.
[172] Reinhard Zimmermann, *The Law of Obligations: Roman Foundations of the Civilian Tradition* (OUP 1996) 904.
[173] W Edwin Peel and James Goudkamp, *Winfield & Jolowicz on Tort* (19th edn 2014) para 1-007.
[174] Convention of 30 June 2005 on Choice of Court Agreements Article 26.
[175] REGULATION (EU) No 1215/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2012 on jurisdiction and the recognition and enforcement of judgments in civil and commercial matters (recast) <eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:351:0001:0032:en:PDF> article 4(1); See also Thomas K Graziano, 'Cross-border traffic accidents in the EU – the potential impact of driverless cars' a June 2016 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee, 8.

'domiciled at the place where it has its: (a) statutory seat; (b) central administration; or (c) principal place of business'.[176] The defendant can also be sued 'in the courts for the place where the harmful event occurred or may occur' for tort actions.[177] For example, a land-based robot controlled by a company registered in Spain and does the bulk of its business in Slovakia crashes into an Estonian family driving their car in Lithuania. According to the rules, the family can sue in the courts of Spain or Slovakia because either could possibly be the company's domicile, or the family can sue Lithuania because that is where the crash happened. Based on the above, one may assume the family cannot sue in an Estonian court. However, the family would be able to sue in Estonia in this case because for claims against the defendant's car liability insurer, the injured party also has the further option to bring a claim before the courts of his or her own domicile, pursuant to articles 13(2) and 11(1)(b) of the Brussels I Regulation (recast).[178] This is an important reminder that the jurisdictional rules introduced above have many exceptions and legal advice should be sought if robot manufacturers or operators find themselves to be in situations where there may be legal disputes.

As for the applicable law, the Rome II Regulation would govern. The general rule is that for tort actions, the applicable law 'shall be the law of the country in which the damage occurs irrespective of the country in which the event giving rise to the damage occurred and irrespective of the country or countries in which the indirect consequences of that event occur'.[179] This means that the law of the Member State in which the direct damage such as injury or death occurred would be used, and not the law where indirect damages such as financial losses to relatives.[180] On this point, it has been outlined that in the context of a road traffic accident:

> If a traffic accident victim brings a claim against the driver, keeper, or owner of a vehicle involved in causing the damage, jurisdiction in the courts in Europe is to be determined by the Brussels I Regulation (recast). A claim may, in principle, either be brought under art 4(1) of the Brussels I Regulation (recast), before the courts of the State of the defendant's domicile, or under art 7(2) of the Brussels I Regulation (recast) before the courts of the place where the accident occurred.[181]

However, if both parties 'have their habitual residence in the same country at the time when the damage occurs, the law of that country shall apply'.[182] This would be the case even if there were no prior relationships.[183] There is a third alternative, which is the law of a state that is 'manifestly more

[176] REGULATION (EU) No 1215/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2012 on jurisdiction and the recognition and enforcement of judgments in civil and commercial matters (recast) Article 63.

[177] REGULATION (EU) No 1215/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2012 on jurisdiction and the recognition and enforcement of judgments in civil and commercial matters (recast) Article 7(2).

[178] REGULATION (EU) No 1215/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2012 on jurisdiction and the recognition and enforcement of judgments in civil and commercial matters (recast) Articles 13(2) and 11(1)(b).

[179] REGULATION (EC) No 864/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 July 2007 on the law applicable to non-contractual obligations (Rome II) Article <eur lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:199:0040:0049:EN:PDF> 4(1).

[180] Lawrence Collins et al, *Dicey, Morris & Collins on the Conflict of Laws* (15th edn Sweet & Maxwell 2012) para 35-024.

[181] Thomas K Graziano, 'Cross-border traffic accidents in the EU – the potential impact of driverless cars' a June 2016 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee, 18.

[182] REGULATION (EC) No 864/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 July 2007 on the law applicable to non-contractual obligations (Rome II) Article 4(2).

[183] Lawrence Collins et al, *Dicey, Morris & Collins on the Conflict of Laws* (15th edn Sweet & Maxwell 2012) para 35-031.

closely connected' to the situation.[184] The law of this state would apply in such a circumstance.[185] This is determined by any pre-existing relationships, including a contractual one, between the parties that is closely connected to the tort action.[186] For example, an operator based in France entered into a contract with a manufacturer based in Poland to purchase an aerial drone for inspection purposes. The contract was signed in Greece, where the drone was delivered, and chose Greek law as the applicable law for any disputes arising from the contract. The drone malfunctions and crashes in Bulgaria, and the operator sues the manufacturer. Although the general rule would lead to Bulgarian law as the one the court would use in litigation, the fact that the contractual relationship was formed in Greece and the parties chose Greek law as the law for the contractual dispute means that the court is likely to find Greek law has the closest connection and choose it as the applicable law for the tort dispute.[187] It should be noted that these rules for determining the applicable apply regardless of whether the incident occurs on land, in the waters, or in the air.[188]

In addition, it is important to note that victims of a road traffic accident also have the option to bring an action against the insurer of the vehicle responsible for causing any damage directly. This allows an action to be brought 'in the courts for the place where the harmful event [that is the accident] occurred'.[189] In addition, that same victim may also bring that claim in the jurisdiction where they, themselves are domiciled.[190] This has been confirmed by the CJEU in the case *Odenbreit*.[191]However, it has been noted that:

> It is not yet established to which extent the laws of the EU Member States provide for direct action against the insurers of manufacturers. Therefore, the holding in the Odenbreit case and the rules in art 13(2), 11(1)(b) of the Brussels I Regulation (recast) cannot be applied in a general way to claims against manufacturer of defective products that caused a traffic accident or their liability insurers. Regarding a claim against manufacturers, the victims thus do not necessarily benefit from a further forum at their own domicile(s).[192]

This is particularly resonant in the context of robotic technology because, where a defect in that technology leads to damage, the routes to compensation available to a victim could potentially be reduced.

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184 REGULATION (EC) No 864/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 July 2007 on the law applicable to non-contractual obligations (Rome II) Article 4(3).

185 REGULATION (EC) No 864/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 July 2007 on the law applicable to non-contractual obligations (Rome II) Article 4(3).

186 REGULATION (EC) No 864/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 July 2007 on the law applicable to non-contractual obligations (Rome II) Article 4(3).

187 See Symeon C Symeonides, 'Rome II and Tort Conflicts: A Missed Opportunity' (2008) 56 American Journal of Comparative Law 173, 204.

188 Lawrence Collins et al, *Dicey, Morris & Collins on the Conflict of Laws* (15th edn Sweet & Maxwell 2012) paras 35-033, 35-034.

189 REGULATION (EU) No 1215/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2012 on jurisdiction and the recognition and enforcement of judgments in civil and commercial matters (recast) Article 11(1)(a).

190 REGULATION (EU) No 1215/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2012 on jurisdiction and the recognition and enforcement of judgments in civil and commercial matters (recast) Article 11(1)(b).

191 Case C-463/06 *FBTO Schadeverzekeringen NV v Jack Odenbreit* (Second Chamber) [2007] ECR-11321.

192 Thomas K Graziano, 'Cross-border traffic accidents in the EU – the potential impact of driverless cars' a June 2016 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee, 53.

- *Fault-based Liability*

While tort systems in Member States vary, they all have some type of fault-based liability regime.[193] To be liable, the defendant would have to have committed a wrong. In other words, it acted in a manner than is deemed insufficient under the circumstances and failed to meet its duty. Specifically in the present circumstance, the manufacturer or supplier would be responsible for the accident and resulting damage if it is shown that they did not meet some kind of objective standard in designing or manufacturing the robot, or the operator would be responsible if it did not meet the objective standard in operating the robot.[194] The focus in fault-based liability is the conduct of the tortfeasor, and 'the idea is that it is fair that liability be imposed wherever the defendant has improperly prioritized his or her interests over the claimant's'.[195] The technological advancement of robotics technology means that the responsible tortfeasor may be harder to determine, as, for example, 'the designer might not be the one training the AI in ways that caused it to subsequently do harm'.[196] In the context of new technologies, it is suggested that for operators, the duty of care would include the duty of 'choosing the right system for the right task and skills', the duty of 'monitoring the system, and the duty 'maintaining the system'.[197] Producers would have the duty to 'design, describe and market products in a way effectively enabling operators to comply with the [aforementioned] duties' and the duty to 'adequately monitor the product after putting it into circulation'.[198]

Being able to show the producer or operator's fault may also be burdensome. Typically, the burden of proving fault is on the plaintiff.[199] However, showing that the duty of care was breached may be difficult in the context of new technologies, so it has been suggested that this burden 'should be reversed if disproportionate difficulties and costs of establishing the relevant standard of care and of proving their violation justify it'.[200] Among the factors that various jurisdictions have recognised to support the shifting of the burden of proof to the defendant are:

a) high likelihood of fault,

b) the parties' practical ability to prove fault,

c) violation of statutory obligation by the defendant,

d) particular dangerousness of the defendant's activity that resulted in damage,

[193] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 64-68.
[194] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 65.
[195] Peter Cane and James Goudkamp, *Atiyah's Accidents, Compensation and the Law* (9th edn CUP 2018) 453.
[196] Mark A Lemley and Bryan Casey, 'Remedies for Robots' (2019) 86 U Chi L Rev 1311, 1378-79.
[197] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 44.
[198] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 44.
[199] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 53.
[200] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 52.

e) nature and scope of the damage.[201]

These factors would have to be considered to determine whether the burden of proof of fault should be shifted in the context of new technologies.

In general, one of the advantages of fault-based liability is its flexibility, as '[t]he level of duty can expand and shrink according to context'. [202]Technological advances and different usages of robots could theoretically be accommodated by existing law. However, with increasing developments in robotics technology, they can become very complex and perform actions that are unforeseeable, especially when different systems are interacting.[203] This could especially be the case if artificial intelligence is writing the algorithms that control the robots.[204] If this does become reality, existing fault-based liability laws may be unable to account for damages caused by such systems due to the importance of foreseeability of the damage as an important element.[205] Foreseeability is the notion that the damage must have been something the reasonable person would not have disregarded as far-fetched.[206] For example, it would be foreseeable for a malfunctioning aerial robot performing inspection near a bridge to cause damages to cars driving on the bridge. However, the foreseeability of the same drone learning how to communicate in a manner it was not designed due to self-learning interacting with a submersible owned by another company that appeared suddenly, resulting in the drone being led into open waters 20 nautical miles away and damaging a cruise ship is more questionable. It may be possible for courts to view the damage as too remote to hold the drone operator liable.

The complexity of the system could also possibly make determination of causation more difficult.[207] Causation is important to show liability because it means the actions of the defendant are responsible for the damage. Without causation, the victim cannot show that it was the defendant's actions or inactions that led to the injury.[208] If a robot malfunctions, the complexity of the system may mean that it could be difficult to determine whether the injury was caused by the software programming by one party, the hardware design of another company, or the coding error that led to the hardware malfunction.[209] Furthermore, the injury could be caused by faulty data or robot's self-

[201] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 54.
[202] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 52.
[203] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 54.
[204] Woodrow Barfield, 'Liability for Autonomous and Artificially Intelligent Robots' (2018) 9 Paladyn, Journal of Behavioral Robotics 193, 199.
[205] Woodrow Barfield, 'Towards a Law of Artificial Intelligence' in Woodrow Barfield and Ugo Pagallo (eds) Research Handbook on the Law of Artificial Intelligence (Edward Elgar 2018) 4.
[206] *Wagon Mound (No. 2)* [1967] AC 617.
[207] Chris Holder, Vikram Khurana, Faye Harrison and Louisa Jacobs, 'Robotics and Law: Key Legal and Regulatory Implications of the Robotics Age (Part I of II)' (2016) 32 Computer Law & Security Review 383, 386.
[208] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 20.
[209] See Jos Lehmann, Joost Breuker and Bob Brouwer, 'Causation in AI and Law' (2004) Artificial Intelligence and Law 279, 280-86. For a suggestion on linking the robot to its creators, see Frank Pasquale, 'Toward a Fourth Law of Robotics: Preserving Attribution, Responsibility, and Explainability in an Algorithmic Society' (2017) 78 Ohio St LJ 1243, 1252-54.

learning and changing its own code.[210] In addition, the software running the robots may be updated periodically, and these updates may not necessarily be done by the original manufacturer.[211] This adds an additional party and possible cause of malfunction that complicates the determination of cause.[212]

The Expert Group on Liability and New Technologies – New Technologies Formation suggests that there should be a balancing test to determine when the bar of the burden of proving causation should be lowered.[213] The factors to consider are:

(a) The likelihood that the technology at least contributed to the harm;

(b) The likelihood that the harm was caused either by the technology or by some

other cause within the same sphere;

(c) The risk of a known defect within the technology, even though its actual causal impact is not self-evident;

(d) The degree of ex-post traceability and intelligibility of processes within the technology that may have contributed to the cause (informational asymmetry);

(e) The degree of ex-post accessibility and comprehensibility of data collected and generated by the technology

(f) The kind and degree of harm potentially and actually caused.[214]

The general rationale for the shifting of the burden of proof is that victims may be in a weaker position to satisfy the burden of proof given the complexity of the technology. [215]

While the law recognises multiple causes, the possibility of multiple causes arising from complicated systems could still lead to protracted litigation and delayed compensation for the claimant. This increasingly loss of control of the machine by the human due to robots making autonomous decisions and having the capacity for autonomous learning results in a 'responsibility gap' where humans can longer be ascribed the liability.[216] If the human operators are not liable, then it leads to the problem of the injured party not being able to receive compensation.[217] Not only could there be a legal vacuum, this gap may also affect the society's moral sense of justice as it appears that no

[210] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 20-21.
[211] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 21.
[212] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 21.
[213] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 49.
[214] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 49-50.
[215] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 50.
[216] Andreas Matthias, 'The Responsibility Gap: Ascribing Responsibility for the Actions of Learning Automata' (2004) 6 Ethics and Information Technology 175, 176-77.
[217] See generally Susanne Beck, 'The Problem of Ascribing Legal Responsibility in the Case of Robotics' (2016) 31 AI & Society 473, 474-77.

humans could be morally culpable. While the robots may be blameworthy morally, they would not be legally liable under current liability regimes.[218]

- *Strict Liability*

Most Member States also have risk-based regimes applicable in certain situations where there is strict liability due to the inherent risk of the thing in question.[219] Instead of focusing on the fault of the party in fault-based regimes, risk is the key. The party that has the greater knowledge and control should bear the risk because it is in a better position to do so. Thus, many jurisdictions have strict liability regimes for wild animals.[220] Product liability law is also another area of strict liability.[221] In the context of robotics, the rationale for the development of strict liability regimes is that a robot operator should take on a greater risk because it is allowed to 'legally exercise a socially useful activity which otherwise (because of its statistically unavoidable risks) should have been forbidden'.[222] Here, 'the focus [is] on the condition of *the product itself*' and not 'the defendant's *conduct*'.[223] While the potential tortfeasor could have performed to a reasonable standard or far exceed it, the conduct is irrelevant if the product ends up being the cause of the harm. It does not matter that there was no fault because the system of strict liability is more interested in how the product itself performed and placing the culpability on the party that had the control over the design, manufacture, and distribution of the product.[224]

A strict liability regime, as it does not require a showing of fault, would usually be an easier path toward obtaining compensation.[225] However, 'often strict liabilities are coupled with liability caps or other restrictions in order to counterbalance the increased risk of liability of those benefiting from the technology' so the compensation received by the victim may be more limited.[226] It has been argued that relying on strict liability, however, may inhibit progress in robotics technology 'since the more the strict liability rules are effective, the less we can test our AI systems, the more such rules may hinder research and development in the field'.[227] On the other hand, it has been suggested, in the context of autonomous cars, that a predictable, strict liability regime 'may better spur innovation than a less predictable system that depends on a quixotic search for, and then assignment of, fault'.[228] As noted in the previous section, finding fault may be difficult in the context of robotics technology. A predictable liability regime that is based on the product and not the actions or

[218] Brent Daniel Mittelstadt et al, 'The Ethics of Algorithms: Mapping the Debate' (2016) 3 Big Data & Society 1, 11.
[219] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 67.
[220] Gerhard Wagner, 'Comparative Tort Law' in Mathias Reimann and Reinhard Zimmermann (eds) The Oxford Handbook of Comparative Law (2nd edn OUP 2019) 1029.
[221] Gerhard Wagner, 'Comparative Tort Law' in Mathias Reimann and Reinhard Zimmermann (eds) The Oxford Handbook of Comparative Law (2nd edn OUP 2019) 1032.
[222] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 67.
[223] Curtis EA Karnow, 'The Application of Traditional Tort Theory to Embodied Machine Intelligence' in Ryan Calo, A Michael Froomkin and Ian Kerr (eds) Robot Law (Edward Elgar 2016) 66.
[224] Taivo, Liivak and Janno Lahe, 'Delictual Liability for Damage Caused by Fully Autonomous Vehicles: The Estonian Perspective' (2018) 12 Masaryk U JL & Tech 49, 57-8.
[225] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 101.
[226] Expert Group on Liability and New Technologies – New Technologies Formation, Liability for Artificial Intelligence and Other Emerging Digital Technologies (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 26.
[227] Ugo Pagallo and Serena Quattrocolo, 'The Impact of AI on Criminal Law, and Its Twofold Procedures' in Woodrow Barfield and Ugo Pagallo (eds) Research Handbook on the Law of Artificial Intelligence (Edward Elgar 2018) 406.
[228] David C Vladeck, 'Machines Without Principals: Liability Rules and Artificial Intelligence' (2014) 89 Wash L Rev 117, 147.

inactions of the potential tortfeasor would take that element away and allow claimants to be compensated without having to address the problems of the foreseeability of the harm and what constitutes a reasonable person in the context of new technologies. According to the Expert Group on Liability and New Technologies, a strict liability regime would be most appropriate when the robots are 'operated in non-private environments and may typically cause significant harm'.[229] By contrast, 'merely stationary robots…employed in a confined environment, with a narrow range of people exposed to risk' would be better served with other regimes, such as a fault-based one.[230] To ensure civil justice for victims, both regime must continue to co-exist.[231] Whether a fault-based or strict liability regime provides better compensation for victims in a particular situation will depend on the specific context and technology, and victims should have the option of choosing the route that would lead to the most just outcome from their perspective.[232]

It is important to note that when discussing liability, it is the entity or person associated with the robot that would be liable for compensation, and not the robot itself, as the latter 'can never bear any legal responsibility until there is a degree of legal personality attributed to it and an acceptance of a legal position to perform legal actions with legal effect'.[233] One difficulty this raises is that it may be difficult to determine who or what is the entity or person behind the robot, as it could include, amongst others, the hardware manufacturer, software developer, and the operator.[234] For now, one way that could possibly be used to form the nexus between the robot and the entity or person is through the perspective of robot-as-tool, so the entity or person using or controlling the tool would ultimately be liable.[235] Since the robot is only a tool, it is the person or company that has control over and wielding the robot that would retain the ultimate responsibility.[236]

- *Legal personhood for robots*

The EU recognises the issue of possibly granting robots legal personality. In the *European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics*, the European Parliament called on the Commission to consider:

[229] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 39.
[230] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 40.
[231] [231] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 36.
[232] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 35-36.
[233] Robert van den Hoven van Genderen, 'Legal Personhood in the Age of Artificially Intelligent Robots' in Woodrow Barfield and Ugo Pagallo (eds) Research Handbook on the Law of Artificial Intelligence (Edward Elgar 2018) 245-46.
[234] Guido Noto La Diega, 'Machine Rules. Of Drones, Robots, and the Info-Capitalist Society' (2016) 2 Italian Law Journal 367, 396.
[235] Paulius Cerka, Jurgita Grigiene and Gintare Sirbikyt, 'Liability for Damages Caused by Artificial Intelligence' (2015) 31 Computer Law & Security Review 376, 385. *See also* Ugo Pagallo, *The Law of Robots: Crimes, Contracts, and Torts* (Springer 2013) 98-99.
[236] Mark A Chinen, 'The Co-Evolution of Autonomous Machines and Legal Responsibility' (2016) 20 Va JL & Tech 338, 360-61.

[C]reating a specific legal status for robots in the long run, so that at least the most sophisticated autonomous robots could be established as having the status of electronic persons responsible for making good any damage they may cause, and possibly applying electronic personality to cases where robots make autonomous decisions or otherwise interact with third parties independently.[237]

Though it urges the careful contemplation of this issue, the European Parliament warns that 'at the present stage the responsibility must lie with a human and not a robot'.[238] In its own report released in April 2018, *Artificial Intelligence for Europe*, the Commission did not include the issue of robotics legal personality.[239] The report *Liability for Artificial Intelligence and Other Emerging Digital Technologies* by the Expert Group on Liability and New Technologies – New Technologies Formation commissioned by the EU also concluded that granting legal personality to robots is unnecessary because liability can always be attributed to some natural or legal persons.[240] As a result, this is a question thus far limited to academia.[241]

Legal personhood for robots is the idea that robots should be considered persons in the eyes of the law.[242] In the context of artificial intelligence, Solum argues that the basic characteristic of personhood is 'intelligence'.[243] However, current law recognises companies as legal persons not for such philosophical or moral reasons.[244] A company is a 'collective body that is separate from the natural persons associated with it as owners, agents, and employees' and became to be treated as legal persons due to economic and pragmatic reasons, as this allowed shareholders to invest in companies while ensuring that the companies could be held legally liable for its actions.[245] If robots were granted legal personhood, they would be capable of being sued in court and be held liable for their actions.[246] Pagallo warns that whether robots should be granted legal personality and how they

[237] European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)) art 59(f).
[238] European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)).
[239] 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 Europe.
[240] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 38.
[241] See Ugo Pagallo, 'Apples, Oranges, Robots: Four Misunderstandings in Today's Debate on the Legal Status of AI Systems' (2018) 376 Philosophical Transactions Research Society A 1. Shawn Bayern et al have argued that artificial intelligence can already be treated as legal persons under current company law. See Shawn Bayern and et al, 'Company Law and Autonomous Systems: A Blueprint for Lawyers, Entrepreneurs, and Regulators' (2017) 9 Hastings Sci & Tech LJ 135; Shawn Bayern, 'The Implications of Modern Business-Entity Law for the Regulation of Autonomous Systems' (2015) 19 Stanford Technology Law Review 93.
[242] SM Solaiman, 'Legal Personality of Robots, Corporations, Idols and Chimpanzees: A Quest for Legitimacy' (2017) 25 Artificial Intelligence and Law 155, 157-61.
[243] Lawrence B Solum, 'Legal Personhood for Artificial Intelligences' (1992) 70 North Carolina Law Review 1231, 1235-40
[244] Gerhard Wagner, *Robot, Inc.: Personhood for Autonomous Systems?* (2019) 88 Fordham Law Review 591, 598.
[245] Gerhard Wagner, *Robot, Inc.: Personhood for Autonomous Systems?* (2019) 88 Fordham Law Review 591, 598; Alan Dignam and John Lowry, *Company Law* (10th edn OUP 2018) 16.
[246] Gerhard Wagner, *Robot, Inc.: Personhood for Autonomous Systems?* (2019) 88 Fordham Law Review 591, 592-93.

could be held accountable should be approached pragmatically in ways that would address the issue rather than be directed politics or dogma. [247]

If the artificial intelligence develops to the state where the robots can operate autonomously and is granted personhood to be held legally liable for its own actions, a challenging question that is raised would be how one can determine the reasonable robot standard, making the application of existing negligence law difficult.[248] Nonetheless, a 'reasonable computer' standard has been proposed which even humans would have to meet once it is shown that computers can make safer decisions than humans.[249] If the robot itself were to be found liable, it has been suggested that making robots the culpable party would limit compensation to the victims and 'diminish the preventive remedial effect of liability law'.[250] In any case, robots 'would need a source of capital in order to pay damages'.[251] Currently, when humans or companies are found liable under tort law, they would be mandated to financially compensate the injured party. The compensation would come from the tortfeasor's assets, such as money in bank accounts, real property, or future earnings. If robots were to be the liable party, they would also need to have some way to compensate the victim. Without a source of funds, a finding of liability on its own would not make the claimant whole. Consequently, to ensure that the goal of tort law would be met in the future if robots are granted personhood and can be found legally liable, this question would need to be addressed.

- *Autonomous vs semi-autonomous robots*

The question of legal personhood for robots is closely intertwined with the level of autonomy of the robot. Different types of robots may have different systems of taxonomy, but robots can generally be divided into four types based on the degree of autonomy: remotely operated, passive, semi-active, and active. Remotely operated and passive do not have any autonomy, whereas semi-active robots are semi-autonomous and active robots are autonomous.[252] Autonomous robots are fully independent, whereas semi-autonomous robots require some sort of human intervention such as pre-programming and prompting to perform certain tasks.[253] Theoretically, there is a stronger rationale to granting autonomous robots legal personhood as they could act and make decisions on their own, and if legal personhood were not granted, attributing liability could be difficult due to

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[247] Ugo Pagallo, 'Apples, Oranges, Robots: Four Misunderstandings in Today's Debate on the Legal Status of AI Systems' (2018) 376 Philosophical Transactions Research Society A 1, 10-15. For other possible ways to treat robots under existing law, see Roger Michalski, 'How to Sue a Robot' (2018) 2018 Utah L Rev 1021, 1052-63.
[248] Jacob Turner, *Robot Rules: Regulating Artificial Intelligence* (Palgrave MacMillan 2019) 88. On why robots cannot be granted legal personality, see Bartosz Brożek and Marek Jakubiec, 'On the Legal Responsibility of Autonomous Machines' (2017) 25 Artificial Intelligence and Law 293.
[249] Ryan Abbott, 'The Reasonable Computer: Disrupting the Paradigm of Tort Liability' (2018) 86 George Washington Law Review 1. For the suggestion of a reasonable algorithm standard, see Karni Chagal-Feferkorn, 'The Reasonable Algorithm' (2018) 2018 U Ill JL Tech & Pol'y 111. See also Ryan Calo, 'Artificial Intelligence Policy: A Primer and Roadmap;' (2018) 3 U Bologna L Rev 180, 200.
[250] Caroline Cauffman, 'Robo-liability: The European Union in Search of the Best Way to Deal with Liability for Damage Caused by Artificial Intelligence' (2018) 25 Maastricht Journal of European and Comparative Law 527, 531-32.
[251] Ioannis Revolidis and Alan Dahi, 'The Peculiar Case of the Mushroom Picking Robot: Extra-contractual Liability in Robotics' in Marcelo Corrales, Mark Fenwick and Nikolaus Forgó (eds) Robotics, AI and the Future of Law (Springer 2018) 74.
[252] GP Moustris et al, 'Evolution of Autonomous and Semi-autonomous Robotic Surgical Systems: A Review of the Literature' (2011) 7 International Journal of Medical Robotics and Computer Assisted Surgery 375, 376.
[253] Thomas Burri, 'The Politics of Robot Autonomy' (2016) 7 European Journal of Risk Regulation 341, 345; GP Moustris et al, 'Evolution of Autonomous and Semi-autonomous Robotic Surgical Systems: A Review of the Literature' (2011) 7 International Journal of Medical Robotics and Computer Assisted Surgery 375, 376.

questions of foreseeability and predictability of the robot's actions.[254] It would be easier to ascribe liability to the human associated with semi-autonomous robots due to the former's control. It must be stressed that this is not currently an issue because given the current state of the technology and the law, there are no robots with legal personhood and only legal or natural persons can be sued.[255]

➢ *Which regime for the future?*

The European Parliament has suggested that the Commission on Civil Law Rules on Robotics study whether the risk management or strict liability approach would be more suitable for the civil liability regime for robots. The former focuses 'on the person who is able, under certain circumstances, to minimise risks and deal with negative impacts' while the latter 'requires only proof that damage has occurred and the establishment of a causal link between the harmful functioning of the robot and the damage suffered by the injured party'.[256] When designing a liability system for new technologies, Wagner warns that 'the normative foundations on which a liability regime for new technologies may be built' needs to be revisited and the regime should 'maximize the net surplus for society by minimizing the costs associated with personal injury and property damage'.[257] These costs include those incurred by the victims who suffer monetary losses and need to pay litigation expenses to make themselves whole, those by potential manufacturers or operators who need to invest in precautionary measures to ensure the robots are of a high enough safety standard, and administrative costs borne by society.[258] This new liability regime for new technologies should have the goal of weighing the different costs and reaching a balance where those who are in the best position to reduce harms, whether it is the manufacturer of the robot, developer of the software, or another party, take measures to do so in a manner that is not as costly as potential measures by other parties and the harm that could be inflicted on the victims that the precautionary measures are designed to prevent.[259] If this balance were attained, the net social cost amongst the parties would be minimised and as a result 'net surplus for society' would be maximised.[260]

Overall, while existing tort laws can be used to make victims whole when losses occur, as technology advances further, it is generally believed that civil liability laws will need to be amended to ensure both just compensation for victims and fairness for humans who may not have any meaningful control over artificially intelligent, autonomous robots.[261] This is due to the fact that these new

[254] Matthew U Scherer, 'Regulating Artificial Intelligence Systems: Risks, Challenges, Competencies, and Strategies' (2016) 29 Harv J L & Tech 353, 363-66.
[255] For a discussion on the need to have specific regulations addressing semi-autonomous robots, see Tracy Hresko Pearl, 'Hands on the Wheel: A Call for Greater Regulation of Semi-Autonomous Cars' (2018) 93 Ind LJ 713.
[256] European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)).
[257] Gerhard Wagner, 'Robot Liability' (June 19, 2018) <http://dx.doi.org/10.2139/ssrn.3198764> 3.
[258] Gerhard Wagner, 'Robot Liability' (June 19, 2018) <http://dx.doi.org/10.2139/ssrn.3198764> 3.
[259] Gerhard Wagner, 'Robot Liability' (June 19, 2018) <http://dx.doi.org/10.2139/ssrn.3198764> 4.
[260] Gerhard Wagner, 'Robot Liability' (June 19, 2018) <http://dx.doi.org/10.2139/ssrn.3198764> 4.
[261] Nathalie Nevejans, European Civil Law Rules in Robotics (2016) <www.europarl.europa.eu/RegData/etudes/STUD/2016/571379/IPOL_STU(2016)571379_EN.pdf> 6; Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 34-36.

technologies lead to ‘fundamental changes to our environments, some of which have an impact on liability law’.[262] These changes include:

(a) complexity,

(b) opacity,

(c) openness,

(d) autonomy,

(e) predictability,

(f) data-drivenness, and

(g) vulnerability

of emerging digital technologies.[263]

Complexity refers to the interaction of multiple parts to create the robot, the multiple parties involved, and ‘the internal complexity of the algorithms involved’.[264] Complexity leads to opacity, as the system becomes difficult to comprehend.[265] Openness refers to the design, as new technologies such as robots must be open to updates and interactions with data or other systems.[266] Autonomy is the lack of ‘human control or supervision’ and the robot’s ability to self-learn and make decisions.[267] Autonomy leads to unpredictability, as ‘the more [systems] are equipped with increasingly sophisticated AI, the more difficult it is to foresee the precise impact they will have once in operation’ as they no longer operate based on preprogrammed routines.[268] Data-drivenness refers to the robots ability to function being based on external input and communication with other systems, which could be a source of failure due to faulty or missing data, communication failure, or sensor errors.[269] Vulnerability in the robots is caused by its open design, as ‘granting access to [outside]

[262] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 5.

[263] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 5.

[264] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 32-33.

[265] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 33.

[266] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 33.

[267] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 33.

[268] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 33.

[269] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 33.

input make these technologies particularly vulnerable to cybersecurity breaches'.[270] All of these factors could make existing liability regime less effective and lead to adjustments to better compensate victims.

However, some disagree that changes to the liability regimes must be made. Cauffman questions 'whether the fact that a robot can take autonomous decisions really makes it impossible to identify a party who can be held liable under the existing rules of civil liability' and argues that 'it seems that most generally accepted principles and rules should remain applicable, even in the case of damage caused by robots'.[271] Hubbard notes that the 'legal schemes for regulating the development and use of robots and for allocating the costs of injuries from robots have successfully balanced innovation and safety in a fair, efficient manner for decades' and can continue to function as is going forward.[272] Regardless of which approach is taken, it is essential that there are concrete rules that both victims and manufacturers and operators can refer to, as legal certainty is important for technological progress and societal acceptance.[273]

The rest of this section introduces the different approaches to tort and delict law in the Member States, as each jurisdiction has its own tort or delict laws.[274] At the risk of overly generalising, the difference between the delict law of the Continental law system, as exemplified by the French Civil code, and the tort law of the common law systems of the United Kingdom and the Republic of Ireland is the difference 'between the unitary law of delict and the pluralistic, fact-driven wrongs of the law of torts'.[275] The act of classifying legal systems into different legal families has been criticized for being Eurocentric, narrowly focused on particular types of law, and not being dynamic.[276] This report acknowledges the shortcomings of such groupings but also recognises that this approach is necessary given the format of the report.

The liability regimes are divided by major legal families as classified by Zweigert and Kötz whose criteria included historical development and sources of law to develop a taxonomic system that has gained widespread acceptance.[277] The various legal approaches to civil liability are discussed. Characteristics in each legal approach are also briefly discussed from a practical perspective showing how they would affect manufacturers, suppliers, or operators of robots, especially in the realm of infrastructure inspection and maintenance. The issue of causation is then discussed in further detail due its influence on different jurisdictions. Finally, insurance is examined.

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270 Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 33-34.

271 Caroline Cauffman, 'Robo-liability: The European Union in Search of the Best Way to Deal with Liability for Damage Caused by Artificial Intelligence' (2018) 25 Maastricht Journal of European and Comparative Law 527, 529.

272 F Patrick Hubbard, 'Sophisticated Robots: Balancing Liability, Regulation, and Innovation' (2014) 66 Florida Law Review 1803, 1872.

273 Sebastian Lohsse, Reiner Schulze and Dirk Staudenmayer, 'Liability for Artificial Intelligence' in Sebastian Lohsse et al (eds) Liability for Artificial Intelligence and the Internet of Things: Münster Colloquia on EU Law and the Digital Economy IV (Nomos Verlagsgesellschaft 2019) 14.

274 Michael P Musielewicz, Who Should You Sue When No-One Is Behind the Wheel? Difficulties in Establishing New Norms for Autonomous Vehicles in the European Union' in Maria Isabel Aldinhas Ferreira et al (eds) Robotics and Well-Being (Springer 2019) 70.

275 Gerhard Wagner, 'Comparative Tort Law' in Mathias Reimann and Reinhard Zimmermann (eds) The Oxford Handbook of Comparative Law (2nd edn OUP 2019) 998.

276 Jaakko Husa, 'The Future of Legal Families' in Oxford Handbooks Online 5-6. *See also* PG Monateri, 'Everybody's Talking: The Future of Comparative Law' (1998) 21 Hastings International and Comparative Law Review 825.

277 Konrad Zweigert and Hein Kötz, *An Introduction to Comparative Law* (3rd edn OUP 1998) 67-73. *See also* H Patrick Glenn, 'Comparative Legal Families and Comparative Legal Traditions' in Mathias Reimann and Reinhard Zimmermann (eds) The Oxford Handbook of Comparative Law (2nd edn OUP 2019) 998.

Legal Approach	Member States examined in report
Common Law	United Kingdom, Ireland
French	France, Belgium, Italy, Portugal, Spain
German	Germany, Austria
Central European	Czech Republic, Hungary, Poland
Nordic	General overview

Table 1. Liability regimes in EU Member States

1.3.2 Common Law Approach

- **United Kingdom**

- *Negligence*

In the United Kingdom, victims of robotics technology could sue for negligence against the manufacturer, designer, others in the supply chain, or the operator for their wrongdoing. For example, the designer could have failed to consider the types of materials maintenance robots need to carry, making them unable to hold certain toxic materials safely and damaging the bridge they were fixing. The manufacturer could have used the wrong materials for the external sensors, making them fail in inclement weather and causing accidents. Or the operator could have been untrained in operating the robots in the rain, leading to injuries of bystanders. All of these situations could lead to civil litigation. The modern tort law in England resulted from the 1932 case *Donoghue v Stevenson*, which found negligence to be a distinct cause of action.[278] There are four elements to negligence: duty of care, breach of the duty by the defendant, causation between the breach and the damage, and proximity of the damage making it foreseeable.[279]

- *Elements of negligence*

Regarding duty, the question is whether it would be 'just and reasonable to impose a liability in negligence on a particular class of would-be defendants'.[280] For there to be duty, according to the *Caparo* test, the harm must be foreseeable, meaning there is proximity between the parties and determination that it is 'fair, just and reasonable' to impose liability.[281] The 'fair, just and reasonable' element is a policy test to reject the existence of duty when there are other important public policy concerns to protect the defendant from being unfairly exposed to liability.[282] Recently, however, the UK Supreme Court decided two cases that put the validity of this test in doubt.[283] Rejecting that *Caparo* set out the three-stage test, the Supreme Court found that it applied an incremental approach, which it endorsed:

[278] [1932] AC 562.
[279] Michael A Jones, Anthony M Dugdale and Mark Simpson, *Clerk & Lindsell on Torts* (22nd edn 2017) para 8-04.
[280] *Barrett v Enfield LBC* [2001] 2 AC 550 at 559.
[281] *Caparo Industries plc v Dickman* [1990] 2 AC 605.
[282] *Marc Rich & Co AG v Bishop Rock Marine Co Ltd (The Nicholas H)* [1996] AC 211.
[283] *Steel v NRAM Limited* [2018] UKSC 13; *Robinson v Chief Constable of West Yorkshire Police* [2018] UKSC 4.

> In cases where the question whether a duty of care arises has not previously been decided, the courts will consider the closest analogies in the existing law, with a view to maintaining the coherence of the law and the avoidance of inappropriate distinctions. They will also weigh up the reasons for and against imposing liability, in order to decide whether the existence of a duty of care would be just and reasonable.[284]

There must be a breach of this duty, meaning the defendant did not act in a way that a reasonable person in the situation would.[285] The reasonable person is knowledgeable of the general practice of the field and is expected to keep abreast of development.[286] In the context of new technologies, due to the rapid pace of advances, manufacturers and operators need to keep track of technological progress and ensure their actions would meet the standard practice.

In the context of robotics technology, this means that the manufacturer or supplier must act with the standard of care of a reasonable person in that situation to the operator, and the manufacturer, supplier, or operator must act with the standard of care of a reasonable person to the victim.[287] Because the situation may be novel, courts may use analogies in the existing law to determine the standard of care, such as vehicles, computers, or other technologies.[288] Courts may also choose to look at soft law standards such as the ISO or IEEE standards to determine the appropriate standards of care. The industry best practices thus gain legal, binding effect through incorporation as an element of negligence.[289]

The initial factual test for the element of causation is the 'but for' test: 'would the damage of which the claimant complains have occurred "but for" the negligence (or other wrongdoing) of the defendant?'[290] If the damage would have happened anyway, the test fails.[291] It should be noted that this is just the general rule, as, for example, it may be possible for multiple causes or tortfeasors to exist.[292] The robot manufacturer's negligence in the manufacturing process and the operator's negligence in using the robot could both be causes if both were required for the loss to occur. Furthermore, the test is 'sometimes relaxed to enable a claimant to overcome the causation hurdle when it might otherwise seem unjust to require the claimant to prove the impossible'.[293]

Proximate cause must also be shown. In order for there to be proximate cause, the act and the damage cannot be too remote.[294] In other words, it must be foreseeable, and the causal link is not

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[284] *Robinson v Chief Constable of West Yorkshire Police* [2018] UKSC 4 at [29].

[285] W Edwin Peel and James Goudkamp, *Winfield & Jolowicz on Tort* (19th edn 2014) para 6-008.

[286] *Stokes v GKN* [1968] 1 WLR 1776 at 1783; *Thompson v Smiths Shiprepairers (North Shields) Ltd* [1984] QB 405.

[287] See *Stokes v GKN* [1968] 1 WLR 1776 at 1783; *Thompson v Smiths Shiprepairers (North Shields) Ltd* [1984] QB 405.

[288] See *Robinson v Chief Constable of West Yorkshire Police* [2018] UKSC 4 at [29].

[289] Stephan Kirste, 'Concept and Validity of Law' in Pauline Westerman et al (eds) Legal Validity and Soft Law (Springer 2018) 50; See also Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 144.

[290] Michael A Jones, Anthony M Dugdale and Mark Simpson, *Clerk & Lindsell on Torts* (22nd edn 2017) para 2-09.

[291] *Barnett v Chelsea and Kensington Hospital Management Committee*, [1969] 1 Q.B. 428.

[292] *Willsher v Essex Area Health Authority* [1988] 1 AC 1074; *Fitzgerald v Lane* [1989] 1 AC 328; *Baker v Willoughby* [1970] AC 467. For other situations in which the 'but-for' test would not be applicable, *see* Simon Deakin and Zoe Adams, Markesinis & Deakin's Tort Law (8th edn OUP, 2019) 207-225.

[293] Michael A Jones, Anthony M Dugdale and Mark Simpson, *Clerk & Lindsell on Torts* (22nd edn 2017) para 2-97.

[294] *Rahman v Arearose Ltd* [2001] Q.B. 351 at [32]–[33].

broken by an intervening event.[295] This is essentially a policy judgment based on the common sense of the judge.[296]. Causation may be shown through inference in a negligence product liability case. In *Grant v Australian Knitting Mills Ltd*, the Privy Council found that '[n]egligence is found as a matter of inference from the existence of the defects taken in connection with all the known circumstances.[297] For robotics, causation may be difficult to ascertain due to the multiple parties involved in designing, building, and operating the robots.[298] Furthermore, machine learning or self-learning robots may perform actions unpredictable to the human based on the programming input, leading to difficulty in determining the cause of the action or harm.[299] This is sometimes known as the 'black box' where machine learning algorithms are unknown to the humans involved, and the resulting outputs could lead to unintended effects.[300]

Finally, foreseeability of the damage must be shown. The question is 'whether the damage is of such a kind as the reasonable man should have foreseen'.[301] Applied to the robotics context, if a robot manufactured for the purpose of maintenance and inspection is used by the operator for the purpose of transporting passengers and there is an accident, the loss may not be seen as foreseeable by the manufacturer and may not be held liable for the damage. In addition, the same 'black box' algorithm problem may make foreseeability of the damage an issue.

❖ *Liability for land robots*

Unlike many other Member States, as will be seen later, motor accidents in England are addressed through the traditional negligence regime rather than a strict liability regime. This is because the common law is 'very cautious and allows strict liability claims in only a very limited number of cases', such as cases with dangerous animals.[302] For operators of robots for infrastructure inspection and maintenance that operate on the roads, this means that to be found liable for an accident, the operator or robot would have had to fail to meet the duty of care and be shown to be at fault. While this may appear to be advantageous for operators of robots on roads as liability is predicated on fault, in practice the regime operates similarly to a strict liability basis due to the exacting standard of fault.[303]

➢ **Ireland**

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[295] Simon Deakin and Zoe Adams, *Markesinis & Deakin's Tort Law* (8th edn OUP, 2019) 203.
[296] *Cork v Kirby MacLean Ltd* [1952] 2 All ER 402 at 407.
[297] *Grant v Australian Knitting Mills Ltd* [1936] AC 85, 101 per Lord Wright.
[298] Curtis EA Karnow, 'Liability for Distributed Artificial Intelligences' (1996) 11 Berkeley Technology Law Journal 147, 182; Chris Holder, Vikram Khurana, Faye Harrison and Louisa Jacobs, 'Robotics and Law: Key Legal and Regulatory Implications of the Robotics Age (Part I of II)' (2016) 32 Computer Law & Security Review 383, 386.
[299] Yavar Bathaee, 'The Artificial Intelligence Black Box and the Failure of Intent and Causation' (2018) 31 Harvard Journal of Law & Technology 889, 923-25. For more on machine learning, see Harry Surden, 'Artificial Intelligence and Law: An Overview' (2019) 35 Ga St U L Rev 1305, 1311-16.
[300] See generally Frank Pasquale, *The Black Box Society: The Secret Algorithms That Control Money and Information* (Harvard University Press 2015). For the cumulative effect of harm that could be caused by algorithms, see Jack M Balkin, '2016 Sidley Austin Distinguished Lecture on Big Data Law and Policy: The Three Laws of Robotics in the Age of Big Data' (2017) 78 Ohio St LJ 1217, 1232-1240.
[301] Michael A Jones, Anthony M Dugdale and Mark Simpson, *Clerk & Lindsell on Torts* (22nd edn 2017) para 2-152.
[302] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 104.
[303] PS Atiyah, *The Damages Lottery* (Hart 1997) 32-8; *Carrier v Bonham* [2000] QDC 226 (Unreported, McGill DCJ, 4 August 2000) [73]; James Goudkamp, 'The Spurious Relationship between Moral Blameworthiness and Liability for Negligence' (2004) 28 Melbourne University Law Review 343, 358-62.

Irish law on negligence is similar to that in English law, where the elements of duty, breach, causation, and damages are required. In general, English case law is followed by the Irish courts.[304] In 2002, *Glencar Exploration plc and Andaman Resources plc v Mayo County Council* added a third element to the duty of care in addition to the proximity of the relationship and the absence of countervailing public policy considerations.[305] The Irish Supreme Court found that the threshold question of whether it is just and reasonable to impose a duty of care on the defendant needs to be overcome for a negligence cause of action.[306] Although the just and reasonable language may be similar to that of *Caparo*, this additional language was meant to 'transform the scope of the duty of care from one based on broad principle to one involving merely incremental progress from one case to another'.[307]

For a robot operator to successfully sue the robot manufacturer from which it purchased the robot in a tort action, it must show that there was a duty of care. The proximity element is likely to be met easily because there was a seller and buyer relationship. There should not be any countervailing public policy considerations since this is a straightforward relationship that does not touch upon public policy concerns. Finally, the court would have to ask whether it would be just and reasonable to impose a duty of care on the robot manufacturer, and the answer would be in the affirmative in this case. The substance of the duty of care would be the reasonable person standard, and if there is no case law on point, the court, similar to the English courts, may use existing case law on other technologies such as computers or cars to establish the standard of care. Also, soft law industry standards could also be used by the court to establish the standard in the absence of other guidance.

The other elements of negligence, breach, causation, and damage, are all similar to the jurisprudence in English law. In particular, both factual causation and proximate cause would have to be shown, and the same difficulties would arise due to the unpredictability of actions due to the complexity of new robotics technology.[308]

- *Complexity of robotic systems and liability*

In both jurisdictions, robotics technology that lead to injuries may lead to negligence actions, though if the loss is purely economic, which is financial loss that is unaccompanied by physical loss such as property damage or bodily injury, it is unlikely they would be successful. In such cases, actions in contract law may prove to be more useful. Because the robots themselves are not the defendant in liability cases, when applying existing law to losses caused by robots:

> [D]etermining the person liable for damage caused by a robot will be a difficult task due to the number of subjects involved in the creation, commercialisation and operation of robots. For instance a single robot may involve different people and organisations in the roles of developers of software (open source software for example will involve a range of authors), service and data providers that collect data and provide services through robots, suppliers, importers, designers, manufacturers, users and owners.[309]

[304] Walter Van Gerven, Pierre Larouche and Jeremy Lever, *Ius Commune Casebooks for the Common Law of Europe: Tort Law Casebooks for the Common Law of Europe* (Hart 2000) 5.
[305] *Anns v Merton London Borough* [1978] AC 728.
[306] [2002] 1 IR 84.
[307] William Binchy, 'Tort Law in Ireland: A Half-century Review' (2016) 56 Irish Jurist 199, 208.
[308] Matthew U Scherer, 'Regulating Artificial Intelligence Systems: Risks, Challenges, Competencies, and Strategies' (2016) 29 Harv J L & Tech 353, 363-66.
[309] Natalia Porto and Daniel Preiskel, 'United Kingdom Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 346-47.

For example, a submersible may have been designed by one company, manufactured by another, and operated by software that has been coded by multiple companies. Different companies supply the sensors and other parts of the robot. Another company advertises it, and yet another company is responsible for distributing it to the operator who uses it for infrastructure inspection and maintenance, which is another company. Any of these companies could be potentially liable if the submersible were to malfunction and cause damages. The interaction of the different systems could make determining the cause of the malfunction difficult to determine. The complexity of the systems may also make determining culpability difficult, especially when the technology is constantly changing. This may mean that the harm would not have been foreseeable by a reasonable person who was involved in bringing the robot into fruition. If the cause is undeterminable or the harm is unforeseeable, the claimant may be left without redress if none of the parties are found liable or may be forced to accept incomplete civil justice if the culpable party could not be determined due to the complexity of the system.

However, a laws are made by court decisions in common law systems and 'judges continue to adapt the common law to changes in commercial practice and social values', determining liability in such complicated novel situations should theoretically be easier in English and Irish law compared to the other Member States because laws will be made with actual fact patterns and would not need to undergo the often time-consuming legislative process.[310] For now, without legal certainty, any of the above parties may be part of the litigation, so entities that are associated with using robots for inspection and maintenance, even if they are not the manufacturer or operator, would have to understand their possible exposure to liability.

The common law is based on case law, so negligence law has been developed by the courts. The four elements of duty, breach, causation, and harm have remained the same in recent years, but the substance on how to determine those elements have been refined or changed by judges throughout the years. The development of new technologies means that the law may have to adjust to keep up with the advances, and while so far it appears to be able to do so, increasingly complex systems means that more fundamental and systematic review of existing law may need to take place to ensure that the elements of foreseeability and causation in common law negligence can still accommodate complex robotics systems.[311]

1.3.3 French Approach

- **France**
- *Fault-based liability*

Fault-based liability is the primary cause of action in tort. In general, the 'overall criterion is whether the tortfeasor has acted in a way that – objectively – differs from the required standard of care, regardless [of] whether he was aware of causing damage to others or not'.[312] This objective standard is that of the reasonable person 'integrated with reference to customs and to the specific duties of conduct laid down in statutory provisions'.[313] In general, the individual's deficiencies or lack of experience would not absolve one of liability except in the case of minors or those with mental

[310] Lord Hodge, The Scope of Judicial Law-making in the Common Law Tradition <www.supremecourt.uk/docs/speech-191028.pdf> para 40.
[311] Ryan Calo, 'Singularity: AI and the Law' (2018) 41 Seattle U L Rev 1123, 1131-32.
[312] Stefano Troiano, '«EC Tort Law» and the Romanic Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 399.
[313] Stefano Troiano, '«EC Tort Law» and the Romanic Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 399.

incapacity.[314] Significantly, these exemptions do not exist in France where 'children (even during early childhood) are not exempted from liability, regardless of their concrete ability of reason' and 'mentally handicapped adults are also liable for the full extent of the damage they cause to others'.[315] While this remains to be seen, the lack of exemptions in French law could possibly extend to robots in the future if robots are treated as legal personalities down the line. Robots that are designed to be less artificial intelligent or have less capacity for learning may be held to the standard of an average robot, leading to a widening of the scope of liability that may not be a problem in other jurisdictions.

France has a general tort clause as encompassed in article 1382 of the *Code civil*, which states: 'Any act whatever of man, which causes damage to another, obliges the one by whose *faute* it occurred, to compensate it' and article 1383 states: 'Everyone is liable for the damage he causes not only by his act, but also by his negligence or by his imprudence'.[316] To prove this claim, the claimant must show 'intention or negligence (*faute*), damage (*dommage*), and causation', and duty of care is unnecessary because 'any relationship can give rise to liability'.[317] Establishing *faute* can be done through showing a statutory rule was violated, breach of pre-existing standard such as that of a 'just or cautious man', non-intentional criminal *faute*, or abuse of one's rights.[318] This is the fault-based liability regime in France that applies to all types of torts and will cover potential damage caused by robots.

Because of the generality of the tort statute in France and the lack of need to show duty of care, it is theoretically more accommodating of new technologies. For example, an aerial drone inspecting a bridge malfunctions and collides with the bridge and subsequently lands on it, leading to a traffic jam that delays a previously injured person from reaching the hospital. The person dies. In other jurisdictions, there may not be a duty between the drone operator and the deceased person because the connection is remote and unforeseeable, but in France, because duty is not an element, it may be possible for the deceased's relatives to sustain a tort action against the operator as long as the other elements are met.

Article 1384 of the *Code civil* provides a strict liability regime for damages caused by 'things', which is defined very loosely and includes 'movable or immovable property, whether or not operated by the hand of man, and whether or not inherently dangerous'.[319] The code itself would undoubtedly apply to robots, but even if not, the French courts have taken a lax attitude in extending the scope of the strict liability regime.[320]

However, if the robot is considered a land motor vehicle or a product, this article would be inapplicable as the special liability regimes dealing with vehicles and products would take precedence respectively.[321] To prove liability under article 1384, it must also be shown that the robot

[314] Stefano Troiano, '«EC Tort Law» and the Romanic Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 400.
[315] Stefano Troiano, '«EC Tort Law» and the Romanic Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 400.
[316] Cees van Dam, *European Tort Law* (OUP 2013) 56; See also Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 143-144.
[317] Cees van Dam, *European Tort Law* (OUP 2013) 57.
[318] Cees van Dam, *European Tort Law* (OUP 2013) 57.
[319] Alain Bensoussan and Jérémy Bensoussan, 'France Chapter', in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 92; See also Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 140-143.
[320] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 104.
[321] Alain Bensoussan and Jérémy Bensoussan, 'France Chapter', in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 92.

played an active role in causing the damage.[322] If the robot were moving, this could be easily shown, but otherwise the circumstances would have to be examined such as the robot's location or behaviour.[323] Finally, the guardian, or the person who has custody of the robot, must be identified, as he or she would be the person liable for compensation.[324] The owner is presumed to be the guardian, but in circumstances where the damage was caused by security breaches to the robot, the manufacturer could also be the one to have custody.[325] It is also worth noting that there are obvious questions that would be asked should there be an attempt to draw an analogy in this context between robots and animals. This is relevant on the basis that article 1385 would extend responsibility for the acts of an animal to the owner.[326] However, it is important to note that under the article 515-14 of the French civil code, animals are considered to be sentient beings with feelings.[327] Clearly, robots do not share these characteristics.

- **Belgium**

Even though there have been recent Dutch, English, and American influences on the Belgian Civil Code, the Belgian fault-based liability regime is similar to that in France.[328] The regime is encompassed in Articles 1382 to 1386 of the Belgian Civil Code.[329] There is also a strict liability regime for damages caused by civil drones.[330] Robots that operate in the air could potentially be liable under this regime.

- **Italy**

Italian tort law is seen as being in between French and German law.[331] This can be seen from the general tort provision in Codice civile Article 2043, which is like that of the French law and the separation of fault from unlawfulness similar to German law.[332] Multiple provisions in the Codice civile may be applicable to robotics liability. Article 2050 'creates a form of objective liability for those who carry out dangerous activities (*responsabilità per esercizio di attività pericolose*), and

[322] Alain Bensoussan and Jérémy Bensoussan, 'France Chapter', in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 92.
[323] Alain Bensoussan and Jérémy Bensoussan, 'France Chapter', in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 92-93.
[324] Alain Bensoussan and Jérémy Bensoussan, 'France Chapter', in Alain Bensoussan, et al (eds) *Comparative Handbook: Robotic Technologies Law* (Éditions Larcier, 2016) 93.
[325] Alain Bensoussan and Jérémy Bensoussan, 'France Chapter', in Alain Bensoussan, et al (eds) *Comparative Handbook: Robotic Technologies Law* (Éditions Larcier, 2016) 93.
[326] See for example Maria A Cappelli, 'Regulation on Safety and Civil Liability of Intelligent Autonomous Robots: The Case of Smart Cars (PhD Thesis, University of Trento 2015) 150.
[327] See Maria A Cappelli, 'Regulation on Safety and Civil Liability of Intelligent Autonomous Robots: The Case of Smart Cars (PhD Thesis, University of Trento 2015) 150; See also Jean-Marc Neumann, 'The Legal Status of Animals in the French Civil Code' (2015) 1 Global Journal of Animal Law 1, 12.
[328] Walter Van Gerven, Pierre Larouche and Jeremy Lever, *Ius Commune Casebooks for the Common Law of Europe: Tort Law Casebooks for the Common Law of Europe* (Hart 2000) 5-6.
[329] Jean-François, Henrotte Alexandre Cassart and Fanny Coton, 'Belgium Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 20; See also Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 143.
[330] Jean-François, Henrotte Alexandre Cassart and Fanny Coton, 'Belgium Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 20.
[331] Walter Van Gerven, Pierre Larouche and Jeremy Lever, *Ius Commune Casebooks for the Common Law of Europe: Tort Law Casebooks for the Common Law of Europe* (Hart 2000) 6; See also See also Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 143.
[332] Walter Van Gerven, Pierre Larouche and Jeremy Lever, *Ius Commune Casebooks for the Common Law of Europe: Tort Law Casebooks for the Common Law of Europe* (Hart 2000) 6.

Article 2049 'deals with the liability of the owner and of the commissioner for the damages'.[333] Article 2051 also creates a strict liability regime. The custodian, which could be the owner or a person with physical control, has the duty to 'adopt adequate precautions to avoid that the thing in custody does find itself in a situation in which it may cause damages to third parties'.[334] The custodian could avoid liability if he or she could show 'the damage was caused by an act of God'.[335] Furthermore, Articles 2048 and 2052 deal with 'liability for harms caused by an individual's children or animals'.[336] There is strict liability for the parent or owner unless actions were not preventable or 'a fortuitous intervening event occurred' respectively.[337] This could be seen as analogous to situations where robots caused the loss. Indeed, it has been suggested that the behaviour of a robot could, in some circumstances, be seen as analogous to that of an animal (likely a pet).[338] However, specific legislation would have to be passed because Italian courts would be unlikely to expand the scope of the strict liability regime.[339]

- **Portugal**

Though Portuguese law has traditionally been grouped with the French Romantic approach, the 1967 Código Civil was greatly influenced by German and Swiss law.340 Portuguese law has three types of regimes that could be applied to damages caused by robots, fault-based, presumption of fault, and strict liability.341 There is a presumption of fault if there is a 'duty to watch over hazardous movable things in one's control, which can be rebutted by a showing of lack of fault or that 'the damage would have occurred regardless of his/her actions'.342 Another situation in which there is a presumption of fault is where there is a duty to prevent danger from 'a dangerous activity', which is defined as 'one that involves a greater likelihood of causing harm than the remaining activities in general and where the danger is assessed beforehand'.343 Finally, there is strict liability for operating a land vehicle.344 Robots that operate on land would be subject to strict liability, whereas it is likely that other robots used for inspection and maintenance could be subject to the presumption of guilt as it may be possible to categorise them as hazardous movable things or dangerous activities. This would depend on how these activities are viewed if there is actual litigation. It may also be possible for robots to be further divided so that semi-autonomous robots may be treated differently from autonomous robots. As there would theoretically be more control over semi-autonomous robots, the activity in which it is engaged may be seen as less dangerous and therefore not subject to the presumption of fault. While this is mere speculation, the possibility that

[333] Guido Noto La Diega, 'Machine Rules. Of Drones, Robots, and the Info-Capitalist Society' (2016) 2 Italian Law Journal 367, 396.
[334] Rebecca Spitzmiller, *Selected Areas of Italian Tort Law: Cases and Materials in a Comparative Perspective* (Editrice il Sirente 2011) 38.
[335] Pericle Salvini et al, 'An Investigation on Legal Regulations for Robot Deployment in Urban Areas: A Focus on Italian Law' (2010) 24 Advanced Robotics 1901, 1912.
[336] Ugo Pagallo, *The Law of Robots: Crimes, Contracts, and Torts* (Springer 2013) 127.
[337] Ugo Pagallo, *The Law of Robots: Crimes, Contracts, and Torts* (Springer 2013) 127.
[338] See for example Maria A Cappelli, 'Regulation on Safety and Civil Liability of Intelligent Autonomous Robots: The Case of Smart Cars (PhD Thesis, University of Trento 2015) 149.
[339] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 104.
[340] Konrad Zweigert and Hein Kötz, *An Introduction to Comparative Law* (3rd edn OUP 1998) 108.
[341] João P Alves Pereira and Belén Granados, 'Portugal Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 264-65.
[342] João P Alves Pereira and Belén Granados, 'Portugal Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 264-65
[343] João P Alves Pereira and Belén Granados, 'Portugal Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 265.
[344] João P Alves Pereira and Belén Granados, 'Portugal Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 265.

robots of different degrees of autonomy could be treated differently by the law exists, and this is an issue that manufacturers, suppliers, and operators must contemplate.

- **Spain**

In Spain, fault-based liability is encompassed in article 1902 of the Civil Code, which states that 'the person who by action or omission causes damage to another by fault or negligence is obliged to repair the damage caused'.[345] The elements that need to be shown by the claimant are '(i) an unlawful act or omission, (ii) fault, (iii) the occurrence of damage, and (iv) the existence of a causal link between the act or omission and damage.'[346] There may also be a cause of action for latent defect per article 1484. Under this provision, 'the seller is bound to remedy hidden defects of the thing sold which render it unfit for the use for which it was intended, or which so impair that use that the buyer would not have acquired it'.[347]

For example, a submersible operating near coastal waters malfunctions due to the operator's error and starts heading toward the beach where there is a crowd of people. Due to the diligence of the lifeguards, people were warned and ran toward land, resulting in no contact between the submersible and anybody. Nonetheless, some of the sunbathers contemplated suing because their vacations were interrupted. Although there is probably fault due to human error, the lack of any damage sustained by the beachgoers means that there would not be a viable delict action.

1.3.4 German Approach

- *Fault-based liability*

In Germany, tort liability (*unerlaubte Handlungen*) is codified in § 823 ff. The codification is supplemented by a 'patchwork' of case law.[348] Germany takes an intermediate approach to tort law between the very general rules of the French Civil Code and the specificity of English jurisprudence on torts.[349] As a result, 'an intermediate approach was chosen by designing three general rules with a restricted scope of application', though in practice 'German tort law now mainly operates on the basis of a general fault rule'.[350]

To show fault-based liability, the claimant must show that a codified normative rule (*Tatbestandswidrigkeit*) was breached, which shows the conduct is unlawful.[351] This can be shown 'by infringing another person's protected right (§ 823 I), by violating a statutory rule (§ 823 II), or by intentionally inflicting damage contra bonos mores (§ 826)'.[352] This objective test of unlawfulness (Rechtswidrigkeit) is separate from fault, or the tortfeasor's attitude[353]. The third element is fault

[345] Spain Civil Code article 1902.
[346] Miquel Martín-Casals, 'Product Liability in Spain' in Piotr Machnikowski (ed) European Product Liability: An Analysis of the State of the Art in the Era of New Technologies (Intersentia 2016) 410-11.
[347] Marc Gallardo, 'Spain Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 310-11.
[348] Cees van Dam, *European Tort Law* (OUP 2013) 75; See also Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 144-145.
[349] Cees van Dam, *European Tort Law* (OUP 2013) 78-9.
[350] Cees van Dam, *European Tort Law* (OUP 2013) 79.
[351] Cees van Dam, *European Tort Law* (OUP 2013) 79.
[352] Cees van Dam, *European Tort Law* (OUP 2013) 80.
[353] Basil S Markesinis and Hannes Unberath, *The German Law of Torts: A Comparative Treatise* (4th edn Bloomsbury 2002) 79.

(*Verschulden*), which is 'fulfilled if the wrongdoer acted intentionally or negligently'.[354] An act is negligent if it is 'contrary to the care required by society'.[355] Causation is also required, which is 'a two-phased inquiry, the first being preoccupied with the question [of] whether the defendant's conduct played some role in bringing about the plaintiff's hurt, while the second seeks to discover which of the main conditions of the harm will also be treated as its legal cause'.[356] These are roughly respectively equivalent to cause in fact and the policy-oriented proximate cause of common law negligence.[357]

A special type of fault-based liability in Germany is manufacturer liability (*Produzentenhaftung*) per Section 823 et BGB, which 'requires an intended or negligent behavior of manufacturer or his employees'.[358] The claimant must show that the manufacturer did not act with reasonable care.[359] It would be difficult to show intentional or negligent behaviour by the robot manufacturer because of the likely secrecy surrounding the process, particularly for new technologies.[360]

- *Strict liability*

There is no general strict liability law in Germany.[361] However, there are also special strict liability regimes for special circumstances, such as those for cars, trains, and aircraft. The rationale is that '[t]he inherent risk of owning a potentially dangerous vehicles is sufficient to justify such liability'.[362] While German courts have been active in interpreting the scope of these strict liability provisions, they have not expanded the ambit of these statutes to cover other situations analogously, so strict liability is still restricted to the activities prescribed by the legislative branch.[363] This means that even if the manufacturer, supplier, or operator exercised reasonable care, it could still be culpable for damages.[364] Robots that could be categorised as any of these could be subject to both the strict liability regime and the fault-based regime, depending on how the claimant would like to proceed. In practice, this may mean that producers and operators of robots for I&M that could be argued to not be one of these types of vehicles could be better protected than those that produce or operate cars, trains, or aircraft, as the former could escape liability if they exercise reasonable care. On the flip side, however, this suggests that the existing liability regime may not be suitable to compensate damages caused by robots, as it would often be difficult to show the lack of reasonable care, and with possible unknowns associated with new technologies, errors leading to harm could occur even

[354] Cees van Dam, *European Tort Law* (OUP 2013) 80.
[355] Cees van Dam, *European Tort Law* (OUP 2013) 80.
[356] Basil S Markesinis and Hannes Unberath, *The German Law of Torts: A Comparative Treatise* (4th edn Bloomsbury 2002) 103.
[357] Basil S Markesinis and Hannes Unberath, *The German Law of Torts: A Comparative Treatise* (4th edn Bloomsbury 2002) 103.
[358] Andreas Lober, Tim Caesar and Wojtek Ropel, 'Germany Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 132.
[359] Andreas Lober, Tim Caesar and Wojtek Ropel, 'Germany Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 132.
[360] Andreas Lober, Tim Caesar and Wojtek Ropel, 'Germany Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 132.
[361] Herbert Zech, 'Liability for Autonomous Systems: Tackling Specific Risks of Modern IT' in Sebastian Lohsse et al (eds) Liability for Artificial Intelligence and the Internet of Things: Münster Colloquia on EU Law and the Digital Economy IV (Nomos Verlagsgesellschaft 2019) 197.
[362] Andreas Lober, Tim Caesar and Wojtek Ropel, 'Germany Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 133.
[363] Basil S Markesinis and Hannes Unberath, *The German Law of Torts: A Comparative Treatise* (4th edn Bloomsbury 2002) 722-23.
[364] Andreas Lober, Tim Caesar and Wojtek Ropel, 'Germany Chapter' in Alain Bensoussan, et al (eds) Comparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 133.

if manufacturers or operators acted with reasonable care, resulting in victims not being offered redress through the liability system.[365]

- *Austrian practice of analogies*

While German law is strict on the scope of the applicability of the strict liability regime, courts in Austria have been willing to 'apply existing strict liability laws analogously' to other circumstances.[366] This could mean that even without legislative amendments, robots used in various contexts could be held to a higher standard of strict liability where the operator could be found liable without fault even though it would not have been a law in the books. Because of this possibility, operators may have to be more cautious in Austria, as courts could find various types of robots operating in different environments to be subject to strict liability when losses occur when the same situation would require fault for liability to be found in other Member States

- *Damages*

Compensation for pure economic losses is very limited under German law:

> Under German tort law, economic loss can be compensated under § 823(1) BGB only if it flows from an injury to one of the legally protected interests specified in that provision including infringements to any "other (absolute) right". If wilful or negligent conduct causes the victim economic damage unrelated to any absolute right ("reiner Vermögensschaden" – pure economic loss), no claim arises under the general rule of § 823(1) BGB.[367]

In fact, 'it could be argued that in no other area of its law of torts does German law demonstrate such an ideological affinity with the Common law as in its refusal to compensate pure economic loss through the medium of tort rules'.[368] The limitation for pure economic losses in Austrian law is similar.[369] Austrian law is unique in Europe for having a statutory definition of 'damage', which, according to 1293 General Austrian Civil Code is 'every detriment which was inflicted on someone's property, rights or persons'.[370]

If an autonomous vessel malfunctions and continues to circle around and blocks a key waterway for other ships, there may be no physical damage to the other ships, but these other ships may suffer economic losses due to being delayed. If the economic loss is due to losing business because the ship not able to reach another port to be hired out, then a tort action would unlikely to be sustained because the loss is purely economic.[371] However, if the delay caused the cargo on the ship to spoil and thus unable to be sold, then a tort action may be possible because the economic loss is connected to the physical loss of the cargo spoilage.

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[365] Andreas Lober, Tim Caesar and Wojtek Ropel, 'Germany Chapter' in Alain Bensoussan, et al (eds) Co3mparative Handbook: Robotic Technologies Law (Éditions Larcier, 2016) 134.
[366] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 103.
[367] Thomas Kadner Graziano and Christoph Oertel, '«EC Tort Law» and the German Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 445.
[368] Basil S Markesinis and Hannes Unberath, *The German Law of Torts: A Comparative Treatise* (4th edn Bloomsbury 2002) 52.
[369] Thomas Kadner Graziano and Christoph Oertel, '«EC Tort Law» and the German Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 446.
[370] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 28.
[371] American courts have been reluctant to find tort liability for purely economic loss from computer software but lawsuits alleging physical harm connected to software have been more successful. Ryan Calo, 'Open Robotics' (2011) 70 Md L Rev 571, 575-76.

1.3.5 Central European Approach

- **Czech Republic**

The Czech Civil Code was overhauled in 2012 and 'establishe[d] a new liability framework based on a differentiation between contractual and non-contractual damages'.[372] Tort liability is enshrined in sections 2909 and 2910 of the Civil Code, which govern 'liability for breach of good morals and liability for breach of a legal obligation' respectively.[373] For the former, the question is whether the standard of a reasonable person 'of average abilities in his private dealings' is breached, while if there is a breach of legal obligation leading to damages, negligence is presumed.[374] For example, an operator for land-based robot for infrastructure inspection would have to meet the standard for an average land-based infrastructure inspection robot operator, and not just that of the average robot operator that travels on the roads.

- **Hungary**

Hungary is unique in that the burden of proof is reversed in fault liability. While the claimant must show damage and causation between the damage and the defendant's unlawful act, the defendant has the burden of proving that there was no fault and the duty of care was met.[375] The situation in H3ungary creates additional burden for robot manufacturers and operators to show that they were not at fault. One the one hand, this could be made difficult by the complexity of robotics technology. On the other hand, it is likely that such robots, especially those manufactured for I&M purposes, would have sensors and cameras installed on the exterior to perform their duties. The sensors and cameras would likely record the situation at the time of the accident and make it easier for the operator to show that it was not at fault.

- **Poland**

In Eastern European tort regimes, 'the main aim…is the compensation of losses sustained'.[376] Traditionally, the Polish law of obligations was influenced by both the French and German legal cultures.[377] For a tort action to be sustained, the following must be shown: 'First, there must be an event triggering damage, second, there must be damage, and third, causation should exist between the event and the damage'.[378] It must be shown that due diligence was not met where '[t]he perpetrator's act is set against the pattern of behaviour of a diligent person acting under the same

[372] Jiří Hrádek and Andrew J Bell, 'The New Czech Civil Code and Compensation for Damage: Introductory Remarks' (2016) 7 Journal of European Tort Law 300, 302.
[373] Jiří Hrádek and Andrew J Bell, 'The New Czech Civil Code and Compensation for Damage: Introductory Remarks' (2016) 7 Journal of European Tort Law 300, 302.
[374] Czech Civil Code Section 2910-2911.
[375] Attila Menyhárd, 'Basic Questions of Tort Law from a Hungarian Perspective' in Helmut Koziol (ed) Basic Questions of Tort Law from a Comparative Perspective (Jan Sramek Verlag 2015) 312.
[376] Luboš Tichý, '«EC Tort Law» and the Eastern-European Legal Family' in Helmut Koziol and Reiner Schulze (eds) Tort Law of the European Community (Springer 2008) 523.
[377] Ewa Bagińska, 'Developments in Personal Injury Law in Poland: Shaping the Compensatory Function of Tort Law' (2015) 8 Journal of Civil Law Studies 309, 312.
[378] Ewa Bagińska, 'Developments in Personal Injury Law in Poland: Shaping the Compensatory Function of Tort Law' (2015) 8 Journal of Civil Law Studies 309, 314.

circumstances'.[379] Causation is shown by the adequacy theory where 'the person obliged to pay damages is liable only for the *normal* consequences of the act or omission from which the damage resulted, where normal consequence is defined as 'a consequence that ensues usually, predominantly, as a rule (which does not mean always) as a result of a given event'.[380] Damage is defined as 'every wrong upon an interest protected by law, be it property or personality interests, suffered by a person against her will'.[381] In recent years, the standard of proof that must be met by the claimant has 'shifted from "probability bordering on certainty" to "a sufficient degree of probability," with the approval of legal scholarship'.[382]

An operator of an aerial drone sues the manufacturer because the drone suddenly stopped working and fell on a crowd of people and caused injuries. When it was sold, the manufacturer expressly informed the operator that the software needs to be updated every month, but it had not done so. In this situation, the operator is unlikely to win against the manufacturer because the manufacturer had shown due diligence. On the other hand, the injured crowd's tort action would likely be successful against the operator because the operator failed to meet the diligent person standard when it failed to update the software.

1.3.6 Nordic Approach

Laws in the Nordic countries occupy a special place because the common law had little influence over their development as they were not as impacted by Roman law, and they had less proclivity to codify their private laws to the extent of other Continental civil law jurisdictions.[383] In general, the tort liability regimes in the region have similar approaches because '[h]istorically, the Nordic countries cooperated with each other when drafting their compensation acts'.[384] Under the general liability rule of negligence, liability is based on fault where the 'criterion is whether the person has acted in a way that differs from the required standard of conduct or from the "right" behaviour'.[385] In principle, this is the reasonable person standard, though '[i]f statutory provisions provide for a description of the standard of care, these provisions are relevant provided it is the aim of the provisions to prevent individuals from causing damage' and 'customary behaviour is relevant'.[386] Personal deficiencies are in general not taken into account for the standard, though there is an exemption for minors.[387] The test for causation is the sine qua non test.[388] As for damages, it is noted that:

[379] Katarzyna Ludwichowska-Redo, 'Basic Questions of Tort Law from a Polish Perspective' in Helmut Koziol (ed) Basic Questions of Tort Law from a Comparative Perspective (Jan Sramek Verlag 2015) 223.
[380] Katarzyna Ludwichowska-Redo, 'Basic Questions of Tort Law from a Polish Perspective' in Helmut Koziol (ed) Basic Questions of Tort Law from a Comparative Perspective (Jan Sramek Verlag 2015) 238-39.
[381] Ewa Bagińska, 'Developments in Personal Injury Law in Poland: Shaping the Compensatory Function of Tort Law' (2015) 8 Journal of Civil Law Studies 309, 315.
[382] Ewa Bagińska, 'Developments in Personal Injury Law in Poland: Shaping the Compensatory Function of Tort Law' (2015) 8 Journal of Civil Law Studies 309, 316.
[383] Walter Van Gerven, Pierre Larouche and Jeremy Lever, *Ius Commune Casebooks for the Common Law of Europe: Tort Law Casebooks for the Common Law of Europe* (Hart 2000) 4.
[384] Bjarte Askeland and Vibe Ulfbeck, «EC Tort Law» and the Scandinavian Legal Family' in Helmut Koziol and Reiner Schulze (eds) Tort Law of the European Community (Springer 2008) 489-90.
[385] Bjarte Askeland and Vibe Ulfbeck, «EC Tort Law» and the Scandinavian Legal Family' in Helmut Koziol and Reiner Schulze (eds) Tort Law of the European Community (Springer 2008) 491.
[386] Bjarte Askeland and Vibe Ulfbeck, «EC Tort Law» and the Scandinavian Legal Family' in Helmut Koziol and Reiner Schulze (eds) Tort Law of the European Community (Springer 2008) 492.
[387] Bjarte Askeland and Vibe Ulfbeck, «EC Tort Law» and the Scandinavian Legal Family' in Helmut Koziol and Reiner Schulze (eds) Tort Law of the European Community (Springer 2008) 492.

> A somewhat imprecise definition of the legal concept of damage is that a person is exposed to a "negative effect". This negative effect must be qualified as relevant to the tort law compensation rules; it must be protected by the law. A core requisite in this respect is that it is possible to estimate the negative effect in monetary terms. Hence, as a general rule the claimant must have suffered an economic loss.[389]

The rigidness of how causation is interpreted in Scandinavian countries, as described in the next section, means that it would be more difficult to show tort liability in a court of law. However, the welfare state model of these states that focuses on insurance rather than the tort regime for compensation would allow the victims to be made whole. Robot manufacturers and operators must understand how the insurance regimes operate in these states and how they would affect their commercial decisions when contemplating whether to conduct business in Scandinavia.

1.3.7 Causation

One of the elements of tort liability, causation, transcends the legal family categorisation and is worth mentioning separately. Causation is important because it makes the connection between the tortfeasor's actions or inactions and the harm suffered by the claimant, an especially key and difficult question to determine in the context of complex, new technologies.[390] Action or inaction without associated harm, or harm that is not caused by the tortfeasor's actions or inactions would not lead to compensation because the defendant would not be culpable. It would be patently unfair for a defendant to be held legally responsible without this causation, especially when the harm itself is not foreseeable. Consequently, being able to show causation, that the action or in action caused the harm, and that the harm is something that is within the realm of possibility, is important in tort and delict law, and the different ways causation is conceived and applied in practice affect the rate of success of these actions. There are three main models of causation in Europe, overarching causation, bounded causation, and pragmatic causation.[391] Countries that take the overarching causation approach include France, Italy, Spain, Poland, and Bulgaria, all of which follow 'the French open-ended approach to liability'.[392] Infantino and Zervogianni note that in these states:

> [C]ausation has a large role to play, because it is used as a privileged instrument to weigh the interests of the parties as well as policy interests in the absence of preliminary filters other than fault and damage. Yet, this weighing of interests, rather than being openly carried out by judges, is generally unexpressed and concealed under the manipulation of the ordinary principles and requirements of causation. As to liability outcomes, the open-endedness of tort law structure in these countries

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388 Bjarte Askeland and Vibe Ulfbeck, «EC Tort Law» and the Scandinavian Legal Family' in Helmut Koziol and Reiner Schulze (eds) Tort Law of the European Community (Springer 2008) 498.

389 Bjarte Askeland and Vibe Ulfbeck, «EC Tort Law» and the Scandinavian Legal Family' in Helmut Koziol and Reiner Schulze (eds) Tort Law of the European Community (Springer 2008) 500.

390 See Jos Lehmann, Joost Breuker and Bob Brouwer, 'Causation in AI and Law' (2004) Artificial Intelligence and Law 279, 280-86.

391 Marta Infantino and Eleni Zervogianni, 'The European Ways to Causation' in Marta Infantino, Eleni Zervogianni (eds) Causation in European Tort Law (CUP 2017) 87-88.

392 Marta Infantino and Eleni Zervogianni, 'The European Ways to Causation' in Marta Infantino, Eleni Zervogianni (eds) Causation in European Tort Law (CUP 2017) 87.

> relates to an overall high rate of success of tort law claims, although significant differences between countries might be detected.[393]

On the other end of the spectrum is the rigid bounded causation in the laws of Germany, Czech Republic, Greece, Portugal, Denmark, and Sweden where 'causation is only one of the many means set up by the system to deny or, in any case, limit tort law liability, whose functions are largely absorbed by other concurrent mechanisms'.[394] As a result, relying on tort law for compensation is more difficult.[395]

In between are the states that take a pragmatic approach:

> [C]ourts are openly sensitive to the concrete implications of their decisions, and tend to propose flexible, case-tailored solutions that are driven neither by the dictates of wide or limited tort law rules, nor by the dogmatic adherence to causation principles, but rather by a concrete and overt policy-making effort.[396]

The determination of the duty of care is also emphasised. States in this category include Austria, the Netherlands, Lithuania, England and Ireland.[397]

The different approaches to causation the legal systems of Member States show that for the same set of facts involving robots causing injuries or property damage, claimants are more likely to receive compensation in states that take the overarching approach, followed by the pragmatic approach, and finally the bounded approach. Manufacturers and operators must take this into account when deciding where they will set up their factories or operate robots for inspection and maintenance, as the likelihood of their being found liable in civil actions differ between the Member States.

Type of causation	Representative Member States
Overarching causation	France, Italy, Spain, Poland, and Bulgaria
Pragmatic causation	Austria, Netherlands, Lithuania, England, Ireland
Bounded causation	Germany, Czech Republic, Greece, Portugal, Denmark, Sweden

Table 2. Types of Causation in EU Member States

1.3.8 Insurance

Insurance is a risk management tool whereby an insured can transfer some or all of the risks to the insurer in exchange for paying a premium.[398] Traditionally, insurance is seen as allocation of risk.[399]

[393] Marta Infantino and Eleni Zervogianni, 'The European Ways to Causation' in Marta Infantino, Eleni Zervogianni (eds) Causation in European Tort Law (CUP 2017) 87.
[394] Marta Infantino and Eleni Zervogianni, 'The European Ways to Causation' in Marta Infantino, Eleni Zervogianni (eds) Causation in European Tort Law (CUP 2017) 87.
[395] Marta Infantino and Eleni Zervogianni, 'The European Ways to Causation' in Marta Infantino, Eleni Zervogianni (eds) Causation in European Tort Law (CUP 2017) 87.
[396] Marta Infantino and Eleni Zervogianni, 'The European Ways to Causation' in Marta Infantino, Eleni Zervogianni (eds) Causation in European Tort Law (CUP 2017) 87-88.
[397] Marta Infantino and Eleni Zervogianni, 'The European Ways to Causation' in Marta Infantino, Eleni Zervogianni (eds) Causation in European Tort Law (CUP 2017) 87.

However, insurance can also reduce the overall amount of risk because it encourages the adoption of practices that minimise the chances of loss.[400] First party insurance is meant to protect one's own life or property, whereas third party insurance, also known as liability insurance, is designed to pay a third party to compensate for the loss for which the insured is legally responsible.[401] If a land-based robot malfunctions and collides with a building, the operator's first party insurance would pay for repairs to the robot and liability insurance would pay for the damages to the building.

In the EU, liability insurance is compulsory for the use of motor vehicles,[402] aircrafts,[403] and passenger-carrying vessels.[404] If the robots fall under the definitions used in these laws, operators would be compelled to purchase insurance. The European Parliament has urged the study of 'establishing a compulsory insurance scheme where relevant and necessary for specific categories of robots whereby, similarly to what already happens with cars, producers, or owners of robots would be required to take out insurance cover for the damage potentially caused by their robots'.[405] A compulsory scheme for different types of robots would cover the gaps of the current compulsory insurance regime, such as submersibles and vessels for infrastructure inspection and maintenance that are not designed to carry passengers. Making insurance compulsory is especially important when there are 'highly significant risks (which may either lead to substantial harm133F and/or cause frequent losses), where it seems unlikely that potential injurers will be capable of compensating all victims themselves (either out of their own funds, with the help of alternative financial securities, or through voluntary self insurance)'.[406]

Compulsory insurance protects both the insured and the victim, as the tortfeasor 'may not necessarily be in a position to effectively assess the likely advantages of having insurance' and it would ensure the victim is compensated.[407] According to the economics literature, strict liability regimes may lead to the risk of underdeterrence, the problem that the tortfeasor does not take all reasonable precautions when the amount of damage exceeds the tortfeasor's wealth.[408] Thus, compulsory insurance is especially important for strict liability regimes because it would ensure the victim is compensated. Insurance is also important to counter the chilling effect liability may have on

398 Malcolm Clarke, 'An Introduction to Insurance Contract Law' in Julian Burling and Kevin Lazarus (eds) Research Handbook on International Insurance Law and Regulation (Edward Elgar 2012) 3.
399 John Birds, *Birds' Modern Insurance Law* (Sweet & Maxwell 10 edn 2016) 8-9.
400 John Rappaport, 'How Private Insurers Regulate Public Police' (2017) 130 Harvard Law Review 1539, 1543
401 John Birds, *Birds' Modern Insurance Law* (Sweet & Maxwell 10 edn 2016) 3-4.
402 Directive 2009/103/EC of the European Parliament and of the Council of 16 September 2009 relating to insurance against civil liability in respect of the use of motor vehicles, and the enforcement of the obligation to insure against such liability.
403 Regulation (EC) No 785/2004 of the European Parliament and of the Council of 21 April 2004 on insurance requirements for air carriers and aircraft operators.
404 Regulation (EC) No 392/2009 of the European Parliament and of the Council of 23 April 2009 on the liability of carriers of passengers by sea in the event of accidents.
405 European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)) art 59(a).
406 Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 62.
407 Aysegul Bugra, 'Room for Compulsory Product Liability Insurance in the European Union for Smart Robots? Reflections on the Compelling Challenges' in Pierpaolo Marano and Kyriaki Noussia (eds) InsurTech: A Legal and Regulatory View (Springer 2019) 174-75. See Gerhard Wagner, 'Robot, Inc: Personhood for Autonomous Systems' (2019) 88 Fordham L Rev 591, 610.
408 Michael G Faure, 'Economic Criteria for Compulsory Insurance' (2006) 31 The Geneva Papers on Risk and Insurance 149, 155-56.

the innovation of technology.[409] Nonetheless, the Expert Group on Liability and New Technologies – New Technologies Formation warns that 'compulsory liability insurance should not be introduced without a careful analysis of whether it is really needed, rather than automatically linked to a certain activity'.[410]

While insurance may play an important role in ensuring that the tortfeasor would not become insolvent from paying damages and that the victim would be compensated, there are some obstacles to tailoring insurance products to robots. First, the types of damages robots could inflict could be novel and unpredictable due to the complexity of the technology[411] Second, the complexity of the robots and lack of existing data on potential risks and accidents make pricing the risk difficult.[412] These problems may prevent insurers from offering insurance to robot manufacturers, suppliers, and operators, lead them to offer existing insurance that is inadequate for the technology, or allow them to only offer insurance at exorbitant prices that outweigh their utility.[413] To combat these problems, it is important for those in the robotics industry to work closely with insurers as technology develops to ensure that the latter has the information to put itself in the position to manage and minimise the risks associated with robotics technology.[414]

Tort or delict actions are necessary for claimants to receive compensation from the tortfeasor, whether it is the party that manufactured the robot or the party that operated it. As the claimant would need to litigate in the courts of Member States using the laws of the Member States, the specific circumstances of each case would determine where the case would take case and what laws would be used applied. While the tort and delict laws differ in each jurisdiction, they share similarities, and all have the aim of making the victim whole through monetary compensation. Each Member State has fault-based liability and strict liability regimes. While the former would be applicable in all cases, the latter is usually reserved for particular circumstances allowed by the law. Fault-based actions require the defendant to have failed to meet the standard of a reasonable person, thus causing the damages, whereas strict liability cases do not require a showing of fault, as the focus in on the product that caused the harm and not the person's actions. While these traditional forms of civil action have so far been able to accommodate the robotics technological advances, it may be increasingly hard to meet the legal standards required for tort and delict actions as technology further progresses, as the complexity of the systems would make determining foreseeability and causation difficult. Whether amendments or complete overhauls of the civil justice regime need to be made remains to be seen, and manufacturers, distributors, and users of robotics liability should keep abreast of the developments not only in the technology but also in the law to ensure their commercial interests are protected.

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409 Maurice Schellekens, 'Self-driving Cars and the Chilling Effect of Liability Law' (2015) 31 Computer Law & Security Review 506, 511-16.

410 Expert Group on Liability and New Technologies – New Technologies Formation, 'Liability for Artificial Intelligence and Other Emerging Technologies' <ec.europa.eu/newsroom/dae/document.cfm?doc_id=63199> 61.

411 Andrea Bertolini et al, 'On Robots and Insurance' (2016) 8 International Journal of Social Robotics 381, 386; Matthew U Scherer, 'Regulating Artificial Intelligence Systems: Risks, Challenges, Competencies, and Strategies' (2016) 29 Harv J L & Tech 353, 363-66.

412 Andrea Bertolini et al, 'On Robots and Insurance' (2016) 8 International Journal of Social Robotics 381, 386.

413 Andrea Bertolini et al, 'On Robots and Insurance' (2016) 8 International Journal of Social Robotics 381, 388. See also Simon Cooper, 'Insurance and Artificial Intelligence' in Barış Soyer and Andrew Tettenborn (eds) New Technologies, Artificial Intelligence and Shipping Law in the 21st Century (Informa Law 2019) 187.

414 Andrea Bertolini, 'Insurance and Risk Management for Robotic Devices: Identifying the Problems' (2016) 16 Global Jurist 291, 308.For an example of data gathering for insurance purposes, see Horst GM Eidenmueller, 'The Rise of Robots and the Law of Humans' (March 26, 2017). Oxford Legal Studies Research Paper No. 27/2017. Available at SSRN: https://ssrn.com/abstract=2941001 or http://dx.doi.org/10.2139/ssrn.2941001.

1.4 Product Safety and Product Liability

This section introduces the product safety and product liabilities regimes of the EU. It then discusses the product safety laws of selected Member States divided by different legal family approaches with an emphasis on the state of the art defence because it is particularly relevant to new technologies. It should be noted that the product liability regimes are applicable in addition to the fault-based and strict liability regimes discussed above, as claimants can assert all the causes of action in litigation to maximise their chances of success due to different elements they have to show and the different defences the designer, manufacturer, or operator may have.

1.4.1 European Product Safety

The product safety and liability regime may be applicable robots because they can generally be classified as products.[415] The European General Product Safety Directive was passed in 2001.[416] Its goal is 'to ensure that products placed on the market are safe'.[417] As such, it plays a preventative role.[418] In general, a product is considered to be safe if it 'does not present any risk or only the minimum risks compatible with the product's use, considered to be acceptable and consistent with a high level of protection for the safety and health of persons'.[419]

The Directive would likely apply to all robotics technology, including those used for I&M, because of the broad definition of product.[420] Product is defined as:

> any product — including in the context of providing a service — which is intended for consumers or likely, under reasonably foreseeable conditions, to be used by consumers even if not intended for them, and is supplied or made available, whether for consideration or not, in the course of a commercial activity, and whether new, used or reconditioned.[421]

This means that products that are not manufactured in the EU but are meant to be used by those in the EU would also have to abide by the Directive. The manufacturers of the robots, or others in the supply chain, must ensure that any products they make available to consumers must be safe by conforming to national laws of the Member State the product is marketed, so long as those laws are 'in conformity with the Treaty...and [lay] down the health and safety requirements which the product must satisfy in order to be marketed'.[422] If technical safety standards promulgated by the industry and standardisation organisations and subsequently published in the *Official Journal of the European Communities* are met by the product, it is presumed to be in conformity.[423] These published standards that give rise to the presumption of conformity are called harmonised standards.[424] Although the standards are voluntary, the European Commission is dedicated to

[415] See generally Andrea Bertolini, 'Robots as Products: The Case for a Realistic Analysis of Robotic Applications and Liability Rules' (2013) 5 Law, Innovation and Technology 214; Karni A Chagal-Feferkorn, 'Am I an Algorithm or a Product: When Products Liability Should Apply to Algorithmic Decision-Makers' (2019) 30 Stan L & Pol'y Rev 61.

[416] DIRECTIVE 2001/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 December 2001 on general product safety.

[417] European General Product Safety Directive Article 1(1).

[418] Cees van Dam, *European Tort Law* (OUP 2d edn 2013) 422.

[419] European General Product Safety Directive Article 2(b).

[420] Taivo Liivak, 'Liability of a Manufacturer of Fully Autonomous and Connected Vehicles under the Product Liability Directive' (2018) 4 International Comparative Jurisprudence 178, 180-81.

[421] European General Product Safety Directive Article 2(a).

[422] European General Product Safety Directive Article 3(2).

[423] European General Product Safety Directive Article 3(2).

[424] https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards_en

facilitating the process because 'standards can influence most areas of public concern such as the competitiveness of industry, the functioning of the Single Market, the protection of the environment and of human health, [and] the enhancement of innovation'.[425]

In the alternative, if no published standards exist, the product must conform to safety requirements that take into account the following:

> a) voluntary national standards transposing relevant European standards other than those referred to in paragraph 2;
> (b) the standards drawn up in the Member State in which the product is marketed;
> (c) Commission recommendations setting guidelines on product safety assessment;
> (d) product safety codes of good practice in force in the sector concerned;
> (e) the state of the art and technology;
> (f) reasonable consumer expectations concerning safety.[426]

The malleable nature of the Directive and lack of specifications make it flexible and geared toward application in diverse circumstances.[427] There is also no requirement that the product attains the highest safety standard possible, so just because a similar product meets higher standards does not mean one that does not is unsafe.[428] There is also no requirement that a third party determine whether safety standards have been met. Indeed, it is each manufacturer and distributor's obligation to ensure their products meet the requirements.[429] This, in addition to the use of guidelines devised by the industry, shows that this Directive employs co-regulation involving the EU, Member State, and private parties to maintain safety standards.[430] The involvement of various parties in the regulation of safety standards is seen as making the regime more robust.[431]

Manufacturers and distributors must monitor their products after they are introduced to the market, inform the consumers of the risks of the product, and if they know that a product is in violation of general safety standards, they must inform the relevant authorities and the consumers.[432] They must also withdraw or recall the product depending on the situation.[433] EU Decision 2019/417 provides guidance on the risk assessment that must be undertaken to determine what actions need to be taken regarding the unsafe product.[434] The Decision offers guidelines on how to navigate the alert system Rapid Exchange of Information System (RAPEX).[435] Should manufacturers or distributors violate the national laws pursuant to this Directive, they would be subject to penalties as provided by

[425] https://ec.europa.eu/growth/single-market/european-standards_en
[426] European General Product Safety Directive Article 3(3).
[427] Stephen Weatherill, *EU Consumer Law and Policy* (Edward Elgar 2005) 207.
[428] European General Product Safety Directive Article Article 2(b).
[429] Christopher Hodges, *European Regulation of Consumer Product Safety* (OUP 2005) 199.
[430] Geraint Howells, 'Product Safety--A Model for EU Legislation and Reform' in Kai Purnhagen and Peter Rott (eds) *Varieties of European Economic Law and Regulation: Liber Amicorum for Hans Micklitz* (Springer 2014) 526.
[431] Harm Schepel, *The Constitution of Private Governance: Product Standards in the Regulation of Integrating Markets* (Hart Publishing 2005) 339.
[432] European General Product Safety Directive Article 5.
[433] European General Product Safety Directive Article 5(1)(b).
[434] COMMISSION IMPLEMENTING DECISION (EU) 2019/417 of 8 November 2018 laying down guidelines for the management of the European Union Rapid Information System 'RAPEX' established under Article 12 of Directive 2001/95/EC on general product safety and its notification system.
[435] Commission Implementing Decision Article 1.

each Member State.[436] The Directive does not specify the penalties besides noting that they must be 'effective, proportionate and dissuasive'.[437]

A major caveat that must be noted is that this Directive applies to products for consumers. Although it does not define 'consumer', it is clear under EU law that only natural persons can be considered consumers and those who act for business or professional purposes are not consumers.[438] As a result, businesses that use robots for infrastructure purposes would not be considered consumers and would consequently not fall within the ambit of this Directive. Nonetheless, the safety measures offered by the Directive can serve as guidance for best practices and for legal reform in the future to extend the regime to the commercial setting. Furthermore, some Member States may extend consumer protection to legal persons or some enterprises, so it would be important to be aware of the national laws of the Member State in which one is considering to conduct business, as robot manufacturers and distributors may still have to abide by the safety standards.[439] Similar to other products, robots would not have be risk free; they just need to meet the standards.[440] Furthermore, this Directive is not applicable to medical devices, pharmaceutical, or food. In the realm of robotics, this may mean that those used for healthcare may not fall under the jurisdiction of this Directive, but for robots in infrastructure inspection and maintenance, this is unlikely to be a concern.[441]

1.4.2 European Product Liability

The Product Liability Directive 85/374/EEC came into effect in 1985. It has largely harmonised the central tenets of product liability laws in EU Member States since its introduction, though there are still diverging interpretations on the margins.[442] The Directive specifies that producers, which include manufacturers and suppliers, are 'liable for damage caused by a defect in his product'.[443] Similar to the Product Safety Directive, the protection is over consumers, which again raises the same set of issues discussed previously, though the product liability regime could serve as useful guidance. While the Product Safety Directive is preventative in nature, the Product Liability Directive seeks to create certainty on how to allocate liability when products do cause personal injuries, death, or property damage.

The burden of proof is on the injured party to show that there is damage, a defect in the product, and that the defect caused the damage.[444] The damage could include bodily injuries, death, or damage to property.[445] The Directive states that '[a] product is defective when it does not provide the safety which a person is entitled to expect', a standard that should take into account the following:

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436 European General Product Safety Directive Article 7.
437 European General Product Safety Directive Article 7.
438 Jana Valant, *Policy Review: Consumer Protection in the EU* (European Parliament 2015) <www.europarl.europa.eu/RegData/etudes/IDAN/2015/565904/EPRS_IDA(2015)565904_EN.pdf> 4.
439 Rafał Mańko, Library Briefing: The notion of 'consumer' in EU law (European Parliament 2013) <www.europarl.europa.eu/RegData/bibliotheque/briefing/2013/130477/LDM_BRI(2013)130477_REV1_EN.pdf> 1-2.
440 Ugo Pagallo, *The Laws of Robot: Crimes, Contracts, and Torts* (Springer 2013) 144.
441 European Commission, Product Safety Rules <ec.europa.eu/info/business-economy-euro/product-safety-and-requirements/consumer-product-safety/product-safety-rules_en>.
442 Geraint Howells, 'Is European Product Liability Harmonised?' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 125-34. See also Fidelma White, 'Directive 85/374/EEC Concerning Liability for Defective Products: Nn the name of Harmonisation, the Internal Market and Consumer Protection' in Paula Giliker (ed) *Research Handbook on European Tort Law* (Edward Elgar 2017) 128-53.
443 Product Liability Directive Article 1.
444 Product Liability Directive Article 4.
445 Product Liability Directive Article 9.

'a) the presentation of the product;
(b) the use to which it could reasonably be expected that the product would be put;
(c) the time when the product was put into circulation.'[446]

These relevant factors show that 'the assessment of the defective character of a product is entirely focused on the consumer' and not the manufacturer or supplier.[447] Nonetheless, this is an objective standard.[448] With new technologies that have autonomous and machine learning capabilities, 'the question of whether unpredictable deviations in the decision-making path can be treated as defects' is one that will have to be answered.[449] Although EU product liability is a strict liability regime, the foreseeability of damage is still relevant and may be used as a defence if an external cause can be shown by the defendant.[450] It has been noted that placing the burden of proof on the consumer is particularly burdensome due to the possible complexity of the matter where the manufacturer would have superior knowledge, though discussions of amending the provision did not result in any changes.[451]

Besides showing there was no damage, defect, or causation, there are six defences to liability the producer and supplier may present. The three that are most notable are that 'he did not put the product into circulation',[452] 'the defect is due to compliance of the product with mandatory regulations issued by the public authorities'[453] and 'the state of scientific and technical knowledge at the time when he put the product into circulation was not such as to enable the existence of the defect to be discovered'.[454] The last defence, known as the state of the art defence or the development risk defence, is one Member States could have chosen not to implement in their national laws per the Directive.[455] Finland and Luxembourg have chosen to derogate from the Directive and not apply this state of the art defence, while France, Hungary, and Spain exclude the defence for certain products.[456]

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[446] Product Liability Directive Article 6.
[447] Giorgio Risso, 'Product liability and Protection of EU Consumers: Is It Time for a Serious Reassessment?' (2019) 15 Journal of Private International Law 210, 220.
[448] Lucas Bergkamp and Rod Hunter, 'Product Liability Litigation in the US and Europe: Diverging Procedure and Damage Awards' (1996) Maastricht Journal of European & Comparative Law 399.
[449] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 28.
[450] Cees van Dam, *European Tort Law* (OUP 2d edn 2013) 320.
[451] Lauren Sterren, 'Product Liability: Advancements in European Union Product Liability Law and a Comparison Between the EU and U.S. Regime' (2015) Michigan State International Law Review 885, 889.
[452] Product Liability Directive Article 7(a).
[453] Product Liability Directive Article 7(d).
[454] Product Liability Directive Article 7(e).
[455] Product Liability Directive Article 15(b).
[456] European Commission, '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' <eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018SC0157&from=EN>.

Figure 1. EU Product Liability elements and affirmative defences

The state of the art defence can raise issues particularly when it comes to new technologies such as robotics for I&M, and this is a question the EU has contemplated recently with the development of artificial intelligence technology. The EU notes:

> In certain cases, when digital technology products or services cause a damage, the allocation of liability may be complex due to their specific characteristics. In addition, ensuring their safety over their lifetime is important, as it can prevent or reduce potential damages and liability issues. It is therefore necessary to examine whether existing rules at EU and national level for safety and for the allocation of liability and the conditions, under which a victim is entitled to obtain compensation for damages caused by products and services stemming from emerging digital technologies, are appropriate and whether, for the producers and services providers, the framework continues to deliver an adequate level of legal certainty.[457]

The 'interdependency between the different components and layers' of new technologies and the increasing autonomy of artificial intelligence and robots that are able to interpret their environment may cast doubt on the present product liability regime.[458] Concepts such as product, producer, and damages may have to be rethought.[459] In addition, questions like 'whether concepts like the liability of a guardian or similar concepts are appropriate to technologies like AI' and 'whether and to what extent it matters for determining liability whether the damage could have been avoided or not' would need to be tackled.[460]

[457] European Commission, COMMISSION STAFF WORKING DOCUMENT Liability for emerging digital technologies 2.
[458] European Commission, COMMISSION STAFF WORKING DOCUMENT Liability for emerging digital technologies 9-10.
[459] European Commission, COMMISSION STAFF WORKING DOCUMENT Liability for emerging digital technologies 18.
[460] European Commission, COMMISSION STAFF WORKING DOCUMENT Liability for emerging digital technologies 19-20.

Toward that end, in March 2018, the EU formed the Expert Group on Liability and New Technologies to investigate whether and how the current liability framework should adapt to the proliferation of new technologies, including robotics.[461] The Expert Group is further divided into two subgroups: the Product Liability Directive formation and the New Technologies formation.[462] The latter released a report in November 2019 entitled *Liability for Artificial Intelligence and Other Emerging Digital Technologies*.[463] Concerning product liability, the report found that fault liability and strict liability for defective products should both 'continue to coexist'. Further, it concluded:

> Existing defences and statutory exceptions from strict liability may have to be reconsidered in the light of emerging digital technologies, in particular if these defences and exceptions are tailored primarily to traditional notions of control by humans.[464]

The New Technologies Formation also found that the state of the art defence should not be applicable in the context of new technologies:

> The producer should be strictly liable for defects in emerging digital technologies even if said defects appear after the product was put into circulation, as long as the producer was still in control of updates to, or upgrades on, the technology. A development risk defence should not apply.[465]

The rationale is that:

> In view of the need to share benefits and risks efficiently and fairly, the development risk defence, which allows the producer to avoid liability for unforeseeable defects, should not be available in cases where it was predictable that unforeseen developments might occur.[466]

The experts further believe that defect should be interpreted more widely temporally for new technologies:

> When the defect came into being as a result of the producer's interference with the product already put into circulation (by way of a software update for example), or the producer's failure to interfere, it should be regarded as a defect in the product for which the producer is liable. The point in time **at which a product is placed on the market** should not set a strict limit on the producer's liability for defects where, after that point in time, the producer or a third party acting on behalf of the producer remains in charge of providing updates or digital services.[467] (bold in original)

[461] https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3592
[462] https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3592
[463] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608>.
[464] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 6`.
[465] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 6.
[466] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 43.
[467] Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 43.

Finally, it recommends shifting the burden of proof in certain situations:

> If it is proven that an emerging digital technology has caused harm, the burden of proving defect should be reversed if there are disproportionate difficulties or costs pertaining to establishing the relevant level of safety or proving that this level of safety has not been met.[468]

The report also concluded that '[t]here should be a duty on producers to equip technology with means of recording information about the operation of the technology' so that the defect or cause of failure could be documented.[469] The lack of such logs 'should trigger a rebuttable presumption that the condition of liability to be proven by the missing information is fulfilled', which means that the burden is on the designer or operator to show that no such defect or causation existed.[470] While an amendment of the Product Liability Directive to keep up with technological advances may not occur for a while, in the meantime, it may be possible to create more certainty when addressing allocation issues with new technologies through soft law guidance, as proposed by Fairgrieve, Howells, and Pilgerstorfer.[471]

The formation of the Expert Group shows that the EU is serious about ensuring that the liability regime will be adequate to address the allocation of responsibility of robotics technology should accidents occur. For now, enterprises manufacturing or using robots must understand and follow the product safety and liability frameworks. However, the rapid development in the legal realm to keep pace with technological advances must be monitored by enterprises to ensure that they make business decisions that would ensure high safety standards possible and minimise risks of liability.

Similar to the civil liability section, the rest of this section discusses the various approaches to product liability in the Member States categorised by legal family approaches.

Legal Approach	Member States examined in report
Common Law	United Kingdom, Ireland
French	France, Italy, Spain
German	Germany, Austria
Central European	Czech Republic, Poland, Slovakia, Hungary
Nordic	Denmark

Table 3. Product Liability Regimes in EU Member States

1.4.3. Common Law Approach

468 Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 6.

469 Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 47.

470 Expert Group on Liability and New Technologies – New Technologies Formation, *Liability for Artificial Intelligence and Other Emerging Digital Technologies* (European Union 2019) <ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36608> 47.

471 See Duncan Fairgrieve, Geraint Howells and Marcus Pilgerstorfer, 'The Product Liability Directive: Time to get Soft?' (2013) 4 Journal of European Tort Law 1.

Directive 85/374/EEC was implemented in the UK by Part I of the Consumer Protection Act 1987, which became effective in March 1988, and it was then amended by the Consumer Protection Act 1987 (Product Liability) (Modification) Order 2000 to implement the amendments in Directive 1999/34/EC. Under the Consumer Protection Act, a product is 'any goods or electricity and…includes a product which is comprised in another product, whether by virtue of being a component part or raw material or otherwise'.[472] Oliphant and Wilcox have doubts as to whether this definition of product would cover new technologies, including robots, and issues could arise if litigation were to concern such technologies.[473]

The English law includes a state of the art defence, which is enshrined in section 4(1)(e). The defendant must show that:

> the state of scientific and technical knowledge at the relevant time was not such that a producer of products of the same description as the product in question might be expected to have discovered the defect if it had existed in his products while they were under his control.[474]

The language deviates from that in the Directive, and it was at first unclear whether it was similar in scope with the defence in the Directive.[475] In the Court of Justice of the EU case *Commission v United Kingdom*, it was ruled that the 'scientific and technical knowledge' in the defence did not include industry safety standards.[476] This means that the producer claiming they followed industry standards such as ISO or IEEE guidelines, which did not allow for discovery of the defects while the robot was under its control would not be a successful defence if knowledge was otherwise available.

In addition, the opinion found that the test for whether there was 'knowledge' is objective and only knowledge that is accessible would count.[477] In this day and age with information widely shared and available on the Internet, accessibility would most likely be interpreted more widely, which means manufacturers would have to be more careful about keeping abreast of new knowledge.

Although redress via the Consumer Protection Act exists, there have not been a significant amount of cases using this cause of action and litigation instead have focused on tort or contract law.[478] Proving liability of robots using the Consumer Protection Act may be difficult, as the Department of Transport noted in *The Pathway to Driverless Cars: A Detailed Review of Regulations for Automated Vehicle Technologies* that the existing liability regime would be difficult for claimants to navigate

[472] Consumer Protection Act 1987.
[473] Ken Oliphant and Vanessa Wilcox, 'Product Liability in England and Wales' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 204.
[474] Consumer Protection Act 1987
[475] Ken Oliphant and Vanessa Wilcox, 'Product Liability in England and Wales' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 194.
[476] Ken Oliphant and Vanessa Wilcox, 'Product Liability in England and Wales' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 194.
[477] Ken Oliphant and Vanessa Wilcox, 'Product Liability in England and Wales' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 194.
[478] Ken Oliphant and Vanessa Wilcox, 'Product Liability in England and Wales' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 197.

because of the complex technology and the need for experts to establish causation and the state of the art.[479]

In Ireland, the Directive was implemented in national law by the Liability for Defective Products Act, 1991. It also includes the state of the art defence, which states: 'that the state of scientific and technical knowledge at the time when he put the product into circulation was not such as to enable the existence of the defect to be discovered'.[480] This is identical to the language in the EU Directive. According to the Act, 'a product is defective if it fails to provide the safety which a person is entitled to expect, taking all circumstances into account, including—(a) the presentation of the product, (b) the use to which it could reasonably be expected that the product would be put, and (c) the time when the product was put into circulation'.[481] Again, this language follows the Directive. As noted previously, as the Irish courts follow the case law in the United Kingdom, product liability law in Ireland is very similar to its UK counterpart.

1.4.4 French Approach

The Romance legal traditions include France, Spain, and Italy, with legal systems modelled after the French Civil Code.[482] Italian tort law, however, has also been influenced by German law.[483] While 'tort liability was traditionally seen as a sanction against a reproachable (illicit) conduct', compensating the victim is now seen as the main goal.[484]

In France, the Product Liability Directive was implemented in domestic law relatively late due to the development risk defence.[485] It was finally inserted into the Civil Code in 1998 after much debate, and some saw the development risk defence as a step back in French consumer protection.[486] The implementation contained several departures from the EU Directive offering greater protection, but they were subsequently amended due to ECJ judgments.[487] Today, the product liability law in France is 'exactly the same as the Directive's' save for the section on recoverable damages.[488] It has also garnered general acceptance, with several hundred cases invoking the cause of action each year.[489]The claimant has the burden of proof for defect, damages, and causation.[490] Like the

[479] *The Pathway to Driverless Cars: A Detailed Review of Regulations for Automated Vehicle Technologies* <assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/401565/pathway-driverless-cars-main.pdf>.
[480] Liability for Defective Products Act, 1991 Sec 6(e).
[481] Liability for Defective Products Act, 1991 Sec 5(1).
[482] Stefano Troiano, '«EC Tort Law» and the Romanic Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 395.
[483] Stefano Troiano, '«EC Tort Law» and the Romanic Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 395.
[484] Stefano Troiano, '«EC Tort Law» and the Romanic Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 396.
[485] Jean-Sébastien Borghetti, 'Product Liability in France' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 209.
[486] Jean-Sébastien Borghetti, 'Product Liability in France' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 211-12
[487] Jean-Sébastien Borghetti, 'Product Liability in France' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 211-12
[488] Jean-Sébastien Borghetti, 'Product Liability in France' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016)212.
[489] Jean-Sébastien Borghetti, 'Product Liability in France' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 235.
[490] Jean-Sébastien Borghetti, 'Product Liability in France' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 228.

Directive, French law does not offer guidance on the specifics of causation between the defect and damage, and case law has only required that the causation be 'certain and direct'.[491]

In Spain, the Product Liability Directive was implemented in 1994 by the Product Liability Act 22/1994.1.[492] The Spanish law includes the development risk defence but excludes its application for 'food, foodstuffs and medicines intended for human consumption'.[493] The Spanish law is not exclusive to the protection of consumers.[494]

In Italy, the Product Liability Directive was first implemented in Presidential Decree 224/88 then incorporated into the Consumer Code in 2005. The development risk defence is available under Italian law.[495] While this defence may absolve the producer of liability in case of defects, it may still be liable for penalties per safety provisions in legislation.[496] While Italian law should be able to accommodate new technologies such as robotics, Comandé notes that several questions need to be further explored:

> (i) the actual scope of the development risk defence; (ii) the possible interplay between product safety regulations and the Product Liability Directive; and (iii) a potential reading of such rules in light of the precautionary principle due to the uncertainties related to new technologies employed in production.[497]

In general, product liability laws in these Member States do not differ significantly from the Product Liability Directive. They face the same questions as the Directive as to whether they could be applied to new technologies such as robots. Scholars generally agree that the general framework should still be applicable but important questions need to be answered to create more certainty.

1.4.5 German Approach

While the major aim of tort law is compensation, one of the other major aims of tort law in the German legal family is the prevention of damages, as the threat of 'liability creates an incentive to act carefully and to avoid damages'.[498] Punishment of the wrongdoer is not an aim, as shown by the lack of punitive damages.[499]

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[491] Jean-Sébastien Borghetti, 'Product Liability in France' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 224.
[492] Miquel Martín-Casals, 'Product Liability in Spain' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 412.
[493] Miquel Martín-Casals, 'Product Liability in Spain' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 413.
[494] Miquel Martín-Casals, 'Product Liability in Spain' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 414.
[495] Giovanni Comandé, 'Product Liability in Italy' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 301.
[496] Giovanni Comandé, 'Product Liability in Italy' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 301.
[497] Giovanni Comandé, 'Product Liability in Italy' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 309.
[498] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 43. Thomas Kadner Graziano and Christoph Oertel, '«EC Tort Law» and the German Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 441.
[499] European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 43. Thomas Kadner Graziano and Christoph Oertel, '«EC Tort Law» and the German Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 442.

In Austria, the product liability law following the Product Liability Directive has been accepted as the dominant and accepted cause of action for product liability cases, with over 100 cases being decided by the Austrian Supreme Court.[500] The Austrian product liability law tracks the Product Liability Directive for the most part. Product is defined as 'any movable tangible property' under §4 PHG. The law defines defect as:

> (1) A product shall be deemed defective if it does not provide the safety which, taking all circumstances into account, may be reasonably expected, in particular with respect to: 1. the presentation of the product, 2. the use to which it can reasonably be expected that the product would be put, 3. the time when the product was put into circulation. (2) A product shall not be considered defective for the sole reason that an improved product was subsequently put into circulation.[501]

While the Product Liability Directive does not offer guidance on the meaning of putting into market, Austrian law seeks to fill the gap:

> A product shall be deemed put into circulation as soon as the entrepreneur – irrespective of the title – has transferred it to another person into the latter's power of disposition or for the latter's use. Dispatching the product to the customer shall be deemed sufficient.[502]

Furthermore, internal use of a product by the producer is also seen as being put into circulation in Austria, as even though the party is the same, it is playing a different role.[503] Consistent with Austrian tort law principles, causation between the damage and the defect must be shown by both factual (*conditio sine qua non*) and legal causation (adequacy of causation).[504]

As for defences to liability, Austria chose to include the development risk defence. The state of the technology is seen as 'the highest imaginable standard of conduct, determined by the totality of any expertise available in science and technology'.[505]

The German acceptance of the product liability law has not been as widespread as in Austria.[506] In Germany, instead of implementing the EU Directive into the existing Civil Code, it was enacted as a separate law.[507] The German law tracks closely with the Directive, and one of the reasons is that 'German law considerably influenced the Directive'.[508] The law applies whether a product is put into

[500] Bernhard A Koch, 'Product Liability in Austria' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 146.
[501] Austrian PHG.
[502] Austrian PHG.
[503] Bernhard A Koch, 'Product Liability in Austria' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 127-8.
[504] Bernhard A Koch, 'Product Liability in Austria' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 137.
[505] Bernhard A Koch, 'Product Liability in Austria' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 139.
[506] Ulrich Magnus, 'Product Liability in Germany' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 243.
[507] Ulrich Magnus, 'Product Liability in Germany' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 241
[508] Ulrich Magnus, 'Product Liability in Germany' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 241

circulation for commercial or non-commercial purposes, so the law is not restricted to protecting consumers.[509]

German law implements the risk development defence, though the standard appears to be slightly different from other jurisdictions. The 'knowledge must be more or less certain and accepted by the respective community of scientists and technicians' and 'it is necessary that a real alternative already exists that has been successfully tested and shown to be better than the present product, and that it can be produced with reasonable means and efforts'.[510] It is not enough that the knowledge exists and is available, but it has to have garnered acceptance and be shown to be replicable. This may make the scope of the defence broader than other jurisdictions that do not explicitly have the latter requirement. The defence not only includes construction defects, but it also includes instruction defects where the producer 'did not warn against dangers which were not known at the time the product and the instruction were put into circulation'.[511]

The German product liability law is seen to be capable of being applied to new technologies so long as it is not interpreted restrictively, as it has shown to be able to adapt to new trends.[512] The fact that it is a separate law is also seen as an advantage for easier amendments.[513]

1.4.6 Central European Approach

The EU Directive was implemented into the Polish Civil Code by the Act of 2 March 2000 on the protection of certain consumer rights, on product liability and the amendment of the Civil Code. Consistent with the Directive, the claimant must show defect, damage, and causation to support a product liability claim. Instead of using the term 'defective product', the Civil Code uses 'unsafe (dangerous) product'.[514] The rationale was to distinguish product liability from breach of warranties.[515] Despite the different wording, the definition is consistent with the Directive.[516] As for causation, there is a two-prong test: 'the causal link between the marketing of the product and the creation of the risk of damage, and then the causal link between the realisation of that risk and the damage inflicted by the claimant'.[517] The state of the art defence is available in the Civil Code.[518]

[509] Ulrich Magnus, 'Product Liability in Germany' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 255.
[510] Ulrich Magnus, 'Product Liability in Germany' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 262-63.
[511] Ulrich Magnus, 'Product Liability in Germany' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 263.
[512] Ulrich Magnus, 'Product Liability in Germany' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 273-74.
[513] Ulrich Magnus, 'Product Liability in Germany' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 241.
[514] Ewa Bagińska, 'Product Liability in Poland' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 384.
[515] Ewa Bagińska, 'Product Liability in Poland' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 384.
[516] Ewa Bagińska, 'Product Liability in Poland' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 384.
[517] Ewa Bagińska, 'Product Liability in Poland' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 392.
[518] Ewa Bagińska, 'Product Liability in Poland' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 394.

Another affirmative defence is that the defect was not revealed when put into the market, but the claimant can overcome this defence by showing that the defect was inherent.[519]

While the Directive is meant to protect consumers, Polish law allows for the same regime to apply to commercial parties and in commercial transactions.[520] However, as with the Directive, the product liability regime is not applicable to legal persons.[521]

In the Czech Republic, Act No 59/1998 Sb on Product Liability implemented the EU Directive into national law. It is a separate law distinct from the Civil Code.[522] Article 4 of the Directive spelling out the elements of defect, damage, and causation was not implemented, but these elements are derived from general tort law.[523] In terms of causation, '[t]he current approach is based on the *conditio sine qua non* rule and on a doctrine of adequacy'.[524] The former refers to '[a]n activity or conduct…is a cause of the victim's damage if, in the absence of the activity, the damage would not have occurred'.[525] The latter means that 'the damage must have been foreseeable and must not have been too remote'.[526] The state of the art defence is also available.[527] Tichý asserts that because the definition of product is so vague in Czech law, it would be able to accommodate new technologies.[528] As such, the current regime should be able to be applied to robotics technology.

In Slovakia, on the other hand, the Directive was 'transposed word for word', with only slight deviations in the notion of product.[529] It was enacted as a separate Act No. 294/1999 rather than incorporated into the Civil code.[530] This was also the case in Hungary, where the Directive was implemented by Act No. X/1993, which was subsequently amended by Act No. XXXVI/2002 to track the amendments to the Directive.[531]

In both Poland and the Czech Republic, it appears that there are deviations from the Directive when implementing them into the domestic laws. There are no explicit provisions limiting their

519 Ewa Bagińska, 'Product Liability in Poland' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 399.
520 Ewa Bagińska, 'Product Liability in Poland' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 389-90.
521 Ewa Bagińska, 'Product Liability in Poland' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 391.
522 Luboš Tichý, '«EC Tort Law» and the Eastern-European Legal Family' Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 514.
523 Luboš Tichý, 'Product Liability in Czech Republic' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 154.
524 Luboš Tichý, 'Product Liability in Czech Republic' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 152.
525 European Group on Tort Law, *Principles of European Tort Law: Text and Commentary* (Springer 2005) 43.
526 Thomas Kadner Graziano and Christoph Oertel, '«EC Tort Law» and the German Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 467.
527 Luboš Tichý, 'Product Liability in Czech Republic' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 152.
528 Luboš Tichý, 'Product Liability in Czech Republic' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 154.
529 Luboš Tichý, '«EC Tort Law» and the Eastern-European Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 514.
530

Luboš Tichý, '«EC Tort Law» and the Eastern-European Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 514.

531

Luboš Tichý, '«EC Tort Law» and the Eastern-European Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 516.

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applicability to consumer protection, so the product liability regimes would likely also apply to commercial parties who are purchasers of robots used for infrastructure maintenance and inspection. The state of the art defence is available to the producer in all the Member States in this section, which, like in the UK, means that litigation could be highly complex when they involve robotics technology.

1.4.7 Nordic Approach

In general, Scandinavian countries see tort law as a preventative mechanism and position the state as the institution that should cover the costs of personal injuries.[532] The Danish Product Liability Act came into effect in 1989 and coexists with previous case law.[533] Today, 'both the court-developed principles (CDPL) and the rules of the PLA apply to personal injury and damage to consumers' property whereas only the court-developed principles apply to damage to non-consumer property'.[534]

The court-developed principles operate on a fault basis, in contrast with the strict liability regime of the product liability law.[535] Danish courts 'often assume causation once the plaintiff has proven a violation of safety rules or clear negligence'.[536] The state of the art defence is incorporated in the law without changes from the Directive.[537]

Product liability cases are rare in Denmark. Holle notes:

> The most likely reason for this is that products on the Danish market are generally relatively safe, because product safety tends to be more a question of preventing than curing. Thus, there are detailed obligations that producers and suppliers must comply with before products can be put onto the market. In addition, the relevant authorities generally seem to be rather active enforcing rules on safety, both before and after products are put into circulation.[538]

Holle also argues that the current regime should be able to accommodate new technologies even if the question of what constitutes a product would have to be evaluated, but such a development should occur above the national level.[539]

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[532] Bjarte Askeland and Vibe Ulfbeck, «EC Tort Law» and the Scandinavian Legal Family' in Helmut Koziol and Reiner Schulze (eds) *Tort Law of the European Community* (Springer 2008) 490.
[533] Marie-Louise Holle, 'Product Liability in Denmark' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 156.
[534] Marie-Louise Holle, 'Product Liability in Denmark' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 157.
[535] Marie-Louise Holle, 'Product Liability in Denmark' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 167.
[536] Marie-Louise Holle, 'Product Liability in Denmark' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 165.
[537] Marie-Louise Holle, 'Product Liability in Denmark' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 167.
[538] Marie-Louise Holle, 'Product Liability in Denmark' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 171.
[539] Marie-Louise Holle, 'Product Liability in Denmark' in Piotr Machnikowski (ed) *European Product Liability: An Analysis of the State of the Art in the Era of New Technologies* (Intersentia 2016) 172.

2 Robots for M&I: Related Works and Conceptual Overview

The European Union has been very active in fostering the development of artificial intelligence in the past few years. The *EU Declaration on Cooperation on Artificial Intelligence* was signed in April 2018. The Member States agreed to work toward 'a comprehensive and integrated European approach on AI and, where needed, review and modernise national policies to ensure that the opportunities arising from AI are seized and the emerging challenges addressed'.[540] Specifically, the signatories agree to cooperate on '[e]nsuring an adequate legal and ethical framework, building on EU fundamental rights and values, including privacy and protection of personal data, as well as principles such as transparency and accountability'.[541] The Declaration, a non-binding instrument, has been signed by all EU Member States and Norway.[542]

The European Commission organised a workshop in January 2018 with the European Association for Artificial Intelligence that resulted in a report entitled *The European AI Landscape* that included country reports from Member States on the AI ecosystem.[543] *Communication on AI: Artificial Intelligence for Europe* and *Coordinated Plan on the Development and Use of Artificial Intelligence Made in Europe* were both published by the European Commission in 2018. The former was a response to the European Council's invitation to draft 'a European approach to artificial intelligence' and calls for a 'coordinated approach to make the most of the opportunities offered by AI and to address the new challenges that it brings'.[544] The latter's goals are 'to maximise the impact of investments at EU and national levels, encourage synergies and cooperation across the EU, including on ethics, foster the exchange of best practices and collectively define the way forward'.[545] It encourages Member States to formulate national artificial intelligence strategies and designates the Member States' Group on Digitising European Industry and Artificial Intelligence as the entity to coordinate amongst the Member States and other stakeholders.[546] The European Commission also released *Building Trust in Human-Centric Artificial Intelligence* in April 2019.[547]

European Commission President Ursula Gertrud von der Leyen who started her term on 1 December 2019 put artificial intelligence as one her top agenda items and vowed to 'put forward legislation for a coordinated European approach on the human and ethical implications of Artificial Intelligence' within her first 100 days in office.[548]

The High-Level Expert Group on Artificial Intelligence formed by the European Commission and comprising experts from academia, civil society, and industry, released three reports in 2019. *Ethics Guidelines for Trustworthy AI*, published in April 2019, provides a framework for trustworthy AI, which should be lawful, ethical, and robust.[549] Concurrently, it also released the *A Definition of AI: Main Capabilities and Disciplines*, which proposes a definition of artificial intelligence:

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540 https://ec.europa.eu/jrc/communities/en/community/digitranscope/document/eu-declaration-cooperation-artificial-intelligence.
541 https://ec.europa.eu/jrc/communities/en/community/digitranscope/document/eu-declaration-cooperation-artificial-intelligence.
542 http://lcfi.ac.uk/media/uploads/files/Stix_Europe_AI_Final.pdf 10.
543 http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=51262.
544 https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=51625.
545 https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=56017.
546 https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=56017.
547 https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=58496.
548 https://ec.europa.eu/commission/sites/beta-political/files/political-guidelines-next-commission_en.pdf 13.
549 https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60419 2.

> Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans3 that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions.
>
> As a scientific discipline, AI includes several approaches and techniques, such as machine learning (of which deep learning and reinforcement learning are specific examples), machine reasoning (which includes planning, scheduling, knowledge representation and reasoning, search, and optimization), and robotics (which includes control, perception, sensors and actuators, as well as the integration of all other techniques into cyber-physical systems).[550]

In June 2019, the High-Level Expert Group also released the *Policy and Investment Recommendations for Trustworthy AI* containing '33 recommendations that can guide Trustworthy AI towards sustainability, growth and competitiveness, as well as inclusion – while empowering, benefiting and protecting human beings'.[551] A second group created by the European Commission is the European AI Alliance. An online platform, membership is open to all and it allows interested parties to engage in discussions with each other and to communicate with the High-Level Expert Group.[552]

For artificial intelligence to function, algorithms are key. Toward that end, the European Commission is conducting a study on algorithmic transparency, which is 'an important safeguard for accountability and fairness in decision-making'.[553]

In addition, *Opinion on AI: Artificial Intelligence – The Consequences of Artificial Intelligence on the (Digital) Single Market, Production, Consumption, Employment and Society* was published by the European Economic and Social Committee in August 2017 and *Artificial Intelligence, Robotics and 'Autonomous Systems'* was released by the European Group on Ethics in Science and New Technologies in March 2018, both of which raise important issues related to the development and use of artificial intelligence, including ethics, privacy, and accountability.[554]

On robotics specifically, the European Parliament passed a resolution on Civil Law Rules on Robotics on 16 February 2017 informed by the results of the RoboLaw Project. It requested the Commission to propose definitions of smart robots and autonomous systems, foster scientific research, study necessary legal reform guided by ethical principles, coordinate cooperation amongst Member States, and work on safety standards for safety and security.[555]

The European Parliament's Legal Affairs Committee also commissioned a report in 2016 entitled *European Civil Law Rules in Robotics*. The report analysed the definitions of robots, their possible consciousness, liability issues arising from their use, and an ethical framework for robotics.[556] This report took the approach that artificial intelligence is a key component of robotics technology.[557] Liability issues of artificial intelligence was also addressed by the November 2019 report on *Liability for Artificial Intelligence and Other Emerging Technologies* drafted by the Expert Group on Liability

[550] https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60651 6.
[551] https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60343 6.
[552] https://ec.europa.eu/digital-single-market/en/european-ai-alliance.
[553] https://ec.europa.eu/digital-single-market/en/algorithmic-awareness-building.
[554] http://lcfi.ac.uk/media/uploads/files/Stix_Europe_AI_Final.pdf 15-16.
[555] http://www.europarl.europa.eu/doceo/document/TA-8-2017-0051_EN.html.
[556] https://www.europarl.europa.eu/RegData/etudes/STUD/2016/571379/IPOL_STU(2016)571379_EN.pdf.
[557] Corinne Cath, 'Artificial Intelligence and the "Good Society": The US, EU, and UK Approach' (2018) 24 Sci Eng Ethics 505, 515.

and New Technologies – New Technologies Formation.[558] The report discusses current civil liability regimes and the challenges that may be faced when attempting to apply them to new technologies.

It is in this context that the current report addresses the issues of safety, regulation, and liability of robotics technology for infrastructure inspection and maintenance. It should be noted that this report focuses on robots that operate in the air, on land, and in the waters because of the general availability of safety and legal regulations concerning these types of technology. Other types of robots that are not aerial drones, autonomous vehicles or autonomous vessels/submersibles, including crawlers and manipulator arms, are also used for infrastructure inspection and maintenance. If the particular robots fall under the definitions of the systems focused in this report, the safety and legal regulations would also apply. Otherwise, there may be gaps in the regime that need to be filled. As for liability issues, the fault-based, strict liability, and product liability regimes would all be applicable to robotics technology so long as the elements of the laws are met.

2.1 Unmanned Aircraft Systems

Aerial drone terminology, much like the technology, is varied and has changed throughout the years. Remotely Piloted Vehicle was the term used in the 1960s, but it is now rarely used.[559] Other terms include unmanned aircraft, remotely piloted aviation systems, remotely piloted aircraft systems, unmanned drones, autonomous drones, and unmanned aerial vehicles (UAV).[560] The European Union uses the term unmanned aircraft systems (UAS) to include both the UAV and the remote controlling equipment.[561]

Though usage of drones in everyday life has been a relatively recent development, language in the Paris Convention of 1919,[562] which was then incorporated into the Convention on International Civil Aviation (also known as the Chicago Convention) that was signed in 1944, refers to the flying of aircraft without pilots. Today, all United Nations states are signatories of the Chicago Convention; consequently, all European Union Member States are bound by the Convention.[563] Article 8 of the Convention forbids an 'aircraft capable of being flown without a pilot' from operating without state authorisation and requires states to take necessary safety measures to prevent accidents resulting from pilotless aircraft. Remote control aircraft, which were developed and used for World War I, were the original intended targets of this provision.[564] Military drones gained widespread usage in World War II and the Vietnam War, but civilian use of drones did not start to emerge until much later as a result of advancements in sensory and communication equipment, GPS technology, and computer processing power.[565] While fully autonomous drones that require no human supervision are being developed, they are not currently in commercial use.[566] If and when they are widely

[558] https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=63199.
[559] Muhammad Nadeem Mirza et al, 'Unmanned Aerial Vehicles: A Revolution in the Making' (2016) 31 Research Journal of South Asian Studies 625, 627.
[560] Benjamyn I Scott, 'Terminology, Definitions and Classifications' in Benjamyn I Scott (ed), *The Law of Unmanned Aircraft Systems: An Introduction to the Current and Future Regulation under National, Regional and International Law* (Wolters Kluwer, 2016) 9, 10-12.
[561] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0945&from=EN.
[562] Convention Relating to the Regulation of Aerial Navigation (signed 13 October 1919) art 15.
[563] 'Convention on International Civil Aviation Signed at Chicago on 7 December 1944' <www.icao.int/secretariat/legal/List%20of%20Parties/Chicago_EN.pdf> accessed 29 November 2019.
[564] IWM Staff, 'A Brief History of Drones' (30 January 2018) <www.iwm.org.uk/history/a-brief-history-of-drones> accessed 29 November 2019; ICAO Circular 328-AN/190 para 4.3.
[565] Lloyd's, 'Drones Take Flight: Key Issues for Insurance' (2015) 2.
[566] Roger Clarke, 'Understanding the Drone Epidemic' (2014) 30 Computer Law and Security Review 230, 233; Robert Harwood, 'The Challenges to Developing Fully Autonomous Drone Technology' ANSYS Blog, 21 November 2019 <www.ansys.com/blog/challenges-developing-fully-autonomous-drone-technology>.

deployed, it is still likely a human pilot would act as a supervisor to ensure the drone is functioning properly. Consequently, because drones are currently semi-autonomous at best, the existence of a remote pilot is necessary, a fact reflected in the regulatory measures. Non-autonomous drones operate 'on the basis of interpretation of data collected via an on-board camera, radar, satellite or other means', whereas autonomous drones 'on the basis of preprogrammed instructions or artificial intelligence, processing data collected from on-board sensors and from other sources (e.g. radar or satellite tracking)'.[567]

2.1.1 Standardisation, Assurance and Certification

This section aims to provide existing safety practitioners with a high-level introduction to the application of safety and risk management processes to unmanned aircraft systems to reduce the complexity of the open challenges problem of UAS operations where the safety model requires more than a solid safety case.

As UAS software-intensive systems become more pervasive and critical, more and more new safety solutions are being developed to solve the UAS open challenges. Safety criteria are a set of high-level goals to define the minimum behavioural properties which must be fulfilled to enforce the safety context. Safety criteria are divided into two categories: qualitative and quantitative, based on ISO 2018 safety criteria are term of references used to determine whether a specified level of risk is acceptable or tolerable. Authors in[568] summarised examples of both categories of safety criteria specification which will be presented in the following table.

Safety statement from standard or regulation (Unmanned aircraft system)	**Page in Original document**	**Source**
"The principal objective of the aviation regulation framework is to achieve and maintain the highest possible uniform level of safety. In the case of UAS, this means ensuring the safety of any other airspace user as well as the safety of persons and property on the ground." … will provide, at a minimum, an equivalent level of safety for the integration of UAS into non-segregated airspace and at aerodromes." "The introduction of RPA [remotely piloted aircraft] must not increase the risk to other aircraft or third parties and should not prevent or restrict access to airspace."[569]	P.4 and P.17	ICAO circular (ICAO 2011)
"UAV operations should be as safe as manned aircraft insofar as	P.11 and P.18	CASA

[567] Kristian Bernauw 'Drones: The Emerging Era of Unmanned Civil Aviation' 227
[568] Clothier, R. A., & Walker, R. A. (2015). Safety risk management of unmanned aircraft systems. *Handbook of unmanned aerial vehicles*, 2229-2275.
[569] Circular, I. C. A. O. (2011). 328, Unmanned Aircraft Systems (UAS). *Montreal, Canada: International Civil Aviation Organization (ICAO)*.

they should not present or create a hazard to persons or property in the air or on the ground greater than that created by manned aircraft of equivalent class or category." "When considering a request for approval to conduct a particular operation with a UAV, CASA must ensure that the operation of the UAV will pose no greater threat to the safety of air navigation than that posed by a similar operation involving a manned aircraft. This characteristic may be termed 'acceptable'."[570]		advisory circular (CASA 2002)
"… UAS operations must be as safe as manned aircraft insofar as they must not present or create a greater hazard to persons, property, vehicles or vessels, whilst in the air or on the ground, than that attributable to the operations of manned aircraft of equivalent class or category."[571]	Section 1, Chapter 1, p.1	CAA-UK Guidance material
"A civil UAS must not increase the risk to people or property on the ground compared with manned aircraft of equivalent category."[572]	P.4	EASA Policy statement
"Enable the operation of small UAS by mitigating, to an acceptable level of risk, the hazards posed to manned aircraft and other airborne objects operating in the National Airspace System (NAS) as well as the public on the surface." "Any sUAS may be operated in such a manner that the associated risk of harm to persons and property not participating in the operation is expected to be less than acceptable threshold value(s) as specified by the Administrator." [573]	P.53	Recommendations from the Aviation Rule-making Committee, FAA (SUAS 2009)

Table 4. Safety Qualitative Specifications for UAS Systems

[570] Australia, C. A. S. A. (2002). AC 101-1 (0)–Unmanned Aircraft Rockets–Unmanned Aerial Vehicle (UAV) Operations, Design Specification, Maintenance and Training of Human Resources. *Advisory Circular, July*.
[571] Clark, S., Gray, N. V., & CAA, U. GUIDANCE ON ORGANISATIONAL STRUCTURES.
[572] Directorate, E. R. (2009). Policy Statement Airworthiness Certification of Unmanned Aircraft Systems (UAS), E. *Y013-01*, *25*.
[573] Small Unmanned Aircraft System Aviation Rulemaking Committee. (2009). Comprehensive set of recommendations for sUAS regulatory development. *Federal Aviation Administration*.

Qualitative specifications are also proposed to quantify safety criteria. These quantitative measures are calculated from historical data. U.S. Range Commanders Council (RCC 1999; RCC 2001)574 and Dalamagkidis et al. (Dalamagkidis, Valavanis et al. 2008)575 proposed a metric of number of ground fatalities per flight hour, $1.0 \times 10^6$and 1.0×10^6 respectively. Another measure, the number of involuntary ground fatalities per flight hour, has been proposed by Clothier et al. (2006)576 and Weibel et al. (Weibel and Hansman 2004)577. Australian Defence Force airworthiness regulations (ADF 2009)578 and ADF airworthiness regulations (ADF 2009)579 proposed the nominal likelihood of a mishap causing serious injury, loss of life or significant damage per flight hour 1.0×10^8. These measures are based on the historical data which makes the measure very sensitive to the targeted period.580.

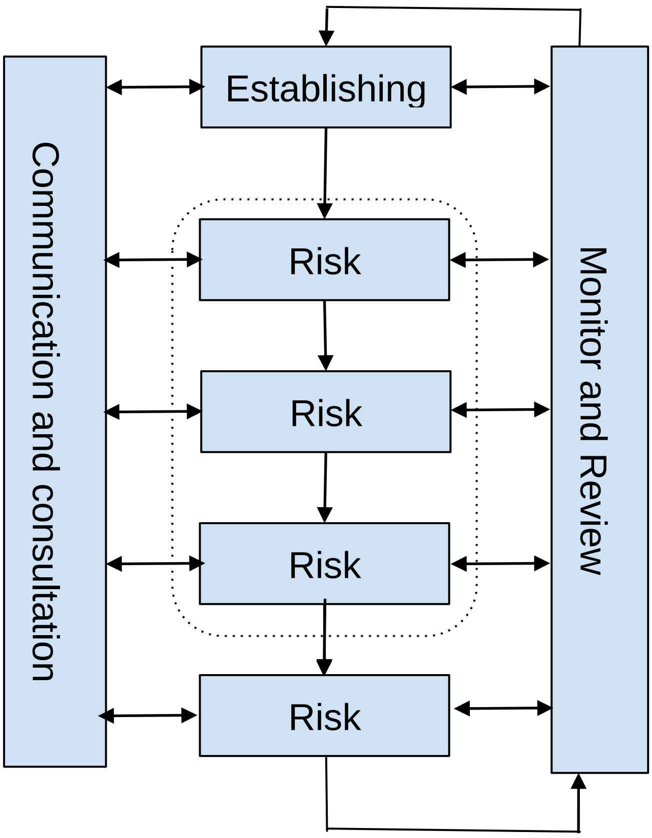

Figure 2. Risk Management Life Cycle

- **Functional Hazard Analysis –**

[574] IRIG, R. C. C. S. 106-04, Telemetry Standards.
[575] Dalamagkidis, K., Valavanis, K. P., & Piegl, L. A. (2008). On unmanned aircraft systems issues, challenges and operational restrictions preventing integration into the National Airspace System. *Progress in Aerospace Sciences*, *44*(7-8), 503-519.
[576] Clothier, R. A., & Walker, R. A. (2006). Determination and evaluation of UAV safety objectives.
[577] Weibel, R. E., & Hansman, R. J. (2006). *Safety considerations for operation of unmanned aerial vehicles in the national airspace system*.
[578] Australian Defence Force airworthiness regulations (ADF 2009)
[579] Smith, P. A. (2007). Aussie UAV Activities: Gaining Momentum. *Association for Unmanned Vehicle Systems International Journal*, *25*(1), 17.
[580] Clothier, R. A., & Walker, R. A. (2015). Safety risk management of unmanned aircraft systems. *Handbook of unmanned aerial vehicles*, 2229-2275.

A predictive risk identification which analyses the safety at different levels of the aircraft system, the identification aims to identify the functional failure of the aircraft system components.581

- **Failure Modes and Effects Analysis (FMEA) –**

FMEA is the process of reviewing how the different subsystems (Components) can fail by identifying the possible failure modes and their interactions. The process also identifies the effects of failure modes on other components, and these analysis can be qualitative or quantitative by using the failure rates. [582]

- **Hazard and Operability Analysis (HAZOP) –**

This is a structured, systematic and qualitative technique for system examination and risk management. HAZOP is a brainstorming approach which identifies the contribution of identified hazard to a system failure. 583

- **Common Cause Analysis (CCA)–**

CCA identifies the common events which contribute to single system failure and aggregates causes from different events to identify the failure causes.584

- **Fault Tree Analysis –**

A top-down graphical risk identification based on boolean logic, FTA is a deductive method which provides information on how the undesired event can contribute to system failure.

2.1.2 Meeting standards: ARP4754 (Aerospace Recommended Practice)

- **ARP4754**

Aerospace Recommended Practice (ARP) ARP4754A (Guidelines For Development Of Civil Aircraft and Systems). ARP4754 is a set of guidelines provided by SAE International (**Society of Automobile Engineers**) to support the development processes of aircraft system, which led to certification of those systems, it addresses the complete aircraft development cycle, including systems requirements, system design and system verification[585]. SAE ARP 4754 has been applied to certify complex electronic systems of civil aircraft since 1996.

- **Aircraft development process and assurance level**

The next figure is a general illustration of an aircraft system development from conceptual definition to certification. The first phase contains research and preliminary development steps which describes the full configuration of the system, the following step will be based on this overall

[581] ARP4754, S. A. E. (1996). Certification considerations for highly-integrated or complex aircraft systems. *SAE, Warrendale, PA*.
[582] Gilchrist, W. (1993). Modelling failure modes and effects analysis. *International Journal of Quality & Reliability Management*, *10*(5).
[583] Kennedy, R., Jones, H., Shorrock, S., & Kirwan, B. (2000). A HAZOP analysis of a future ATM system. *Contemporary Ergonomics*, 2-6.
[584] Eurocontrol, F. A. A. (2007). Communications operating concept and requirements for the future radio system (cocr). *Eurocontrol/FAA*.
[585] Bill Potter. *Complying with DO-178C and DO-331 using Model-Based Design* (PDF). SAE 2012 Aerospace Electronics and Avionics Systems Conference (12AEAS). MathWorks, Inc. Retrieved 2019-02-13.

configuration of the system. The development phase contains four steps which start by defining each function from the concepts phase and ends with the implementation step, this process is repetitive after any changes or improvements on the overall functions of the system. The Production/operation phase is the final phase which is readying the implementation of the development phase.

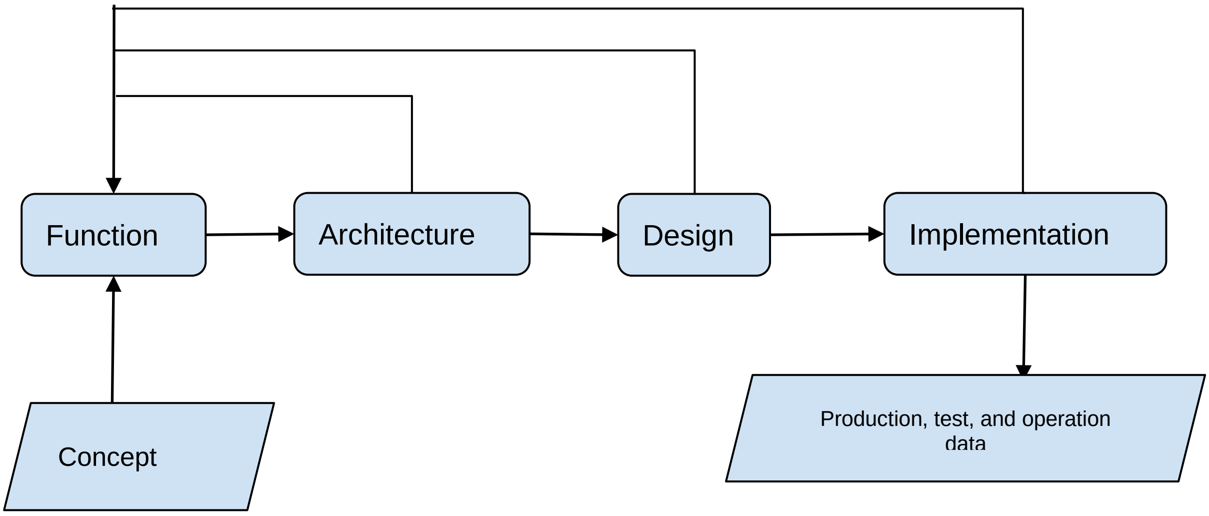

Figure 3.Aircarft System General Development Life Cycle

Each function of the aircraft system has a development assurance level (DAL), which indicates the level of rigor of the development of a function of an aircraft system. DALs are divided in five classes of failure condition:

- **Catastrophic**:

Failure may cause a crash. Error or loss of critical function required to safely fly and land aircraft.

- **Hazardous:**

Failure has a large negative impact on safety or performance, or reduces the ability of the crew to operate the aircraft due to physical distress or a higher workload, or causes serious or fatal injuries among the passengers. (Safety-significant)

- **Major**:

Failure is significant, but has a lesser impact than a Hazardous failure (for example, leads to passenger discomfort rather than injuries) or significantly increases crew workload (safety related)

- **Minor**:

Failure is noticeable, but has a lesser impact than a Major failure (for example, causing passenger inconvenience or a routine flight plan change)

- **No Effect:**

Failure has no impact on safety, aircraft operation, or crew workload.

These five assurance levels are classification of any potential software failure. The software components are divided in their development to classes based on the severity of the effect on safety. The following table shows the amount of rigor required in the software development life cycle.

Level	Failure condition	Failure rate	Objectives	With independence
A	Catastrophic	≤ 1x10-9	71	33
B	Hazardous	≤ 1x10-7	69	21
C	Major	≤ 1x10-5	62	8
D	Minor	1x10-5	26	5
E	No safety effects	N/A	0	0

Table 5. Design Assurance Levels (DAL)

2.1.3 Legislation and Policy

It is now important to consider the legislation and policy that is applicable to the use of drone technology. First, the relevant international regime will be considered briefly. Second is a discussion of relevant EU regulation. Third, examples of national laws which regulate drones in a handful of EU Member States will be considered. This is done in order to highlight the variance which exists between them. Finally, liability issues which could arise through the use of drone technology will be outlined.

2.1.3.1 International Regime

The Chicago Convention led to the establishment of the International Civil Aviation Organization (ICAO), which is a United Nations body that aims to achieve uniformity in international civil aviation regulation.[586] ICAO considers drones aircraft and existing references to aircraft in its documents are applicable to drones.[587] Nonetheless, ICAO has established an RPAS panel to systemically amend the Annexes to the Chicago Convention to reflect the reality of the widespread use of UAVs.[588] The approach to not segregate the regulatory frameworks for manned and unmanned aircraft means that there is not a total lack of regulations to accommodate the newly developed technology because existing regulations on manned aviation would also be applicable to drones.[589] However, there remains gaps to be filled. Importantly, the lack of harmonisation may cause difficulties even if drones were to operate within domestic airspace or on the high seas, as they may be in the vicinity of aircraft registered in other states.[590] ICAO has also developed a toolkit for drones.

[586] The History of ICAO and the Chicago Convention <www.icao.int/about-icao/History/Pages/default.aspx> accessed 29 November 2019.
[587] ICAO Circular 328-AN/190 para 2.5-2.6.
[588] Anna Masutti and Filippo Tomasello, *International Regulation of Non-Military Drones* (Edward Elgar 2018).
[589] Biljana M Cincurak Erceg, 'Legal Regulation of Unmanned Aircraft Systems in the European Union with Reference to the Legislation of the Republic of Croatia''(2019) 53 Zbornik Radova 327, 330.
[590] Kristian Bernauw, 'Drones: The Emerging Era of Unmanned Civil Aviation' (2016) 66 Collected Papers of Zagreb Law Faculty - Zbornik Pravnog Fakulteta U Zagrebu 223, 234.

2.1.3.2 The EU Position

The European Union has taken the development and regulation of drones very seriously. As far back as 2002, the Joint Aviation Authorities (JAA), the predecessor of the EASA, cooperated with the European Organization for the Safety of Air Navigation (EUROCONTROL) to form a UAV Task Force.[591] Its aim was to develop guidelines for regulating drones for civil use.[592] Consultation meetings were held on this subject. One such meeting, the Riga Conference, resulted in the Riga Declaration on remotely piloted aircraft (drones) in 2015, which included five guiding principles for the development of a European regulatory framework: 1. Drones should be treated as new types of aircraft with risk-based regulation; 2. safety measures governing drone use must be developed forthwith; 3. investment in technological advances is necessary to achieve full integration of drones into the European airspace; 4. public acceptance of drone usage is a key consideration; and 5. The drone operator is ultimately responsible for its usage.[593]

The European Aviation Safety Agency (EASA) released its Concept of Operations for Drones: A risk based approach to regulation of unmanned aircraft in 2015, which first categorised the types of drone operations as open, specific, and certified. This three-pronged approach forms the basis of the eventual European-wide regulation.[594] Later in the same year, the EASA also released a Technical Opinion, which it was tasked with at the Riga Conference.[595] The Opinion consists of twenty-seven proposals for a framework to regulate the use of drones in Europe. The EASA collaborated with the Joint Authorities for Rulemaking on Unmanned Systems (JARUS), consisting of international aviation regulatory experts, to devise a single set of guidelines for the certification of UAS.[596]

The attention paid to UAVs by the EU has resulted in a much more developed regulatory regime compared to other types of robots. Regulatory measures currently exist in most Member States, all of which will be replaced by a common rule in July 2020 with the publication of the Commission Delegated Regulation (EU) 2019/945 and the Commission Implementing Regulation (EU) 2019/947 in June 2019. This means that once a drone is certified for usage in one Member State, it can be legally operated throughout the European Union. It should be noted that the European Union regulations are not applicable to UAS 'intended to be exclusively operated indoors', which may mean that certain RIMA technologies may be exempt if the inspection and maintenance occur indoors.[597]

- ***Risk-based Categorisation***

Under the new common rule, UAS operations are divided into three risk-based categories: open, specific, and certified, and each category has its own requirements operators of drones must meet

[591] The Joint JAA/EUROCONTROL Initiative on UAVs, 'UAV Task-Force Final Report: A Concept for European Regulations for Civil Unmanned Aerial Vehicles (UAVs)' <www.easa.europa.eu/system/files/dfu/NPA_16_2005_Appendix.pdf> accessed 29 November 2019.
[592] Claudia Stöcker et al, 'Review of the Current State of UAV Regulations' (2017) 9 Remote Sensing 459, 466.
[593] Riga Declaration on Remotely Piloted Aircraft (drones): "Framing the Future of Aviation" Riga - 6 March 2015 <ec.europa.eu/transport/sites/transport/files/modes/air/news/doc/2015-03-06-drones/2015-03-06-riga-declaration-drones.pdf> accessed 29 November 2019.
[594] EASA, 'Concept of Operations for Drones: A Risk Based Approach to Regulation of Unmanned Aircraft' 3-6 <www.easa.europa.eu/sites/default/files/dfu/204696_EASA_concept_drone_brochure_web.pdf> accessed 29 November 2019.
[595] EASA, 'Technical Opinion: Introduction of a Regulatory Framework for the Operation of Unmanned Aircraft' 4 <www.easa.europa.eu/sites/default/files/dfu/Introduction%20of%20a%20regulatory%20framework%20for%20the%20operation%20of%20unmanned%20aircraft.pdf> accessed 29 November 2019.
[596] Joint Authorities for Rulemaking on Unmanned Systems <jarus-rpas.org/> accessed 29 November 2019.
[597] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 2(4).

before they can be deployed.[598] This risk-based approach and proportional risk mitigation measures for each category is a hallmark of retaining the flexibility of the regulations in a comprehensive regulatory approach.[599] Open operations do not require prior authorisation or operational declaration.[600] Specific operations require authorisation or declaration, depending on the circumstances, and certified operations require certification of the UAS and certification of the operator and licensing of the pilot before the drones can be operated.[601] The operator is the legal entity responsible for the UAV, whereas the pilot is the actual person in control of the drone.[602]

Operations are considered open, or low risk, when six conditions are met. First, the 'UAS belongs to one of the classes set out in Delegated Regulation (EU) 2019/945 or is privately built',[603] or while not complying with the Delegated Regulation, meets the definition of Decision No 768/2008/EC and was 'placed on the market before 1 July 2022'.[604] There are five classes, ranging from 0 to 4, which are divided by the maximum take-off mass (MTOM) of the UAV.[605] A class C0 UAV has a MOTM of less than 250 g including payload,[606] while a class C4 UAV has a MOTM of less than 25 kg including payload.[607]

598 For a discussion on the advantages of the European regulatory regime, see Adem Ilker, 'Regulating Commercial Drones: Bridging the Gap Between American and European Drone Regulations' (2016) 15 Journal of International Business and Law 313.
599 Biljana M Cincurak Erceg, 'Legal Regulation of Unmanned Aircraft Systems in the European Union with Reference to the Legislation of the Republic of Croatia' (2019) 53 Zbornik Radova 327, 338.
600 Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 3(a).
601 Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 3(b)-(c).
602 Luna Vanderispaillie, 'Remote Pilot or UAS Operator? To-ma-to, To-mah-to or Significant Difference? An International Legal Perspective' <www.unifly.aero/news/remote-pilot-or-uas-operator> accessed 29 November 2019.
603 Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 4(a).
604 Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 20.
605 Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Annex Parts 1-5.
606 Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Annex Part 1(1).
607 Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Annex Part 5(1).

UAS		Operation			Operator/pilot	
Class	MTOM	Subcategory	Operational restrictions	Distance from people	Operator Registration Required	Remote pilot competence
Privately built C0	< 250 g	A1	▪Operate in visual line of sight below 120 m altitude ▪Fly away from airports ▪Respect specific rules defined by the zone in which you operate	You can fly over uninvolved people (not over crowds)	No	Read owner manual
C1	< 900 g				Yes	▪Read owner manual ▪Perform online training ▪Pass online test
C2	< 4 kg	A2		You can fly at a safe distance from uninvolved people		▪Read owner manual ▪Perform online training ▪Pass online test ▪Pass a theoretical test in a centre recognised by the aviation authority (only if you intend to fly close to non involved people)
C3 C4 (model aircraft) Privately built	< 25 kg	A3		You should: ▪ Fly in an area where it is reasonably expected that no uninvolved people will be endangered ▪ Keep a safety distance from urban areas		▪ Read owner manual ▪ Perform online training ▪ Pass an online test

Second, the maximum take-off mass is less than 25 kg.[608] Third, the pilot maintains a safe distance between the drone and people and does not fly over 'assemblies of people'.[609] Assemblies of people is defined as 'gatherings where persons are unable to move away due to the density of the people present'.[610] Fourth, the remote pilot must keep the drone in visual line of sight unless the drone is 'flying in follow-me mode or when using an unmanned aircraft observer as specified in Part A of the Annex'.[611] Follow-me mode is when the UAV 'constantly follows the remote pilot within a predetermined radius'.[612] Fifth, the drone is 'maintained within 120 metres from the closest point of the surface of the earth, except when overflying an obstacle, as specified in Part A of the Annex'.[613] And finally, the drone 'does not carry dangerous goods and does not drop any material'.[614] Open categories operations are further divided into three categories 'on the basis of operational limitation, requirements for the remote pilot and technical requirements for UAS'.[615] The subcategories are A1, A2, and A3 and trigger different requirements.[616]

Figure 4. Aerial Drone Classifications (Credit: https://dronerules.eu)

[608] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 4(b).
[609] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 4(c).
[610] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 2(3).
[611] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 4(d). Annex Part A UAS.OPEN.060(4) states: '[R]emote pilots may be assisted by an unmanned aircraft observer, situated alongside them, who, by unaided visual observation of the unmanned aircraft, assists the remote pilot in safely conducting the flight. Clear and effective communication shall be established between the remote pilot and the unmanned aircraft observer.'
[612] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 2(14).
[613] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 4(e). Annex Part A UAS.OPEN.010(3) states: 'When flying an unmanned aircraft within a horizontal distance of 50 metres from an artificial obstacle taller than 105 metres, the maximum height of the UAS operation may be increased up to 15 metres above the height of the obstacle at the request of the entity responsible for the obstacle.'
[614] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 4(f).
[615] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019UAS.OPEN.010(1).
[616] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Annex Part A.

Operations that do not meet one or more of the above requirements are categorised as specific, which is considered moderate risk, and operators must obtain authorisation prior to flying the drones.[617] The application for authorisation must include a risk assessment of the operation.[618] This risk assessment should be detailed and must 'describe the characteristics of the UAS operation', 'propose adequate operational safety objectives', 'identify the risks of the operation on the ground and in the air', 'identify a range of possible risk mitigating measure', and 'determine the necessary level of robustness of the selected mitigating measures in such a way that the operation can be conducted safely'.[619] The risks identified must take into account the possibility of endangering life or property on the ground, the characteristics of the drone, the purpose of the operation, the type of drone, and weigh 'the probability of collision with other aircraft and class of airspace used'.[620] Operators must also consider 'the type, scale, and complexity of the UAS operation or activity' and 'the extent to which the persons affected by the risks involved in the UAS operation are able to assess and exercise control over those risks'.[621] The regulations also require the inclusion of specific information on the operation,[622] 'target level of safety',[623] the risks,[624] and the measures sufficiently proportionate to mitigate the risks.[625]

In October 2019, the EASA released guidelines on how drone operators could comply with the risk assessment for the specific category by utilising the SORA (Specific Operation Risk Assessment) methodology, which was first drafted by JARUS.[626] The guidelines also include the first pre-defined risk assessment (PDRA) of many to be released in the coming years, which will streamline the process for operators when applying for authorisation.[627]

The competent authority evaluates the risk assessment and either grants the operational authorisation or denies the application with reasons for the rejection.[628] Should the operator wish to operate outside the state of registration of the UAS or conduct cross-border operations, it must submit details of the operations including the location and 'updated mitigation measures, if needed, to address those risks...which are specific to the local airspace, terrain and population characteristics and the climatic conditions'.[629]

[617] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 5(1).
[618] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 5(2).
[619] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 11(1).
[620] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 11(1)(c)(i)-(iii).
[621] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 11(1)(c)(iv)-(v).
[622] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 11(2).
[623] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019Article 11(3).
[624] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 11(4).
[625] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 11(5).
[626] EASA, 'Milestone achieved for safe drone operations in Europe EASA publishes Guidance Material (GM) and Acceptable Means of Compliance (AMC)' <www.easa.europa.eu/newsroom-and-events/news/milestone-achieved-safe-drone-operations-europe> accessed 29 November 2019; Joint Authorities for Rulemaking of Unmanned Systems, 'JARUS guidelines on Specific Operations Risk Assessment (SORA): Executive Summary' (30 January 2019) <jarus-rpas.org/sites/jarus-rpas.org/files/jar_doc_06_jjarus_sora_executive_summary.pdf> accessed 29 November 2019.
[627] EASA, 'Civil drones (Unmanned aircraft)' <www.easa.europa.eu/easa-and-you/civil-drones-rpas> accessed 29 November 2019.
[628] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 12(3).
[629] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 13(1)(b).

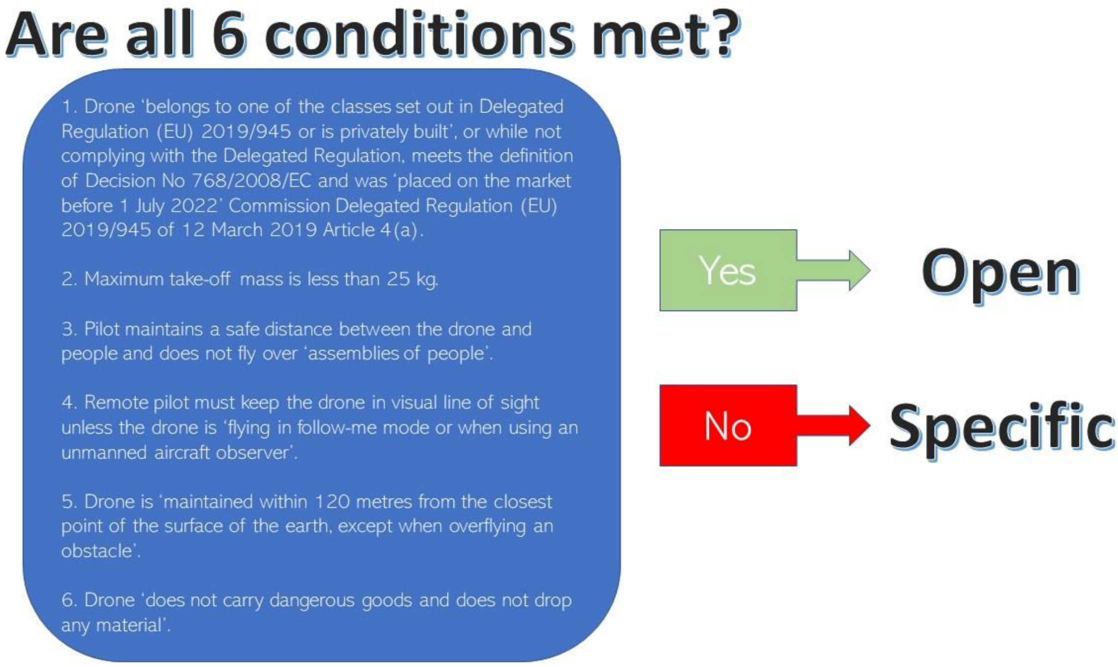

Figure 5. Open vs Specific Categories of Aerial Drones

Operations are high risk and must be certified if one of three conditions for the drone and one of three conditions for the operation are met. For the UAS, the drone has a 'characteristic dimension of 3 m or more, and is designed to be operated over assemblies of people', 'is designed for transporting people', or 'is designed for the purpose of transporting dangerous goods and requiring a high level of robustness to mitigate the risks for third parties in case of accident'.[630] In terms of the operation, it is conducted 'over assemblies of people', involves the transport of people', or 'involves the carriage of dangerous goods, that may result in high risk for third parties in case of an accident'.[631] In addition, the certification authority can also require certification for operations that do not meet the above criteria based on the risk assessment submitted by the drone operator.[632] For robotics for I&M, the most likely scenario where an operation would be considered certified would be where the drone would be carrying dangerous goods for the purpose of maintenance and operators should take prudent care to determine whether certification of the operation is necessary.

Figure 6. Determination of Certified Aerial Drone Category

- ***Geographic limits***

While the EU regulation is meant to harmonise the regulation of drones throughout the EU, it is also designed with flexibility in mind for the Member States.[633] One example of this is that the Member States are allowed to define geographical zones for 'safety, privacy or environmental reasons'.[634] It is therefore important for operators to understand whether the area is legal for their operations. This should not be an independent concern for specific and certified operations as the risk assessment would have already taken into account the location of the operations and the application would have been rejected should the geographical area the operators want to deploy the drones was deemed off limits by the Member State.

- ***Pilot qualifications***

Remote pilots of drones must meet minimum requirements as set forth. For the open category, the requirements differ for the type of operation and the class of aircraft, which includes different trainings and examination on different subjects.635 For operations in the specific category, the following competencies are the bare minimum required:

> (a) ability to apply operational procedures (normal, contingency and emergency procedures, flight planning, pre-flight and post-flight inspections);
> (b) ability to manage aeronautical communication;
> (c) manage the unmanned aircraft flight path and automation;
> (d) leadership, teamwork and self-management;
> (e) problem solving and decision-making;
> (f) situational awareness;
> (g) workload management;
> (h) coordination or handover, as applicable.[636]

The minimum age requirement for remote pilots for open and specific categories is 16, though this is waived if the drone is a toy, is privately-built with a MTOM of less than 250 g, or if the pilot is directly supervised by another remote pilot who is 16 years or older.[637] Another example of flexibility is that Member States may also lower the minimum age for the open and specific categories to 12 and 14 respectively should the risk assessment of the specific situation of the state deem this suitable, but these remote pilots would be unable to pilot operations in other Member States.[638] As robots used for I&M will be operated by professionals in the respective industries with the relevant training and experience, it is highly unlikely the pilots would be disqualified due to lack of competence or age.

- ***Registration***

Certain UAVs and operators must be registered with the relevant authority. The European Union mandates Member States establish a system of registry to keep track of the drones being operated within their jurisdictions that are subject to certification and 'operators whose operation may

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[633] Biljana M Cincurak Erceg, 'Legal Regulation of Unmanned Aircraft Systems in the European Union with Reference to the Legislation of the Republic of Croatia'(2019) 53 Zbornik Radova 327, 337.
[634] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 15(1).
[635] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Annex Part A.
[636] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 8(2).
[637] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 9(1)-(2).
[638] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 9(3)-(4).

present a risk to safety, security, privacy, and protection of personal data or environment'.[639] Operators need to register when they operate within the specific category or when they operate within an open category a drone 'with a MTOM of 250 g or more, or, which in the case of an impact can transfer to a human kinetic energy above 80 Joules' or one that is 'equipped with a sensor able to capture personal data'.[640] Operators are exempt from registration for the latter if the drone complies with Directive 2009/48/EC and is considered a toy.[641]

While drones or operators of drones in the open category do not have to be registered, operators in the specific category must provide their full name and date of birth (or identification number if the operator is a legal person), address, email address, telephone number, insurance policy number for the UAS if applicable, a declaration of competence, and the operational authorisations, light UAS operator certificates issued, and the confirmation of receipt and completeness for submitting a declaration for 'an operation complying with a standard scenario'.[642] The regulations also mandate a registration system for drones 'whose design is subject to certification'.[643] The operators must submit the name of the drone manufacturer, the manufacturer designation of the drone, its serial number, and the details and contact information of the person, natural or legal, to which the drone is registered.[644]

- ***Data protection***

Drones must operate within the confines of the General Data Protection Regulation (GDPR), which came into force in May 2018. As a result, although the main purpose of I&M drones is not to collect personal data, compliance with the GDPR is still necessary should data where a person is identified or identifiable is captured in the course of its work.[645] However, if the captured data is, for example, power lines or oil rigs, operators need not worry as there is no personal data involved.[646] Care must still be taken to ensure that the drone is not inadvertently capturing personal data on its way or back from inspections, otherwise GDPR obligations would be triggered and the data would need to be secure and regularly deleted.[647] Such data should also not be used for other purposes that are unrelated to the operation of the drone.[648] The DroneRules PRO project, which is EU-funded and focuses on privacy issues regarding drones, has published the Privacy Code of Conduct: A practical guide to privacy and data protection requirements for drone operators and pilots, which serves as guidance for compliance with the GDPR by drone operators.[649]

[639] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 14(1).
[640] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 14(5(a).
[641] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 14(5(a)(ii).
[642] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 14(2); Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 12(5)(b)
[643] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 14(3).
[644] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 Article 14(3)(a)-(d).
[645] DroneRules.euPro, 'DroneRules PRO: Creating a Privacy Culture among Europe's UA Professionals' <dronerules.eu/assets/covers/DroneRules_factsheet_0vf.pdf> accessed 29 November 2019.
[646] Mahashreveta Choudhary, 'Eight Points on How GDPR Will Affect Commercial Drone Industry; (*Geospatial World*, 21 May 2018) accessed <www.geospatialworld.net/blogs/eight-points-on-how-gdpr-will-affect-commercial-drone-industry/> 29 November 2019.
[647] 'Nosy Drones? Know the Rules Before You Fly' (Trilateral Research, 4 April 2019) <trilateralresearch.co.uk/nosy-drones-know-the-rules-before-you-fly/> accessed 29 November 2019; Grigorios Tsolias, 'Data Protection Risks From The Use of Remotely Piloted Aircraft Systems (RPAS) under Vague Legal and Regulatory Framework' (2016) 2 Eur Data Prot LRev 399, 399-400.
[648] Jordan M Cash, 'Droning On and On: A Tort Approach to Regulating Hobbyist Drones' (2016) 46 University of Memphis Law Review 695, 707.
[649] https://dronerules.eu/assets/files/PCC_DR_final-for-printing_9-November-2018.pdf

2.1.3.3 National Laws

All EU Member States have existing laws regulating the use of drones in their jurisdictions in one form or another. States were eager to develop regulatory measures due to a combination of the dangerousness of the use of the technology and the slow and deliberative process of the EU.[650] Existing laws that do not conform to the European common rule will have to be amended accordingly prior to June 2020. Before the deadline, the current national laws will still be applicable. Because of the different regulations in different jurisdictions, operators must conform to and apply for authorisation, if necessary, in each state in which they intend to operate, an obstacle that has been seen to inhibit the growth of done usage.[651] Relevant laws on UAVs range from welcoming to restrictive, though there are many common aspects that appear to have emerged without official coordination, such as UAV weight limits, distance and height limits, and the need for registration.[652] As noted in the previous section, as the European common rules only apply to outdoor operations, drones that are used indoors will still be required to abide by national laws even after June 2020. The rest of this section introduces portions of laws which regulate drones in a handful of EU Member States.

- *Belgium*

Belgium's approach to the regulation of drone technology stems for The Royal Decree of the 10th of April 2016. These regulations apply to all drones except where the drones are to be used for recreational purposes, which are exempt under strict conditions set out in article 3 of the decree. Such drones will have a maximum take-off mass of no more than 1kg, be flown no higher than 10 meters above the ground and must be flown within the eyesight of the pilot at all times. They must not be used in public space, meaning that they should be flown over private properties where permission has been granted by the owner. Relevant safety recommendations must also be followed. It is also notable that drones may not be used for freight type purposes.[653]

- *Italy*

In Italy, drones are regulated by the ENAC Regulation. Having previously been defined under the blanket term of aircraft, they are categorised as either an 'Areomodel', intended to be used recreationally, or an 'SAPR', intended to be used in more specialised areas (such as scientific research).[654] SAPRs are classified based on take-off mass (whether above, or below 25kg).[655] Further, when that weight exceeds 25kg they must be registered with Registry of Aero-Vehicles.[656] In addition, even where the weight is below 25kg, a proposed pilot must obtain certificate

[650] Reka M Pusztahelyi, 'Reflections on Civil Liability for Damages Caused by Unmanned Aircrafts' (2019) 53 Zbornik Radova 311, 313,

[651] European Commission, Communication from the Commission to the European Parliament and the Council, A New Era for Aviation: Opening the Aviation Market to the Civil Use of Remotely Piloted Aircraft Systems in a Safe and Sustainable Manner, COM (2014) 207 final (Apr. 8, 2014).

[652] Miguel Rosa, Gavin O'Brien and Vadim Vermeiren, 'Spain-UK-Belgium Comparative Legal Framework: Civil Drones for Professional Commercial Purposes' in María de Miguel Molina and Virginia Santamarina-Campus (eds), *Ethics and Civil Drones: European Policies and Proposals for the Industry* (Springer 2019) 44.

[653] See The Belgian Royal Decree of Avril 10th 2016; See also <https://dronerules.eu/nl/professional/news/new-drone-legislation-in-belgium> Accessed 4th December 2019; Jean-Francois Henrotte, Alexandre Cassart, and Fanny Coton and Daniel 'Belgium Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies* (Éditions Larcier 2016) 26.

[654] Raffaelle Zallone 'Italy Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies* (Éditions Larcier 2016) 214.

[655] ENAC Regulation on Remotely Piloted Aerial Vehicles, Issue No. 2 16 July 2015, Article 6.

[656] ENAC Regulation on Remotely Piloted Aerial Vehicles, Issue No. 2 16 July 2015, Section 14.

demonstrating their competence.[657] For those weighing in excess of 25kg a full pilot's license is required.[658]

- *France*

In France, the UAV regulatory measures are the Arrêté du 17 décembre 2015 relatif à l'utilisation de l'espace aérien par les aéronefs qui circulent sans personne à bord (Order of December 17, 2015, Regarding the Use of Airspace by Unmanned Aircraft) and the Arrêté du 17 décembre 2015 relatif à la conception des aéronefs civils qui circulent sans personne à bord, aux conditions de leur emploi et aux capacités requises des personnes qui les utilisent (Order of December 17, 2015, Regarding the Creation of Unmanned Civil Aircraft, the Conditions of Their Use, and the Required Aptitudes of the Persons That Use Them). The regulatory authority for UAVs is the French Civil Aviation Authority. Drones that are over 800 g must be registered, at which time a registration number that must be affixed on the UAV is issued.[659] For commercial purposes, remote pilots must pass a written exam and be provided adequate training by the operator for the specific aircraft and type of operation.[660] Usage of commercial drones are categorised into four scenarios:

> S-1: Using a drone outside a populated area, without flying over any third party, staying within the pilot's line of sight, and within a horizontal distance of no more than 200 meters from the pilot.
> S-2: Using a drone outside a populated area, where no third party is within the area of operation, within a horizontal distance of no more than 1 kilometer from the pilot, and not falling within the definition of S-1.
> S-3: Using a drone in a populated area, but without flying over any third party, staying within the pilot's line of sight, and within a horizontal distance of no more than 100 meters from the pilot;
> S-4: Using a drone outside a populated area, but not in a manner falling within the definitions of S-1 or S-2.[661]

To fly over 50 m in S-2, the drone must be under 2 kg.[662] For S-3, untethered drones must be less than 8 kg.[663] For S-4, the drone must be under 2 kg and are restricted to passive activities such as measurement taking or observation.[664] In all scenarios, if the drone is untethered, they cannot be operating autonomously.[665] Drones that meet certain specifications - drones over 25 kg, drones used outdoors (S2 and S4 scenarios), and drones used in the S-3 scenario that are over 2 kg - must submit a certification of design before operations can commence.[666] This submission must include specific

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657 ENAC Regulation on Remotely Piloted Aerial Vehicles, Issue No. 2 16 July 2015, Section 21.
658 ENAC Regulation on Remotely Piloted Aerial Vehicles, Issue No. 2 16 July 2015, Article 22.
659 'Drone Laws in France: A List of Drone Regulations and Links for Drone Pilots in France' <uavcoach.com/drone-laws-in-france/> accessed 29 November 2019.
660 'Drone Laws in France: A List of Drone Regulations and Links for Drone Pilots in France' <uavcoach.com/drone-laws-in-france/> accessed 29 November 2019.
661 Nicolas Boring, 'Regulation of Drones: France' (US Library of Congress April 2016) <www.loc.gov/law/help/regulation-of-drones/france.php> accessed 29 November 2019.
662 Nicolas Boring, 'Regulation of Drones: France' (US Library of Congress April 2016) <www.loc.gov/law/help/regulation-of-drones/france.php> accessed 29 November 2019.
663 Nicolas Boring, 'Regulation of Drones: France' (US Library of Congress April 2016) <www.loc.gov/law/help/regulation-of-drones/france.php> accessed 29 November 2019.
664 Nicolas Boring, 'Regulation of Drones: France' (US Library of Congress April 2016) <www.loc.gov/law/help/regulation-of-drones/france.php> accessed 29 November 2019.
665 Nicolas Boring, 'Regulation of Drones: France' (US Library of Congress April 2016) <www.loc.gov/law/help/regulation-of-drones/france.php> accessed 29 November 2019.
666 Nicolas Boring, 'Regulation of Drones: France' (US Library of Congress April 2016) <www.loc.gov/law/help/regulation-of-drones/france.php> accessed 29 November 2019.

details about the UAV itself and the operation, including potential dangers and mitigation measures for third parties.[667] There are also basic safety requirements that apply to all scenarios and particular ones for each scenario. Non-compliance could result in a one-year sentence and a fine of €75,000.[668] The operator must make a declaration describing the activities of the drone every two years and submit annual reports detailing the number of flight hours and any problems encountered, among other things.[669]

- *Germany*

In Germany, the key legislation in the context of drones is the German Civil Aviation Act (LuftVG), as well as the Air Traffic Order (LuftVO). Drones that are used for sport or leisure type activities are not considered to be 'aircraft'.[670] The result is that they are subject to less stringent regulations than is the case for drones used for other purposes. For example, these drones must not exceed 5kg in weight[671] and must be operated within the eyesight of the operator.[672] Drones used for other purposes are subject to more stringent regulations.[673] For example, drones used for commercial purposes, such as for parcel deliver, would be treated as aircraft.[674]

- *Greece*

Greece is ahead of its European peers in terms of conforming to the upcoming EU-wide standard. Its 2016 Regulation - General Framework for Flights of Unmanned Aircraft Systems - UAS follows the three-tiered categorisation first proposed in the Riga Declaration and subsequently in the draft EU regulation in 2015. UAV flights are categorised as open, specific, or certified, and each category requires different levels of supervision from the regulatory authority, the Hellenic Civil Aviation Authority (HCAA).[675] The open category is only for drones with a MTOM of under 25 kg that are flying less than 500 metres from the pilot.[676] To fly over a crowd of people, the pilot must be commercially licensed and registered to conduct such manoeuvres and the drone must be equipped with appropriate safety devices.[677] Operators and pilots in the open category must be registered if the control range is over 50 meters.[678] Like the EU regulation, drone flights in the open category are further subdivided into three categories depending on the MOTM.[679]

When registering, the HCAA may decide that a flight should be placed in the specific category, which requires the operator to file an Operation Authorisation. This filing must include a risk assessment, the operator's manual, and proof of insurance.[680] The HCAA could further classify the operation as certified after the aforementioned application. This triggers further requirements, including the

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[667] Nicolas Boring, 'Regulation of Drones: France' (US Library of Congress April 2016) <www.loc.gov/law/help/regulation-of-drones/france.php> accessed 29 November 2019.
[668] Nicolas Boring, 'Regulation of Drones: France' (US Library of Congress April 2016) <www.loc.gov/law/help/regulation-of-drones/france.php> accessed 29 November 2019.
[669] Nicolas Boring, 'Regulation of Drones: France' (US Library of Congress April 2016) <ww.loc.gov/law/help/regulation-of-drones/france.php> accessed 29 November 2019.
[670] See LuftVG, Section 2.
[671] See LuftVO, Section 20, Para 1, No 1.
[672] See LuftVO, Section 19, Para 3.
[673] See for example Andreas Lober, Tim Caesar, and Wojtek Ropel 'Germany Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies* (Éditions Larcier 2016) 145-146.
[674] As per the definition in LuftVG, Section 1.
[675] Regulation - General Framework for Flights of Unmanned Aircraft Systems - UAS article 3.
[676] Regulation - General Framework for Flights of Unmanned Aircraft Systems - UAS Article 6(1)(a)-(b).
[677] Regulation - General Framework for Flights of Unmanned Aircraft Systems - UAS Article 6(1)(e).
[678] Regulation - General Framework for Flights of Unmanned Aircraft Systems - UAS Article 6(1)(f).
[679] Regulation - General Framework for Flights of Unmanned Aircraft Systems - UAS Article 7.
[680] Regulation - General Framework for Flights of Unmanned Aircraft Systems - UAS Article 8(1).

implementation of a Safety Management System, and the issuance of a Special Certificate of Airworthiness after approval.[681]

- *Croatia*

Similar to Greece, Croatia also amended its regulatory regime to comply with the EU regulations.

- *Spain*

Spain was one of the first European states to implement laws to regulate the use of UAVs.[682] The governmental body in charge of drones is the State Agency for Air Safety, which is tasked with the 'supervision, inspection, and management of air transport, air navigation, and airport security'.[683] The first form of regulation was through Royal-Decree Law 8/2014, which was passed into law as Law 18/2014 in October 2014.[684] The law was subsequently updated in 2017.[685] The new law applies to drones under 150 kg that are for commercial use.[686] It allows for drone operations during night-time, over crowds of people and buildings, and in controlled airspace so long as a security analysis is performed and prior authorisation of the flight obtained.687 The security analysis is similar to the risk assessment required under the EU regulations and must include mitigation measures.[688]

- *United Kingdom*

The United Kingdom has also developed a substantial amount of regulation to address the use of drones. The Civil Aviation Authority (CAA) is the regulatory body, and the principal regulatory measure is Air Navigation Order 2016 (ANO 2016). The scope is limited to outdoor usage, and drone operating indoors would have to abide by relevant Health and Safety at Work regulations.[689] Commercial usage of drones, which is defined as 'any flight by a small unmanned aircraft…in return for remuneration or other valuable consideration' is only allowed if permission is granted by the CAA.[690] The permissions are valid for one year and must be renewed if the drone is to be used past

681 Regulation - General Framework for Flights of Unmanned Aircraft Systems - UAS Article 9.

682 Miguel Rosa, Gavin O'Brien and Vadim Vermeiren, 'Spain-UK-Belgium Comparative Legal Framework: Civil Drones for Professional Commercial Purposes' in María de Miguel Molina and Virginia Santamarina-Campus (eds), *Ethics and Civil Drones: European Policies and Proposals for the Industry* (Springer 2019) 51.

683 Miguel Rosa, Gavin O'Brien and Vadim Vermeiren, 'Spain-UK-Belgium Comparative Legal Framework: Civil Drones for Professional Commercial Purposes' in María de Miguel Molina and Virginia Santamarina-Campus (eds), *Ethics and Civil Drones: European Policies and Proposals for the Industry* (Springer 2019) 51.

684 Miguel Rosa, Gavin O'Brien and Vadim Vermeiren, 'Spain-UK-Belgium Comparative Legal Framework: Civil Drones for Professional Commercial Purposes' in María de Miguel Molina and Virginia Santamarina-Campus (eds), *Ethics and Civil Drones: European Policies and Proposals for the Industry* (Springer 2019) 51.

685 Raul Rubio, 'Spain - Government Approves a Permanent Regulation for the Civil Use of Drones' (*Lexology* 14 February 2018) <www.lexology.com/library/detail.aspx?g=be5dbecf-a874-4cb5-82d3-9fbe0213e157&g=be5dbecf-a874-4cb5-82d3-9fbe0213e157> accessed 29 November 2019.

686 'The Definitive Regulation with Regard to Drones' (Osborne Clarke, 22 January 2018) <www.osborneclarke.com/insights/the-definitive-regulation-with-regard-to-drones/> accessed 29 November 2019.

687 Raul Rubio, 'Spain - Government Approves a Permanent Regulation for the Civil Use of Drones' (*Lexology* 14 February 2018) <www.lexology.com/library/detail.aspx?g=be5dbecf-a874-4cb5-82d3-9fbe0213e157&g=be5dbecf-a874-4cb5-82d3-9fbe0213e157> accessed 29 November 2019.

688 Raul Rubio, 'Spain - Government Approves a Permanent Regulation for the Civil Use of Drones' (*Lexology* 14 February 2018) <www.lexology.com/library/detail.aspx?g=be5dbecf-a874-4cb5-82d3-9fbe0213e157&g=be5dbecf-a874-4cb5-82d3-9fbe0213e157> accessed 29 November 2019.

689 Civil Aviation Authority, 'Regulations Relating to the Commercial Use of Small Drones' <www.caa.co.uk/Commercial-industry/Aircraft/Unmanned-aircraft/Small-drones/Regulations-relating-to-the-commercial-use-of-small-drones/> accessed 29 November 2019.

690 ANO 2016 Article 94[5].

the expiry date.[691] For an application to operate UAVs under 20 kg, the operator must demonstrate the competence of the remote pilot through knowledge of aviation principles and a flight test and submit an Operations Manual detailing the procedures for the type of flight planned.[692] For more complex flights that may involve additional safety concerns, an Operating Safety Case, or risk assessment, is also required.[693] UAVs with an operating mass of over 20 kg must meet all aviation requirements, and not only those particular to drones, so operations must apply for specific authorisation with the CAA before commencing flight. A risk assessment detailing the safety concerns and mitigating measures must be included in the application.[694]

2.1.3.3 Liability Issues

Liability issues regarding the operation of drone technology, otherwise known as Remotely Piloted Air Systems (RPAS) were highlighted as early as 2014. A communication from the EU commission outlined that 'progressive integration of RPAS into the airspace from 2016 onwards must be accompanied by adequate public debate on the development of measures which address societal concerns including safety, privacy and data protection, third-party liability and insurance or security'.[695] Importantly, it was acknowledged that 'even with the highest safety standards, accidents may happen and victims need to be compensated for any injury or damage'.[696] This would require 'that those liable can be easily identified and are able to meet their financial obligations'.[697]

In addition, it was also outlined that the third-party insurance regime that was in place would be in need of amendment on the basis that mass (or total weight) of the aircraft in question determined the minimum level required with respect to insurance. This was set at 500kg, a problematic level as many RPAS would weigh well below that threshold.[698] With that in mind, there was a need to update the approach in order to accommodate and regulate a rapidly developing and increasingly widespread area of technology.

Next, a report commissioned by the European Commission and prepared by Steer Davis Gleave highlighted a number of potential issues related to the use of drone technology. These included first, the importance of insurance,[699] as well as the indemnification of parties that have suffered damage. The way that this would be covered by insurance policies for third-party liability was also considered, with the suggestion made being that where 'the operator did not have third-party liability insurance

[691] Civil Aviation Authority, 'Permissions and Exemptions for Commercial Work Involving Small Unmanned Aircraft and Drones' <www.caa.co.uk/Commercial-industry/Aircraft/Unmanned-aircraft/Small-drones/Permissions-and-exemptions-for-commercial-work-involving-small-unmanned-aircraft-and-drones/> 29 November 2019.
[692] CAP 722: Unmanned Aircraft System Operations in UK Airspace - Guidance & Policy.
[693] CAP 722: Unmanned Aircraft System Operations in UK Airspace - Guidance & Policy.
[694] CAP 722: Unmanned Aircraft System Operations in UK Airspace - Guidance & Policy.
[695] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL, 'A new era for aviation: Opening the aviation market to the civil use of remotely piloted aircraft systems in a safe and sustainable manner' Brussels, 8.4.2014 COM (2014) 207 final, 5.
[696] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL, 'A new era for aviation: Opening the aviation market to the civil use of remotely piloted aircraft systems in a safe and sustainable manner' Brussels, 8.4.2014 COM (2014) 207 final, 8.
[697] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL, 'A new era for aviation: Opening the aviation market to the civil use of remotely piloted aircraft systems in a safe and sustainable manner' Brussels, 8.4.2014 COM (2014) 207 final, 8.
[698] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL, 'A new era for aviation: Opening the aviation market to the civil use of remotely piloted aircraft systems in a safe and sustainable manner' Brussels, 8.4.2014 COM (2014) 207 final, 8.
[699] 'Study on the Third-Party Liability and Insurance Requirements of Remotely Piloted Aircraft Systems (RPAS) European Commission' a November 2014 report prepared by Steer Davies Gleave for the European Commission, Para 4.5.

or operated in conditions outside its insurance terms (meaning that its insurance policy would be void) then the operator would be required to pay the full extent of the liability itself, again including through liquidation of its assets if required'.[700]

Whether variation in third-party liability frameworks within the EU was the next consideration. Key suggestions were that there was no evidence that variation in those frameworks had at that time 'hindered the development of the market or creates a problem in ensuring the adequate compensation of victims, although it does complicate the work of the RPAS insurance and legal industry'.[701] Also, there was no visible desire for a harmonised regime of this type. With this in mind it was noted that 'there is no harmonised liability framework across the EU for motor vehicles and that this does not stop the Motor Insurance Directive from offering a high level of protection to third-parties'.702 The conclusion of the report was the chance of reaching an agreement on a harmonised regime within the EU was very low and thus, such harmonisation should not be pursued.703 However, as will become clear later, this view has since been disputed.

The 2015 Riga declaration outlined that drone accidents were an inevitable symptom of their widening use, and also that 'Member States should clarify the applicable insurance and third-party liability regime and monitor the compensation mechanisms for potential victims'.[704] Other issues, including the establishment of compensation funds to cover loss caused by uninsured drone users, as well as the need for a coherent system for incident reporting were also highlighted.[705] Next, a 2016 SESAR study featured a focus on liability insurance, balanced alongside economic viability.[706] It outlined that liability should be addressed, both at a national, and EU level, keeping in mind the provision of affordable insurance rates within a 2-5 year period (from publication).[707] This would include a harmonisation across Member States.[708] Variation in liability insurance premiums based on drone type was also noted, with the distinction between certified and specific drones being highlighted.[709] This is particularly relevant 'as current standards are established mostly for manned aircraft'.[710] However, it has been suggested that the legal system is 'adequately equipped to deal

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[700] 'Study on the Third-Party Liability and Insurance Requirements of Remotely Piloted Aircraft Systems (RPAS) European Commission' a November 2014 report prepared by Steer Davies Gleave for the European Commission, Para 4.6.

[701] Study on the Third-Party Liability and Insurance Requirements of Remotely Piloted Aircraft Systems (RPAS) European Commission' a November 2014 report prepared by Steer Davies Gleave for the European Commission, Para 4.83.

[702] 'Study on the Third-Party Liability and Insurance Requirements of Remotely Piloted Aircraft Systems (RPAS) European Commission' a November 2014 report prepared by Steer Davies Gleave for the European Commission, Para 4.83.

[703] 'Study on the Third-Party Liability and Insurance Requirements of Remotely Piloted Aircraft Systems (RPAS) European Commission' a November 2014 report prepared by Steer Davies Gleave for the European Commission, Para 4.84.

[704] RIGA DECLARATION ON REMOTELY PILOTED AIRCRAFT (drones) "FRAMING THE FUTURE OF AVIATION" Riga - 6 March 2015.

[705] RIGA DECLARATION ON REMOTELY PILOTED AIRCRAFT (drones) "FRAMING THE FUTURE OF AVIATION" Riga - 6 March 2015.

[706] SESAR 'European Drones Outlook Study: Unlocking the value for Europe, November 2016, See page 16, and page 33.

[707] SESAR 'European Drones Outlook Study: Unlocking the value for Europe, November 2016, 48.

[708] SESAR 'European Drones Outlook Study: Unlocking the value for Europe, November 2016, 48.

[709] SESAR 'European Drones Outlook Study: Unlocking the value for Europe, November 2016, 78.

[710] Michael Calvo, 'Uncertainty and Innovation: The Need for Effective Regulations to Foster Successful Integration of Personal and Commercial Drone' (2016) 22 Southwestern Journal of International Law 189, 204-205; See also SESAR 'European Drones Outlook Study: Unlocking the value for Europe, November 2016, 78; Communication from the Commission to the European Parliament and the Council, A New Era for Aviation: Opening the Aviation Market to the Civil Use of Remotely Piloted Aircraft Systems in a Safe and Sustainable Manner, at 3-4, COM (2014) 207 final.

with liability issues related to the deployment of unmanned aircraft. Proven negligence (errors, mistakes, shortcomings, omissions) of humans involved in their operation may trigger civil, disciplinary and criminal liability'.[711] It was noted that within the EU, 'commercially operated drones equal or superior to 20 kg are required to have a third-party liability insurance proportional to their weight'.[712] However, the problem that 'most commercially operated drones in EU Member States have a weight under 20kg, and can still cause major damage such as a collision with a passenger plane' was highlighted.[713]

- ***More Recent Developments***

The position taken within a 2018 study focused on liability rules for drones that was commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee was that rules concerning liability, as well as requirements concerning insurance 'ought to be regulated at EU level in order to avoid excessive fragmentation'.[714] In addition, it was argued that hard law should be adopted to achieve this.[715] The report's findings regarding liability rules across Member States were outlined in the table included below. Fault is categorised by relevant legislation, liable party, as well as by the nature of liability, whether strict, or fault-based in nature. Limits and exemptions on liability are also noted, as well as whether there is a duty for parties to insure against the risk of causing damage.

Member State	Legal Act	Liable Party	Nature of Liability	Limitations & Exemptions	Duty to Insure

[711] Kristian Bernauw, 'Drones: The Emerging Era of Unmanned Civil Aviation' (2016) 66 Zbornik PFZ 223, 243.
[712] Jean-Louis Van de Wouwer, 'Nascent Drone Regulations Worldwide: A Legal Framework for Civil RPAS (Remotely Piloted Aircraft Systems)' 4(2) European Networks Law and Regulation Quarterly 132, 137.
[713] Jean-Louis Van de Wouwer, 'Nascent Drone Regulations Worldwide: A Legal Framework for Civil RPAS (Remotely Piloted Aircraft Systems)' 4(2) European Networks Law and Regulation Quarterly 132, 137; See also Regulation (EC) No 785/2004 of the European Parliament and of the Council on insurance requirements for air carriers and aircraft operators, OJ 2004, L 138/1.
[714] 'Artificial Intelligence and civil law: liability rules for drones' a November 2018 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee, 68.
[715] 'Artificial Intelligence and civil law: liability rules for drones' a November 2018 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee, 68.

Spain	Real Decreto 1036/2017 (Article 15, Article 16) & Navegacion Aerea (Article 119, Article 120)	Operator	Strict	Limitation to compensation : 220,000 special drawing rights except in case of gross negligence or intentional misconduct	Yes
France	Arrête du 17 decembre 2015 & Code des transports (Article L6131.1)	Operator/Owner (in case of leasing)	Strict	Unlimited	Yes
Belgium	Arrête royal 10 Avril 2016 (Article 80, Article 81)	Operator/Pilot	Strict	-	Yes. Exception: non-commercial use
UK	Civil Aviation Act 1982, Air Navigation Order 2016 (Article 94, Article 241), Air Navigation (Amendment) Order 2018	Person in Charge	Fault Based	Unlimited	Yes

Italy	Regolamento ENAC & Codice della Navigazione (r.d. 327/1942, Article 965, Article 971) & Rome Convention (Article 1)	Operator/User	Strict	Limitations to compensation: minimum insurance coverage in accordance with European legislation, except if the operator is negligent	Yes
Denmark	Air Navigation Act (Chapter 9, paragraph 126; Chapter 10, paragraph 127)	Owner/User	Strict	Unlimited	Yes
Sweden	Swedish Aviation Act 2010:500 (Chapter 9) & Swedish Act on Liability for Injury as a Result of Aviation 1922:382 (Article 1)	Owner/ Possessor	Strict	Unlimited	Yes
Czech Republic	Czech Aviation Law 49/1997 (Article 3.1.1, Article 3.1.9 of Chapter 3)	Operator	Fault Based	-	Mandatory for drones > 20kg; for non-commercial purposes, even if < 20kg

Poland	Regulation of 26 March 2013 (Annexes 6 and 7)	Operator	Strict	-	Mandatory for drones used for commercial purposes; for drones > 5kg even if used for leisure activities
The Netherlands	Regeling op afstand bestuurde luchtvaartuigen Geldend van 01-07-2016 t/m 06-10-2017 & Wet luchtvaart Geldend van 28-07-2018 t/m heden	Owner	Strict	-	If < 4kg insurance against civil liability for damages to third parties. If commercial, as for <4kg but with €1 million coverage
Austria	Paragraph 146 ff of the Austrian Aviation Act	Owner, unless he proves that drone was being employed against his will	Strict	Liability cap according to MTOM	Yes (exception: toy drones)

Germany	German Aviation Regulation (LuftVG, Article 33)	Owner, unless he proves that drone was being employed against his will	Strict	Liability cap according to MTOM	Yes
Ireland	Irish Aviation Authority Small Unmanned Aircraft (Drones) and Rockets Order 2015 (Article 7)	Person in Charge	Fault Based	Unlimited	No, recommended

Table 6. Civil Liability Rules for Drones by Country.[716]

It was highlighted that there is a lack of consistency in the way liability issues pertaining to the use of drones is dealt with across Member States. This is perhaps most notable with respect to the variance in terms of identifying the liable party where a remotely piloted drone causes damage to an individual or their property.

Ultimately, the study made a number of policy recommendations. It outlined that:

- Liability rules should be strict, not fault-based, and burden one party specifically, pursuant to a one-stop-shop approach.
- Said Party should also be prima facie responsible for damages deriving from a defect in the device, or human errors in the operation of the drone. In such cases the party should then be allowed to sue in recourse the manufacturer and the pilot respectively.
- If more parties were held liable they should be jointly and severally liable for the same damages.
- The operator is the party best positioned to be held liable because he is best positioned to identify and manage the risk and acquire insurance.
- In the case of a non-commercial use of drones, the owner might be more easily identifiable and thence be held responsible as opposed to the operator or jointly and severally obliged with him.[717]

[716] 'Artificial Intelligence and civil law: liability rules for drones' a November 2018 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee, 52-54.

[717] Artificial Intelligence and civil law: liability rules for drones' a November 2018 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee, 69.

The need to adapt to the increasingly widespread use of drone technology has also been noted within the relevant academic literature. Questions have been raised regarding liability issues, particularly with respect to harm caused to third parties, and the question of who should be responsible.[718] Notably, it has been outlined that 'international conventions that apply to drones are limited in their ability to effectively regulate drones',[719] highlighting that this is an issue with international significance. For example, on the Rome Convention, Hodgkinson and Johnston outline four relevant issues. First, it is not universally ratified, meaning that 'it is not able to effectively regulate an internationally recognised framework for liability'.[720] Second, it is outdated with respect to calculating levels of compensation.[721] Third, under this convention 'liability is determined according to the weight of aircraft (manned or unmanned)'.[722] This is problematic because it could lead to a 'significant imbalance between the damage caused and the extent of liability that attaches to that damage as even small drones can cause significant harm'.[723] The fourth issue that is outlined is that 'the strict liability regime may not be appropriate for remotely piloted aircraft. For example, if a drone is operating using defective software, the question arises as to whether the manufacturer or the remote operator is liable'.[724]

It is also noted that despite the fact that the:

> Convention for the Suppression of Unlawful Acts against the Safety of Civil Aviation 2009 (General Risks Convention) and Convention for the Suppression of Unlawful Acts against the Safety of Civil Aviation 2009 (Unlawful Interference Compensation Convention), modernised the Rome Convention, their applicability to drone regulation is limited because issues relating to strict liability and weight-based liability continue to be a part of these conventions.[725]

In addition, these conventions are not, as yet, in force. The issue of mandatory insurance for drone use was also noted, highlighting significant variation of such requirements worldwide.[726]

Hodgkinson and Johnston also noted that any level of liability that is to be imposed on the operators of a drone technology may need reassessing on the basis that 'they require little human input to

[718] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 16; See also Anna Masutti, 'Proposals for the Regulation of Unmanned Air Vehicle Use in Common Airspace' (2009) 34 Air and Space Law 1, 9.
[719] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 23.
[720] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 23.
[721] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 23.
[722] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 23; See also Sofia Michaelides-Mateou and Chrystel Erotokritou, 'Flying into the Future with UAVs: The Jetstream 31 Flight' (2014) 39 Air and Space Law 111, 123.
[723] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 23-24.
[724] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 23-24; See also Sofia Michaelides-Mateou and Chrystel Erotokritou, 'Flying into the Future with UAVs: The Jetstream 31 Flight' (2014) 39 Air and Space Law 111, 123; Pam Stewart, 'Drone Danger: Remedies for Damage by Civilian Remotely Piloted Aircraft to Persons or Property on the Ground in Australia' (2016) 23 Torts Law Journal 290.
[725] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 24.
[726] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 36.

operate'.[727]Also, attempting to apply the law which relates to manned aircraft, to done technology is problematic because '[g]iven the drone and its operator are at some remove, there are potential issues associated with the application of a strict liability regime (such as the one currently applicable to some manned aircraft) to drones'.[728]

More broadly, the importance of improving both the legal framework, as well as the technology itself was noted. It is intuitive that the development of technological solutions would 'help minimize liability and provide solutions to issues such as bodily injury, property damages, and personal liability caused by crashes'.[729] With this in mind, it was outlined that 'as drone technology continues to develop and is used more in public and commercial applications, it is important that manufacturers create technical solutions to avoid liability, legislators create clear laws governing drone liability'.[730] Most recently, Pusztahelyi has suggested that in situations where injuries are sustained, 'the EU policymakers prefers product liability in situations when the injured person can claim compensation on more bases of liability'.[731] This falls under the provisions included within Council Directive No.85/374/EEC which concern liability for defective products which requires harmonisation across EU member states.[732] However, with a focus on the approach that has been adopted in Hungary, it was outlined that 'recently published judgments hold the operators (owners) liable more and more frequently and for less and less dangerous activity'.[733] Further, it was noted that 'most types of drones and their usage seem to be dangerous "enough" to establish the strict liability of the pilot'.[734]

Finally, the potential for a third party's right to privacy to be infringed by the use of drones is another potential liability issue. It is outlined that:

> The operator and the remote pilot of an unmanned aircraft must be aware of the applicable Union and national rules relating to the intended operations, in particular with regard to safety, privacy, data protection, liability, insurance, security and environmental protection. The operator and the remote pilot must be able to ensure the safety of operation and safe separation of the unmanned aircraft from people on the ground and from other airspace users. This includes good knowledge of the operating instructions provided by the producer, of safe and environmentally-friendly use of unmanned aircraft in the airspace, and of all relevant functionalities of the unmanned aircraft and applicable rules of the air and ATM/ANS procedures.[735]

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[727] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 25; See also Kristian Bernauw, 'Drones: The Emerging Era of Unmanned Civil Aviation' (2016) 66 Collected Papers of Zagreb Law Faculty 223, 244–245.
[728] David Hodgkinson and Rebecca Johnston, *Aviation Law and Drones: Unmanned Aircraft and the Future of Aviation* (Routledge 2018) 27.
[729] Vivek Sehrawat, 'Liability Issue of Domestic Drones' (2018) 35 Santa Clara High Tech LJ 110, 132.
[730] Vivek Sehrawat, 'Liability Issue of Domestic Drones' (2018) 35 Santa Clara High Tech LJ 110, 133-134.
[731] Reka M Pusztahelyi, 'Reflections on Civil Liability for Damages Caused by Unmanned Aircrafts' (2019) 53 Zbornik Radova 311, 316.
[732] See Section 3, 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) COM(2018) 246 final.
[733] Reka M Pusztahelyi, 'Reflections on Civil Liability for Damages Caused by Unmanned Aircrafts' (2019) 53 Zbornik Radova 311, 323.
[734] Reka M Pusztahelyi, 'Reflections on Civil Liability for Damages Caused by Unmanned Aircrafts' (2019) 53 Zbornik Radova 311, 323.
[735] REGULATION (EU) 2018/1139 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2018, Annex IX, 1.1.

Consequently, it is clear that the 'risk of infringement of privacy creates a need to establish a rule of strict liability to successfully protect these rights'.[736] It is suggested that a 'strict liability rule for drone usage would be a possible way to allocate fairly the damages and react to the above-mentioned risk of immaterial harms of personal rights'.[737]

- ***Insurance***

Commercial usage of drones must comply with Regulation (EC) 785/2004 on insurance for air carriers and aircraft operators.[738] The regulation requires operators to purchase insurance in order to adequately compensate victims should the drone be involved in an accident. The minimum cover for third party liability insurance is dependent on the MTOM and is categorised as follows by the EU per Article 7(1):

Category	**MTOM (kg)**	**Minimum insurance (million SDRs)**
1	< 500	0,75
2	< 1 000	1,5
3	< 2 700	3
4	< 6 000	7
5	< 12 000	18
6	< 25 000	80
7	< 50 000	150
8	< 200 000	300
9	< 500 000	500
10	≥ 500 000	700

Table 7. Compulsory Insurance for Drones (Source: Regulation (EC) 785/2004)

Third party liability insurance is designed to cover property damage on the ground or another aircraft or loss or bodily injury or death of people on the ground. Though some current general liability

736 Reka M Pusztahelyi, 'Reflections on Civil Liability for Damages Caused by Unmanned Aircrafts' (2019) 53 Zbornik Radova 311, 324.
737 Reka M Pusztahelyi, 'Reflections on Civil Liability for Damages Caused by Unmanned Aircrafts' (2019) 53 Zbornik Radova 311, 324; cf Jordan M Cash, 'Droning on and on: A Tort Approach to Regulating Hobbyist Drones' (2016) 46 University of Memphis Law Rev 695, 725.
738 'Summary of Insurance Rules in EU' accessed 29 November 2019 <dronerules.eu/en/professional/obligations/summary-of-insurance-rules-in-eu> accessed 29 November 2019.

policies may cover the liabilities that arise from the use of drones, the policy must still comply with Regulation (EC) 785/2004. Insurers are increasingly developing drone specific third-party insurance products. In addition to indemnity for bodily or property damage or losses, policies to cover GDPR breaches are also available.[739] In some ways, the insurance industry has regulatory power over the drone operators who must comply with the policy terms to ensure continued coverage, and it would be likely that insurers would want operators to take all the necessary safety precautions available to them.[740] Nonetheless, because these products are relatively new, it is likely that there may be uncertainty in the scope of coverage, resulting in commercial disputes should accidents occur.[741]

Regulation (EC) 785/2004 also specifies minimum cover for passengers, baggage, and cargo, though it is unlikely drones for I&M would require these types of insurance cover because they would not be transporting any of the above.[742] Though first-party insurance is not currently required for operating drones, I&M drone operators should consider purchasing such cover to cover damage or replacement of the drone.[743] Furthermore, the pilot or operator may be the injured party in an operation, so this should also be a consideration.[744]

To ensure that the insurance would cover each operation, the operator should inform the insurer or broker of all activities in which the drone may partake, check the policy language to see whether the proposed product would be sufficient, look out for any exclusions under which the insurance would not indemnify or conditions that must be fulfilled to maintain cover, and ensure the liability limit is sufficient for the risk of damage instead of purchasing the minimum amount required. Operators should also inform the insurer of any changes in circumstances to avoid the possibility that cover may be voided after having gone into effect.[745]

2.2 Autonomous Road Vehicles

Autonomous vehicles were first proposed in the 1940s, with serious research starting in the 1950s and 1960s.[746] GM worked with RCA to develop a system where sensors were installed at the front of vehicles which interacted with wires laid on the road to create a steering system.[747] In 1977, a team led by Sadayuki Tsugawa at the Mechanical Engineering Laboratory ‘presented the first visually guided autonomous vehicle that could record and process (on-board) pictures of lateral guide rails on the road via two cameras’.[748] Around the same time, Hans Moravec and the Artificial Intelligence Lab at Stanford University successfully navigated a cart with camera onboard in an obstacle-filled room without human operation, though the vehicle only moved one metre every ten to 15

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739 Albert Küller and Guy Sellers, ‘Lloyd’s Market Insight: The Rise of the Drone Insurance Market April 2017’ 17.
740 Daniel North, ‘Private Drones: Regulations and Insurance’ (2015) 27 Loy Consumer L Rev 334, 356.
741 Sarah Jane Fox, ‘The Rise of the Drones: Framework and Governance - Why Risk It’ (2017) 82 J Air L & Com 683, 693.
742 Regulation (EC) 785/2004 article 6.
743 Albert Küller and Guy Sellers, ‘Lloyd’s Market Insight: The Rise of the Drone Insurance Market April 2017’ 17.
744 Reka M Pusztahelyi, ‘Reflections on Civil Liability for Damages Caused by Unmanned Aircrafts’ (2019) 53 Zbornik Radova 311, 316.
745 DroneRules.eu Pro, ‘Insurance Checklist’ <dronerules.eu/en/professional/resources/insurance-checklist-pro> accessed 29 November 2019.
746 Sven A Beiker, ‘Legal Aspects of Autonomous Driving: The Need for a Legal Infrastructure that Permits Autonomous Driving in Public to Maximize Safety and Consumer Benefit’ (2012) 52 Santa Clara L Rev 1145, 1146.
747 Fabian Kröger, ‘Automated Driving in Its Social, Historical and Cultural Contexts’ in Markus Maurer et al. (eds) *Autonomous Driving: Technical, Legal and Social Aspects* (Springer 2016) 53.
748 Fabian Kröger, ‘Automated Driving in Its Social, Historical and Cultural Contexts’ in Markus Maurer et al. (eds) *Autonomous Driving: Technical, Legal and Social Aspects* (Springer 2016) 58.

minutes.[749] Technological advancements in the 1980s and cooperation between academia and industry led to rapid development.[750] Industry preferred a system of 'lateral guidance of cars using electromagnetic fields generated by cables in the road' but the successful demonstration of autonomous lane changing and passing capability by Ernst Dickmanns of the University of the Federal Armed Forces in Munich and subsequently researchers in the United States and Italy shifted the focus to the type of autonomous driving that is being tested today.[751]

Various benefits would stem from the development and availability of autonomous vehicles. For example, it is suggested that benefits would include a reduction in the number of 'traffic fatalities and injuries, significant gains in individual productivity, unprecedented mobility for the elderly and disabled populations, greater flexibility in urban planning, and a reduction in harmful vehicle emissions'.[752] With this in mind, it is important that this technology is both effectively developed, as well as regulated.

It should be noted that land-based robots do not necessarily have to be in the form of what is popularly considered a vehicle that has wheels. As robots for infrastructure inspection and maintenance are likely to operate in commercial and off-road settings, many of the regulations concerning autonomous vehicles may not apply. Further, some robots that operate on land are not even considered vehicles and are crawlers that move with robotic limbs.[753] A motor vehicle is defined as 'a mechanically propelled vehicle, intended or adapted for use on roads' under English Road Traffic Act 1988 section 185(1) and 'any power-driven vehicle which is normally used for carrying persons or goods by road or for drawing, on the road, vehicles used for the carriage of persons or goods' under Article 1(p) of the Vienna Convention on Road Traffic. While neither require wheels, they do limit the definition to those that travel on the roads and be carrying passengers or cargo. Insofar as the crawler is designed to travel the roads and carry passengers or goods, the laws and regulations on autonomous vehicles would apply to them. Otherwise, they are likely currently largely unregulated or regulated only by industry standards. Nonetheless, this section provides an overview of the current safety, regulatory, and legal liability issues concerning autonomous vehicles because even if they may not apply to all robots for infrastructure inspection and maintenance, they offer useful guidance and may be helpful in determining the specific measures that need to be developed to regulate and allocate liability for robots that operate in specific commercial domains.

2.2.1 Achieving Safety Assurance

Autonomous vehicles are being developed by many traditional car manufacturers and technology companies worldwide, and Europe is not an exception.[754] As roughly 95% of road traffic accidents involve human error, the use of autonomous vehicles where the computer is responsible for driving

[749] Fabian Kröger, 'Automated Driving in Its Social, Historical and Cultural Contexts' in Markus Maurer et al. (eds) *Autonomous Driving: Technical, Legal and Social Aspects* (Springer 2016) 58-9.
[750] Jessica S Brodsky, 'Autonomous Vehicle Regulation: How an Uncertain Legal Landscape May Hit the Brakes on Self-Driving Cars' (2016) 31 Berkeley Technology Law Journal 851, 854-55.
[751] Fabian Kröger, 'Automated Driving in Its Social, Historical and Cultural Contexts' in Markus Maurer et al (eds) *Autonomous Driving: Technical, Legal and Social Aspects* (Springer 2016) 58-60.
[752] Jeremy A Carp, 'Autonomous Vehicles: Problems and Principles for Future Regulation' (2018) 4 University of Pennsylvania Journal of Law & Public Affairs 81, 85; See also David Levinson 'Climbing Mount Next: The Effects of Autonomous Vehicles on Society' (2015) 16 Minnesota Journal of Law, Science & Technology 787, 795-798.
[753] See, eg, James Vincent, 'Robots with Legs are Getting Ready to Walk Among Us' (The Verge 22 Feb 2017) <www.theverge.com/2017/2/22/14635530/bipedal-legged-robots-mobility-advantages>.
[754] '40+ Corporations Working on Autonomous Vehicles' (CB Insights 28 August 2019) <www.cbinsights.com/research/autonomous-driverless-vehicles-corporations-list/> accessed 29 November 2019.

may significantly increase the safety of road travel.[755] The technology may also facilitate mobility for people with disabilities or the elderly.[756] Autonomous vehicles are also likely to be more environmentally friendly due to the decrease in congestion and the associated development of electrical cars.[757]

Because of their imminent introduction onto the roads, whether as consumer products or for commercial purposes such as I&M, Europe has been engaged in determining the appropriate regulations for vehicles that traverse the roadways. Although autonomous cars and connected cars are both being developed and the terms are sometimes used interchangeably, there is a distinction between the two. Connected cars are those that can communicate with other vehicles (Vehicle-to-Vehicle) or specialised infrastructure (Vehicle-to-Infrastructure) to adapt its driving based on outside conditions and avoid collisions.[758] Autonomous vehicles refer to cars that are driven by the on board technology, which does not necessarily need to communicate with others.[759] While the two terms are not synonymous and need not exist simultaneously, manufacturers have found network connections to essential for autonomous vehicles to function properly.[760] Understanding the intimate connection between the two, the European Commission has taken an 'integrated approach between automation and connectivity in vehicles'.[761]

Vehicles can be divided into six levels of autonomy:

[755] Saving Lives: Boosting Car Safety in the EU Reporting on the monitoring and assessment of advanced vehicle safety features, their cost effectiveness and feasibility for the review of the regulations on general vehicle safety and on the protection of pedestrians and other vulnerable road users.COM(2016) 787 final https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016DC0787&from=EN

[756] Leslie P Francis, 'Disability and Automation: The Promise of Cars That Automate Driving Functions' (2018) 20 J Health Care L & Pol'y 229, 230; Dorothy J Glancy, 'Autonomous and Automated and Connected Cars - Oh My: First Generation Autonomous Cars in the Legal Ecosystem' (2015) 16 Minn JL Sci & Tech 619, 623; Henry Claypool et al, *The Ruderman White Paper: Self-Driving Cars: The Impact on People with Disabilities* (Ruderman Family Foundation January 2017) <secureenergy.org/wp-content/uploads/2017/01/Self-Driving-Cars-The-Impact-on-People-with-Disabilities_FINAL.pdf> accessed 29 November 2019.

[757] Daniel J Fagnant and Kara Kockelman, 'Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations' (2015) 77 Transportation Research Part A 167, 171; COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS. On the road to automated mobility: An EU strategy for mobility of the future. COM(2018) 283 final. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2018:0283:FIN:EN:PDF.

[758] Jeffrey K Gurney, 'Driving into the Unknown: Examining the Crossroads of Criminal Law and Autonomous Vehicles' (2015) 5 Wake Forest JL & Pol'y393, 400-401.

[759]Dorothy J Glancy, 'Privacy in Autonomous Vehicles' (2012) 52 Santa Clara Law Review 1171, 1176-77.

[760] Jeffrey K Gurney, 'Driving into the Unknown: Examining the Crossroads of Criminal Law and Autonomous Vehicles' (2015) 5 Wake Forest J L & Pol'y 393, 400.

[761] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS. On the road to automated mobility: An EU strategy for mobility of the future. COM(2018) 283 final. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2018:0283:FIN:EN:PDF.

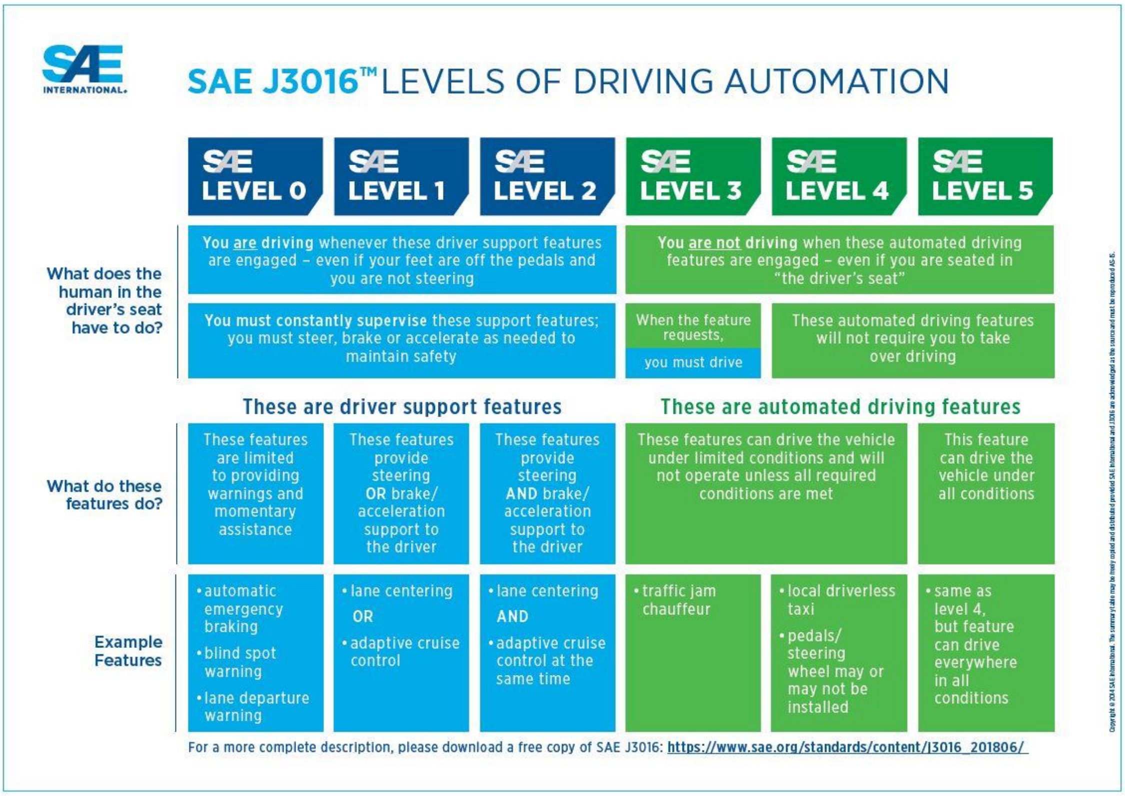

Figure 7. Levels of Driving Automation (Credit SAE)

While fully autonomous vehicles are not available to the public, Level 2 cars are currently being driven on public roads.[762] In 2017, the EC estimated that Level 4 vehicles will be available in 2020 but fully autonomous vehicles would not be deployed for up to another decade.[763]

Safety assurance, the aim of avoiding collision, of autonomous vehicles is a difficult task. The vehicle should be safe to use and keep a safe distance from all other objects which share the same road with the vehicle. Using machine learning and non-deterministic based decision making approach for autonomous systems led to the new question of whether the vehicle is safe enough. As such, researchers for autonomous systems now try to answer the question of "How safe is safe enough?". Figure 8 displays the geographical distribution of autonomous safety projects throughout the world.

[762] Daniel A Crane et al, 'A Survey of Legal Issues Arising from the Deployment of Autonomous and Connected Vehicles' (2017) 23 Michigan Telecommunications and Technology Law Review 191, 198.

[763] Digital Transformation Monitor, *Autonomous Cars: A Big Opportunity for European Industry* (January 2017) <ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Autonomous%20cars%20v1.pdf> accessed 29 November 2019.

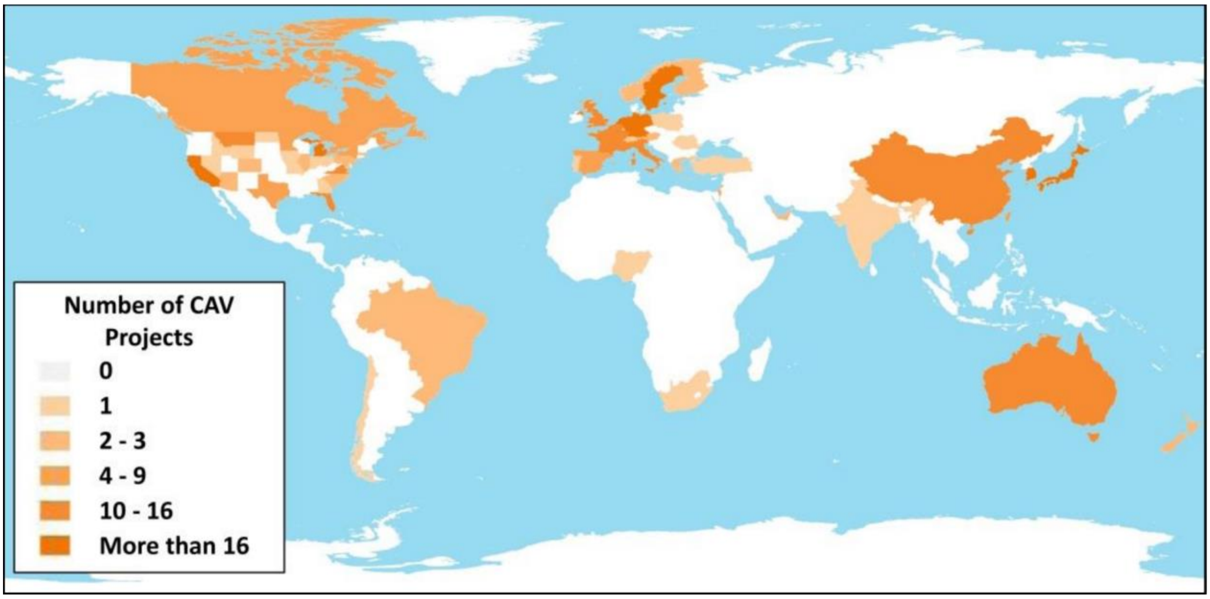

Figure 8. World Map Showing Projects by Country (State for US-based Projects) Source: CAR 2015.

Mainly, there are two families of approaches to making autonomous vehicles safe: the first approach learns from previous accidents and tries to put barriers for the safe state, and the second category is based on dynamic risk assessment.[764]

2.2.2 Standard and Certificate

2.2.2.1 ISO 26262

ISO 26262, an international standard for road vehicles (Functional safety), was defined by the International Organisation for Standardisation (ISO) in 2011. ISO 26262 covers the entire product development of EE (Electrical/Electronic) automotive products.[765]

[764] Wardziński, A. (2008, September). Safety assurance strategies for autonomous vehicles. In *International Conference on Computer Safety, Reliability, and Security* (pp. 277-290). Springer, Berlin, Heidelberg.
[765] Palin, R., Ward, D., Habli, I., & Rivett, R. (2011). ISO 26262 safety cases: Compliance and assurance.

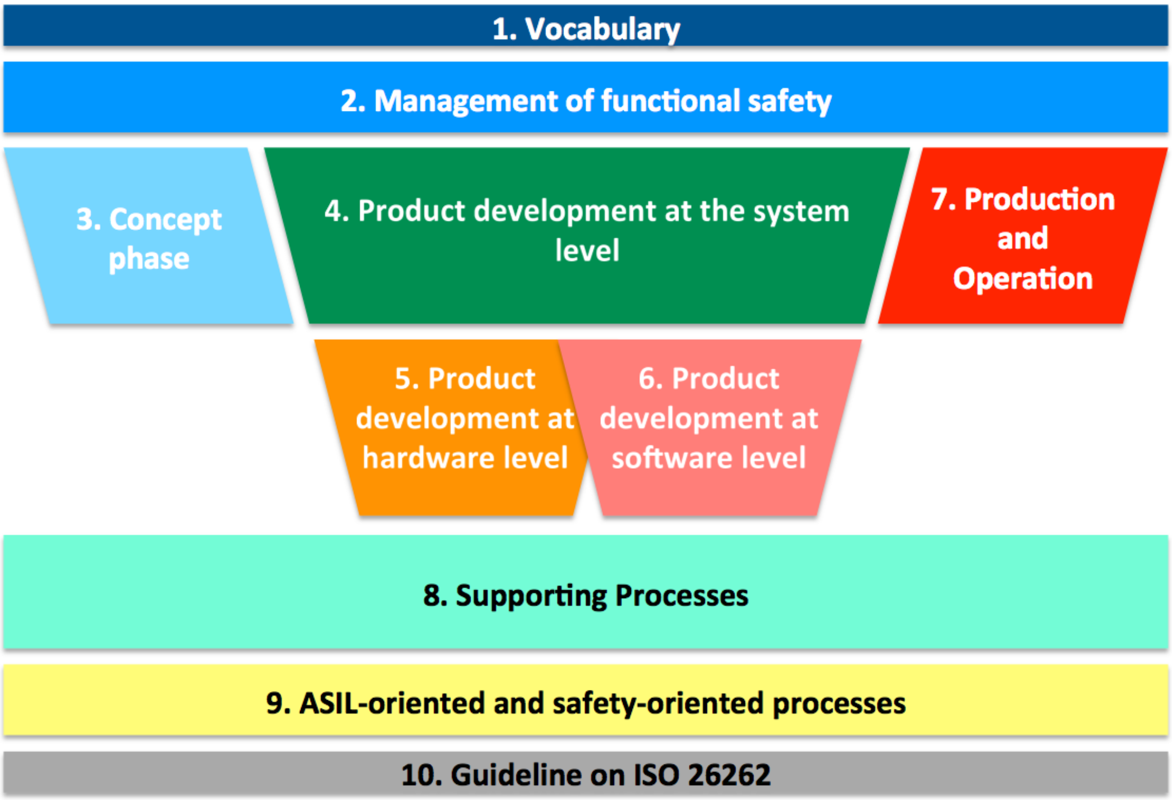

Figure 9. ISO26262 Parts (ISO 26262).

The ten parts of ISO 26262 are as follows:

1. Vocabulary: define abbreviations, terms and acronyms of the different used terminologies.
2. Management of functional safety: treats both aspects of the management of safety requirements: projects and organizational point of view.
3. Concept phase: This part initiate the safety lifecycle, by describing the project definition and the safety requirements and criteria for the whole project.
4. Product development at the system level: detailed requirements analysis, system synthesis, functional allocation, and V&V (Validation and verification).
5. Product development at the hardware level: covers the system design and implementation of hardware.
6. Product development at the software level: covers the system design and implementation of software.
7. Production and operation: defines the requirements for system production, operation installation, servicing, and decommission.
8. Supporting processes: defines the requirement of the development effort form support part, including the used tool, the documentation and management process.
9. Automotive Safety Integrity Level (ASIL)-oriented and safety-oriented analysis: defines and the process of safety requirement allocation and things related to the ASILs.
10. Guideline on ISO 26262

2.2.2.2 J3016: Taxonomy and Definition for Terms Related to Driving Automation Systems for On-Road Motor Vehicles

The SAE international's new standard J3016 is a new standard aimed to define a taxonomy for terms and concepts related to On-Road vehicles automated systems. Standardising the levels of driving automation and supporting terms serves several purposes, [766] including:

1- Clarifying the role of the (human) driver, if any, during driving automation system engagement.

2- Answering questions of scope when it comes to developing laws, policies, regulations, and standards.

3- Providing a useful framework for driving automation specifications and technical requirements.

4- Providing clarity and stability in communications on the topic of driving automation, as well as a useful short-hand that saves considerable time and effort.

The J3016 refers to the human as the main actor of the system which contains the driving system and other objects.

2.2.2.3 Future Certification of Automated/Autonomous Driving Systems

The vehicle safety certificate label certifies that the vehicle meets the current operational country safety standards. The certificate is mainly used by technicians to identify the safety related information and guarantees that the developed system meets the safety requirements. The objectives of the certificate are to maintain safety, protect consumers and certify industry standard.

Traditional safety standards define a set of performance criteria and approve test methods to evaluate the safety level of the car. The following figure represents an example of a tyre test with traditional approach.[767]

[766] Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles J3016_201806.

[767] Informal document GRVA-02-09 2nd GRVA, 28 January – 1 February 2019 Agenda item 5 (a), OICA

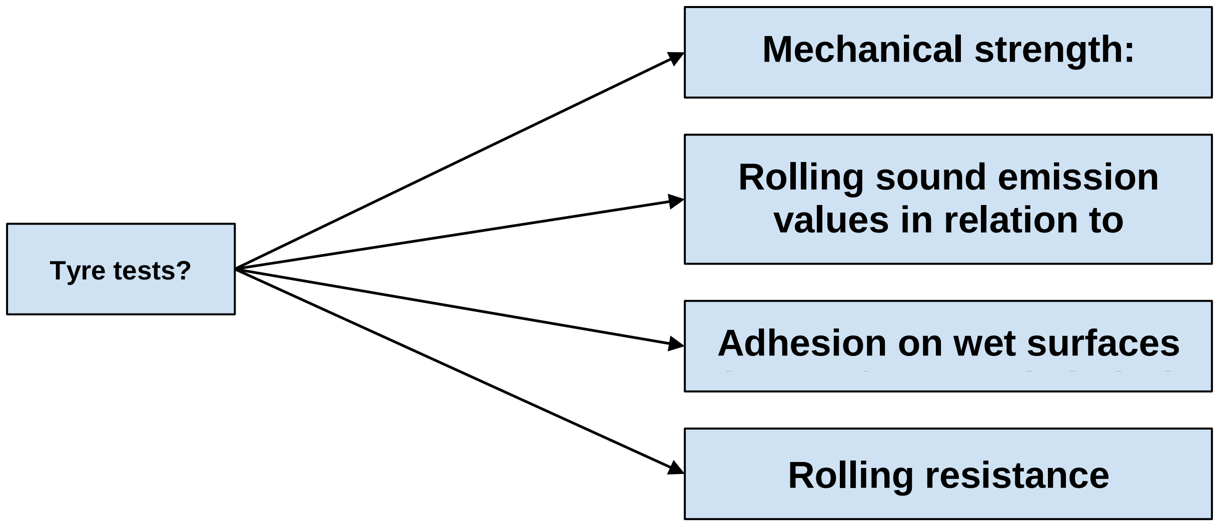

Figure 10. Vehicle Tyre Test With Traditional Approach

Safety Principles	Europe (EC Guidance)	USA (NHTSA FAVP 3.0)	Japan (MLIT-Guideline)	Canada (Transport Canada)
			Vision: "0" accidents with injury or fatality by ADV Ensure Safety : Within ODD ADV shall not cause rationally foreseeable & preventable accidents	
1 Safe Function (Redundancy)	7) Safety assessment – redundancy; safety concept	1) System Safety 9) Post Crash Behavior	ii) System safety by redundancy	6) Safety systems (and appropriate redundancies)
2 Safety Layer	2)	3) (OEDR)	ii) Automatic stop	4) International

	Driver/operator/ passenger interaction - takeover delay; camera & voice link for driverless systems		in situations outside ODD iii) Compliance with safety regulation iii) Compliance with standards recommended vii) for unmanned services: camera link & notification to service center	standards and best practices
3 Operational Design Domain	1) System performance in automated mode – description 2) Driver/operator/ passenger interaction – boundary detection	2) Operational Design Domain	i) Setting of ODD	2) Operational design domain
4 Behavior in Traffic	1) System performance in automated mode – behavior 4) MRM – traffic rules; information	3) OEDR 12) Federal, State and local Laws		3) OEDR
5 Driver's Responsibilities	2) Driver/operator/ passenger interaction – information;		v) HMI – driver monitoring for conditional automation	1) Level of automation and intended use 7) HMI and access of controls –

	driver monitoring			accidental misuse
6 Vehicle Initiated Take-Over	3) Transition of driving task – lead time; MRM; HMI 4) MRM	4) Fallback (MRC) 6) HMI	ii) Automatic stop in situations outside ODD iv) HMI – inform about planned automatic stop	
7 Driver Initiated Transfer	1) System performance in automated mode - takeover	6) HMI		7) HMI and Accessibility of Controls
8 Effects of Automation				7) HMI and Accessibility of Controls – unsafe misuse
9 Safety Certificate	7) Safety assessment – product; processes; risk assessment; standards		viii) Safety evaluation via simulation, track & real world testing ix) In-use safety - inspection	5) Testing and validation 11) After market repairs / modifications
10 Data Recording	5) Data storage system	10) Data Recording	v) Installation of data recording devices	12) User privacy 13) Collaboration with government agencies & law enforcement
11Security	5) Data storage system	7) Vehicle Cybersecurity	vi) Cybersecurity – safety by design ix) In-use safety –	10) Cyber security 11) System update

			software update	
12 Passive Safety		8) Crashworthiness		9) User protection during collision & system failure
13Driver's training	8) information provision to users	11) Consumer Education/Training	x) Information provision to users	8) Public education and awareness

Table 8. Comparison of Safety Principles in Different Countries (OICA).

Experts from the Organisation Internationale des Constructeurs d'Automobiles (OICA) proposed a new vision for certification of autonomous cars.[768] The approach is called Three Pillars: the Audit/assessment, Physical certification and Real world test drive (APR).

2.2.3 Legislation and Policy

As was the case when discussing drone technology, it is now important to consider the legislation and policy that apply to the autonomous vehicles. Once more, the first issue that will be considered is the relevant international regime that is in place. Second will be a discussion of relevant EU regulation. Third is a discussion of national laws which regulate autonomous vehicles in a handful of EU Member States. Finally, issues relating to the apportionment of liability which could stem from the use of autonomous vehicles will be considered.

2.2.3.1. International Regime

The Convention on Road Traffic, otherwise known as the Vienna Convention on Road Traffic (Vienna Convention), was concluded in 1968 and came into force in 1977.[769] All EU Member States are signatories except Cyprus, Ireland, and Malta.[770] The Vienna Convention requires that '[e]very moving vehicle or combination of vehicles shall have a driver',[771] and a driver is defined as 'any person who drives a motor vehicle or other vehicle (including a cycle), or who guides cattle, singly or in herds, or flocks, or draught, pack or saddle animals on a road'.[772] A plain reading of the language indicates a human needs to be the driver of a vehicle to conform to the Convention and an artificial

[768] Informal document GRVA-02-09 2nd GRVA, 28 January – 1 February 2019 Agenda item 5 (a), OICA
[769] Vienna Convention on Road Traffic (8 November 1968) 1042 UNTS 17.
[770] United Nations Treaty Collection <treaties.un.org/Pages/ViewDetailsIII.aspx?src=TREATY&mtdsg_no=XI-B-19&chapter=11>.
[771] Vienna Convention Article 8(1).
[772] Vienna Convention Article 1(v).

agent would not suffice, which would exclude autonomous vehicles.[773] However, it has also been argued, whether persuasively is another matter, that a legal person would also satisfy the definition of a person.[774] While it was considered relatively detailed and advanced at the time of its drafting, the Vienna Convention was unable to foresee the creation of autonomous vehicles without human drivers facilitated by the 'jump in technological evolution in parallel with the appearance of new tendencies in the field of motor vehicle improvements'.[775] European states realised this provision was causing them to lag behind the United States in creating a regulatory environment conducive to developing autonomous cars as the latter is not a signatory.[776] To keep up with technological advances, this provision was amended in 2016 to allow for the use of autonomous vehicles on the roads.[777] The additional language states:

> 5bis. Vehicle systems which influence the way vehicles are driven shall be deemed to be in conformity with paragraph 5 of this Article and with paragraph 1 of Article 13, when they are in conformity with the conditions of construction, fitting and utilization according to international legal instruments concerning wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles* Vehicle systems which influence the way vehicles are driven and are not in conformity with the aforementioned conditions of construction, fitting and utilization, shall be deemed to be in conformity with paragraph 5 of this Article and with paragraph 1 of Article 13, when such systems can be overridden or switched off by the driver.[778]

Under this new provision, as long as the autonomous vehicle technology meets international standards or if the automated mode can be switched off, autonomous vehicles would be allowed to be driven on public roads of states that are members of the Convention as long as there is a human driver ready to take over. It has been noted that further technological developments leading to Level 5 autonomous vehicles that do not expect humans to be attentive becoming the norm would necessitate future amendments to the Vienna Convention.[779]

Though most of the research on autonomous vehicles has been on the carriage of passengers, driverless cars will also be able to be used to transport cargo. In this situation, the Convention on the Contract for the International Carriage of Goods by Road (CMR) signed in 1956 may become relevant. The CMR 'appl[ies] to every contract for the carriage of goods by road in vehicles for reward, when the place of taking over of the goods and the place designated for delivery, as specified in the contract, are situated in two different countries, of which at least one is a contracting country, irrespective of the place of residence and the nationality of the parties'.[780] The definition of vehicle in the CMR does not explicitly require human drivers, but it has been argued persuasively

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[773] Antje von Ungern-Sternberg, 'Autonomous Driving: Regulatory Challenges Raised by Artificial Decision-Making and Tragic Choice' in Woodrow Barfield and Ugo Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 261.

[774] Economic Commission for Europe, Inland Transport Committee, Seventy-third session, Automated Driving, Informal document No. 4, 14 September 2016.

[775] Agnes B Juhasz, 'The Regulatory Framework and Models of Self-Driving Cars' (2018) 52 Zbornik Radova 1371, 1374.

[776] Miranda A Schreurs and Sibyl D Steuwer, 'Autonomous Driving—Political, Legal, Social, and Sustainability Dimensions' in Markus Maurer et al (eds) *Autonomous Driving: Technical, Legal and Social Aspects* (Springer 2016) 159.

[777] Economic Commission for Europe, Report of the sixty-eighth session of the Working Party on Road Traffic Safety. ECE/TRANS/WP.1/145. <www.unece.org/fileadmin/DAM/trans/doc/2014/wp1/ECE-TRANS-WP1-145e.pdf> accessed 29 November 2019.

[778] Vienna Convention Article 8(5bis).

[779] Agnes B Juhasz, 'The Regulatory Framework and Models of Self-Driving Cars' (2018) 52Zbornik Radova 1371, 1375.

[780] Convention on the Contract for the International Carriage of Goods by Road Article 1(1).

that based on an evolutionary interpretation of the CMR, the Convention would be applicable to autonomous vehicles carrying goods internationally.[781]

The United Nations Economic Commission for Europe (UNECE), which includes states in Europe, Asia, and Africa, has been involved in fostering the development of autonomous vehicles since 2014.[782] In June 2019, the UNECE World Forum for Harmonization of Vehicle Regulations (WP.29), under the leadership of the EU, China, Japan, and the US, issued a framework to guide the future work of the UN on autonomous vehicles.[783] It states:

> This Framework document's primary purpose is to provide guidance to WP.29 subsidiary Working Parties (GRs) by identifying key principles for the safety and security of automated/autonomous vehicles of levels 3 and higher. The framework document also defines the work priorities for WP.29 and indicates the deliverables, timelines and working arrangements for those certain work products related to those priorities.[784]

The World Forum's Working Party on Automated/Autonomous and Connected Vehicles is continuing the work with the establishment of technical groups tasked to explore issues related to autonomous vehicles, including cybersecurity and event data recorders.[785]

The lack of binding regulations on the international level allows for flexibility at the regional and national levels but could also create divergences that would need to be harmonised especially when data generated and collected by robots would inevitably cross national borders. Efforts to harmonise regulations internationally would need to understand and respect the values and principles of the jurisdictions that led to the frameworks and rules they created in order to reach a shared buy-in that would result in consistent implementations and interpretations.[786]

2.2.3.2 The EU Position

Although the EU was late to enter the development of autonomous vehicles, it has since been keeping pace or leading the pack globally.[787] In April 2016, EU Member States signed the Declaration of Amsterdam on cooperation in the field of connected and automated driving, memorialising the EU Commission and the Member States' shared objective of developing autonomous vehicles in the

[781] Marta Katarzyna Kotacz and Gerald Hopster,'When Technology Takes the Wheel' (2017) 9 European Journal of Commercial Contract Law 41, 45-47.
[782] UNECE, 'Relevant UNECE Activities on Automated Driving' <www.unece.org/trans/themes/transtheme-its/automated-vehicles/automated-driving.html> accessed 29 November 2019.
[783] Economic Commission for Europe, Revised Framework Document on Automated/Autonomous Vehicles <www.unece.org/fileadmin/DAM/trans/doc/2019/wp29/ECE-TRANS-WP29-2019-34-rev.1e.pdf> accessed 29 November 2019.
[784] Economic Commission for Europe, Revised Framework Document on Automated/Autonomous Vehicles art 1 <www.unece.org/fileadmin/DAM/trans/doc/2019/wp29/ECE-TRANS-WP29-2019-34-rev.1e.pdf> accessed 29 November 2019.
[785] UNECE, 'Safety at Core of New Framework to Guide UN Regulatory Work on Autonomous Vehicles' (4 September 2019) <www.unece.org/info/media/presscurrent-press-h/transport/2019/safety-at-core-of-new-framework-to-guide-un-regulatory-work-on-autonomous-vehicles/doc.html> accessed 29 November 2019.
[786] Souichirou Kozuka, 'A Governance Framework for the Development and Use of Artificial Intelligence: Lessons from the Comparison of Japanese and European Initiatives' (2019) 24 Uniform Law Review 315, 328.
[787] Early EU strategic documents on mobility and the automobile industry did not explicitly address autonomous vehicles. Miranda A Schreurs and Sibyl D. Steuwer, 'Autonomous Driving—Political, Legal, Social, and Sustainability Dimensions' in Markus Maurer et al (eds) *Autonomous Driving: Technical, Legal and Social Aspects* (Springer 2016) 153-56.

EU.[788] However, it has been suggested that its 'indications on the future legal framework are rather generic'.[789]

GEAR 2030, also known as the High Level Group on the Competitiveness and Sustainable Growth of the Automotive Industry in the European Union, drafted a discussion paper for the European Commission detailing the need to create a legal framework for automated vehicles.[790] In October 2017, the High Level Group released its final report on the future of the automotive industry in the EU and the need to foster the development of new technologies with a 'shared strategy on automated and connected vehicles'.[791]

Beyond EU Member States, in March 2017, EEA members Norway, and Switzerland signed a Letter of Intent 'to intensify cooperation on testing of automated road transport in cross border test sites'.[792] In May 2017, the European Commission signalled its commitment to connected and automated mobility as part of a grand plan for European transport.[793] As part of this initiative, the Juncker Commission, in May 2018, reiterated the EU's aim to 'make Europe a world leader in the deployment of connected and automated mobility, making a step-change in Europe in bringing down the number of road fatalities, reducing harmful emissions from transport and reducing congestion' in a communication entitled *On the road to automated mobility: An EU strategy for mobility of the future*.[794]

One of the most instrumental acts by the EU was the overhaul of the approval of vehicles in the EU and combining it with market surveillance in 2018.[795] Vehicles after September 2020 that are certified in one Member State do not need to undergo another certification within the EU.[796] This new approach will allow the EU Commission to harmonise technical standards on safety across the EU, including those relevant to autonomous vehicle technology. While new vehicular technologies

[788] Declaration of Amsterdam: Cooperation in the Field of Connected and Automated Driving <www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2016/04/29/declaration-of-amsterdam-cooperation-in-the-field-of-connected-and-automated-driving/declaration-of-amsterdam-cooperation-in-the-field-of-connected-and-automated-driving.pdf>

[789] Francesco P Patti, 'The European Road to Autonomous Vehicles' (2019) 43 Fordham International Law Journal 125, 128.

[790] Agnes B Juhasz, 'The Regulatory Framework and Models of Self-Driving Cars (2018) 52 Zbornik Radova 1371, 1380.

[791] GEAR 2030, High Level Group on the Competitiveness and Sustainable Growth of the Automotive Industry in the European Union <ec.europa.eu/docsroom/documents/26081/attachments/1/translations/en/renditions/native> 4.

[792] 'EU and EEA Member States sign up for cross border experiments on cooperative, connected and automated mobility' (23 March 2017) <ec.europa.eu/digital-single-market/en/news/eu-and-eea-member-states-sign-cross-border-experiments-cooperative-connected-and-automated>.

[793] 'Europe on the Move: Commission takes action for clean, competitive and connected mobility' 31 May 2017) <ec.europa.eu/commission/presscorner/detail/en/IP_17_1460>.

[794] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS: On the road to automated mobility: An EU strategy for mobility of the future. COM(2018) 283 final <ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf>.

[795] REGULATION (EU) 2018/858 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, amending Regulations (EC) No 715/2007 and (EC) No 595/2009 and repealing Directive 2007/46/EC <eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0858&from=EN>.

[796] REGULATION (EU) 2018/858 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, amending Regulations (EC) No 715/2007 and (EC) No 595/2009 and repealing Directive 2007/46/EC <eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0858&from=EN>.

such as autonomous cars were already able to go through a certification process prior to the new regulation, this overhaul requires Member States to be consistent in their processes.[797] It has been noted that the increased complexity of the autonomous vehicle technology may lead to growing technical errors, which highlights the need for harmonisation of standards.[798]

- *Testing*

Testing of autonomous vehicles in Europe has been seen as lagging behind other major markets such as the US and China.[799] This lag has been attributed to the fact that 'Europe emphasises more on protecting citizens from technological risks'.[800] It was not until the Vienna Convention as amended that autonomous vehicles could be tested on public roads, and even now, unlike in other jurisdictions, there must be a driver in the vehicle during the testing.[801] Because of the requirement that there be a driver in the vehicle except for a few exceptions such as the UK, Belgium, and the Netherlands, fully autonomous robots for I&M could not currently be tested on public roads. Manufacturers would need to either design the robots to fit a driver who can take over or limit their testing to private property. Consequently, in most jurisdictions, autonomous vehicles for I&M that are meant to operate without humans on board must be tested on private property for the time being.[802]

- *Data Privacy*

There are no specific regulations concerning data privacy and the use of autonomous vehicles, but all autonomous vehicles will have to abide by the GDPR once they are deployed on the roads.[803] Although many European automotive trade associations attempted to distinguish between personal data and technical data and argued that only the former would be protected by data privacy laws, this position has been refuted because technical data could still be linked to individual users, however indirectly.[804] The use of autonomous vehicles lead to the collection of various types of information not required for traditional vehicles because of the need for interactions with the environment.[805] Autonomous vehicles capture data in order to determine the best course of action

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[797] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS: On the road to automated mobility: An EU strategy for mobility of the future. COM(2018) 283 final <ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180283_en.pdf>.

[798] Araz Taeihagh & Hazel Si Min Lim, 'Governing Autonomous Vehicles: Emerging Responses for Safety, Liability, Privacy, Cybersecurity, and Industry Risks' (2019) 39 Transport Reviews 103, 107.

[799] Wim van de Camp, Report on autonomous driving in European transport (2018/2089(INI)) Committee on Transport and Tourism <www.europarl.europa.eu/doceo/document/A-8-2018-0425_EN.pdf>.

[800] Araz Taeihagh & Hazel Si Min Lim, 'Governing Autonomous Vehicles: Emerging Responses for Safety, Liability, Privacy, Cybersecurity, and Industry Risks' (2019) 39 Transport Reviews 103, 109.

[801] Araz Taeihagh & Hazel Si Min Lim, 'Governing Autonomous Vehicles: Emerging Responses for Safety, Liability, Privacy, Cybersecurity, and Industry Risks' (2019) 39 Transport Reviews 103, 109.

[802] For the limits of autonomous vehicle testing, see Roget Kemp, 'Regulating the Safety of Autonomous Vehicles Using Artificial Intelligence' (2019) 24 Comm L 24, 29-30.

[803] Roeland de Bruin, 'Autonomous Intelligent Cars on the European Intersection of Liability and Privacy' (2016) 7 Eur J Risk Reg 485, 496. See generally Kaori Ishii, 'Comparative Legal Study on Privacy and Personal Data Protection for Robots Equipped with Artificial Intelligence: Looking at Functional and Technological Aspects' (2019) 34 AI & Society 509.

[804] Federation Internationale de l'Automobile, What EU legislation says about car data: Legal Memorandum on connected vehicles and data' <www.osborneclarke.com/wp-content/uploads/2017/08/OSB100213_FIA-Car-Data-Report_v1.pdf> 2.

[805] Kai Rannenberg, 'Opportunities and Risks Associated with Collecting and Making Usable Additional Data' in Markus Maurer et al (eds) Autonomous Driving: Technical, Legal and Social Aspects (Springer 2016) 498.

to take while driving, such as steering and braking.[806] Data that autonomous vehicles could potentially capture can be divided into external and internal. External data include the road conditions and the presence of pedestrians or other vehicles, while internal data can include identifiable information about the drivers or passengers.[807] The latter could lead to profiling and prediction that could potentially be used to manipulate the vehicle user's behaviour.[808] The security of the data is a particular concern when vehicle technologies have to be compatible with each other or the infrastructure in order to communicate, which could lead to the use of widely accepted and stable software that is outdated and full of vulnerabilities.[809] In addition to data collection, the storage of the data is also a privacy issue that needs to be addressed.[810] The threat of not having ownership and control of one's data is a real concern, even if the data is used to create a better experience for the user.[811]

In the context of autonomous vehicles for I&M, privacy concerns with internal data should not be a concern because the vehicles would not be occupied by people. External data would also be unlikely to infringe on privacy rights because the sensors would be capturing data on the infrastructure on which the robot is working and not unrelated third parties. However, like the case with drones, it may be possible that the autonomous vehicle could inadvertently capture data of people it encounters to and from the work site. Any data gathered in this manner would have to be treated in accordance with the GDPR.

In October 2017, the Commission Nationale de l'Informatique et des Libertés (CNIL), the French data privacy authority, published a compliance package for connected cars and data privacy.812 The guidelines cover the 'processing of personal data collected via vehicle sensors, telematics boxes, or mobile applications, whether the data are processed inside the vehicles or exported to a centralised server'.[813] It provides guidance on how to comply with the provisions of the GDPR in different scenarios depending on whether the data is processed by the vehicle, transmitted to a service provider with no automatic actions triggered in the vehicle, and transmitted to a service provider that triggers automatic action by the vehicle.[814]

The International Working Group on Data Protection in Telecommunications of the International Conference of Data Protection & Privacy Commissioners also published a Working Paper on Connected Vehicles in 2018 that specifically addresses ways autonomous vehicle manufacturers can maintain data privacy though it does not specifically reference the GDPR.[815]

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806 Dorothy J Glancy, ''Privacy in Autonomous Vehicles' (2012) 52 Santa Clara Law Review 1171, 1175.

807 Roeland de Bruin, 'Autonomous Intelligent Cars on the European Intersection of Liability and Privacy' (2016) 7 Eur J Risk Reg 485, 496.

808 Lisa Collingwood, 'Privacy Implications and Liability Issues of Autonomous Vehicles' (2017) 26 Information & Communications Technology Law 32.

809 Zoltan Nagy et al, 'Smart Vehicles on the Roads: Background, Potentials, Risks and Solutions' 153 Studia Iuridica Auctoritate Universitatis Pecs Publicata 121, 132.

810 Johan Axhamn, 'Look Out: Self-Driving Vehicles Around the Corner' (2018) 65 Scandinavian Studies in Law 367, 374.

811 Eduard Fosch Villaronga & Antoni Roig, 'European Regulatory Framework for Person Carrier Robots' 33 Computer Law & Security Review 502, 512.

812 Commission Nationale de l'informatique et des Libertés, 'Compliance Packlage: Connected Vehicles and Personal Data' </www.cnil.fr/sites/default/files/atoms/files/cnil_pack_vehicules_connectes_gb.pdf>.

813 Commission Nationale de l'informatique et des Libertés, 'Compliance Packlage: Connected Vehicles and Personal Data' </www.cnil.fr/sites/default/files/atoms/files/cnil_pack_vehicules_connectes_gb.pdf>.

814 Commission Nationale de l'informatique et des Libertés, 'Compliance Packlage: Connected Vehicles and Personal Data' </www.cnil.fr/sites/default/files/atoms/files/cnil_pack_vehicules_connectes_gb.pdf>.

815 International Working Group on Data Protection inTelecommunications, 'Connected Vehicles: 63rd meeting, 9-10 April 2018, Budapest, Hungary' <www.datenschutz-berlin.de/fileadmin/user_upload/pdf/publikationen/working-paper/2018/2018-IWGDPT-Working_Paper_Connected_Vehicles.pdf>.

2.2.3.3 National Laws

As shown in the previous section, although the EU has shown its commitment to play an instrumental role in facilitating the development of autonomous vehicles in Europe, much of its work has not been in the direct regulation of manufacturers or operators of autonomous vehicles. Rather, European institutions have been engaged in attempting to bring together the relevant parties and try to harmonise the efforts throughout the EU.

To encourage the development of autonomous vehicle technology in the EU while ensuring the safety of the public, Member States have drafted their own legislation and guidelines to regulate autonomous vehicles within their borders.[816] Because of the nature of technological development, much of the regulatory measures are designed as what can be termed 'responsive regulation' that is flexible and can accommodate advances in technology rather than the traditional command-and-control approach.[817]

- ***Austria***

In June 2016, the Austrian Ministry of Transport, Innovation and Technology released the *Action Plan for Automated Driving*.[818] In the same year, the Austrian Motor Vehicles Amendment Act and the Automatic Driving Regulation were passed to respond to the development of autonomous vehicles.[819] The new laws allowed for the trialling of autonomous vehicles in limited cases provided applications with information such as the system being tested, testing site, testing driver, and insurance are submitted prior to the testing.[820] Only self-driving buses and highway lane changing assistance systems could be trialled.[821] During the trial, the driver must be vigilant and is responsible for taking over controls when necessary.[822] The Ministry for Traffic, Innovation and Technology published a *Code of Conduct* for further guidance on testing.[823] In March 2019, the regulations were amended for trialling of more functions by the automated system and of autonomous parking.[824]

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[816] Similarly, in the United States, autonomous vehicle regulations have been promulgated by the individual states rather than the federal government. See Alessandro Di Rosa, 'Autonomous Driving between Technological Evolution and Legal Issues' (2019) 19 Diritto & Questioni Pubbliche 125.
[817] Ronald Leenes et al, 'Regulatory Challenges of Robotics: Some Guidelines for Addressing Legal and Ethical Issues' (2017) 9 Law, Innovation and Technology 1, 37.
[818] Karl Rehrl and Cornelia Zankl, 'Digibus©: Results from the First Self-driving Shuttle Trial on a Public Road in Austria' (2018) 10European Transport Research Review 51, 51.
[819] Baker McKenzie, 'Global Driverless Vehicle Survey 2018' <www.bakermckenzie.com/-/media/files/insight/publications/2018/03/global-driverless-vehicle-survey-2018/mm_global_driverlessvehiclesurvey2018_mar2018.pdf> 27.
[820] Kyriaki Noussia, 'International Comparisons' in Matthew Channon, Lucy McCormick and Kyriaki Noussia (eds), The Law and Autonomous Vehicles (Informa Law 2019).
[821] Baker McKenzie, 'Global Driverless Vehicle Survey 2018' <www.bakermckenzie.com/-/media/files/insight/publications/2018/03/global-driverless-vehicle-survey-2018/mm_global_driverlessvehiclesurvey2018_mar2018.pdf> 28.
[822] Motor Vehicles Act 1967, § 102, para. 3b, sentence 2.
[823] Baker McKenzie, 'Global Driverless Vehicle Survey 2018' <www.bakermckenzie.com/-/media/files/insight/publications/2018/03/global-driverless-vehicle-survey 2018/mm_global_driverlessvehiclesurvey2018_mar2018.pdf> 28.
[824] Johannes Stalzer, 'Austria Paves the Legal Way for (Partly) Autonomous Vehicles' (21 March 2019) <www.schoenherr.eu/publications/publication-detail/austria-paves-the-legal-way-for-partly-autonomous-vehicles/>.

➢ *Belgium*

In 2016, the Ministry of Mobility of Belgium published a *Code of Good Practice* for companies wishing to conduct trials of autonomous vehicles on public roads.[825] The code was based on the *Code of Conduct for Testing* issued by the UK the previous year.[826] The testing driver must have the appropriate license for the type of vehicle and training, and the trialling organisation must conduct a risk analysis and develop risk management strategies.[827] The vehicle and driver must also be insured.[828] The *Code of Conduct* requires that when conducting trials, 'a fully automated vehicle has the facility to resume manual control at any time'.[829]

Prior to May 2018, Belgian law requires all vehicles to have drivers.[830] And driver is defined as anyone who drives a vehicle.[831] De Bruyne and Tanghe conclude that based on interpretations of the Belgian Court of Cassation, for autonomous vehicles, 'the person who is responsible for driving is the person whose task it is to supervise the operating system…[and] must at least have the possibility to influence the movements of his vehicle'.[832] In general, the driver may be liable for accidents even if the conduct was performed by the automated system, 'as art 8.3 of the Code stipulates that the driver needs to have his vehicle well under control at all times'.[833]

A Royal Decree came into force in May 2018 that allowed for time limited exemptions to the provision mandating a human driver inside the vehicle subject to approval by the Ministry of Mobility and monitoring of the vehicle remotely.[834] As such, autonomous vehicles without humans inside are now allowed on Belgian public roads for the purpose of trialling.

➢ *Czech Republic*

The Ministry of Transport released the *Action Plan for the Deployment of Intelligent Transport Systems (ITS) in the Czech Republic until 2020 (with the prospect of 2050)* in June 2016.[835] The report specifically cites supporting the development of autonomous vehicles as one of its objectives.[836]

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[825] Lawrence Freeman et al, 'Latest Developments around the World Regarding Driverless Cars (*Bird & Bird* March 2019) <www.twobirds.com/en/news/articles/2019/global/at-a-glance-autonomous-vehicles>.

[826] Lucy McCormick, 'Testing Autonomous Vehicles' in Matthew Channon, Lucy McCormick and Kyriaki Noussia (eds), The Law and Autonomous Vehicles (Informa Law 2019)

[827] Federal Public Service Mobility and Transport, 'Autonomous Vehicles: Code of Practice for Testing in Belgium <mobilit.belgium.be/sites/default/files/resources/files/code_of_practice_en_2016_09.pdf> 6.

[828] Federal Public Service Mobility and Transport, 'Autonomous Vehicles: Code of Practice for Testing in Belgium <mobilit.belgium.be/sites/default/files/resources/files/code_of_practice_en_2016_09.pdf> 6.

[829] Federal Public Service Mobility and Transport, 'Autonomous Vehicles: Code of Practice for Testing in Belgium <mobilit.belgium.be/sites/default/files/resources/files/code_of_practice_en_2016_09.pdf> 4.

[830] Article 8.1 of the Belgian Highway Code.

[831] Article 2.13 of the Belgian Highway Code.

[832] Jan De Bruyne and Jochen Tanghe, 'Liability for Damage Caused by Autonomous Vehicles: A Belgian Perspective' (2018) 8 Journal of European Tort Law 324, 341.

[833] Jan De Bruyne and Jochen Tanghe, 'Liability for Damage Caused by Autonomous Vehicles: A Belgian Perspective' (2018) 8 Journal of European Tort Law 324, 342.

[834] Lawrence Freeman et al, 'Latest Developments around the World Regarding Driverless Cars (*Bird & Bird* March 2019) <www.twobirds.com/en/news/articles/2019/global/at-a-glance-autonomous-vehicles>.

[835] Ministry of Transport, 'Action Plan for the Deployment of Intelligent Transport Systems (ITS) in the Czech Republic until 2020 (with the Prospect of 2050)' <www.czechspaceportal.cz/files/files/ITS_new/AP%20ITS/AP%20ITS%20EN%20(HQ).pdf>.

In 2018, an amendment to the Act on Operation Surface Communications was introduced.[837] The bill would widen the definition of 'driver' to include an operator of an autonomous vehicle who is ready to take over the controls.[838] It also included safety specifications the vehicle must meet.[839] While the Ministry of Transport and private companies have been supportive of closed testing sites, it is unclear whether there have been any testing performed on public roads thus far.[840]

- **Germany**

Germany was the first European state to amend its regulatory framework to welcome the introduction of autonomous vehicles.[841] Although the SAE classification of autonomous vehicles has been largely accepted by governments, industry, and academics, the German Association of the Automotive Industry uses a slightly different standard:

0 Driver only
1 Assisted
2 Partial driving automation
3 High driving automation
4 Full driving automation
5 Driverless[842]

In July 2016, a committee of 14 members appointed by the German Federal Minister of Transport and Digital Infrastructure was tasked with developing a code of ethics for Level 4 and Level 5 autonomous vehicles in Germany.[843] The code was released in June 2017 and consists of 20 ethical guidelines designed to influence future regulation in Germany.[844] One committee member notes that 'no legislation in Germany will be able to completely neglect or circumvent it'.[845] Nonetheless, the ethical guidelines have been criticised for missing two major principles:

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836 Ministry of Transport, 'Action Plan for the Deployment of Intelligent Transport Systems (ITS) in the Czech Republic until 2020 (with the Prospect of 2050)' <www.czechspaceportal.cz/files/files/ITS_new/AP%20ITS/AP%20ITS%20EN%20(HQ).pdf> 83-84.

837 Tomáš Matejovský and Petr Beneš, 'Draft bill facilitates autonomous car usage in the Czech Republic' (*Lexology* 20 June 2018) <www.lexology.com/library/detail.aspx?g=e4bb3c1a-3c28-4aeb-8741-13f3a712e77a>.

838 Tomáš Matejovský and Petr Beneš, 'Draft bill facilitates autonomous car usage in the Czech Republic' (*Lexology* 20 June 2018) <www.lexology.com/library/detail.aspx?g=e4bb3c1a-3c28-4aeb-8741-13f3a712e77a>.

839 Tomáš Matejovský and Petr Beneš, 'Draft bill facilitates autonomous car usage in the Czech Republic' (*Lexology* 20 June 2018) <www.lexology.com/library/detail.aspx?g=e4bb3c1a-3c28-4aeb-8741-13f3a712e77a>.

840 Baker McKenzie, 'Global Driverless Vehicle Survey 2018' <www.bakermckenzie.com/-/media/files/insight/publications/2018/03/global-driverless-vehicle-survey-2018/mm_global_driverlessvehiclesurvey2018_mar2018.pdf> 73-74.

841 Agnes B Juhasz, 'The Regulatory Framework and Models of Self-Driving Cars' (2018) 52 Zbornik Radova 1371, 1373; See also Francesco P Patti, 'The European Road to Autonomous Vehicles' (2019) 43 Fordham International Law Journal 125, 134.

842 Christoph Luetge, 'The German Ethics Code for Automated and Connected Driving' (2017) 30 Philosophy & Technology 547.

843 Christoph Luetge, 'The German Ethics Code for Automated and Connected Driving' (2017) 30 Philosophy & Technology 547.

844 Christoph Luetge, 'The German Ethics Code for Automated and Connected Driving' (2017) 30 Philosophy & Technology 547.

845 Christoph Luetge, 'The German Ethics Code for Automated and Connected Driving' (2017) 30 Philosophy & Technology 547.

> Two glaring omissions from the guidelines are the principles of transparency and trust in the development of autonomous vehicle software. Both transparency and trust are critical and related: transparency will lead to an entry level of trust, both for regulators and the general public.[846]

The German government has also been active in facilitating the development of autonomous vehicles through legal amendments. In order to conform domestic law to the newly amended Vienna Convention that permits autonomous vehicle technology to be used on public roads, the German government enacted a law on December 13, 2016.[847] In 2017, the Road Transportation Act was amended, which now 'sets legal requirements for the operation of highly and fully automated vehicles and mainly preserves the existing liability and insurance framework, characterised by a combination of strict liability of the vehicle owner and fault-based liability of the (human) driver'.[848] Autonomous vehicles are more clearly defined in this law than in the UK and have the following characteristics: 'with full control of the driving task', 'capable of conforming to traffic regulations in full automation', 'that allow the driver to manually override or deactivate the automation at any time', 'with the capacity to recognize that it is necessary for the driver to take control and deactivate the automation', 'with the visual and acoustic and tactual indication that the driver shall take control with sufficient time for the driver to take control', and 'with the capacity to indicate wrong use to one of the system descriptions'.[849]

While testing an autonomous vehicle, there must be a driver who can take over control from the computer.[850] The driver is obligated to be attentive and 'must not rely entirely on the automated driving system'.[851] The trialling driver is required to have insurance cover and would be liable for accidents while the vehicle is under human control, but unlike the clarity offered in the UK, the law is not specific on who would be liable if an accident were to occur while the vehicle is in autonomous mode.[852] It has been suggested, however, that the manufacturer would be liable under such circumstances per general product liability law.[853] The law requires the installation of a black box in the autonomous vehicle to collect data that would aid the determination of the cause of accidents,

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[846] Hannah YeeFen Lim, *Autonomous Vehicles and the Law: Technology, Algorithms and Ethics* (Edward Elgar 2018) 130.
[847] Antonios E Kouroutakis, 'Autonomous Vehicles; Regulatory Challenges and the Response from UK and Germany' (August 22, 2019) (2020) 46 Mitchell Hamline Law Review forthcoming. Available at SSRN: https://ssrn.com/abstract=3441264 or http://dx.doi.org/10.2139/ssrn.3441264.
[848] Fabian Pütz et al, 'Reasonable, Adequate and Efficient Allocation of Liability Costs for Automated Vehicles: A Case Study of the German Liability and Insurance Framework' (2018) 9 Eur J Risk Reg 548, 549.
[849] Antonios E Kouroutakis, 'Autonomous Vehicles; Regulatory Challenges and the Response from UK and Germany' (August 22, 2019) (2020) 46 Mitchell Hamline Law Review forthcoming. Available at SSRN: https://ssrn.com/abstract=3441264 or http://dx.doi.org/10.2139/ssrn.3441264.
[850] Antonios E Kouroutakis, 'Autonomous Vehicles; Regulatory Challenges and the Response from UK and Germany' (August 22, 2019) (2020) 46 Mitchell Hamline Law Review forthcoming. Available at SSRN: https://ssrn.com/abstract=3441264 or http://dx.doi.org/10.2139/ssrn.3441264.
[851] Kyriaki Noussia, 'International Comparisons' in Matthew Channon, Lucy McCormick and Kyriaki Noussia (eds), The Law and Autonomous Vehicles (Informa Law 2019)
[852] Antonios E Kouroutakis, 'Autonomous Vehicles; Regulatory Challenges and the Response From UK and Germany' (August 22, 2019) (2020) 46 Mitchell Hamline Law Review forthcoming. Available at SSRN: https://ssrn.com/abstract=3441264 or http://dx.doi.org/10.2139/ssrn.3441264.
[853] Antonios E Kouroutakis, 'Autonomous Vehicles; Regulatory Challenges and the Response from UK and Germany' (August 22, 2019) (2020) 46 Mitchell Hamline Law Review forthcoming. Available at SSRN: https://ssrn.com/abstract=3441264 or http://dx.doi.org/10.2139/ssrn.3441264.

including whether the technology or human was in control.[854] To assuage data privacy concerns, the law requires data to be deleted after six months unless there were an accident.[855]

- ***Lithuania***

The Lithuania government has been eager to have organisations and developers test autonomous cars in the state with ongoing discussions with Poland, Latvia, and Estonia to create a corridor for testing.[856] In December 2017, a new law was passed that allows for autonomous vehicles to operate without a human driver in the car.[857] The new legislation was designed to encourage testing in the state.[858] The Road Administration has also touted the country's highway as an ideal place for autonomous vehicles testing.[859]

- ***Poland***

In January 2018, the Law on Electromobility and Alternative Fuels was passed. It amends the Polish Road Transport Act to define an autonomous vehicle as one that is 'equipped with technology and systems which control the vehicle's movement and...allows the vehicle to drive without any driver interaction'.[860] As a result, only electric or hybrid cars could meet the definition.[861] To conduct trials on public roads, the developer must submit an application, which includes proof of insurance.[862] The owners of property along the planned testing route are given an opportunity to voice their objections.[863] During the actual test, a driver must be in the vehicle ready to take control at any

[854] Peter Sayer, 'Germany Will Allow Self-driving, but Not Driverless, Cars on Its Roads (*CIO* 12 May 2017) <www.cio.com/article/3196429/germany-will-allow-self-driving-but-not-driverless-cars-on-its-roads.html>.
[855] Sandra Link, 'Autonomous Cars - Opportunities and Challenges in Germany' (*Lexology* 16 January 2018) <www.lexology.com/library/detail.aspx?g=051836a2-45cd-42c0-a66a-ea62137a2188
[856] Transport Minister: Lithuania Ready to Test Driverless Cars (*Delphi* 16 June 2019) <en.delfi.lt/business/transport-minister-lithuania-ready-to-test-driverless-cars.d?id=81460471>.
[857] 'Parliament Opens Lithuania's Roads to Driverless Autonomous Vehicles' (*Delphi* 8 December 2017) <en.delfi.lt/politics/parliament-opens-lithuanias-roads-to-driverless-autonomous-vehicles.d?id=76583023>.
[858] Kwinten Wouters, 'Pioneering Lithuania Opens Its Roads to Driverless Cars' (*150Sec* 24 January 2018) <150sec.com/pioneering-lithuania-opens-its-roads-to-driverless-cars/8150/>.
[859] 'Lithuania Seeks to Attract Manufacturers of Self-driving Cars' (*Delphi* 19 March 2018) <en.delfi.lt/business/lithuania-seeks-to-attract-manufacturers-of-self-driving-cars.d?id=77464399>.
[860] Cyprian Szeretucha, 'Draft Bill on Testing Autonomous Vehicles on Public Roads in Poland' (Bird & Bird May 2017) <www.twobirds.com/en/news/articles/2017/poland/draft-bill-on-testing-autonomous-vehicles-on-public-roads-in-poland>.
[861] Cyprian Szeretucha, 'Draft Bill on Testing Autonomous Vehicles on Public Roads in Poland' (Bird & Bird May 2017) <www.twobirds.com/en/news/articles/2017/poland/draft-bill-on-testing-autonomous-vehicles-on-public-roads-in-poland>.
[862] Bartłomiej Jaworski, 'Autonomous Vehicles: The Legal Landscape of Using and Testing Autonomous Cars in Poland' in Dominika Cendrowicz and Agnieszka Chrisidu-Budnik (eds) *Comparative Perspectives for Public Administration and Administrative Law* (Wydział Prawa, Administracji i Ekonomii Uniwersytetu Wrocławskiego 2019) 201.
[863] Bartłomiej Jaworski, 'Autonomous Vehicles: The Legal Landscape of Using and Testing Autonomous Cars in Poland' in Dominika Cendrowicz and Agnieszka Chrisidu-Budnik (eds) *Comparative Perspectives for Public Administration and Administrative Law* (Wydział Prawa, Administracji i Ekonomii Uniwersytetu Wrocławskiego 2019) 202.

time.[864] The road on which the test is conducted must also be fitted with signs warning others of the ongoing tests.[865]

- ***Netherlands***

In 2015, the Decree on Exemption of Exceptional Transport was amended.[866] This is a different approach from other jurisdictions because ‘instead of drafting extensive new laws or formulating non-binding regulations, the Dutch Vehicle Authority (RDW) has been given the competence to grant exemptions from certain laws if these exemptions are useful for the testing of automated vehicle functions’.[867] There are no set criteria for the granting of exemptions, but the RDW would review the application, including the test plan, risk analysis, and insurance.[868] If it is satisfied, the vehicle would be permitted to be tested on a closed site first.[869] If successful, then an exemption is granted for trialling on public roads subject to conditions set by the RDW, which could include ‘type of road and the weather conditions under which testing is allowed’ or ‘additional insurance’.[870] Traditionally under Dutch case law, the definition of driver is relatively wide and could include passengers or pedestrians who influence the speed or direction of the vehicle by operating the controls.[871] However, for the sake of clarity, the Dutch Road Traffic Act was amended in October 2018 to allow autonomous vehicles to be tested without the presence of a human driver on board.[872]

- ***Hungary***

In 2017, the Ministerial Decree K6HEM No. 5/1990 of 12 April 1990 on the technical inspection of road vehicles and the Ministerial Decree K6HtM No. 6/1990 of 12 April 1990 on the technical conditions for placing and keeping road vehicles in circulation were amended to accommodate the testing of autonomous cars.[873] The term used in the Hungarian regulations is ‘autonomous vehicle for experimental purposes’.[874] These vehicles are ‘aimed at the development of partially or fully

[864] Cyprian Szeretucha, ‘Draft Bill on Testing Autonomous Vehicles on Public Roads in Poland’ (Bird & Bird May 2017) <www.twobirds.com/en/news/articles/2017/poland/draft-bill-on-testing-autonomous-vehicles-on-public-roads-in-poland>.
[865] Cyprian Szeretucha, ‘Draft Bill on Testing Autonomous Vehicles on Public Roads in Poland’ (Bird & Bird May 2017) <www.twobirds.com/en/news/articles/2017/poland/draft-bill-on-testing-autonomous-vehicles-on-public-roads-in-poland>.
[866] Baker McKenzie, ‘Global Driverless Vehicle Survey 2018’ <www.bakermckenzie.com/-/media/files/insight/publications/2018/03/global-driverless-vehicle-survey-2018/mm_global_driverlessvehiclesurvey2018_mar2018.pdf> 139.
[867] Nynke E Vellinga, ‘From the Testing to the Deployment of Self-driving Cars: Legal Challenges to Policymakers on the Road Ahead’ (2017) 33 Computer Law & Security Review 847, 854.
[868] Baker McKenzie, ‘Global Driverless Vehicle Survey 2018’ <www.bakermckenzie.com/-/media/files/insight/publications/2018/03/global-driverless-vehicle-survey-2018/mm_global_driverlessvehiclesurvey2018_mar2018.pdf> 140.
[869] Nynke E Vellinga, ‘From the Testing to the Deployment of Self-driving Cars: Legal Challenges to Policymakers on the Road Ahead’ (2017) 33 Computer Law & Security Review 847, 854.
[870] Nynke E Vellinga, ‘From the Testing to the Deployment of Self-driving Cars: Legal Challenges to Policymakers on the Road Ahead’ (2017) 33 Computer Law & Security Review 847, 854.
[871] Nynke E Vellinga, ‘Automated Driving and the Future of Traffic Law’ in Leonie Reins (ed) *Regulating New Technologies in Uncertain Times* (Springer 2019) 75.
[872] Library of Congress, ‘Regulation of Artificial Intelligence: Europe and Central Asia’ <www.loc.gov/law/help/artificial-intelligence/europe-asia.php>.
[873] Agnes B Juhasz, ‘The Regulatory Framework and Models of Self-Driving Cars’ (2018) 52 Zbornik Radova 1371, 1382.
[874] Agnes B Juhasz, ‘The Regulatory Framework and Models of Self-Driving Cars’ (2018) 52 Zbornik Radova 1371, 1382.

automated operation' and must have a qualified driver who can take over control of the vehicle.[875] To conduct trials on public roads, the organisation must apply for approval and the vehicle can only be registered if it meets ISO Standard 26262, titled Road vehicles – Functional safety.[876] The software for the automated system must also pass a tested via simulation, test bench, and at a closed road or site before the vehicle can go on public roads, and there must be comprehensive insurance cover for the entire period.[877]

- **United Kingdom**

In 2015, the UK established a new governmental agency to oversee the development of autonomous vehicles. Named the Centre for Connected and Autonomous Vehicles (CCAV), it is part of both the Department for Transport and the Department for Business, Energy & Industrial Strategy.[878] CCAV 'aims to make the UK a premier development location for connected and automated vehicles'.[879]

The CCAV has thus far released four guidance and regulations: Prototype vehicles: Regulations for manufacturers on constructing and testing prototype vehicles on roads, Trialling automated vehicle technologies in public, Connected and autonomous vehicle research and development projects, and Principles of cyber security for connected and automated vehicles.[880] The eight cyber security principles that are designed 'for use throughout the automotive sector'[881] are:

1. Organisational security is owned, governed and promoted at board level

2. Security risks are assessed and managed appropriately and proportionately, including those specific to the supply chain

3. Organisations need product aftercare and incident response to ensure systems are secure over their lifetime

4. all organisations, including sub-contractors, suppliers and potential 3rd parties, work together to enhance the security of the system

5. Systems are designed using a defence-in-depth approach

6. The security of all software is managed throughout its lifetime

7. The storage and transmission of data is secure and can be controlled

[875] Agnes B Juhasz, 'The Regulatory Framework and Models of Self-Driving Cars' (2018) 52 Zbornik Radova 1371, 1382.
[876] Baker McKenzie, 'Global Driverless Vehicle Survey 2018' <www.bakermckenzie.com/-/media/files/insight/publications/2018/03/global-driverless-vehicle-survey-2018/mm_global_driverlessvehiclesurvey2018_mar2018.pdf> 100.
[877] Baker McKenzie, 'Global Driverless Vehicle Survey 2018' <www.bakermckenzie.com/-/media/files/insight/publications/2018/03/global-driverless-vehicle-survey-2018/mm_global_driverlessvehiclesurvey2018_mar2018.pdf> 101.
[878] Centre for Connected and Autonomous Vehicles <www.gov.uk/government/organisations/centre-for-connected-and-autonomous-vehicles>.
[879] Centre for Connected and Autonomous Vehicles, About Us, <www.gov.uk/government/organisations/centre-for-connected-and-autonomous-vehicles/about>.
[880] Centre for Connected and Autonomous Vehicles, Guidance and Regulation, <www.gov.uk/search/guidance-and-regulation?organisations%5B%5D=centre-for-connected-and-autonomous-vehicles&parent=centre-for-connected-and-autonomous-vehicles>.
[881] HM Government, 'The Key Principles of Cyber Security for Connected and Automated Vehicles' <assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/661135/cyber-security-connected-automated-vehicles-key-principles.pdf> 1.

8. the system is designed to be resilient to attacks and respond appropriately when its defences or sensors fail[882]

On 19 July 2018, the Automated and Electric Vehicles Act 2018 received royal assent.[883] It is a forward thinking law because it will not be in force until a later date deemed by the Secretary of State for Transport when secondary legislation is issued.[884] When autonomous vehicles are ready to hit the road, the law will be ready to ensure there is certainty on insurance issues related to the use of autonomous vehicles. The Act does not transform the current regime but instead clarifies the insurance liability allocation in the current regulatory environment.[885] The Department for Transport and the Centre for Connected and Autonomous Vehicles conducted a consultation on autonomous vehicles and decided that this would be the more suitable model instead of the originally proposed product liability regime.[886] The product liability model would have compelled the driver to purchase product liability insurance in addition to traditional motor insurance.[887]

The Act provides for a 'single insurer model' where the driver would continue to only deal with the motor insurer.[888] Vehicles are 'automated vehicles' subject to this Act if they are determined by the Secretary of State to be 'designed or adapted to be capable, in at least some circumstances or situations, of safely driving themselves' and 'may lawfully be used when driving themselves, in at least some circumstances or situations, on roads or other public places in Great Britain'.[889] This language was meant to cover Level 4 and Level 5 autonomous vehicles.[890] When an automated vehicle 'driving itself' causes an accident, 'the vehicle is insured', and 'an insured person or any other person suffers damage', the insurer is liable.[891] This means that the insurer would pay for the loss at the outset, but if it determines that the vehicle technology is at fault and the manufacturer should be liable, then it could claim the damages with the manufacturer.892 The insurer can also seek contribution from the injured party based on the theory of contributory negligence or from the person responsible for altering the vehicle software or failing to install critical updates if they were

[882] 'Principles of cyber security for connected and automated vehicles' (6 August 2017) <www.gov.uk/government/publications/principles-of-cyber-security-for-connected-and-automated-vehicles>.

[883] Automated and Electric Vehicles Act 2018 Briefing Paper, Number CBP 8118, 15 August 2018 <researchbriefings.files.parliament.uk/documents/CBP-8118/CBP-8118.pdf> 3.

[884] Automated and Electric Vehicles Act 2018 sec 21; See also Francesco P Patti, 'The European Road to Autonomous Vehicles' (2019) 43 Fordham International Law Journal 125, 134-136.

[885] For further analyses on the Automated and Electric Vehicle Act 2018, see Ken Oliphant, 'Liability for Road Accidents Caused by Driverless Cars' (2019) 2019 Sing Comp L Rev 190 (2019); Matthew Channon, Lucy McCormick and Kyriaki Noussia (eds), The Law and Autonomous Vehicles (Informa Law 2019).

[886] Automated and Electric Vehicles Act 2018 Briefing Paper, Number CBP 8118, 15 August 2018 <researchbriefings.files.parliament.uk/documents/CBP-8118/CBP-8118.pdf> 7; See also Francesco P Patti, 'The European Road to Autonomous Vehicles' (2019) 43 Fordham International Law Journal 125, 158 which suggests that as a result of issues relating to the Product Liability Directive in this context, 'it seems clear that in the long run a suitable legal framework cannot be reached through a mere evolutionary interpretation of the existing law'.

[887] Department for Transport & Centre for Autonomous & Connected Vehicles, Pathway to Driverless Cars: Consultation on Proposals to Support Advanced Driver Assistance Systems and Automated Vehicles Government Response (January 2017) <www.gov.uk/government/uploads/system/uploads/attachment_data/file/581577/pathway-to-driverless-cars-consultation-response.pdf>.

[888] DfT, Pathway to driverless cars: Consultation on proposals to support Advanced Driver Assistance Systems and Automated Vehicles Government Response, 6 January 2017, para 1.10

[889] Automated and Electric Vehicles Act 2018 sec 1(a)-(b).

[890] Automated and Electric Vehicles Bill – Committee (1st Day): Part of the Debate – In the House of Lords at 4:45 pm on 9th May 2018 <www.theyworkforyou.com/lords/?id=2018-05-09c.172.2>.

[891] Automated and Electric Vehicles Act 2018 Sec 2(1).

[892] Automated and Electric Vehicles Act 2018 Sec 5(1).

the causes of the accident.[893] If the accident occurred 'wholly due to the person's negligence in allowing the vehicle to begin driving itself when it was not appropriate to do so', then the insurer would also not be liable.[894] The law is silent on how liability would be determined, and there is concern that more clarity is needed regarding contributory negligence, causation, and the type of data collected by the vehicle to assist with this task and how long to retain them, issues that will need to be addressed.[895] As technology advances, the law may need to be amended, as '[i]n the more distant future - when fully driverless vehicles dominate - insurance taken out by the individual might complete its evolution into a transport policy for first-party loss only' as only the car manufacturer would require third-party insurance to cover product liability.[896]

As this law is not yet in force, it would not be applicable to autonomous vehicles currently being trialled on public roads. Parties trialling autonomous vehicles would still have to purchase appropriate insurance, ensure the vehicle is roadworthy by first testing on closed roads, and make sure there is a human driver inside the vehicle or outside who can remotely take control at any moment per the Code of Practice: Automated vehicle trialling published by the CCAV in February 2019, which was an update to *The Pathway to Driverless Cars: A Code of Practice for Testing* published in 2015 by the Department of Transport.[897] The vehicle must also be fitted with a black box to record data in case of accidents.[898] Human drivers are not required to be in the autonomous vehicles in the UK because it is not bound by the Vienna Convention, having signed but not ratified the instrument.[899] The trialling organisation should inform the CCAV before road testing and need to develop a safety case and safety contingency before the actual testing.[900] Though exemptions can be granted for prototypes, test vehicles must, in general, comply with the Road Vehicles (Construction and Use) Regulations 1986, Road Vehicles Authorised Weight Regulations 1998, and Road Vehicles

[893] Automated and Electric Vehicles Act 2018 Sec 3(1); Automated and Electric Vehicles Act 2018 Sec 4.
[894] Automated and Electric Vehicles Act 2018 Sec 3(2). Different from the UK regime, Melinda Florina Lohmann advocates for 'a system of strict liability of the vehicle holder for damage caused by the operation of his vehicle, paired with mandatory insurance and a direct legal claim of the victim against the insurer'. Melinda Florina Lohmann, 'Liability Issues Concerning Self-Driving Vehicles' (2016) 7 European Journal of Risk Regulation 335, 338.
[895] Law Commission and Scottish Law Commission, 'Automated Vehicles: Analysis of Responses to the Preliminary Consultation Paper' <s3-eu-west-2.amazonaws.com/lawcom-prod-storage-11jsxou24uy7q/uploads/2019/06/Automated-Vehicles-Analysis-of-Responses.pdf> 85-98.
[896] Alex Glassbrook, *The Law of Driverless Cars: An Introduction* (Law Brief Publishing 2017).
[897] Centre for Connected & Autonomous Vehicles, 'Code of Practice: Automated Vehicle Trialling' (February 2019) <assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/776511/code-of-practice-automated-vehicle-trialling.pdf> 8.
[898] Lucy McCormick, 'Testing Autonomous Vehicles' in Matthew Channon, Lucy McCormick and Kyriaki Noussia (eds), The Law and Autonomous Vehicles (Informa Law 2019).
[899] Lucy McCormick, 'Testing Autonomous Vehicles' in Matthew Channon, Lucy McCormick and Kyriaki Noussia (eds), The Law and Autonomous Vehicles (Informa Law 2019).
[900] Centre for Connected & Autonomous Vehicles, 'Code of Practice: Automated Vehicle Trialling' (February 2019) <assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/776511/code-of-practice-automated-vehicle-trialling.pdf>.

Lighting Regulations 1989.[901] In October 2019, high profile testing of Level 4 autonomous vehicles were conducted in London.[902]

The Law Commission of England and Wales and the Scottish Law Commission have been commissioned by the CCAV to review the regulatory framework of autonomous vehicles in the UK.[903] Consisting of three rounds of consultations from 2018 to 2021, the final recommendations are due to be released in 2021.[904] The first consultation focused on safety and civil and criminal liability, the second covers 'remotely operated fleets of automated vehicles and their relationship with public transport' and is awaiting comments, and the third consultation will consolidate the comments to form final proposals.[905] In the first consultation paper, the Law Commissions introduced the role of 'driver-in-charge' who would be in the vehicle while it is in Level 4 automated mode and be fully qualified to intervene if necessary.[906] The second consultation paper introduces the idea of Highly Automated Road Passenger Services (HARPS), which 'refers to a service which uses highly automated vehicles to supply road journeys to passengers without a human driver or user-in-charge'.907 They propose a new national regulatory system using a single safety standard to license operators.[908] In this transportation model, there would be no driver-in-charge; instead, the vehicles would be monitored by remote supervisors.[909] Just as with the first consultation paper, the focus of HARPS is on passengers, though the Law Commissions are open to comments addressing the transportation of freight, which could be relevant to vehicles for I&M that need to transport supplies for maintenance.[910]

2.2.3.4 Liability Issues

The development of a coherent, uniform liability regime which applies to the operation of Autonomous Vehicles (AV) is unsurprisingly limited when compared with that which applies to RPAS.

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[901] Department of Transport, 'Information Sheet: Prototype Road Vehicles -- Construction Requirements' (July 2015) <assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/780601/Information_Sheet_Prototype_Vehicles.pdf>.

[902] James Allen, 'Autonomous Taxis Have Made Their Driverless Debut in London: Are London Cabbies' Days Numbered? (*Sunday Times* 8 October 2019) <www.driving.co.uk/news/autonomous-taxis-made-driverless-debut-london/>.

[903] Law Commission, 'Automated Vehicles: Current Project Status' <www.lawcom.gov.uk/project/automated-vehicles/>.

[904] Law Commission, 'Automated Vehicles: Current Project Status' <www.lawcom.gov.uk/project/automated-vehicles/>.

[905] Law Commission, 'Automated Vehicles: Current Project Status' <www.lawcom.gov.uk/project/automated-vehicles/>.

[906] Law Commission and Scottish Law Commission, 'Automated Vehicles: Summary of the Analysis of Responses to the Preliminary Consultation Paper' (19 June 2019) <s3-eu-west-2.amazonaws.com/lawcom-prod-storage-11jsxou24uy7q/uploads/2019/06/Summary-of-Automated-Vehicles-Analysis-of-Responses.pdf>.

[907] Law Commission and Scottish Law Commission, 'Automated Vehicles: Summary of the Analysis of Responses to the Preliminary Consultation Paper' (19 June 2019) <s3-eu-west-2.amazonaws.com/lawcom-prod-storage-11jsxou24uy7q/uploads/2019/06/Summary-of-Automated-Vehicles-Analysis-of-Responses.pdf> 1.

[908] Law Commission and Scottish Law Commission, 'Automated Vehicles: Summary of the Analysis of Responses to the Preliminary Consultation Paper' (19 June 2019) <s3-eu-west-2.amazonaws.com/lawcom-prod-storage-11jsxou24uy7q/uploads/2019/06/Summary-of-Automated-Vehicles-Analysis-of-Responses.pdf> 9.

[909] Law Commission and Scottish Law Commission, 'Automated Vehicles: Summary of the Analysis of Responses to the Preliminary Consultation Paper' (19 June 2019) <s3-eu-west-2.amazonaws.com/lawcom-prod-storage-11jsxou24uy7q/uploads/2019/06/Summary-of-Automated-Vehicles-Analysis-of-Responses.pdf> 13.

[910] Law Commission and Scottish Law Commission, 'Automated Vehicles: Summary of the Analysis of Responses to the Preliminary Consultation Paper' (19 June 2019) <s3-eu-west-2.amazonaws.com/lawcom-prod-storage-11jsxou24uy7q/uploads/2019/06/Summary-of-Automated-Vehicles-Analysis-of-Responses.pdf> 2.

This is primarily based on the fact that the state of the technology itself is at a far earlier stage of development than is the case for RPAS, which are already widely used.

This is an important issue to consider on the basis that it is intuitive that 'decisions made by an AV in the face of an unavoidable collision will result in questions of liability that courts and legislatures have not heretofore faced'.[911] The problem is that 'unlike conventional vehicles, AV crashes can be caused by the software components of the operating system-the hardware and software that execute the dynamic driving task'.[912] Of particular note is the risk that 'the algorithms in the vehicles' on-board computers will result in some innocent person being selected as the victim of the crash'.[913] As a result, it is suggested that existing 'theories of tort ... will not sufficiently address this situation, because those theories look for a liable party based upon control of the vehicle's design or manufacture, or the use of the vehicle by a consumer, neither of which will apply to an autonomous vehicle'.[914] However, it is also noted that there is a need to balance the interest of providing protection to victims with 'protecting the autonomous vehicle industry, which will be a clear benefit to society, from debilitating absolute liability'.[915] On this point, the European Added value assessment suggests that:

> [I]t is necessary to revise the current legislative EU framework for liability rules and insurance for connected and autonomous vehicles. Not only would revision ensure legal coherence and better safeguarding of consumers rights but it would also be likely to generate economic added value.[916]

Further, a 2016 report on cross-border road traffic accidents within the EU requested by the JURI committee provides examples of liability related issues which could arise in such circumstances.[917] The report highlights a number of ways which accidents involving AVs would interact with existing legislation.[918] This is likely to lead to a lack of clarity in terms of how such accidents would be dealt with from a legal perspective, with the primary focus on where and how parties would go about bringing actions against those liable for damage or injury suffered where multiple jurisdictions could be available. For example, it is noted that:

> For a victim of a traffic accident in which autonomous technologies were involved, it may be difficult, costly, and time consuming to identify the exact cause of the

[911] AR Cowger, 'Liability Considerations when Autonomous Vehicles Choose the Accident Victim' (2018) 19 J of High Technology 1, 4; See also Jeffrey R Zohn, When Robots Attack: How Should The Law Handle Self-Driving Cars that Cause Damages' (2015) University of Illinois Journal of Law, Technology and Policy 461, 473-74

[912] Mark A Geistfeld, 'The Regulatory Sweet Spot for Autonomous Vehicles' (2018) 53(2) Wake Forest Law Review 337, 354-355. See also Gary E Marchant and Rachel A Lindor, 'The Coming Collision Between Autonomous Vehicles and the Liability System' (2010) 52 Santa Clara L Rev 1321, 1326-30.

[913] Alfred R Cowger, Jr, 'Liability Considerations when Autonomous Vehicles Choose the Accident Victim' (2018) 19 J of High Technology 1, 60.

[914] Alfred R Cowger, Jr, 'Liability Considerations when Autonomous Vehicles Choose the Accident Victim' (2018) 19 J of High Technology 1, 60.

[915] Alfred R Cowger, Jr, 'Liability Considerations when Autonomous Vehicles Choose the Accident Victim' (2018) 19 J of High Technology 1, 60.

[916] European Added Value Assessment, A common EU approach to liability rules and insurance for connected and autonomous vehicles, February 2018 <http://www.europarl.europa.eu/RegData/etudes/STUD/2018/615635/EPRS_STU(2018)615635_EN.pdf>

[917] Thomas K Graziano, 'Cross-border traffic accidents in the EU – the potential impact of driverless cars' a June 2016 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee.

[918] These include The Brussels I Regulation (Recast) (EU) 1215/2012; The Rome II Regulation (EC) 864/2007; The Hague Traffic Accident Convention 1971; The Hague Products Liability Convention 1973; The Vienna Convention on Road Traffic 1968; The Motor Insurance Directive 2009/103/EC.

> accident, to provide proof of that cause, and consequently to decide against whom to bring a liability claim (the keeper of a car or its liability insurer on the one hand, or a car or component manufacturer on the other).[919]

Also:

> Some European jurisdictions provide very short limitation periods for extra-contractual liability claims. These might work (well) in a purely national context. However, given the particular challenges a victim of a cross-border accident might face when new technologies play a role, short limitation periods may end up being particularly harsh on victims of cross-border traffic accidents.[920]

With issues such as these in mind, and in the absence of a coherent, clear EU-wide liability regime which applies to AVs, it is necessary to investigate the varying approaches adopted by individual Member States.[921] For this purpose, an indicative sample of Member States which exhibit varying degrees of adaption of their liability regimes to accommodate AVs will now be assessed.

- **Germany**

First, Germany is perhaps the most advanced in terms of adapting their liability system with the imminent use of AVs in mind. This is illustrated by the German Road Traffic Act (StVG) as amended on July 17th 2017 with section 1(a) accounting for 'motor vehicles with highly or fully automated driving function', and 1(b) dealing with 'Rights and responsibilities of the driver when using highly or fully automated driving functions'.[922] Broadly the German approach is one of strict liability,[923] with scope for liability to be avoided if the accident is caused by force majeure,[924] or where it can be proven that fault lies elsewhere.[925] It is unclear how this regime will function 'in a highly automated system, unless the driver is obliged to monitor the car operation at all times'.[926] There is also scope for the existing regimes on product liability,[927] as well as manufacturer liability,[928] to be triggered here.

- **France**

France exhibits some evidence of an attempt to adapt to the use of AVs in the future. However, this is far from comprehensive, particularly when compared to the developments in Germany. An obvious example is the provision to allow for the testing of such vehicles. The Law on Energy Transition for Green Growth notes liability briefly, outlining that:

[919] Thomas K Graziano, 'Cross-border traffic accidents in the EU – the potential impact of driverless cars' a June 2016 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee, 10-11.
[920] Thomas K Graziano, 'Cross-border traffic accidents in the EU – the potential impact of driverless cars' a June 2016 study commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the Request of the JURI Committee, 11.
[921] See for example Melinda F Lohmann, 'Liability Issues Concerning Self-Driving Vehicles' (2016) 7 European Journal of Risk Regulation 335, 336-337.
[922] The German Road Traffic Act (StVG), Section 1.
[923] The German Road Traffic Act (StVG), Section 7.
[924] The German Road Traffic Act (StVG), Section 7(2).
[925] The German Road Traffic Act (StVG), Section 18.
[926] Andreas Lober, Tim Caesar, and Wojtek Ropel 'Germany Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies* (Éditions Larcier 2016) 150.
[927] The German Product Liability Act (Produkthaftung), Section 1.
[928] The German Civil Code on Manufacturer Liability (Produzentenhaftung) Sections 823 and 831 BGB.

> The Government is authorized to take, by way of ordinance, any measure falling within the scope of the law in order to allow the traffic of vehicles with total or partial delegation of driving on public roads, whether passenger cars, goods transport vehicles or passenger transport vehicles, for experimental purposes, under conditions ensuring the safety of all road users and providing, if necessary, an appropriate liability regime.[929]

It has been noted that the current liability regime regarding road traffic accidents which makes the driver responsible 'cannot … be applied "as is" to accidents caused by an autonomous or driverless car since, in this case, the driver has no direct control of the car'.[930] Also, the same issue would arise should an accident be caused by a driver assistance feature such as cruise control.[931] As a result, it is suggested that 'the future ordinance authorizing the testing of autonomous cars on public roads should determine the appropriate liability regime for autonomous cars'.[932] However, the route by which this would be achieved is unclear.

- **United Kingdom**

The UK has no general body of law pertaining to liability issues stemming from the operation of AVs that is currently in force.[933] Prior to the drafting of the Automated and Electric Vehicles Act 2018, it was considered to be intuitive that the Road Traffic Act 1998 would apply. It was also been suggested that the UK's product liability regime would apply.[934] However, it has previously been outlined that:

Certain concepts related to product liability may not be appropriate to deal with liability in respect of robots. For instance, it is unclear how the requirements for foreseeability, in order to establish legal causation in claims related to breach of contract and the tort of negligence, would be applicable in the context of robots with a high degree of automation.[935]

Potential Liability issues were acknowledged briefly in a recent Code of Practice document provided by The Centre for Connected & Autonomous Vehicles, focused on the testing of AVs on UK roads. The document notes that the failure to comply with the Code of Practice 'may be relevant to liability in any legal proceedings; similarly, compliance with the Code does not grant immunity from any liability'.[936] Importantly, liability issues have been acknowledged within the Automated and Electric Vehicles Act 2018, which considers the liability of insurers where an accident is caused by an automated vehicle.[937] Undoubtedly, this act of Parliament will be of great importance in future.

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[929] Law 2015-992 of 17 August 2015 on energy transition for green growth, art. 37, IX.
[930] Alain Bensoussan and Jérémy Bensoussan, 'France Chapter', in Alain Bensoussan, et al (eds) *Comparative Handbook: Robotic Technologies Law* (Éditions Larcier, 2016)118.
[931] Alain Bensoussan and Jérémy Bensoussan, 'France Chapter', in Alain Bensoussan, et al (eds) *Comparative Handbook: Robotic Technologies Law* (Éditions Larcier, 2016)118.
[932] Alain Bensoussan and Jérémy Bensoussan, 'France Chapter', in Alain Bensoussan, et al (eds) *Comparative Handbook: Robotic Technologies Law* (Éditions Larcier, 2016)118.
[933] Note that the Automated and Electric Vehicles Act 2018 is not yet in force.
[934] The Consumer Protection Act 1987 (which implemented Directive 85/374/EC on Product Liability); See also The Consumer Rights Act 2015, Sections 1 and 2.
[935] Natalia Porto and Daniel Preiskel 'UK Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies Law* (Éditions Larcier 2016) 347.
[936] Centre for Connected & Autonomous Vehicles, 'Invitation to Comment: Code of Practice: Automated vehicle trialling (February 2019) 7.
[937] The Automatic and Electric Vehicles Act 2018, Part 1; See also Francesco P Patti, 'The European Road to Autonomous Vehicles' (2019) 43 Fordham International Law Journal 125, 160 which notes that 'as a matter of principle, places liability directly on the insurer'.

- **Italy**

In Italy, liability issues arising from the use of AVs are not directly regulated and thus, the presumption is that product liability rules will apply.[938] Additionally, the EU Directive on Product Safety[939] has an impact as its implementation that 'the notion of liability looks not merely at the actual manufacturer, but to a number of subjects, i.e. the producer, the importer, all subjects involved in the distribution of the product'.[940]

- **Portugal**

In Portugal there is no liability regime that is specifically focused on AVs. As such, it is assumed that they would be governed by existing rules on product liability as well as the strict liability system which applies to vehicles generally.[941]

- **Spain**

In Spain there is no specific liability framework which applies to AVs. As such, it appears that the general rules on civil liability will apply, which includes the fact that liability of a manufacturer is strict in the case of a defective product.[942] With this in mind, it has been suggested that:

> [C]urrent mechanisms of civil liability will certainly not be suitable for advanced robotics or autonomous robots. The more the robot will be empowered to take decisions freely, on its own, the more difficult it will be to allocate liability among the different agents that may be involved (e.g. the artificial intelligent platform designer, the manufacturer, the user, the robot itself)'.[943]

- **Belgium**

Similarly, in Belgium there is currently no specific regime in place. As such, the existing system of fault-based liability would apply.[944] In addition, it has been suggested that there is a need to modify the Belgian Road Traffic Act to reflect the development of AV technology.[945]

- ***Insurance***

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[938] DPR 224 of May 24 1988 (which implemented Directive 85/374/EC on Product Liability); See also D. Lgs 115 of March 17, 1995 (which implemented Directive 59/92/EC on general product safety); Raffaelle Zallone 'Italy Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies Law* (Éditions Larcier 2016) 204.

[939] D. Lgs 115 of March 17, 1995 (which implemented Directive 59/92/EC on general product safety).

[940] Raffaelle Zallone 'Italy Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies Law* (Éditions Larcier 2016) 206.

[941] The Portuguese Civil Code, Article 503(1); See also Joao P Alves Pereira and Belen Grandos, 'Portugal Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies* (Éditions Larcier 2016) 283-284.

[942] See for example The Spanish Civil Code, Article 1101 (on the nature and effect of obligations); See also Article 1484 (On the warranty against hidden defects or encumbrances of the things sold); Article 1902 (On obligations arising from fault or negligence); The Legislative Royal Decree 1/2007 of November 16, Article 128-149.

[943] Marc Gallardo, 'Spain Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies Law* (Éditions Larcier 2016) 312.

[944] The Belgian Civil Code, Articles 1382-1386.

[945] Jean-Francois Henrotte, Alexandre Cassart, and Fanny Coton and Daniel 'Belgium Chapter' in Alain Bensoussan, Jérémy Bensoussan, Bruno Bonnell, and Mady Delvaux-Stehres, *Comparative Handbook: Robotic Technologies* (Éditions Larcier 2016) 27.

The EU Motor Insurance Directive passed in 2009 requires that motor vehicles be covered by compulsory third party liability insurance and ensures that insurance cover in a Member State extends across the EU when the vehicle is in another Member State. The EU Commission conducted a REFIT review of the Directive in 2018 and did not propose any changes to specifically cover autonomous vehicles because the impact assessment found the current Directive to already cover autonomous and semi-autonomous vehicles.[946]

Autonomous vehicles used for the purpose of I&M may be exempt from this Directive, which defines a vehicle as 'any motor vehicle intended for travel on land and propelled by mechanical power'.[947] Though the text may indicate that vehicles for I&M operations may be covered because they would be traveling on land, the 2017 Rodrigues de Andrade judgement by the Court of Justice of the European Union clarified that third party liability insurance is only required for 'normal use of the vehicle as a means of transport'.[948] Specifically, the vehicle in the case that was found to not meet the definition was an agricultural tractor,[949] which is similar to autonomous vehicles for I&M that would not be used as 'a means of transport'. Nonetheless, as commercial operations, operators operating on land should purchase insurance coverage even if EU regulations do not make it compulsory.

Although the current insurance scheme has been determined to cover autonomous vehicles, a European added value assessment on autonomous and connected cars notes that the new autonomous technology leads to novel and distinct risks that could cause problems and create gaps should they not be addressed systematically.[950] The four main types identified are:

(1) risks relating to the failure of the operating software that enables the AVs to function,
(2) risks relating to network failures,
(3) risks relating to hacking and cybercrime, and
(4) risks/externalities relating to programming choice.[951]

It has been suggested the liability regime, and consequently the insurance framework be amended in order to create certainty over liability if accidents were to occur.[952] The liability regime must be adjusted first because as one scholar warned: 'when there is a fundamental disagreement about the underlying liability rules, the uncertainty is systemic and cannot be eliminated by the pooling of

946 https://ec.europa.eu/info/law/better-regulation/initiative/1407/publication/237387/attachment/090166e5baec10b7_en Rodrigues de Andrade Judgement (C-514/16).

947 https://ec.europa.eu/info/law/better-regulation/initiative/1407/publication/237387/attachment/090166e5baec10b7_en Rodrigues de Andrade Judgement (C-514/16).

948 https://ec.europa.eu/info/law/better-regulation/initiative/1407/publication/237387/attachment/090166e5baec10b7_en Rodrigues de Andrade Judgement (C-514/16) The EU Commission proposed that the result of this judgment, along with that of Vnuk judgement (C-162/13) and Torreiro Judgement (C-334/16) be codified in the Directive to make its scope more explicit.

949 https://ec.europa.eu/info/law/better-regulation/initiative/1407/publication/237387/attachment/090166e5baec10b7_en Rodrigues de Andrade Judgement (C-514/16).

950 https://www.europarl.europa.eu/RegData/etudes/STUD/2018/615635/EPRS_STU(2018)615635_EN.pdf 24-25.

951 https://www.europarl.europa.eu/RegData/etudes/STUD/2018/615635/EPRS_STU(2018)615635_EN.pdf 25.

952 https://www.europarl.europa.eu/RegData/etudes/STUD/2018/615635/EPRS_STU(2018)615635_EN.pdf 24.

individual risks within an insurance scheme'.[953] However, another scholar predicted that because fault-based liability 'always depends on human action or inaction', it will increasingly become of limited value when machines are performing the actions.[954]

The rapid pace of technological development of autonomous vehicles means that insurers will also need to respond quickly in order to accurately price the risk.[955] Operators of I&M autonomous vehicles should be aware of the developments associated with the type of robot they are using to ensure that their insurance needs are consistently being met.

2.3 Vessels/Submersibles

Unmanned Marine Vehicles (UMVs) are vehicles that travel in the waters, and they can be divided into Unmanned (Water) Surface Vehicles (USVs) and Unmanned Underwater Vehicles (UUVs).[956] The former can also be called surface vessels while the latter submersibles. This report addresses both in the same section because for the most part, laws and regulations apply to them equally, though there may be question as to whether submersibles would be covered under the same regime in some contexts due to the language of the legal instruments. Much more effort has been placed on the use of robotics and AI for surface vessels, but in the absence of clear contrary evidence, it is likely that the two would be treated similarly.

The Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) project was one of the earlier efforts by the EU to develop research on autonomous vessels. Active from 2012 to 2015, MUNIN was focused on ships 'primarily guided by automated on-board decision systems but controlled by a remote operator in a shore side control station'.[957] One of the main objects of the project was to '[p]rovide an in-depth economic, safety and legal assessment showing how the results will impact European shipping's competitiveness and safety'.[958] The project concluded that while certain current regulations would have to be adapted for unmanned vessels and liabilities would have to be allocated, they 'do not pose an unsurmountable obstacle in legal terms'.[959]

Another project, the I2C, focused on 'partly automated monitoring system for shipping-related threats' and found that further scrutiny of current laws and amendments to accommodate autonomous vehicles is necessary.[960] The European Commission has also funded the currently ongoing Autonomous Shipping Initiative for European Waters project to develop the next generation of autonomous vessels in Europe focused on short sea shipping and inland waterways.[961]

In addition, the European Defence Agency funded the "Safety and Regulations for European Unmanned Maritime Systems" (SARUMS) project.[962] The project necessarily had a military bent and

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953 Mark A Geistfeld, 'A Roadmap for Autonomous Vehicles: State Tort Liability, Automobile Insurance, and Federal Safety Regulation' (2017) 105 California Law Review 1611, 1618.
954 Thomas Kirchberger, 'European Union Policy-Making on Robotics and Artificial Intelligence: Selected Issues' (2017) 13 Croatian Yearbook of European Law and Policy 191, 204.
955 National Academies of Sciences, Engineering, and Medicine 2016. A Look at the Legal Environment for Driverless Vehicles. Washington, DC: The National Academies Press. P. 52.
956 Eric Van Hooydonk, 'The Law of Unmanned Merchant Shipping – An Exploration' (2014) 20 Journal of International Maritime Law 403, 404.
957 http://www.unmanned-ship.org/munin/
958 http://www.unmanned-ship.org/munin/about/munins-objectives/
959 http://www.unmanned-ship.org/munin/wp-content/uploads/2016/02/MUNIN-final-brochure.pdf
960 Eric Van Hooydonk, 'The Law of Unmanned Merchant Shipping – An Exploration' (2014) 20 Journal of International Maritime Law 403, 404.
961 https://trimis.ec.europa.eu/project/autonomous-shipping-initiative-european-waters#tab-outline
962 http://www.lighthouse.nu/sites/www.lighthouse.nu/files/autonomous_safety_on_vessels_-_webb.pdf

focused on smaller autonomous vessels, including submersibles.[963] Similar to the conclusions of MUNIN, SARUMS founds that while international conventions did not account for the possibility of autonomous ships, the new technology can nevertheless fit into the existing legal framework as long as issues subject to interpretation are clarified and defined.[964] The project also stressed that the technological advances and regulatory developments need to proceed simultaneously.[965]

2.3.1 Certification of Unmanned Underwater Vehicles/ Vessels

DNV GL is an international accredited registrar and classification society for ship certification.[966] DNV GL defined a set of rules that vessels and any offshore robots must comply, including, safety, reliability and environmental requirements. The main objectives of the society are to put requirements on classification, verification, risk-management, training and technical advisory to the maritime industry on safety, enhanced performance, fuel efficiency, etc. GL provide a certification for safety and reliability of all involved parties within a framework of predefined procedures. Today's underwater robot market is on its way to be competitive area (see the following figure[967]), but still as much attractive as other robots. This is one of the main reasons plus security why there is a lake in information of underwater robots.

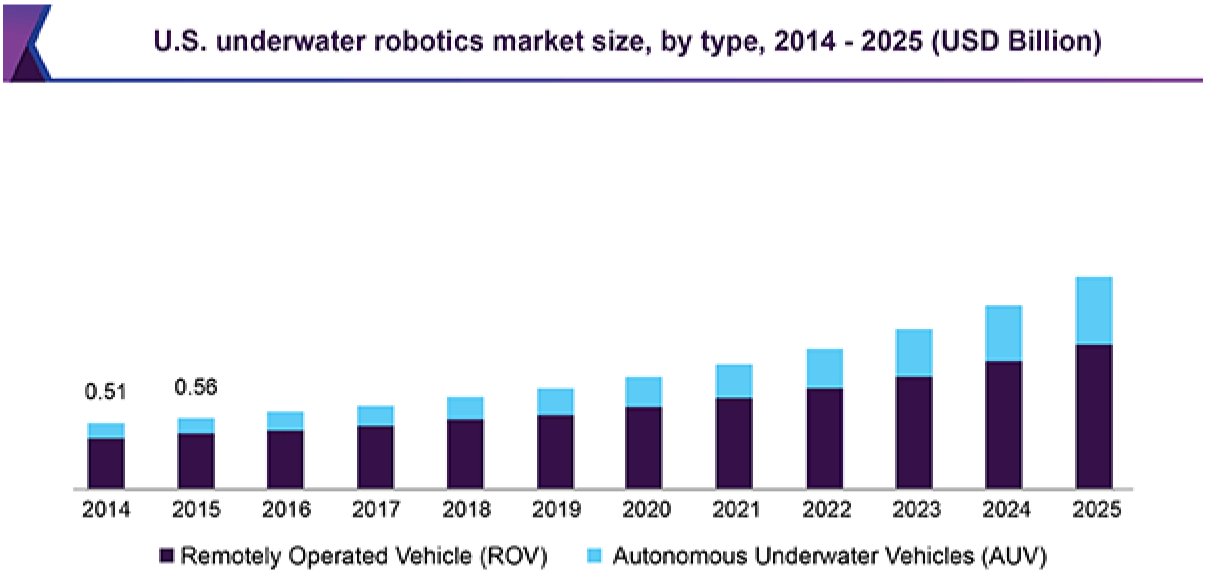

Figure 11: U.S Underwater Robots Market Size[968]

2.3.3 Legislation and policy

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[963] http://www.lighthouse.nu/sites/www.lighthouse.nu/files/autonomous_safety_on_vessels_-_webb.pdf
[964] http://www.lighthouse.nu/sites/www.lighthouse.nu/files/autonomous_safety_on_vessels_-_webb.pdf
[965] http://www.lighthouse.nu/sites/www.lighthouse.nu/files/autonomous_safety_on_vessels_-_webb.pdf
[966] Smale, Will. "The Norwegian firm that tests the world's ships". *bbc.co.uk*. BBC. Archived from the original on 11 February 2015. Retrieved 16 February 2015.
[967] Hinz, S. D., Hagenah, K. D., & Pauli, H. (2010). Certification of Unmanned Underwater Vehicles and Working Machines-Safety and Reliability under Deep-Sea and Offshore Conditions. *IFAC Proceedings Volumes*, *43*(20), 1-4.
[968] *Underwater Robotics Market Size, Share & Trends Analysis Report By Type (ROV, AUV), By Application (Commercial Exploration, Defense & Security, Scientific Research), By Region, And Segment Forecasts, 2018 - 2025*

Once again, relevant legislation and policy issues that apply to the use of UMVs must now be discussed. As has been the case in previous sections of this report, the first point for consideration is the relevant international regime that applies to UMVs. This will be followed by a discussion of the EU position, before moving on to consider national laws that are relevant in this area. The final step will involve considering potential liability issues that could arise through the use of UMVs.

2.3.1.1 International Law

Autonomous vessels can be divided into four levels of autonomy according to the International Maritime Organization (IMO), the UN agency that is 'the global standard-setting authority for the safety, security and environmental performance of international shipping':[969]

Degree one: Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.

Degree two: Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.

Degree three: Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.

Degree four: Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.[970]

Ringbom stresses the importance of differentiating between the level of manning and level of autonomy for autonomous ships and finds the IMO categorisation lacking in gradation.[971] The former involves whether there are crew members on board, whereas the latter is 'the division of tasks between humans and automated systems in complex decision-making processes, such as bridge watchkeeping functions'.[972] He also warns that the level of autonomy on a vessel can change depending on the particular operation involved and should not be determined by the equipment.[973] Furthermore, determining the level of autonomy may be important to answering the question of whether the current international regulatory framework would apply.[974]

Lloyd's Register divides autonomous vessels into seven levels:

> AL 0) Manual: No autonomous function. All action and decision-making performed manually (n.b. systems may have level of autonomy, with Human in/ on the loop.), i.e. human controls all actions.
>
> AL 1) On-board Decision Support: All actions taken by human Operator, but decision support tool can present options or otherwise influence the actions chosen. Data is provided by systems on board.

[969] http://www.imo.org/en/About/Pages/Default.aspx
[970] http://www.imo.org/en/MediaCentre/MeetingSummaries/MSC/Pages/MSC-100th-session.aspx
[971] Henrik Ringbom, 'Regulating Autonomous Ships—Concepts, Challenges and Precedents' (2019) 50 Ocean Development & International Law 141, 149.
[972] Henrik Ringbom, 'Regulating Autonomous Ships—Concepts, Challenges and Precedents' (2019) 50 Ocean Development & International Law 141,142-46.
[973] Henrik Ringbom, 'Regulating Autonomous Ships—Concepts, Challenges and Precedents' (2019) 50 Ocean Development & International Law 141, 146.
[974] Robert Veal and Henrik Ringbom, 'Unmanned Ships and the International Regulatory Framework' (2017) 23 Journal of International Maritime Law 100.

AL 2) On &Off-board Decision Support: All actions taken by human Operator, but decision support tool can present options or otherwise influence the actions chosen. Data may be provided by systems on or off-board.

AL 3) 'Active' Human in the loop: Decisions and actions are performed with human supervision. Data may be provided by systems on or off-board.

AL 4) Human on the loop, Operator/ Supervisory: Decisions and actions are performed autonomously with human supervision. High impact decisions are implemented in a way to give human Operators the opportunity to intercede and over-ride.

AL 5) Fully autonomous: Rarely supervised operation where decisions are entirely made and actioned by the system.

AL 6) Fully autonomous: Unsupervised operation where decisions are entirely made and actioned by the system during the mission.[975]

One of the most salient legal problems raised by autonomous vessels is whether an unmanned ship is still considered a ship.[976] Various international legal instruments define ships differently or not at all due to the fact that they are 'very much a function of the subject matter concerned'.[977] The United Nations Convention on the Law of the Sea (UNCLOS) does not define vessel or ship, and customary international law offers no guidance either.[978] Other international legal instruments may be more useful. Under the International Convention for the Prevention of Pollution from Ships (MARPOL), a ship is 'a vessel of any type whatsoever operating in the marine environment and includes hydrofoil boats, air-cushion vehicles, submersibles, floating craft and fixed or floating platforms'.[979] The Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (SUA Convention) defines a ship as 'a vessel of any type whatsoever not permanently attached to the sea-bed, including dynamically supported craft, submersibles, or any other floating craft'.[980] From the text, it is clear that these two conventions cover both surface vessels and submersibles, and autonomous surface vessels and submersibles that do not have passengers or cargo could be defined as vessels and possibly be subject to these conventions.

However, the International Regulations for Avoiding Collisions at Sea (COLREGs) uses the following definition of a vessel: 'every description of watercraft, including nondisplacement craft and seaplanes, used or capable of being used as a means of transportation on water'.[981] This definition introduces some doubt as to its applicability to unmanned vessels because it is unclear whether 'transportation' means there must be passengers, or if the transportation of cargo would be sufficient. One scholar suggests that 'there is no requirement to read into the definition of "vessel" any necessity for transporting someone or something characterisable as "separate" from the vessel'.[982] If this were the case, autonomous vessels for I&M that will most likely not be carrying

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975 http://info.lr.org/l/12702/2017-06-19/431vy2/12702/163649/LR_Code_for_Unmanned_Marine_Systems__February_2017.pdf pp 1-2.

976 Eric Van Hooydonk, 'The Law of Unmanned Merchant Shipping – An Exploration' (2014) 20 Journal of International Maritime Law 403, 406.

977 W Tetley International Maritime and Admiralty Law (Cowansville Québec 2002) 35

978 Eric Van Hooydonk, 'The Law of Unmanned Merchant Shipping – An Exploration' (2014) 20 Journal of International Maritime Law 403, 406.

979 International Convention for the Prevention of Pollution from Ships (MARPOL) (London 2 November 1973 as amended). Article 2.4.

980 Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (SUA Convention) (Rome 10 March 1988 as amended). Article 1.1(a).

981 Convention on the International Regulations for Preventing Collisions at Sea, 1972, 1050 U.N.T.S. 16, Rule 3(a).

982 Rob McLaughlin, 'Unmanned Naval Vehicles at Sea: USVs, UUVs, and the Adequacy of the Law' (2011) 21 JL Inf & Sci 100, 112.

passengers or cargo would meet the definition of a vessel under COLREGs and may be subject to its jurisdiction. The text of the COLREGs definition may also suggest that it does not cover submersibles because of its use of 'on water', but the convention has been interpreted 'apply to submarines when operating on the surface in the same manner as they apply to surface vessels'.[983] One scholar notes that while 'submarines seem to exist in a sort of quasi-vessel status, depending on where they operate...for all practical purposes, they are treated like any other ship on the seas'.[984]

The United Nations Convention on Conditions for Registration of Ships defines a ship as 'any self-propelled sea-going vessel used in international seaborne trade for the transport of goods, passengers, or both, with the exception of vessels of less than 500 gross registered tons'.[985] For the purpose of this convention, there is a weight minimum, and the vessel must be for 'trade' which would undoubtedly exclude vehicles for I&M. Even if there were no stipulation on weight, the definition would unlikely be applied to surface ships or submersibles traveling on inland waterways.

The definitions offered by international conventions have been described as circular and not useful for generating 'a common understanding as to what generally constitutes a ship' as 'the correct interpretation must be that the definition of a ship is left to individual states' discretion'.986 Nonetheless, it is generally accepted by scholars that unmanned ships are considered ships for the purposes of the law of the sea.[987] This would be especially true given the evolutionary approach of treaty interpretation that takes into account the 'object and purpose',[988] which in the context of the law of the sea is to provide a legal framework for the oceans that can accommodate advances in technology.[989]

As ships, autonomous vessels would be subject to the current international framework governing manned vessels. The aforementioned UNCLOS is widely considered the 'Constitution of the Oceans' and creates a framework for ocean governance, including the rights and duties of vessels.[990] One of the main basic questions for whether autonomous vessels would be lawful under UNCLOS (and other maritime instruments such as the Hague Rules[991] and the Rotterdam Rules[992]), is the question of seaworthiness of the ship, which flag states must ensure.[993] Current understanding of seaworthiness is that vessels must be properly manned, and the lack of any crew members on board may raise

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983 Michael R Benjamin and Joseph A Curcio, COLREGS-Based Navigation of Autonomous Underwater Marine Vehicles, Proceedings of the Institute of Electrical and Electronics Engineers (IEEE) Conference on Autonomous Unmanned Vehicles, at 32 (2004). Whether submarines and submersibles are the same is another legal question without a clear answer. Robert Veal, Michael Tsimplis and Andrew Serdy. 'The Legal Status and Operation of Unmanned Maritime Vehicles' (2019) 50 Ocean Development & International Law 23, 30.

984 Andrew H Henderson, 'Murky Waters: The Legal Status of Unmanned Undersea Vehicles' (2006) 53 Naval L Rev 55, 65.

985 United Nations Convention on Conditions for Registration of Ships (Geneva 7 February 1986) Article 2.

986 Robert Veal, Michael Tsimplis and Andrew Serdy. 'The Legal Status and Operation of Unmanned Maritime Vehicles' (2019) 50 Ocean Development & International Law 23, 26.

987 See James Kraska 'The Law of Unmanned Naval Systems in War and Peace' [2010] The Journal of Ocean Technology 44, 51–53; Eric Van Hooydonk, 'The Law of Unmanned Merchant Shipping – An Exploration' (2014) 20 Journal of International Maritime Law 403, 409;
compare Andrew H Henderson 'Murky Waters: The Legal Status of Unmanned Undersea Vehicles' [2006] Naval Law Review 55, 64-67, 72.

988 Article 31(1) of the Vienna Convention on the Law of Treaties.

989 Robert Veal, Michael Tsimplis and Andrew Serdy. 'The Legal Status and Operation of Unmanned Maritime Vehicles' (2019) 50 Ocean Development & International Law 23, 27.

990 Alex G Oude Elferink, 'Introduction' in Alex G Oude Elferink (ed), Stability and Change in the Law of the Sea: The Role of the LOS Convention (Martinus Nijhoff Publishers 2005) 2.

991 Hague Rules Article 3.1

992 Rotterdam Rules Article 14.

993 UNCLOS art 94.

problems.[994] Scholars have suggested that even if there is no crew on board, the obligation of seaworthiness could be met as long as the vessel can be operated safely.[995] This can include having qualified pilots onshore to operate the vessel remotely.[996]

The IMO is the agency in charge of setting standards for international shipping through drafting international conventions and offering other guidance.[997] It 'functions as a legislative authority' though the power remains with Member States of the IMO.[998] In June 2017, the Maritime Safety Committee (MSC) of the IMO agreed to initiate a regulatory scoping exercise 'to determine how the safe, secure and environmentally sound operation of Maritime Autonomous Surface Ships (MASS) may be introduced in IMO instruments'.[999] The Facilitation Committee and Legal Committee subsequently decided to do the same for legal instruments under their purview.[1000] Notably, UNCLOS is not being analysed by the IMO in this process.[1001] The consensus to use the term MASS going forward created a common language and limited the scope of the exercise by the IMO on surface ships.[1002] However, there is no obvious reason to conclude that the results would be inapplicable to submersibles insofar as the relevant legal instrument applies to submersibles also. The results of the regulatory scope exercise are expected by mid-2020.1003 The possible outcomes are: 'Equivalences as provided for by the instruments or developing interpretations; and/or Amending existing instruments; and/or Developing new instruments; or None of the above as a result of the analysis.'[1004] Should the conclusion be that regulations need to be amended to account for autonomous vessels, this work would then begin, and it is hoped that a regulatory framework would be devised by 2028.[1005]

In June 2019, the MSC approved interim guidelines on the testing of MASS.[1006] The interim guidelines state that 'trials should be conducted in a manner that provides at least the same degree of safety, security and protection of the environment as provided by the relevant instruments'.[1007] The objectives the trialling party should consider are: 'Risk management', 'Compliance with mandatory instruments', 'Manning and qualifications of personnel involved in MASS trials', 'Human element

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[994] *Hong Kong Fir Shipping Co v Kawasaki Kisen Kaisah* [1962] 2 WLR 474

[995] Robert Veal and M Tsimplis, 'The Integration of Unmanned Ships into the Lex Maritima' [2017] Lloyd's Maritime and Commercial Law Quarterly 303, 320; Luci Carey, All Hands Off Deck? The Legal Barriers to Autonomous Ships (August 24, 2017). NUS Law Working Paper No. 2017/011. Available at SSRN: https://ssrn.com/abstract=3025882 or http://dx.doi.org/10.2139/ssrn.3025882 4. But see Anthony Morrison and Stuart Kaye, 'Operating Unmanned Surface Vessels at Sea: Is International Law Ready for the Future?' in Myron H Nordquis et al (eds) *Legal Order in the World's Oceans UN Convention on the Law of the Sea* (Brill Nijhoff 2017) 449.

[996] Marel Katsivela, 'The Effect of Unmanned Vessels on Canadian Law: Some Basic Legal Concepts' (2018) 4 Maritime Safety and Security Law Journal 47, 60; Rodriguez Delgado and Juan Pablo, 'The Legal Challenges of Unmanned Ships in the Private Maritime Law: What Laws Would You Change?' (2018). Maritime, Port and Transport Law between Legacies of the Past and Modernization, 5 Diritto marittimo – Quaderni, Italy 493, 508.

[997] Aldo Chircop, 'The International Maritime Organization' in Donald R Rothwell, Alex G Oude Elferink, and Karen N Scott (eds), The Oxford Handbook of the Law of the Sea (Oxford 2015), 419-20.

[998] Robert Beckman and Zhen Sun, 'The Relationship between UNCLOS and IMO Instruments' (2017) 2 Asia-Pacific Journal of Ocean Law and Policy 201, 204.

[999] http://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx

[1000] http://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx

[1001] http://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx

[1002] Sean T Pribyl, 'Advanced Automation in Shipping Takes Center Stage at IMO' (2018) 1 RAIL 381, 382.

[1003] http://www.imo.org/en/MediaCentre/MeetingSummaries/MSC/Pages/MSC-98th-session.aspx

[1004] http://www.imo.org/en/MediaCentre/MeetingSummaries/MSC/Pages/MSC-100th-session.aspx

[1005] Paul Dean and Henry Clack 'Autonomous Shipping and Maritime Law' in Baris Soyer and Andrew Tettenborn (eds) *New Technologies, Artificial Intelligence and Shipping Law in the 21st Century* (Informa Law 2019) . 87.

[1006] https://www.register-iri.com/wp-content/uploads/MSC.1-Circ.1604.pdf

[1007] MSC.1/Circ.1604.

(including monitoring infrastructure and human-system interface)', 'Infrastructure for safe conduct of trials', 'Trial awareness', 'Communications and data exchange', 'Reporting requirements and information sharing', 'Scope and objective for each individual trial', 'Cyber risk management'.[1008] The testing is subject to all relevant conventions and the approval of the relevant flag state agency, though 'authorization should also be obtained from the coastal State and/or port State Authority where the trial will be conducted'.[1009]

Besides the IMO, the Comité Maritime International (CMI) has also been active in analysing the legal issues raised by the development of autonomous vessels. CMI is an organisation founded in 1897 with the aim of codifying international maritime law.[1010] Its membership includes over 50 national maritime law organisations, and it has consultative status with the IMO and the UN.[1011] CMI formed the Working Group on Maritime Law for Unmanned Crafts to study the issue of autonomous ships. It released a position paper on unmanned ships and subsequently surveyed its member national maritime law associations on the current status of autonomous vessels under their respective national laws.[1012] It also analysed IMO legal instruments to determine their compatibility with autonomous ships.[1013] The results of both were submitted to the MSC in February 2018.[1014]

On the private front, in addition to the CMI, the International Network for Autonomous Ships (INAS) has also been formed in 2017 to facilitate collaboration amongst national and regional organisations. It serves 'as a repository for information of common interest and as a central node for distribution of information between member organisations', which hail from the UK, Finland, Norway, Germany, Korea, the US, Canada, Singapore, Denmark, Japan, Belgium, Sweden, the Netherlands, Estonia, China, and Australia.[1015] The Satellite for 5G initiative of the European Space Agency and the European Maritime Safety Agency are also participants.[1016]

2.3.1.2 National Laws

As discussed in the previous section, whether unmanned vessels constitute vessels as defined by law depends on the particular treaty in international law, and the situation is similar for domestic laws governing ships where it is dependent on the jurisdiction. Domestic law is important in this realm because UNCLOS stipulates that '[e]very State shall effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag'.[1017] It is the domestic law of where the ship is registered that has jurisdiction over the vessel, so whether the domestic law can accommodate autonomous vessels would be highly influential to the technological development and industry acceptance. It is also noteworthy that whether or not an unmanned vessel is likely to be categorised as a 'ship' varies between Member States. This is particularly important with respect to the issues of limiting liability which will be discussed later. The rest of this section discusses this variance across a sample of EU Member States.

[1008] MSC.1/Circ.1604.
[1009] MSC.1/Circ.1604.
[1010] Stuart Hetherington, 'International Law: Current Issues at CMI' (2014) 28 Austl & NZ Mar LJ 51, 51.
[1011] https://comitemaritime.org/wp-content/uploads/2018/06/a-brief-history-wiswall.pdf
[1012] https://comitemaritime.org/wp-content/uploads/2018/05/CMI-Position-Paper-on-Unmanned-Ships.pdf; https://comitemaritime.org/wp-content/uploads/2018/05/CMI-IWGUS-Questionnaire-24-03-2017.docx
[1013] MSC/99.
[1014] MSC/99.
[1015] http://www.autonomous-ship.org/
[1016] http://www.autonomous-ship.org/members.html
[1017] UNCLOS article 94.

➢ *Belgium*

In Belgium, a ship is defined to mean:

[A]ny floating craft, self-propelled or not, with or without any water displacement, used or fit to be used as a means of locomotion, in, above or under the water, including the installations not permanently attached to the shore or to the soil; a ship under construction is considered to be a ship as soon as the building contract has been signed.[1018]

This suggests that unmanned vessels which operate both on the surface and underwater are very likely to be classified as ships. The specific reference to operating 'above or under the water' is particularly relevant here.

The Belgian authorities have released a Smart Shipping Code of Practice for testing in Flanders for testing autonomous vessel trialling in inland waterways.[1019] It sets the minimum standards for testing and 'additional conditions may be imposed for specific applications which may vary according to the waterway and the kind of vessel covered by the application'.[1020] The testing organisation must perform a risk management analysis and devise risk mitigation strategies prior to the testing.[1021] The Code requires insurance cover and for the testers to be sufficiently trained and certified for the type of vessel being trialled even if it is operating on autonomous mode.[1022] While testing, the vessel must collect the following data if they are relevant to the type of vessel being trialled:

- whether the vessel is operating in classic or automated mode;
- the speed of the vessel;
- steering commands and activation;
- braking commands and activation;
- activation of the vessel's audible warning system;
- the location of the vessel (on the waterway);
- the operation of the vessel's lights and indicators;
- sensor data concerning the presence of other waterway users or objects in the vicinity of the vessel;
- remote commands that (may) influence the vessel's movements (where applicable)[1023]

Belgium has not released regulations or guidelines to regulate unmanned ships, but it has been working closely with the IMO on the regulatory exercise.[1024]

➢ *Denmark*

Denmark has been one of the international leaders in studying the feasibility of autonomous vessels. Under the Danish Merchant Shipping Law, ships are defined negatively: 'floating docks, cable drums,

[1018] The Belgian Ship Registration Act of 21 December 1990, Section 1(1).
[1019] https://www.vlaamsewaterweg.be/sites/default/files/download/smart_shipping_code_of_conduct.docx
[1020] https://www.vlaamsewaterweg.be/sites/default/files/download/smart_shipping_code_of_conduct.docx
[1021] https://www.vlaamsewaterweg.be/sites/default/files/download/smart_shipping_code_of_conduct.docx
[1022] https://www.vlaamsewaterweg.be/sites/default/files/download/smart_shipping_code_of_conduct.docx
[1023] https://www.vlaamsewaterweg.be/sites/default/files/download/smart_shipping_code_of_conduct.docx
[1024] https://mobilit.belgium.be/en/shipping/semi_autonomous_shipping

floating containers and other similar equipment are not considered ships'.[1025] As this provision is silent on whether the vessel is crewed, autonomous vessels would likely be considered ships under domestic law.

In December 2017, the Danish Maritime Authority (DMA) released a report 'to identify, systematise and present recommendations for how to handle the regulatory barriers to the development of autonomous ships'.[1026] The report recommends, inter alia, that the IMO is able to regulate autonomous vessels on as wide a basis as possible to ensure international harmonisation and that the EU should wait for the IMO to take action before devising regulatory measures to fill the gaps.[1027] It also recommends that states should remain flexible and address trialling of autonomous vessels on a case-by-case basis instead of relying on general rules.[1028] For the Danish government specifically, the report recommends the areas of national law that need to be addressed:

The first intermediate goal in terms of preparing national regulation could be to adapt the definition of the concept of the "master" and to lay down new definitions of the concepts "autonomous ships" and "remote operator" and to clarify which rights/obligations should rest with a "remote operator". In addition, it would be important to amend national regulation requiring ships always to be manned or documents to always be physically available on board.[1029]

- ***France***

In France, it appears that the key consideration when assessing whether an unmanned vessel would be classified as a ship is whether or not it would be manned. While it is outlined that maritime navigation may include both surface and submarine navigation,[1030] the evident requirement is that a crew must operate on board in order for a vessel to be considered a ship.[1031] Clearly this could be problematic with respect to unmanned vessels. This is particularly important when considering the potential for limiting liability,[1032] as under French law, this is applicable only to ships.[1033]

- ***Greece***

In Greece, a ship is defined as 'any vessel which can move or be moved on the water for transportation of persons or goods, towage, salvage, fishing, pleasure, scientific research or any

[1025] Danish Merchant Shipping Law section 11(2).

[1026] https://www.dma.dk/Documents/Publikationer/Analysis%20of%20Regulatory%20Barriers%20to%20the%20Use%20of%20Autonomous%20Ships.pdf 1.

[1027] https://www.dma.dk/Documents/Publikationer/Analysis%20of%20Regulatory%20Barriers%20to%20the%20Use%20of%20Autonomous%20Ships.pdf 14.

[1028] https://www.dma.dk/Documents/Publikationer/Analysis%20of%20Regulatory%20Barriers%20to%20the%20Use%20of%20Autonomous%20Ships.pdf 14.

[1029] https://www.dma.dk/Documents/Publikationer/Analysis%20of%20Regulatory%20Barriers%20to%20the%20Use%20of%20Autonomous%20Ships.pdf 16.

[1030] See The French Transport Code 2010, Article L.5000-1.

[1031] See The French Transport Code 2010, Article L.5000-2; See also *Compagnie Armoricaine et al v Etablissements Sanrapt et al* (1949) 1 [1949] DMF 380; *Entreprise Caroni v Société Béarnaise et al* (1949) 1 [1949] DMF 241.

[1032] See Section 2.3.1.3.

[1033] See The French Transport Code 2010, Article L.5121-3 other purpose'.[1034] As a result of this broad definition, it appears that unmanned vessel could well be considered to be a 'ship' under the Greek law.

- ***Netherlands***

The Civil Code of the Netherlands defines ships as 'all things "that are not an aircraft, which pursuant to their construction are intended for flotation and which float or have floated"'.[1035] Further, a 'seagoing ship' is defined to mean 'ships registered as 'sea-going ship[s]' in the public registers referred to in Section 3.1.2, and ships not registered in those public registers that, according to their construction, are intended exclusively or principally for floating on the sea'.[1036] This suggests that unmanned surface vessels would be considered ships, though whether submersibles would be is not as clear. Though submersibles are meant to go underwater, they nonetheless could still be 'intended for flotation' when operating on the surface (at the beginning or end of missions for example). This suggests that under Dutch law, it may still be ambiguous as to whether laws that reference ship would apply to submersibles.

In 2017, the Joint Industry Project (JIP), a Dutch project with over 20 partners, was launched and focused on the technical aspects of autonomous shipping.[1037] It conducted trials in the North Sea in March 2019 and 'took part in several nautical scenarios to determine how the vessel would interact with seagoing traffic'.[1038] The initial project ended in November 2019, but further joint projects are planned, including those working on autonomous shipping in inland waterways.[1039] However, to date, no regulatory guidelines on autonomous shipping have been released by the government or industry.

- ***Poland***

In Poland, a 'sea-going vessel' is defined to mean 'any floating structure appropriated or employed in navigation at sea'.[1040] This is a particularly broad definition which does not appear to limit the ability for an unmanned vessel to be classified as a ship.

- ***Spain***

In Spain, the definition of a vessel extends to 'not only craft intended for coastal or high seas navigation, but also ... floating docks, pontoons, dredges, hopper barges or any other floating devices destined or capable of being used in maritime or inland transport for industrial or commercial purposes'.[1041] Additionally, this extends to 'all vessels, craft and maritime apparatus irrespective or their origin, tonnage or activity'.1042 As a result, it appears possible that unmanned vessels could well be registered as 'ships' in Spain.

[1034] See The Greek Code of Public Maritime Law, Article 3.
[1035] The Dutch Civil Code, Book 8, Article 8:1.1.
[1036] The Dutch Civil Code, Book 8, Article 8:2.1.
[1037] https://worldmaritimenews.com/archives/236788/dutch-consortium-to-study-autonomous-shipping/
[1038] http://autonomousshipping.nl/download/161/.
[1039] https://www.rivieramm.com/news-content-hub/news-content-hub/shortsea-shippers-bet-on-autonomous-vessels-56192
[1040] See The Polish Maritime Code of 2001, Article 2(1).
[1041] See JM Alcantara, 'Chapter on Spain' in M Huybrechts (ed) *International Encyclopedia of Laws: Transport Law, Volume 3* (Kluwer, 2014) 63; See also The Spanish Commercial Registration Regulations 1597/1989 of 29 December.
[1042] See JM Alcantara, 'Chapter on Spain' in M Huybrechts (ed) *International Encyclopedia of Laws: Transport Law, Volume 3* (Kluwer, 2014) 63; See also The Royal Decree 1027/1989 of 28 July.

➢ *Sweden*

In Sweden, a ship is defined as a vessel that is at least twelve meters in length with a breadth of at least four meters.[1043] The result is that a vessel that are smaller than these specifications are categorised as boats. However, the potential application of either definition to unmanned vessels is currently unclear.

➢ *UK*

Under Merchant Shipping Act 1995, a ship 'includes every description of vessel used in navigation'.[1044] Though the legislation defines 'ship' using 'vessel' without defining vessel, it appears that this purposefully vague definition is likely to extend to unmanned ships, including both surface vessels and submersibles. Further, none of the relevant case law on the subject has directed otherwise.[1045]

In September 2014, the Marine Autonomous Systems Regulatory Working Group (MASRWG) was established by the United Kingdom Marine Industries Alliance. Its aim is to 'identify the regulatory voids that exist for USVs within IMO legislation and has also developed The Maritime Autonomous Systems Surface Industry Code of Practice'.[1046] The initial version of the Code of Practice was released in November 2017 and focused on design and construction.[1047] An updated version, which added guidance on the operation of the vessel, was released in November 2018.[1048] Neither version have the force of law and are for guidance for vessels under 24 metres operating in UK waters, both at sea and in inland waterways.[1049] Both of these reports followed the Working Group's first report titled The Maritime Autonomous Systems Surface, MAS(S) Industry Code of Conduct that raised the issues preliminarily and foreshadowed the two upcoming reports.[1050] Notably, 2017 marked the first time an unmanned ship was registered in the UK Register.[1051]

The UK Maritime and Coastguard Agency (MCA) has been active on the technological development of autonomous ships by partnering with industry and also designating a testing location to facilitate data sharing.[1052] The designated site is also the location of the Maritime Autonomy Regulatory Lab (MAR Lab) which is meant to 'provide an environment to discuss regulatory proposals and vessel testing with stakeholders, identifying regulatory gaps and legislative barriers to further the development of autonomous vessels in UK waters'.[1053] Thus far, the UK government has not published any regulatory guidance on unmanned ships but the MCA has reviewed the Code of

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[1043] See The Swedish Maritime Code 1994, Section 2.
[1044] Sec 313(1)(c).
[1045] See for example *R v Goodwin* [2006] 1 WLR 546 (which distinguished jet-skis from 'ships' or 'vessels' on the basis that they are not 'used in navigation'); See also *Clark v Perks* [2001] EWCA 1228 (which confirmed that a navigational capacity is a key requirement for ships).
[1046] Trudi Hogg and Samrat Ghosh, 'Autonomous Merchant Vessels: Examination of Factors that Impact the Effective Implementation of Unmanned Ships' (2016) 8 Australian Journal of Maritime & Ocean Affairs 206, 209.
[1047] https://www.maritimeuk.org/media-centre/publications/maritime-autonomous-surface-ships-uk-code-practice/
[1048] https://www.maritimeuk.org/media-centre/publications/maritime-autonomous-surface-ships-uk-code-practice/
[1049] The Maritime Autonomous Systems Surface, MAS(S) Industry Code of Conduct 8.
[1050] https://www.maritimeuk.org/documents/228/UK-MIA-MAS-CoC-2016.pdf
[1051] https://worldmaritimenews.com/archives/235207/first-unmanned-vessel-joins-uk-ship-register/
[1052] https://www.gov.uk/government/news/test-site-to-help-develop-autonomous-ship-work; https://www.porttechnology.org/news/uk_government_launches_autonomous_shipping_project/
[1053] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/773219/technology-innovation-route-map.pdf 56.

Practice.[1054] The government also pledged to work with the IMO on its regulatory scoping exercise.[1055]

2.3.1.3 Liability Issues

It is clear that operators of autonomous vessels and submersibles should be concerned with the potential liability that could arise through their use.[1056] The suggestion is that issues could extend beyond product liability type claims,[1057] to situations where third-parties seek compensation should an algorithm lead to a collision which causes damage, injury, or even death.[1058] This would be particularly problematic as there appears to be no prospect for parties to protect themselves by limiting liability for such incidents, as would be the case in usual commercial shipping cases.[1059]

In the context of commercial shipping the ability for parties to limit their liability, subject to certain conditions, is well established.[1060] Briefly, this allows 'shipowners (as well as certain other parties concerned with the ship's operation) the right to limit their liability for one particular incident against all potential claimants'. [1061] This approach was established 'well before submarines were developed and its purpose was to promote the development of commercial shipping'.[1062] However, it is suggested that because submarines do not constitute a 'paradigm of a ship, the application of limitation of liability to them is well outside the purpose of the regime'.[1063] With this in mind, it has been noted that uncertainty regarding the way that liability rules will be applied will be reflected in the increased premiums that insurers will inevitably charge. This would in turn increase the operational costs attached to using this technology which could have a prohibitive impact on its commercial viability.[1064]

In January 2015, a team at the University of Southampton delivered a comprehensive report titled Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy as part of a project with the European Defence Agency. The report concluded that while existing liability regimes in national jurisdictions can be applied to autonomous vessels and submersibles, it urged that '[t]he development of a coherent, international legal framework must be a priority for the UMV

[1054] Report ver 2. P. 7.
[1055] http://data.parliament.uk/DepositedPapers/Files/DEP2018-0306/MCA_Business_Plan_2018-19.pdf 12; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/773219/technology-innovation-route-map.pdf 57.
[1056] See Stephanie Showalter, 'The Legal Status of Autonomous Underwater Vehicles' (2004) 38 The Marine Technology Society Journal 80, 82.
[1057] That would be covered by Council Directive No 85/374/EEC.
[1058] Simon Baughen, 'Who is the Master Now? Regulatory and Contractual Challenges of Unmanned Vessels' in Baris Soyer and Andrew Tettenborn (eds) *New Technologies, Artificial Intelligence and Shipping Law in the 21st Century* (Informa Law 2019) 139.
[1059] See Baris Soyer, 'Autonomous vessels and third-party liabilities: The elephant in the room' in Baris Soyer and Andrew Tettenborn (eds) *New Technologies, Artificial Intelligence and Shipping Law in the 21st Century* (Informa Law 2019) 107.
[1060] See The Convention on Limitation of Liability for Maritime Claims, 1976; See also the Protocol of 1996 to Amend the Convention on Limitation of Liability for Maritime Claims of 19 November 1976.
[1061] Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 90.
[1062] Robert Veal and Michael Tsimplis, 'The integration of unmanned ships into the *lex maritima*' (2017) LMCLQ 303, 314.
[1063] Robert Veal and Michael Tsimplis, 'The integration of unmanned ships into the *lex maritima*' (2017) LMCLQ 303, 314.
[1064] See Baris Soyer, 'Autonomous Vessels and Third-party Liabilities: The Elephant in the Room' in Baris Soyer and Andrew Tettenborn (eds) *New Technologies, Artificial Intelligence and Shipping Law in the 21st Century* (Informa Law 2019) 106-107.

sector'.[1065] Like other fault-based claims, it would be important to determine the standard of care, which is the prudent seaman for vessels, but this standard may be difficult to determine with autonomous vessels and submersibles.[1066] Also, the 'status of UMVs as "ships" is a question of fundamental importance'[1067] on the basis that this has a significant impact on the regulations to which it would be subject.[1068]

Furthermore, it is noted that 'it would be very difficult if not impossible for certain UMVs to be considered as ships, even with significant broadening of the scope of the IMO Conventions'.[1069] This is important on the basis that:

For UMVs which are not ships, extant shipping regulations applicable to "ships" will not apply and any inability to comply therewith does not itself present difficulty. In such a case, UMV operations will not exist in a legal vacuum. Instead, in civil jurisdictions a broader legal code will apply to prescribe liability and in common law jurisdictions a duty of care is owed between sea-users vis-à-vis each other. For the operation of such UMVs in areas beyond the jurisdiction of a state, it will be the responsibility of the deploying state to ensure safety of navigation and protection of the rights of other users of the sea. Therefore, the standards applicable with respect to the regulation of safety will be those of the flag/deploying state. However, where such a UMV collides in an area beyond national jurisdiction with another object or a ship deployed by other states, significant issues regarding the applicable law and the standards for safe navigation will arise.[1070]

Additionally, through reviewing various international conventions, it was concluded that most, including the International Safety Management (ISM) Code and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention, would not be applicable to autonomous vessels or submersibles, but that compliance would aid in finding absence of liability or fault if an accident were to occur.[1071] Also, in the event that the good seamanship standards set out in these conventions are not met, the collision could be determined to have been caused by negligence.[1072]

- *International Convention for the Safety of Life at Seas (SOLAS)*

On the subject of whether SOLAS would bind autonomous vessels and submersibles, the report found that while Chapter V applies to all ships, 'the other parts of SOLAS are generally only applicable to ships larger than 500 grt'.[1073] Chapter V deals with the safety of navigation, Regulation

[1065] Robert Veal et al, 'Liability for Operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) X.
[1066] Simon Baughen, *Shipping Law* (Routledge 7th edn 2018) 280.
[1067] Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 146 <https://www.waterborne.eu/media/18564/Liability-for-Operations-in-Unmanned-Maritime-Vehicles-with-Differing-Levels-of-Autonomy.pdf> Accessed 29 November 2019.
[1068] As discussed in 2.3.1.2 National Laws.
[1069] Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 226. <https://www.waterborne.eu/media/18564/Liability-for-Operations-in-Unmanned-Maritime-Vehicles-with-Differing-Levels-of-Autonomy.pdf> Accessed 29 November 2019.
[1070] Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 226. <https://www.waterborne.eu/media/18564/Liability-for-Operations-in-Unmanned-Maritime-Vehicles-with-Differing-Levels-of-Autonomy.pdf> Accessed 29 November 2019.
[1071] Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 80.
[1072] Michael Tsimplis, 'The Liabilities of the Vessel' in Yvonne Baatz et al (eds) *Maritime Law* (Routledge 4th edn 2017) 235.
[1073] Robert Veal et al, 'Liability for Operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 58.

14 of which requires that ships be adequately manned at all times. It is, however, suggested that autonomous vessels may still meet the requirement for 'adequate manning for the purpose of safety of life at sea',[1074] should a State 'consider manning requirements to be significantly reduced, non-existent or replaced by shore-based controllers'.[1075] However, there is a risk that the requirement for manual control in certain circumstances could be compromised where a remote crew is responsible for operating the ship. This is because in situations where a delay or interruption occurs, 'switching between automated and manual navigation would not be immediate'.[1076]

Ultimately, it appears that non-compliance with SOLAS could lead to accusations that the standard of care was not met, which could in turn lead to liability. In particular, 'operators of UMVs have no certification benchmark to guard them against civil liability resulting from shortcomings in UMV design…[and the] lack of an analogue certification regime also means that the coastal or port state may impose its own idiosyncratic standards on UMVs if it so wishes'.[1077]

- *Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs)*

Autonomous vessels, like currently available ships, must comply with COLREGs, rules designed 'to make navigation safer by establishing common navigational behavioral patterns and standardizing certain equipment found on vessels'.[1078] Previously this had been unclear, though compliance with COLREGs was advised.[1079] COLREGs 'harmonises the national systems and makes the establishment of fault the basis of liability for collision between ships' and non-compliance with its rules for good seamanship could result in liability.[1080] Consequently, they are not merely guidelines but must be strictly complied when navigating the seas.[1081]

While not explicitly stated, COLREGs appears only to apply to vessels operating at the surface, and not to submersibles.[1082] Some scholars have suggested that in its current form, COLREGs privileges the navigation rights of autonomous vessels over manned vessels.[1083] This is because the former may not be 'under command' or is 'restricted in her ability to manoeuvre', meaning that they are to be given the right of way under COLREGs.[1084] COLREGs applies when accidents are the fault of the pilot.

[1074] Robert Veal et al, 'Liability for Operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 49.
[1075] Robert Veal et al, 'Liability for Operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 49.
[1076] Robert Veal et al, 'Liability for Operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 52.
[1077] Robert Veal, Michael Tsimplis and Andrew Serdy, 'The Legal Status and Operation of Unmanned Maritime Vehicles' (2019) 50 Ocean Development & International Law, 23, 35.
[1078] Paul W Pritchett, 'Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology' (2015) 40 Tul Mar LJ 197, 206.
[1079] Stephanie Showalter, 'The Legal Status of Autonomous Underwater Vehicles' (2004) 38 The Marine Technology Society Journal 80, 81.
[1080] Robert Veal et al, 'Liability for Operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) ix.
[1081] Thomas Schoenbaum, *Admiralty and Maritime Law* (West Academic 6th edn 2018) 695.
[1082] Robert Veal et al, 'Liability for operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 65.
[1083] Brendan Gogarty and Meredith Hagger, 'The Laws of Man over Vehicles Unmanned: The Legal Response to Robotic Revolution on Sea, Land and Air' (2008) 19 Journal of Law, Information and Science 73, 115.
[1084] The Convention on the International Regulations for Preventing Collisions at Sea, 1972 Rule 18.

With this in mind, it is suggested that for unmanned vessels where there are onshore pilots, 'nothing will change regarding liability'.[1085]

It may be argued that COLREGs does not apply to I&M autonomous vessels on the basis that 'crafts which are not capable of conveyance of persons or things do not come within the scope of COLREGS'.[1086] This is because these autonomous vessels are used for maintenance and inspection. As a result, it would be up for interpretation as to whether the incidental conveyance of things for the purpose of maintenance would mean that COLREGs would be applicable. Even if the COLREGs are not applicable, all ships, including autonomous ones, would still be required to maintain a standard of good seamanship in their operation.[1087]

An additional problem that could arise regarding COLREGs and the use of autonomous vessels is that 'unwritten, long-standing navigational customs may also have the force of law, so long as they do not conflict with the rules of navigation'.1088 The issue concerns whether or not computer technology would be able to make determinations regarding these customs in the same way that an experienced human operator would. This would depend on the algorithms used for machine learning, which would have a substantial impact on their ability to interpret relevant rules. In fact, some existing models of autonomous ships have shown that they have been unable to abide by the rules to avoid collisions in a timely manner.[1089] An obvious issue in this case is that '[w]hen rules by their very nature are vague or unwritten, collision liability becomes a precarious thing'.[1090] To accommodate autonomous vessels and make clear where liability lies, this uncertainty may have to be corrected in the future.[1091]

In a carriage contract, the shipowner or carrier of the autonomous vessel may face questions of whether the vessel is seaworthy. Article III of the Hague-Visby Rules states that:

> The carrier shall be bound before and at the beginning of the voyage to exercise due diligence to:
> (a) Make the ship seaworthy;
> (b) Properly man, equip and supply the ship[1092]

Failure to meet the principles of the ISM Code, even if the code may not directly apply as discussed above, 'could be argued to render the vessel unseaworthy'.[1093] The question is whether autonomous vessels would be considered seaworthy and properly manned, and also what would amount to due diligence in this context. Under current laws, 'it is vague whether an unmanned ship can be

[1085] Eric Van Hooydonk, 'The Law of Unmanned Merchant Shipping – An Exploration' (2014) 20 Journal of International Maritime Law 403, 421.
[1086] Robert Veal et al, 'Liability for Operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 64.
[1087] Robert Veal et al, 'Liability for Operations in Unmanned Maritime Vehicles with Differing Levels of Autonomy' (2016) 65.
[1088] Stephanie Guerra, 'Ready about, Here Comes AI: Potential Maritime Law Challenges for Autonomous Shipping' (2017) 30 USF Mar LJ 69, 80.
[1089] Paul W Pritchett, 'Ghost Ships: Why the Law Should Embrace Unmanned Vessel Technology' (2015) 40 Tul Mar LJ 197, 207.
[1090] Stephanie Guerra, 'Ready about, Here Comes AI: Potential Maritime Law Challenges for Autonomous Shipping' (2017) 30 USF Mar LJ 69, 81.
[1091] Stephanie Guerra, 'Ready about, Here Comes AI: Potential Maritime Law Challenges for Autonomous Shipping' (2017) 30 USF Mar LJ 69, 81.
[1092] Hague-Visby Rules Art III.
[1093] Filippo Lorenzon, 'Safety and Compliance' in Yvonne Baatz et al (eds) *Maritime Law* (Routledge 4th edn 2017) 357.

considered seaworthy in the strict legal sense'.[1094] Given that a case-by-case analysis carries requirements regarding seaworthiness, this question may have to be solved by case law after autonomous vessels are deployed and subsequently encounter this issue. In the alternative, the charterparty, the contract between the shipowner and the charterer, could also include explicit definitions of what makes the autonomous vessel seaworthy.[1095] Seaworthiness is connected to the issue of the insurance cover of the vessel on the basis that the Marine Insurance Act 1906, which is applicable to the vast majority of international insurance contracts, requires that all ships be warranted to be seaworthy, meaning they are 'reasonably fit in all respects to encounter the ordinary perils of the seas of the adventure insured'.[1096]
When collisions occur, preservation of evidence is important. Fortunately, with the advances in autonomous vessel technology, data surrounding the accident would become more abundant due to the need for such information to operate properly.[1097] In national jurisdictions, the shipowner's liability is generally fault-based[1098] In addition, the shipowner may also be vicariously liable for the actions of the master or crew.[1099] Causation must exist between the breach of the duty and the loss.[1100] However, if the vessel is fully autonomous, a fault-based approach may not make sense:

[T]here is reason to presume that it makes no sense to talk about liability based on fault to the extent that navigation and decisions of importance to the ship's course and speed are taken by an autonomous system without human interference. It must be presumed that this could, in the longer term, change the liability norm, at least in connection with collisions, to the shipowner's strict liability.[1101]

Ringbom notes that:

> [T]he most important point, in terms of authorising autonomous operations, but also with respect to assessing responsibility and liability, is the moment at which "monitored autonomy" turns into "constrained autonomy." It is at this point that the system is partially authorized to act on its own, without human supervision, and its role shifts from offering assistance to being in charge.[1102]

Ultimately, as autonomous vessel technology becomes more sophisticated, bringing with it an increase in their level of autonomy, the liability regime may shift toward one of strict liability. For the time being, though, it appears that under current rules, apportionment of liability for accidents involving autonomous vessels will remain be fault-based. With this in mind, there are practical steps for the development of a liability regime as proposed by Soyer:

> i) to introduce a liability regime for autonomous ships, ideally through an international convention;

1094 Thanasis Karlis, 'Maritime Law Issues Related to the Operation of Unmanned Autonomous Cargo Ships' (2018) 17 WMU J Marit Affairs 119, 126.
1095 Yvonne Baatz, 'Charterparties' in Yvonne Baatz et al (eds) *Maritime Law* (Routledge 4th edn 2017) 132.
1096 Marine Insurance Act 1906 sec 39(4).
1097 Nigel Meeson and John Kimbell, *Admiralty Jurisdiction and Practice* (Informa Law 5th edn 2017) 243-44
1098 https://static.mycoracle.com/igpi_website/media/article_attachments/maritime_autonomous_ships_report_dec_18_6URrRcy.pdf 8.
1099 Craig H Allen, 'Limitation of Liability' (2000) 31 J Mar L & Com 263, 268.
1100 Michael Tsimplis, 'The Liabilities of the Vessel' in Yvonne Baatz et al (eds) Maritime Law (Routledge 4th edn 2017) 237.
1101 Danish Maritime Authority, ANALYSIS OF REGULATORY BARRIERS TO THE USE OF AUTONOMOUS SHIPS FINAL REPORT 85.
1102 Henrik Ringbom, 'Regulating Autonomous Ships—Concepts, Challenges and Precedents' (2019) 50 Ocean Development & International Law 141, 146.

ii) to impose a strict liability regime when such vessels operate in an autonomous fashion;

iii) to channel liability to the registered shipowner, not the manufacturer;

iv) to leave the risk caused by cyber-attacks or losing connection with an autonomous ship on the shoulders of the shipowner; and

v) to enable shipowners to have a recourse action against those responsible in the manufacture of an autonomous vessel.[1103]

3. Guidelines in RIMA Domains

- ***Oil and Gas Industry***

There are no European laws or regulations specifically addressing the use of robotics in the oil and gas industry. In June 2013, the European Commission passed the Directive 2013/30/EU of the European Parliament and of the Council of 12 June 2013 on safety of offshore oil and gas operations and amending Directive 2004/35/EC.1104 While this directive does not explicitly address the issue of the use of robots in the oil and gas industry, it does contain provisions operators must consider. Owners or operators must submit documents before engaging in offshore oil and gas operations, which include accident prevention policies, reports on major hazards, internal emergency response plans, and other documents.[1105] For robot operators, these documents should be prepared with the use of robotics technology in mind so risk assessments and responses could take into account its use.

In the UK, Pipelines Safety Regulations 1996 governs the design, construction, and maintenance of pipelines, including those for oil and gas.[1106] Section 13 states that '[t]he operator shall ensure that a pipeline is maintained in an efficient state, in efficient working order and in good repair'.[1107] Nothing in the regulations specifies that the maintenance must be performed by humans, so the use of robots to ensure the integrity of the pipes would be lawful under existing regulations.

Oil & Gas UK, a trade association, released the Unmanned Aircraft Systems (UAS) Operations Management Standards and Guidelines in January 2017 for drones used in the oil and gas sector. In addition to meeting the basic requirements of operating drones, there is additional guidance on operating specifically in the oil and gas domain.[1108] The risk assessment must take into consideration the special nature of the operations on the oil and gas installations.[1109] The emergency response plan must also be tailored to the industry and should include, for example, procedures for 'containment of damaged batteries and specific handling instructions and equipment...for some composite materials'.[1110]

[1103] Barış Soyer, 'Autonomous Vessels and Third-party Liabilities: The Elephant in the Room' in Barış Soyer and Andrew Tettenborn (eds) *New Technologies, Artificial Intelligence and Shipping Law in the 21st Century* (Informa Law 2019) 115.
[1104] https://euoag.jrc.ec.europa.eu/files/attachments/osd_final_eu_directive_2013_30_eu1.pdf
[1105] https://euoag.jrc.ec.europa.eu/files/attachments/osd_final_eu_directive_2013_30_eu1.pdf art 11(1).
[1106] http://www.legislation.gov.uk/uksi/1996/825/made
[1107] http://www.legislation.gov.uk/uksi/1996/825/made section 13.
[1108] https://oilandgasuk.co.uk/wp-content/uploads/2019/05/OGUK-Unmanned-Aircraft-Systems-Standards-and-Guidelines-Issue-1.pdf
[1109] https://oilandgasuk.co.uk/wp-content/uploads/2019/05/OGUK-Unmanned-Aircraft-Systems-Standards-and-Guidelines-Issue-1.pdf
[1110] https://oilandgasuk.co.uk/wp-content/uploads/2019/05/OGUK-Unmanned-Aircraft-Systems-Standards-and-Guidelines-Issue-1.pdf

The operator must have in place a safety management system.1111 The pilot must have specific oil and gas training and certification to deal with the specific conditions of the industry.[1112] The training must include '[f]urther systems training'. '[h]azard awareness and risk management in complex industrial environments', '[o]perations in magnetic interference areas', '[o]perations in congested areas', '[o]perations in potentially explosive environments', and '[m]anual flight skills assessments in confined areas and close to structures'.[1113] Competence in these areas allows for further training on advanced systems, dangerous goods, hazard awareness and risk management in complex offshore environments, and advanced flight training.[1114] The aerial robot itself 'should ideally be capable of being operated safely in wind speeds of up to 25 knots in order to offer a practical operational envelope' due to the likely offshore conditions.[1115]

RenewableUK, a trade association, has also provided high level guidelines on incorporating the use of drones for projects on the UK Continental Shelf.[1116] The factors that need to be considered are: 'Safety Management System', 'Operating Requirements and Procedures', 'Operating Safety Case', 'Training, Assessment and Currency', 'Aircraft Systems', 'Task Specific Risk Assessment', and 'Emergency Procedures'.[1117]

Gómez and Green propose a number of factors that need to be assessed when choosing drones to be used in monitoring in the oil and gas industry. Most importantly, the type of information needed, terrain conditions, flight distance, and the type of offshore platform are considerations that must be taken into account.[1118]

- ***Nuclear***

Similarly, there are currently no laws or regulations governing the use of robots in the nuclear sector in the EU[1119] However, there are efforts of drafting guidelines and standards. The ERNCIP Thematic Group Radiological & Nuclear Threats to Critical Infrastructure, in a report entitled Impact of Novel Technologies on Nuclear Security and Emergency Preparedness, notes that 'standards play an important role in enabling interoperability between these systems' hardware and software', referring to radiation detection.[1120] Specifically, the data format needs to be standardised:

Low-level data format standards such as IEC 63047 improve the interoperability between hardware and software. While this is expected to be a bliss for system integrators and developers of software systems for data analysis, the success of the standard will depend on the willingness of

1111 https://oilandgasuk.co.uk/wp-content/uploads/2019/05/OGUK-Unmanned-Aircraft-Systems-Standards-and-Guidelines-Issue-1.pdf
1112 https://oilandgasuk.co.uk/wp-content/uploads/2019/05/OGUK-Unmanned-Aircraft-Systems-Standards-and-Guidelines-Issue-1.pdf
1113 https://oilandgasuk.co.uk/wp-content/uploads/2019/05/OGUK-Unmanned-Aircraft-Systems-Standards-and-Guidelines-Issue-1.pdf
1114 https://oilandgasuk.co.uk/wp-content/uploads/2019/05/OGUK-Unmanned-Aircraft-Systems-Standards-and-Guidelines-Issue-1.pdf
1115 https://oilandgasuk.co.uk/wp-content/uploads/2019/05/OGUK-Unmanned-Aircraft-Systems-Standards-and-Guidelines-Issue-1.pdf
1116 https://cdn.ymaws.com/www.renewableuk.com/resource/collection/0B792CF1-8B8A-474B-95B6-17886BF724A7/ORAG_Aviation_Guidance_26-04-19_INTERACTIVE.pdf
1117 https://cdn.ymaws.com/www.renewableuk.com/resource/collection/0B792CF1-8B8A-474B-95B6-17886BF724A7/ORAG_Aviation_Guidance_26-04-19_INTERACTIVE.pdf
1118 https://cdn.ymaws.com/www.renewableuk.com/resource/collection/0B792CF1-8B8A-474B-95B6-17886BF724A7/ORAG_Aviation_Guidance_26-04-19_INTERACTIVE.pdf
1119 https://robohub.org/enrich-will-test-robots-in-real-world-radiological-and-nuclear-scenarios/
1120 https://publications.jrc.ec.europa.eu/repository/bitstream/JRC117583/_impact_of_novel_tech_final-with-identifiers.pdf 16.

manufacturers who offer complete systems to implement the standard as an alternative to the proprietary data format that they use between the hardware and software component.[1121]

The group has compiled a 'set of potential standards for unmanned systems in [radiological and nuclear] measurement scenarios':[1122]

> A widely accepted standard collection of frameworks for robot software development is the Robot Operating System (ROS). Further important standards concerning communication with robots and control of unmanned systems are the Battle Management Language (BML), InterOperability Profile (IOP) and Joint Architecture for Unmanned Systems (JAUS). Furthermore, there are efforts for standardisation in the International Electrotechnical Commission (IEC) regarding international standards for [radiological and nuclear] measurements with unmanned systems.[1123]

There are currently very few standards or guidance for robotics technologies used in specific RIMA domains, including in the oil and gas and nuclear industries. Due to the heightened levels of risk associated with working in these domains and the increasing use of robots, regulations, either through law or industry guidelines, are likely to be needed to ensure safety standards are met by designers, manufacturers, and operators. This will ensure that the maintenance and inspection are done safely and efficiently.

Conclusion

This report has surveyed the existing safety standards and regulations machinery in general and on various types of specific robotics technology, namely those that travel in air, in or on water, and on land. Safety standards from the technological perspective and laws regulating the use of these robots and those relevant to the allocation of liabilities in case of accidents were discussed. Much of the existing standards and regulations are not specific to robots for I&M. Indeed, because of the novelty of the technology and the relatively recent interest from the legal realm in such technologies, the laws and regulations are by and large technology-specific rather than industry-specific. As a result, laws and regulations that could apply to robots for I&M are on a general level and do not address the particular issues facing robots operating in RIMA domains. Nonetheless, the Machinery Directive by and large applies to current industrial robots used for infrastructure inspection and maintenance, at least for the terrestrial setting.

As the report has shown, the regulatory measures for the different types of technology are in different stages of development. While there is an EU-wide regulation for aerial drones, the laws for autonomous vehicles have been more nationally-based and although there appears to be communication between the governments of the Member States, there are no harmonised standards. Meanwhile, for vessels and submersibles, the focus has been more internationally focused due to the nature of maritime matters. This difference may be partly attributed to the fact that aerial drones are a reality, whereas autonomous vehicles and seafaring robots are not as developed as technologies.

The lack of harmonisation means that businesses that operate in more than one Member State would have to abide by multiple rules governing the same conduct, resulting in confusion and higher costs. This lack of consistency may lead to burdensome transactional costs to achieve compliance in

1121 https://publications.jrc.ec.europa.eu/repository/bitstream/JRC117583/_impact_of_novel_tech_final-with-identifiers.pdf 16.
1122 https://robohub.org/enrich-will-test-robots-in-real-world-radiological-and-nuclear-scenarios/
1123 https://robohub.org/enrich-will-test-robots-in-real-world-radiological-and-nuclear-scenarios/

multiple jurisdictions and possibly hinder the wider adoption of the use of robots in infrastructure inspection and maintenance. However, with the rapid pace of development of technologies, stakeholders must soon contemplate whether a similar-EU wide regulation would be feasible for the latter technologies, and if so, how to best proceed. The experience of devising a harmonising instrument for aerial drones may offer guidance on how the EU may want to proceed with regard to regulating other types of robots.

Toward that end, this findings of this report facilitates working with national, regional, and international standardisation organisations to devise standards to fill the regulatory gaps and collaborating with other interested stakeholders that are also examining similar issues to ensure that clear, harmonised regulations can be implemented in the EU and internationally. Insofar as existing regulations may differ from Member State to Member State, this report has shown that the variations are not significant, though some Member States have been more proactive than others. It is imperative that a formal process be conducted for autonomous vehicles, though Member States may not be incentivised to do so until technology develops further. As for autonomous vessels, this process has already begun through the Member States working with the IMO and should continue at the international level due to the nature of the maritime sector.

Furthermore, this report has also shown that there are very few legal regulations specific to submersibles and robots operating in RIMA domains. While submersibles operate under water, they may have more in common with aerial drones than autonomous vessels given the types of operations and sizes of the robots. Consequently, the aerial drone regulatory framework of different measures for different types of risk categories may be a possible regime that can be explored for submersibles. Regulations specific to RIMA technologies must build on the existing frameworks for the different types of robots and consider what additional regulations are necessary depending on the additional risk factors in the respective domains. To develop a comprehensive regime for robots in the RIMA domains, it would be necessary to transition from viewing robots by the method they operate to the environment in which they operate. Nonetheless, categorisations based on risk could also be a workable and possibly ideal approach to exploring the framework to regulate RIMA technologies.

Next Steps

This report has summarised in a single place the best practices for the safety of robots and the legal and regulatory measures governing robots across the EU, with a particular emphasis on issues important for robots used for I &M. In the period after submitting this report, Task 7.3 will develop this further:

- We will improve the coverage of the current report by incorporating other kinds of robots which are not included in this report.
- In parallel, we will hold two workshops to bring together people for industry and application environment together with academics to share knowledge and extract new insight. The workshop is primarily for review and improvement of the interim report content
- We will also start collecting data from industry and from lawyers and legal scholars on regulatory measures and liability regimes concerning robots in the form of surveys.

The results of the previous tasks will be the next (and final) deliverable from the task, which will have two parts:

- Online access to a section of the AAIP Body of Knowledge[1124] specifically oriented to the RIMA network's concerns. This will incorporate key material both from this report and from the further activities listed above and will be integrated with the rest of the Body of Knowledge so that the RIMA network benefits from the wider information contained therein.
- A short report (formal RIMA deliverable D7.5) which will summarise how all the above content was generated and provide a catalogue of the RIMA-specific Body of Knowledge content.

[1124] This is being developed by the Assuring Autonomy International Programme (AAIP) with the ambition "to become the definitive reference source on assurance and regulation of robotics and autonomous systems". There is more information, including a description of the planned structure, at https://www.york.ac.uk/assuring-autonomy/body-of-knowledge/

Standardisation, assurance and certification; legislation and policy: **Next steps**