Look Out – Self-driving Vehicles Around the Corner!

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1 The Development and Regulation of Self-driving Vehicles

It has become increasingly common to speak of an emerging *fourth industrial revolution* consisting of interconnected systems that belong to several fields and applications.[1] A prime example of this is self-driving vehicles – sometimes referred to as automated vehicles,[2] driverless cars,[3] or robotic cars[4] – equipped with sensors and intelligent logic (*artificial intelligence*). Self-driving vehicles are held to be one of the most transformative and innovative technologies of our time, with a wide impact on society.

There is currently no settled definition of self-driving vehicles, either nationally or internationally. Vehicles may be "self driving" to different degrees. A host of technologies assist driving and they are developing fast. Examples of such techniques include lane assistance, automatic braking, cruise control and steering assistance. Combining different driver support technologies increases the degree of automation.

A level-by-level approach is often used to classify the automation of vehicles. Several systems of classification have been proposed,[5] and although they have similarities, they differ in number of levels, terminology and what is included in each level. One of the most commonly referred to systems is the 6-level division developed by the Society of Automotive Engineers (SAE).[6] This classification is not based on where the driver is located, but primarily on how control over the vehicle is exercised. Very simplified, at levels 0–3 a physical driver exists and either drives (possibly with the aid of the automated system) or is ready to take over the driving when the system requests it. At levels 4–5 an automated system drives the vehicle and the vehicle can also handle situations in which automated driving is not possible. On the other hand, a vehicle with automated features in the higher levels can also be manually operated (dual function). The difference between level 4 and level 5 is that level 4 vehicles can only drive in certain traffic situations or in certain areas, while level 5 vehicles can handle all situations and environments that a physical driver can handle.

The potential benefits of self-driving vehicles are said to include reduced transport and infrastructure costs, and increased safety and mobility. Self-driving vehicles are also predicted to improve traffic flow; provide enhanced mobility for children, the elderly, disabled and poor; relieve travellers of driving and

1 *See* e.g. Schwab, *The Fourth Industrial Revolution*, World Economic Forum (2016).

2 *See* e.g. *The Federal Automated Vehicles Policy: Accelerating the Next Revolution In Roadway Safety*, U.S. Department of Transportation, National Highway Traffic Safety Administration (2016).

3 Freedland, *Driverless Cars and the Railways of 1830* (2018). Available at "www. bbc.com/news/topics/c90ymkd8lglt/driverless-cars" (last visited on April 20, 2018).

4 Lyon, *Self-Driving Robot Car Borne From Nissan-NASA Collaboration*, Forbes, January 29, 2018.

5 *See* e.g. Swedish Government Official Reports (SOU) 2016:28 p. 37 ff.

6 SAE International, J3016 standard "Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems". Cf. Burgess, *When does a car become truly autonomous? Levels of self-driving technology explained*, Wired, April 21, 2017.

navigation drudgery: lower fuel consumption; significantly reduce the need for parking spaces; and facilitate business models for transportation as a service, especially via the sharing economy. All this shows the vast disruptive potential of the emerging technology.

Many experts believe that efforts toward full automation can follow one of two different paths. The first, evolutionary, path involves gradual improvement of automated driving systems in conventional vehicles, allowing human drivers to transfer more and more of the dynamic driving work to these systems as they become capable of increasingly complex tasks. The second, revolutionary, path involves direct introduction of highly automated vehicles and gradually expanding operations to more geographical areas and contexts. The two paths can be summed up as *something everywhere* (evolutionary development) and *everything somewhere* (revolutionary development).[7]

Despite the various potential benefits of increased vehicle automation, a number of problems have yet to be resolved. These include safety and technology issues; disputes concerning liability; resistance by individuals to losing control of their cars; customer concerns about the safety of self-driving vehicles; implementation of a legal framework and establishment of government regulations; and privacy concerns.

There is at present no international or EU regulation of self-driving vehicles, although discussions are ongoing at several levels and in different fora. Existing regulations – both nationally and internationally – usually require the presence of a physical person as a driver who can be held liable if necessary. EU regulations – and hence Sweden's regulations as well – are based on the fundamental rules for road traffic, drivers, vehicles and driving licenses set out in the 1968 Vienna Convention on Road Traffic. The Vienna Convention's provisions that every vehicle on the road must have a driver and that the driver must have control of the vehicle are primary obstacles to increasing automation. Amendments to the Convention were introduced in 2016 which permit certain automated functions, provided there is a driver who is capable and prepared to take over the driving, and able to override the automated functions. However, even with these latest amendments, scope to introduce fully automated vehicles (level 5) is limited in the short term, before international norms have been fully adopted. Efforts are in progress within the scope of UNECE's Global Forum for Road Traffic Safety to allow road use of self-driving vehicles operating at the highest level. Efforts are also in progress within the EU to facilitate the introduction of automated vehicles. Although there are no express requirements for drivers for every road vehicle, the third Directive on Driving Licences[8] includes an implicit requirement to have a driver.

Against this backdrop, this article will focus on the recent trend towards automated driving (section 2), legislative proposals at national, Swedish level (section 3), and some further deliberations on data protection (section 4). Concluding remarks will follow in section 5.

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7 *See* e.g. Swedish Government Official Reports (SOU) 2018:16 p. 2013.

8 European Parliament and Council directive 2006/126/EC of 20 December 2006 on driving licenses, the third Directive on Driving Licenses.

2 The Development of Automated Driving

Experiments with automated driving systems began in the 1920s.[9] However, it is only in the last few years that serious, large-scale attempts have been made. A major driving force has been technological developments related to information processing.

In the United States, a non-signatory country to the Vienna Convention on Road Traffic, state vehicle codes generally do not envisage — but do not necessarily prohibit — highly automated vehicles. To clarify the legal status of and otherwise regulate such vehicles, several states have enacted or are considering specific laws. Nevada was the first US state to authorize the operation of autonomous vehicles in 2011. Since then, a further 21 states have passed legislation related to autonomous vehicles.[10] In Europe, several countries have allowed or are planning to operate transport systems for autonomous cars.

In Sweden, a test drive of driverless vehicles – described as the world's largest so far – was started in late 2017. The trials were made possible by legislation introduced in Sweden earlier that year.[11] They will include an array of self-driving vehicles ranging from ordinary passenger cars to minibuses in ordinary environments. Beginning in December 2017, the first self-driving *Volvo*-manufactured cars appeared on Swedish roads in a project called Drive Me, manned with regular drivers able to control them.[12]

In September 2017, *Audi* stated that its latest A8 would be autonomous at speeds up to 60 km/h using its "Audi Artificial Intelligence".[13] The car is said to be able to process large amounts of data acquired underway by various assistance systems faster than ever, and synchronize and share it with other road users. The car can reportedly use the data to determine traffic patterns. The driver would not have to do safety checks such as frequently gripping the steering wheel. The Audi A8 was claimed to be the first production car to reach level 3 autonomy.

Uber's robotaxis ferry riders around in Pittsburgh and Phoenix.[14] *Waymo*, the self-driving-car unit of Google's parent company *Alphabet*, hopes to launch an autonomous "robotaxi" service in the suburbs of Phoenix, Arizona during

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9 *See* e.g. Dormehl & Edelstein, *Sit back, relax, and enjoy a ride through the history of self-driving cars*, January 18, 2018. Available at "www.digitaltrends.com/cars/history-of-self-driving-cars-milestones/" (last visited on April 21, 2018).

10 *See* National Conference of State Legislatures: Self-driving vehicles enacted legislation. Available at "www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx" (last visited on April 21, 2018).

11 Förordning (2017:309) om försöksverksamhet med självkörande fordon.

12 *See* "www.volvocars.com/en-om/about/our-innovation-brands/intellisafe/autonomous-driving/drive-me" (last visited on April 21, 2018).

13 *See On autopilot into the future: the Audi vision of autonomous driving*, available at "www.audi-mediacenter.com/en/on-autopilot-into-the-future-the-audi-vision-of-autonomous-driving-9305" (last visited on April 20, 2018).

14 *See Self-Driving Ubers, The world's first Self-Driving Ubers are on the road in the Steel City*, available at "www.uber.com/cities/pittsburgh/self-driving-ubers/" (last visited on April 20, 2018).

2018.[15] General Motors plans its own robotaxi service for 2019.[16] And in February 2018 the US state of California abolished the rule that experimental autonomous vehicles must always have a safety driver on board ready to assume control.[17]

In other parts of the world, driverless shuttles ferry passengers on university campuses, in business parks or along special bus lanes. Autonomous vehicles stole the show at CES, the world's biggest technology fair, in Las Vegas in January 2018.[18]

The previously mentioned ”sharing economy” is a trend that will most certainly affect the development of automated vehicles. The sharing economy is based on sharing things (e.g. through renting or lending) instead of owning them. Once the car becomes autonomous, the relevance of car ownership is believed to drop materially. Today's cars sit unused 95% of the time, so a widespread switch to "robotaxis" would let urban land wasted on parking be reallocated.[19]

Boston Consulting Group reckons that by 2030 a quarter of passenger-miles travelled on US roads will be in shared, self-driving vehicles, reducing the number of cars on city streets by 60%,[20] and the bank UBS anticipates urban car ownership will fall by 70% by 2050.[21] Globally, the "passenger economy" created by the convergence of autonomous vehicles and ride hailing will be worth $7trn a year by 2050, according to consulting firm Strategy Analytics.[22]

Carmakers, technology giants, start-ups and ride-hailing firms are already engaged in a battle to dominate this emerging industry. The carmakers know less about complex software. The tech firms know about machine learning and computer vision, but not making cars. The ride-hailing firms have their apps installed on millions of users' phones, providing the obvious route to market. The result has been a constantly evolving web of alliances. Self-driving vehicles are thus said to be as disruptive a technology as the smartphone. Carmakers will face enormous change; instead of selling to individuals, they will supply fleet operators, or reinvent themselves as "mobility service" providers.

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15 *See* Shepardson, *Waymo to use Jaguar I-PACE electric vehicles in robotaxi program*, March 27, 2018. Available at "www.reuters.com/article/autos-selfdriving-waymo/waymo-to-use-jaguar-i-pace-electric-vehicles-in-robotaxi-program-idUSL8N1R86WJ" (last visited on April 20, 2018).

16 The Economist, *GM takes an unexpected lead in the race to develop autonomous vehicles*, January 25, 2018.

17 *See Driverless Testing of Autonomous Vehicles*, available at "www.dmv.ca.gov/portal/dmv/detail/vr/autonomous/auto" (last visited on April 20, 2018).

18 Nicol, At CES 2018, *autonomous cars took the wheel and drove into the future*, January 11, 2018. Available at "www.digitaltrends.com/cars/autonomous-cars-self-driving-ces-2018/" (last visited on April 20, 2018).

19 *See* eg. Morris, *Today's Cars Are Parked 95% of the Time*, Fortune, March 13, 2016.

20 *See* "www.bcg.com/industries/automotive/self-driving-vehicles-car-sharing.aspx" (last visited on April 21, 2018).

21 *Self-driving cars will require new business models*, The Economist, March 1, 2018.

22 Ibid.

The recent development of automated driving is part of a wider trend towards automation and connectivity across society in general. Several technology solutions such as personal computers, mobile phones, Internet, wireless communication and faster connectivity are now integrated and used with machines that can perform tasks independently. This trend is sometimes referred to as the *Internet of Things*.[23] Examples include everyday household appliances, clothing and accessories, but also machines, vehicles and buildings, which are equipped with built-in sensors and computers and with Internet connectivity, allowing them to link physically or wirelessly and then exchange data.

5G technology has been described as a prerequisite for the Internet of Things. Today's 4G has a theoretical maximum connection speed of 300 megabits per second. 5G will reach speeds over 20 gigabits per second. This means that ordinary consumers will be able to use mobile connections for things that were previously impossible. For automated vehicles, the quick connection and reduced delay will enable a new level of safety and precision in driving and positioning. The vehicle is increasingly considered a "connected vehicle", that is permanently connected via various communication technologies to the Internet and able to interact with infrastructure via vehicle-to-infrastructure (V2I) services and other vehicles via vehicle-to-vehicle (V2V) services. A trend towards hyperconnected vehicles, i.e., vehicle-to-everything (V2X) is emerging, where the vehicle beyond V2I and V2V also interacts and exchanges information with any entity capable of doing so, e.g., V2P (vehicle-to-pedestrian), V2D (vehicle-to-device), V2G (vehicle-to-grid) etc.

3 The Inquiry on Self-driving Vehicles, Commissioned by the Swedish Government

3.1 General

In order to prepare the market for self-driving vehicles, the Swedish government set up a committee of inquiry in 2016 with the task of proposing a better legal framework for the introduction of automated driving of vehicles on public roads.[24] In its final report,[25] the committee stresses that, as a starting point, Sweden should aim to – as far as possible – promote a rapid introduction of vehicles with automated functions. In the opinion of the committee, multi-stage development of regulations is required to deal with developments in the field of automated mobility so that this development can take place in a safe, sustainable manner. The committee recommends an adaptation of the regulations so that these do not impede the development of new solutions for enhanced attainment of transport policy targets.

23 Burgess, *What is the Internet of Things?*, Wired, February 16, 2018.

24 Kommittédirektiv 2015:114, *Självkörande fordon på väg*.

25 Swedish Government Official Reports (SOU) 2018:16, *Vägen till självkörande fordon – introduktion*.

The committee proposes that in the short term (over the next five years), Swedish regulations should be adapted to prepare for automated driving and facilitate the introduction of highly or fully automated vehicles (essentially corresponding to SAE levels 4–5). During this time, focus should be on facilitating the market introduction of certain self-driving vehicles and facilitating trials of advanced automated functions for driving in convoy (platooning), freight transport and passenger transport. To this end, the committee proposes a new Act on automated driving, consisting of three sections; one relating to the driver, one relating to penalties and one relating to data storage.

3.2 A New Term for "Drivers"

In the opinion of the committee, EU law does not yet permit vehicles without drivers, at least insofar as requirements are in place for specific driving licenses in accordance with EU regulations. Therefore, the requirement for drivers in vehicles where licensing is regulated in accordance with the provisions of the Directive on Driving Licenses should be retained. The main rule in the proposal is therefore that a vehicle must have a driver while being driven automatically. However, there are major opportunities for trials and the introduction of advanced automatic functions due to the national interpretation of the term "driver" that is being introduced.

The committee proposes a definition of the term "driver" on the basis of current Swedish practice. According to the proposal, a driver is a human. A driver may operate one or more vehicles simultaneously. A driver may be in or outside the vehicle, meaning that a vehicle may be operated remotely, when the driver is either in the immediate vicinity of the vehicle or at a distance from it, if this can be deemed safe during a risk analysis. This interpretation paves the way for rearranging of vehicles where a driver operates or controls multiple vehicles simultaneously, e.g. when parking or otherwise moving vehicles. This also paves the way for other trials where a driver can control vehicles from a location other than a driver's seat.

According to the proposal, there should normally be one driver for one automated vehicle, even when this is operated automatically, i.e. when there is no need for any human to take control. However, this is a kind of "engineered driving" with limited obligations and responsibilities. During automated driving, such a driver must meet the applicable requirements for the vehicle in question regarding licensing (driving license and any professional authorization), sobriety and other requirements to be able to maintain a basic ability to perform the tasks for which the driver is responsible as specified below. This is no less important for vehicles that assume that a driver will take over driving at any time or in certain situations.

3.3 Penalties Introduced for Vehicle Owners

Manual and automated driving will be mixed on most streets and roads in the foreseeable future. Therefore, the same rules should apply to the operation of vehicles regardless of the degree of automation. If there is no driver who is responsible for compliance with road traffic rules, financial liability for any offences should be introduced. Consequently, the committee proposes that a provision be introduced concerning penalties for the owners of motor vehicles during automated driving. In other words, responsibility must rest with the owner for the vehicle's offences during automated driving. If the vehicle commits an offence during automated driving, the vehicle's owner must pay a penalty. This penalty is intended to replace the fines that drivers would have to pay for similar offences. In the event of insurance cases or accidents, claims for damages may be filed against vehicle manufacturers, for example.

3.4 Collection and Storage of Data in Automated Vehicles

The committee holds that, given the introduction of penalties and provisions relating to the driver's liability, sector-specific regulations are required for personal data with a view to investigating liability (both criminal and civil) during automated driving. Following an incident or accident, or contravention of road traffic rules, there is a need to clarify whether a driver or an automatic driving system was operating the vehicle at the time. Thus, the purpose of collecting and storing data should be to facilitate personal data processing to investigate legal liability if a vehicle can be operated both manually and automatically. As little data as possible is to be stored, and only for as long as it is necessary for its intended purpose, to protect the individual's privacy and integrity. For this reason, information on the vehicle's location must not be collected.

Certain information on driving must be collected and stored for any automated vehicle that is designed to be operated manually by a driver and automatically by an automatic driving system. Personal data may be processed for the purposes of preventing, detecting, investigating or prosecuting crimes and so that individuals can exercise their rights in civil cases. An obligation is proposed for anyone who has manufactured or provided such an automated vehicle to collect and store data on i) activation and deactivation of automated driving, ii) the vehicle's requests to the driver to switch from automated driving to manual driving, and iii) error messages from the vehicle during automated driving.

For each of i) – iii), the vehicle's identity and the time of the incident must be collected and stored at the same time. In the event of a specific incident such as a road traffic accident, information on the vehicle's speed must also be collected. It is proposed that the data, as a rule, should be stored outside the vehicle within the European Economic Area (EEA), but be available to access in Sweden. This data may be stored in the vehicle for a short time while awaiting transfer. Vehicle manufacturers may instruct others to carry out storage.

3.5 Long Term Proposals

The committee considers that, in the long term, a great deal of effort will be needed, primarily at authority level, to facilitate market introduction of automated vehicles at a high level. In the first instance, this will involve efforts at international and EU levels and, at a later stage, introducing and adapting vehicle-related regulations and general recommendations in a manner that promotes the development of automation of the transport system.

In addition, the committee concludes that, besides the changes to international regulations that will have direct repercussions for Swedish provisions, a great number of national regulations – relating to matters such as community-funded travel, public transport and regulations relating to taxis, hire car operations and infrastructure – will need to be reviewed in the event of a broader market introduction.

4 Self-driving Cars and Aspects of Privacy and Data Protection

As regards data protection, the committee's proposal suggests that the information that may be collected and processed related to automated vehicles will be quite limited. However, large amounts of data are generated by automated vehicles and traffic, and it is likely that this trend will grow in future. Who may use the data is therefore of paramount importance, an issue which includes aspects of data protection.

Some cars began collecting data decades ago through EDRs (Event Data Recorders) or *black boxes* to help reconstruct the last few seconds before a crash. The EDR tends to store only a limited number of minutes of recording just prior to a crash, and it utilizes loop recording so that prior data is overwritten. Today, however, vehicles are becoming more creative and sophisticated data-consuming-and-generating machines, providing predictable insights into people's lifestyles and preferences.

Self-driving vehicles will generate even greater amounts of information. Autonomous cars perceive the world through a combination of sensors including cameras, radar and LIDAR – a radar-like technique that uses invisible pulses of light to create a high-resolution 3D map of the surrounding area. The three complement each other. Cameras can see road markings, but cannot measure distance; radar can measure distance and velocity, but cannot see in fine detail; LIDAR provides fine detail. A combination of sensors is probably needed to ensure safety and reliability, and thus for the automated vehicle to function as intended. Having combined the data from its sensors, the car needs to identify the items around it: other vehicles, pedestrians, cyclists, road markings, road signs and so forth. Humans are much better at this than machines, which must be "trained" with lots of carefully labelled examples.

Extrapolated out across a lifetime, the information will reveal more intimate life patterns: not just current location, but all the places a vehicle has been. Not just the current destination, but also all the places it frequents – or the spots it no

longer visits or avoids. Such information has great commercial value, for example for various applications and Big Data analyses.

Without proper privacy and data protection, drivers, passengers and pedestrians will not be able to control or even monitor the processing of personal data relating to them, or even be aware that such processing takes place. Thus, one of the main challenges for the future development of self-driving vehicles is how to reconcile the possibilities with the need to protect privacy.

Legal scholars have argued that privacy risks may depend on the degree to which self-driving cars are autonomous (how much control the driver has vs. no driver at all) as well as communicative (how much information is on board vs. transmitted to third parties or company servers). As with any other technological systems, the lifecycle and treatment of data from autonomous cars will depend on the precise technologies used and the organizations that govern them. This makes data privacy more complicated to grasp. Mapping out how and where data flows, to whom and for what purpose, is a critical starting point for understanding the true value and weight of privacy trade-offs. Another key challenge is the question of who has access to the data.

Within the EU, the General Data Protection Regulation (GDPR) sets out norms on the protection of natural persons regarding the processing of personal data and on the free movement of such data.[26] In addition, the EU ITS Directive provides the legal framework to support the coordinated and coherent deployment and use of Intelligent Transport Systems (ITS) within the European Union.[27] Article 10.1 of that directive holds that Member States shall ensure that the processing of personal data in the application of ITS applications or ITS services is carried out in accordance with Union rules on the protection of the individual's fundamental rights and freedoms. The importance of privacy protection has also been emphasized by the International Working Group on Data Protection in Telecommunications (IWGDPT), which has stressed that the increased use of ITS poses challenges in the field of personal data protection.[28]

5 Concluding Remarks

The proposals by the committee are intended to facilitate trials of the automated functions in vehicles that are to be driven on roads. Furthermore, a market introduction of such technology must be promoted. It is assumed that all trials and market introductions will take place following thorough testing to ensure

26 Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

27 Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport.

28 International Working Group on Data Protection in Telecommunications, Working Paper on Event Data Recorders (EDR) on Vehicles Privacy and data protection issues for governments and manufacturers, 4 April, 2011.

that they can take place safely, i.e. following testing in safe areas and after a risk assessment.

The proposals involve clarification of the fact that a driver can control several vehicles, including remotely. This paves the way for trials with the driver in the first vehicle only, or operation by remote control, when the technology is mature enough to offer this.

Trials involving shuttles for passenger transport may take place, provided that there is a driver and a permit for the trial. The proposed term "driver" and extended authorisation for municipalities (road owners) to prescribe the use of a certain road or carriageway for automated public transport, for example, expands these options. By way of example, the activities and trials in progress – in Europe and elsewhere – often take place on restricted and specific routes with a certain road or a special lane for the vehicles, often with limited other traffic.

The new term "driver" proposed by the committee paves the way for a range of applications involving a driver controlling multiple vehicles remotely, e.g. when vehicles are moved within a site or for parking, docking in loading bays, etc.

As regards data protection, the committee's proposal suggests that the information that may be collected and processed related to automated vehicles might be quite limited. However, large amounts of data are generated by automated vehicles and traffic, and it is likely that this trend will continue. The question of who may use the data is therefore of great importance, an issue which includes aspects of data protection. This issue needs further analysis in the future.