From ISA to Speed-Control Technologies

Managing a faster transition to a safer, smarter and more sustainable urban mobility.

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From ISA to Speed-Control Technologies.
Managing a faster transition to a safer, smarter and more sustainable urban mobility.

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Abstract:

Since ten years ago, the reduction of people killed and injured by traffic accidents in the world and the EU is stagnated. The WHO reports road accidents as the primary cause of death among people younger than 29 years. Moreover, many of these accidents happen in cities, and speeding is a significant source of incidents. The result of this research shows that the evolution of technologies that limit the speed of cars automatically into technologies that allow external control of the speed can reduce this problem in a faster, smarter and more sustainable way in the cities of the EU. Transition Management and different methods like literature review, situation mapping, a survey (N=189), field observations and GIS analysis were triangulated to assess: The relationship between smart and sustainable urban mobility, and Intelligent Speed Assistance (ISA), a well-known speed-limiting technology that now is required in all new models of cars in the EU. The status of cities and citizens in the face of the deployment of this new technology. The challenges attached and the possible roadmap to transition from ISA to speed-control technologies as desired. Additionally, a set of KPIs has been designed to measure a defined concept of readiness and can be used at different levels and exported easily for the evaluation of other technologies. Moreover, along with the findings, possible options for future research have been identified. Complementary or substitute measures to reduce the impact or accelerate the transition have also been identified.

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Summary

Despite the increasing focus on sustainability and the proposed goals around safety in transport and infrastructure—as the Sustainable Development Goals (SDG)—in the last ten years, there has been stagnation in the reduction of people killed and injured by traffic accidents. Road accidents are the primary cause of death among people younger than 29 years. Moreover, many of these accidents happen in cities, and exceeding the speed limits is a significant source of incidents. This problem is happening at the global level as well as in Europe.

Attending this reality, the main result of this research is the knowledge that the evolution of technologies that limit the speed of cars automatically into technologies that allow external control of the speed can reduce this problem in a faster, smarter and more sustainable way in the cities of the European Union.

This proposal of a solution is based on a new regulation introduced in the EU, which mandates that from this year on, new technologies known as Advanced Driver Assistance Systems (ADAS) should be included in all new vehicles in the EU. One of these ADAS is called Intelligent Speed Assistance, and it has the functionality of detecting the allowed speed on the road where the car is circulating and warning drivers or directly limiting the speed of cars if required. This technology is what is called in this research a speed-limiting technology. So, the primary inquiry of this research is the possibility of evolving from ISA to a new technology which allows the external control of the speed limit in vehicles.

The main result is the product of different findings that—departing from the mentioned regulation—are produced in this research. The dissertation was composed of three analyses—or phases– conducted following a planned structure. The next paragraphs describe those results and how they were obtained.

First, there is a connection between the equipment of ISA in cars and the sustainability of cities. This result means that if ISA is improved, the city will be smarter, and it will facilitate the improvement of the sustainability of cities. This research elaborated a deep understanding of the cities, citizens, technologies, infrastructure and their interactions to get this finding. Similarly, main concepts such as sustainability, smart city, urban mobility and intelligent transport systems were studied. Several scientific, governmental and non-governmental publications were reviewed and integrated to build the resultant connection to this knowledge. The recollected knowledge allowed the creation of a situation map that illustrates the mentioned system and elements.

Second, cities and citizens are not entirely ready for the implementation of ISA. Therefore they are not ready for the next step, the transition to speed control technologies. However, there is a degree in the readiness and, more importantly, specific points have been identified that should be managed to achieve the objective. A definition of readiness was constructed in this research to assess this statement. Similarly, a set of Key Performance Indicator (KPI) was developed from indicators associated with the concept of readiness, the official specification of ISA and the system described in the first phase. Then cities' KPIs were calculated with data collected through physical observation in two cities in Denmark. The citizens' KPIs were calculated with data obtained in a survey answered by people from 17 countries in the EU. The resultant data provided the readiness status and context information used in the analysis of the following step.

Third, it is possible to transition to speed control technologies from a technological and systemic perspective. However, the acceptance and willingness of citizens and politicians—respectively— need to be improved. Furthermore, there is a need to solve significant challenges to achieve the desired goal. To arrive at this conclusion, the collected knowledge from the previous steps was used to identify the challenges that need to be addressed for the implementation of ISA and the transition to speed control. Then using the Transition Management Theory, a goal was established and a roadmap was traced, looking to minimize possible conflicts. The challenges were grouped as themes that should be tackled at different levels collaboratively. The result is a possible recipe to achieve a reduction in casualties in a faster way. In any case, as in several other documents, this research stresses the role of participation and collaborative learning as the main ingredients of any transition.

Finally, this document has exposed the necessity of further research in several fields, e.g. the appliance of improved KPIs at different levels. The document also discussed the possibility of using different solutions that could be more intelligent, e.g. the disincentive of the use of cars in cities.

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Acronyms

AB Acknowledgement of the Benefit. 40, 41
ACC Adaptive Cruise Control. 5
ACSW Adaptive Curve Speed Warning. 6, 29, 45
ADAS Advanced Driver Assistance Systems. iii, 4, 8, 26, 48
ADM Accuracy of the Digital Map. 34, 36, 38
AEB Autonomous Emergency Braking. 5
AII Accuracy of the Installed Infrastructure. 34, 36, 38
AR Acknowledgement of the Regulation. 40, 41
AT Acceptance of the Technology. 40, 41

BSD Blind Spot Detection. 5

CRI Citizen Readiness Index. 40, 42, 43, 53, 55

EDR Event Data Recorder. 15, 29, 43, 46, 50
EGNOS European Geostationary Navigation Overlay Service. 28
ESC Electronic Stability Control. 4
EU European Union. ii, vii, 1–3, 5–8, 10, 11, 31, 39, 41, 43, 45, 50, 55

FCW Forward-Collision Warning. 5

GIS Geographic Information System. ii, 15, 20
GNSS Global Navigation Satellite System. 5, 15, 28
GPS Global Positioning System. 5
GSR General Safety Regulation. 8

I2V Infrastructure to Vehicle. 28
ICT Information and Communications Technology. 15, 27
ISA Intelligent Speed Assistance. ii–iv, vii, 3, 5, 11, 15, 18, 22, 27–29, 31–38, 40, 44–48, 50–52, 54, 55, 77
ITS Intelligent Transport Systems. 8, 25, 27, 44

KPI Key Performance Indicator. ii–iv, vii, 4, 14, 20, 31, 34, 39, 41, 43, 44, 53, 55

LDW Lane Departure Warning. 5
LIDAR Laser Imaging, Detection and Ranging. 4
LKA Lane Keeping Assist. 5

MS Member States. 4, 6, 8, 9, 14, 16, 24, 26, 28, 45, 46, 48–50

PT Penetration of the Technology. 40, 42

SCF Speed Control Function. 27, 28, 48, 49

SDG Sustainable Development Goals. iii, 1, 2, 4, 6
SDMC Speed Digital Map Coverage. 33, 35, 37
SLIF Speed Limit Information Function. 27, 28
SLWF Speed Limit Warning Function. 27, 28, 48

TSA Traffic Signs Availability. 33, 35, 37
TSVQ Traffic Signs Visibility Quality. 33, 35, 38, 53

UN United Nations. 1
URI Urban Readiness Index. 33, 36, 38–40, 43, 53, 55

V2I Vehicle to Infrastructure. 15
V2V Vehicle-to-Vehicle. 15
V2X Vehicle to Everything. 6, 15, 49
VRU Vulnerable Road Users. 2, 3, 13, 38, 46, 53

WHO World Health Organization. ii, 1

Introduction 1

Every year, the number of severe and fatal injuries produced by road accidents continues to increase globally. In the Global Status Report on Road Safety 2018, the World Health Organization (WHO) shows that the number of deaths reached 1.35 million, being this the eighth cause of death in the globe and the number one for people between 5-29 years old. Moreover, road accidents produce non-lethal injuries to between 30 to 50 million people every year (Filippova and Buchou, 2020).

1.1 The Global Context

In the last 25 years, there has been some progress, but death rate reduction is not happening at the required velocity (WHO, 2018). At the same time, those rates decrease unequally in different parts of the planet. Except for the Eastern Mediterranean region, high-income countries had a decrease in the number of road traffic deaths per 100.000 inhabitants; and the rate of road rates in middle-income countries is approximately three times higher than in high-income countries (WHO, 2018). On the other hand, low-income countries have three times more risk of death than the high-income ones (WHO, 2018). The number of deaths for every 100 000 people has been reduced since 2000, but the population and the number of motor vehicles have increased in the same period. Because of this, the number of crashes has increased; then, the situation is not worst but is far from being improved as planned in the Sustainable Development Goals (SDG) (WHO, 2018). If the solutions are not strong enough, it is projected that road accidents will be the seventh cause of death by 2030 (Filippova and Buchou, 2020). Moreover, 95% of the accidents are produced because of human errors (EC, 2018). In Europe, this number is estimated near to 92% (EP, 2017).

Road accidents have repercussions far beyond injuries and deaths. It is estimated that road accidents cost governments between three to five per cent of the GDP (Filippova and Buchou, 2020). In the EU, attached costs such as healthcare, rehabilitation, and material damages, are estimated to be above € 100 billion per year (EC, 2018). Unsafe roads contribute to inactivity, which induces another kind of impact on public health (WHO, 2018). Moreover, an intrinsical connection exists between road safety and "mental and physical health, development, education, equity, gender equality, sustainable cities, environment and climate change, as well as the social determinants of safety" (Infrastructure (SV), 2020).

> "There is an urgent need for governments to scale up their road safety efforts to live up to their commitments made in the Sustainable Development Agenda 2030." (WHO, 2018, p. 80)

Several efforts from the United Nations (UN) have been deployed to address this wicked problem. In September 2015, the UN defined two SDG targets—directly related to road safety—and their respective indicators as follows:

- "**Target 3.6:** By 2020, to halve the number of global deaths and injuries from road traffic crashes.
  Indicator 3.6.1: Death rate due to road traffic injuries" (UN, no date[b]).
- "**Target 11.2**: By 2030, to provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons.
  Indicator 11.2.1: Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities" (UN, no date[a]).

Similarly, in 2017, the WHO established 12 Global Voluntary Performance Targets (see Appendix A.2). The target number six looks to reduce by half the proportion of vehicles surpassing the speed limit by 2030. Target five proposes that all the vehicles should have 'high-quality safety standards' by 2030. Targets three and four relate to roads which comply with the technical standards for safety. However, the goals were still far away from being achievable.

In 2020, the Third Global Ministerial Conference on Road Safety gathered the principal stakeholders in road safety in Stockholm, Sweden. In the event, the panel welcomed the strategies adopted by the European Union (EU) for the reduction of deaths and injuries, but—more important—also recognised that SDG 3.6 would not be achieved (Infrastructure (SV), 2020). Fact also mentioned by the UN (2020, p. 61), but unfortunately not corroborated in UN (2021), possibly due to problems in the flux of information caused by COVID-19 as the authors expressed.

It was agreed in the Stockholm Declaration, published by the Infrastructure (SV) (2020), that countries and all the relevant actors should focus, among other things, on speed management, incentives for safe vehicles, and road infrastructure. Then, all new vehicles should have improved safety performance by 2030, understanding that advanced vehicle safety technologies are the most effective. Furthermore, the document recognises the distinctive challenges implied by the growing safety threads in cities, especially for Vulnerable Road Users (VRU) (in section 2.1 a definition of VRU is elaborated). Finally, the declaration stresses that all the relevant actors— "public and private sectors, academia, professional organisations, nongovernmental organisations and the media"—must be involved and collaborate in conjunction with global cooperation, strong national leadership and evidence, leading to innovation. It is possible to infer that a natural step is—in the search for a transition to safer and more sustainable cities—the analysis of speed, technology and infrastructure as elements of a system where actors should be understood in a cooperative framework. On the other hand, cities—or urban areas—are more than relevant in the safety pursuit.

1.1.1 Cities, an Increasing Risk

Nowadays, half of the world's annual road fatalities happen in cities, 38% in the case of the EU. On the other hand, recent numbers estimate that currently, 3.5 billion people live in cities—half of the global population—and it will increase to 70% by 2050 (Filippova and Buchou, 2020). Urbanisation produces an increase in vehicles, travel, and congestion. These increase, in turn, the number of accidents, which successively increases the risk of injuries and deaths due to the combination of several combined factors (EC, 2018). So, in practical terms, cities are of special interest as the pressure will continue increasing on them. A special focus is required to achieve an actual reduction in accidents and mortality and injury rates.

The EC (2018) enlists the factors that intervene in the causality of traffic accidents in cities as drivers, vehicles and infrastructure. Going further, the EC explains that there are several causes for accidents grouped in structural and behavioural factors. Examples of structural factors are urbanisation, road maintenance, and fewer resources for enforcement. Examples of behavioural factors are speeding and the use of mobile phones. Indeed, the WHO (2018) includes speed and vehicle safety as key risk factors that should be addressed by legislation to prevent road traffic deaths. For Filippova and Buchou (2020), speed is the most prominent.

Due to the mentioned facts, it is observable the roles of speed, vehicle safety—for occupants and non-occupant people—and the state of the roads as variables that should be controlled to achieve a lower death and injury incidence rate. Caragliu, Del Bo, and Nijkamp (2011) mention that typical solution to problems related to 'urban agglomeration' implies creativity, collaboration, and science, which introduces the idea of 'smart' solutions. This visualisation allows us to think of smart cities as places where smart solutions are enacted in terms of speed, vehicle safety and infrastructure.

1.1.2 Speed Matters

A report from the OECD shows that more than 30% of road accidents are caused by "excessive or inappropriate speed" (EC, 2019). Different actors over time have ratified this fact. For the European Commission, speeding is one of the main causes of fatal accidents (Carsten, 2012). For the European Parliament—more recently—, inappropriate speed levels and speeding are the main causes of fatalities (EP, 2017) even though the majority of drivers do not recognise speeding as a crime (Vlassenroot, 2011).

It is well recognised that the speed of road vehicles is directly related to the risk of a crash, the causality numbers, the severity of injuries and the probability of death (Carsten, 2012; Council of the European Union, 2017; WHO, 2018; Elvik et al., 2019). An increase of 1% in the speed increases up to 4% the risk of having a fatal crash (WHO, 2018). Similarly, a reduction of 1 km/h in the EU speed average could reduce 2 200 road deaths per year, and a reduction of 5% in speed could reduce deaths by 30% (WHO, 2018). The OECD mentions that the probability of death when a pedestrian is hit by a car is 10% if the car travels at 30km/h but is 80% at 50 km/h (Vlassenroot, 2011). Vlassenroot (2011, ch. 2) presents other impacts associated with speed: from the environmental perspective, hydrocarbons (HC) and NOX emissions are reduced at lower speeds, but CO and CO2 emissions increases at speeds below 15 km/h; the more speed, the more amount of noise produced; from the energy perspective, the more speed, the more fuel consumption. Speed stresses other road users, especially the most vulnerable as cyclists and pedestrians (Filippova and Buchou, 2020; Vlassenroot, 2011), but also other drivers. 70% of drivers in urban areas manifested to feel unsafe seeing other vehicles speeding (Vlassenroot, 2011). On the other hand, the other way around is also true; VRU stresses speeding drivers. This double effect of unsafety increases the risk of accidents.

Therefore, speed management is then a necessity because of its possible effects. The WHO (2018) mentions the relevance of using traditional methods for containing speeding, e.g., the use of police enforcement initiatives. On the other hand, the WHO also recognises the importance of using a combined methodology—automated and manual—to enforce speed limits. They mention that automated enforcement is "highly cost-effective" for low-resources settings. In any case, for cities, these methods imply resources from local and national governments, which will be more and more stressed in the future, as mentioned above. The wise use of desegregated technology presents an opportunity to reduce those costs. One example is the Intelligent Speed Assistance (ISA), a technology that will increase speed limit compliance without increasing enforcing costs (EC, 2018). For this reason, and the speed effects mentioned above, this research focuses its interest on ISA as an accelerated way of reducing injuries and costs, achieving and helping to achieve different SDGs.

A defined best practice endorses the use of three criteria to assess speed management laws, it includes as mentioned by the WHO (2018):

- The presence of a national speed law,
- a speed limit of 50 km/h in urban areas and 30 km/h in residential areas, and
- the empowerment of local authorities to modify speed limits as an adaptation to the local reality.

Unfortunately, several countries "prioritise traffic speed of movement over safety" (Filippova and Buchou, 2020); that is why only 46 countries have laws that comply with the limitation of speed in urban areas following the best practices—below 50 km/h (WHO, 2018). Given the importance of the speed limit compliance, data will be collected among the Member States (MS), and the following Key Performance Indicator (KPI) has been defined as a point of departure: "**KPI for speed:** Percentage of vehicles travelling within the speed limit." (EC, 2019, p. 15). The importance of KPIs is discussed along with this document as a fundamental concept of the proposed research.

Vehicle safety measures obtain significant reductions in deaths and serious injuries (see section 1.2), which avoid crashes or reduce the severity of injuries, but not all the vehicles in the world are required to have them yet (WHO, 2018). Furthermore, the UN prioritised eight safety standards for vehicles (the complete list is available in Appendix A.1). However, most of the points are meant to give protection after a crash, except the points three and eight, which help prevent crashes. From those two, only the number three is related to cars, commending countries for adopting the use of the Electronic Stability Control (ESC). As a context, 124 countries apply none or one of the vehicle safety standards (WHO, 2018). Going deeper, many vehicle standards that protect car occupants are not spread in not high-income countries, where manufacturers are now also implementing protective systems for road users out-the-car (WHO, 2018).

1.2 Last Developments in Speed-limit Enforcing

There have been poor improvements in the last decade from the infrastructure design perspective. The UN (2009) recommended using in urban areas measures to oblige the drivers to use a lower speed, as speed limit reductions in residential areas to 30 km/h "30 zones", roundabouts, and speed-control humps. Nowadays, humps are found in vertical and horizontal formats. The recommendation is still valid. The most advanced development found at this moment is the use of intelligent humps. These devices are installed in the street—like any 'classical' hump—along with a speed sensor. The humps only activate—this means increasing its height—when the sensors detect that a vehicle is going faster than allowed, forcing the driver to reduce the vehicle's speed (smartbumps.com, no date).

From the vehicle perspective, the development is another story. Advanced Driver Assistance Systems (ADAS) represent the evolution of several technologies known as Active Safety Systems that are used in motor vehicles. They are in-vehicle technologies designed to assist drivers in avoiding accidents or—in case of—prevent serious or fatal injuries (Peiris et al., 2022). Several of these systems are currently available in the market. In order to operate, ADAS constantly monitor the performance and the surroundings of the vehicle using cutting-edge technology such as Laser Imaging, Detection and Ranging (LIDAR), image radar, long-range radar, GPS, cameras and sensor fusion (Texas Instruments, no date). There are public figures in the field of road safety in cities that consider ADAS as a 'turning point' because of their contribution to the reduction of casualties (Translated by Content Engine LLC, 2022). Different sources (Drew, 2019; AAA, 2019; Peiris et al., 2022) mention that the most relevant ADAS are:

- **Adaptive Cruise Control (ACC):** Sustain automatically a regular distance to another vehicle in the front.
- **Autonomous Emergency Braking (AEB):** Applies automatically the breaks in the vehicle when a potential collision is detected.
- **Blind Spot Detection (BSD):** Alert drivers when another vehicle is in a rear-side position out of the visible range.
- **Forward-Collision Warning (FCW):** Alert for possible frontal collision to drivers.
- **Lane Departure Warning (LDW):** Alert drivers when the vehicle is next to or crossing lane markers.
- **Lane Keeping Assist (LKA):** Maintain automatically the vehicle in the current lane of circulation.
- **Intelligent Speed Assistance (ISA):** Alert or control the speed of vehicles automatically to comply with the current speed limits.

It is important to mention that these are the common name of the systems. There are several different technologies that alone or in conjunction perform the same functionality, e.g. Intelligent Speed Assistance and Intelligent Speed Adaptation terms are used in different literature to refer to the same functionality. Twitching even more the situation, different manufacturers adopt different names for the technology or the function (AAA, 2019).

Of all the mentioned ADAS, ISA has a special place in safety systems due to its speed-limit enforcing functionality, which creates the enormous potential—as mentioned above—of reducing the lethal and serious injuries attached to speed.

Intelligent Speed Assistance (ISA) is "a system to aid the driver in maintaining the appropriate speed for the road environment by providing dedicated and appropriate feedback" 'Regulation (EU) 2019/2144' (2019). To operate, ISA could use a camera to observe speed-limit road signs, Global Positioning System (GPS) or Global Navigation Satellite System (GNSS) in conjunction with digital maps and a speed-limit databases or other technologies for assessing the allowed speed limit. The system compares the assessment with the actual vehicle speed. Then uses sound, visual or haptic alerts to warn the driver or directly reduce the speed of the vehicle if required (ETSC, 2017; RoadSafetyFacts.eu, no date).

Surprisingly, ISA is not a new technology at all. Carsten (2012) dates the first ISA research in 1982. Several studies from several perspectives have been performed around ISA from that date on. Lahrmann, Agerholm, Tradisauskas, Næss, et al. (2012) mention that the first ISA field study was performed in 1992 by the University of Lund from Sweden. Another angles are technological feasibility (Lahrmann, Agerholm, Tradisauskas, Berthelsen, et al., 2012), acceptability (Vlassenroot, 2011; Lahrmann, Agerholm, Tradisauskas, Næss, et al., 2012), and behaviour (Vlassenroot, 2011). There was a 'boom' in the early years of the last decade around ISA. Unfortunately, at that moment, one of the conclusions was that ISA was technically ready, but after "[...]decades of ISA research, there has been no breakthrough of ISA in road traffic." (Lahrmann, Agerholm, Tradisauskas, Næss, et al., 2012). Another conclusion came from (Carsten, 2012), who assessed —using the work of Lahrmann, Agerholm, Tradisauskas, Næss, et al. as a reference—that there is plenty of evidence about ISA acceptance and benefits; however, there is a lack of political willingness for its implementation. Finally, in 2019 the breakthrough of ISA in road traffic has materialised in the EU thanks to the modification of several regulations oriented to reducing road injuries and deaths through the use of built-in speed-limiting enforcement technologies.

In parallel, the motor vehicle industry has been developing ISA—as well as ADAS—and introducing them to the market. As an example, in 2017 ETSC (2017) presented a list of 33 models from 12 different brands with ISA equipped. At present, the number is higher, but there is no available comprehensive list that assesses the real number. On the other hand, car manufacturers have been working hard on vehicle automation. It is expected that in the future automated mobility will become a 'backbone' of the economy at the global level (Alessandrini, Domenichini, and Branzi, 2021a). It is also expected that autonomous cars will reduce fatalities and injuries related to road accidents near zero. Evaluating ISA using the SAE scale of automation level in vehicles mentioned by Alessandrini, Domenichini, and Branzi (2021a), it could be graded at level zero or one. Level zero means that the system only warns the driver for specific situations; level one implies that the driver assistance system controls the speed of the vehicle automatically. So, ISA could be or not be a step on the road to automated vehicles depending on if it allows controlling the speed of the vehicle.

Nowadays, there are further developments in ISA with interesting proposals and again from diverse angles as—per example—the following ones. A test is being performed, at a city level, in Sweden using geofencing—virtual fences that establish a specific area in a digital map that using the geo-position of the vehicle in relation to the defined area, trigger predetermined actions depending on the position of the vehicle—to control ISA and enforce the speed limit on cars in some parts of the city (Mohn, 2022). Models for adaptive ISA are being developed, e.g. (Herranz-Perdiguero and López-Sastre, 2018) uses a regression model and deep learning to estimate from video images the limit speed due to traffic conditions; on the other hand, Abdelkader, Elgazzar, and Khamis (2021) review the use of connected vehicle technologies like Vehicle to Everything (V2X) to increase the security of Adaptive Curve Speed Warning (ACSW), an evolution of ISA that solves the limitation of the system in curves. Multi-purpose technology is being developed, e.g. Stereo Visions Sensing (SVS) by Veoneer; it consists of stereo cameras and in-house software which detects and classifies objects and can be used by different ADAS, ISA included (just-auto, 2022).

New European regulations define some of the ADAS technologies to be deployed in conjunction with a technological framework that will be a guideline in the development of new technologies. This makes sense as advanced technology is relevant to achieve SDG and resolve the possible trade-offs (Independent Group of Scientists appointed by the Secretary-General, 2019). In the following section, a description of the European context and the regional regulations is elaborated as the preamble of the problem formulation matter of this research.

1.3 The EU Status

As commented before, the EU is leading and a global reference in the regulations development and the application of vehicle safety systems, so it is relevant to understand what is happening in the region.

In the EU, the number of deaths and injured people has improved in the last three decades thanks to regional, national and local efforts targeting vehicle safety, infrastructure and behaviour (EC, 2018). Even though there are still dead people as a result of vehicle incidents, especially in its cities, it is observable in Figure 1.1—using numbers updated in 2019—that the reduction has been stagnant in the last ten years. It is also visible that the reduction of killed people rate is developing faster than the number of injured people. In 2019, more than 21 700 were killed, and above 1,7 million people were seriously injured. Furthermore, EC (2019) emphasises that in some countries, the numbers are rising again in recent years. This fact was also observed by the European Road Safety Observatory in EC (2021). In the document, the EC explains how the MS and even the NUTS-

2 regions have different levels of mortality reductions; the ten best and the ten worst NUTS-2 regions, by their mortality change, are shown in Figure 1.2. These differences are also aligned with the fact that from 2006 to 2019—doing the math—there is not an observable correlation between the growth of the GDP and the reduction in the number of deaths related to road accidents in OECD countries (OECD, no date[b]; OECD, no date[a]). The distribution of deaths by road user type in Europe is 48% four-wheeled vehicle occupants, 27% pedestrians, and 20% other (WHO, 2018, fig. 6).

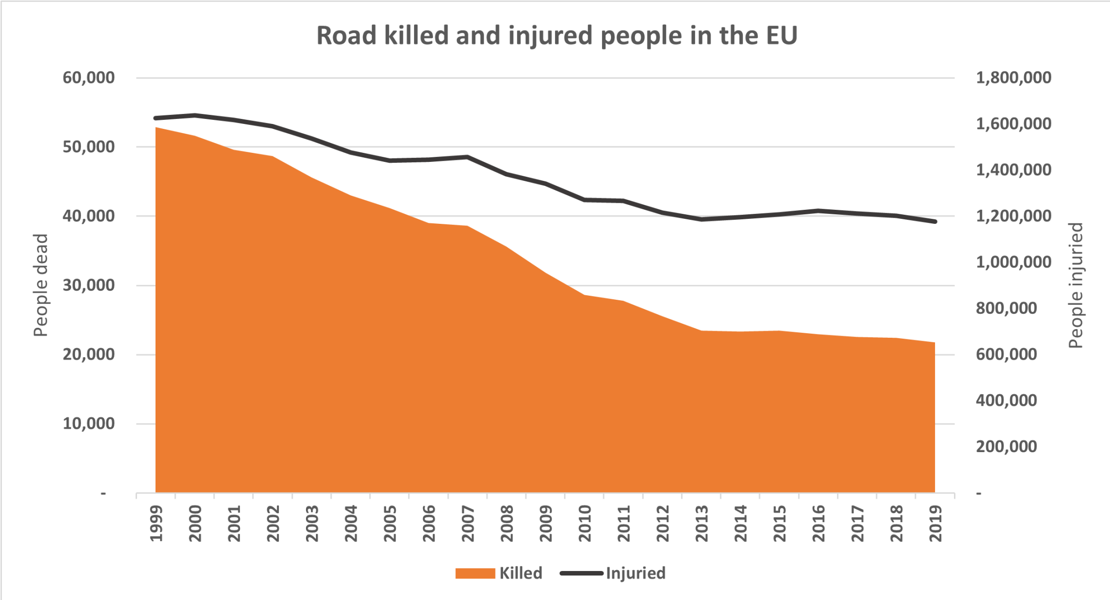

Figure 1.1. Road killed and injured people in the EU. Data from Eurostat (2022) and ITF (2022). It does not include the Netherlands due to incomplete data, or the UK. The number of injured people is estimated in the following cases: 2019 (Austria, Ireland, Malta, Spain); 2018 (Malta).

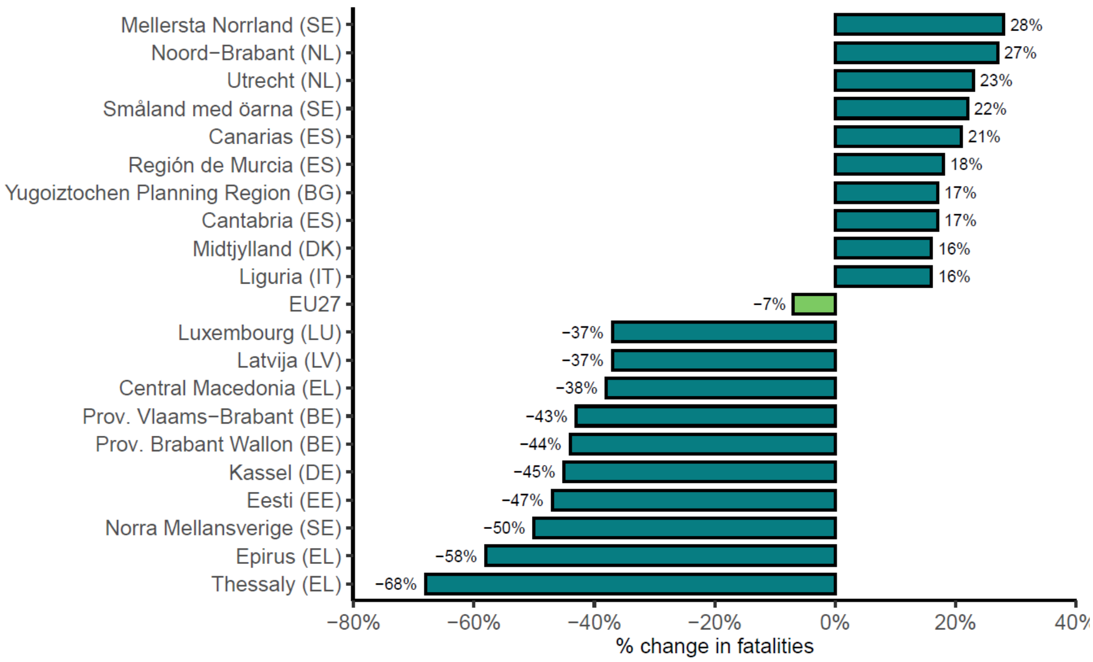

Figure 1.2. Percentage change in the number of fatalities, ten best and ten worst performing NUTS-2 regions in the EU27 (2012-2014 and 2017-2019). Reproduced from EC (2021, fig. 4)

At the global level, in the EU, the increasing size of the population and vehicles stresses cities' road safety. In the EU, by 2040—in comparison to 2010—it is projected an increase in the total vehicle fleet size among the different types of vehicles: Passenger cars (M1), 29%; Buses and coaches (M2 and M3), 35%; Vans (N1), 34%; Trucks (N2 and N3), 70% (EC, 2018, p. 117). If well, the increasing of trucks is bigger than any other type of vehicle, passenger cars and vans are the most used inside cities.

Systematically, goals are not achieved, and they should be an object of concern, study, and reflection. The regional objectives for 2010—reduce 50% in 2001 road fatalities by 2010 (Vlassenroot, 2011, p. 1)—was not achieved. After that, same as the global level, the 2020 goal—reducing the number of road deaths in 2010 to 15 000 by 2020—was also not accomplished. This last one was a fact mentioned as a possibility and a matter of concern since 2017 in the Valletta Declaration.

As the EC (2019) explains, in the Valletta Declaration, all the transport ministers of the EU set the goal for 2030 of halving the 2020 number of severe injuries. The same source mentions that in order to achieve this, a new approach was required:

1. Vision Zero must be reassured or—as they wrote— "needs to take hold more than it has so far".
2. The Safe System should be implemented in all of the EU.
3. Be ready for the new trends as distractions (e.g. mobile phones) and new technologies (e.g. automation of vehicles). These new technologies—in some cases—could help with the vision but also present big challenges.

The concepts of Vision Zero—as well as the Safe System Approach—are discussed in more detail in sections 2.1.1 and 2.1.2 respectively.

Taking as a reference the Safe System Approach, and being a precedent for the Stockholm Declaration, Valletta Declaration stresses the relevance of a collaborative approach where all the actors play their part in a coordinated manner (EC, 2019). The Council of the European Union (2017) also states the importance of collecting standard and reliable data from the Member States (MS), making special efforts in countries with improvement below the average of the EU. It was also defined as important, improving drivers behaviour, developing Intelligent Transport Systems (ITS) and technologies—" especially those automated driving functions and driver assistance systems that reduce the effects of human error and distraction"—looking for setting a speed limit of 30 km/h in urban areas and enforcing the measures. Furthermore, the declaration called upon the Commission to deploy new safety measures in vehicles through the General Safety Regulation (GSR). Accordingly, the EP (2017) recommended the mandatory introduction of driver assistance systems in vehicles; the selected technologies should comply with: demonstrated scientific evidence of improvement of road safety, good cost-benefit ratio, market maturity, and affordable final user costs; moreover, economic instruments were proposed for stimulating their introduction.

1.3.1 New Regulations

Attending to the existent non-complete safety in the EU roads and all the problems and factors mentioned above, a revision of the GSR was presented as the required point of inflexion. In November 2019, the EU approved the 'Regulation (EU) 2019/2144' (2019). This regulation applies to vehicles in the categories M, N, and O. It mandates the motorised vehicle manufacturers to include some of the most fully tested ADAS in all the new models to be EU-type approved since July 6, 2022, and all new vehicles available for customers from July 7, 2024 on-wards. The selected technologies are Advanced emergency braking systems, intelligent speed assistance, emergency lane-keeping systems, driver drowsiness and attention warning, advanced driver distraction warning, and reversing detection. It is understood that the the impact of these measures will rely on the improvements and gradual penetration of these technologies (EC, 2018).

On the other hand, these new rules are aligned with the road to automated vehicles and move for the needed adaptation of the infrastructure (EC, 2019).

The mandatory use of these technologies in combination is "conservatively estimated to save at least 7 300 lives and avoid 38 900 serious injuries by 2030, but bringing the expected number of lives saved to 25 000 and 140 000 serious injuries by 2037" (EC, 2019, p. 11). Moreover, in the cost-benefit analysis performed by the EC (EC, 2018), the benefits were defined as "casualties avoided due to the intervention". The document also mentions that for society, the benefits for casualties prevented or mitigated are estimated at €1 870 000 for every death, €243 100 for serious injuries, and €18 700 for slight injuries. This amount does not consider indirect benefits, e.g. reductions in congestion or possible reductions in car insurance premiums. Similarly, the analysis estimates the costs for the additional measures in vehicles as €516 per passenger car, €521 per light commercial vehicle, €970 per bus, and €1 013 per truck. It is not expected that these costs are not translated entirely to the final users. From the MS perspective, facing the new regulations, it is clear that resources are required to support the transition. The European Commission and the European Investment Bank made it available the "Safer Transport Platform" for this purpose in 2019 (EC, 2019).

Among the selected technologies, the regulation gave special treatment to ISA. The minimum requirements for ISA in the 'Regulation (EU) 2019/2144' are:

- When the drivers exceed the limit speed, there should be appropriate feedback.
- It should activate with the car turn-on, but it shall be possible to disable the system as wanted.
- The system shall take the speed limit information from "the observation of road signs and signals, based on infrastructure signals or electronic map data, or both".
- It should not impede the drivers from surpassing the speed limits.

A more detailed specification of ISA is elaborated in the 'Regulation (EU) 2021/1958' (2021) and it is widely boarded in chapter 3.

In this work, it will be discussed that managing transitions require establishing structured evaluations. Something remarkable about the 'Regulation (EU) 2019/2144' is that it also regulates how reports should be elaborated every five years, measuring achievements, penetration rates and convenience for users, assessing if the measures act as stipulated. On the other hand, it is questionable if five years is—perhaps—too much time, considering the acceleration of new technologies availability and the urgency of the problems at hand. However, being—without any doubt—a big step in the right direction, it is impossible to skip notice that ISA—one of the selected technologies—was created 40 years ago. Being speed, as presented above, such an important factor for road safety, it makes to wonder—and not for the first time—why it took so much time to be mandatory for all vehicles? More important, this calls to reflect on if these steps have the required 'momentum' to achieve cities' "Vision Zero" and sustainability goals on time, or—why not?—faster. The theory of Transition Management is a possible way to achieve the required acceleration.

1.4 Problem Formulation

Looking at the stagnant reduction of casualties at the global level and the increasing problems originating from the necessities of cities, as previously explained (see sections 1.1 and 1.1.1), the modified—not accomplished—SDG, and all the new—and old kicked to 2030—targets assumed by the international community, it is a fact the willingness of several actors to reduce to the minimum expression the number of deaths and hurt people generated by road incidents. There have been global efforts to address this problem with the EU as an international reference in the solution and results, but those efforts are not enough and are too slow. The EU understands speeding as one of the major sources of road accidents (see section 1.1.2) and recognises it in the new GSR with the introduction of ISA technology as a mandatory one for new vehicles (see section 1.3.1). With these actions, old—surprisingly old, highly studied, and not solved yet—as well as new challenges arise; some of these challenges are explained in this chapter, but there are more. Furthermore, ISA technology has several years of existence in the market, but there is a delay of at least ten years in the massive deployment. Nowadays, the evolution of the technology is being used and tested on the road to achieving smarter cities and the autonomy in vehicles (see section 1.2, stressing the delay. Despite ISA having —in not so recent studies— high acceptability among users, the challenges need to be solved in the short term to warrant the success of the measures on the established time. Furthermore, it could be possible the reduction of casualties even faster if the technology adoption is addressed with a different approach. Then the problem to be studied in this research is formulated in the following question:

Is the transition from limiting-speed technologies to control-speed technologies a smart and sustainable solution for increasing the safety of cities' roads faster?

This research aims to assess—through a KPI proposal—the readiness of the cities and citizens for the adoption of speed limiting technologies and understand the associated challenges in the face of a transition into a speed-controlled society. The second purpose is to elaborate on how the changes could be managed and integrated into the ITS and Smart Cities framework, using Transition Management and a collaborative approach to achieve the proposed goals faster and in a sustainable way. With this in mind, to solve the formulated problem, it was separated into the following sub-questions, which are meant to be answered with this project:

Sub-question 1: How do speed-control technologies fit in the smart city concept?

To establish a framework of sustainable transition, is required to understand the inter-relationship between smart cities and the state-of-the-art technologies, or more specifically, the speed-control. Moreover, the answer to this question will give this project a broad image of the link between smart cities and sustainable mobility. Finally, once the framework is established, this will make it possible to understand the approach's pros, cons, and trade-offs. Literature review and expert interviews are used to do so, as described in section 2.3.

Sub-question 2: Are cities and citizens ready for the transition?

On the verge of the implementation of the new GSR in the EU, the answer to this question intends to generate a picture of the general status of the EU from an it-is-mandatory perspective. For this, and departing from the previous sub-question, an understanding of the current challenges is created. Furthermore, the answer generates and uses a proposal of KPIs for future development in the Safe System Approach to assess the readiness status of cities and citizens on behalf of the introduction of ISA technology. Different methods, such as a literature review and a survey, are developed to assess citizen status. Moreover, an index is elaborated to assess cities' status from case studies supported by literature review, field observations and GIS analysis. In section 2.3 a description of the selected methods is presented.

Sub-question 3: How could speed-control technologies implementation be managed?

The answer to this question is the climax of the study. It aims to understand how the next step of speed-limiting technologies such as ISA could be implemented to reduce casualties faster in the EU. Using a triangulation method (as presented in section 2.3), all the knowledge generated with the answer to the previous questions is reviewed in the light of the Transition Management Theory with the Collaborative Learning Approach as a catalyser for the proposed transition.

1.5 Research Design

In this research, to tackle the established problem and questions mentioned above, a combination of quantitative, qualitative and case study research design is elaborated following a flow of knowledge obtained through different methods and presented along with different chapters of this document. Figure 1.3 presents the research structure used in this work.

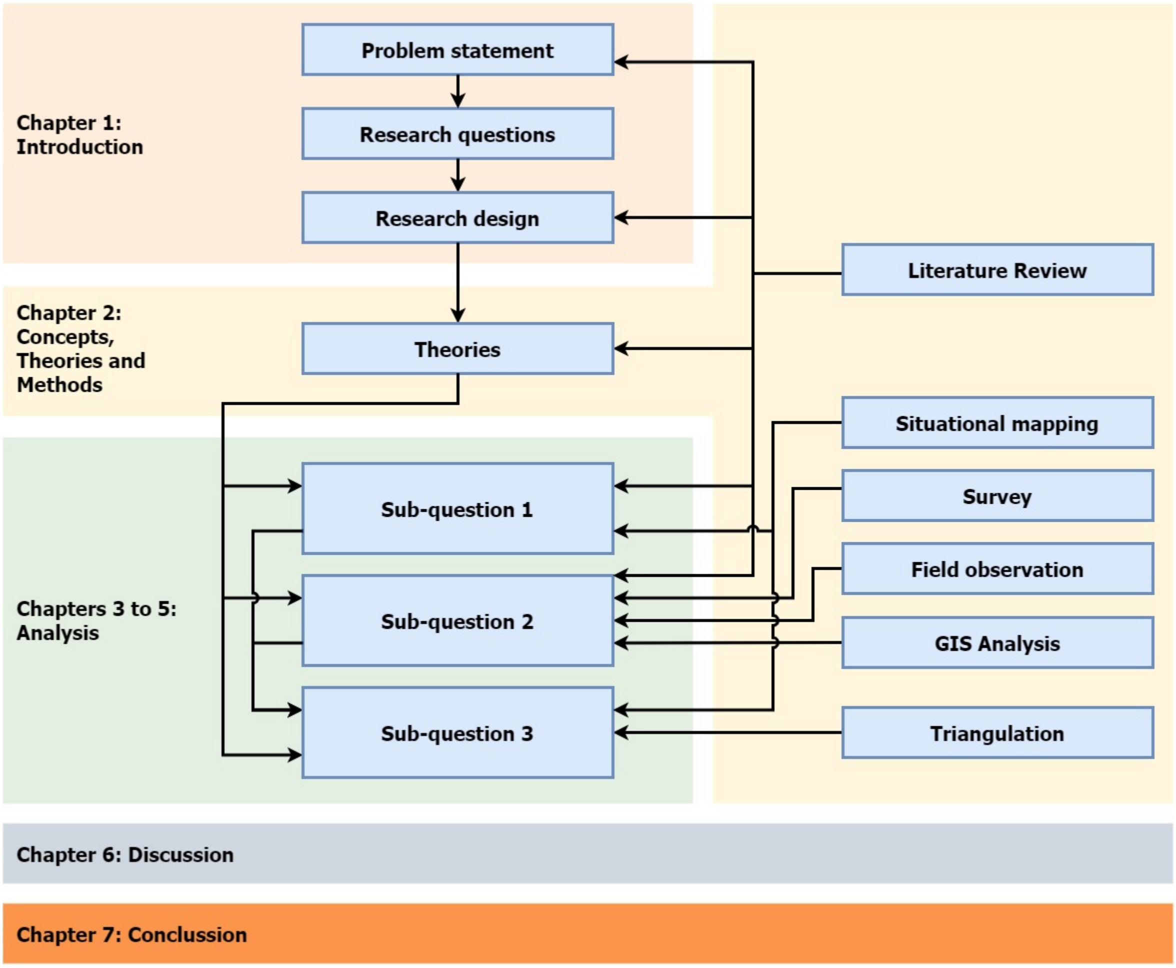

Figure 1.3. Research structure diagram

Once introduced the landscape, the problem, and the methodology to be followed, in chapter 2 a description of the main concepts, theories and methods used in this study is presented. The chapter is followed by the successive answers to the sub-questions defined in the previous section. chapter 3 is dedicated to explaining the relationship between speed-control and smart cities looking for a sustainable— safer, for instance—path that frames the evolution of cities and their inhabitants' mobility. Using this framework, in chapter 4 KPIs are defined and used, along with the empirical information gathered, to assess if the cities and citizens are ready for the adoption of the new EU regulations and the attached new technologies. Finalising the analysis, chapter 5 presents Transition Management—a well-developed theory—as a possible way to improve safety rates faster using the 'snapshot' of cities and citizens' readiness as a point of departure and the established framework as a guide. Once the analysis is concluded, chapter 6 presents a reflection on the study, taking into consideration the results of the previous chapters, followed by the conclusions in chapter 7.

Concepts, Theories and Methods 2

As a point of departure for this chapter, some concepts are introduced to create a base of understanding for the interpretation of this document. This process is followed by introducing the selected theories to finalise with the description of the methodologies used for the construction of the study purpose.

2.1 Main Concepts

Some concepts are defined and explained in this section due to their relevance in the study and with the purpose of facilitating and centralising the information.

Vulnerable Road Users (VRU): A common definition used to describe a segment of the road users that "includes non-motorised road users, such as pedestrians and cyclists, as well as motor-cyclists and persons with disabilities or reduced mobility and orientation" (Council of the European Union, 2017) that can be especially damaged in a crash. In this document, a wider definition of VRU will be used, including elders and people younger than seven years, as the Department of Infrastructure (2022) does. This adaptation is in the understanding that kids are another important group of pedestrians that must be protected and have special necessities.

Speed Control: For this project, the word control should be understood as the capacity to determine the behaviour or action of a subject—as the vehicles—instead of the other often-used and now obsolete connotation of *check or verify* (Oxford English Dictionary, no date). Then, *speed control* is defined as the capacity of speed limit enforcers (human or non-human) to modify remotely, beyond the capacity of the drivers, the speed of a vehicle.

2.1.1 Vision Zero

Vlassenroot (2011) relates that "Vision Zero" is a term created by the Swedish government in 1997 to name a new resolution—or philosophy—where a road without death or seriously injured people due to accidents is envisioned as a long-term goal. For the author, it is based on people's interest, discussion, motivation, shared responsibility, design and performance of the road transport system. In this vision, road designs should not allow serious or fatal injures (Filippova and Buchou, 2020). Vlassenroot also mentions that a good example of this philosophy is the measure –now worldwide spread—of enforcing a 30 kph speed limit in urban areas to motor vehicles as a way to warranty that VRU survives a collision.

2.1.2 The Safe System Approach

The Safe System Approach, as explained by the EC (2019), recognises that people make mistakes, and for this reason, accidents are inevitable. This system proposes a multi-level framework of protective measures to prevent deaths and injuries generated from those mistakes. These layers of protection complement each other compensating when one of them fails. This line of thinking disagrees with the traditional way of looking at the nature of accidents which states that "[...]road traffic crashes are not 'accidents'. They are completely preventable" (WHO, 2018, p. vii). With this approach, the accidents are seen as part of human nature and not entirely preventable, but they could be minimised in frequency and consequences.

The Safe System Approach "requires a shift in responsibility from the people using roads to the people designing them [...] people who design, set policy, execute operations, and otherwise contribute to the mobility system" (Filippova and Buchou, 2020). This characterisation implies that all the systems of governance and their elements are included in the new approach. Furthermore, in order to work, the system is based on a 'performance framework' with hierarchic targets (see Figure 2.1) where a set of initial Key Performance Indicators was presented and then complemented and refined to achieve the required understanding. KPIs are the foundation of goals fulfilment or—in other terms—a powerful tool for a transition that is supported by data provided by the MS. It is important to mention that reporting data from the MS to the Commission is voluntary (EC, 2019). In the next chapters, the absence of mandatory data will be exposed as one of the main challenges to be solved.

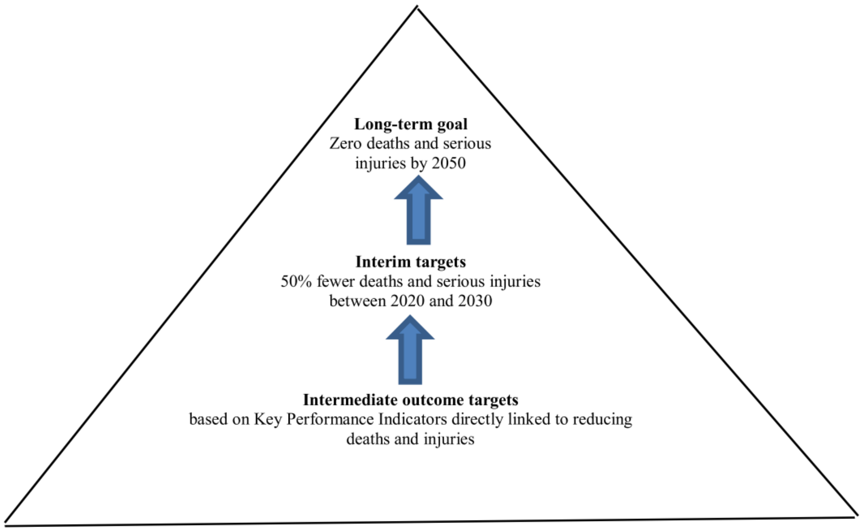

Figure 2.1. Safe System results hierarchy at EU level. Reproduced from EC, 2019, p. 5

2.1.3 Readiness

In this research, the term readiness should not be used indistinctly with the term acceptance. Acceptance—term used for several authors in the field as mentioned in Chapter 1—implies a behavioural—psychological, for instance—attitude towards the object of study, as technologies. In contrast, readiness means: "state of preparedness" (Dictionary, no date[a]). For this study, the word readiness is preferred for two reasons. First, it is more clear from the language perspective. It is a regular-used and common word; e.g. if someone says "dinner is ready", it is possible that people get the message "at this moment, all the required elements are in disposition to eat", even if they don't know—necessarily—what are all those elements. Second, it is easily defined and expanded using agreed elements. It is easy to agree—using the same example—that the unknown elements are: "table is set" and "food is cooked", so now it is possible to understand that the readiness of dinner means that the food is cooked and the table is set. Therefore, the concept of readiness could include acceptance as an element to define it.

2.1.4 Smart City and Smart Mobility

With the passing of the years and attending to the challenges that cities possess, several definitions of the concept "smart cities"—also used as the label "smart city" —has been developed. Albino, Berardi, and Dangelico (2015) work present a meta-analysis of 24 definitions of 'Smart City' used by different authors. The authors conclude that the concept, despite having been created for the appliance of communication technologies in cities—Information and Communications Technology (ICT)—is now far from it, also looking for people and community needs. As a point of departure, the following definition will be used: "Being a smart city means using all available technology and resources in an intelligent and coordinated manner to develop urban centres that are at once integrated, habitable, and sustainable. Barrionuevo et al. (2012)" (Albino, Berardi, and Dangelico, 2015, table 1). On the other hand, Albino, Berardi, and Dangelico mention that smart cities are composed of six aspects; one of those aspects, *Smart Mobility*, should be understood as "the use of ICT in modern transport technologies to improve urban traffic" (Albino, Berardi, and Dangelico, 2015, p. 11). In Chapter 3, these definitions are used to construct a relationship between smart cities and speed-control technologies.

2.1.5 Sustainability

There are multiple definitions and conceptualisations of sustainable or sustainability. With the idea of elaborating on them in the next chapter, two definitions are selected. One that gives a framework: "Sustainability refers to a process and a standard and not to an end state" (Kemp, Loorbach, and Rotmans, 2007, p. 79). And a more detailed definition: Sustainable means that the "achievement of affordability, effectiveness and attractiveness must be able to be maintained on a long-term basis economically, socially and environmentally" (Lyons, 2018, p. 9).

2.1.6 Intelligent Transport Systems

ITS bring new opportunities for managing resources more efficiently and in a more sustainable way (Filippova and Buchou, 2020). ITS are a leap in the evolution of transport through technology.

Yigitcanlar (2016) mentions that ITS are distributed through stand-alone applications that can be installed in all kinds of vehicles and infrastructure for different purposes. This flexibility allows for traffic management, different interactions of vehicles as Vehicle to Infrastructure (V2I), Vehicle-to-Vehicle (V2V) and Vehicle to Everything (V2X)—and vice-versa (Alessandrini, Domenichini, and Branzi, 2021d)—as well as different warning and information services in vehicles and infrastructure; moreover, ITS facilitates vehicle automation. For Filippova and Buchou (2020), ICT is a fundamental part—that is constantly evolving—of ITS; some examples are: Cartographic databases and Geographic Information System (GIS), Automatic identification systems (AEI/AVI), and Blockchain. Since the publication of the referenced report, other ITC are available, for example: Event Data Recorder (EDR), Global Navigation Satellite System (GNSS), and Intelligent Speed Assistance (ISA). The finality of ICT is to provide data that can be used by planners, users—and now, systems—to make decisions and get the most out of transport (Lyons, 2018). One of the possible applications of ITS is Safety, using technologies in, e.g. collision avoidance in vehicles and road signs notifications (Yigitcanlar, 2016), which is validated by the enlisted examples.

2.2 Theories

2.2.1 Systemic Approach

Environmental problems—as well as urban and planning, i.e. sociotechnical problems—are complex because they evolve fast and include multiple parties or actors. Increasing the difficulty, these actors have different and multiple interests, legal requirements, cultures, values, political discourse, and scientific knowledge. These complex problems are known as *wicked problems*, and a systemic approach is an option to deal with them (Daniels and Gregg Walker, 2001; Lissandrello, 2021).

A systemic approach—or "systems thinking"—looks for "interrelationships and possibilities rather than linear cause-effect chains, and processes of change rather than snapshots" [(Daniels and Gregg Walker, 2001, p. 101)]. This approach fosters integrative—and holistic—thinking. For this purpose, a system should be understood as a set of things working together and composed of elements, relationships, inputs, outputs, a boundary, and an environment (Emborg, 2021). Analogically, sociotechnical systems are composed of actors, networks, material artefacts, and knowledge (Lissandrello, 2021). Going further, Daniels and Gregg Walker (2001) explain that systems could be classified into hard and soft; hard systems have a clear objective function defined; in the case of soft systems, the function is not clear, or there are multiple functions. Complex problems usually involve a mixture of hard and soft systems. They also mention that systems respond to dynamic complexity, which emphasises: connections, interrelationships and unintended consequences, and that systems' most relevant features are: Transformation: Systems transform other things, and the system can be transformed. Feedback loops: Systems could have a repetition of patterns that reinforce themselves. Scales/Emergent properties: Properties at the system level could not necessarily happen in their parts.

Several systemic approaches have been developed in the sociotechnical context, for example, the Multi-level Perspective (MLP) (Geels, 2005) or the Strategic Niche Management (SNM) (Schot and Geels, 2008). The use of systemic approaches is generalised and has contributed to so much extent to science that the EEA (2019, ch. 17) endorses its use among the MS and goes even further, elaborating on the importance of transitions and how they could be managed to achieve sustainability goals. In this dissertation, Transition Management—a well known systemic approach—was selected as a developing tool. In the next section, it is explained as a pillar for the analysis in the next chapters.

2.2.2 Transition Management

One of the definitions of transition is the pass from one condition to another (Dictionary, no date[b]). In short words, a change. For Lissandrello (2021), at the level of societal functions, a transition is a radical and persistent systemic change between 'states' due to the interaction of sociotechnical systems.

Kemp, Loorbach, and Rotmans (2007) explain that sustainable development is a "never-ending process of progressive social changes". It needs radical changes in functional systems, government policies and governance systems, and it also involves system innovations and co-evolution, which creates, in turn, new problems that should be solved with policies. For Kemp, Loorbach, and Rotmans a co-evolutionary view of governance systems is important because of their inherent properties of scale and feedback loops; moreover, an open, adaptive, learning and experimented oriented type of governance is required to achieve the sustainable development. With this in mind, the authors take the concept of "Transition Management" developed by Romans in 2000—which proposed a way to explore beforehand trajectories of social alternatives—and reshape it as a model that allows managing processes of co-evolution.

> "Transition management is a multi-level model of governance which shapes processes of co-evolution using visions, transition experiments and cycles of learning and adaptation [...] help societies to transform themselves in a gradual, reflexive way through guided processes of variation and selection, the outcomes of which are stepping stones for further change." (Kemp, Loorbach, and Rotmans, 2007, p. 78).

In order to close the gaps between top-down planning and bottom-up incrementalism, Kemp, Loorbach, and Rotmans use the Dutch model of Transition Management, which, through new types of interaction and cycles of learning and innovation, coordinate different levels of governance and fosters self-organisations. The authors identify other problems—it is observable that some of them are inherent to the nature of a wicked problem—as:

1. Dissent: different people have different ideas of goals, means and nature of the problem. Structuring methods could be used to solve this problem.
2. Distributed control: Control—or power—is distributed among different actors with different interests. It requires joint visions and common goals.
3. Determination of short-term steps: It is hard to know how long term goals could be achieved in short-term steps. Forecasting and back-casting are an option to solve this problem.
4. Danger of lock-in: To get locked into a particular, not optimal solution. It is necessary to develop and use a portfolio of options.
5. Political myopia: Transitions in sociotechnical systems take various political cycles. Politicians should wait for long-term results or set transitions arenas if there is an urgency.

The solutions to these problems are the general strategies of transition management, and they could be structured by addressing the interaction of three levels: strategic (e.g. long-term goals formulation), tactical (e.g. networking), and operational (e.g. project building). Each level has its specific actors interacting, and the three levels interact as well, generating a transition. For this reason, every level and interaction could require a specific policy.

Finally, Kemp, Loorbach, and Rotmans elaborate some characteristics of Transition Management. It uses goals but does not look to control the future; it could be considered a 'directed incrementalism'; it combines bottom-up and top-down approaches. This kind of approach implies a necessity for participation.

There have been critiques of Transition Management from different perspectives. One of the most important is the not so well considered power of the political sphere in transitions (Avelino and Grin, 2017). Indeed Shove and Gordon Walker (2007) observe that there are politicians that play out their power to direct the intervention, and they are not properly measured in the literature. Similarly, they consider that the political business-as-usual can govern the transition through the role of transition managers. Moreover, the question of who is, or should be, in charge of deciding the path to follow—the more sustainable direction—

also points to the current lack of study of the abandoned systems. Finally, the authors mention that the transition in practice could lack knowledge about the future, misrepresent stakeholders, and oversimplify the debate around systemic change. Avelino and Grin (2017) elaborate on two other critiques of Transition Management. First, there is a lack of reflection on the notion of sustainability and the possible exploitation of the ambiguity of the concept in the political discourse. Second, there is a concern around the involvement of—beyond researchers—policy-makers and other actors in creating the current Transition Management model. Finally, the authors express that, at the moment, there are still "underlying epistemological issues" that should be addressed in TM. In this research, participation is presented in Chapter 5 as a way to overcome these critiques.

2.3 Methods

In this research, as presented previously in Section 1.5, diverse methods are used to answer the inquiries of the project. The methods described in the following sections were selected, obeying the necessity of acquiring qualitative and quantitative data, analysing it and combining the results to get a holistic approach.

2.3.1 Literature Review

Literature Review is the point of departure of this research. In this document, it is used as a method to obtain information on the selected topic from different sources and perspectives, looking to determine and frame the nature of the problem and the angle and support the answer to the different questions. Literature review is a process where the concepts are organised to be presented in a text; it "is a thinking process that involves piecing together and integrating diverse sources" (DePoy and Gitlin, 2016, ch. 6).

For the acquisition of the knowledge used in this research, different searches were performed in web-portals from different institutions and databases as Aalborg University Library (`www.en.aub.aau.dk`), Scopus (`www.scopus.com`), Web of Science (`www.webofscience.com`), and Google Scholar (`scholar.google.com`). The selected academic literature complies with relevance in the topic, novelty or notorious prestige, and being reviewed by peers.

2.3.2 Situation Mapping

Situation mapping, an evolution of mind mapping, is a powerful learning tool that allows the visual representation of a situation in a system to understand its elements and interrelationships (Daniels and Gregg Walker, 2001). A situation map is a perfect point of departure for identifying key actors and their roles. Moreover, Daniels and Gregg Walker (2001) explain that collaborative mapping is an activity that helps develop collaborative learning and, with it, the creation of a base for the solution of complex sociotechnical conflicts and the evolution of the system at hand.

In this project, situation mapping will be used for the understanding of the current Urban Mobility System in chapter 3, and the implications and requirements of its evolution from speed-limiting to the speed-control technologies in chapter 5.

2.3.3 Survey

For the assessment presented in Chapter 4 about citizens' readiness towards the implementation of ISA stated in the Sub-question 2 (see Section 1.4), an online survey was selected as the most effective method to obtain the required empirical data. The information is used as well as a context for the elaboration of a transition proposal in chapter 5. A survey—administered questionnaires—allows the acquisition of information when statistical data or information from a particular topic is required; a questionnaire is a fixed set of questions that are asked following the same procedure to all the respondents (Peters, 2022).

The goal of the survey was defined as:

To determine the level of readiness of people for the adoption of new speed-control technologies in cities.

On the other hand, the survey's target population was any inhabitant of urban areas in the EU, Norway, and Switzerland above 17 years old.

Using the findings from the literature review, different types of questions were selected from previous questionnaires as well as designed attending the different necessities of knowledge. The complete questionnaire is included in Appendix C.1.

The included standard socio-demographic variables were: age, gender, location, and income. The last was included due to the clear correlations between speeding-income found in previous studies, e.g. Shinar et al. (2001) mentioned by Vlassenroot (2011). Moreover, for the income variable, the currency was defined as dependent on the respondent country because the purpose of the variable was to acquire data on magnitudes more than precise amounts. On the other hand, the variable education was not included to increase the number of responses.

The questions *Do you live in an urban area?* and *How often do you visit an urban area?* were included with the purpose to only have responses from inhabitants or visitors of urban areas.

The variables driving permit possession, car ownership and intention of car purchasing were included to assess the driving status of the respondents. For driver respondents, the question *How often do you exceed speed limits?* was included in order to assess the number of speeders. Moreover, an adaptation of Silcock's list with the prevalent reasons for justifying speeding, as enlisted by Vlassenroot (2011) was included in order to verify sensible changes in the behaviour of nowadays speeders. Finally, a question to assess the number of respondents that had an accident produced by speeding was also included.

Looking to understand the accessibility—or penetration—and the acceptance of ISA among respondents, as well as its changes in the last decade, a set of questions were included (see questions 13 to 17 in Appendix C.1).

Going further, questions to assess the awareness of the current regulation, operation, repercussions, and participation in ISA were added (questions 18 to 22).

Finally, the last three questions determine the disposition of urban areas' inhabitants to give driving habits information to public and private sectors. From these, the last question *In which of the following scenarios do you think authorities should be able to control the speed of vehicles externally?* looks to establish the readiness of people around the possible external control of speed in vehicles.

The survey was constructed and launched in a digital format with the web-tool *SurveyXact provided by Ramboll* (`www.surveyxact.com`). The tool allowed the configuration of the required branching and validation of questions as needed. The questionnaire was designed in English and translated to Danish, German, Spanish, and Polish in order to increase the number of respondents. The translations were performed using *Google Translate* (`translate.google.com`), then corrected by native speakers in their respective language. The survey was advertised through printed flyers in Aalborg University and several buildings in Aalborg. It was also advertised through the digital displays located in Aalborg University Libraries, different local and international *Facebook groups* (`www.facebook.com`), and SurveySwap (`www.surveyswap.io`), a specialised website for survey response exchanges. SuveyXact and IBM-SPSS Statistics v27 (`www.ibm.com/docs/en/spss-statistics/27.0.0`) were used for the analysis and presentation of the collected data.

One potential limitation of online surveys is that the respondent population is unknown, which does not allow to easily identify possible biases, and the generalisation of the results could be not completely trust-able (Hesse-Biber and Johnson, 2015). This limitation is accepted as it is no intention of the survey to assess the general status of the EU inhabitants but to identify the status of a specific place—as a part of a whole—and construct a tool for further research.

2.3.4 GIS Analysis and Field Observation

The first objective of this project—as expressed in Section 1.4—looks to assess the readiness of cities for ISA implementation. A KPI is presented in Chapter 4 and used with empirical data in two case study areas to answer the first part of the sub-question number two, which addresses specifically this objective. Geographic Information System (GIS) analysis and field observation were selected as the right methods to gather the empirical data for this KPI.

GIS allows researchers to use several techniques to store, visualise, analyse, process and manage geospatial data, as well as relate these capabilities and data with attributes in order to generate more data and understand the social world (Peters, 2022). In this research, the role of the GIS analysis is limited to the linear measure of roads' length in a delimited area; measures were taken for all the roads with indicated speed-limit. Using the limit-speed map, the number and position of the needed speed-limit transition zones—which in this document will be labelled as "nodes"—were identified, labelled and included in a database. The work was performed using the software *QGIS Desktop v3.22.5-Białowieża*. The software was also used to elaborate different map visualisations for this document.

The field observation goal was to assess cities' readiness for ISA implementation. Observation is an important and systematic way of collecting data, and it has characteristics such as structure, participation, focus, and temporality (DePoy and Gitlin, 2016, ch. 16). Field observations were performed in selected areas of Aalborg and Copenhagen cities, looking for an answer for the second part of sub-question number two. The observation has the objective of comparing the physical infrastructure installed to regulate speed—from an ISA requirements perspective—versus the digital speed-limit maps. The speed-limit map of Aalborg was provided by (Municipality, 2022), while the Copenhagen data-set was obtained from *Trafikhastigheder* (no date). Both cities were chosen because their respective number of road deaths per capita differs. This difference could open the possibility of having different levels of readiness that could be compared. The selected areas were *Sankt Markus Parish* in Aalborg and *Vor Frue Parish* in Copenhagen. The selection of the areas was made looking for a combination of high diversity in the land use and a high number of speed-limit changes.

The field observation was performed in-situ, following a structured and local-focused approach; it was done with a difference of two days between cities. Moreover, the process was done with good visibility due to weather and illumination factors emulating the conditions for ISA testing in the model approval as established in the 'Regulation (EU) 2021/1958' (2021). For each node, data was gathered on the following variables: Number of required traffic signs, Number of existent traffic signs, Number of visible existent traffic signs, Number of traffic signs matching with the digital map. Then the data was summarised, getting the total quantities in the area of study for each one of the variables.

2.3.5 Triangulation

In this research, triangulation will integrate the information collected with the methods mentioned above, theories, and concepts. Triangulation—also known as Crystallization —in research looks to increase the accuracy of the collected information through the use of multiple methods; with triangulation, one or more sources of information are used to check the others, converging the knowledge and developing a deeper understanding (DePoy and Gitlin, 2016). The triangulation of the collected data will be performed in the analysis of the three sub-questions and described in the next three chapters. Similarly, the knowledge generated individually by the sub-questions one and two (Chapters 3 and 4 respectively) will be triangulated as an important part of the analysis of sub-question three (Chapter 5). A graphical representation of this process can be observed in Figure 1.3.

Speed-control Technologies and Smart Cities 3

> "The future of urban mobility depends on a nexus of infrastructures, mobility devices [...] and IT systems" (Filippova and Buchou, 2020, p. 154).

For the reasons exposed in chapter 1, urban areas are places of particular importance. There are multiple and increasing necessities in urban areas—especially cities—worldwide. Urban areas are conformed by several interrelated sociotechnical systems (Mora et al., 2021). Every necessity and solution are part of those systems. Then when there is a problem, it is a wicked problem. The Independent Group of Scientists appointed by the Secretary-General (2019) describe Smart Cities as places with more significant opportunities and capacities to deal with the complexity that different systems bring to cities, e.g. climate change adaptation, pollution and traffic congestion, and accidents as the matter of this dissertation. The more wicked the problem is, the more intelligent the solution needs to be and, by extension, the smarter the city could be.

Departing from the adopted definitions of the concepts *Smart City* and *Smart mobility* (see section 2.1), in this chapter, a deep analysis of the Smart City is performed, exploring the concepts of *smart*, *intelligent transport systems*, *intelligent*, *sustainability*, and their interrelationships. This analysis will give this research a framework to support the importance of sustainable urban mobility and its relationship with vehicle technologies and, more specifically, with ISA as a speed-limiting technology and as an angular stone for speed control.

Elaborating on the topic of this chapter, it is important to stress the inherent relationship between *Smart* and technology, even if it is not strictly necessary; the term Smart was created because of technology appliance. Moreover, the purpose of this research is about the application of a specific technology in cities. Nevertheless, the word *Smart*, as discussed previously, could be translated into the notion of "use everything at your disposal in an intelligent and coordinated way". This notion implies that there could be intelligent solutions that do not use technologies and solutions that use state-of-the-art technology but are not intelligent. Indeed, Lyons (2018) comments over this conundrum but uses the term smart. On the other hand, it is important to stress that the terms *Smart* and *Intelligent* should not be confused; it is recognized that *Intelligent* is inherent to *Smart* (Albino, Berardi, and Dangelico, 2015).

These ideas create the necessity to evaluate what is intelligent and what is not. Having places integrated, habitable and with improved safety requires having an idea of the correct dose of intelligence and smartness. The term *Sustainable* could be used then to fill the gaps. Sustainability can be used as a parameter to measure the intelligence of a solution and the level of integration, habitability, mobility capacity, and other attributes of a place. Sustainability is enacted from the changes in the urban environments and how the necessities are covered (Mora et al., 2021).

However, Smart Cities are not born from the air or random coincidences. Smart Cities are designed and built; they are planned. Nevertheless, it is also true—and perhaps more likely to what happens in reality—that they could be integrated and, for instance, evolve from the addition of different smart urban systems that compose them, as mentioned in the introduction. Understanding how many smart systems or which ones are required to catalogue a city as smart is not a matter of this research. However, what is essential for this research is that the design, planning and implementation of smart systems, such as Smart Mobility, can lead to Smart Cities. On the other hand, when an urban system fails, a sustainability transition mechanism starts to change the sociotechnical system into a more sustainable one (Mora et al., 2021).

For Independent Group of Scientists appointed by the Secretary-General (2019) the key to sustainable development is the use of multi-sector technological innovation and the access to data. Moreover, the adoption of smart technologies—e.g. smart grids or ITS—that improves the sustainability of sociotechnical systems in a continual change is a characteristic of a Smart Cities (Mora et al., 2021). Looking at the problem matter of this dissertation, it is arguable that urban mobility is a sociotechnical system crucial in the future development of Smart and Sustainable Cities.

A Systemic Approach presents itself as the best option to understand better the Urban Mobility System, its changes, and the interactions of its elements. To understand it, a situation map—as commented in section 2.3.2— was elaborated and presented in Figure 3.1. The map shows a possible urban mobility system, focusing on the problems generated by cars and the speed control from drivers.

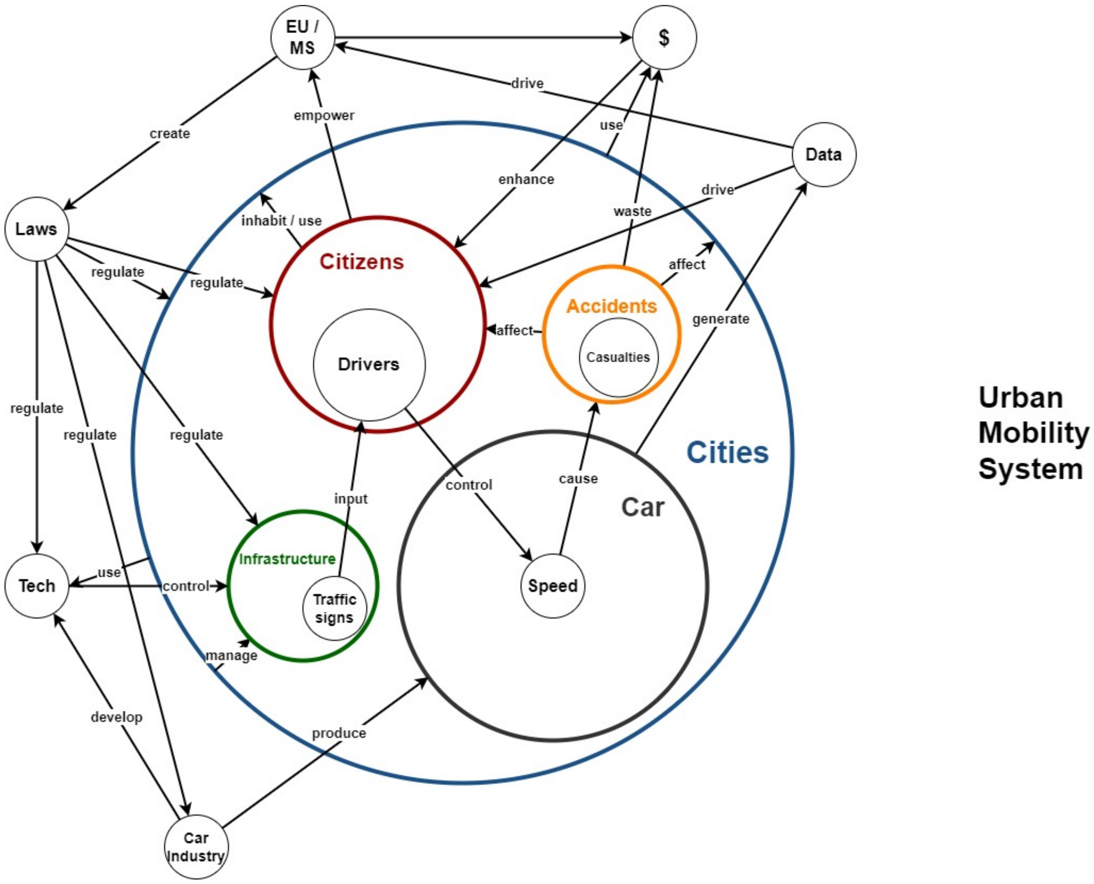

Figure 3.1. Urban mobility system situation map focusing in cars and speed safety issues.

In the map, it is also possible to identify important sub-systems and feedback loops. One graphically simple but not straightforward at all is the Citizens-EU/MS-legislation cycle. In this cycle, citizens empower the government to legislate, which in turn regulates citizens. This cycle is the key that enables participation as a way to achieve transitions. In chapter 5 a deeper discussion on the importance of this is elaborated. As a note, for simplicity EU/MS should be interpreted as the government, so it could also represent local authorities. At the same time, legislation regulates cities which in turn host citizens, which again empowers governments; this cycle explains how cities affect citizens and then are modified by new regulations.

On the other hand, an example of a feedback loop is the citizen-driver-car-data-government-legislation-citizen system. This cycle illustrates how the legislation defines technology–the car—that should be used to gather data that will drive the government to define new legislation. This situation is the particular case of the EU and the regulations 'Regulation (EU) 2019/2144' (2019) and 'Regulation (EU) 2021/1958' (2021), which define ISA and how data should be collected for further analysis and improvement of the legislation. Interestingly, in the situation map, it is visible how technology also drives citizens, who, in turn, can modify the power of authorities—which is the base of democracy and, as mentioned before, defines the importance of participation—to modify those laws. The last relevant sub-system—from a driver perspective—involves the driver having direct control over the speed of the car, as illustrated in Figure 3.2. A driver who is a citizen controls the car's speed supported by the visualisation of traffic signs as inputs; and has the possibility of generating an accident and, in certain scenarios, producing causalities affecting other citizens and other sub-systems.

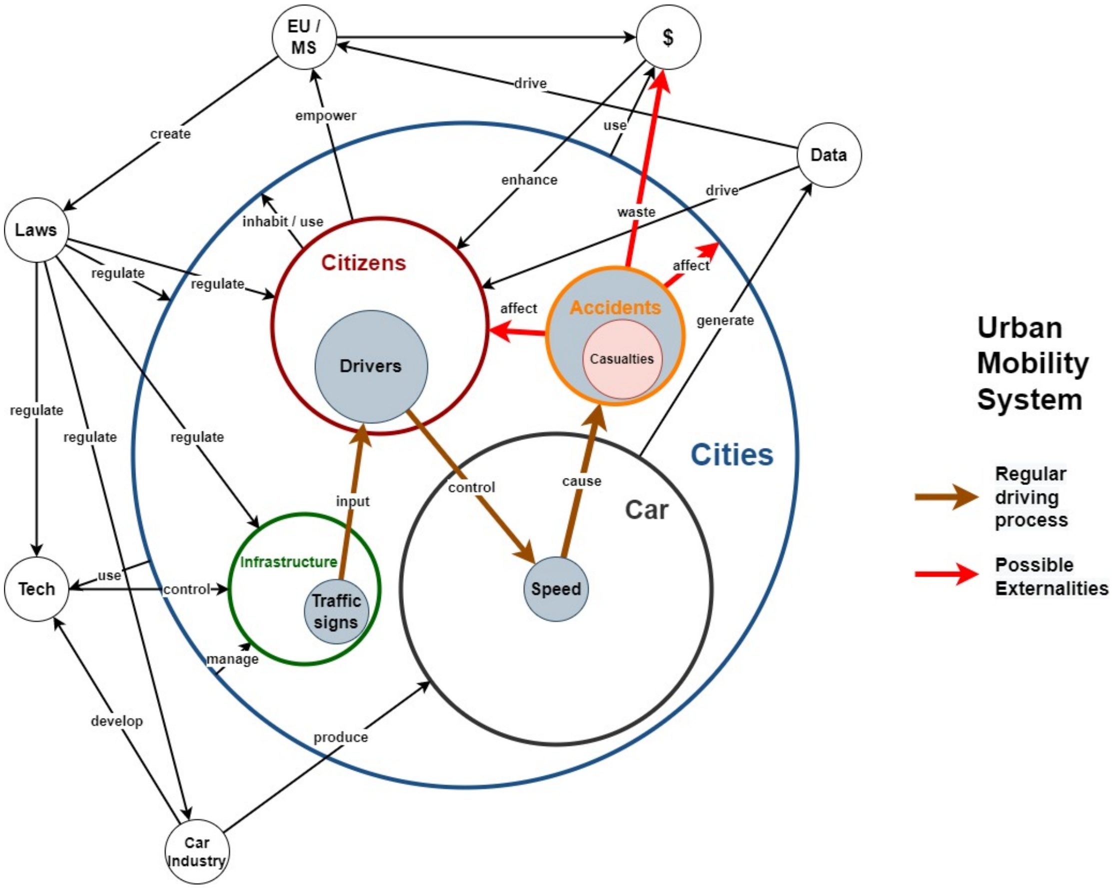

Figure 3.2. Urban mobility from a driver perspective. The driver has all the control over speed.

In order to understand how this sociotechnical system is smart and sustainable and how a transition could magnify these qualities, it is necessary to construct a definition of urban mobility that support both of them.

3.1 Sustainable Urban Mobility

Sustainable Urban Mobility "sought to ensure the mobility of the population by reorienting transport demand towards safer and more environmentally friendly modes of transport" (Filippova and Buchou, 2020, p. 5). Taking this definition—and the definitions of sustainability from the last chapter—it is possible to create an image of what is sustainable urban mobility: the continuous process of ensuring that the mobility of the population in urban areas is affordable, effective and attractive, minimising the impacts on the economy, society and the environment.

As mentioned above, sustainability can be used as a way to give context to—or measure—the intelligence of solutions and systems and define if *Smart* is really smart. So, it is necessary to understand how both terms smart and sustainability are "aligned". Looking for this alignment, in his work *Getting smart about urban mobility* Lyons (2018) presents a brilliant conceptualisation of the link between smart and sustainable.

Lyons explains that understanding the evolving complexity in cities; urban mobility should help to pursue sustainability. So, for Lyons, 'The Sustainable Mobility Paradigm' sets an approach for urban mobility which it is fostered the reductions of travels in quantity and length and the modal shift. At the same time, technology and communications bring the opportunity of having smart mobility, so it makes sense to think that the search for smart mobility and the search for sustainable mobility are connected. Then, for Lyons there are four different scenarios of interaction between smart and sustainable inside the urban mobility paradigm research and development: a) smart and sustainable are individual spheres with some things in common, b) smart is the same as sustainable, c) sustainable is a part of smart, and d) smart is a part of sustainable. The last option "suggest[s] a stronger level of stewardship over urban futures in which the smart paradigm is subservient to the sustainable paradigm, with the former 'confined' to contributing to the latter" (Lyons, 2018, p. 8). For this reason, it is a good approach for this research; then, sustainable urban mobility could be achieved through smart urban mobility.

As a preamble to the explanation of smart urban mobility, it is fundamental to take into consideration that new technologies are not enough to make urban areas more sustainable, so sociotechnical transition paths should be defined to ensure the technologies work (Mora et al., 2021). In this research, Transition Management is proposed to help do this job.

3.2 Smart Urban Mobility

Elaborating on the definition of ITS and the previous ideas, developing a Smart Mobility in a city also develops smarter cities. Smart mobility in cities could be called as *Smart Urban Transport Systems* or *Smart Urban Mobility*. Yigitcanlar (2016, ch. 4) explains that Smart Urban Transport Systems are a way of managing transport systems intelligently. For the author, Intelligent Transport Systems (ITS) enacts this purpose with the use of high technology in informatics, communication and sensors, enhancing road networks and transport systems to increment comfort, efficiency and safety. On the other hand, Lyons (2018) defines *smart urban mobility* as "connectivity in towns and cities that is affordable, effective, attractive and sustainable". While both definitions go in the same direction, the first weighs more on the means, and the second stresses more on the ends. Nevertheless, smart urban mobility is more than people and goods moving in urban areas, but the interconnection of the land use, transport and communications systems (Lyons, 2018).

Then, it is clear that some ADAS integrates ICT and, by extension, makes the vehicle that equips it part of an ITS. The interconnection of ITS creates a Smart Urban Mobility. Indeed, for Alessandrini, Domenichini, and Branzi (2021d), the systems enabled by ITS are the core of Smart Mobility. But for some applications, the last affirmation is true if, and only if, the vehicle is inside an area with smart mobility infrastructure developed, or at least with a specific quality level in some elements. The potential that infrastructure has if ITS is implemented and the importance of infrastructure for ITS deployment is remarkable. There is also a clear and similar interrelationship between ITS and vehicles.

Despite having relevance in the future of smart urban mobility, it is important to stress that technology should not be prioritised over the services that it should provide (Lyons, 2018).

3.3 Smart Infrastructure

> "Road infrastructures are complex systems formed by static elements (the roadway) and time-dependent components (characteristics that evolve under traffic and weather constraints), surrounded by the environment (other vehicles and landscape) whose characteristics rapidly change along the route" (Alessandrini, Domenichini, and Branzi, 2021d, p. 250)

Current technology allows the existence of two types of infrastructure, the traditional and well-known physical and the digital, e.g. the digital cartography mentioned above, traffic or speed-limit data. The definition of digital infrastructure is based on the same ground as ITS from a technology perspective (Alessandrini, Domenichini, and Branzi, 2021d). Moreover, digital infrastructure is aligned with the current digitalisation of the world, which impacts in the mobility field are—in the words of the Filippova and Buchou (2020, p. 156) "systemic and huge". Both types of infrastructure complement each other.

The EP (2017) call to MS to improve road infrastructure with adequate maintenance, innovating in solutions that allow the interoperability with driving assistant systems—nowadays Advanced Driver Assistance Systems (ADAS) and autonomous vehicles—creating then Intelligent Infrastructure. This call is especially important as infrastructure has an important role in the reduction of accidents, especially automated—at any level—vehicles (Alessandrini, Domenichini, and Branzi, 2021a). Danish research estimates that 30% of accidents are related to road infrastructure (EC, 2019). Considering the long-term objectives of the EU, the Safe System Approach, and the fact that ISA—and other ADAS—have some degree of automation, then the infrastructure should be evaluated at that level, the highest. There have been efforts to classify and evaluate infrastructure. For example, to assess the level of support that infrastructure provides to autonomous vehicles—which for practicality it will be called RILS in this project—a scale of five levels, from E to A—where A is the most advanced level—is proposed by Carrera et al. (2018) (Alessandrini, Domenichini, and Branzi, 2021d, fig. 7.10). Other approaches are traditional and indirect as risk mapping or the assessment of location and visibility of traffic signs which is required by ISA (EC, 2019).

The natural differences in new technologies give relevance to the role of infrastructure, which should indicate what technologies can be used safely in it and define legal limits to responsibility, which implies the necessity of certifying the digital and physical infrastructure and that both match exactly (Alessandrini, Domenichini, and Branzi, 2021d). The EU addressed this situation by creating a specification on the selected technologies—ISA included—which adapts "easily" to the current infrastructure. For example, traffic signs usually are cheaper than other types of infrastructure. New vehicle technologies require traffic signs with a high-level maintenance (Alessandrini, Domenichini, and Branzi, 2021b); a fact in the case of ISA. Although another option for increasing safety is—if there is not a good level of infrastructure or enough resources—to reduce speed limits (Vlassenroot, 2011); it is also an intelligent option. Smart infrastructure in conjunction with ISA could help to increase safety, especially in zones classified with high complexity and changing speeds—e.g. city centres —or high speeds as urban collector roads (Alessandrini, Domenichini, and Branzi, 2021d). Again, this seems the right path, but it makes the researcher wonder if it is the fastest. This issue is addressed in chapter 5. Political support is needed to support the transition into smart infrastructure with the creation of niche services, policies and legal frameworks (Alessandrini, Domenichini, and Branzi, 2021d).

To understand the complexities of a smart urban mobility evolution —from the perspective of a sociotechnical system—it is necessary to understand its processes, actors, context and the interdependence among them (Lyons, 2018). Especially if it is approached as a path to sustainability, for this reason, a systemic approach still presents itself as a good tool for developing the subject. Observing Figures 3.1 and 3.2, it is possible to identify multiple options to have urban mobility where the technology—which is a medullar element—can be changed to analyse or propose other solutions to the causalities problem. For example, ones with no vehicles attached or others where the driver is removed from the system.

Following the line of thinking, it is possible to affirm that the mandatory car technology ISA is a ICT. Therefore it is part of an ITS and could integrate Smart Mobility and foster Smart Cities. But, all these steps have some characteristics that modify the final extent of their impact in a Smart City. To assess this is required to know how ISA is expected to operate in more detail.

3.4 Speed Control in Smart Cities

At this point, a great quantity of information about ISA–a speed-limiting technology—has been presented in this document, and, as mentioned, it has a big potential to increase safety in vehicles and reduce injuries. It has a variable degree of autonomy (see section 1.2). Taking the elaborations in this chapter, it is clear that the level of contribution of ISA to Smart Urban Mobility, Smart Cities and Sustainability for the next years—at least ten, taking into consideration the times specified in 'Regulation (EU) 2019/2144' (2019)—resides in the specification of the system and the legal framework. While the specifications are discussed in the following lines of this chapter, the implications of the last are discussed to more extent in chapters 5 and 6.

3.4.1 Speed-Limiting creates Smart Cities

The specifications for ISA were established for the EU in the 'Regulation (EU) 2021/1958' (2021). The more relevant requirements in the document—from the perspective of this research—are described as follows:

ISA as a whole:

1. Shall be composed by three subsystems, a Speed Limit Information Function (SLIF) and either a Speed Limit Warning Function (SLWF) or a Speed Control Function (SCF).
2. There should be several methodologies for feedback, and the manufacturers should be able to choose among those.

3. The speed delimitation system could be, among others, camera observation, map data or machine learning. Anyway, explicit numerical speed limit signs take precedence over any other input. Nevertheless, the driver is always responsible for respecting the local rules.
4. An international catalogue—or database—with the available speed limit signals options of all the MS shall exist for testing and development.
5. MS are 'encouraged' to ensure the correct placement and maintenance of speed limit signs on streets and roads.
6. It is not required to have self-driving capabilities.
7. System's digital map is not required to have a 'turn-by-turn' navigation quality. Anyway, digital maps along with camera systems and GNSS—which should be compatible, at least, with Galileo and European Geostationary Navigation Overlay Service (EGNOS) systems—are considered the state of the art systems.
8. Should not continuously record, nor retain or transmit other data—as speeding events—than the required.

Speed Limit Information Function (SLIF):

9. Should automatically detect—or allow the manual input—of the country where the vehicle is located.
10. It is not required that it takes into account special variable conditions such as, among others, environmental conditions or hour of the day.
11. The system's reliability should be 14 years; similarly, manufacturers' responsibility is to update all the digital information at least once per year, over the air, automatically, free of charge, and for seven years from the manufacture of the vehicle.

Speed Limit Warning Function (SLWF):

12. Should provide a warning indication "by any of the following: (a) a visual warning and a cascaded acoustic warning; (b) a visual warning and a cascaded haptic warning; or (c) a haptic warning alone".

Speed Control Function (SCF):

13. Should attempt to reduce the vehicle's propulsion power and driveline torque in case of the detection of excessive speed.

Taking into consideration these requirements, Figure 3.3 presents the "co-evolution" of the urban mobility system into a smarter one incorporating ISA as a new technology to help with the compliance with speed limits. In the figure, it is observable how the complexity of the system increase as well as the number of players, interdependence, possibilities and uncertainties.

Furthermore, a new interdependence on the different elements of the urban mobility system can be observed in contrast to the observed in Figure 3.2. The equipment of the ISA technology in cars generates to the drivers the possibility of having redundancy in the management of speed or even delegating the control (see Figure 3.4). The redundancy must be understood as the enacting of the Safe System Approach. The new configuration reduces the possibility of surpassing the allowed speed, reducing the risk of accidents, casualties, and other externalities. It can also be observed from the infrastructure perspective—although it is not remarked in the figure—the role of traffic signs in the systems. These facts confirm the function of ISA as an ITS because of its ICT capabilities. ISA interacts with the infrastructure through a Infrastructure to Vehicle (I2V) visual communication between traffic signs and the system and delivers data in different ways to the driver or takes control of the car's speed. On the other hand, ISA can generate data that could be shared or used by other systems, e.g. EDR or ACSW. So, the result of equiping ISA is the creation of a smart urban mobility that can get the status of sustainable urban mobility if the process continues generating the benefits over time.

3.4.2 The Transition from Speed-Limiting to Speed-Control

Following the definition of control explained in section 2.1, it is possible to understand that speed control means reducing the participation of the driver and switching the control of limiting the speed of cars to another entity as the infrastructure. So, using systemic thinking over the current Urban Mobility System, the transition requires that ISA evolves, reducing the driver's participation. Then, the transition could be done in three steps or phases. Step 1, eliminate the possibility of disabling ISA. Step 2, prioritise SCF over the SLWF, which eventually could be eliminated. Step 3, allow external control over the SCF. Even though it is possible to argue that this modification can transform the system completely, its relationship with the city and its sustainability could be the same but improved. Moreover, the modification is completely aligned with the automation objectives. Nevertheless, it is possible to foresee some challenges that even nowadays should be tackled. This transition will be discussed widely in chapter 5.

In this chapter—using previous definitions, literature review, and a systemic approach—an analysis of the definitions and interconnection between sustainability, smart cities, and smart mobility concepts has been performed. The logic of the analysis was elaborated from the point of view of using cars in an urban population and reducing casualties due to the bad use of speed through the mandatory equipment of ISA in cars. Following the arguments presented in this analysis, it is possible to conclude that ISA—a speed-limiting technology— has the potential to modify Urban Mobility Systems with the use of technology. And—in intelligent ways—integrate a Smart Urban Mobility reducing the number of killed and injured people—and other additional effects on citizens, cities and resources—due to road accidents, fostering then Smart and Sustainable Cities. Answering the question *How do speed-control technologies fit in the smart city concept?*, speed control must be understood as a natural evolution of ISA, which can inherit the potentials and the benefits, being also a contributor to Sustainable and Smart Cities, with the difference that, maybe, it can contribute to a faster and broader extent.

In order to propose any transition, it is necessary to know the status of the point of departure. If well, in this chapter, the "big picture" of the sociotechnical system around ISA has been presented in chapter 4 a 'snapshot' on the status of cities and citizens about the implementation of ISA and its possible evolution is performed.

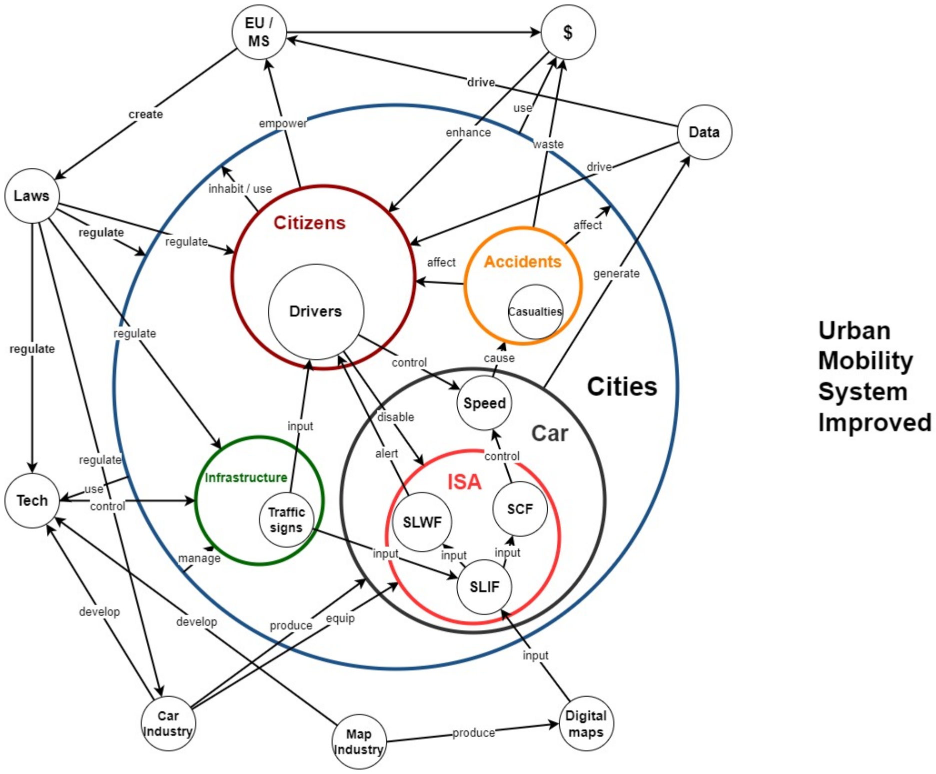

Figure 3.3. Urban mobility system including ISA.

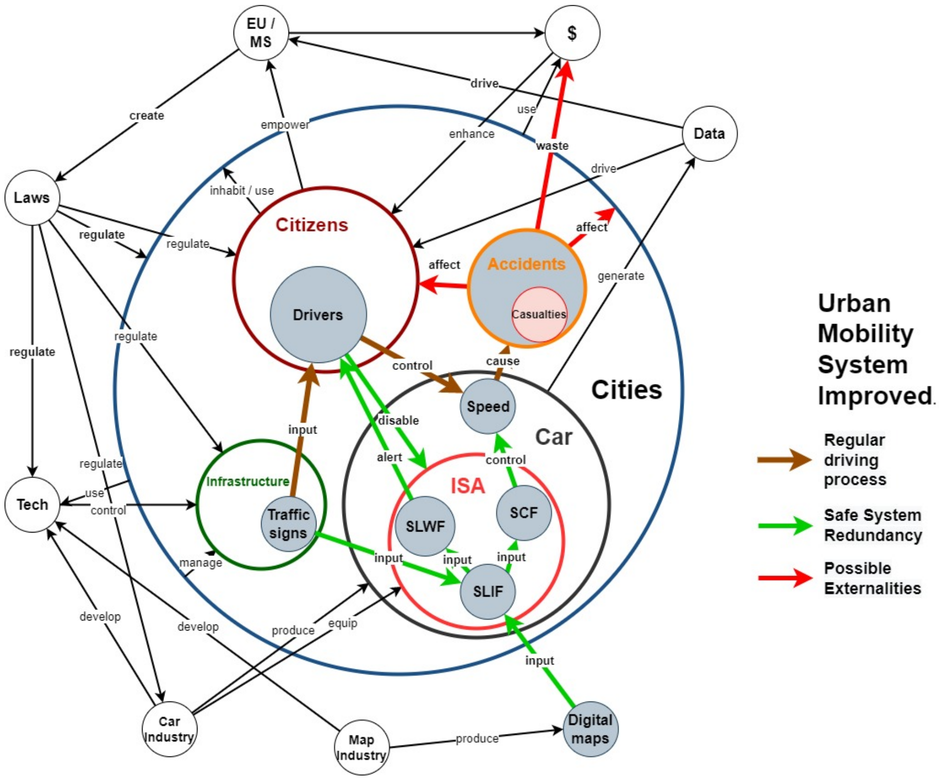

Figure 3.4. Smart urban mobility system with ISA. The redundancy on speed-limiting in the driving sub-system enacts the Safe System Approach with the potential of reducing accidents, casualties and improving the sustainability.

Cities' and Citizens' Readiness 4

In chapter 1 an introduction to the problem around road safety is presented at the global and the EU level, stressing the increasing challenges in cities and the role of speed which the EU approaches by new measures. In chapter 3, a connection between speed-limiting technologies—specifically ISA—, smart cities, and sustainable cities was elaborated, locating the three concepts in a sociotechnical system and defining the relationship between them.

Answering the question that Carsten (2012) asked ten years ago, "Is intelligent speed adaptation ready for deployment?" it is possible to say that ISA is ready at a technological level, but at social and spacial is something that still needs to be assessed. In this chapter, having this "playground" set, an analysis of cities' and citizens' readiness is performed. As commented in section 2.1.3, the concept of *readiness* is something that could be constructed. In this project, the readiness for the implementation of ISA will be constructed and assessed from cities' and citizens' angles in the form of Key Performance Indicator (KPI) with two objectives. First, to propose an objective way of measuring *readiness* that can be used as the base of the Safe System Approach and as a tool for monitoring the progress of the desired evolution. Second, define a baseline as a point of departure for the transition management from a speed-limiting system into a control-limiting system.

Then, to get the data required for the KPI assessment of cities, a questionnaire was used following the method described in section 2.3.3. At the same time, the survey collected information that helps to understand the context where the sociotechnical system is placed; this information is used in chapter 5 for further analysis. A general description of the most important findings is presented as a point of departure.

4.1 General Results of the Survey

The survey—performed as discussed in section 2.3.3—collected 189 valid responses from 17 countries in Europe. In this section, the most important findings are presented. The most relevant data is available in the Appendix C where the observed frequency tables are shown (section C.2), as well as the correlation analysis (section C.3, and the most relevant dependencies found. Of the total respondents—as shown in Table C.1—105 (55.6%) are female, and the rest is male; no further distinction on gender has been performed. The age of the respondents was classified into five segments. The persons younger than 30 were the predominant respondents of the survey (63.5%), followed by the group with ages going from 30 to 42 (16.4%). This fact could be attributed to the survey being performed digitally, a medium more familiar among young people. Another possible factor is that the survey was advertised more emphatically among students and mostly around Aalborg University.

Most of the respondents live in urban areas (94.7%), while the remnant pct. Visit urban areas one or more times per month (see Table C.1). It is important to mention that the respondents who answered that they do not reside in an urban area and never visited them are not included as valid ones.

The respondents reside in 16 countries from the EU and Switzerland. The countries with more participation were Denmark (41.8%), Spain (14.8%), Germany (14.3%), and the Netherlands (7.9%) (see Table C.1). The high number of respondents in Denmark could be associated with the high promotion performed in Aalborg University as well as the ads placed in several buildings in the city.

The level of income among the respondents—only the 14.8% preferred not to answer this question— has a diverse representation between the categories established (see Table C.1). Moreover, there is a statistically positive correlation between income level and age $\rho(187) = .243, p < .001$

The 89.9% of the respondents have a valid driving permit, 67.2% own or use a car, and 40.2% are planning to buy a car in the next two or three years (see Table C.2).

Of the 127 respondents that own or use a car, 85% exceed speed limits in some degree of frequency. Only 3.1% do it all the time. Moreover, of the 108 respondents that exceed speed, 53.7% do it not intentionally, while 32.4% do it when they are in a hurry, and 25% do it because, in their perception, the limit is incorrect. Only 2.1% of the total respondents had an accident because of speeding (see Table C.2). There is a negative correlation between the frequency of speeding and the respondent's age $\rho(125) = -.302, p < 0.001$. And a strong dependence between the perception of having wrong speed limits and the frequency of speeding $\chi^2(3) = 25.73, p < 0.001, \varphi_c = 0.45$.

Only 15% of the cars used by the respondents have ISA. Moreover, from all the respondents, 57.7% acknowledged never had used ISA, and 18.8% do not know if they had done it. Of the 48 respondents that have used ISA, 77.1% have a perception between good and excellent about driving with the system. However, 29.2% found the sound alerts and 20.8% the visual alerts annoying. Furthermore, 27.1% do not like to be limited. Important to mention that 10.4% found the experience unsafe. There is a negative correlation between income level and the experience satisfaction using ISA $\rho(46) = -.288, p = .047$. A reason mentioned twice as a cause for a bad perception of ISA is the system's misreadings of the signs. Finally, 45.8% of the people that use or have used ISA think that practice is required to use the system (see Table C.3).

88.9% of all the respondents do not know that ISA will be mandatory from 2024 onward. Knowing the fact and the technology, 61.4% thinks that drivers should be able to disable ISA only in specific situations or never at all (9.5%). The majority of the surveyed people (91%) acknowledge that ISA will help to some degree of the extent to reduce road traffic injuries. Only 30.2% mentions that it could help to a great extent. Furthermore, there is a positive correlation between the additional safety expected by ISA and: the age of the respondents $\rho(187) = 0.185, p = 0.011$, the experience using ISA $\rho(46) = .385, p = .007$, and the perception of safety for road users respecting the speed limits $\rho(187) = .383, p < 0.001$.

As road users, 88.9% of the respondents feel somewhat, or to a great extent, safe when others respect the speed limits (see Table C.3). Moreover, between this perception of safety and the frequency of speeding, there is a negative correlation $\rho(125) = -.306, p < .001$, and a positive with the experience using ISA $\rho(46) = .298, p = .04$.

The willingness to participate in the regulation processes of ISA is almost equally divided among the respondents, being the majority (51.3%) willing to do it. On the other hand, 23.6% of the respondents are willing to share their speeding history anonymously with the government; 55.9% is willing if there is some benefit attached, and 20.5% do not want to do it. Similarly, 63.8% is willing to share their data with insurance companies if there is any benefit, 24.4% never want to do it, and 11.8% wants to do it all the time (see Table C.4).

Other findings will be discussed in the following chapters to give context to the desired transition.

4.2 Cities' readiness

As deeply discussed in the previous chapter, from the Urban Mobility System perspective, infrastructure plays a major role. Moreover, infrastructure is a fundamental element for the correct operation of ISA. For this reason, it is clear the necessity of a scale that reflects their state. This research then presents a KPI assessing the state of the speed-limiting infrastructure to express how ready a selected urban area is to attend to the necessity of its inhabitants, legislation and technologies.

4.2.1 Urban Readiness Index

For evaluating the current readiness—and possible future evaluation—of cities, a set of indicators—that could also be conceptualised as KPI by their right—are integrated into one global KPI. This KPI will be referred to as Urban Readiness Index (URI) and the equation that represents it:

$$URI = SDMC + TSA + TSVQ + ADM + AII \tag{4.1}$$

Where:

Speed Digital Map Coverage (SDMC): Evaluates the level of development of the speed-limit digital maps in the selected area. It is expressed by the equation:

$$SDMC = \frac{\text{Total length of roads covered by the digital speed-limit map in the area [m]}}{\text{Total length of roads in the area [m]}} \tag{4.2}$$

It is important to clarify that in this study, it is assumed that the technology in ISA will use digital maps with linear vectors, like the ones presented by the municipalities. Additionally, the quantity of roads in the area includes all the roads regardless if they are public or private under the principle that—with the current specification—cars, and perhaps some humans, can not understand the difference.

Traffic Signs Availability (TSA): Defines the availability of the road signs in the current area, taking as a reference the digital speed-limit map. The resultant is a decimal number, and it is expressed by the formula:

$$TSA = \frac{\text{Number of traffic signs existent in the area [unit]}}{\text{Number of traffic signs required in the area[unit]}} \tag{4.3}$$

Traffic Signs Visibility Quality (TSVQ): Express in a decimal number the proportion of the existent traffic signs that are visible—i.e. can be observed and interpreted correctly—by vehicles. A traffic sign is considered visible when it is in a state that allows it to be read by a regular driver, under good light and weather conditions, as defined by the test procedures in 'Regulation (EU) 2021/1958' (2021). It is calculated with the equation:

$$TSVQ = \frac{\text{Number of visible traffic signs in the area[unit]}}{\text{Number of existent traffic signs in the area [unit]}} \tag{4.4}$$

Accuracy of the Digital Map (ADM): Measure the accuracy of the digital map quantifying the length of roads that have wrong information in comparison to the reality in the area. It is expressed as a decimal number and calculated using the following formula:

$$ADM = \frac{\text{Total length of roads wrongly mapped [m]}}{\text{Total length of roads mapped [m]}} \tag{4.5}$$

Accuracy of the Installed Infrastructure (AII): Measure the accuracy of the installed infrastructure as a result of the proportion between the number of traffic signs that are wrongly positioned in the area giving wrong information to drivers and ISA. This scenario is the most dangerous because it mischief the safety system and the driver, who is—as explained in the previous chapters– the final responsible for speed control in the car. It is expressed as a decimal number and calculated using the following formula:

$$AII = 1 - \frac{\text{Number of wrong traffic signs in the area[unit]}}{\text{Number of required traffic signs in the area[unit]}} \tag{4.6}$$

Node: It should be understood as a point in the road where there is a transition of the speed limit for vehicles identified by an indication in the digital speed limit's map or by the presence of traffic signs in the street indicating such change. A node could include interconnected streets, different vehicle paths, and one or more traffic signs.

Following the definition of the expressions, it is clear that the maximum possible outcome of the KPI is five points. Then, a city is considered *ready* when it has a URI = 5. If the KPI is inferior to five, it will indicate a level of readiness. But it is clear that it is Utopian to expect to have a perfect score in this indicator, being a 'snapshot' as it is. A result of five will be the exception, not the rule, but smart cities should aspire to maintain it as high as possible, becoming then more sustainable.

All the required data for the different variables, and the calculus of the indicators, were gathered following the field observation methods explained in section 2.3.4. In the following two sections, the results of those observations and the formulation of the KPI are analysed and presented for each one of the defined areas. Furthermore, it should be noted that both case study areas are located in Denmark, so some facts should be considered. The standard speed inside urban areas is 50 km/h. The speed-limit traffic signs comply with the European regulations in general and are included in the catalogue of the ISA specification 'Regulation (EU) 2021/1958' (2021).

4.2.2 The Case of Vor Frue Parish in Copenhagen

Vor Frue Parish is a central area in the heart of Copenhagen, Denmark. It covers an estimated area of 1.24 km2. The total length of roads was calculated at 13 892 m, and there are three different speed limits: 30, 40 and 50 km/h. Twenty-seven nodes were identified in the area. In Figure 4.1, it is possible to observe the delimited area, the identified nodes, and the speed limits in every street.

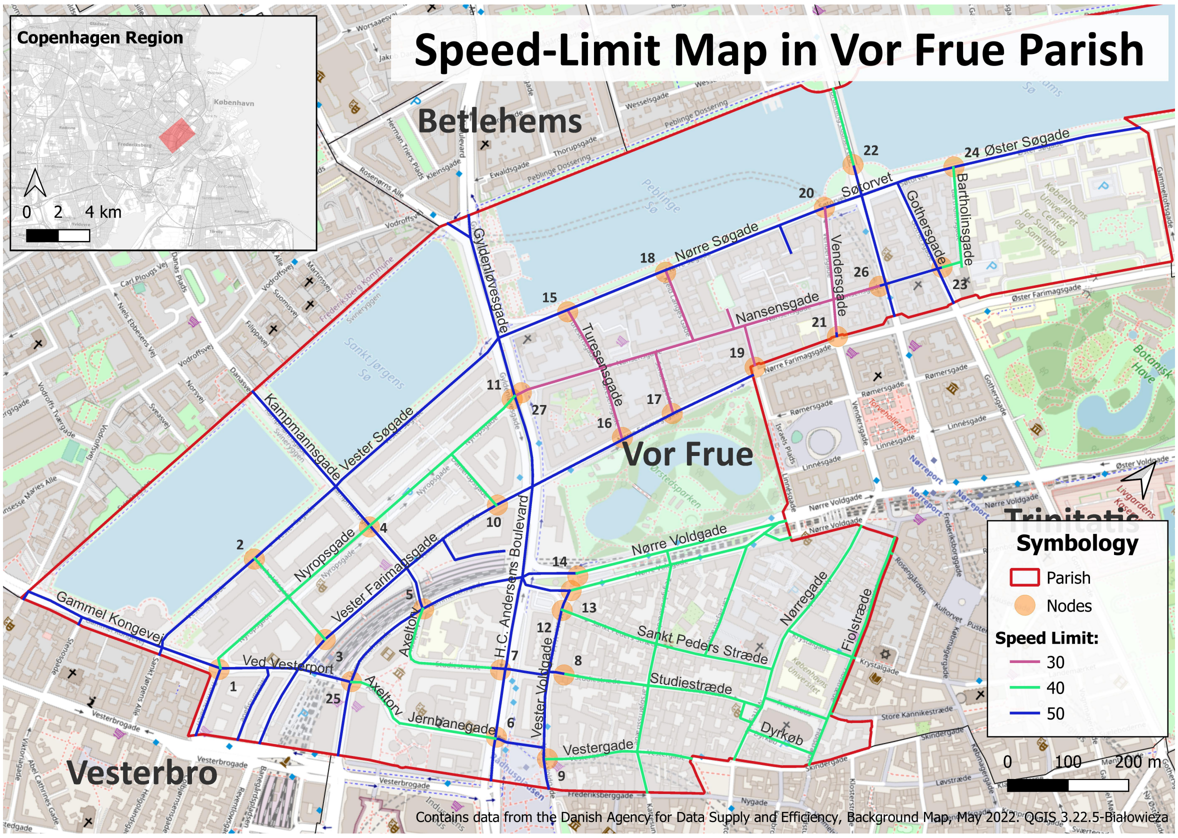

Figure 4.1. Speed-Limit map and identified nodes in Vor Frue Parish, Copenhagen. With data provided by *Trafikhastigheder* (no date).

The indicators were calculated with the information published by the municipality and the collected data at the field observation. Both the data and the calculations are included in Appendix B.1. The results are the following:

SDMC = 1.00

The Municipality of Copenhagen's speed-limit digital map covers effectively 100% of the free-access roads in the area, as observable in Figure 4.1.

TSA = 0.73

Several traffic signs in the area are not installed, which implies that the knowledge of the speed limit resides exclusively in the digital map if ISA is enabled. Another factor observed is the lack of signs in those places where construction processes are using the street somehow.

TSVQ = 0.59

The lowest score in the area. The visibility of the traffic signs is compromised by multiple—and sometimes combined—factors such as:

- The sign is located too close to the beginning of the street, making it difficult for drivers, particularly for ISA, when the vehicle is turning and entering the mentioned street due to the angle of vision. Moreover, ISA's camera "shall not be required to observe more than the forward field of vision of the driver through the motor vehicle's front windscreen" 'Regulation (EU) 2021/1958' (2021, Annex I, article 5.1). An example of this phenomenon is the Node 15—Nørre Søgade and Turesensgade—where the speed limit is difficult to be observed for those drivers and cars running on Nørre Søgade and turning to the right to enter Turesensgade (see Figure 4.2).

- False positives in the identification. Some signs are located in positions that allow a misinterpretation of the correct speed limit by drivers and ISA. This is the case—for example—of the sign located in the Node 25 where cars and drivers circulating on Hammerichsgade can be confused by a traffic sign that means to control the speed on the crossing street Axeltorv (see Figure 4.3.
- Obstacles in the line of vision.
- Degraded quality of the sign because of ageing or vandalism.

Figure 4.2. Visibility issue in Vor Frue at Nørre Søgade and Turesensgade (Node 15). When entering the signed street, drivers and cars do not see the sign correctly, coming from a turn to the right.

Figure 4.3. False positive in Vor Frue at Hammerichsgade and Axeltorv (Node 25). A driver and a car circulating on Hammerchisgade can easily confuse the speed sign installed for Axeltorv (the crossing street).

ADM = 1.00

There were no observable differences between the digital map and the reality in the streets of the whole area.

AII = 1.00

There were no traffic signs wrongly installed or information generating conflicts or confusion in the interpretation of the speed limit in the streets of the entire area.

URI = 4.32

The Vor Frue Parish is ready only to some degree for the deployment of ISA. Then, the city of Copenhagen is not ready for the deployment of ISA, reducing the impact of the Safe System Approach.

4.2.3 The Case of Sankt Markus Parish in Aalborg

The Sankt Markus Parish covers an area of 1.53 km2, and it is located near downtown Aalborg, Denmark. The area has —predominantly—a mixed land use. Inside the area, there are 20 854 m of roads which allows speeds going from 15 to 60 km/h. In the Parish, 38 nodes were identified and visited. In Figure 4.4, it is possible to observe the delimited area, the identified nodes, the speed limits in every street, as well as some additional discoveries.

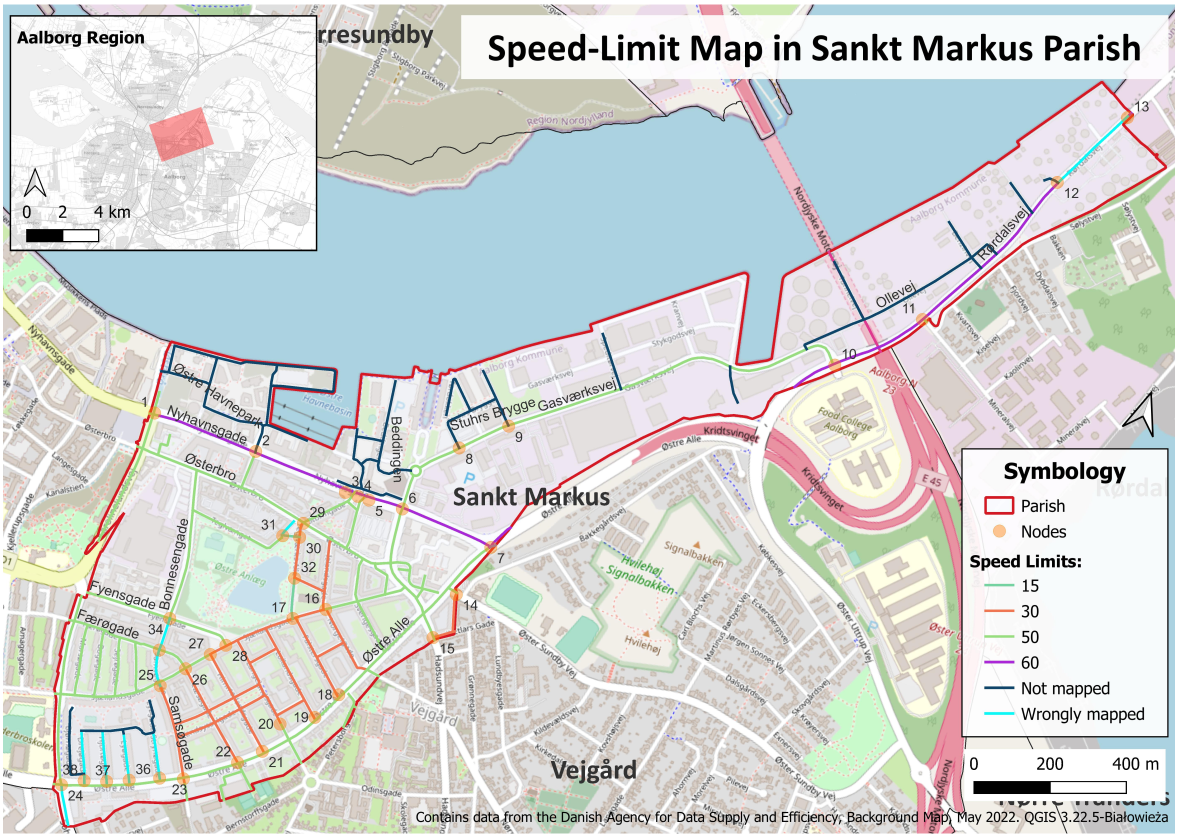

Figure 4.4. Speed-Limit map and identified nodes in Sankt Markus Parish, Aalborg. With data provided by Municipality (2022)

The indicators for the KPI were calculated using the collected data in the field observation and the data provided by Aalborg Municipality. Both the data and the calculations are included in Appendix B.2. The results are the following:

SDMC = 0.78

The indicator originated from the difference between the speed-limit digital map of the Aalborg Municipality—which covers an estimation of 16 165 m of roads—versus the calculated length of 20 854 m of free-access roads in the area. It is possible—but it was not verified in this research—that the roads marked as *Not mapped* in Figure 4.4 are private. Nevertheless, all the vehicles can access the street then. They should have the best information available to comply with the Safe System Approach and enable ISA.

TSA = 0.77

Several traffic signs in the area are not installed, which implies that the knowledge of the speed limit relies exclusively on the digital map if ISA is enabled. In this study case, this is the worst valued indicator. An example is Node 11 at the intersection of Rørdalsvej and Mineralvej. At this point, a transition from 60 to 50 km/h is indicated on the digital map, but there are no traffic signs installed (see Figure 4.5). So there is an error on the map or a lack of infrastructure. In any case, the safety could be assured by ISA thanks to the digital map.

TSVQ = 0.90

The visibility of the traffic signs is compromised by multiple—and sometimes combined—factors such as:

- Similarly to the case in Copenhagen, some signs are located too close to the beginning of the street, making it difficult—as explained above—its readability. This problem was identified in Tegiværks Alle (Node 30), where the limit speed is set at 15 km/h due to the presence of VRU. Moreover, in this case, a false positive could also be produced (see Figure 4.6).
- Obstacles in the line of vision.
- Degraded quality of the sign because of ageing or vandalism.

Figure 4.5. Lack of speed signs in Sankt Markus at the intersection of Rørdalsvej and Mineralvej (Node 11). The point is a transition from 60 to 50 km/h, as indicated in the digital map.

Figure 4.6. Visibility issue in Sankt Markus at Tegiværks Alle (Node 30), an access to a VRU zone. Despite of that drivers can see the sign, ISA possibly not, or could generate a false positive.

ADM = 0.93

In the field observation, it was possible to notice discrepancies between the digital map and the reality on the streets. An amount of 1 147 m was mapped with a different speed than the indicated in the traffic signs.

AII = 0.99

In this case, there was only one wrongly-installed sign in node 25. This error could be attributed to recent civil work performed in the area. Nevertheless, this generates conflicts with the speed limit in a sector. It is possible also to think that the same works generated a problem with the digital map's accuracy as it has an error starting from the same point.

URI = 4.37

The infrastructure in Sankt Markus Parish is not ready yet for the implementation of ISA. Anyway, it is to some degree. Then, the city of Aalborg is not ready—considering the established parameters—for the deployment of ISA.

4.2.4 Contrasting URIs

Both of the studied cases are not fully ready for implementing ISA. This point means that they are also not ready to implement speed-control technologies, at least not with the current specifications of ISA.

The comparison of the indicators is presented in Table 4.1. Even though both areas are of a similar status having a very advanced degree of readiness, it is remarkable the level of mapping in Vor Frue, as the quality of visibility in the traffic signs in Sankt Markus. Both areas have similar status in the implementation of the infrastructure, and, in both cases, there are practically no errors in the placement of the infrastructure. Nevertheless, in the case of Vor Frue the visibility of the speed-limit traffic signs is quite poor. This last fact contributes heavily to having a URI with better performance in Aalborg that in Copenhagen.

KPI	Vor Frue	Sankt Markus	Both areas
SDMC	1.00	0.78	0.87
TSA	0.73	0.77	0.75
TSVQ	0.59	0.90	0.80
ADM	1.00	0.93	0.96
AII	1.00	0.99	0.99
URI	**4.32**	**4.37**	**4.37**

Table 4.1. Cities readiness KPI Summary

Finally—despite not being possible to generalise the results to Denmark or the EU—taking the numbers of both areas altogether gives an idea of how danish cities' readiness is. This scenario is also presented in Table 4.1. It is observable that the lack of infrastructure—physical and digital—is the principal challenge, followed by the quality of the visibility, in the case of the physical, and the coverage of the digital. Using the situation map of the urban mobility sociotechnical system elaborated in chapter 3, it is possible to venture that this is the result of the maintenance or supervision cycles—or planning—in the respective areas. It can also be generated or amplified by the resources available. On the other hand, the installation has almost no mistakes which show good execution processes.

Applying this methodology in bigger samples could generate more detailed information.

4.3 Citizens' readiness

Evaluating the readiness of citizens is much more complex than evaluating cities' readiness. This complexity is because of the role that plays citizens—people—and their interactions in the Urban Mobility System. Citizens have multiple factors that interact and modify how citizens behave, affect or get affected by other citizens and cities (see Figure 3.1). Those factors— in the form of elements, sub-systems, and interactions— are: the presence of regulations for cities, citizens and technology; the existence of a sub-system of accidents which is produced because of the acts—as the control of speed—of citizens; the existence of "new" technologies that can help to reduce the accidents drastically; the access to those technologies as equipment in cars and the willingness to use it. The integration of these factors as KPI could result in a measure of the readiness of citizens to speed-limiting and control technologies.

4.3.1 Citizen Readiness Index

Just as the URI, a set of KPI is defined—taking into consideration the factors mentioned above—and integrated into one global KPI. Citizen Readiness Index (CRI) is proposed as a way to measure the level of readiness of citizens. The following formula represents this index:

$$CRI = AR + AB + AT + PT \tag{4.7}$$

Where:

Acknowledgement of the Regulation (AR): Indicates if the resident of an urban area knows about the existence of the regulation about ISA. The number is expressed in decimals and is calculated with the following formula:

$$AR = \frac{\text{Number of persons that knows about the regulation [people]}}{\text{Total number of persons[people]}} \tag{4.8}$$

Acknowledgement of the Benefit (AB): Measures, as a decimal number, if the people know the magnitude of the benefit of the introduction of the speed-limiting technology regulation.

$$AB = \frac{\text{Number of persons that acknowledge the benefit of the technology [people]}}{\text{Total number of persons[people]}} \tag{4.9}$$

Acceptance of the Technology (AT): Measures, in decimals, if the people are willing to use the technology.

$$AT = \frac{\text{Number of persons who think the technology must be used [people]}}{\text{Total number of persons[people]}} \tag{4.10}$$

Penetration of the Technology (PT): Indicates if citizens acknowledge the availability of ISA in the cars. It is important to understand that this implies that the penetration goes beyond the actual presence of the technology in the car. In this proposal, the index includes the fact that the drivers acknowledge it. The number is expressed in decimals.

$$PT = \frac{\text{Number of persons that have access to the technology [people]}}{\text{Number of persons that use a car[people]}} \tag{4.11}$$

A CRI = 4 implies that citizens are completely ready for the new regulation. However, it is ridiculous to think that a perfect score is achievable because it implies that all the people have—at this moment—a similar base of knowledge, resources and preferences. It is not real. Then, it is important to define the elements that integrate the concept of citizens' readiness and the level that is sufficient to achieve it. In other words, it is necessary to define which levels are enough to achieve the vision zero and the sustainability goals. Assessing these levels is out of this project's scope, but future research could build on this at local and regional levels. Then, in this project, the absolute scale will be used to assess readiness.

4.3.2 The cases of Denmark, Germany and Spain

As mentioned above, most of the survey's respondents reside in—or visit frequently—urban areas in Denmark, Spain, Germany and The Netherlands. For this reason, a case study of this segment is elaborated on the results obtained in the survey on these countries, as an example of the use of the defined KPI.

Acknowledgement of the Regulation (AR) = 0.11

The numbers required for this indicator are gathered with the question *Are you aware that in the EU, ISA technology will be mandatory in all new vehicles from 2024 onwards?* from the survey. The numbers obtained for the selected countries are visible in Table 4.2. It is the indicator with the lower score, and it could be a sign of low interest in the regulations happening at the EU level.

Country	Yes	No	Total	AR
Denmark	5	74	79	**0.06**
Germany	1	26	27	**0.04**
Netherlands	2	13	15	**0.13**
Spain	9	19	28	**0.32**
Total	**17**	**132**	**149**	**0.11**

Table 4.2. AR in selected countries.

Looking at the analysis country by country, a big difference between Spain and the rest of the countries is observable.

Acknowledgement of the Benefit (AB) = 0.81

The question *To what extent do you think ISA could help deal with road traffic injuries and deaths?* provided the data for this indicator. As mentioned in chapter 1, it is expected that the mandatory equipment of ISA in cars benefits to a great extent the safety of roads. For this reason, the answers *somewhat* and *to a great extent* are considered as aligned with the available knowledge and then added to get the number of people that acknowledge the benefit. The results are shown in Table 4.3

Country	To a great extent	Somewhat	Very little	Not at all	Total	AB
Denmark	21	36	8	14	79	**0.72**
Germany	10	14	2	1	27	**0.89**
Netherlands	5	8	2	0	15	**0.87**
Spain	13	14	0	1	28	**0.96**
Total	**49**	**72**	**12**	**16**	**149**	**0.81**

Table 4.3. AB in the selected countries

There is a big difference between Denmark, which has a low score, and the other countries in this indicator. Nevertheless, as a whole, this indicator has the highest score, reflecting a high level of understanding of the benefits of ISA.

Acceptance of the Technology (AT) = 0.68

The indicator takes the data from the question *Do you think drivers should be able to turn off the ISA system?* taking into consideration that people should not want to turn off ISA if they find something useful on it. With this in mind, the answers *Only in specific situations* and *Never* are added to get the number of persons who think the technology must be used. The numbers are shown in Table 4.4.

Country	Never	Only in specific situations	At any moment	Total	AT
Denmark	11	38	30	79	**0.62**
Germany	4	15	8	27	**0.70**
Netherlands	0	12	3	15	**0.80**
Spain	1	21	6	28	**0.79**
Total	**16**	**86**	**47**	**149**	**0.68**

Table 4.4. AT in the selected countries

Again, Denmark has —by far—the lowest score while the Netherlands and Spain have the highest ones similarly.

Penetration of the Technology (PT) = 0.17

The required data comes from the question *Does the car you use have Intelligent Speed Assistance (ISA)?* The sum of *Yes* responses—as defined above— is considered as the number of persons that have access to the technology. The numbers are shown in Table 4.5.

Country	Yes	No	I don't know	Total	PT
Denmark	4	38	4	46	0.09
Germany	5	16	2	23	0.22
Netherlands	1	4	2	7	0.14
Spain	7	15	3	25	0.28
Total	**17**	**73**	**11**	**101**	**0.17**

Table 4.5. PT on selected countries

The result shows a very low penetration with a big difference between the countries.

Citizen Readiness Index (CRI) = 1.78

Following the established formulas, the CRI was determined as shown in Table 4.6.

Country	AR	AB	AT	PT	CRI
Denmark	0.06	0.72	0.62	0.09	**1.49**
Germany	0.04	0.89	0.70	0.22	**1.85**
Netherlands	0.13	0.87	0.80	0.14	**1.94**
Spain	0.32	0.96	0.79	0.28	**2.35**
Total	**0.11**	**0.81**	**0.68**	**0.17**	**1.78**

Table 4.6. CRI in the selected countries

The resultant CRI shows that citizens are far to be ready for the implementation of ISA. However, as mentioned previously, this is only a "snapshot" of the current system, and the information is valuable to construct a better one. Moreover, the results of this analysis can not be generalised, but future studies could get representative samples and confirm the tendency.

4.4 The readiness of the Smart Urban Mobility System

In this chapter, a definition of readiness has been built from the Smart Urban Mobility System created in chapter 3. This definition is represented as a KPI that can be used to support the existent one defined by the UE (see section 1.1.2). URI and CRI was constructed from different indicators, which allows the redefinition of the concepts with the addition or removal of new indicators. At the same time, the presented KPI can be escalated and can be easily transformed to measure the readiness of other technologies, e.g. the EDR. Furthermore, there is the possibility—it is not explored in this research—of including the CRI as one of the indicators that are part of URI. This possibility is enhanced under the premise that citizens inhabit—and use, form, and transform—cities as visible in the so-mentioned Smart Urban Mobility System. The other way around is also a possibility.

On the other hand, answering the sub-question two *Are cities and citizens ready for the transition?*, it is clear that an absolute answer is a utopia, but it is possible—and necessary—to have a degree of readiness. However, if an absolute grade is required, it is possible to say that cities and citizens in the EU are not ready as some of its parts are not ready for the transition to the mandatory use of speed-limiting technologies or a further speed-control technology. Moreover, talking about cities, it seems that there are important advances. However, citizens require different strategies to improve their readiness and facilitate the transition. The technology's acceptance and the awareness of its benefits are high—as has been in the last ten years—but the knowledge of the proposed solutions at the EU level and the penetration of the technology are low—as has been since more than ten years.

Talking then about a transition for a more advanced level of ISA—which allows the external control of speed in cars—sounds like a fantasy. But having the technology as it is now, it is possible to think in a faster transition. In chapter 5 a proposal on how to manage it is presented.

Transition Management, From ISA to Speed Control 5

In this chapter, the "playground" defined in chapter 3 and the data gathered and analysed in chapter 4 are used to envision a possible way to achieve the Vision Zero faster—from the car usage in cities' perspective—using the theory of Transition Management.

5.1 Where is the Urban Mobility System Now?

The first step is to define where citizens and cities are with this objective in mind. At this point, the great problem of injuries and fatalities on roads, the role of speed and its effects on cities have been exposed. Now, it is possible to understand the urban mobility system—from a car usage in cities perspective. The most critical elements and interrelationships have been identified, e.g. cities, citizens, technology, and regulations. It is understood how the modification of the regulations impacts such sociotechnical systems, creating new elements and new interrelations that exemplify the redundancy desired by the Safe System Approach. It is clear how KPIs are the base of the Safe System Approach and the relevance of the Safe System approach to creating sustainable cities; and how KPIs can be constructed to assess the concept of readiness. Moreover, it is understood what is required to consider the urban mobility system as a smart and sustainable one and the difference between intelligent and smart concepts. It is clear how ISA is an ITS and its role in the transition of the system, its benefits, and potential in the road of automation. A set of KPIs was proposed as a complement to the defined by the EU (see 1.1.2) assessing the readiness of cities and citizens upon the introduction of ISA. Those KPIs—and the information gathered for their use—had raised information on the readiness of the cities and citizens to adopt the speed-limiting technology.

Then, the mandatory implementation of ISA is a fact. The measure helps to construct smart mobility, a smart city and contributes to the sustainability of cities through the reductions of deaths and injuries from road accidents and the improvement of road safety. KPIs can measure the readiness for its deployment, and a sample using them showed that cities and citizens are not completely ready yet. At the same time, the survey showed that citizens have "some" disposition to share data. It also showed that the majority think it is good to have external control of the speed, at least in some scenarios such as being unconscious or during criminal activities. From the perspective of this research, there are conditions to think that speed-control—following an incremental path to autonomous vehicles (Alessandrini, Domenichini, and Branzi, 2021b)—could be a real option in the short term.

However, this research has found multiple challenges that need to be solved just for ISA implementation. So it makes sense to elaborate on them to achieve a successful and quick deployment and pave the road to speed-control technologies.

5.1.1 Challenges

The implementation of ISA in the EU—as required in the last regulation—implies several challenges that need to be addressed, and there are more if the objective—as proposed in this research—is to achieve a faster reduction of casualties and the eventual transition—as desired by the EU—to automated mobility. In the literature review, several conflicts were identified. From those, in the following lines, the most relevant are presented.

- The level of development in the MS is far to be equal (Filippova and Buchou, 2020), so the expected time for a real implementation of ISA in vehicles could be longer than expected.
- It is still a polemic matter the definition of speed limits in the roads among MS (Translated by Content Engine LLC, 2022). As commented in the general results of the survey, this is one of the reasons—with a strong dependence—why people exceed speed limits. Moreover, this has not changed in the last 22 years since Silcock—mentioned by Vlassenroot (2011)—found the correlation.
- There is a lack of road geometry considerations in ISA (Abdelkader, Elgazzar, and Khamis, 2021). This fact opens the door to other kinds of the evolution of the technology that are required but are not included in the legislation as ACSW, implying that manufacturers may or may not integrate it as a proprietary subsystem.
- ISA speed-limit signs miss-recognition and difficulty to distinguish small modifiers on them is a known issue reported by the car industry and specialists (AutoTrader, 2021). The recognition problem was confirmed by the survey respondents in this research (see appendix C.2).
- The capacity of disabling the system as a whole or in parts, invalidate the purpose of the system completely or reduce the effect of the measure at least (Vlassenroot, 2011; AutoTrader, 2021). Even not disabling ISA, the system can be overridden just by ignoring the alerts, a fact that does not make any sense (AutoTrader, 2021).
- Auditive and visual alerts from ISA could be annoying for drivers (Lahrmann, Agerholm, Tradisauskas, Næss, et al., 2012; AutoTrader, 2021). On the other hand, in this research's survey, only a portion of the drivers that had used ISA found it annoying (see section 4.1). However, people that dislike the alerts may turn them off (Council et al., 2021). This research found a dependence between the respondents who always want to be able to turn off the system and found annoying the auditive $\chi^2(2) = 36.84, p < 0.001, \varphi_c = 0.441$, and visual $\chi^2(2) = 19, p < 0.001, \varphi_c = 0.317$ alerts.
- There is a possibility of having people without the proper preparation for its use; in the case of vehicle technologies, this could be fatal, so training could be required. Indeed, the EP (2017) stresses the necessity of training in the use of mandatory ADAS and the use of economic incentives as well. This necessity is supported by the survey findings that show that 45.6% of respondents think that practice is needed to drive a car with ISA, and 14.6% thinks they actually can not, meaning that new training is required. Moreover, there is a statistical dependence between the need for training and having experienced discomfort in ISA's deceleration process $\chi^2(2) = 7.96, p = .019, \varphi_c = .407$.
- Physical infrastructure requires completion and a high level of maintenance. As shown in section 4.2.4, some places lack traffic speed-limit signs, and there is also a large number of signs that require an improvement in their visibility. Although the implementation of ISA in cars transfers the cost of speed-limit compliance enforcement from the society to drivers, a big portion of resources is still needed to warranty the level of infrastructure required. Infrastructure requires an international standard not only in the signs, but in the core of the MS legislation's (ANEC,

2021; Alessandrini, Domenichini, and Branzi, 2021b), and monitoring or—ideally—certification (Alessandrini, Domenichini, and Branzi, 2021a).

- Variable message signs are designed for human readability, and they present technical challenges to visual sensors (Alessandrini, Domenichini, and Branzi, 2021b).
- Digital infrastructure requires an international standard and validation. It also requires completion and a high level of maintenance, as shown in section 4.2.4. The entire responsibility of equipping and maintaining the speed-limiting maps in vehicles resides in the manufacturers without a mechanism of validation or certification from the MS 'Regulation (EU) 2021/1958' (2021). Moreover, the participation of the private sector to reduce the risk to VRU is fundamental as there are roads of high use that are at risk of not being covered because they are not "public", and it is not defined how ISA should behave in private roads. On the other hand, ISA regulations do not take into consideration conditional speed limits in digital maps, which nowadays could be available, nor the fact that road authorities should be the providers of the information to update (Here and Tomtom, 2021).
- The society—meaning all the actors involved—needs to define the level of responsibility of the different parts when accidents happen with a certain level of automation (Alessandrini, Domenichini, and Branzi, 2021d); this is the case if ISA is used as a speed-control technology.
- Insurance companies should jump in and create products and incentives for the adoption of ISA. Nevertheless, it could take time. As a reference, by 2019, there were only seven countries with products related to EDR technologies (Europe, 2019). Having new products is a possibility now that the problem of multiple technologies and functionalities is, to some degree, solved with the EU specification. Moreover, insurance firms have an opportunity; drivers are willing to reduce speed if there is a benefit in their premiums (Lahrmann, Agerholm, Tradisauskas, Berthelsen, et al., 2012). This fact is supported by the majority of the respondents in the survey that see an option to share their historical speed data if there is a benefit associated (see section 4.1).
- Sharing data related to car use patterns is still taboo for multiple reasons. Among the respondents of the survey, the willingness to share data with the government or private companies is polarised between always and never (see section 4.1). The new regulation specifies that some should be shared from drivers to manufacturers and from them to the government, but users always can opt not to do it. The collection of information is crucial for having good improvements in future regulations, as shown in the urban mobility system map.
- There is a paradox in the sustainability of ISA. The trade-off of having a technology that lasts for 14 years—as required in 'Regulation (EU) 2021/1958' (2021)—is that modern technologies evolve faster and could have an improved sustainability faster (Here and Tomtom, 2021). However, having long-last technology reduces, e.g. consumption patterns that nowadays are generating several unsustainable practices in all the world or inequality (Independent Group of Scientists appointed by the Secretary-General, 2019).
- A good deal of citizens are not aware of ISA legislation as documented in section 4.3.1. In the survey, a statistical dependence was found between the acknowledgement of the new regulation and the age of the respondents $\chi^2(4) = 19.91, p < 0.001, \varphi_c = 0.325$.
- Among society in general, there is still a big discussion on the ethical dimension of using technology to limit citizens' behaviour and storing and sharing of their information. On the one hand, it is the ethical position of road managers that must ensure the safety of citizens (Alessandrini, Domenichini, and Branzi, 2021c). On the other hand, some citizens do not like the idea of being limited, monitored or surveyed in general (Yigitcanlar, 2016). In the survey, it was found a statistical dependence between

not liking to be limited by ISA and the frequency of speeding $\chi^2(3) = 12.22, p < 0.007, \varphi_c = 0.31$.

- By 2017, only 75% of vehicles have equipped those driver assistance systems required by law (EP, 2017). Five years later, this lack of advanced technologies are aligned with the survey results—where ISA is only equipped in 15% of respondents' vehicles—and the analysis in the citizens' readiness section. Moreover, it implies that many vehicles need to be replaced or modified to achieve the penetration of technology required.
- The solution proposed for speed-limiting control does not imply an external connection at the software level in a fist stance. However, it opens the possibility of "hacking" vehicles' functionality. This problem increases exponentially if the control technologies communicate at the software level (Alessandrini, Domenichini, and Branzi, 2021b).
- There is a lack of willingness of politicians to move road safety proposals as a priority (WHO, 2018). It took 40 years to implement ISA, and the posture of politicians a decade ago (Lahrmann, Agerholm, Tradisauskas, Næss, et al., 2012; Carsten, 2012) has not improved—fact confirmed by Lahrmann (2022). The actual regulation does not accelerate the transition processes, condemning a delay in the evolution of the technologies that are ready now.

Adding cities' challenges and their inevitable transition into Smart Cities to the mixture allows us to elaborate a hypothesis where the transitions into new technologies and smart cities are managed collaboratively; fostering innovation on variables such as speed, vehicle safety and infrastructure, which are measured through KPIs, and leading into a faster and sustainable reduction of killed and injured people in cities.

5.2 Where Should the System Go?

> "Bringing new technologies into society is not sufficient to improve urban sustainability. For this goal to be achieved, a sociotechnical transition path must be created through complementary actions, whose cumulative effects make it possible to replace a stabilised technological trajectory with a new configuration that works." (Mora et al., 2021, p. 3)

It is easy to see that on the road to car automation—as the EU envisions—the evolution of the speed-limiting technologies is the control-limiting technologies. Otherwise, it implies the assumption that regular users of autonomous cars will be able to program cars to surpass speed limits, which is absurd, perhaps possible, but illegal. Nevertheless, why speed control technologies? Speed control, using the definition of control in section 2.1, implies that external entities regulate the maximum speed allowed for a vehicle to circulate, so it reduces the possibility of human error considerably and builds safer roads at the cost of cut completely the possibility of speeding, i.e. enforcing the law. Make sense to trace a path where the actual smart urban system is transformed into a more sustainable one.

The New Goal

So in terms of Transition Management, the new goal is expressed as the desirable near future where the incremental transition to autonomous vehicles turns into a very low—near-zero—number of deaths and injuries as a product of speeding in cities. Considering the necessity of technical changes or the complete change of cars— non-autonomous —, the near future could be defined by 2035.

5.3 How to Change the System?

Following the definition of general problems performed by Kemp, Loorbach, and Rotmans (2007), it is possible to define a roadmap to avoid them.

The smart urban system illustrated in Figure 3.3 has been used to get knowing the system, its actors—or elements—and its interconnections is a fundamental exercise to understand the positions, ideals and goals of each one. This situational map should be enriched with the collaboration of society, academia, government and industry and include their interests. This helps reduce or eliminate the *dissent problem*. The mechanic's execution could help address the biggest systemic challenges as speed limits and infrastructure standardisation.

Once recognised the different points of view, interests, and the balances—and more importantly, the imbalances—of power, agreements and concessions should be assured in a systematic way solving the problem of *distributed control*. New regulations frame a joint vision and common goals among the MS. Moreover, the actual regulations on ADAS, and the specification on ISA is distributing control. This distribution is something that should not change. One example is that digital maps are now the responsibility of manufacturers and their providers. However, this does not eliminate the requirement of supervision or generation of data from the government.

There is a clear *technology lock-in* with the requirement of a camera and digital maps in the ISA specification, which was exposed by the manufacturing industry (Ford Europe, 2021). Nevertheless, this research acknowledges a need for technical specifications to allow further agreements on a matter of safety. Even though the new regulations have "open doors" to incorporate new technologies, it is also necessary to say that it is unclear how much this could change now, considering all the transformations involved. This lock-in is another reason why the convenience of elaborating on what is available now.

Watching at the macro level, it is clear that the new regulations have a long-term vision (see section 1.3.1). However, road safety has not been prioritised, and the advances are taking too much time, so perhaps, in this case, the problem of *political myopia* is switched to a *political astigmatism*. Transition arenas are an option considering the premise of achieving the goals faster, (Kemp, Loorbach, and Rotmans, 2007). So departing for collaboration, there should be a transition to empowerment. The other actors must pressure governments to create and maintain the arenas and foment the participation of citizens.

Looking for a faster advance in reducing traffic accidents related to speeding by 2035 implies a more aggressive approach to speed-limiting enforcing methods such as speed control. A speed-control vision could require very advanced technology and new complex systems, but not really in a first and quick approach. The sociotechnical system right now only requires a slight modification in technological elements that we have at hand, and ISA is the key. Building on the required steps for a transition mentioned in the sociotechnical analysis in chapter 3, a complete proposal of short-term steps are:

1. Eliminate the driver's faculty to disable ISA and its subsystems. So it will always be vigilante—and "annoying".
2. Increase the quantity of remote-controlled digital traffic signs. This measure could give traffic managers immediate and effective control over speed-limit enforcement.
3. Elevate to mandatory the presence of the SCF in cars. The equipment of this system and the short-term elimination of SLWF in the cars is a factor that upgrades and fixes the level of the system—and

perhaps the car—in the automation scale (see section 1.2). Moreover, with this step, indirect control over cars becomes a reality.

4. Allow external control over the SCF. This action is the most venturous of the short-term goals, as it requires a solution to all the challenges and high advances in V2X technologies. For this reason, it could be possibly catalogued as a mid-term step.

Every step should be supported by measuring the proposed KPIs, following the Safe System Approach.

Then, once the previous steps are followed, the envisioned future sociotechnical system is visualised in Figure 5.1.

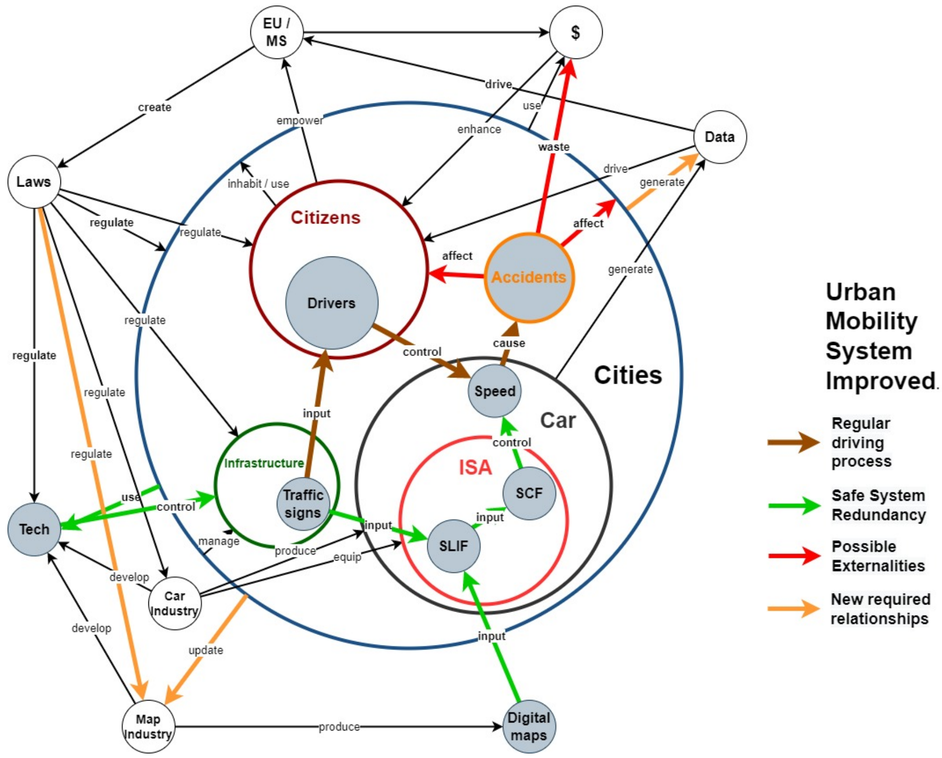

Figure 5.1. New urban mobility system including ISA oriented to speed-control.

5.3.1 Transition Management

Looking for the resolution of the challenges mentioned above and having a road map to avoid general problems, the transformation should be structured in the three levels to manage—as proposed by Kemp, Loorbach, and Rotmans (2007)—the transition. This distribution proposal follows the necessity of interrelation and collaboration at every level and across all the levels, enhancing a top-down and a bottom-up approach.

Strategic level

At this level, managing the transition and changing mentality from speed limit to speed control should be engaged and planned. This new focus implies modifying the actual regulations to reflect the proposed goals as soon as possible. Eliminate the possibility of disabling ISA and agree on the timing for the next steps. Foster the development of non-expensive technologies that can be adapted without the necessity of changing the whole car. Specify the role of the MS in the digital infrastructure as well the role of the privates.

Similarly, the standardisation of speed limits as well as physical and digital infrastructure in the MS should be done. Moreover, the new definition of responsibilities in case of accidents should be defined. Increasing the awareness of citizens and their participation should be prioritised. Last but not least, the inequity of income in MS should be addressed as a priority of the EU, as it affects the quick adoption of this—and any other—measures (Independent Group of Scientists appointed by the Secretary-General, 2019).

Tactical level

At this level, the transitions arenas should be enacted as well as the mechanisms for the opening and discussion of the data recollected by KPIs—as presented in this project—, manufacturers, ISA and related technologies, e.g. EDR. The divulging of new proposals and the construction of new developments for the evolution of the legislation should be nurtured by the governments in the form of collaboration between government, industry, academy, and the entire society. Governments have the key role of being the facilitators of the transition (Mora et al., 2021).

Operation level

The actual regulation assures information collection, but they should also define the mechanisms to use that information for all the actors and the times to produce the expected results. The regulation, KPIs, and data should drive all the interactions and executions at this level. Local authorities should improve and supervise the infrastructure and incentive the adoption of ISA and the sharing of data through safe channels. Moreover, they should ensure that citizens have the needed knowledge to use the new technology. Finally, they should balance and perform a cost-benefit analysis to adopt more sustainable and intelligent measures. Car and subsystem manufacturers should improve the technology by prioritising the visual sensors problems and the digital safety and assuring fair prices to increase the penetration of the technology. The insurance sector should propose new models of business giving incentives to ISA users and drivers who share data; society should acknowledge the speeding problem and the benefits of the proposal in reducing casualties. The academy should develop science that enables and facilitate all the previously mentioned, but it is important to acknowledge that scientific knowledge is falling short (Mora et al., 2021), so additional efforts are required.

5.3.2 Collaboration

At this point, it is easy to observe that, in order to achieve a sustainable smart urban mobility transition, an international, multidisciplinary, inter-sectoral, multilevel collaboration is needed (WHO, 2018; Lyons, 2018; Independent Group of Scientists appointed by the Secretary-General, 2019; EEA, 2019; Infrastructure (SV), 2020; Filippova and Buchou, 2020; Mora et al., 2021).

Society, in general terms— has its way of collaborating through different levels of participation in the processes. For example, in the case of ISA, the survey shows that the majority of the respondents are willing to participate in the regulations (see section 4.1). Furthermore, this moves this dissertation to face one crucial paradox. The more complex—, the more wicked—is the problem, the more important is the participation of the society, but the more needed is the expertise of the solvers (Daniels and Gregg Walker, 2001). In order to solve this fundamental paradox—as called by Daniels and Gregg Walker (2001)—the transition arenas should follow techniques that allow the understanding of citizens' necessities to policymakers and the complexity of the solutions to regular citizens. An example of this technique is the *Collaborative Learning*

Approach which uses elements from such areas as psychology and communication to allow different actors to engage in processes of civic discourse, disagreement and finding common ground to find solutions to complexities (Daniels and Gregg Walker, 2001). As explained in chapter 2, one of the main critiques of the Transition Management theory is the lack of relevance to the political sphere. At the same time, the transition management could stay at a level that does not necessarily have a point of contact with the society in general but only with the "relevant" stakeholders. This research acknowledges the importance of politicians as enablers of the transitions and the participation of the society as the key to moving the political will and connecting the transition arenas with the society. Moreover, those transformations where the society is involved have more probability of being achieved and sustained over the time (Independent Group of Scientists appointed by the Secretary-General, 2019; Daniels and Gregg Walker, 2001).

5.4 From a Smart Urban Mobility System to a Smarter One

In this chapter, understanding that the benefits of introducing new technologies as ISA could take too much time, a goal to reduce to near zero the casualties by 2035 was presented. To achieve this goal, a transition from cars with ISA into cars where the speed limit is enforced externally is presented as a solution. This goal means that a change in the recently defined sociotechnical urban mobility system is required as a natural evolution from a smart system to a smarter and more sustainable one. Answering the question, How could speed-control technologies implementation be managed? Transition Management is presented as a way to achieve the defined goal. A process was followed to identify different challenges and establish a road map to avoid known general problems and define steps that should be accomplished. Finally, the required changes were classified in the strategic, tactical and operational levels, which interactions allow the management of the transition.

In the process, it was observed that the vision is possible from a technological and systemical point of view. Nevertheless, from a societal perspective achieving the change is something that should be worked with participation as a tool for moving political willingness and for assuring the acceptance and sustainability of the measures. Collaboration is presented as a fundamental part of transition management.

Discussion 6

Forty years have transcurred since the conception of ISA, and this year it became a reality. Although it took much time—as mentioned repeatedly in the previous chapters—it is inspiring to observe the appliance of technology to build a safer future. Nevertheless, at the same time it is challenging. The increasing presence of actors and intermixed interests—that already is a lot—creates systems more and more complex every day. At the same time, there are more people, and the number of necessities is increasing as well. The relevance of having intelligent paths to solve the conflicts in a sustainable way is—at least—overwhelming, so all the available options should be compared. As explained in this document, Smart Cities is an excellent tool for solving conflicts and finding new possible solutions using technology and data. However—and repeating—it is indispensable to find not only smart but intelligent solutions as the resources are limited.

This necessity makes this researcher wonder, are speed-limiting and speed-control technologies necessarily the best solution for safety issues? Perhaps not. Society should ask itself if there is a fundamental necessity to control speeding. Furthermore, they may find that the answer is—again—no. If cars were not built with the capacity to achieve speeds beyond the international or local allowed speeds, the necessity of ISA or control systems could be not so indispensable in the macro. Inside urban areas, this could be less beneficial because the different speed-limits and the lack of standardisation. However, there is a speeding culture—historically repeated habits—that is the result of commercial interests and a created demand for the status quo, in this researcher's opinion. So, a more intelligent way of achieving safer roads could be the reduction of the native speed capacity in cars. Fortunately, some policy creators think similarly, and there are car manufacturers that are planning those reductions in their models (Translated by Content Engine LLC, 2022).

On the other hand, it is complicated to think of a future without technology. Another solution—a smart one—is coming based on technology, autonomous cars. As commented in the previous chapter, it is ludicrous to think that autonomous cars will be able to surpass speed limits in fully autonomous mode. Then, autonomous cars may be speed-controlled, or problems—such as the impossibility of stopping them in case of an accident—will be a matter of every day. On the other hand, if they are circulating along with non-autonomous cars, there is a risk if those are not limited. However, if the resumed list of challenges for the implementation of ISA—presented in section 5.1.1—seems long, it is possible to think that the list of challenges for autonomous cars should be, well, complicated. Even though it is true that the amount of resources dedicated to this goal is also enormous, there is not a clear definition—as far as the knowledge at this point— of when fully autonomous cars will be commercially available.

In any of these scenarios, cities require to be ready—in the terms defined in this research—and the infrastructure is crucial in the case of ISA and any further development of autonomous vehicles. City planners and policymakers need to have this in mind in order to plan the future of cities as presented in the research. Nevertheless, returning to the intelligent measures, speed limiting technologies present the possibility of disincentive the use of cars that are well known for being so unsustainable in urban areas. Increasing areas exclusive for VRU, reducing the speed in areas beyond scholar and residential and thinking in terms of mobilities could reduce the pressure on the necessity of speed limits enforcement, in the infrastructure, and the required resources, which is more sustainable. Moreover, digital connectivity is a real substitute for motorised transport (Lyons, 2018). On the other hand, having access to more resources could allow the implementation of smart solutions to increase safety in areas where cars are needed, but just the minimum to avoid future difficulties and expenses (Alessandrini, Domenichini, and Branzi, 2021d).

Returning to the smart solutions, in the design of future policies, infrastructure, and cities, the necessity of data is crucial, as commented in previous chapters. It has not been surprising that several people are willing to share personal information about their speed habits if there is a benefit attached, as found in the survey. The reason is literally at hand nowadays millions of people, car users and not, share all their personal information through their mobile smartphones—note the smart—every second, and the scope of that information goes far beyond their speeding habits, and people do not know or do not care. In this researcher's opinion, the ulterior motive of concern about sharing the historical speed information is the possibility of being penalised, but this is a matter of future research. However, it is clear that—in terms of intelligent solutions—a method of this kind for speed-limit enforcement could also be an easy and non-so-expensive measure; understanding why it is not taken into consideration is also an interesting topic for future research.

This possibility of enforcing through information opens another critical point of reflection. Where is the end of the citizens' right to mobilising as they want—even speeding? Where is the beginning and the end of the obligation of the authorities to limit destructive behaviours? Moreover, where is the beginning of the right of all road users that do not drive— especially the VRU—to feel safe? Well, there is not a straight or easy answer for this. The nature of wicked problems implies that the solutions could have winners and losers (Daniels and Gregg Walker, 2001); therefore, the importance of collaboration in the resolution processes. In any case, this researcher thinks that a rule of common sense should prevail, and speed limiting should be controlled as other dangerous situations are, e.g. smoking inside closed spaces or, going to the extreme, carrying guns. Another important argument to support this line of thinking is that 88.9% of the respondents of the survey express that they feel safer when vehicles respect speed limits (see section 4.1).

Continuing with the importance of data, the use of KPIs for its interpretation and measure is an interesting proposal from the Safe System Approach. In the case of this research, the proposed KPIs could and should be improved. In the case of the CRI, one possible improvement is the inclusion of an indicator that measures the citizens' acknowledgement of the problem, looking to give more sense to the measure of the perceived benefit. In order to do that, a specific question should be designed and incorporated into the questionnaire. Furthermore, this research intends to get a general idea of the readiness of cities and citizens. Both methodologies should be applied in parallel in the case of a specific area analysis, which can be done at several levels. In the case of the questionnaire, bias in the application should be avoided. In this research, most of the respondents were young, making it impossible for the results to be generalised beyond that group. In the case of the URI, one crucial improvement could be the inclusion of an indicator that measures the reflectivity of the traffic signs as a part of the TSVQ.

In summary, the transition of the existing urban mobility system into the safer one explored in this document could be complemented with subsystems—possibly in a positive feedback loop—that could generate awareness and behavioural changes in citizens, reduce the use of the car in cities, improve the willingness to generate and share data, and implement another smart solution to enforce speed limits in a short time. It also could include the evolution of the measurement tools as the proposed KPIs in the processes of data driving cities, citizens and governments into new legislation. These complements could also help to reduce the challenges that modern complexities present and, finally, accelerate the implementation of the evolution of ISA which hopefully would take much less than 40 years.

Conclusion 7

Concluding, it is possible to say that the transition to speed-control technologies could generate—faster—safer cities in a smart and sustainable way if there is an immediate collaboration among society, industry, academy and government.

Cities and citizens in the EU are not ready—from the perspective of this study—as some of its parts are not ready for the transition to the mandatory use of the speed-limiting technology Intelligent Speed Assistance (ISA). Then, they are not ready for a transition to speed-control technologies. Citizens require different strategies to improve their readiness and facilitate the transition. The technology's acceptance and the awareness of its benefits are high, but the knowledge of the proposed solutions at the EU level and the penetration of the technology is low. On the other hand, cities have significant advances, reducing the main problems to the lack of speed limit signs and their visibility. It is understood that absolute readiness is almost impossible to achieve. However, it is possible—and necessary—to have a degree of readiness and—for the purpose of this research—it has been measured through two KPIs, Urban Readiness Index (URI) and Citizen Readiness Index (CRI). Both KPIs were used to know the level—a 'snapshot'—of readiness of cities and citizens. This analysis was also used as a point of departure for ISA's transition proposal.

An advanced level of ISA—which allows the external control of speed in cars—sounds like a fantasy. However, having the technology as it is now, it is possible to think in a fast transition. In this research, a goal to reduce to near zero the casualties by 2035 is presented as a possibility. Similarly, Transition Management is introduced as a way to achieve it. ISA, being a technology, has the potential to modify Urban Mobility Systems and—in intelligent ways—integrate a Smart Urban Mobility. Reducing the number of killed and injured people—and other additional effects on citizens, cities and resources—due to road accidents, ISA fosters Smart and Sustainable Cities.

Speed control must be understood as a natural evolution of ISA that can inherit its potential and benefits, being also a contributor—but to a faster and broader extent—to sustainable and smart cities. Speed control means reducing the driver's participation and switching the control of limiting the speed of cars to another entity as the infrastructure. Furthermore, this possible transition is wholly aligned with the EU automation objectives. In this research, a road map was established to avoid known general problems, and different challenges of different magnitudes and scope—that must be addressed—were identified. Four steps or phases have been proposed as short steps to achieve the transition. The required changes were classified in the strategic, tactical and operational levels, which interactions can be used to manage the changes.

Finally, it is possible to transition from speed-limiting to control-oriented technologies following the proposed goals and strategy. From a technological and systemic point of view, some obstacles can be sorted with not many complications. Nevertheless, from a societal perspective, achieving the change is something very complex that needs to be worked with collaboration and participation as the tools for moving political willingness and assuring the acceptance and sustainability of the measures in citizens. Moreover, further research is required on ethics, different technological possibilities and uses, governance and power exertion. On the other hand, the studied change is only one more possibility in the universe of solutions, and those solutions should be taken into consideration in the sociotechnical system and also managed in order to get the most intelligent transition to safer roads with the benefit of the accomplishment of local and international goals.

References

'Regulation (EU) 2019/2144' (2019). "Regulation (EU) 2019/2144 on Type-Approval Requirements for Motor Vehicles and Their Trailers, and Systems, Components and Separate Technical Units Intended for Such Vehicles, as Regards Their General Safety and the Protection of Vehicle Occupants and Vulnerable Road Users". In: *Official Journal* L 325. URL: https://eur-lex.europa.eu/eli/reg/2019/2144/oj (visited on 02/28/2022).

'Regulation (EU) 2021/1958' (2021). "Comission Delegated Regulation (EU) 2021/1958 Supplementing Regulation (EU) 2019/2144 of the European Parliament and of the Council by Laying down Detailed Rules Concerning the Specific Test Procedures and Technical Requirements for the Type-Approval of Motor Vehicles with Regard to Their Intelligent Speed Assistance Systems and for the Type-Approval of Those Systems as Separate Technical Units and Amending Annex II to That Regulation". In: *Official Journal* L 409. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1958 (visited on 02/28/2022).

AAA (2019). *AAA Recommends Common Naming for ADAS Technology*. AAA Newsroom. URL: https://newsroom.aaa.com/2019/01/common-naming-for-adas-technology/ (visited on 04/30/2022).

Abdelkader, Ghadeer, Khalid Elgazzar, and Alaa Khamis (2021). "Connected Vehicles: Technology Review, State of the Art, Challenges and Opportunities". In: *Sensors (Basel, Switzerland)* 21.22, pp. 7712–. ISSN: 1424-8220.

Albino, Vito, Umberto Berardi, and Rosa Maria Dangelico (2015). "Smart Cities: Definitions, Dimensions, Performance, and Initiatives". In: *Journal of Urban Technology* 22.1, pp. 3–21. ISSN: 1063-0732, 1466-1853. DOI: 10.1080/10630732.2014.942092. URL: http://dx.doi.org/10.1080/10630732.2014.942092 (visited on 04/30/2022).

Alessandrini, Adriano, Lorenzo Domenichini, and Valentina Branzi (2021a). "Chapter 1 - Introduction". In: *The Role of Infrastructure for a Safe Transition to Automated Driving*. Ed. by Adriano Alessandrini, Lorenzo Domenichini, and Valentina Branzi. Elsevier, pp. 1–6. ISBN: 978-0-12-822901-9. DOI: 10.1016/B978-0-12-822901-9.00003-8. URL: https://www.sciencedirect.com/science/article/pii/B9780128229019000038.

— (2021b). "Chapter 2 - Automation Functions, Philosophies, and Levels". In: *The Role of Infrastructure for a Safe Transition to Automated Driving*. Ed. by Adriano Alessandrini, Lorenzo Domenichini, and Valentina Branzi. Elsevier, pp. 7–47. ISBN: 978-0-12-822901-9. DOI: 10.1016/B978-0-12-822901-9.00006-3. URL: https://www.sciencedirect.com/science/article/pii/B9780128229019000063.

— (2021c). "Chapter 4 - The Safe System Approach". In: *The Role of Infrastructure for a Safe Transition to Automated Driving*. Ed. by Adriano Alessandrini, Lorenzo Domenichini, and Valentina Branzi. Elsevier, pp. 65–146. ISBN: 978-0-12-822901-9. DOI: 10.1016/B978-0-12-822901-9.00008-7. URL: https://www.sciencedirect.com/science/article/pii/B9780128229019000087.

— (2021d). "Chapter 7 - Infrastructures to Accommodate Automated Driving". In: *The Role of Infrastructure for a Safe Transition to Automated Driving*. Ed. by Adriano Alessandrini, Lorenzo Domenichini, and Valentina Branzi. Elsevier, pp. 237–366. ISBN: 978-0-12-822901-9. DOI: 10.1016/B978-0-12-822901-9.00004-X. URL: https://www.sciencedirect.com/science/article/pii/B978012822901900004X.

ANEC (Apr. 2021). "Response to Public Consultation : Vehicle Safety – Technical Rules & Test Procedures for Intelligent Speed Assistance". In: URL: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12222-Vehicle-safety-technical-rules-&-test-procedures-for-intelligent-speed-assistance/F2256590_en.

AutoTrader, director (June 30, 2021). *Mandatory Car SPEED LIMITERS Are Coming!* URL: https://www.youtube.com/watch?v=u90uIuoqnQ0 (visited on 05/27/2022).

Avelino, Flor and John Grin (2017). "Beyond Deconstruction. a Reconstructive Perspective on Sustainability Transition Governance". In: *Environmental Innovation and Societal Transitions* 22, pp. 15–25. ISSN: 22104224. DOI: 10.1016/j.eist.2016.07.003. URL: http://dx.doi.org/10.1016/j.eist.2016.07.003 (visited on 05/03/2022).

Caragliu, Andrea, Chiara Del Bo, and Peter Nijkamp (2011). "Smart Cities in Europe". In: *Journal of Urban Technology* 18.2, pp. 65–82. ISSN: 1063-0732, 1466-1853. DOI: 10.1080/10630732.2011.601117. URL: https://doi.org/10.1080/10630732.2011.601117 (visited on 05/02/2022).

Carsten, Oliver (2012). "Is Intelligent Speed Adaptation Ready for Deployment?" In: *Accident Analysis and Prevention* 48, pp. 1–3. ISSN: 00014575. DOI: 10.1016/j.aap.2012.05.012. pmid: 22664661.

Council, European Transport Safety et al. (Apr. 16, 2021). *Concerns Regarding Delegated Acts on Event Data Recorders (EDR) and Intelligent Speed Assistance (ISA)*. Letter. URL: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12222-Vehicle-safety-technical-rules-test-procedures-for-intelligent-speed-assistance/F2242327_en (visited on 03/28/2022).

Council of the European Union (2017). *Valletta Declaration on Road Safety*. URL: https://eumos.eu/wp-content/uploads/2017/07/Valletta_Declaration_on_Improving_Road_Safety.pdf (visited on 03/14/2022).

Daniels, Steven and Gregg Walker (2001). *Working through Environmental Conflict: The Collaborative Learning Approach*. Westport, Conn: Praeger. 299 pp. ISBN: 978-0-275-96473-3.

Department of Infrastructure (2022). *Fact Sheet: Vulnerable Road Users*. National Road Safety Strategy. URL: https://www.roadsafety.gov.au/nrss/fact-sheets/vulnerable-road-users (visited on 06/01/2022).

DePoy, Elizabeth and Laura N. Gitlin (2016). *Introduction to Research: Understanding and Applying Multiple Strategies*. Fifth edition. St. Louis, Missouri: Elsevier. 398 pp. ISBN: 978-0-323-26171-5.

Dictionary, Oxford English (no date[a]). *Readiness, n.* In: *OED Online*. Oxford University Press. URL: http://www.oed.com/view/Entry/158863 (visited on 04/25/2022).

— (no date[b]). *Transition, n.* In: *OED Online*. Oxford University Press. URL: http://www.oed.com/view/Entry/204815 (visited on 05/03/2022).

Drew, Dorian (2019). *Everything You Need to Know about Car Safety Features*. URL: https://www.caranddriver.com/features/g27612164/car-safety-features/ (visited on 02/24/2022).

EC (2018). *COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT, Accompanying the Document Proposal for a Regulation of the European Parliament and of the Council on Type-Approval Requirements for Motor Vehicles and Their Trailers, and Systems, Components and Separate Technical Units Intended for Such Vehicles, as Regards Their General Safety and the Protection of Vehicle Occupants and Vulnerable Road Users, Amending Regulation (EU) 2018/... and Repealing Regulations (EC) No*

78/2009, (EC) No 79/2009 and (EC) No 661/2009) No 78/2009, (EC) No 79/2009 and (EC) No 661/2009. European Commission. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CONSIL:ST_9006_2018_ADD_2 (visited on 03/02/2022).

— (2019). "COMMISSION STAFF WORKING DOCUMENT, EU Road Safety Policy Framework 2021-2030 - Next Steps towards "Vision Zero"". In: pmid: 25246403.

— (2021). *Facts and Figures Regional Distribution of Fatalities*. 20206. Europan Road Safety Observatory. Brussels, European Comission, Directorate General of Transport. URL: https://ec.europa.eu/transport/road_safety/statistics-and-analysis/data-and-analysis/facts-and-figures_en.

EEA (2019). *The European Environment - State and Outlook 2020*. European Environment Agency. ISBN: 978-92-9480-090-9. DOI: 10.2800/96749. URL: https://www.eea.europa.eu/publications/soer-2020.

Elvik, Rune et al. (2019). "Updated Estimates of the Relationship between Speed and Road Safety at the Aggregate and Individual Levels". In: *Accident Analysis & Prevention* 123, pp. 114–122. ISSN: 0001-4575. DOI: 10.1016/j.aap.2018.11.014. URL: https://www.sciencedirect.com/science/article/pii/S000145751830839X.

Emborg, Jensen (Sept. 12, 2021). "Environmental Conflict (L13) How to Handle Complexity?" PowerPoint Presentation. Conflict Management Course (University of Copenhagen, Science, IFRO).

EP (2017). *Report on Saving Lives: Boosting Car Safety in the EU (2017/2085(INI))*. European Parliament. URL: https://www.europarl.europa.eu/doceo/document/A-8-2017-0330_EN.html (visited on 03/04/2020).

ETSC (Sept. 27, 2017). "Briefing: Intelligent Speed Assistance (ISA)". In: URL: https://etsc.eu/briefing-intelligent-speed-assistance-isa/ (visited on 04/29/2022).

Europe, Insurance (2019). "European Motor Insurance Market". In: (February), p. 32. URL: www.insuranceeurope.eu.

Eurostat (2022). *Statistics - Persons Killed in Road Accidents by Category of Persons Involved (Source: CARE)*. URL: https://ec.europa.eu/eurostat/databrowser/view/TRAN_SF_ROADUS__custom_2500597/default/table?lang=en (visited on 04/13/2022).

Filippova, Rimma and Nicolas Buchou (2020). *A Handbook on Sustainable Urban Mobility and Spatial Planning: Promoting Active Mobility*. Geneva: United Nations, Economic Commission for Europe, Sustainable Transport Division. ISBN: 978-92-1-004859-0. URL: https://library-gva.un.org/alma/sites/prod.alma/files/unpublications/ECE_TRANS_298_R.pdf (visited on 04/10/2022).

Ford Europe (2021). "Draft Consultation Response: Vehicle Safety –Technical Rules & Test Procedures for Intelligent Speed Assistance(ISA)". In: URL: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12222-Vehicle-safety-technical-rules-&-test-procedures-for-intelligent-speed-assistance/F2256545_en.

Geels, Frank W. (2005). "The Dynamics of Transitions in Socio-Technical Systems: A Multi-Level Analysis of the Transition Pathway from Horse-Drawn Carriages to Automobiles (1860-1930)". In: *Technology Analysis and Strategic Management* 17.4, pp. 445–476. ISSN: 09537325. DOI: 10.1080/09537320500357319.

Here and Tomtom (Apr. 2021). "Public Consultation on the Draft Delegated Regulation for Intelligent". In: URL: https://ec.europa.eu/info/law/better-regulation/have-your-say/

initiatives/12222-Vehicle-safety-technical-rules-&-test-procedures-for-intelligent-speed-assistance/F2256555_en.

Herranz-Perdiguero, Carlos and Roberto J López-Sastre (2018). "ISA^2: Intelligent Speed Adaptation from Appearance". In: DOI: https://arxiv.org/abs/1810.05016.

Hesse-Biber, Sharlene Nagy and Burke Johnson (2015). *The Oxford Handbook of Multimethod and Mixed Methods Research Inquiry*. ISBN: 978-0-19-993363-1. URL: https://ebookcentral.proquest.com/lib/concordiaab-ebooks/detail.action?docID=2044599 (visited on 05/07/2022).

Independent Group of Scientists appointed by the Secretary-General (2019). *Global Sustainable Development Report 2019: The Future Is Now – Science for Achieving Sustainable Development*. 1. United Nations. pmid: 28253485.

Infrastructure (SV), Minister for (2020). *Stockholm Declaration*. Third Global Ministerial Conference on Road Safety. URL: https://www.roadsafetysweden.com/about-the-conference/stockholm-declaration/ (visited on 03/03/2022).

ITF (2022). *"Road Accidents", ITF Transport Statistics*. (database). URL: https://doi.org/10.1787/g2g55585-en (visited on 04/13/2022).

Just-auto (2022). "Global Light Vehicle Safety Systems Market - Forecasts to 2035: 2022 Q1 Edition: Markets". In: *Just - Auto*. Bromsgrove: Aroq Limited, pp. 112–132.

Kemp, René, Derk Loorbach, and Jan Rotmans (2007). "Transition Management as a Model for Managing Processes of Co-Evolution towards Sustainable Development". In: *International Journal of Sustainable Development and World Ecology* 14.1, pp. 78–91. ISSN: 17452627. DOI: 10.1080/13504500709469709.

Lahrmann, Harry (2022). *Interview with Harry Lahrmann. Interviewed by Alan Fernández.*

Lahrmann, Harry, Niels Agerholm, Nerius Tradisauskas, Kasper K. Berthelsen, et al. (2012). "Pay as You Speed, ISA with Incentive for Not Speeding: Results and Interpretation of Speed Data". In: *Accident Analysis and Prevention* 48, pp. 17–28. ISSN: 00014575. DOI: 10.1016/j.aap.2011.03.015. pmid: 22664664. URL: http://dx.doi.org/10.1016/j.aap.2011.03.015.

Lahrmann, Harry, Niels Agerholm, Nerius Tradisauskas, Teresa Næss, et al. (2012). "Pay as You Speed, ISA with Incentives for Not Speeding: A Case of Test Driver Recruitment". In: *Accident Analysis and Prevention* 48, pp. 10–16. ISSN: 00014575. DOI: 10.1016/j.aap.2011.03.014. pmid: 22664663. URL: http://dx.doi.org/10.1016/j.aap.2011.03.014.

Lissandrello, Enza (Mar. 31, 2021). "Lecture 9: Transition Theory 1". PowerPoint Presentation. The Sociotechnical Context of Planning (Aalborg University).

Lyons, Glenn (2018). "Getting Smart about Urban Mobility – Aligning the Paradigms of Smart and Sustainable". In: *Transportation Research Part A: Policy and Practice* 115, pp. 4–14. ISSN: 09658564. DOI: 10.1016/j.tra.2016.12.001. URL: https://linkinghub.elsevier.com/retrieve/pii/S0965856416311028 (visited on 05/02/2022).

Mohn, Tanya (Mar. 28, 2022). "Can Controlling Vehicles Make Streets Safer and More Climate Friendly?" In: *The New York Times. World*. ISSN: 0362-4331. URL: https://www.nytimes.com/2022/03/28/world/europe/geofencing-sweden.html (visited on 04/03/2022).

Mora, Luca et al. (2021). "Assembling Sustainable Smart City Transitions: An Interdisciplinary Theoretical Perspective". In: *Journal of Urban Technology* 28.1-2, pp. 1–27. ISSN: 1063-0732, 1466-1853. DOI: 10.1080/10630732.2020.1834831. URL: https://www.tandfonline.com/doi/full/10.1080/10630732.2020.1834831 (visited on 05/13/2022).

Municipality, Aalborg (Mar. 30, 2022). *Hastighedskort*. E-mail.

OECD (no date[a]). *Gross Domestic Product (GDP) - GDP and Spending*. URL: https://www-oecd-ilibrary-org.zorac.aub.aau.dk/economics/gross-domestic-product-gdp/indicator/english_dc2f7aec-en?parentId=http%3A%2F%2Finstance.metastore.ingenta.com%2Fcontent%2Fthematicgrouping%2F4537dc58-en (visited on 02/23/2022).

— (no date[b]). *Road Accidents - Transport*. URL: https://www-oecd-ilibrary-org.zorac.aub.aau.dk/transport/road-accidents/indicator/english_2fe1b899-en?parentId=http%3A%2F%2Finstance.metastore.ingenta.com%2Fcontent%2Fthematicgrouping%2F8dacf707-en (visited on 02/23/2022).

Oxford English Dictionary (no date). *Control, v.* In: *OED Online*. Oxford University Press. URL: https://www-oed-com.zorac.aub.aau.dk/view/Entry/40563?rskey=wWquOm&result=2#eid (visited on 02/24/2022).

Peiris, Sujanie et al. (2022). "Quantifying the Lost Safety Benefits of ADAS Technologies Due to Inadequate Supporting Road Infrastructure". In: *Sustainability* 14.4, p. 2234. ISSN: 20711050. DOI: 10.3390/su14042234.

Peters, Kimberley (2022). "Your Human Geography Dissertation: Designing, Doing, Delivering". In: pages 106-125. 55 City Road: SAGE Publications Ltd. DOI: 10.4135/9781529714869. URL: https://sk.sagepub.com/books/your-human-geography-dissertation.

RoadSafetyFacts.eu (no date). *Active Safety Systems: What Are They and How Do They Work?* RoadSafetyFacts.eu. URL: https://roadsafetyfacts.eu/active-safety-systems-what-are-they-and-how-do-they-work/ (visited on 04/29/2022).

Schot, Johan and Frank W. Geels (2008). "Strategic Niche Management and Sustainable Innovation Journeys: Theory, Findings, Research Agenda, and Policy". In: *Technology Analysis & Strategic Management* 20.5, pp. 537–554. ISSN: 0953-7325, 1465-3990. DOI: 10.1080/09537320802292651. URL: http://www.tandfonline.com/doi/abs/10.1080/09537320802292651 (visited on 05/03/2022).

Shove, Elizabeth and Gordon Walker (2007). "Caution! Transitions Ahead: Politics, Practice, and Sustainable Transition Management". In: *Environment and Planning A: Economy and Space* 39.4, pp. 763–770. ISSN: 0308-518X, 1472-3409. DOI: 10.1068/a39310. URL: http://journals.sagepub.com/doi/10.1068/a39310 (visited on 05/03/2022).

smartbumps.com (no date). *SmartBumps – Intelligent Speed Bumps*. URL: https://smartbumps.com/ (visited on 04/03/2022).

Texas Instruments (no date). *Advanced Driver Assistance Systems (ADAS) - Overview*. URL: https://www.ti.com/applications/automotive/adas/overview.html (visited on 04/30/2022).

Trafikhastigheder (no date). In collab. with Københavns Kommune. Dataset. URL: https://www.opendata.dk/city-of-copenhagen/trafikhastigheder (visited on 04/03/2022).

Translated by Content Engine LLC (Feb. 2022). "The DGT's Bad Omen If You Buy a Car That Goes Faster than 200 Km/h". In: *CE Noticias Financieras, English Ed.* URL: https://www.proquest.com/wire-feeds/dgts-bad-omen-if-you-buy-car-that-goes-faster/docview/2630487161/se-2?accountid=8144.

UN (Aug. 14, 2009). *CONSOLIDATED RESOLUTION ON ROAD TRAFFIC*. URL: https://unece.org/best-practices-road-traffic-and-road-signs-and-signals (visited on 06/05/2022).

— (2020). *Sustainable Development Goals Report 2020*. S.l.: UNITED NATIONS. ISBN: 978-92-1-101425-9.

UN (2021). *Sustainable Development Goals Report 2021*. United Nations. URL: https://unstats.un.org/sdgs/report/2021/.

— (no date[a]). *Goal 11 - Department of Economic and Social Affairs*. URL: https://sdgs.un.org/goals/goal11 (visited on 03/26/2022).

— (no date[b]). *Goal 3 - Department of Economic and Social Affairs*. URL: https://sdgs.un.org/goals/goal3 (visited on 03/26/2022).

Vlassenroot, Sven (2011). "The acceptability of in-vehicle Intelligent Speed Assistance (ISA) systems: from trial support to public support". PhD thesis. Delft, The Netherlands: Netherlands TRAIL Research School. ISBN: 9789055841448.

WHO (2018). *Global Status Report on Road Safety 2018*. World Health Organization. ISBN: 978-92-4-156568-4.

Yigitcanlar, Tan (2016). *Technology and the City: Systems, Applications and Implications*. 1st ed. Abingdon, Oxon ; New York, NY : Routledge, 2016.: Routledge. ISBN: 978-1-315-73909-0. DOI: 10.4324/9781315739090. URL: https://www.taylorfrancis.com/books/9781317575696 (visited on 05/13/2022).

The UN efforts A

A.1 Priority UN Vehicle Safety Standards

The WHO (2018, p. 62) presents the following list of the UN standards as a priority that the nations should follow in order to increase the safety in vehicles:

"1-2: Frontal impact protection and side impact protection (R94- R95): ensure that cars withstand the impacts of a frontal and side impact crash when tested at certain speeds. These crash worthiness regulations help to protect occupants withstand the impact of front and side impact crashes.

3: Electronic stability control (R140): prevents skidding and loss of control in cases over-steering or under-steering and is effective at reducing crashes and saving lives. It is effective in avoiding single car and roll over crashes, reducing both fatal and serious injuries.

4: Pedestrian front protection (R127): provides softer bumpers and modifies the front ends of vehicles (e.g. removes unnecessarily rigid structures) that can reduce the severity of a pedestrian impact with a car.

5-6: Seat-belts and seat-belt anchorages (R14 & R16): ensure that seat-belts are fitted in vehicles when they are manufactured and assembled and that the seat-belt anchor points can withstand the impact incurred during a crash, to minimize the risk of belt slippage and ensure that passengers can be safely removes from their seats if there is a crash.

7: Child restrains (R129): ensure that the child seat is in place with the adult seat-belt and that ISOFIX child restraint anchorage points are fitted to secure the restraint.

8: Motorcycle anti-lock braking systems (R78): help the rider maintain control during an emergency braking situation and reduce the likelihood of a road traffic crash and subsequent injury."

A.2 Global Voluntary Performance Targets for Road Safety Risk Factors and Service Delivery Mechanisms

In 2017, the WHO established the Global Voluntary Performance Targets for Road Safety Risk Factors and Service Delivery Mechanisms. The WHO (2018, p. 19) enlist them as follows:

- "Target 1: By 2020, all countries establish a comprehensive multisectoral national road safety action plan with time-bound targets.
- Target 2: By 2030, all countries accede to one or more of the core road safety-related UN legal instruments.

- Target 3: By 2030, all new roads achieve technical standards for all road users that take into account road safety, or meet a three star rating or better.
- Target 4: By 2030, more than 75% of travel on existing roads is on roads that meet technical standards for all road users that take into account road safety.
- Target 5: By 2030, 100% of new (defined as produced, sold or imported) and used vehicles meet high quality safety standards, such as the recommended priority UN Regulations, Global Technical Regulations, or equivalent recognized national performance requirements.
- Target 6: By 2030, halve the proportion of vehicles travelling over the posted speed limit and achieve a reduction in speed related injuries and fatalities.
- Target 7: By 2030, increase the proportion of motorcycle riders correctly using standard helmets to close to 100%.
- Target 8: By 2030, increase the proportion of motor vehicle occupants using safety belts or standard child restraint systems to close to 100%.
- Target 9: By 2030, halve the number of road traffic injuries and fatalities related to drivers using alcohol, and/or achieve a reduction in those related to other psychoactive substances.
- Target 10: By 2030, all countries have national laws to restrict or prohibit the use of mobile phones while driving
- Target 11: By 2030, all countries to enact regulation for driving time and rest periods for professional drivers, and/or accede to international/regional regulation in this area.
- Target 12: By 2030, all countries establish and achieve national targets in order to minimize the time interval between road traffic crash and the provision of first professional emergency care."

Field Observation Results B

B.1 Data collected in Vor Frue Parish, Copenhagen

Node Label	Required traffic signs	Existent traffic signs	Visible traffic signs	Wrong traffic signs
1	2	2	1	0
2	2	2	1	0
3	2	0	0	0
4	4	2	1	0
5	2	2	0	0
6	2	2	2	0
7	2	2	2	0
8	1	1	1	0
9	1	0	0	0
10	2	0	0	0
11	1	1	1	0
12	1	1	1	0
13	1	1	1	0
14	1	1	1	0
15	1	1	0	0
16	1	1	0	0
17	1	1	1	0
18	1	0	0	0
19	2	2	1	0
20	1	0	0	0
21	1	0	0	0
22	2	2	2	0
23	2	2	1	0
24	2	0	0	0
25	2	2	1	0
26	2	2	1	0
27	2	2	0	0
Total	**44**	**32**	**19**	**0**

Table B.1. Data collected in Vor Frue

B.2 Data collected in Sankt Markus Parish, Aalborg

Node Label	Required traffic signs	Existent traffic signs	Visible traffic signs	Wrong traffic signs
1	2	2	1	0
2	5	3	3	0
3	1	0	0	0
4	1	1	1	0
5	1	1	1	0
6	4	0	0	0
7	2	0	0	0
8	2	2	2	0
9	2	2	2	0
10	5	4	3	0
11	3	1	1	0
12	0	0	0	0
13	0	0	0	0
14	2	2	1	0
15	2	2	2	0
16	2	2	2	0
17	2	2	2	0
18	2	2	2	0
19	2	2	1	0
20	2	2	2	0
21	2	2	2	0
22	2	2	1	0
23	2	2	2	0
24	0	0	0	0
25	2	0	2	1
26	2	2	2	0
27	2	2	2	0
28	2	2	2	0
29	2	2	2	0
30	2	2	1	0
31	2	1	1	0
32	2	2	2	0
33	4	4	4	0

Continuation of Table B.2

Node Label	Required traffic signs	Existent traffic signs	Visible traffic signs	Wrong traffic signs
34	6	2	2	0
35	2	2	0	0
36	2	2	2	0
37	2	2	2	0
38	2	2	2	0
Total	**82**	**63**	**57**	**1**

Table B.2. Data collected in Sankt Markus

Survey C

C.1 Questionnaire

Hi,

As a part of a master's degree thesis project at Aalborg University, my research aims to understand the readiness of inhabitants and visitors in urban areas toward the generalized use of speed-limiting technologies in cars.

The present survey is for people residing in the European Union, Norway or Switzerland. Responders should be older than 17. The participation is anonymous, and the recollected data will be confidential.

It should not take more than 6 minutes to complete.

Thanks for your help!

1. What is your gender? (1) Male (2) Female
2. What is your year of birth? (9) 2004 (10) 2003 (11) 2002 (12) 2001 (13) 2000 (14) 1999 (15) 1998 (16) 1997 (17) 1996 (18) 1995 (19) 1994 (20) 1993 (21) 1992 (22) 1991 (23) 1990 (24) 1989 (25) 1988 (26) 1987 (27) 1986 (28) 1985 (29) 1984 (30) 1983 (31) 1982 (32) 1981 (33) 1980 (34) 1979 (35) 1978 (36) 1977 (37) 1976 (38) 1975 (39) 1974 (40) 1973 (41) 1972 (42) 1971 (43) 1970 (44) 1969 (45) 1968 (46) 1967 (47) 1966 (48) 1965 (49) 1964 (50) 1963 (51) 1962 (52) 1961 (53) 1960 (54) 1959 (55) 1958 (56) 1957 (57) 1956 (58) 1955 (59) 1954 (60) 1953 (61) 1952 (62) 1951 (63) 1950 (64) 1949 (65) 1948 (66) 1947 (67) 1946 (68) 1945 (69) 1944 (70) 1943 (71) 1942 (72) 1941 (73) 1940 (74) 1939 (75) 1938 (76) 1937 (77) 1936 (78) 1935 (79) 1934 (80) 1933 (81) 1932 (95) Before 1932
3. Do you live in an urban area? (1) Yes (2) No
4. How often do you visit urban areas? (1) Never (2) 1-2 times per month (3) 3-15 times per month (4) 15-30 times per month
5. In which country is the mentioned urban area located? Please select one option from the list. (1) Austria (2) Belgium (3) Bulgaria (4) Croatia (5) Republic of Cyprus (6) Czech Republic (7) Denmark (8) Estonia (9) Finland (10) France (11) Germany (12) Greece (13) Hungary (14) Ireland (15) Italy (16) Latvia (17) Lithuania (18) Luxembourg (19) Malta (20) Netherlands (29) Norway (21) Poland (22) Portugal (23) Romania (24) Slovakia (25) Slovenia (26) Spain (27) Sweden (28) Switzerland
6. Which of these ranges describes your last year's income (use your local currency)? (9) Prefer not to answer (1) 0 (2) 1 to 9 999 (3) 10 000 to 24 999 (4) 25 000 to 49 999 (5) 50 000 to 74 999 (6) 75 000 to 99 999 (7) 100 000 to 149 999 (8) 150 000 or greater
7. Do you have a valid driver's permit? (1) Yes (2) No
8. Do you own or use a car? (1) I own a car (2) I use someone else's car (like family, company, rental, etc.) (3) I do not use a car

9. Are you planning to buy a car in the next 2-3 years? (1) Yes (2) No
10. How often do you exceed speed limits? (1) Never (3) Sometimes (4) Often (5) All the time
11. Which of the following statements explains better why you exceed speed limits? (1) I'm in a hurry (e.g. to an important meeting). (4) My car has the necessary technology to be safe, even at high speeds. (2) I feel pressured to speed (e.g. if someone is 'tailgating' me). (3) The limit is incorrect (there are similar roads with higher limits). (7) Others also do it, even worse than me. (6) The limit does not apply to me because I am a great driver. (9) Not intentionally (8) Other:
12. Did you have any car accidents in the past 5 years because of speeding? (1) Yes (2) No
    The following questions are about a car technology called Intelligent Speed Assistance.

    Intelligent Speed Assitance (ISA) uses cameras, digital maps, and other sensing technologies to alert drivers when the vehicle surpasses the current allowed speed. Some vehicles with this technology can even auto-limit the speed to avoid going beyond the permitted speed.

13. Does the car you use have Intelligent Speed Assitance (ISA)? (1) Yes (2) No (3) I don't know
14. Have you ever driven a vehicle with ISA? (1) Yes (2) No (3) I don't know
15. How was your experience driving a vehicle with ISA? (1) Excellent (2) Good (3) Not so good (4) Bad
16. Which of these explains better the graded experience? Please choose all the appliable options. (8) It is a great experience. (1) The sound alert is annoying. (2) The visual alert is annoying. (3) The pedal sensation is annoying. (4) The deacceleration process is not comfortable. (5) It is unsafe. (6) I do not like to be limited. (7) Other:
17. Do you think all the actual drivers can drive a car with integrated ISA? (1) Yes (2) Yes, but practice is required. (3) No
18. Are you aware that in the EU, ISA technology will be mandatory in all new vehicles from 2024 onwards? (1) Yes (2) No
19. Do you think drivers should be able to turn off the ISA system? (1) Never (2) Only in specific situations (e.g., in an emergency) (3) At any moment
20. To what extent do you think ISA could help deal with road traffic injuries and deaths? (1) To a great extent (2) Somewhat (3) Very little (4) Not at all
21. As a road user (walker, cyclist, driver), to what extent do you feel more secure if cars (other cars if you are a driver) comply with speed limits? (1) To a great extent (2) Somewhat (3) Very little (4) Not at all
22. If there is an opportunity to participate in ISA regulations, would you like to do it? (1) Yes (2) No
23. In which of the following scenarios would you share your speeding history anonymously with the government? (1) All the time. (2) Only if there is an accident. (3) Only if it represents a tax reduction. (4) Only if there is an accident or if it represents a tax reduction. (5) Never
24. In which of the following scenarios would you share your speeding history with insurance companies? (1) All the time. (2) Only if there is an accident. (3) Only if it represents a premium cost reduction. (4) Only if there is an accident or if it represents a premium cost reduction. (5) Never
25. In which of the following scenarios do you think authorities should be able to control the speed of vehicles externally? Please choose all the appliable options. (1) All the time. (2) The vehicle is used for criminal purposes (e.g. escaping, terrorism). (3) The vehicle is in a scholar area. (4) The vehicle is in a residential area. (5) The driver is unconscious. (6) Never.

Thanks!

C.2 Survey frequency and open responses

In the following tables, the results of the survey are displayed.

What is your gender?

	Percent	Respondents
Male	44.4%	84
Female	55.6%	105
Total	**100.0%**	**189**

Age group

	Percent	Respondents
17 - 29	63.5%	120
30 - 42	16.4%	31
43 - 55	12.2%	23
56 - 68	4.2%	8
69 - 81	3.7%	7
Total	**100.0%**	**189**

What is your year of birth?

	Percent	Respondents
2004	0.5%	1
2002	0.5%	1
2001	3.2%	6
2000	5.8%	11
1999	7.9%	15
1998	10.6%	20
1997	10.1%	19
1996	9.5%	18
1995	6.9%	13
1994	3.7%	7
1993	2.6%	5
1992	2.1%	4
1991	1.6%	3
1990	2.6%	5
1989	1.6%	3
1988	1.1%	2

Continuation of Table C.1

1987	0.5%	1
1985	1.1%	2
1984	0.5%	1
1983	1.1%	2
1982	0.5%	1
1981	0.5%	1
1980	1.6%	3
1979	3.7%	7
1978	4.8%	9
1977	3.2%	6
1976	0.5%	1
1975	0.5%	1
1974	0.5%	1
1972	0.5%	1
1969	0.5%	1
1968	0.5%	1
1966	1.1%	2
1965	0.5%	1
1963	1.1%	2
1957	0.5%	1
1956	0.5%	1
1953	1.6%	3
1952	0.5%	1
1951	0.5%	1
1950	1.1%	2
1947	1.6%	3
Total	**100.0%**	**189**

Do you live in an urban area?

	Percent	**Respondents**
Yes	94.7%	179
No	5.3%	10
Total	**100.0%**	**189**

How often do you visit urban areas?

	Percent	**Respondents**

Continuation of Table C.1		
Never	0.0%	0
1-2 times per month	20.0%	2
3-15 times per month	40.0%	4
15-30 times per month	40.0%	4
Total	**100.0%**	**10**

In which country is the mentioned urban area located?

	Percent	**Respondents**
Austria	0.5%	1
Belgium	0.5%	1
Denmark	41.8%	79
France	5.3%	10
Germany	14.3%	27
Greece	1.1%	2
Hungary	1.1%	2
Ireland	0.5%	1
Italy	4.8%	9
Lithuania	0.5%	1
Netherlands	7.9%	15
Poland	1.6%	3
Portugal	1.1%	2
Slovakia	1.1%	2
Spain	14.8%	28
Sweden	1.6%	3
Switzerland	1.6%	3
Total	**100.0%**	**189**

Which of these ranges describes your last year's income?

	Percent	**Respondents**
Prefer not to answer	14.8%	28
0	4.8%	9
1 to 9 999	10.6%	20
10 000 to 24 999	15.9%	30
25 000 to 49 999	10.6%	20
50 000 to 74 999	15.9%	30
75 000 to 99 999	7.4%	14

Continuation of Table C.1		
100 000 to 149 999	7.4%	14
150 000 or greater	12.7%	24
Total	**100.0%**	**189**

Table C.1. Socio-demographic frequency data

Do you have a valid driver's permit?

	Percent	**Respondents**
Yes	89.9%	170
No	10.1%	19
Total	**100.0%**	**189**

Do you own or use a car?

	Percent	**Respondents**
I own a car	38.1%	72
I use someone else's car (like family, company, rental, etc.)	29.1%	55
I do not use a car	32.8%	62
Total	**100.0%**	**189**

Are you planning to buy a car in the next 2-3 years?

	Percent	**Respondents**
Yes	40.2%	76
No	59.8%	113
Total	**100.0%**	**189**

How often do you exceed speed limits?

	Percent	**Respondents**
Never	15.0%	19
Sometimes	65.4%	83
Often	16.5%	21
All the time	3.1%	4
Total	**100.0%**	**127**

Which of the following statements explains better why you exceed speed limits?

Continuation of Table C.2

	Percent	Respondents
I'm in a hurry (e.g. to an important meeting).	32.4%	35
My car has the necessary technology to be safe, even at high speeds.	13.0%	14
I feel pressured to speed (e.g. if someone is 'tailgating' me).	19.4%	21
The limit is incorrect (there are similar roads with higher limits).	25.0%	27
Others also do it, even worse than me.	15.7%	17
The limit does not apply to me because I am a great driver.	1.9%	2
Not intentionally	53.7%	58
Other	12.0%	13
Total	**100.0%**	**108**

Which of the following statements explains better why you exceed speed limits? - Other

It still feels safe

A certain freedom from pain and boredom if you stick to it

Because limits are often low, I see no personal danger going faster a little faster

Sometimes I don't realize it and I usually exceed it on very few occasions.

Inattentive or cocky

After all, time is money, and time in the car is a waste of time unless you spend time on the phone and talk to customers

Often it is the general speed of the area

Because the police can't measure and you can't get fines for the 5-10% I drive too fast

Sometimes I drive 120 all the way. 10km/h below speed limits in some places and 10 km/h above other places

Because the traffic situation allows it

The limit is not optimal for gear shift

Dutch roads used to be 130, they changed it to 100, so now im driving 110

Did you have any car accidents in the past 5 years because of speeding?

	Percent	Respondents
Yes	2.1%	4
No	97.9%	185
Total	**100.0%**	**189**

Table C.2. Car-usage frequency data and open responses

Does the car you use have Intelligent Speed Assitance (ISA)?

	Percent	Respondents
Yes	15.0%	19
No	71.7%	91
I don't know	13.4%	17
Total	**100.0%**	**127**

Have you ever driven a vehicle with ISA?

	Percent	Respondents
Yes	17.1%	29
No	64.1%	109
I don't know	18.8%	32
Total	**100.0%**	**170**

How was your experience driving a vehicle with ISA?

	Percent	Respondents
Excellent	18.8%	9
Good	58.3%	28
Not so good	18.8%	9
Bad	4.2%	2
Total	**100.0%**	**48**

Which of these explains better the graded experience?

	Percent	Respondents
It is a great experience.	45.8%	22
The sound alert is annoying.	29.2%	14
The visual alert is annoying.	20.8%	10
The pedal sensation is annoying.	10.4%	5
The deacceleration process is not comfortable.	14.6%	7
It is unsafe.	10.4%	5
I do not like to be limited.	27.1%	13
Other	16.7%	8
Total	**100.0%**	**48**

Which of these explains better the graded experience? - Other

Continuation of Table C.3
Made a wrong acceleration on the highway: the system read a sign incorrectly and accelerated from 80 to 130, even though 80 was allowed limit
Practice must be acquired
In some cases, the limitations do not make sense, stand around for a long time on paths and no longer apply
Didn't quite pride it.
There wasnt any visual or Sound Warning. The car just drove the speed i told it too, until i pushed the breaks
I didn't mind
The system misreads the signs quite often
It does not interfere with my driving, only indicates the speed limit and helps in setting the cruise control.
Do you think all the actual drivers can drive a car with integrated ISA?

	Percent	**Respondents**
Yes	39.6%	19
Yes, but practice is required.	45.8%	22
No	14.6%	7
Total	**100.0%**	**48**

Are you aware that in the EU, ISA technology will be mandatory in all new vehicles from 2024 onwards?

	Percent	**Respondents**
Yes	11.1%	21
No	88.9%	168
Total	**100.0%**	**189**

Do you think drivers should be able to turn off the ISA system?

	Percent	**Respondents**
Never	9.5%	18
Only in specific situations (e.g., in an emergency)	61.4%	116
At any moment	29.1%	55
Total	**100.0%**	**189**

To what extent do you think ISA could help deal with road traffic injuries and deaths?

Continuation of Table C.3

	Percent	Respondents
To a great extent	30.2%	57
Somewhat	52.4%	99
Very little	8.5%	16
Not at all	9.0%	17
Total	**100.0%**	**189**

Table C.3. ISA frequency data and open answers

As a road user (walker, cyclist, driver), to what extent do you feel more secure if cars (other cars if you are a driver) comply with speed limits?

	Percent	Respondents
To a great extent	51.3%	97
Somewhat	37.6%	71
Very little	10.1%	19
Not at all	1.1%	2
Total	**100.0%**	**189**

If there is an opportunity to participate in ISA regulations, would you like to do it?

	Percent	Respondents
Yes	51.3%	97
No	48.7%	92
Total	**100.0%**	**189**

In which of the following scenarios would you share your speeding history anonymously with the government?

	Percent	Respondents
All the time.	23.6%	30
Only if there is an accident.	26.0%	33
Only if it represents a tax reduction.	6.3%	8
Only if there is an accident or if it represents a tax reduction.	23.6%	30
Never	20.5%	26
Total	**100.0%**	**127**

Continuation of Table C.4

In which of the following scenarios would you share your speeding history with insurance companies?		
	Percent	**Respondents**
All the time.	11.8%	15
Only if there is an accident.	22.8%	29
Only if it represents a premium cost reduction.	10.2%	13
Only if there is an accident or if it represents a premium cost reduction.	30.7%	39
Never	24.4%	31
Total	**100.0%**	**127**

In which of the following scenarios do you think authorities should be able to control the speed of vehicles externally?		
	Percent	**Respondents**
All the time.	12.2%	23
The vehicle is used for criminal purposes (e.g. escaping, terrorism).	54.0%	102
The vehicle is in a scholar area.	34.9%	66
The vehicle is in a residential area.	19.6%	37
The driver is unconscious.	57.7%	109
Never.	23.8%	45
Total	**100.0%**	**189**

Table C.4. Regulation frequency data

C.3 Spearman's Correlations

In the following table, the analysis of correlation results is presented.

		Correlation - Spearman's rho					
		Age Group	**Income level**	**Freq. of speeding**	**Experience**	**ISA benefit**	**Speed safe**
Age Group	**Correlation Coefficient**	–					
	Sig. (2-tailed)						
	N	189					
Income level	**Correlation Coefficient**	,243**	–				
	Sig. (2-tailed)	0.001					
	N	189	189				
Freq. of speeding	**Correlation Coefficient**	-,302**	0.064	–			
	Sig. (2-tailed)	0.001	0.474				
	N	127	127	127			
Experience	**Correlation Coefficient**	-0.183	-,288*	-0.050	–		
	Sig. (2-tailed)	0.213	0.047	0.767			
	N	48	48	38	48		
ISA benefit	**Correlation Coefficient**	,185*	-0.133	-0.064	,385**	–	
	Sig. (2-tailed)	0.011	0.068	0.475	0.007		
	N	189	189	127	48	189	
Speed safe	**Correlation Coefficient**	0.123	-0.031	-,306**	,298*	,383**	–
	Sig. (2-tailed)	0.093	0.668	0.000	0.040	0.000	
	N	189	189	127	48	189	189

****. Correlation is significant at the 0.01 level (2-tailed).**

***. Correlation is significant at the 0.05 level (2-tailed).**

Table C.5. Correlation analysis results using Spearman's rho. Table adapted from SPSS output.

C.4 Chi Square's Dependencies

In the following table, the most relevant dependencies found in the survey are presented.

Table C.6. Dependencies results using Chi Squared analysis. Table adapted from SPSS output.

Turn off ISA * Exp - sound

Chi-Square Tests

	Value	df	Asymptotic
Pearson Chi-Square	36,838a	2	**0.000**
Likelihood Ratio	37.412	2	0.000
Linear-by-Linear Association	27.960	1	0.000
N of Valid Cases	189		

a. 2 cells (33,3%) have expected count less than 5. The minimum expected count is 1,33.

Symmetric Measures

	Value	Asymptotic	Approximate T(b)	Approximate Significance
Phi	0.441			0.000

Continuation of Table C.6

Nominal by Nominal	Cramer's V	0.441			0.000
Interval by Interval	Pearson's R	0.386	0.048	5.716	,000c
Ordinal by Ordinal	Spearman Correlation	0.403	0.051	6.019	,000c
N of Valid Cases		189			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Turn off ISA * Exp - visual

Chi-Square Tests

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	19,003a	2	0.000
Likelihood Ratio	17.724	2	0.000
Linear-by-Linear Association	14.971	1	0.000
N of Valid Cases	189		

a. 2 cells (33,3%) have expected count less than 5. The minimum expected count is ,95.

Symmetric Measures

		Value	**Asymptotic Standard Error(a)**	**Approximate T(b)**	**Approximate Significance**
Nominal by Nominal	Phi	0.317			0.000
	Cramer's V	0.317			0.000
Interval by Interval	Pearson's R	0.282	0.056	4.022	,000c
Ordinal by Ordinal	Spearman Correlation	0.294	0.059	4.202	,000c
N of Valid Cases		189			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Continuation of Table C.6

c. Based on normal approximation.

Why-incorrect limit * Freq. of speeding

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25,734a	3	0.000
Likelihood Ratio	25.802	3	0.000
Linear-by-Linear Association	18.868	1	0.000
N of Valid Cases	127		

a. 4 cells (50,0%) have expected count less than 5. The minimum expected count is ,85.

Symmetric Measures

		Value	Asymptotic Standard Error(a)	Approximate T(b)	Approximate Significance
Nominal by Nominal	Phi	0.450			0.000
	Cramer's V	0.450			0.000
Interval by Interval	Pearson's R	0.387	0.058	4.692	,000c
Ordinal by Ordinal	Spearman Correlation	0.426	0.073	5.258	,000c
N of Valid Cases		127			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Need capacitation * Exp - acceleration

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)

Continuation of Table C.6

Pearson Chi-Square	7,965a	2	0.019
Likelihood Ratio	9.457	2	0.009
Linear-by-Linear Association	7.711	1	0.005
N of Valid Cases	48		

a. 3 cells (50,0%) have expected count less than 5. The minimum expected count is 1,02.

Symmetric Measures

		Value	**Asymptotic Standard Error(a)**	**Approximate T(b)**	**Approximate Significance**
Nominal by Nominal	Phi	0.407			0.019
	Cramer's V	0.407			0.019
Interval by Interval	Pearson's R	0.405	0.113	3.005	,004c
Ordinal by Ordinal	Spearman Correlation	0.398	0.099	2.940	,005c
N of Valid Cases		48			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Exp - limited * Freq. of speeding

Chi-Square Tests

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	12,222a	3	0.007
Likelihood Ratio	7.353	3	0.061
Linear-by-Linear Association	3.967	1	0.046

Continuation of Table C.6

N of Valid Cases	127

a. 4 cells (50,0%) have expected count less than 5. The minimum expected count is ,31.

Symmetric Measures

		Value	**Asymptotic Standard Error(a)**	**Approximate T(b)**	**Approximate Significance**
Nominal by Nominal	Phi	0.310			0.007
	Cramer's V	0.310			0.007
Interval by Interval	Pearson's R	0.177	0.105	2.016	,046c
Ordinal by Ordinal	Spearman Correlation	0.193	0.106	2.195	,030c
N of Valid Cases		127			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Exp - limited * Income level

Chi-Square Tests

	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	17,865a	8	0.022
Likelihood Ratio	17.509	8	0.025
Linear-by-Linear Association	0.086	1	0.769
N of Valid Cases	189		

a. 9 cells (50,0%) have expected count less than 5. The minimum expected count is ,62.

Symmetric Measures

		Value	**Asymptotic Standard Error(a)**	**Approximate T(b)**	**Approximate Significance**
	Phi	0.307			0.022

Continuation of Table C.6

Nominal by Nominal	Cramer's V	0.307			0.022
Interval by Interval	Pearson's R	0.021	0.079	0.292	,770c
Ordinal by Ordinal	Spearman Correlation	0.018	0.076	0.240	,810c
N of Valid Cases		189			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

ISA law * Age Group

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	19,910a	4	0.001
Likelihood Ratio	15.667	4	0.004
Linear-by-Linear Association	11.290	1	0.001
N of Valid Cases	189		

a. 4 cells (40,0%) have expected count less than 5. The minimum expected count is ,78.

Symmetric Measures

		Value	Asymptotic Standard Error(a)	Approximate T(b)	Approximate Significance
Nominal by Nominal	Phi	0.325			0.001
	Cramer's V	0.325			0.001
Interval by Interval	Pearson's R	-0.245	0.083	-3.457	,001c
Ordinal by Ordinal	Spearman Correlation	-0.264	0.075	-3.749	,000c
N of Valid Cases		189			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Continuation of Table C.6

c. Based on normal approximation.