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COMPETITION AND INNOVATION IN LAND TRANSPORT

-- Background Note by the Secretariat --

28 November 2016

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Ania Thiemann, Global Relations Manager: Ania.THIEMANN@oecd.org; +33145249887

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COMPETITION AND INNOVATION IN LAND TRANSPORT

Background paper by the Secretariat[*]

Abstract

The dynamics of competition in land transport are about to undergo significant changes. The main trend in transportation markets is their increasing digitalisation, as in other areas of the economy, which is changing the way transport services are offered. 'Intelligent Transport Systems' are being developed in which information and communication technologies are applied to transport, including infrastructure and vehicles, traffic management, and interfaces between road and other modes of transport. In road transport, these developments will lead to increasing automation, vehicle-sharing, and electrification. In rail, the adoption of digital technologies, particularly when coupled with location data, will yield a much more efficient use of railways and significantly reduce costs.

Competition agencies are likely to face a number of challenges brought about by these developments in both passenger and freight markets. Technological changes are likely to change existing market dynamics and create new markets; lead to mergers between traditional market players and new entrants; enhance the pro-competitive effects of co-operation arrangements between transportation companies, and between transportation companies and public authorities; generate incentives for beleaguered incumbents to engage in anticompetitive practices and lobby for protectionist measures; and result in the obsolescence of regulations, particularly those that impede beneficial innovations favoured by consumers from entering the market. This provides an opportunity for competition agencies to intervene through their enforcement and advocacy powers in order to promote greater competition and maximise consumer welfare.

[*] This paper was written by Pedro Caro de Sousa, OECD Competition Division, with comments from Antonio Capobianco, Sean Ennis, James Mancini and Ania Thiemann.

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COMPETITION AND INNOVATION IN LAND TRANSPORT

1. Introduction

1. The dynamics of competition in land transport are about to undergo significant changes. Yogi Berra, the legendary American baseball player, is often quoted as saying that predictions are hard, especially when they involve the future. Nonetheless, changes to land transport are safe to predict in the light of a number of technological innovations, and the growth and speed of processing of exploitable and often open data.[1]

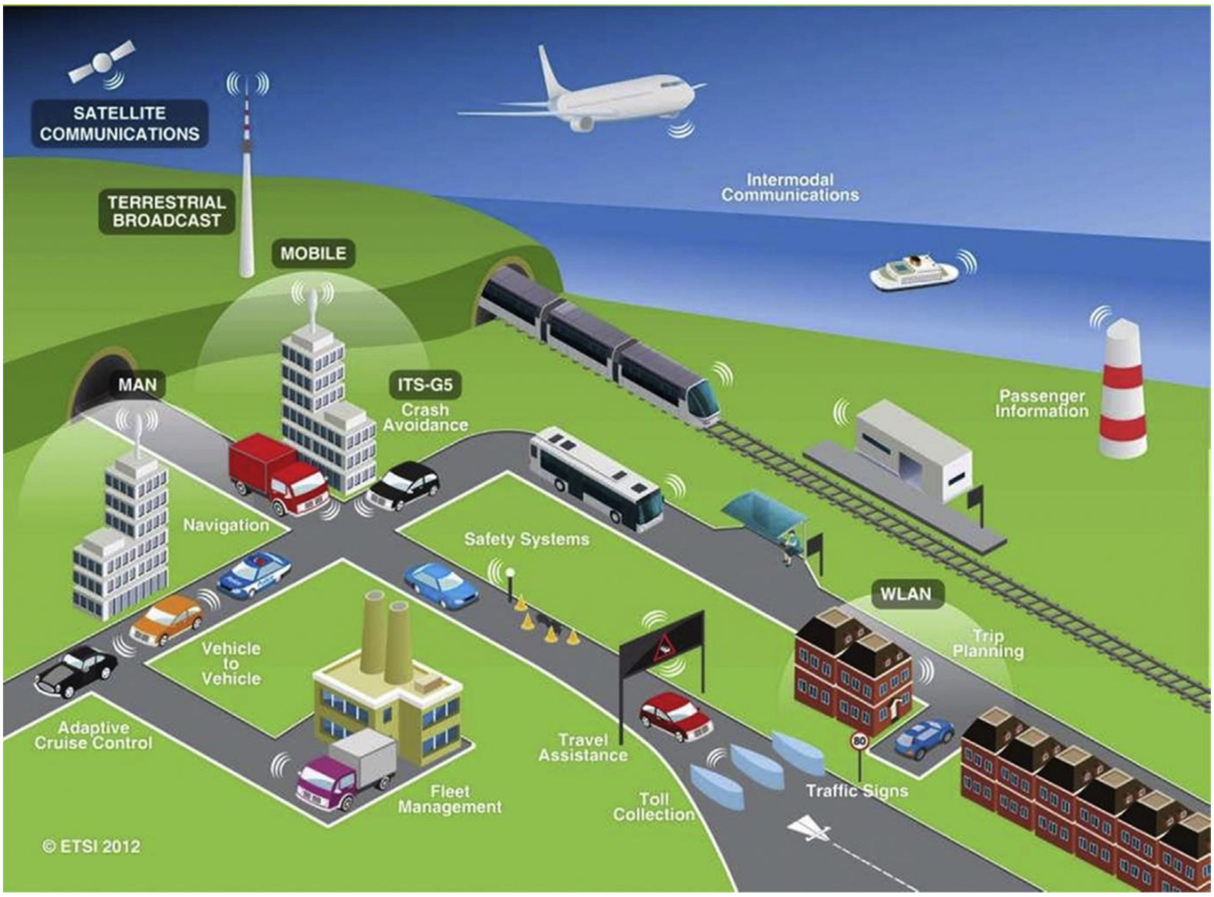
2. Different modes of land transport are potentially interchangeable. Passengers prefer door-to-door journeys and, if using public transport, that these journeys be typified by seamless multi-modal services available from a single booking. Consumers of freight services do not much care how their goods reach their destination, as long as they do so on time. Developments affecting one mode of land transport can have an impact other transport modes, even if the extent of such impact will be affected by the geographic, demographic and economic features of different transportation markets, and by the specific advantages that each mode of transport possesses over the others.[2] For example, high-speed rail services occupy a natural market starting at distances around 150 km where their speed dominates the ready availability and flexibility of cars, but below distances of around 800 km where airplanes' higher speed eventually takes over.[3] The innovations reviewed in this paper will thus change competition in land transport both within and between different transport types.

3. The main trend in transportation markets at present is their increasing digitalisation, which is changing the way transport services are offered. The sourcing of data is evolving quickly, largely via the proliferation of handheld devices, such as smartphones, and automobile-based devices (e.g. portable navigation devices, in-vehicle navigation devices and connected vehicles). Around 80% of vehicles in Europe and North America are expected to be two-way connected by 2018.[4] Mobile sensor-generated data has already given rise to the development of new business models. In 2015, approximately three billion apps relied on location-based data.[5]

4. At the same time, travellers' needs and expectations in such a digitalised world are also changing, with service providers promising to offer travellers easy, flexible, reliable, value-for-money, and environmentally sustainable travel options. These options include, for example, public transport, bicycle-sharing, ride-sharing, car-sharing, car leasing and road use, as well as more efficient freight and last-mile delivery possibilities.

5. In addition to these developments, 'Intelligent Transport Systems' are being developed in which information and communication technologies (ICT) are applied to transport, including infrastructure and vehicles, traffic management, and interfaces between road and other modes of transport. For example, on-board units were traditionally used to support logistics for fleet operations and monitor their performance, but now are being used by transport authorities to implement country-wide electronic tolling solutions for heavy goods vehicles weighing more than 12 tonnes.[6]

Figure 1. A Schematic Structure of an Intelligent Transport System



6. Competition agencies are likely to face a number of challenges brought about by these developments. Technological changes may change market dynamics and create new markets; lead to mergers between traditional market players and new entrants; enhance the pro-competitive effects of co-operation arrangements between transportation companies, and between transportation companies and public authorities; generate incentives for beleaguered incumbents to adopt anticompetitive practices and lobby for protectionist measures; and result in the obsolescence of regulations, particularly those that impede beneficial innovations favoured by consumers from entering the market. It is not clear that authorities and regulations within and outside the transport sector have kept pace with the proliferation of new developments in this sector.[7] Competition agencies can play an important role in shaping the future of land transport, not only through their enforcement efforts, but also by ensuring that regulatory interventions are pro-competitive and facilitate innovation that benefits consumers.

7. This paper will describe expected developments in land transport, their potential impact on competition, and the challenges these developments will likely raise for competition agencies. It will review developments in passenger transport and freight in turn, by focusing on individual transport modes and how intra- and inter-modal competition is likely to be affected. The various technological and market developments affecting these segments will be reviewed, alongside the implications of these developments for market dynamics and regulatory frameworks. A subsequent section will then look at the specific challenges competition authorities will likely face in the near future when dealing with land transport, both from enforcement and from a regulatory perspective.

2. Passenger Transport

2.1. Individual Transportation

8. Transport options are changing. Growth in passenger vehicle travel has plateaued in several high-income economies. While people living in less populated areas are more likely to hold a driver's licence than those who live in urban areas, per capita car use has declined across the board, especially among young adults, and there is established evidence of a decline in the average rate of driver's license holding, again particularly among young people.[8]

9. International experiences show that we are currently seeing a major change in perceptions of cars from vehicle ownership to vehicles as a service, particularly among young, urban dwellers ('millennials').[9] Businesses have acknowledged this reality. Auto-makers have been experimenting with iterations of their business models: Mercedes is expanding its Car2Go service which rents cars on a per-use basis in over 30 cities in Europe and the US, and Ford is experimenting with its own Uber-like app. At the same time, Google and Tesla are both publically experimenting with self-driving cars, while BMW has already introduced autonomous highway driving into one of its latest high-end models.

10. In the short term, three main trends can be expected to influence not only individual road transport, but road transportation more generally: (i) autonomous driving; (ii) vehicle sharing; (iii) electrification. We shall now review each in turn.

2.1.1 Automation

11. Vehicle automation is part of much larger revolutions in automation and connectivity.[10] These revolutions have converged with each other and are now blending with machines that sense and respond to the physical environment.[11]

12. There is yet no consensus on the commercial maturity of fully automated or even highly automated driving. In the near-term, the focus will be on deploying driver-assist and danger-warning functions in order to ease the driving task and make it safer. This focus will shortly, and arguably already is, shifting to the conditional deployment of autonomous driving in specific cases such as driving in congestion, in highways, and in vehicle platoons or road trains.[12]

13. Different levels of vehicle automation are likely to require different types of regulation. With the goal of providing a common terminology for automated driving, SAE International issued in January 2014 a now-widely accepted "Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems" which identifies six levels of driving automation from "no automation" to "full automation".[13]

Table 1. Summary of SAE's International's Levels of Driving Automation for On-Road Vehicles

Level	Name	Definition	Execution of steering and acceleration / deceleration	Monitoring of driving environment	Fall-back performance of dynamic driving tasks	System Capability
Human Driver Monitors the Driving Environment						
0	No Automation	Full time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems.	Human Driver	Human Driver	Human Driver	-
1	Driver Assistance	The driving mode specific execution by a driver-assistance system of steering or acceleration / deceleration using information about the driving environment with the expectation that the human driver perform all remaining aspects of the dynamic driving task.	Human Driver and System	Human Driver	Human Driver	Some driving modes
2	Partial Automation	The driving-mode specific execution by one or more driver-assistance systems of both steering and acceleration / deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.	System	Human Driver	Human Driver	Some driving modes
Automated Driving System Monitors the Driving Environment						
3	Condition Automation	The driving-mode specific performance by an automated driving system of all aspects of the dynamic driving task (including latitudinal and longitudinal control) with the expectation that the human driver will respond appropriately to a request to intervene.	System	System	Human Driver	Some driving modes
4	High Automation	The driving-mode specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene. If the human driver fails to take control of the vehicle, the system steers the vehicle to the side of the road in a controlled fashion and stops it.	System	System	System	Some driving modes
5	Full Automation	The full-time performance by an automated driving system of all aspects of dynamic driving task under all roadway and environmental conditions.	System	System	System	All driving modes

Source: SAE International, 2014

14. Some manufacturers have announced the arrival of highly automated and possibly fully automated vehicles as soon as 2017, while others have advanced much later dates (up to 2030).[14] Many companies have carried out trials or are engaged in continuous on-road testing of highly automated vehicle prototypes, including auto-makers such as Ford and Tesla, but also Internet and high-tech companies such

as Google and Uber. Automated vehicles have crossed the US almost solely in self-driving mode and have undertaken long-distance motorway and arterial trips in Europe and Japan.[15]

15. From a technical point of view, current technology for highly automated driving in controlled environments is quite mature. Many of today's production vehicles are capable of driver assistance, typically through the use of adaptive cruise control to adjust speed based on following distance. A small number of vehicles also incorporate an active lane-keeping assist feature in a way that makes them capable of partial automation. Some custom vehicles currently operate without any real-time input from human drivers – but autonomous driving remains limited to highly specific contexts, including particular routes or speeds, tyre-based container repositioning vehicles in ports, or fully automated ore trucks in some open-air mines.[16]

Box 1. Public Projects on Automated Driving

Across the world, and in addition to efforts to update regulatory frameworks, public authorities are taking initiatives to spur the development of automated driving.

In Australia, the Centre for Road Safety, New South Wales is conducting a Cooperative Intelligent Transport Initiative (CITI) trial of vehicle-to-vehicle and vehicle-to-infrastructure communications systems. The trial is being conducted on a 42-kilometer route from the Hume Highway to Port Kembla on the coast. The focus of this trial is to determine truck positions and speed and send alerts about incidents or potential crashes back to truck drivers to improve safety. The roadside units will also transmit traffic signal conditions so that vehicles can be alerted to stop.

In Japan, the government set up an Autopilot System Study Group in 2012 to study automated driving on expressways, under the guidance of the parliamentary secretary for the Ministry of Land, Infrastructure, Transport and Tourism. Further, in 2014 a "Public-Private ITS Initiatives and Roadmap" consisting of strategies and a roadmap for automated driving systems and the use of traffic data was announced. That same year, a Cross-ministerial Strategic Innovation Promotion Program (SIP) that included an Automated Driving Systems project to actively and strategically promote automated driving was established.

In the EU, work is underway to promote connected vehicle operation. Early efforts, like the development of a co-operative ITS corridor test bed – the ECoAT project – will lay the groundwork for future deployment of connected vehicles. This project centres on the deployment of cooperative ITS services on a test bed corridor linking the Netherlands, Germany and Austria. The project sketches out a joint road map for the introduction of initial cooperative ITS services, promotes the development of connected ITS services by agreeing common functional descriptions of an initial set of cooperative ITS services as well as their technical specifications, and frames the implementation of these services along the test bed corridor. In its first phase, ECoAT will develop and deploy two cooperative ITS services: one based on standardised and machine-readable and interpretable warning data regarding road works, and another service seeking to improve traffic management by exploiting vehicular and infrastructure data. These and further services yet to be developed by the ECoAT living lab will contribute to a comprehensive systems specification for co-operative ITS services developed by national authorities and industrial partners.

The United States is thinking of developing testbeds and trialling connected service frameworks. US Transportation Secretary Anthony Foxx revealed in January that the US budget proposal included a 10-year, nearly USD 4 billion investment to accelerate the development and adoption of safe vehicle automation through work with the technology industry and auto manufacturers to test connected and autonomous cars in designated corridors throughout the country.

Singapore has launched an Autonomous Vehicle Initiative (SAVI) to provide a technical platform for industry partners and stakeholders to conduct research and development (R&D) and test-bed automated driving technology, applications and solutions. Applicants may test their automated mobility concepts at a test bed consisting of a six km-long network of roads.

16. Initial regulatory approaches have involved the issuance of context-dependent operating licenses that match vehicle classes and specific contexts (e.g. non-motorway operation with maximum speeds of no more than 40 km/hr).[17] However, it is not yet clear whether authorities will seek to follow this vehicle-context licensing path and, if so, whether this would only be a short-term phenomenon or a more permanent aspect of automated vehicle regulation.[18]

2.1.2 Vehicle Sharing

17. According to the International Transportation Forum, an OECD sister body, cars are underused assets – most are used less than one hour a day. Much of their capacity is also underused, since cars typically display low levels of occupancy in each trip – often only one occupant.[19] Efficiently matching supply and demand – e.g. driver/vehicles and passengers – is the fundamental problem that must be solved to enable cars to be more efficiently used. The logistical challenges of achieving this balance are numerous, and the historic inability to address these challenges adequately has given rise to persistent service challenges.[20]

18. With the arrival of ubiquitous Internet access and dedicated app-based services, car sharing and ride-sharing have quickly grown in popularity and sophistication as numerous successful services have been deployed around the world. These services cut transaction costs, improve the allocation of available capacity, and reduce information asymmetries between drivers, fleet operators and passengers. Consumers value them for providing easy, consistent and universally available services. As a result, these services have gained ground in recent years, especially in urban areas, and have seen a tremendous influx of new entrants, a few of which have generated billions of dollars in market capitalisation.[21]

19. The street hail and taxi rank markets are still qualitatively different from other for-hire markets. This is essentially because lack of, and uncertainty around, supply-demand synchronisation in the street hail and taxi rank markets leads to situations where, absent regulatory control, taxis can exploit natural monopolies at the expense of the consumer. These concerns diminish, or may be even absent, in other for-hire services since the potential client can shop around for taxis according to their availability and fares. Nonetheless, for-hire transport is often extensively regulated, including cases of over-specification which can be perceived as being directed at preventing competition (particularly with taxis). The importance of the regulatory framework for car and ride sharing cannot be overstated, since, depending on this framework, competition between the various types of for-hire transport can be intense, partial or non-existent.[22]

Box 2. Rules on Private Hire Vehicle Specifications in France

Private hire vehicles are a separate class of for-hire services that cover car-services that operate on the basis of pre-negotiated fares (that preclude fares set on actual trip duration and distance) and pre-arranged reservations. There is a long history of regulating private hire vehicle-type services in France, often in a way to make these services qualitatively different from taxis and, incidentally, to minimise the chance of the former competing with the latter.

In 2014, the so-called "Loi Thévenoud" set out the conditions for private hire vehicle services in France. The law seeks to establish "sustainable conditions for balanced competition between individual modes of passenger transport". It sets the conditions for decrees that will define the "conditions of professional competence" required from the private hire vehicles' drivers and the "technical conditions and comfort" to be met by vehicles.

The law's enabling decrees specify dimensions and characteristics for private hire vehicles, ostensibly to ensure customer comfort. Private hire vehicles must be at least 4.50 metres long and have a minimum engine power of 88 kilowatts. This precludes the use of the compact and sub-compact vehicles that are most common on French roads. The law's implementing decrees also raise the level of driver training to 250 hours of paid courses (not required for taxi drivers), without any subsequent test regarding knowledge or skills. Due to the investment in time and money (approximately EUR 5,000) required for these courses, this requirement effectively limits the number of unemployed who might otherwise seek employment as private hire vehicle drivers.

The "Loi Thévenoud" requires private hire vehicles to return immediately after each trip to the operator's premises or to an underground car park where, incidentally, mobile phone networks work only imperfectly – thus limiting the ability to redeploy vehicles with technology-based platforms. Finally, the law bans the use of the very technology that is at the heart of smartphone-based apps' very success by prohibiting private hire vehicle "and the intermediaries that they use, informing a customer before booking / ... /, regardless of the means used, both of the location and of the availability, immediate or future of a vehicle / ... / when this vehicle is on a public road."

2.1.3 Electrification

20. Electric vehicles have a number of interesting characteristics that make them a favoured instrument in strategies for sustainable road traffic: (i) high energy efficiency, (ii) low CO2 emissions depending on energy source, and (iii) low local pollution.[23]

21. Fuel-cell electric vehicles have been considered as a viable technology option in the past decade; their high production costs, however, have shifted the focus to hybrid and battery electric vehicles. Most major vehicle manufacturers currently offer hybrids, and the first generation of plug-in hybrids and mass-produced battery electric vehicles are currently being introduced into the market.[24] The markets for these vehicles in Japan, Europe, and the US are highly dynamic; new vehicles are introduced almost on a monthly basis.[25]

22. Nonetheless, the current prospects for electric vehicles are hampered by high vehicle prices paired with a comparatively low use value – including limited payload, uncertainty regarding durability and safety, and short driving range. This is not unusual for novel automotive technologies. Air-bags, anti-lock braking systems, and electronic stability controls offer additional value to consumers but were expensive when they were launched. These technologies were therefore first introduced into high-price vehicles for which consumers are willing to accept a price premium in exchange for superior product functionality. Eventually, technological learning reduces production costs and enables the diffusion of novel technologies into mid-price and low-price vehicles.[26]

23. At present, a number of studies foresee price-parity between electric and fossil fuel vehicles to occur sometime between 2020 and 2030.[27] Importantly, however, vehicle manufacturers and policy makers support the gradual electrification of road transport via the introduction of innovative plug-in hybrid-electric vehicles, battery-electric vehicles, and fuel-cell-electric vehicles. As such, these vehicles often benefit from subsidies and other advantages that seek to level the playing field with fossil fuel vehicles absent price-parity.

2.1.4 Practical Implications

24. The intersection of digital innovation, automation, vehicle sharing and electrification has a number of implications for individual transportation, and car markets in particular. Some are already evident, such as the entry of tech-based companies into car markets. Other consequences, which also deserve attention, are the creation of new markets for car transportation services, into which both new entrants and incumbent automakers are entering; increased collaboration between incumbent automakers and digitally savvy companies; and, potentially, changes in the underlying structure of the provision of private and public transportation services.

25. Competition authorities will be faced with these developments in their day-to-day activities. Agencies will have to review mergers and co-operation agreements between incumbent automakers and tech companies. They will also need to update market definitions and identify competition dynamics; and will have to advise on the adoption of regulations and standards to ensure they are pro-competitive. They will also have to monitor markets for anti-competitive behaviour and infringements of competition law.

26. The introduction of innovative transportation services by new entrants is one of the most visible ways that new technologies are making their presence felt. The best-known examples of this are commercial transportation applications such as Uber and Lyft in the US, Cabify in Spain and South America, and Didi in China.

27. The rapid growth of new service providers, such as car-sharing (e.g. Zipcar, AutoLib) and ride-sharing services (Blablacar, Liftshare), in urban areas in particular signals the growing importance of these

services, which can be provided by private and public entities alike. For example, Autolib, an electric car sharing service in use in Paris, France, has today around 130,000 registered users with around 10,000 individual uses per day.[28]

28. The combination of automated driving and ride-sharing has the potential to completely change passenger transportation, particularly in urban environments. This is not a far-fetched possibility. Uber has since August 2016 allowed customers in downtown Pittsburgh to summon self-driving cars from their phones (supervised by persons in the driver's seat for the time being).[29] Almost simultaneously, a month-long trial was launched in Helsinki, Finland, whereby self-driving buses will operate alongside normal traffic.[30]

29. Auto-makers are also entering the new passenger transportation services markets made possible by these technological developments. BMW, in partnership with RideCell, a San Francisco-based company whose software serves as a kind of high-tech traffic controller, recently launched a new car-sharing service, ReachNow, which will enable Seattle residents to pick up and drop off 400 cars wherever they like.[31] Daimler has a similar service called Car2Go that is available in New York, Austin, Minneapolis, Vancouver and Portland. Audi also launched a car-sharing service in San Francisco and Miami called Audi at Home (though it is currently limited to residents of one luxury condominium complex in each city).

30. In addition to competition between new entrants and incumbents, there are also examples of increased co-operation between them. It requires institutional knowledge to navigate the supplier networks for vehicle production, which creates incentives for automakers and tech companies to ally.

31. In April 2016, General Motors[32] teamed up with Lyft to create a US-wide network of self-driving cars; General Motors will also become a preferred provider of cars to Lyft drivers for short-term use, and set up hubs where Lyft drivers can rent and operate cars without owning them.[33] Also in April 2016, the Volkswagen Group acquired a USD 300 million stake in Gett, an Israeli ride-hailing start-up that operates in over 60 cities worldwide, with the stated goal of adopting a joint growth strategy focused on the collaborative development and market expansion of on-demand transportation services in Europe and beyond. Also in April, Toyota and Uber entered into a memorandum of understanding regarding future collaboration, starting with trials in countries where ride-sharing is expanding[34], while Google and Fiat Chrysler Automobiles announced a partnership with a view to integrate Google's autonomous driving technology into the latter's vehicles[35]. Finally, Apple announced in May 2016 an investment of USD 1 billion in Didi, China's biggest ride-hailing service.[36]

32. In short, individual passenger transportation markets and business models are changing. As a result of these developments, buses and rail will face increasing competition from car-based transport, particularly in densely populated areas and in short-distance routes. Previously separate services, such as taxis, private-hire vehicles[37], commercial transportation applications, and car- and ride-sharing services will increasingly adopt the same or similar technologies, which may lead to the merger of previously separate markets.[38] Auto-makers' business models forecast a shift from selling cars and buses to selling 'travel time well spent'. This focus on the user experience beyond the driving task could result in entirely new markets – markets that traditional vehicle manufacturers will have to share with new entrants.[39]

Box 3. Long term possibilities for urban transport

Sharing individually-owned vehicles, driving partially automated vehicles and adopting hybrid electric vehicles may only be a bridge towards a more fundamental shift to an “Internet of vehicles” where lines between private and public transport will be blurred and where the identification of the most effective means of conveyance for the trip at hand will matter more. Such a system would not only reduce the environmental impact of daily mobility, it could also fundamentally change the way in which people move and live, particularly in cities.

Vehicle automation is particularly appropriate for low-speed travel during peak periods. At present, self-driven passenger shuttles and taxis might operate at low speeds in central business districts, corporate campuses, university campuses, military bases, retirement communities, resorts, shopping centres, airports and other semi-closed environments, as well as for first and last-mile transit applications. Particular parking facilities may support automated valet functions, and conventional cars assigned to car sharing programmes might eventually reposition themselves by traveling at low speeds on particular roads during non-peak periods.

Urban applications of these technologies may benefit from specialised infrastructure. Physical infrastructure might include vehicle-to-vehicle and vehicle-to-infrastructure communications equipment, ground-based units for global navigation systems, dedicated facilities comparable to bus and bicycle lanes, on-street parking restrictions, and specific roadway or pavement modifications. Digital infrastructure might include the maintenance of highly detailed roadway maps and pertinent traffic operations data. Use of intelligent transport systems and new vehicle-to-vehicle and vehicle-to-infrastructure communication technologies may go a long way to optimising the use of infrastructure.

It is highly likely that urban transportation will end up being better managed to deliver smoother high-capacity flows. For example, the International Transport Forum (ITF) conducted a study examining the changes that might result from the large-scale uptake of a shared and self-driving fleet of vehicles in a mid-sized European city where a dispatcher system manages the centralised task of assigning mobility requests to cars. The conclusions of this study were that car sharing may make it possible, at the extreme, to remove 9 out of every 10 cars in a mid-sized European city, while simultaneously significantly reducing average waiting and travel times. Furthermore, self-driving fleets would almost completely remove the need for on-street parking, thereby releasing significant urban areas for other uses. A particularly striking result is how a shared mobility system is forecast to improve social access and inclusion: in the ITF’s simulation, inequalities in access to jobs, schools or health services across the city virtually disappeared.

An example of a current system that may pre-figure these future developments is UbiGo. Under this system, which is currently being tested in Gothenburg, paying households have been subscribing to a fully integrated mobility service that combines public transport, car-sharing, rental car service, taxi and a bicycle system – all in one app and one invoice. The project works like a flexible mobile phone subscription but with units for public transport, car, taxi, etc., accessible to all members of a household through digital punch cards in the cloud.

2.2. Public Transportation

33. Passengers want different transport modes to be fully integrated within the transport system so that they can plan and purchase door-to-door journeys with confidence. The provision of seamless door-to-door services across combined geographic areas requires a degree of coordination and co-operation between neighbouring networks and modes of transport, e.g. timetables planned to minimise inconvenience. As a result, public authorities often have a responsibility to make sure that public transport is functioning seamlessly across modes and areas.[40]

34. In rural areas, it is difficult for conventional public transport to meet the needs of different population sizes and densities. Mobile applications allow for the development of new services better suited to individual needs, and can underpin innovative transport services to provide alternative transport supply solutions. For example, recourse to new technologies and digital platforms can improve the utilisation of existing vehicle stock, particularly by facilitating the pooling of passengers and structuring demand-responsive transport systems in which the routes travelled by buses, their stops, and the timing of the service can be flexibly adapted to passenger demand.41

35. In the short term, there are potential new markets in road transport for demand-responsive transport to railway stations and airports, for access to workplaces outside urban areas, and for integrated demand-responsive transport supply for the general public supplementing or replacing regular public transport services.[42] New technologies may also make combinations of transport services primarily provided for other purposes – e.g. post or freight – with passenger transport services an attractive option.

2.2.1 Rail Transport

36. Railways are also benefiting from innovations, even if they seem to be more incremental than those in road transportation. The next wave of developments in rail transport will nonetheless likely come from the adoption of digital technologies. Digitisation will improve punctuality, safety and the flow of railway traffic. Highly reliable and resilient systems will offer network-wide traffic management capabilities that will be able to track the precise location and current status of every train on the network.[43]

37. Related developments could also lead to increasing rail automation.[44] A recent paper has identified a number of technologies that are relevant for rail automation, and clustered them into four groups: (1) data collection[45], (2) data transfer[46], (3) data management[47], and (4) devices[48].[49] While several of these technologies are already available, integrating them in a smarter manner has the potential to optimise operations such as train traffic control, ticketing, security and passenger counting.[50]

38. Other passenger rail innovations, especially High Speed Rail, have acted to extend the competitive range of rail services. A number of "soft" innovations in policy, structure and regulation (such as the breakdown of integrated railways into owner-tenant approaches or the EU's efforts to engage full infrastructure separation, which follow the Recommendation of the OECD Council's 2001 Recommendation on the Structural Separation in Regulated Industries [C(2001)78/FINAL]) have led to the expansion of the role of the private sector through franchises, concessions or even full privatisation.[51]

39. Rail is a multi-product natural monopoly, entailing extremely high fixed costs which can hinder market entry and exit. It comprises different levels of production, including the rail infrastructure and rail operators.[52] Although some parts of the industry cannot sustain competition and are best structured as regulated monopolies, many countries have tried to establish mechanisms for introducing intra-modal competition in attempts to revitalise the market and increase efficiency.[53] Intra-modal competition can take a number of forms depending on the structure of the railway system and the nature of the infrastructure. The most important forms of intra-modal competition are: side-by-side competition[54]; end-to-end competition[55]; competition between tenants and owner or among tenants[56]; and competition for the market[57].[58] Nonetheless, some countries retain a monopoly system, an option which can be driven by a desire to achieve economies of scale or to ensure stable operations without extra transaction costs.[59]

40. The main developments in OECD railway sector reform since 2005 have been the opening-up of rail services to competition. The impact of these efforts is not yet completely clear. For example, while efforts in the European space to establish structural separation should have incentivised market entry, few companies have disclosed their intentions to invest in passenger rail operations. The potential impact of new entrants on the rail market seems limited in the short run, and the lead-time needed to procure rolling stock and the level of investment required is likely to limit market moves. As such, competition is expected to be driven mainly by incumbent passenger rail operators expanding their operations in other jurisdictions rather than by new entrants.[60]

2.2.2 Buses and Coaches

41. In most jurisdictions, the provision of public transport is provided by public authorities, either directly or through a concession, or it is subject to licensing, which is usually conditional on requirements

regarding reliability, professional competence, vehicle certification, quality of service, and financial stability, among others. Bus services can be provided either publicly, privately or through a mix of both, and the level of market liberalisation varies across jurisdictions. From a competition perspective, ensuring a level playing field between public and private companies, and limiting harmful distortions of competition that may result from subsidies have been identified as priorities[61] – and, as is made evident in the box below, competition agencies may face requests for advice on how to ensure competition in this sector.

Box 4. Competition and Markets Authority's Advice to Local Authorities

The UK's CMA was consulted by a number of local transport authorities (LTAs) as to rules on network planning for local bus services and as to joint ticketing.

On transport partnerships, the CMA recommended to LTAs that the network planning process should: (a) allow for rival operators to seek approval to run services in competition with an existing operator; (b) allow the provision of services to evolve, particularly if there are already restrictions in place due, for example, to congestion and pollution concerns; (c) not take into account the commercial impact on an incumbent operator of another operator establishing a new service. Furthermore, as part of a partnership scheme, LTAs may wish to seek minimum standards for bus operators participating in the scheme, for example in terms of the quality of the fleet that they are operating. While minimum standards can deliver benefits to passengers in terms of overall service quality and satisfaction, it should not be made unnecessarily difficult for operators to meet requirements to run bus services within the local area. Entry requirements should be proportionate and clearly justified in relation to the objectives of the scheme.

As regards ticketing agreements, the CMA recognised that a variety of smart ticketing technologies have been and will continue to be introduced, resulting in the development and introduction of new ticket formats and new types of tickets (new products) to be offered to consumers. While such agreements may *prima facie* infringe the prohibition on anticompetitive agreements, they can also result in benefits that outweigh their negative impact on competition. Such schemes can deliver increased convenience to those passengers who choose to use multi-operator ticketing products, while helping smaller or growing operators to overcome barriers to entry and expansion. In this way, implementation of an effective ticketing scheme can enhance competition. However, arrangements for integrated customer management records, smart ticketing and real time data have the potential to harm competition if they were to result in competing operators being able to share commercially sensitive information which, in turn, could allow operators to coordinate their activities. When considering setting up such arrangements, LTAs should establish appropriate firewalls.

42. While competition *for the market* is the most common form of competition in this sector, the reasons why this may be preferable to competition *in the market* may be eroded by technological developments. For example, one reason why tendering bus services may be preferable to competition between bus operators is that passengers are mostly interested in the timing of service on point-to-point trips rather than in the nature of the provider, which creates strong incentives for opportunistic behaviour by bus operators. Further, a number of routes are not commercially viable, but providing services on them may be important for social reasons; subsidies thus become necessary.[62]

43. Digitisation allows for demand-responsive services that diminish the need for subsidies by allowing for better targeted and more cost-effective services, and remove the scope for opportunistic behaviour. Furthermore, when a contract is awarded and the winner becomes the sole provider of the service for a certain number of years, appropriate *ex post* monitoring is essential to ensure that safety and quality standards are satisfactory. As in other sharing economy services, standards of security and quality may be better enforced through rating systems reflecting user evaluation than through sporadic public monitoring – even if regulatory goals which may not be effectively monitored by customers, such as environmental standards or accessibility for disable passengers, will still require public enforcement. Thus, current legislation on public transport may need to be reconsidered in the light of these new services, enabling innovation and market entry where possible.

2.2.3 Intermodal Competition

44. While buses and rail are likely to face increasing competition from car-based transport, the intensity of competition in longer routes and in less densely populated areas will vary, and it is likely to be affected by patterns of use and local coverage of public transportation services. Further, changes in the competitive dynamics of road transport may indirectly affect rail through inter-modal competitive pressure. Many rail services have close substitutes in other transport modes, and face competition in particular from buses on shorter or medium distances.[63]

45. An important element of inter-modal competition is price. However, the price charged to customers often does not reflect the full costs of the provision of the service. For example, substitutes for the rail mode – particularly road transport – are frequently not efficiently priced, since they do not reflect all infrastructure, accident, environmental and congestion costs. Although toll roads and various forms of road pricing are becoming increasingly common, it is not yet common practice in OECD countries to directly charge road users for the use of the major part of the road network.

46. As a result, some of the costs of using the road network, such as the cost of providing the infrastructure or congestion costs, may be under- or unpriced.[64] If the road mode is under-priced, it is economically efficient (if only second best) to also under-price the rail mode, with associated subsidies if necessary. In part due to mispricing of substitute modes, virtually all OECD countries subsidise the rail sector in some way – at least through public financing of new infrastructure, and often through direct subsidies for passenger services. The effect of these regimes is the absence of a level playing field absent subsidies and the potential distortion of inter-modal competition.

47. Particular regimes may benefit one mode of transport or another depending on the regulatory regime; however, technological developments could affect the existing balance of transport modes. Subsidies are often now available for electric vehicles in a number of jurisdictions, reflecting lower pollution costs. Developments in road transport may allow for more efficient pricing of road transport, and thus change the calculus regarding the desirability of subsidising rail. For example, should environmentally clean road transport be able to replace rail in the provision of socially desirable services, one of the reasons underpinning rail subsidies may be eroded; however, concerns with increased road congestion may counterbalance this, and the calculus may also be influenced by considerations regarding the ability to charge for the use of the road infrastructure.[65]

48. Ultimately, there is no universally applicable policy prescription – regulatory regimes may grant an advantage to one mode of transport or another depending on the circumstances, and legitimate political decisions can be adopted favouring some transport modes over others. Given the speed of developments, regulators should nonetheless routinely review the regulatory framework and seek to identify, at any given point in time, what regulatory concerns can now be best addressed by the market. The goal is to maximise competition, while simultaneously creating an environment conducive to investment and innovation on passenger transport where regulatory concerns are addressed and political preferences implemented.

3. Freight

3.1 Rail

49. Innovations in freight technology, such as heavy haul techniques, signalling improvements and inter-modal systems have significantly reduced the cost of rail freight services.66 The adoption of digital technologies, particularly when coupled with location data, will yield a much more efficient use of railways, with a related impact on their competitive position.67 Automated data collection in the railway network will allow for the continuous monitoring of the railway infrastructure condition, providing more

accurate real-time information on, for example, rail wear and the need for safety device replacements, thereby helping to prevent disruptions caused by deficient conditions. Digitalisation will also allow customised real-time information on specific journeys to be provided to customers.68

50. It is widely accepted that there is great potential for the adoption of automation in rail transport.[69] It has been predicted that, if technological change continues we may expect in the future to have: trains without crews (which is already done today in some urban subways); real-time system management of all trains without wayside signals; real time monitoring of all equipment condition and maintenance planning (which already done by some US freight railways); and even tighter integration of rail services into logistics chains.[70]

51. Rail automation offers possibilities for further and more efficient optimisation in different areas of the rail freight market. It allows distances between trains, conflicts at junctions and energy consumption to be optimised. For infrastructure and rolling stock, automation allows maintenance processes to be optimised.[71]

3.2 Trucks

52. Road freight is an area which is likely to both benefit from and provide a basis for further developments in automated driving. Technologies for the automation of heavy goods traffic are already rather advanced, if not fully operational. Recently, for example, Daimler unveiled a truck that is advanced enough to enable the driver to cede full control in certain traffic or environmental conditions.[72] Companies are also testing heavy vehicle platooning. Vehicle platoons are a particularly promising application for automated driving in freeways, which is likely to start being deployed in the short- to medium-term. Already, a convoy of mostly self-driving trucks drove across Europe in April 2016 from Sweden to the port of Rotterdam.[73]

53. The fulfilment of the benefits brought about by developments in road freight will depend on the regulatory framework allowing these developments to be implemented. A number of countries have already started working on rules for self-driving road transport, particularly in Europe[74], the US[75] and Japan[76].

54. Benefits of automating road freight may include significant fuel savings from platooning technologies and, for fleet operators, lower labour costs, which currently correspond to between 50% and 75% of all road freight costs. Further, whereas drivers are restricted by law from driving more than a certain number of hours per day without taking an 8-hour break, a driverless truck could drive nearly 24 hours per day. Thus, automation technology could double the output of transportation while more than halving costs. Since trucking represents a considerable portion of the final cost of all consumer goods, consumers everywhere will experience this change as lower prices and higher standards of living.[77]

55. Regulators can expect to face a number of challenges brought about by truck automation. First, given the impact on employment of the technological developments outlined above, a political reaction and advocacy of protectionist measures by certain sectors of society are to be expected. Second, given the cost advantages that truck automated technologies may provide to first-movers, the allocation of trucks to companies may well prove problematic, given bottleneck issues and the potential for discrimination by truck makers. Regulators, including competition agencies, may face complaints regarding the behaviour of truck manufacturers, or even be asked to arbitrate the allocation of automated trucks. Last, while there is an international convention on road freight, there are concerns regarding the absence of common standards on automated driving, the interaction of different regulatory regimes, and the obstacles these regimes may place to competition. Thus, competition agencies can expect to play a role in incentivising international co-operation in this field.

3.3 Intermodal Competition

56. Developments in road freight are occurring in parallel to a number of innovations in rail freight which have led to an increase in efficiency and reduced the cost of rail freight service by as much as half. Taken together, these trends may lead to changes in the dynamics of inter-modal freight competition.

57. In freight markets, railways typically move large lots, ranging from a wagonload weighing 50 tonnes to entire trainloads (unit or block trains) of 20,000 net tonnes or more. Rail freight services are typically relatively slow, with unpredictable arrival times due to marshalling and changes of locomotives and crews. This makes rail suitable for movements of large quantities of lower valued cargo over longer distances at low tariffs.

58. As a general rule, the rail mode has a competitive advantage over road transport in carrying large quantities of goods which have a low value per unit weight – these are the so-called “bulk” goods, such as grain, coal, oil, minerals and chemicals. For almost all other freight services, rail faces strong competition from the road mode.[78] Trucks move shipments that are at most half a rail freight wagonload, but they move them significantly faster and more dependably, while charging much higher tariffs. The competitive interfaces among the freight modes are determined by the availability of these alternatives, as well as by the shipper’s logistics cost, which are in turn determined by cargo value, minimum shipment size, average speed of the alternative services, and tariffs. Competition between road and rail for freight is likely to continue to increase.

59. Growth in demand for transport of goods in units and products in smaller volumes in single wagons has exceeded growth demand for transport of bulk material or heavy loads hauled in whole trains. Rail transport may be in this respect disadvantaged vis-à-vis road transport as it is limited by its network character, low average speed and insufficient inter-operability of national rail systems.

60. Drones may become increasingly relevant for last-mile delivery, adding a new dimension to intermodal competition in freight. 80% of packages delivered by UPS fall within the payload capacity of existing drones, and their cost is low, on par with ground-based couriers. There are already private companies, such as Flirtey and Amazon, who seek to deliver products at home through drones.[79] Swiss Post will attempt drone deliveries using Matternet, a company which drones can transport items up to 1 kilogram (2.2 pounds) over 20 kilometres on one charge.[80]

61. The main obstacles to drone delivery at the moment are regulatory. Some regulators are already embracing them, however: in the US, a number of companies, including Google, Amazon and Flirtey have obtained FAA approval. In Europe, a number of countries have rules on the commercial use of drones. In Germany, for example, companies using commercial drones up to 5 kg must apply for a flight permit from the relevant federal state authority

62. While it is clear that developments in freight will lead to lower costs and lower prices for final customers, the full benefits of multi-modal transport and freight logistics will only be reaped when the full range of infrastructure requirements (including terminals, seamless connections of all modes, ICT systems, etc.) are in place along transport routes. Multimodal logistics require appropriate infrastructure, well-situated and equipped nodal points (logistics platforms, rail freight terminals, urban nodes), and for individual transport modes to be effectively interconnected – physically and digitally – at the appropriate nodes. Seamless transport chains across modes and logistics solutions require focused investments in physical infrastructures, superstructures and transhipment equipment; and the establishment of the appropriate digital infrastructures, which must be interconnected and interoperable.[81]

63. The planning and management of logistics chains and its optimisation is in principle a task for business, but public authorities can help in establishing the right framework conditions to operate them, hand in hand with removing technical and administrative barriers and investing in the necessary infrastructure and in the intelligent use of available resources and capacities. Ultimately, these efforts require a co-operative approach between all stakeholders, which can be facilitated by the availability of data and ICT systems.[82] While desirable in principle, this co-operation may nonetheless need to be subject to antitrust control to ensure it is pro-competitive.

4. Challenges

64. This section will summarise, and expand on, the challenges that competition agencies face from an enforcement and regulatory advocacy standpoint in the light of the developments in land transport reviewed above.

4.1 Enforcement

65. While competition agencies' antitrust enforcement activities in land transport are unlikely to be greatly affected, the various developments described in this paper are likely to lead to some changes in the agencies' focus and practices.

4.1.1 Cartels and Monopolistic Practices

66. In recent times, enforcement has focused on a limited number of practices and sectors, such as cartels by vehicle manufacturers - e.g. regarding the price of trucks and car parts[83] – and rail operators – e.g. on the provision of rail cargo transport services[84]. In rail, industry structures such as the one prevalent in Europe create incentives for the infrastructure monopolist incumbent to favour its own downstream subsidiaries which compete with other operators. Competition policy can complement non-discriminatory access requirements imposed through regulation by prohibiting, for example, practices that would prevent or degrade access of railway undertakings to indispensable infrastructure.[85]

Box 5. Antitrust Enforcement in Rail

Austria – the private rail operator WESTbahn applied for track access rights on the main rail corridor connecting Vienna to Salzburg. The incumbent operator ÖBB held a monopoly on the line, which was deemed to be 'commercially viable' and therefore was operated by ÖBB without any state subsidies. WESTbahn's market access and growth were delayed by a number of events. The operator made several complaints to the Austrian regulator and competition authority, including in relation to discriminatory access to essential facilities by the integrated infrastructure manager (ÖBB Holding), and to unfair competition involving predatory pricing by the incumbent operator. Despite these initial difficulties, WESTbahn commenced operations in December 2011 and operated more than 3 billion train-km in 2013, equal to a market share of 20-25% on the Vienna-Salzburg route and an overall 3% share nationally (own calculations).

Czech Republic – RegioJet – an established coach and bus provider – entered the long-distance rail passenger market in 2011 and started competing with the incumbent ĈD on the Prague-Ostrava route, the busiest domestic rail corridor. In November 2012, a second new entrant arrived – Leo Express, funded by a private equity fund. Following complaints by the new entrants, administrative procedures against ĈD were launched by the regulatory authority, accusing the incumbent of undercutting competition by abusing its dominant position. These accusations notwithstanding, new entrants operated a combined 4.5 billion train-km in 2013, equivalent to a market share of 40-50% on the Prague-Ostrava route and an overall 3.5% share nationally (own calculations).

Germany - the German Authorities have recently closed an investigation against Deutsche Bahn following the latter's commitment to change its business practice to allow competing rail passenger operators better opportunities to sell tickets, in particular through shops in train stations. Deutsche Bahn offered commitments to standardize and reduce commissions paid for ticket sales by competitors. Rivals selling tickets for local passenger traffic will also be able to use ticketing machines to sell longer-distance tickets.

Italy – the monopoly held by Trenitalia was interrupted in April 2012 with the entry of NTV into the high-speed rail network connecting Italy's largest urban areas. NTV has complained about entry barriers, partly due to the behaviour of FS Holding (controlling both the incumbent operator Trenitalia and the infrastructure manager RFI), which slowed down the process of *de facto* market opening. Alleged barriers included delays in processing path applications, limited access to essential facilities (e.g. Rome Termini and Milan Centrale stations), and cross-subsidisation in order to sustain Trenitalia's predatory pricing policies. Both the competition authority and the new transport regulator (ART) set up in 2013 intervened with structural and behavioural remedies to ensure non-discriminatory conditions. Additionally in October 2014, track access charges for the high-speed rail network were reduced by around 30% in order to support competition and reduce the costs of operations.

67. The developments reviewed in this paper are unlikely to have an impact on these types of anticompetitive practices, which will continue to be the object of antitrust enforcement.

4.1.2 Co-operation Agreements

68. Passengers can benefit from effective partnerships between transport operators, local transport authorities, or a combination of both. Beneficial outputs from co-operation include better integrated networks, greater coverage, multi-operator ticketing schemes and integrated information management. The challenge is to strike an appropriate balance between competition and co-operation, providing scope for continuing rivalry between operators.86

69. While these concerns are likely to remain, the increasing deployment of IT technologies is likely to enhance the potential efficiencies from intra- and inter-modal co-operation. From a customer point of view, transportation should be provided door-to-door regardless of transport mode. Operators and local authorities already offer services and connection information through phone apps. Improved interchanges between modes will reduce overall travel time.[87] Coordination of public transport services can provide efficiency gains by grouping passengers together, improving the utilisation of existing vehicle stock and more generally through economies of scale.[88] Other possibilities created by new technologies and digital platforms include opening up special transport services to the public, and common planning and purchasing of publicly funded transport services.[89] Similar considerations apply to freight.

70. Achieving these efficiencies will require coordination between the various operators, including the disclosure of commercially sensitive information, which is usually perceived as being potentially anticompetitive.[90] As technologies develop, the balance between pro- and anti-competitive effects of co-operation arrangements may well change, as will the amount and type of information exchanged. Thus, competition agencies may want to influence or supervise, depending on the type of co-operation, efforts to promote and optimise multimodal transportation and logistics systems in order to ensure that they are pro-competitive.

71. Another type of co-operation agreements more likely to be brought to the attention of competition agencies – and likely subject to merger control – are partnership agreements between transport incumbents and tech companies. These partnerships provide an indication of the industry´s view about how business models and markets will change, and, assuming present market trends do not change, they are likely to become more common in the future, even as automakers and tech companies become effective competitors. Competition agencies are thus likely to have to devote attention to reviewing such agreements.

4.1.3 Market Definition and Competition Assessments

72. Competition agencies are likely to see different markets merge into single product markets – which will cause a flurry of mergers in the land transport sector, and particularly in road transport markets – alongside the creation of altogether new product markets. For example, and as noted above, previously

distinct services such as taxis, private-hire vehicles, commercial transportation applications, and car- and ride-sharing services may become increasingly inter-changeable from a consumer perspective. As markets change, competition agencies will need to keep abreast of developments in order to identify the correct product and geographic markets in a dynamic environment.

73. In addition to market definition, competition agencies may also have to face changing market dynamics. In the road transport sector, a drastic reduction in the number of cars needed would significantly impact car manufacturer business models. Vehicles will be used much more intensely than before, which may require different car models than those currently available. Industry structure will change as new vehicle types are adopted, but so will the intensity of competition as shorter life-cycles for vehicles can be expected (with implications for the quicker adoption of new, cleaner technologies). New services will develop under these conditions, but it is unclear who will manage them and how they will be monetised. Some markets may be affected by increased public provision of previously private services – e.g. car-sharing in Paris is influenced by the presence of Autolib, a public electric car sharing service.[91] In short, previous assumptions regarding market dynamics and competitive constraints are likely to prove outdated, with implication for the outcome of competition assessments.

4.1.4 Barriers to Entry

74. A particular concern in this sector, as in other areas of the digital economy, may be the entrenchment of early-movers. Market success for many new commercial transport operators relies on rapidly achieving sufficient scale to deliver attractive services in terms of reduced wait times for, and increased reactivity to, customer ride requests. The drive for scale may explain some of the practices that have characterised the early deployment of commercial transport application services, including their willingness to simultaneously act on the margins of current regulatory frameworks while seeking to change these rules. Early success at achieving scale may create market share barriers difficult for new entrants to overcome.[92]

75. In addition to barriers related to scale, competition agencies are likely to identify other barriers to entry as a new ecosystem is created where digital services are integral to market success. At present it is unclear whether such barriers will be effective (new entrants may be able to sub-contract their way around them) but we will review them here.

76. A first set of barriers relates to data collection and data protection. Data protection concerns are widespread in the digital economy, and are related to the possibility of highly sensitive personal information being misused or stolen. In addition to the potential barriers created by the ability of established incumbents to ensure the safety of data, new entrants may also face significant regulatory burdens in complying with relevant data protection legislation. It is also highly possible that incumbents, with the use of algorithms and machine learning, are able to entrench their positions, making it difficult if not impossible for newcomers to enter their market.[93]

77. Other barriers relate to the ability to deal with cyber-security risks, especially when networked-based systems interact directly or indirectly with the primary control systems of vehicles. A recent survey of US cars identified a number of potential vulnerabilities posing variable risks depending on vehicle and sub-system design.[94] Two recent examples of cyber-attacks on mission critical systems involve spoofing of Global Positioning System (GPS) signals used to pilot ships and aircraft.[95] While these attacks were against flying machines, there is no reason why land-based transportation systems would not be vulnerable to similar interference.

78. Cyber-security risks are also a concern for transport systems more broadly, as increasing complexity and connectedness open up new avenues for malicious interventions. Spoofing or manipulating

data could have important and severe consequences for traffic system operations that depend on these data feeds to coordinate emergency services, signal timing and traffic variable messaging systems, among others.[96]

79. Ultimately, transportation vehicles that depend on software and / or are networked are vulnerable to cyber-attacks which means that any entrant into the market must ensure the safety of their vehicle. While it is possible that protection against cyber-attacks will be an independent, ancillary service provided to vehicle owners or companies, it may also become an important parameter of competition, particularly if connection to specific transportation networks and infrastructure ever becomes a competitive advantage.

4.2 Regulation

80. Business model innovation, including innovative uses of data and novel data sources, is happening in parallel with the development of new technologies. These processes are accelerating at a much faster pace than governments and transport agencies are typically used to. By the time evolving business models and the technologies that facilitate their adoption converge and start to play out on city streets and public spaces, it is often difficult or even too late for regulators to act effectively.[97] Commercial transport apps are a good example. They do not typically fall under existing regulatory structures as the deployment of new technologies blurs the line between existing regulatory categories. Some commercial transport apps have taken advantage of this regulatory ambiguity to deploy services that, in the minds of many regulators, contravene or challenge the spirit of existing rules and regulations.

81. Incremental responses often fail to anticipate and provide a sufficiently flexible regulatory framework for even greater disruptions building up on the horizon. Legislation is often obsolete by the time it is rolled out in view of technological developments.[98] New models for anticipatory but flexible policy-making may be necessary but are yet to be developed.[99] Flexible regulation might more easily accommodate existing regional differences, local start-ups, and unique demonstration projects.[100] It has been suggested that regulation should focus on principles rather than specifics, and that its application could be limited in time – i.e. with sunset clauses or mandatory review of regulatory appropriateness following relatively short-time periods.[101] Yet another option is to leverage data-led regulation to lighten the regulatory burden – i.e. operators could be given the choice between providing extensive data relevant for regulators and being subject to light regulatory schemes, or not providing such data and being subject to more burdensome regulatory frameworks.[102]

82. Competition agencies, with their knowledge of markets and awareness of the benefits of innovation and competition for consumers, have a role to play in assisting regulators address the new challenges they will be facing. Competition agencies will also have a role in shaping developments in the market, mainly through merger control and potential decisions on standard-setting, in addition to the normal course of competition enforcement.[103]

4.2.1 Supervising Private Entities with Regulatory Roles

83. Competition agencies have a valuable role given the increasing role that the private sector plays in the regulating of markets. Some governments fear that they no longer have the right tools or sufficient information to accompany these changes and to deliver on public policy objectives. An increasing amount of actionable data pertaining to road safety, traffic management and travel behaviour is held by the private sector, crowding out more traditional data collection methods employed by transport authorities.104 Innovative data-sharing partnerships between the public and private sectors going beyond today's simple supplier-client relationship may become more usual, signalling a delegation of duties traditionally pursued by public authorities to the private sector.105 This shift from public to private regulation is already

happening – effective control is being outsourced in some instances to commercial operators managing traffic control centres.

84. While the benefits of involving the private sector in improving the management of public goods are real, so are its potential costs. There is a risk that the private sector is inadvertently creating 'regulatory capture' which will lead to a future where most traffic operations and control responsibilities are effectively outsourced to those that hold the data. For example, in a not too distant future it could be possible to see navigation services providers, which are already layering traffic information, digital mapping and navigation algorithms over the road infrastructure, taking over or replacing traffic signals.

85. This creates a related risk, one which competition agencies are particularly well-placed to deal with – the fact that, increasingly, phenomena of supplier lock-in are manifesting themselves, where it becomes very difficult to change suppliers and systems due to scale, compatibility or learning effects. Nonetheless, agencies should be aware that there is also an increase in the number of suppliers offering services, allowing authorities to pay only the marginal costs of subscribing to services and alleviating the risk of lock-in. Furthermore, the whole process is very much innovation driven, with new providers and new solutions constantly entering the market. Competition agencies may want to consider promoting open standards, which may provide some assurance of cross-compatibility and decrease learning and other transaction costs associated with changing suppliers, thus reducing the risks from technology or system lock-in.[106]

4.2.2 Preventing Anticompetitive Regulations

86. A risk often associated with regulatory capture, but which can materialise independently from it, is the adoption of anticompetitive regulation. As markets and the technologies deployed change, regulations will have to adapt accordingly. Some incumbents – both private and public – can be expected to react by proposing or adopting regulations that attempt to stop or delay innovations that may benefit consumers. Competition agencies have an important role in ensuring that the forthcoming regulatory environment is pro-competitive.

87. For example, shared transportation benefits depend on creating the right market conditions and operational frameworks. Today's technologies make possible shared transport solutions at lower prices that provide quality transportation to all citizens with significantly reduced traffic volumes, fewer emissions and less need for public parking space. However, these technologies can displace powerful companies and have significant impact on labour, so political reactions that advocate restricting competition are to be expected.

88. Ultimately, the regulatory framework will evolve. The challenge – to which competition agencies can contribute – will be to provide a sufficiently flexible framework that does not stifle innovation, while protecting regulatory goals and providing certainty for market actors.[107]

4.3.3 Standards

89. Common interoperability standards are required for intermodal transport. Together with other public authorities, competition authorities have a role to play in the development of integrated transport networks. In particular, competition agencies should endeavour to ensure that the intermodal infrastructure, and particularly the associated digital architecture being implemented, is open and interoperable – thereby maximising the possibilities of competition and market entry, and minimising the chances for discrimination and anticompetitive practices.

90. Network planning often suffers from a lack of coordination between neighbouring jurisdictions and levels of authority. Transport network integration cannot end at a city's or a country's borders;

international agreements are needed to help connect different types of infrastructure and provide common standards. Fragmentation can result in high costs whenever journeys cross regulatory boundaries or require transfers between different transportation modes. Even within the same transport mode, lack of coordination and common standards pose serious challenges. While there is an international convention on road freight, similar concerns arise regarding the interaction of different regimes and standards on competition on freight.[108]

91. An area where lack of standardisation and common rules is likely to prove an issue is automated driving. Different automation standards may increase barriers to entry and create protectionist obstacles to market access. As different jurisdictions adopt different sets of rules, or react differently to different levels of automation, automated vehicles may be prevented in one jurisdiction and allowed in another, and/or auto-makers will have to prepare vehicles to operate in a variety of different regulatory environments. These could create obstacles to manufacturers and road users alike.

92. Similarly, shared transport networks may impose certain standards that, if not aligned internationally or even regionally, may benefit certain producers to the detriment of others, thereby limiting competition and benefiting those companies with the resources necessary to meet multiple standards and regulatory barriers.

93. The Amsterdam Declaration signed by EU transport ministers on 14 April 2016 seeks to address this. It lays down an agreement on the steps necessary for the development of self-driving technology in the EU. The goal is to promote coherent international, European and national rules, with a common framework in place by 2019. The declaration requires the legal framework to offer sufficient flexibility to accommodate innovation, facilitate the introduction of connected and automated vehicles in the market, and enable their cross-border use. The declaration further acknowledges that interoperability and standardisation will be key factors in driving scale, both at the European and international level, and as such supports the development of common standards.

94. Yet another such initiative is being pursued by the United Nations Economic Commission for Europe (UNECE). Under the auspices of the World Forum for harmonisation of vehicle regulations, the UNECE Working Party on Brakes and Running Gear reviewed in early 2016 a proposal to amend existing regulations with a view to introduce technical provisions for self-steering systems. These systems will be used for Lane Keeping Assist Systems and Autopilot Systems in traffic jam conditions. Under specific driving circumstances, these systems will take over the control of the vehicle under the permanent supervision of the driver. The Working Party also reviewed policies and guidance concerning self-parking functions (e.g. when the driver instructs the car to park while he/she is outside the car) and highway autopilots (e.g. when the vehicle would be self-driving at high speeds on highways).[109]

95. Concerning rail, the absence of common standards is an outstanding issue. When neighbouring rail networks serve different geographic areas, the provision of seamless end-to-end services across the combined geographic area requires a degree of coordination and co-operation between the neighbouring networks. At a minimum, the provision of “seamless” services requires that neighbouring networks share common technical standards and specifications, such as track gauge, signalling systems and traction.

96. Efforts on the adoption of common regional standards are especially strong in Europe, in the context of efforts to create a single railway market. Innovations in signalling and automation combined with GPS, enhanced communications and computers present railways with a major opportunity to improve safety and productivity. One part of this type of efficiency improvement will be standardization through programs like ERTMS in the EU or its US equivalent (PTC). These systems will become increasingly important if traffic density on the rail networks continues to increase, and will be especially important for

mixed passenger and freight lines and HSR lines where the safety margin of error is smaller and the potential damage from accidents is higher.[110]

97. In short, competition agencies can play a role in the development and adoption of common standards, particularly by incentivising international co-operation and promoting non-discriminatory open standards that allow market entry.

4.3.4 Level Playing Field

98. Competition authorities also aim to ensure competitive neutrality, both between modes of transport and between the technologies being brought to the market.

99. As noted, a first challenge reflects the absence of effective pricing of the various transport modes. For example, although there are individual exceptions, road prices (where they exist) usually do not vary with congestion levels. If the road mode is under-priced, the price of rail services would be too high and the consumption of rail services would be too low relative to road transport modes in the absence of government intervention. In part due to mispricing of substitute modes, virtually all OECD countries subsidise the rail sector in some way – at least through public financing of new infrastructure, and often through direct subsidies for passenger services. The design of these subsidies will directly affect the incentives of operators and is therefore a key part of the design of the overall regulatory regime.[111]

100. This is an area where technological developments are already playing a role in improving pricing. For example, tolling solutions for certain types of freight have already been implemented in a few countries.[112] However, the potential of digital developments – e.g. individual travel data, particularly when coupled with smart infrastructures – has only started to be tapped in this regard.

101. Subsidies, however, are not only granted to rail pricing in road transport. Policy makers support the gradual electrification of road transport, mainly for environmental reasons. Given the higher cost and price of electric vehicles compared to more polluting alternatives, one of the ways in which this support has expressed itself more clearly is through the subsidisation of the price of electric vehicles to final consumers.

102. Ultimately, the creation of a level playing for road transport will depend on political decisions regarding the optimal transportation framework. Such a framework will take into account such disparate concerns as the environment, inclusiveness, congestion, among others. The challenge for competition agencies is to ensure, within this framework, that innovations that will bring benefits to consumers can easily reach the market, and that the various modes of transport are able to compete in a level playing field in order to lower prices, increase quality and provide better services to final consumers.

5. Conclusion

103. The dynamics of competition in land transport are about to undergo significant changes. The main trend in transportation markets is their increasing digitalisation, as in other areas of the economy, which is changing the way transport services are offered. In road transport, these developments will lead to increasing automation, vehicle-sharing, and electrification. In rail, the adoption of digital technologies, particularly when coupled with location data, will yield a much more efficient use of railways and significantly reduce costs.

104. From an enforcement perspective, competition agencies are likely to continue to face cases of collusion and abuse of market power in land transport. However, the developments reviewed in this paper mean it is likely that agencies will also be required to establish whether an increasing number of co-operation agreements between potential competitors are pro- or anti-competitive; review an increasing

number of merger notifications; define new markets and engage with new market dynamics; and assess the impact of a number of new barriers to entry. On the advocacy side, agencies will have the opportunity to supervise the increasing regulatory role that the private sector plays in land transport; support the adoption of pro-competitive regulations and industry standards; and, ultimately, contribute to the development of a level-playing field in this area. Ultimately, these developments not only pose new challenges for competition agencies, but create opportunities for interventions that promote greater competition and maximise consumer welfare across the economy.

ENDNOTES

1 ITF (2015) 'Big Data and Transport – Understanding and Assessing Options', available at http://www.itf-oecd.org/sites/default/files/docs/15cpb_bigdata_0.pdf, p. 6

2 For example, in the US, Canada and Australia – which feature lower population densities and larger distances between major urban areas – rail passenger services have a smaller share of the passenger transport market than in Europe – where population densities are higher and roads tend to be more congested. See OECD (2005), Structural Reform in the Rail Industry, DAF/COMP(2005)46, p. 26; OECD (2013), Recent Developments in Rail Transportation Services, DAF/COMP(2013)24, p. 15.

3 OECD (2013), Recent Developments in Rail Transportation Services, DAF/COMP(2013)24, p. 8, 15, 32.

4 2014 International Transportation Forum Highlights, p. 17, available at http://www.internationaltransportforum.org/Pub/pdf/14Highlights.pdf.

5 GNSS (2015) 'Market Report', available at http://www.gsa.europa.eu/system/files/reports/GNSS-Market-Report-2015-issue4_0.pdf, p. 17.

6 See ITF (2016) 'Data Driven Transport Policy', available at http://www.itf-oecd.org/sites/default/files/docs/data-driven-transport-policy.pdf, p. 16-17. See also Cox, P, and Trautmann, C. (2016) 'Boosting Intelligent Transport Systems' in "Issues Paper of European Coordinators: TEN-T Corridors: Forerunners of a forward-looking European Transport System", available at http://ec.europa.eu/transport/themes/infrastructure/news/doc/2016-06-20-ten-t-days-2016/issues-papers.pdf, p. 19-20.

7 ITF (2015) 'Big Data and Transport – Understanding and Assessing Options', available at http://www.itf-oecd.org/sites/default/files/docs/15cpb_bigdata_0.pdf, p. 6.

8 ITF (2015) 'International Experiences on Public Transport Provision in Rural Areas', available at http://www.internationaltransportforum.org/Pub/pdf/15CSPA_RuralAreas.pdf, p. 10; Leviakangas, P. (2016) 'Digitalisation of Finland's Transport Sector' in Technology in Society 47 1, p. 10.

9 ITF (2015) 'International Experiences on Public Transport Provision in Rural Areas', available at http://www.internationaltransportforum.org/Pub/pdf/15CSPA_RuralAreas.pdf, p. 10.

10 Smith, B. W. (2014) 'Proximity-Driven Liability' Georgetown Law Journal, Issue 102.

11 ITF (2015) 'Automated and Autonomous Driving: Regulation Under Uncertainty', available at http://www.internationaltransportforum.org/Pub/pdf/15CPB_AutonomousDriving.pdf, p. 11.

12 2014 International Transportation Forum Highlights, p. 22, available at http://www.internationaltransportforum.org/Pub/pdf/14Highlights.pdf.

13 The role of the human driver at different levels of automation has been described as follows: (1) the system only supports one aspect while the driver takes care of other aspects and monitors the driving environment; (2) the driver must monitor the driving environment; (3) the driver may disengage and undertake other tasks while driving, but if necessary, it must take control of the vehicle (i.e. start driving the vehicle); (4) the driver may even be asleep, as the system gives a warning if the driver needs to take control of the vehicle; (5) no driver is needed. On levels 1-4 of automation, the driver must have the possibility of safely taking over the control of an automated vehicle in all situations. See Pilli-Sihvola, E., Miettinen, K., Toivonen, K., Sarlin, L., Kiiski, K., Kulmala, R. (2015) 'Robots on Land, in Water and in the Air. Promoting Intelligent Automation in Transport Services', p. 9, available at

http://www.lvm.fi/documents/20181/514467/Julkaisuja+14-2015/0567d84e-2a01-4cb7-9b6f-6148ba47047c?version=1.0.

14 ITF (2015) 'Automated and Autonomous Driving: Regulation Under Uncertainty', available at http://www.internationaltransportforum.org/Pub/pdf/15CPB_AutonomousDriving.pdf, p. 12.

15 Nature, 'Autonomous vehicles: No drivers required', 4 August 2015, available at http://www.nature.com/news/autonomous-vehicles-no-drivers-required-1.16832;

16 ITF (2015) 'Automated and Autonomous Driving: Regulation Under Uncertainty', available at http://www.internationaltransportforum.org/Pub/pdf/15CPB_AutonomousDriving.pdf, p. 12-16.

17 For example, in the US, California is presently considering a bill allowing a pilot project testing autonomous vehicles not equipped with steering wheels, brake pedals, accelerators, or operators inside, at specified locations and speeds under 35 miles per hour. For a more detailed overview of regulatory initiatives, see notes 74 to 76 below.

18 ITF (2015) 'Automated and Autonomous Driving: Regulation Under Uncertainty', available at http://www.internationaltransportforum.org/Pub/pdf/15CPB_AutonomousDriving.pdf, p. 16.

19 ITF (2015) 'Urban System Upgrade – How shared self-driving cars could change city traffic', available at http://www.itf-oecd.org/sites/default/files/docs/15cpb_self-drivingcars.pdf, p. 9.

20 TRB (2016) 'Between public and private mobility: Examining the rise of technology-enabled transportation services', Washington, DC: Transportation Research Board.

21 ITF (2015) 'Urban Mobility System Upgrade – How shared self-driving cars could change city traffic', available at http://www.itf-oecd.org/sites/default/files/docs/15cpb_self-drivingcars.pdf, p. 9; ITF (2016) 'App-Based Ride and Taxi Services – Principles for Regulation', available at http://www.itf-oecd.org/sites/default/files/docs/app-ride-taxi-regulation.pdf, p. 6; TRB (2016) Between public and private mobility: Examining the rise of technology-enabled transportation services"', Washington, DC: Transportation Research Board.

22 ITF (2016) 'App-Based Ride and Taxi Services – Principles for Regulation', available at http://www.itf-oecd.org/sites/default/files/docs/app-ride-taxi-regulation.pdf, p. 6-11.

23 Lindberg, G., and Fridstrom, L. (2015) 'Policy Strategies for Vehicle Electrification' Discussion Paper No. 2015-16, p. 11.

24 The battery of hybrid electric vehicles is recharged by regenerative braking and through the work of the internal combustion engine. Plug-in hybrid electric vehicles also allow recharging the battery by an external power source. Battery electric vehicles are passenger cars that draw energy for mechanical propulsion solely from a rechargeable electric power storage device.

25 Weiss M., Patel, M.K., Junginger, M., Perujo, A., Bonnel, P., van Grootveld, G. (2012) 'On the electrification of road transport – Learning rates and price forecasts for hybrid-electric and battery-electric vehicles' Energy Policy, p. 374-6.

26 Id., p 375.

27 See the review of various studies in id., p. 374 – 393; Lindberg, G., and Fridstrom, L. (2015) 'Policy Strategies for Vehicle Electrification' Discussion Paper No. 2015-16, p. 30; McKinsey and Company (2010). 'A portfolio of power-trains for Europe: a fact-based analysis. The role of Battery Electric Vehicles, Plug-in Hybrids and Fuel Cell Electric Vehicles' McKinsey and Company, London, UK; Fulton,

L., and Bremson, J. (2014) 'Assessing the Impacts of Rapid Uptake of Plug-in Vehicles in Nordic Countries' Research Report UCD-ITS-RR-14-02, Institute of Transportation Studies, University of California, Davis.

28 ITF (2015) 'Urban Mobility System Upgrade – How shared self-driving cars could change city traffic', available at http://www.itf-oecd.org/sites/default/files/docs/15cpb_self-drivingcars.pdf, p. 9; ITF (2015) 'International Experiences on Public Transport Provision in Rural Areas', available at http://www.internationaltransportforum.org/Pub/pdf/15CSPA_RuralAreas.pdf, p. 11.

29 Bloomberg, 18 August 2016, 'Uber's First Self-Driving Fleet Arrives in Pittsburgh This Month', available at http://www.bloomberg.com/news/features/2016-08-18/uber-s-first-self-driving-fleet-arrives-in-pittsburgh-this-month-is06r7on.

30 Guardian, 18 August 2016, 'Self-driving buses take to roads alongside commuter traffic in Helsinki', available at https://www.theguardian.com/technology/2016/aug/18/self-driving-buses-helsinki.

31 TechCrunch, 16 April 2016, 'BMW Just Jumped Into the US Car-Sharing Biz with the Help of YC Alumni Ridecell', at http://techcrunch.com/2016/04/08/bmw-just-jumped-into-the-u-s-car-sharing-biz-with-the-help-of-yc-alum-ridecell/. RideCell's new partnership with BMW will largely allow BMW to operate its fleet of car-share vehicles — including 3 Series sedans, Mini Coopers and its electric i3 models — more efficiently. For example, if a driver hops in a car with a low battery, RideCell might prompt BMW to offer the driver a discount if he or she is willing to use a charging station as their final destination.

32 General Motors has been working on autonomous driving and plans to launch a semi-autonomous feature that will let cars handle themselves on the highway by 2017,

33 Wired, 1 April 2016, 'GM and Lyft are building a network of self-driving cars', at https://www.wired.com/2016/01/gm-and-lyft-are-building-a-network-of-self-driving-cars/; Wired, 25 April 2016, 'Calling an Uber is Cooler than Owning a Car – And Auto-makers Want In', at http://www.wired.com/2016/05/calling-uber-cooler-owning-car-automakers-want/?mbid=social_twitter

34 Wired, 25 April 2016, 'Calling an Uber is Cooler than Owning a Car – And Auto-makers Want In', at http://www.wired.com/2016/05/calling-uber-cooler-owning-car-automakers-want/?mbid=social_twitter

35 Wired, 5 April 2016, 'Google's Self Driving Minivans Can Bring Autonomy to Us All', available at https://www.wired.com/2016/05/google-self-driving-minivans/

36 Wired, 13 May 2016, 'Apple Invests $1 Billion in Didi, Uber's Biggest Rival in China ' available at http://www.wired.com/2016/05/apple-invests-1-billion-didi-ubers-biggest-rival-china/. In August, Didi purchased Uber's operations in China.

37 Private hire vehicles (PHVs) are a separate class of for-hire services that cover car-services that operate on the basis of pre-negotiated fares (that preclude fares set on actual trip duration and distance) and pre-arranged reservations.

38 ITF (2016) 'App-Based Ride and Taxi Services – Principles for Regulation', available at http://www.itf-oecd.org/sites/default/files/docs/app-ride-taxi-regulation.pdf, p. 8.

39 2014 International Transportation Forum Highlights, p. 22, available at http://www.internationaltransportforum.org/Pub/pdf/14Highlights.pdf.

40 OECD (2005) 'Structural Reform in the Rail Industry', DAF/COMP(2005)46, p. 26; Technical Strategy Leadership Group (TSLG), (2012) 'The Future Railway – The Industry's Rail Technical Strategy', available at http://www.rssb.co.uk/Library/Future%20Railway/innovation-in-rail-rail-technical-strategy-2012.pdf, p. 60-61; Amadeus (2012) 'The Rail Journey to 2020: Facts, figures and trends that will define

the future of European passenger rail', available at http://www.amadeus.com/web/binaries/blobs/795/633/RAIL_informe130321,0.pdf, p. 19; Leviakangas, P. (2016), 'Digitalisation of Finland's Transport Sector' in Technology in Society 47 1, p. 9.

41 ITF (2015) 'International Experiences on Public Transport Provision in Rural Areas', available at http://www.internationaltransportforum.org/Pub/pdf/15CSPA_RuralAreas.pdf, p. 9-10.

42 Id., p. 8-12.

43 Id., p. 14. This option is not new: in some countries the postal service operator is also a major bus operator. In the United Kingdom, some experiments were made on postbus operation, where minibuses replaced mail vans on routes connecting local sorting centres and collection points.

44 Today, rail automation is implemented at different levels of the rail industry. For long-distance trains, single processes such as rail signalling and logistic scheduling are automated. For public transport applications, such as metro trains, whole systems are fully automated. Key elements for fully automated systems are automatic train protection (ATP), automatic train operation (ATO) and automatic train control (ATC). ATP is responsible for basic safety functions, such as red signal overrunning, speed limits and collisions. ATO takes over all functions of the driver, except for closing the doors, and automatically brings a train to the next station after the doors have been closed. ATC brings in train scheduling, route setting and train regulation skills. All three systems working together result in a fully automated rail system where no on-board staff is needed.

45 'Data collection' comprises monitoring sensors for both trains and infrastructure and other technologies developed for the process of logging data on, among other things, obstacle detection and satellite-based real-time train positioning. Besides these, new and existing communication standards, a cloud environment, an open network, and the internet of things all make large amounts of data available that can be used by, for example, intelligent control systems.

46 'Data transfer' comprises technologies developed for data transmission. New technologies include optimised interfaces between trains, track and control systems, as well as high-capacity voice and data communication systems, allowing the transmission of the increased amount of collected data.

47 'Data management' comprises technologies analysing collected and transferred data. Data management systems for railway application need to store big amounts of data over long periods of time. Forecasting methods, appropriate safety and security mechanisms, and mixed-traffic capabilities are required for analysing data.

48 'Devices' comprises technologies not related to data processing but developed for machines and devices used in the railway industry. For example, automated maintenance and inspection machines perform both preventive and required repair tasks.

49 Hansen, C., Daim, T., Horst, E., Herstatta, C. (2016), 'The future of rail automation: A scenario-based technology roadmap for the rail automation market', Technological Forecasting and Social Change (110), 196–212, 206.

50 Leviakangas, P. (2016) 'Digitalisation of Finland's Transport Sector' in Technology in Society 47 1, p. 9.

51 Thompson, L. (2010) 'A Vision for Railways in 2050', International Transport Forum, Forum Paper 4, available at http://www.internationaltransportforum.org/Pub/pdf/10FP04.pdf, p. 5.

52 Casullo, L. (2016) 'The efficiency impact of open access competition in rail markets' Discussion Paper No. 2016-07, p. 5; OECD (2013), Recent Developments in Rail Transportation Services, DAF/COMP(2013)24.

53 One area where it has been difficult to introduce competition is high-speed trains: the skills and resources needed to operate HSR trains are so demanding that typically only consortia including incumbent operators have been able to do so. To date competitive provision of high-speed services has emerged only in Italy, where a rival operator has begun to operate services in competition with the incumbent on a massive scale.

54 Side-by-side, or parallel, competition is a form of "competition in the market" that takes place where competing vertically integrated railroads have their own infrastructure to serve a given market pair. This form of competition is prevalent in North America.

55 End–to-end competition is also a form of "competition in the market" that happens between vertically integrated railroads, but it concerns market pairs where their networks do not completely overlap, but compete in providing one leg of a multi-modal journey. This form of competition tends to be more effective for freight than for rail passenger services, as passengers tend to be more time-sensitive.

56 This consists of competition on the same railroad between different service providers. This kind of competition can happen in vertically integrated railroads, where tenants enter a market where the owner of the railroad already provides services, or in systems where the owner of the infrastructure either is not involved in the provision of freight and passenger services, or is separated from its downstream operation.

57 When providers of rail services bid to obtain an exclusive franchise on a specific destination pair. Tenders are especially common where train services are subsidised (e.g. commuter services in the Netherlands, Sweden and Germany) because, when properly designed and managed, competition between bidders can significantly reduce the amount of the financial support needed.

58 OECD (2013), 'Recent Developments in Rail Transportation Services' DAF/COMP(2013)24, p. 15.

59 2014 International Transportation Forum Highlights, p. 43, available at http://www.internationaltransportforum.org/Pub/pdf/14Highlights.pdf; Casullo, L. (2016) 'The efficiency impact of open access competition in rail markets' Discussion Paper No. 2016-07Discussion Paper No. 2016-07, p. 5.

60 Amadeus (2012) 'The Rail Journey to 2020: Facts, figures and trends that will define the future of European passenger rail', available at http://www.amadeus.com/web/binaries/blobs/795/633/RAIL_informe130321,0.pdf, p. 17.

61 OECD (2013) 'Methods for Allocating Contracts for the Provision of Regional and Local Transportation Services', DAF/COMP (2013)12, p. 5.

62 ITF (2015) 'International Experiences on Public Transport Provision in Rural Areas', available at http://www.internationaltransportforum.org/Pub/pdf/15CSPA_RuralAreas.pdf, p. 8-10.

63 2014 International Transportation Forum Highlights, p. 22, available at http://www.internationaltransportforum.org/Pub/pdf/14Highlights.pdf.

64 OECD (2005) 'Structural Reform in the Rail Industry' DAF/COMP(2005)46, p. 27; OECD (2013) 'Recent Developments in Rail Transportation Services' DAF/COMP(2013)24, p. 15.

65 OECD (2013) 'Recent Developments in Rail Transportation Services', DAF/COMP(2013)24, p. 9.

66 Thompson, L. (2010) 'A Vision for Railways in 2050', International Transport Forum, Forum Paper 4, available at http://www.internationaltransportforum.org/Pub/pdf/10FP04.pdf, p. 5.

67 Id., p. 15.

68 UIC eNews (No 485) 'Finland: The Finnish Transport Agency's digitalisation project paves way for future transport', 16 February 2016.

69 Pilli-Sihvola, E., Miettinen, K., Toivonen, K., Sarlin, L., Kiiski, K., Kulmala, R. (2015) 'Robots on Land, in Water and in the Air. Promoting Intelligent Automation in Transport Services', Publications of the Ministry of Transport and Communications 14/2015 ,Finland, available at http://www.lvm.fi/documents/20181/514467/Julkaisuja+14-2015/0567d84e-2a01-4cb7-9b6f-6148ba47047c?version=1.0 28.

70 Casullo, L. (2016) ' The efficiency impact of open access competition in rail markets' (2016) Discussion Paper No. 2016-07, p. 16.

71 Hansen, C., Daim, T., Horst, E., Herstatta, C. (2016) 'The future of rail automation: A scenario-based technology roadmap for the rail automation market', Technological Forecasting and Social Change (110), 196–212, 198.

72 Verge, 6 May 2015, 'This is the first road-legal big rig that can drive itself' at http://www.theverge.com/2015/5/6/8556791/self-driving-semi-big-rig-freightliner-inspiration-truck

73 TechCrunch, 25 April 2016, 'The driverless truck is coming, and it is going to automate millions of jobs', at http://techcrunch.com/2016/04/25/the-driverless-truck-is-coming-and-its-going-to-automate-millions-of-jobs/. It is reported that Uber is planning to extend its service into long-haul trucking in the US – see Bloomberg, 18 August 2016, 'Uber's First Self-Driving Fleet Arrives in Pittsburgh This Month', available at http://www.bloomberg.com/news/features/2016-08-18/uber-s-first-self-driving-fleet-arrives-in-pittsburgh-this-month-is06r7on.

74 The Netherlands approved a law in 2015 to allow large-scale tests with self-driving passenger cars and trucks on public roads, under which the Dutch Vehicle Authority has the option of issuing an exemption for self-driving vehicles. Companies that wish to test self-driving vehicles must first convince and demonstrate that the tests will be conducted in a safe manner. The UK Department for Transport launched on 11 July 2016 a nationwide consultation on driverless cars. On 14 April 2016, the EU's transport ministers signed the Amsterdam Declaration laying down their agreement on steps necessary for the development of self-driving technology in the EU, which envisages a coherent European framework for the deployment of interoperable connected and automated driving to be available by 2019.

75 California passed a law allowing driver-assistive truck platooning in 2015, and has allowed autonomous driving – subject to additional legislation – since 2012; Florida has allowed autonomous vehicles since 2012, and permitted the operation of autonomous vehicles on public roads by individuals with a valid driver license earlier in 2016; Michigan has allowed the testing of automated vehicles since 2013; the District of Columbia has allowed automated driving but requires a human driver "prepared to take control of the autonomous vehicle at any moment" since 2013; Nevada has authorised the operation of autonomous vehicles and a driver's license endorsement for operators of autonomous vehicle since 2011; and Tennessee has prohibited local governments from banning the use of motor vehicles equipped with autonomous technology in 2015.

` In late September 2016, the US Department of Transport announced a Federal Automated Vehicles policy with a view to accelerating the adoption of highly autonomous vehicles – see https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016.

76 Japan is currently consulting on guidelines regarding self-driving. According to draft guidelines released by the National Police Agency, Japan will not impose time and place restrictions on autonomous driving tests on public roads.

77 ITF (2015) 'Automated and Autonomous Driving: Regulation Under Uncertainty', available at http://www.internationaltransportforum.org/Pub/pdf/15CPB_AutonomousDriving.pdf, p. 17; Pilli-Sihvola,

E., Miettinen, K., Toivonen, K., Sarlin, L., Kiiski, K., Kulmala, R. (2015) 'Robots on Land, in Water and in the Air. Promoting Intelligent Automation in Transport Services' , Publications of the Ministry of Transport and Communications 14/2015, Finland, available at http://www.lvm.fi/documents/20181/514467/Julkaisuja+14-2015/0567d84e-2a01-4cb7-9b6f-6148ba47047c?version=1.0, p. 29.

78 OECD (2005) 'Structural Reform in the Rail Industry' DAF/COMP(2005)46, p. 26; OECD (2013) 'Recent Developments in Rail Transportation Services' DAF/COMP(2013)24, p. 15.

79 Siegel, M., 'I just watched the first drone with FAA approval deliver food. Here's what happened...', at https://www.linkedin.com/pulse/i-just-watched-first-drone-fda-approval-deliver-food-heres-siegel

80 TechCrunch, 23 April 2015, 'Matternet To Test The First Real Drone Delivery System In Switzerland', at http://techcrunch.com/2015/04/23/matternet-to-test-the-first-real-drone-delivery-system-in-switzerland/

81 Balázs, P. and Peijs, P. (2016) 'Enabling multi-modality and efficient freight logistics' in "Issues Paper of European Coordinators: TEN-T Corridors: Forerunners of a forward-looking European Transport System", available at http://ec.europa.eu/transport/themes/infrastructure/news/doc/2016-06-20-ten-t-days-2016/issues-papers.pdf, p. 11-13.

82 Id., p. 11-12.

83 See the European Commission's decisions in Case AT 39824 – Trucks, Case AT.39748 — Automotive wire harnesses, and Case AT.39801 — Polyurethane foam, and Case AT.40028 — Alternators and Starters.

84 Including cartels on the provision of rail cargo transport services in connection with blocktrains (see the European Commission's decision in Case AT.40098 — Blocktrains).

85 Or dealing with ancillary activities, such as ticketing – see MLex , 24 May 2016, 'Deutsche Bahn changes ticketing practices to end German antitrust probe', available at http://www.mlex.com/GlobalAntitrust/DetailView.aspx?cid=798034&siteid=190&rdir=1.

86 CMA Letter to the South Yorkshire Passenger Transport Executive dated 27 July 2015, available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/490517/CMA_response_to_South_Yorkshire_Passenger_Transport_Executive.pdf ; CMA Letter to the Chief Executive Officer and Director of Transport Local Transport Authority dated 29 February 2016, available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/504172/CMA_open_letter_to_LTAs.pdf.

87 Technical Strategy Leadership Group (TSLG), (2012) 'The Future Railway – The Industry's Rail Technical Strategy', available at http://www.rssb.co.uk/Library/Future%20Railway/innovation-in-rail-rail-technical-strategy-2012.pdf, p. 60-61.

88 ITF (2015) 'International Experiences on Public Transport Provision in Rural Areas', available at http://www.internationaltransportforum.org/Pub/pdf/15CSPA_RuralAreas.pdf, p. 12.

89 Id., p. 8; Leviakangas, P. (2016) 'Digitalisation of Finland's Transport Sector' in Technology in Society 47 1, p. 10.

90 Balázs, P. and Peijs, P. (2016) 'Enabling multi-modality and efficient freight logistics' in "Issues Paper of European Coordinators: TEN-T Corridors: Forerunners of a forward-looking European Transport System", available at http://ec.europa.eu/transport/themes/infrastructure/news/doc/2016-06-20-ten-t-days-2016/issues-papers.pdf, p. 4, 11-12, 14.

91 ITF (2015) 'International Experiences on Public Transport Provision in Rural Areas', available at http://www.internationaltransportforum.org/Pub/pdf/15CSPA_RuralAreas.pdf, p. 11.

92 ITF (2016) 'App-Based Ride and Taxi Services – Principles for Regulation', available at http://www.itf-oecd.org/sites/default/files/docs/app-ride-taxi-regulation.pdf, p. 12. Nonetheless, competitive pressures amongst commercial transport applications are presently understood to be strong and the early successes of some companies may motivate others to follow that path despite legal complications, since the uncertainty regarding regulatory sanctions is greater than the certainty of loss of competitive position.

93 The Secretariat Background Note for the Competition Committee hearing on Big Data on 29 November discusses these issues DAF/COMP(2016)14.

94 Miller, C., and Valasek, C. (2014) 'A Survey of Remote Automotive Attack Surfaces', s.l.: Illmatics. One response to the growing complexity of vehicle hardware-software interfaces is to develop comprehensive but variable secure system architecture based on critical risk assessments. For instance, the EU project EVITA outlines trust models and security measures that are based on core hardware security modules hard-wired into each electronic control unit. These have various levels of strength depending on the mission-criticality of each sub-system. In this case, electronic control units controlling speed, forward and backward motion, steering and braking receive the highest level of protection, and those controlling the on-board environment receive lower protection. At the core of the system are strong cryptographic methods that ensure the integrity and authenticity of system messages and allow for the detection of tampered, altered or non-authentic messages to or from vehicle systems. (EVITA, 2012)

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96 Cerrudo, C. (2014) 'Hacking US Traffic Control Systems'. s.l., DEFCON Hacking Conference.

97 ITF (2016) 'Data Driven Transport Policy', available at http://www.itf-oecd.org/sites/default/files/docs/data-driven-transport-policy.pdf, p. 18.

98 ITF (2016) 'App-Based Ride and Taxi Services – Principles for Regulation', available at http://www.itf-oecd.org/sites/default/files/docs/app-ride-taxi-regulation.pdf, p. 9.

99 ITF (2016) 'Data Driven Transport Policy', available at http://www.itf-oecd.org/sites/default/files/docs/data-driven-transport-policy.pdf, p. 18.

100 ITF (2015) 'Automated and Autonomous Driving: Regulation Under Uncertainty', available at http://www.internationaltransportforum.org/Pub/pdf/15CPB_AutonomousDriving.pdf, p. 27.

101 2014 International Transportation Forum Highlights, p. 17, available at http://www.internationaltransportforum.org/Pub/pdf/14Highlights.pdf.

102 ITF (2016) 'App-Based Ride and Taxi Services – Principles for Regulation', available at http://www.itf-oecd.org/sites/default/files/docs/app-ride-taxi-regulation.pdf, p. 7.

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